IAEA
International Atomic Energy Agency

ANNUAL REPORT 2008

Annual Report 2008

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

This report covers the period 1 January to 31 December 2008.

GC(53)/7

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(designation as of 31 December 2008)

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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 located in Vienna. The IAEA's principal objective is "to accelerate and enlarge the contribution of atomic energy to peace, health and prosperity throughout the world".

The Agency at a Glance

(as of 31 December 2008)

145 Member States.

68 intergovernmental and non-governmental organizations worldwide invited to observe the Agency's General Conference.

51 years of international service.

2326 professional and support staff.

€277 million total regular budget for 2008, supplemented by extrabudgetary contributions received in 2008 amounting to **€29.7 million**.

$80 million target in 2008 for voluntary contributions to the Agency's Technical Cooperation Fund, supporting projects involving **2811** expert and lecturer assignments, **3673** meeting participants, **2744** participants in training courses and **1621** fellows and scientific visitors.

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

2 international laboratories (Seibersdorf and Monaco) and research centres.

11 multilateral conventions on nuclear safety, security and liability adopted under the Agency's auspices.

4 regional/cooperative agreements relating to nuclear science and technology.

109 Revised Supplementary Agreements governing the provision of technical assistance by the Agency.

125 active CRPs involving **1637** approved research, technical and doctoral contracts and research agreements. In addition, **77** Research Coordination Meetings were held.

237 safeguards agreements in force in **163** States involving **2036** safeguards inspections performed in 2008. Safeguards expenditures in 2008 amounted to **€96.4 million** in regular budget and **€10.7 million** in extrabudgetary resources.

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

14 million monthly hits to the Agency's iaea.org site, representing **2.1 million** pages viewed per month.

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

1.2 million documents, technical reports, standards, conference proceedings, journals and books in the IAEA Library and **8000** visitors to the Library in 2008.

184 publications and newsletters issued (in print and electronic formats) in 2008.

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 the area of nuclear technologies, the Board considered the *Nuclear Technology Review 2008* and, in addition, a Secretariat report on the *International Status and Prospects of Nuclear Power.*

In the area of safety and security, the Board discussed the *Nuclear Safety Review for the Year 2007* and it established Agency safety standards in a number of areas. It also debated the *Nuclear Security Report 2008 — Measures to Protect against Nuclear Terrorism.*

As regards verification, the Board considered the *Safeguards Implementation Report for 2007*. It approved a number of safeguards agreements and additional protocols. The Board kept under its consideration the implementation of the NPT safeguards agreement and relevant provisions of United Nations Security Council resolutions in the Islamic Republic of Iran and the issue of the application of safeguards in the Democratic People's Republic of Korea. The Board also considered the implementation of the NPT safeguards agreement in the Syrian Arab Republic.

The Board discussed the *Technical Cooperation Report for 2007* and approved the Agency's technical cooperation programme for 2009.

The Board discussed the *Report of the Commission of Eminent Persons on the Future of the Agency.*

Composition of the Board of Governors (2008–2009)

Chairperson: HE Ms. Taous FEROUKHI
Ambassador, Governor from Algeria

Vice-Chairpersons: HE Ms. Kirsti KAUPPI
Ambassador, Governor from Finland

HE Mr. Cornel FERUTĂ
Ambassador, Governor from Romania

Afghanistan
Albania
Algeria
Argentina
Australia
Brazil
Burkina Faso
Canada
China
Cuba
Ecuador
Egypt
Finland
France
Germany
Ghana
India
Iraq
Ireland
Japan
Lithuania
Malaysia
Mexico
New Zealand
Philippines
Romania
Russian Federation
Saudi Arabia
South Africa
Spain
Switzerland
Turkey
United Kingdom of Great Britain and Northern Ireland
United States of America
Uruguay

The General Conference

The General Conference comprises all Member States of the Agency and meets once a year. It debates the annual report of the Board of Governors on the Agency's activities during the previous year, approves the Agency's accounts and 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 the medium and long term.

In 2008, the Conference — upon the recommendation of the Board — approved Oman, Lesotho and Papua New Guinea for membership of the Agency. By the end of 2008, the Agency's membership had risen to 145 States.

Notes

- The *Annual Report 2008* 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 19, generally follows the programme structure as given in *The Agency's Programme and Budget 2008–2009* (GC(51)/2).

- The introductory chapter, 'The Year in Review', 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. More detailed information can be found in the latest editions of the Agency's *Nuclear Safety Review, Nuclear Technology Review, Technical Cooperation Report* and the *Safeguards Statement for 2008 and Background to the Safeguards Statement*. 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 provided on the attached CD-ROM, and is also available on the Agency's web site at *http://www.iaea.org/Worldatom/Documents/Anrep/Anrep2008/.*

- Except where indicated, all sums of money are expressed in United States dollars.

- The designations employed and the presentation of material in this document do not imply the expression of any opinion whatsoever on the part of the Secretariat concerning the legal status of any country or territory or of its authorities, or concerning the delimitation of its frontiers.

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

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

Abbreviations

ABACC	Brazilian–Argentine Agency for Accounting and Control of Nuclear Materials
AFRA	African Regional Co-operative Agreement for Research, Development and Training Related to Nuclear Science and Technology
ARCAL	Co-operation Agreement for the Promotion of Nuclear Science and Technology in Latin America and the Caribbean
BWR	Boiling water reactor
CRP	Coordinated research project
EBRD	European Bank for Reconstruction and Development
EC	European Commission
ESTRO	European Society for Therapeutic Radiology and Oncology
Euratom	European Atomic Energy Community
Europol	European Police Office
FAO	Food and Agriculture Organization of the United Nations
FORATOM	European Atomic Forum
GEF	Global Environment Facility
HEU	High enriched uranium
IAEA-MEL	IAEA Marine Environment Laboratory
ICAO	International Civil Aviation Organization
ICPO-INTERPOL	International Criminal Police Organization – INTERPOL
ICRP	International Commission on Radiological Protection
ICRU	International Commission on Radiation Units and Measurements
ICTP	Abdus Salam International Centre for Theoretical Physics
IEA	International Energy Agency (OECD)
ILO	International Labour Organization
INFCIRC	Information Circular (IAEA)
INIS	International Nuclear Information System
INPRO	International Project on Innovative Nuclear Reactors and Fuel Cycles (IAEA)
IOC	Intergovernmental Oceanographic Commission (UNESCO)
IRPA	International Radiation Protection Association
ISO	International Organization for Standardization
LEU	Low enriched uranium
LMFR	Liquid metal fast reactor

LWR	Light water reactor
NATO	North Atlantic Treaty Organization
NPT	Treaty on the Non-Proliferation of Nuclear Weapons
OECD	Organisation for Economic Co-operation and Development
OECD/NEA	OECD Nuclear Energy Agency
OPEC	Organization of the Petroleum Exporting Countries
PAHO	Pan American Health Organization/WHO
PET	Positron emission tomography
PHWR	Pressurized heavy water reactor
PWR	Pressurized water reactor
RBMK	Light boiling water cooled graphite moderated pressure tube reactor
SAL	Safeguards Analytical Laboratory (IAEA)
SQ	Significant quantity
TCF	Technical Cooperation Fund (IAEA)
UNDESA	United Nations Department of Economic and Social Affairs
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNICEF	United Nations Children's Fund
UNIDO	United Nations Industrial Development Organization
UNOPS	United Nations Office for Project Services
UNSC	United Nations Security Council
UNSCEAR	United Nations Scientific Committee on the Effects of Atomic Radiation
WHO	World Health Organization
WMO	World Meteorological Organization
WNA	World Nuclear Association
WWER	Water cooled and moderated energy reactor

The Year in Review

Half a century after its founding, the International Atomic Energy Agency continues to serve as the focal point for worldwide cooperation in the peaceful uses of nuclear technology, for promoting global nuclear safety and security and, through its verification activities, for providing assurances that international obligations to use nuclear material and facilities for peaceful purposes are being complied with. What follows is a survey of 'nuclear developments' around the world in 2008, and how they affected the work of the Agency, within the framework of the three pillars of technology, safety and security, and verification.

"Current expansion, as well as near term and long term growth prospects, remained centred in Asia."

reactor coming on-line. However, construction started on ten new reactors — the largest number in any one year since 1985. Altogether, there were 44 nuclear power reactors under construction at the end of 2008 and a total of 438 in operation, supplying about 14% of the world's electricity.

Current expansion, as well as near term and long term growth prospects, remained centred in Asia. Of the ten construction starts in 2008, eight were in this region, as were 28 of the 44 reactors under construction at the end of the year. Moreover, 28 of the last 39 new reactors to have been connected to the grid were in Asia. Looking at individual countries, China is considering a significant increase in its growth targets for nuclear power. In 2008, six of the ten construction starts were in China. India's planned fifteenfold expansion of its civilian nuclear power programme over the next two decades is expected to be facilitated by the removal by suppliers in 2008 of restrictions on the supply of nuclear technology that were previously imposed on it. Targets were raised in the Russian Federation, to 52–59 GW(e) of nuclear power capacity by 2020. The United States Nuclear Regulatory Commission received combined licence applications for 18 new reactors, bringing the total number of new reactors under review to 26.

Technology

Nuclear Power, Nuclear Fuel Cycle and Sustainable Development

Nuclear Power: Status and Trends

The year 2008 was paradoxical for nuclear power. Projections of future growth were revised upward, but no new reactors were connected to the grid — the first year since 1955 without at least one new

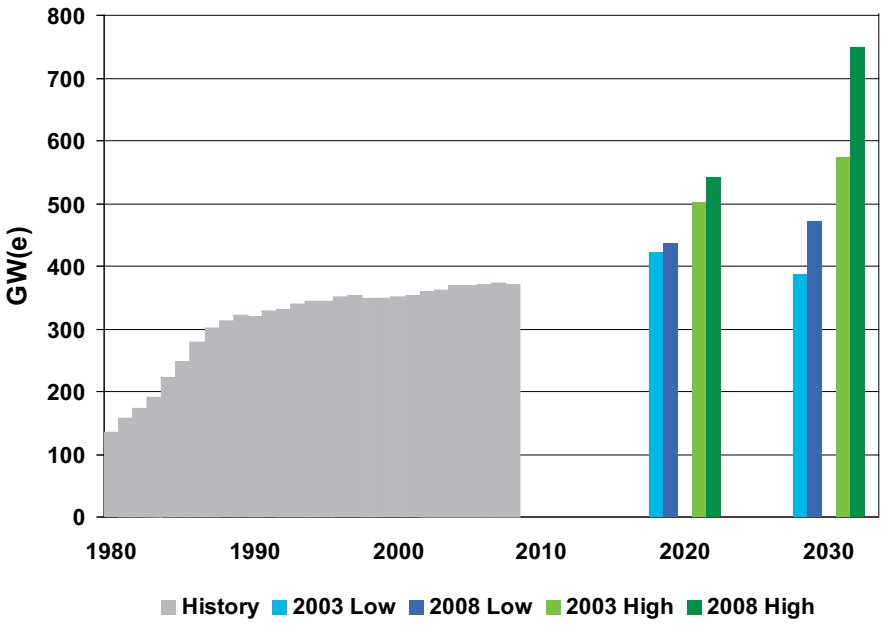


FIG. 1. Comparison of projections made in 2003 and 2008 for installed global nuclear power capacity.

In 2008, the Agency revised upward its medium term projections for nuclear power, to 473 GW(e) and 748 GW(e), respectively, in its low and high projections for 2030 (Fig. 1).[1] The International Energy Agency also raised its projections.[2]

Innovative Nuclear Technologies

The Agency continued to facilitate coordination and information sharing in the area of technology innovation and development. Specifically, it compiled the expectations of developing countries in the form of 'common user considerations' for appropriate designs to be developed in the near term. Six countries completed assessments of innovative nuclear systems using the evaluation methodology developed by the Agency's International Project on Innovative Nuclear Reactors and Fuel Cycles (INPRO), and a group of eight countries completed a similar joint study. The results will be used to update the INPRO methodology.

The Generation IV International Forum, or GIF, was established to lead the collaborative efforts of the world's leading nuclear technology nations to develop next generation nuclear energy systems to meet future energy needs. In 2008, China signed a 'system arrangement' for joint work on very high temperature reactors. France, Japan and the USA are harmonizing work on prototype sodium cooled fast reactors. Other projects are under way on system integration, safety and operation, advanced fuel, balance of plant, and the 'global actinide cycle international demonstration'. In October, the Agency and GIF organized a workshop on the application of software in the evaluation of the economics of high temperature gas cooled reactors.

Assurances of Supply

In 2008, there were a number of positive responses to the proposal of the Director General to establish a nuclear fuel reserve of last resort, under Agency auspices, in the event of supply disruptions. In September 2006, the Nuclear Threat Initiative made an offer to the Agency of $50 million, contingent on contributions of an additional $100 million by Member States. By the end of the year, contributions and pledges to support the possible establishment of an Agency reserve of low enriched uranium (LEU) were made by Norway ($5 million), the United Arab Emirates ($10 million), the USA ($50 million) and the European Union (€25 million), bringing the Agency quite close to the sum of $150 million needed for that purpose.[3] Also in 2008, progress was made on other proposals related to assurances of fuel supply made by Member States.[4] These included Germany's proposal for setting up a multilateral enrichment sanctuary project,[5] and the Russian Federation's initiative to establish an LEU reserve to be provided to the Agency, upon its request, for use by Member States,[6] which would be located at an international uranium enrichment centre in Angarsk.

"In 2008, there were a number of positive responses to the proposal of the Director General to establish a nuclear fuel reserve ..., under Agency auspices, in the event of supply disruptions."

Launching Nuclear Power Programmes

While every country has the right to use nuclear power as an energy source, it also has the responsibility to ensure that this energy source is employed in a safe and secure manner. In 2008, interest continued to grow among Member States in starting nuclear power programmes. This was reflected in a larger number of requests for Agency assistance in analysing energy options

[1] Gigawatt-electric (GW(e)): 1 billion watts of electrical capacity.

[2] All of these revisions were made before the onset of the financial crisis in late 2008. At the time of writing, no projections were available that have analysed the impact of the crisis on the growth of nuclear power.

[3] By March 2009, the required matching contributions had been received as a result of a $10 million pledge made by Kuwait.

[4] The proposals were listed in *Possible New Framework for the Utilization of Nuclear Energy: Options for Assurance of Supply of Nuclear Fuel Report by the Director General* (GOV/INF/2007/11, 13 June 2007).

[5] *Communication dated 30 May 2008 received from the Permanent Mission of the Federal Republic of Germany to the Agency with regard to the German proposal for a Multilateral Enrichment Sanctuary Project* (INFCIRC/727, 30 May 2008); and *Communication dated 22 September 2008 received from the Permanent Mission of Germany to the Agency regarding the German proposal on a Multilateral Enrichment Sanctuary Project* (INFCIRC/735, 25 September 2008).

[6] *Communication dated 13 March 2009 received from the Resident Representative of the Russian Federation to the IAEA on the Russian initiative to establish a guaranteed reserve of low enriched uranium* (INFCIRC/748, 1 April 2009).

and in preparing for the introduction of nuclear power. Specifically, more than 50 Member States expressed interest in considering the introduction of nuclear power. The number of approved technical cooperation projects on analysing energy options went up, from 29 in 2006–2007 to 41 in 2008, while the number of projects on considering the introduction of nuclear power increased from 13 to 44 during the same period.

The Agency conducted four missions in 2008 — to the Cooperation Council for the Arab States of the Gulf, Nigeria, the Philippines and Sudan — to advise on their consideration of nuclear power. In December, the Agency introduced a new Integrated Nuclear Infrastructure Review (INIR) service. The goal is to assist States in adopting a comprehensive and integrated approach to the introduction of nuclear power. The service will help States in determining the status of their infrastructure, analysing gaps in the planning process and focusing assistance. In addition, the Agency published *Evaluation of the Status of National Nuclear Infrastructure Development* and held a workshop to discuss the evaluation guidance.

Energy Assessment Services, Nuclear Investment Costs and Financing

There was increased demand for Agency assistance in assessing national and regional energy systems and energy strategies; its analytical tools are now being used in 115 Member States and six international organizations. In 2008, the Agency trained 402 energy analysts and planners from 58 countries in the use of its analytical tools. To expand its capacity to meet the increased demand for training, and following a successful pilot project, the Agency in 2008 introduced 'technology supported learning' using multimedia training packages for distance learning and the cyber platforms of the Asian Network for Education in Nuclear Technology (ANENT) and the Latin American Energy Organization.

"There was increased demand for Agency assistance in assessing national and regional energy systems and energy strategies ..."

For a country contemplating the introduction of nuclear power, the high capital costs are an important consideration. Cost estimates have generally increased, from 2006 figures of between $1200–$2510 per kW(e) — which was when the Agency previously reviewed the data — to $1400–$6000 per kW(e) in 2008. Possible explanations are: (1) the inclusion of a larger number of estimates from utilities — whose figures may be more conservative than those of vendors; (2) tight commodity markets and steeply rising international market prices for steel, cement and energy; (3) estimates from countries without recent construction experience, and thus possibly higher levels of uncertainty; (4) new reactor designs with incremental 'first of a kind' costs; and (5) a shift from a buyers market to a suppliers market as a result of greater interest in nuclear power.[7]

It is as yet too soon to predict how the current financial crisis will affect these trends; and every country will be affected differently. States that have built their energy planning capacity using the Agency's tools can reassess their plans as needed based on their own projections of how these trends develop.

Human Resource Issues

A number of countries have expressed their concern about the possible lack of skilled workers needed for the future introduction or expansion of nuclear power. However, data are scarce on both the size of the skilled workforce available today and the number of training programmes. Quantitative estimates of future needs are also scarce. In countries with established nuclear power programmes, past reductions in the skilled workforce have varied according to the size of the nuclear power programme, with the paradoxical result that concerns about staff shortages generally appear to be lower in countries with faster growing programmes. Worries about possible shortages have prompted initiatives by government and industry to attract students and expand education and training in nuclear related fields. For example, largely as a result of the University Reactor Infrastructure and Education Assistance Program, the overall number of nuclear engineering degrees awarded in the USA has increased (Fig. 2).

In 2008, the Agency provided training, assistance missions and guidance to support both the planning for and development of human resources. Its INIR

[7] The economic considerations involved in building nuclear power plants are detailed in an Agency report entitled *Financing of New Nuclear Power Plants* (IAEA Nuclear Energy Series No. NG-T-4.2).

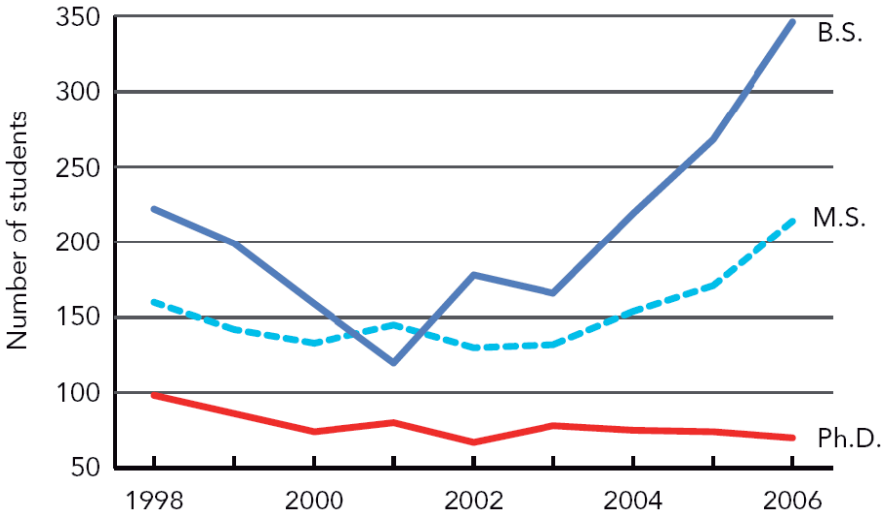


FIG. 2. Nuclear engineering degrees obtained at US universities (source: OECD/NEA).

service reviews human resource needs for countries considering the introduction of nuclear power. In addition, the Agency completed two reports, *Commissioning of Nuclear Power Plants: Training and Human Resource Considerations* and *Managing Human Resources in the Field of Nuclear Energy*, both in the IAEA Nuclear Energy Series.

Uranium Supply Issues

The 22nd edition of the OECD/NEA–IAEA's *Uranium 2007: Resources, Production and Demand* (the 'Red Book'), published in 2008, reported an increase in uranium resources, reflecting recent growth in exploration activities worldwide. The report noted that resources would last 83 years at the current rate of consumption. This compares favourably to reserves to production ratios of 30–50 years for other commodities (e.g. copper, zinc, oil and natural gas). However, demand is projected to grow, and resources in the ground need to be mined. Existing, committed, planned and prospective uranium production facilities could satisfy requirements in the Agency's high projection until about 2025. For the longer term, preliminary results show sufficient uranium resources in the ground. However, their accessibility will depend on a range of financial considerations and public acceptance of nuclear power.

As interest in uranium mining has increased in countries that are new to the mining of this resource, the number of Agency technical cooperation projects on uranium exploration and mining has doubled. As part of this effort, the Agency encourages the use of best practices through workshops for new uranium producers, an education and training network for the uranium cycle, and the preparation of reference publications. In 2008, the Agency assisted uranium mine developers, operators and regulators in improving their capacities to deal with the environmental consequences of mining, including the remediation of sites, as well as the associated public concerns.

"As interest in uranium mining has increased in countries that are new to the mining of this resource, the number of Agency technical cooperation projects on uranium exploration and mining has doubled."

Improving the Utilization of Research Reactors

The number of operating research reactors is projected to decrease from the current level of 245 to between 100 and 150 in 2020. New research reactors will continue to be built, although not as fast as old ones are retired. To help ensure broad access and efficient use, and to facilitate greater international cooperation, the Agency began establishing a number of regional networks in 2008, including the Eastern European Research Reactor Initiative (EERRI), the Caribbean Research Reactor Coalition, the Mediterranean Research Reactor Utilization Network and the Baltic Research Reactor Utilization Network.

The Agency in 2008 increased the number of technical cooperation projects supporting research reactors from four to ten for the project cycle starting in 2009. For Member States with little or no nuclear infrastructure, the Agency and EERRI developed

a training course to help build up the necessary human resources.

Nuclear Fusion

International efforts to develop nuclear fusion energy recorded a number of milestones in 2008. In February, the ITER International Fusion Energy Organization (ITER Organization) formally applied for a construction permit to build the International Thermonuclear Experimental Reactor in Cadarache, France. Massive ground development work is already under way to construct facilities that will house the sophisticated equipment for ITER. In addition, the ITER Organization and the Agency signed a cooperation agreement in October to facilitate interactions with Member States.

The 22nd IAEA Fusion Energy Conference was held in October in Geneva to commemorate and review 50 years of international progress in this area.

Nuclear Applications

The application of nuclear technologies in the areas of food security, disease prevention and control, water resources and environmental management has increasing importance in the world today. In 2008, the Agency strengthened its partnerships, responding to the world's food, environmental and cancer crises by enhancing State and regional capacities to use relevant technologies for sustainable solutions.

"The Agency's coordinated research activities resulted in advanced mutant lines being developed by national breeding programmes ..., increasing the nutritional value of tomato, sweet pepper and mustard."

Food Security

In 2008, the world faced a growing food crisis, with FAO estimating that the number of undernourished people had grown to approximately 960 million. Food commodity prices went up during the year, causing immense hardship to people in many developing countries. Factors contributing to this crisis were climate change (including extreme weather events), changes in land use, scarcity of fresh water, transboundary animal and plant pests and diseases, loss of biodiversity as well as increasing demand for biofuels.

One of the responses to this crisis has been the application of advanced technology. For example, farmers in some of the world's most remote regions witnessed quantifiable impacts following the introduction of nuclear technologies. In southern Peru, the Tacna and Moquegua regions were declared free of the Mediterranean and *Anastrepha* fruit flies in 2008, preventing losses of $12 million in fruit and vegetable production, and contributing to a significant reduction in insecticide use. This was achieved through the area-wide application of the sterile insect technique (SIT), representing the culmination of over two decades of work by governments and institutions.

The Agency encouraged private sector involvement in the production of sterile insects for use in pest control by developing *A Model Business Plan for a Sterile Insect Production Facility*. For example, a technical cooperation pilot project in South Africa led to the establishment of a private sector company and a mass rearing facility that uses SIT to control the false codling moth, an insect pest of citrus crops.

Efforts to enhance food security included the release in 2008 of 41 mutant varieties from 13 crop species in more than 10 countries, a direct consequence of increases in the efficiency of mutation assisted breeding in over a dozen institutes and laboratories worldwide. For instance, the Agency supported a wheat breeding programme in Kenya that released a mutant variety, which, under drought conditions, yields 11% more than the best varieties currently available. The Agency's coordinated research activities resulted in advanced mutant lines being developed by national breeding programmes in Bulgaria, China and Pakistan, increasing the nutritional value of tomato, sweet pepper and mustard.

There was progress in developing techniques for the early and rapid diagnosis of transboundary animal diseases, including diseases that can be transferred to humans. More than 60 Member States received support and technical guidance in such areas as diagnostic and vaccine technologies and preventive measures.

To help European Member States control the spread of bird flu, the Agency held a training course in the Russian Federation on the latest diagnostic and treatment technologies. In addition, the Agency assisted Belize in protecting its poultry sector,

primarily by enhancing its diagnostic capacity to differentiate between avian influenza and Newcastle disease, which was prevalent in the country.

In 2008, more than 16 Member States requested the assistance of the Agency in using post-harvest phytosanitary applications of food irradiation to meet quarantine requirements and to facilitate international trade in fresh produce. In the area of food safety, the Agency developed analytical methods and procedures to detect and monitor chemical hazards.

Water Resources

Despite a range of international efforts, the world is still far from preventing the unsustainable use of water resources. In this regard, the management of transboundary water resources — which extend across country borders and include both surface water bodies (such as lakes and rivers) and groundwater systems (aquifers) — is of increasing concern, not only because of overutilization and pollution problems, but also because these shared resources can be a source of conflict between countries. Globally, over 260 transboundary river basins have been identified. Transboundary aquifers are equally important, but until recently were largely unidentified. Efforts are under way around the world to map them, and so far 89 transboundary aquifers have been identified in Europe alone.

"... the Agency — in partnership with the GEF — initiated a project in 2008 to facilitate the sharing of water resources among the riparian countries of the Nile Basin in Africa."

Managing transboundary water resources can be extremely challenging, particularly in the absence of hydrological information upon which to make informed decisions. Agency activities, aimed at increasing the availability of scientific data using isotope techniques, focused on improving the understanding of the distribution and renewability of groundwater resources. In this regard, in 2008 it cooperated with UNESCO, the International Association of Hydrogeologists and others to finalize a world hydrogeological map of groundwater resources.

Partnering with the Global Environment Facility (GEF), the Organization of American States, the World Bank, and national counterparts, the Agency completed a project where isotope hydrology was used to assess the key characteristics of and develop a sustainable management approach for the transboundary Guarani Aquifer in South America. With one of the largest freshwater reserves on the continent, this aquifer, which extends across Argentina, Brazil, Paraguay and Uruguay, covers an area more than twice the size of France, with 90 million people living in this region. In addition, the Agency — in partnership with the GEF — initiated a project in 2008 to facilitate the sharing of water resources among the riparian countries of the Nile Basin in Africa.

With the need for global and regional isotope data increasing dramatically, the Agency expanded its isotope networks. In addition, over 80 technical cooperation projects focused on local and national water supply and quality problems.

Medical Applications of Radiopharmaceuticals

The isotope technetium-99m, derived from molybdenum-99 (a related radioactive substance), is used in some 80% of all diagnostic nuclear medicine procedures around the world. It is injected into patients undergoing cardiac stress tests or body scans for cancer, heart disease and bone or kidney illnesses. This medical radioisotope is currently produced only in a few ageing research reactors. The uncertainty of this supply situation was underlined in 2008 when the simultaneous outages of three medical isotope production facilities in Europe resulted in a worldwide shortage of technetium-99m. An unexpected outage extension of a Canadian research reactor resulted in a similar shortage in late 2007 Agency activities in 2008 to help find a solution to this problem included the initiation of a CRP and close interaction with governments and industry. There is growing global consensus that technology using LEU to produce molybdenum-99 is both technically and financially viable.

Facilitating the Development of Comprehensive Cancer Control Programmes

The world's incidence of cancer doubled during the last three decades of the 20th century and continues to increase, with cancer predicted to become the leading cause of death around the world by 2010. While age adjusted cancer incidence and death rates have begun to decrease in high income countries, low and middle income (LMI) countries

FIG. 3. President Jakaya Kikwete of the United Republic of Tanzania (left) at the official inauguration of a radiotherapy machine donated through PACT.

will bear the brunt of the increase. WHO estimates that without intervention, more than 100 million people will die in the next ten years. Currently, more than 70% of all cancer deaths already occur in LMI countries, where resources for prevention, diagnosis and treatment are limited or are non-existent.

To ensure high quality in the diagnosis and treatment of cancer and other diseases, the IAEA–WHO dosimetry audit service reviewed approximately 450 hospital beams and resolved 25 discrepancies. Several quality control/quality assurance manuals on imaging were also approved for publication.

"The Agency advised Member States in planning, preparing and establishing PET centres and in building up the requisite human resources."

With the aim of strengthening its Programme of Action for Cancer Therapy (PACT), the Agency formalized partnership agreements with four leading international cancer organizations and agencies, and finalized an agreement for a Joint Programme on Cancer Control with WHO.

The Agency conducted 11 imPACT missions in 2008 to assess national cancer profiles and cancer control capacity, and to develop and implement recommendations for comprehensive national cancer control programmes. In total, 57 Member States have requested such imPACT reviews.

Resource mobilization in 2008 included $13.5 million in long term development loans from the OPEC Fund for Development and the Arab Bank for Economic Development in Africa to build a cancer control programme in Ghana, with Agency assistance. Direct fundraising by PACT resulted in donations of more than $400 000.

Highlights from the implementation of PACT Model Demonstration Sites (PMDSs) in 2008 included the dedication by the President of the United Republic of Tanzania of a radiotherapy machine donated through PACT (Fig. 3). A second machine donated to the PMDS in Nicaragua was installed in 2008.[8] And a tripartite agreement was concluded by which India will donate a 'Bhabhatron' teletherapy machine to support Vietnam's PMDS initiatives.

In the field of nuclear medicine and medical imaging, positron emission tomography (PET) and PET/computed tomography (CT) have improved cancer management programmes in Member States. While there are currently more than 1000 PET centres in North America and Western Europe, there are only around 50 such centres in Latin America and fewer than 10 in Africa, underlining the need for greater assistance in these regions. The Agency advised Member States in planning, preparing and establishing PET centres and in building up the requisite human resources. Nuclear medicine activities also emphasized the use of these and

[8] Both radiotherapy machines were donated by MDS Nordion/Best Medical International.

other nuclear technologies in the diagnosis and treatment of cardiovascular disorders. And the Agency continued to support the establishment and operation of medical cyclotron facilities and the production of PET tracers.

Environment

Challenges and threats to the marine and terrestrial environment, such as climate change and pollution, are of growing concern. Raising awareness about the need to encourage the sustainable development of natural resources in all countries is essential. In 2008, the Agency focused on the impacts of ocean acidification, increased temperatures, and contaminants, including radionuclides, in the marine environment on fisheries and marine biodiversity (Fig. 4).

"In 2008, the Agency focused on the impacts of ocean acidification, increased temperatures, and contaminants, including radionuclides, in the marine environment on fisheries and marine biodiversity."

The role of nuclear techniques to predict socioeconomic outcomes and support environmental mitigation in the marine environment was another important area of research in 2008. For example, radiotracers were used on commercially important species of fish, such as sea bream, sea bass and cuttlefish, to assess the incorporation of trace elements such as cadmium and zinc — commonly found in marine ecosystems — under future ocean chemistry scenarios. The presence of these contaminants is expected to increase in the future as a result of industrial growth.

At the second international symposium on the 'Ocean in a High CO_2 World', held in Monaco in October 2008, the 'Monaco Declaration' was signed by 155 countries. This declaration calls for greater efforts to combat carbon dioxide driven ocean acidification, a phenomenon that is expected to be a leading cause in the future decline of global marine ecosystems.

In line with its role of setting standards for the study of radionuclides, the Agency developed new parameters and models of radionuclide transfer in terrestrial and freshwater environments for use, among others, by regulators engaged in environmental impact assessments.

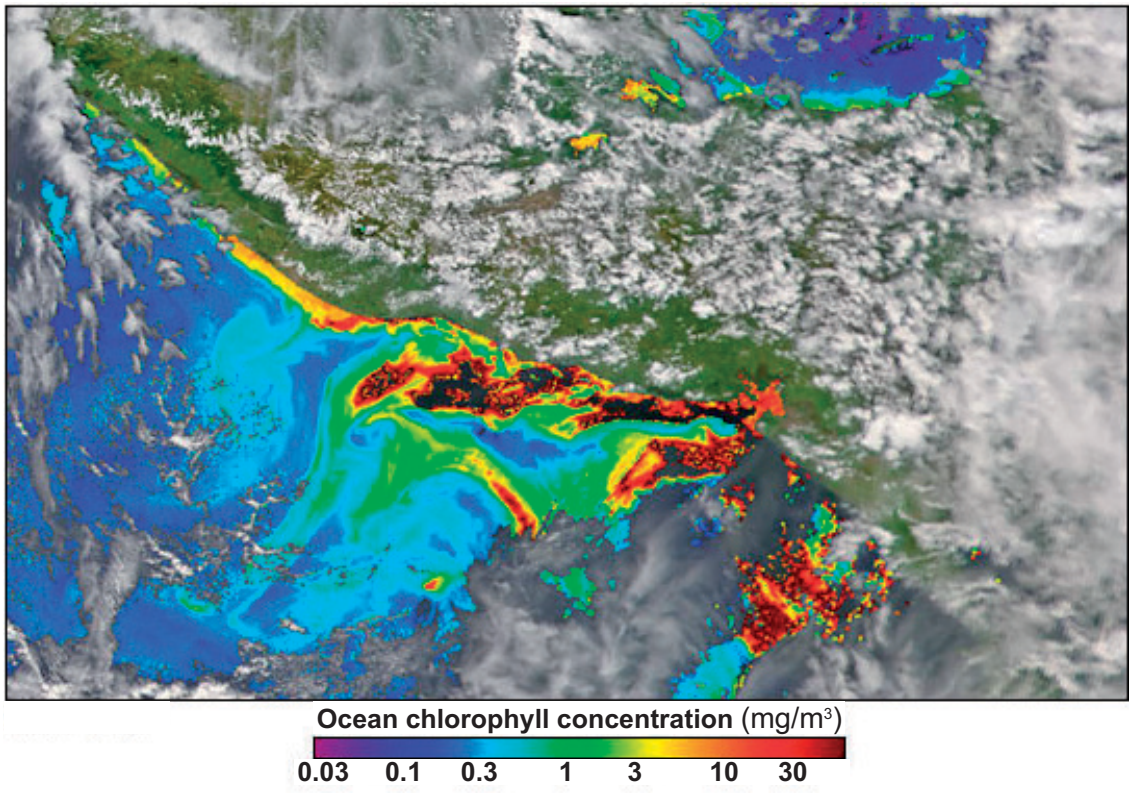


FIG. 4. As part of a technical cooperation project, the Agency monitored ocean chlorophyll concentrations, which influence harmful algal blooms, off the coast of El Salvador (photograph courtesy of NASA).

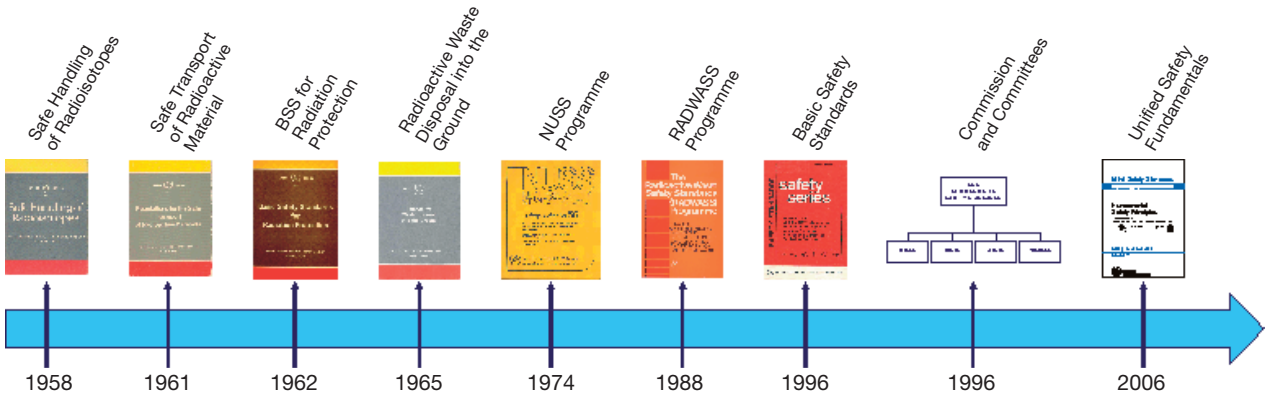


FIG. 5. Evolution of the Agency's safety standards.

Nuclear Safety and Security

Status of Nuclear Safety and Security

The safety and security of civil nuclear installations around the world in recent years has remained at a high level. However, it is important to avoid complacency. As the uses and the introduction of nuclear technologies expand, greater vigilance must be exercised by the global nuclear community. Levels of safety and security must keep pace with emerging technologies, expanding nuclear programmes and new entrants to the global nuclear community.

"... the Agency is ... well placed to coordinate international efforts devoted to ensuring that new nuclear power programmes are safe and secure."

Safety and security are primarily the responsibility of the State, but the far reaching consequences of possible accidents or nuclear terrorist acts have led to the recognition that strong global arrangements to address these risks are necessary. The Agency plays an important role, supporting the development and implementation of international conventions and codes of conduct, helping to establish international standards and guidelines, helping Member States through peer review missions to enhance their national safety and security infrastructures, and supporting regional and global knowledge networks. An example of this role is the proposed European Union Directive setting up a framework for nuclear safety which is based in part on the Agency's *Fundamental Safety Principles*.

An increasing number of Member States are considering a nuclear power programme for the first time. These new entrants may have an effective safety and security infrastructure for their current nuclear applications, but do not yet have the infrastructure appropriate for nuclear power. While the Agency is not the only organization providing assistance to these new entrants, it is well placed to coordinate international efforts devoted to ensuring that new nuclear power programmes are safe and secure.

Conventions, Standards and Guidance

Even though all of the international safety and security conventions recorded additional parties in 2008, participation in these conventions is by no means universal; this limits their influence.[9] This is of particular concern with regard to the Amendment to the Convention on the Physical Protection of Nuclear Material, which was ratified, approved or accepted by only 22 States Party, far short of the number required to bring the amendment into force.

In 2008, Contracting Parties to the Convention on Nuclear Safety held their fourth review meeting in which they, inter alia, recognized that the Agency's Safety Requirements and supporting

[9] By the end of 2008, the Convention on Nuclear Safety had 62 Contracting Parties; the Convention on Early Notification of a Nuclear Accident had 102 Contracting Parties; the Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency had 101 Contracting Parties; the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management had 46 Contracting Parties; the Convention on the Physical Protection of Nuclear Material had 138 Contracting Parties; and the Amendment to the Convention on the Physical Protection of Nuclear Material had 22 Contracting States.

guides are increasingly being implemented in national legislation. Contracting Parties to the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management held an organizational meeting in preparation for their third review meeting in 2009.

The Agency's safety standards and security guidance advise States on how to meet their international obligations. They also support States in meeting their national safety and security objectives. In 2008, the Agency celebrated the 50th anniversary of its safety standards programme. Since the *Safe Handling of Radioisotopes* was issued in December 1958, more than 200 safety standards have been published (Fig. 5).

The Agency continued to assist Member States in assessing their safety and security needs and vulnerabilities. In more than 150 safety review, security review and expert missions and more than 170 workshops, seminars and training courses in 2008, the Agency helped Member States appraise national application of safety standards and security guidelines and provided appropriate advice and assistance.

"The Agency, together with WHO and professional societies, supported efforts around the world to minimize unintended exposures in medical procedures."

Integrated Regulatory Review Service

The Integrated Regulatory Review Service (IRRS), introduced in 2005, is an international mechanism for sharing regulatory knowledge and experience among senior regulators. In 2008, IRRS missions visited Botswana, Côte d'Ivoire, Germany, Guatemala, Madagascar, Namibia, Sierra Leone, Spain and Ukraine. The modular nature of the IRRS enabled the scope of the service to be tailored to the needs and desires of each Member State.

One of the major goals of the IRRS is to promote high quality self-assessments. To this end, the Agency developed a methodology that not only supports the IRRS, but can also be used for other self-assessment activities. The Agency also assisted the Islamic Republic of Iran, Lebanon, Peru, Ukraine and Vietnam with their self-assessments in preparation for IRRS missions to these countries.

The Spanish Nuclear Safety Council hosted a workshop in Seville in November 2008 to discuss ways of improving the effectiveness of regulatory bodies using feedback from IRRS missions. Another mechanism used in 2008 for improving international regulatory communication is a network for sharing information among Member State regulatory bodies. This network is in the early stages of development and has strong support from a number of Member States.

Incident and Emergency Preparedness and Response and Seismic Safety

By the end of 2008, 14 Member States had registered their expert capabilities with the Agency's Response Assistance Network. In July 2008, an emergency exercise, ConvEx3 (2008), tested the international response to a simulated accident at a nuclear power plant. The Agency used its Incident and Emergency Centre (IEC) as the global focal point for international communication and response during the exercise. One outcome was confirmation that, in order to successfully fulfil its obligations under the Early Notification and Assistance Conventions in the event of a large nuclear accident, the IEC requires additional human resources as well as improvements in equipment and technology.

Recent extreme earthquakes and other natural events have demonstrated the need to reevaluate the safety of existing and future nuclear power plant designs. In 2008, the Agency established the International Seismic Safety Centre. Supported by a scientific committee of high level experts, the Centre serves as a focal point for seismic safety at nuclear installations worldwide.

Radiation Safety in Medical Applications

Medical radiation exposures have increased significantly over the past decade. The field is rapidly evolving, with increasingly advanced medical radiation technologies and a growing complexity of techniques.

Accidents during medical procedures, some fatal, continue to occur at an unacceptably high frequency. The Agency, together with WHO and professional societies, supported efforts around the world to minimize unintended exposures in medical procedures. For example, through its technical cooperation programme, it introduced assessment methodologies for clinical audits in radiation medicine and diagnostic radiology in

several Member States. In addition, international efforts addressed the problem of occupational exposure to radiation for medical workers, which has reached high levels for some modalities.

Denials and Delays of Shipment

Denials and delays of the shipment of radioactive material continue to occur in all parts of the world. The International Steering Committee on Denials of Shipment of Radioactive Material, set up by the Agency in 2006, continues to guide international activities. In 2008, the Committee organized four workshops on establishing regional networks to deal with the issue. It also oversaw the establishment of a database for denials of shipment, receiving more than 100 denial reports by the end of 2008.

Classification of Radioactive Waste

In 2008, the Agency completed an updated safety standard on the classification of radioactive waste. This publication covers all types of radioactive waste and recognizes the clearance concept for identifying the boundary between waste that needs to be managed as radioactive waste and that which can be removed from regulatory control for management as conventional waste.

Civil Liability for Nuclear Damage

The importance of having effective civil liability mechanisms in place to insure against harm to human health and the environment, as well as actual economic loss caused by nuclear damage, continues to be a subject of increased attention among Member States, especially in light of the renewed interest in nuclear power around the world. The International Expert Group on Nuclear Liability (INLEX) continues to serve as the Agency's main forum for dealing with questions related to nuclear liability and seeks to contribute towards a better understanding of, and adherence to, the international nuclear liability instruments adopted under the auspices of the Agency. INLEX outreach activities included the 3rd Regional Workshop on Liability for Nuclear Damage for African countries, held in South Africa in February 2008.

The deposit by the USA of its instrument of ratification of the Convention on Supplementary Compensation for Nuclear Damage (CSC) in May 2008 marked an important milestone in the Agency's efforts to strengthen the global international nuclear liability regime. To date, 13 countries have signed the CSC.[10] The CSC will enter into force 90 days after the date on which at least five States with a minimum of 400 000 MW of thermal power from nuclear reactors have deposited instruments of ratification.

Nuclear Security

States continued to give high priority to the threat of a malicious act involving nuclear or other radioactive material. In helping them to address these concerns, the Agency in 2008 supported improvements to physical protection measures in over 15 States, provided training to more than 1700 people from approximately 90 States in all aspects of nuclear security, and assisted in recovering more than 1500 disused radioactive sources and moving them to safe and secure national storage facilities. Nearly 600 pieces of radiation detection equipment were delivered to 24 States, in some cases in association with Agency training in the use of such equipment.

"... the Agency in 2008 ... assisted in recovering more than 1500 disused radioactive sources and moving them to safe and secure national storage facilities."

Assisting States by establishing nuclear security information tools continued to be a high priority. During the year, ten States approved Integrated Nuclear Security Support Plans (INSSPs), developed by the Agency as a blueprint for nuclear security work to be implemented over time. Membership in the Agency's Illicit Trafficking Database, an information resource covering trafficking and other unauthorized acts involving nuclear and other radioactive material, grew from 99 to 104 States.

The Agency's nuclear security programme continued to depend very heavily on extrabudgetary funds from a few Member States and others. In 2008, financial contributions were received from 11 Member States and the European Union, and a number of other States made contributions in kind through the donation of equipment and services. Though these contributions are important, many continue to have conditions

[10] Argentina, Australia, the Czech Republic, Indonesia, Italy, Lebanon, Lithuania, Morocco, Peru, the Philippines, Romania, Ukraine and the USA.

which, combined with the lack of predictable and assured funding for the Nuclear Security Fund (NSF), create problems in programme planning and affect the Agency's ability to develop priorities for the programme in accordance with the requests of Member States.

Nuclear Security at Major Public Events

The Agency continued to help States to meet the nuclear security challenges associated with hosting major public events. This assistance included training, detection equipment, knowledge sharing and information support. In what was the largest security project in which it has been involved, the Agency worked with the Chinese authorities to ensure nuclear security at the Beijing Olympic Games. The Agency also provided security support to the Peruvian authorities for the Latin American and Caribbean–European Union Summit and the Asia–Pacific Economic Cooperation CEO Summit.

Technical Cooperation

The Agency's technical cooperation programme is one of the principal mechanisms for promoting tangible socioeconomic impacts in Member States and ensuring that nuclear technology is used in a safe, secure and peaceful manner. Through this programme the Agency supports the use of appropriate nuclear science and technology to address major sustainable development priorities at the national, regional and interregional levels.

Support is delivered principally in six thematic areas: human health; agricultural productivity and food security; water resources management; environmental protection; physical and chemical applications; and sustainable energy development. A cross-cutting thematic area is safety and security. In so doing, the programme supports the achievement of the United Nations Millennium Development Goals. The programme is developed in close collaboration with Member States, from initial formulation to implementation and evaluation, ensuring that the programme goals and objectives are aligned with the development goals and objectives of the Member States.

The Technical Cooperation Programme in 2008

During 2008, the main focus of activities in the Asia and Pacific region was on strengthening the technical capacity of national and regional institutions and resource centres for applications in health, agriculture, environmental protection and energy. In Africa, the Agency supported 37 Member States in developing technical, managerial and institutional capacities in nuclear science and technology and applications. The Agency emphasized human resources development and the promotion of technical cooperation between developing countries using African resource institutions, notably those under the AFRA programme. In Latin America, the Agency supported 22 Member States in the areas of human health, food and agriculture, and radiation and transport safety. In Europe, fuel repatriation, core conversion and related research reactor upgrades and activities continued in 2008. The Agency also supported countries interested in starting a nuclear power programme (Fig. 6).

"The Agency's technical cooperation programme is one of the principal mechanisms for promoting tangible socioeconomic impacts in Member States and ensuring that nuclear technology is used in a safe, secure and peaceful manner."

Financial Resources

The technical cooperation programme is funded by contributions to the TCF, as well as through extrabudgetary contributions, government cost sharing and contributions in kind. Overall, new resources reached a total of some $92 million in 2008, with approximately $80 million for the TCF, $10 million in extrabudgetary resources and about $1.7 million representing in-kind contributions. These resources were applied directly to technical cooperation projects.

The rate of attainment[11] stood at 94.7% at the end of the year, while payment of national participation costs totalled $0.2 million out of a total

[11] The rate of attainment is a percentage arrived at by taking the total voluntary contributions paid to the TCF by Member States for a particular year and dividing them by the TCF target for the same year. As payments can be made after the year in question, the rate of attainment can increase over time.

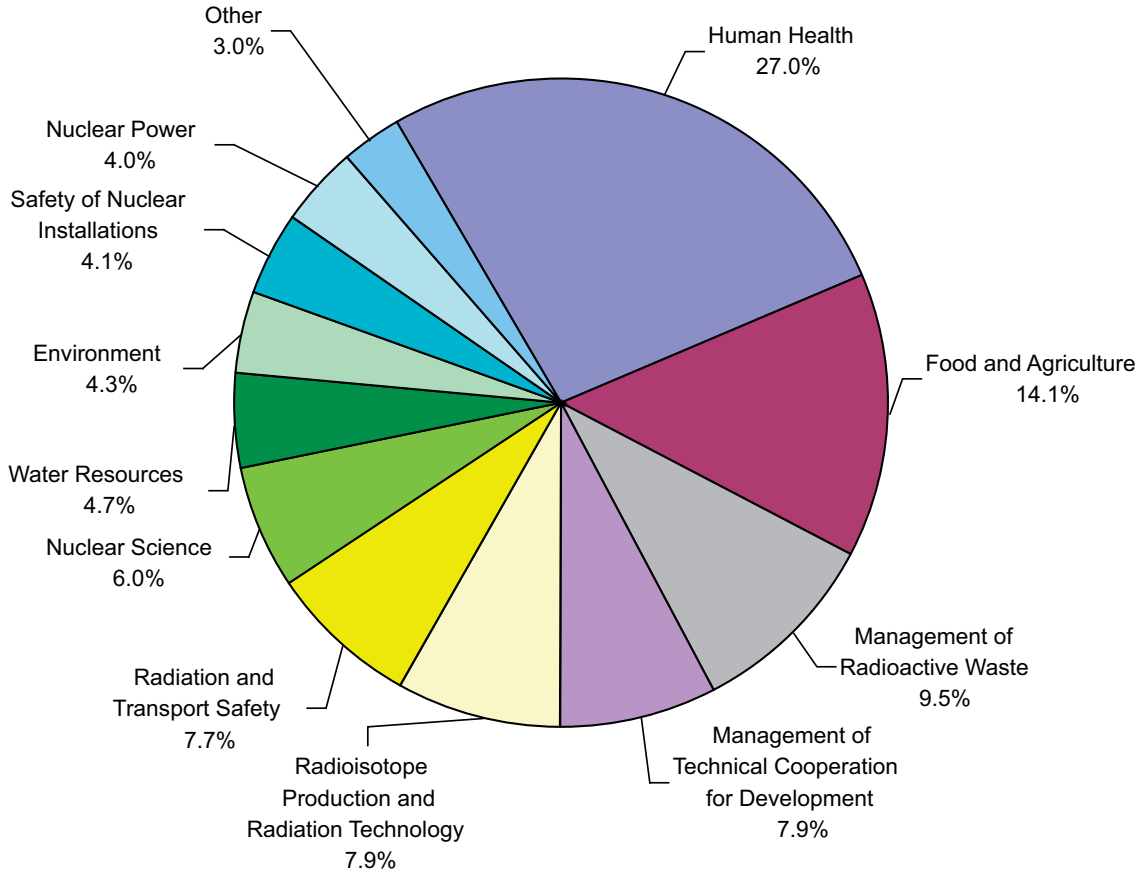


FIG. 6. Distribution of technical cooperation disbursements in 2008 by Agency programme (percentages in this chart may not add up exactly to 100% due to rounding).

of $0.3 million.[12] Resources were sufficient to carry out the core technical cooperation programme as planned for 2008. However, some $46 million of 'footnote-a/'[13] components of projects remained unfunded in 2008.

Disbursements

In 2008, approximately $96.4 million were disbursed to 123 countries or territories, of which 26 were least developed countries, reflecting the Agency's continuing effort to address the pressing development needs of the world's poorest States. Human health remains the single overriding priority in all regions in the technical cooperation programme, accounting for 27% of the budget. For example, health projects in Africa concentrate on the management of cancer, the development of capabilities for nuclear medicine investigations and the control of communicable human diseases.

Verification

A major pillar of the Agency's programme provides assurances to the international community regarding the peaceful use of nuclear material and facilities. The Agency's verification programme thus remains at the core of multilateral efforts to curb the proliferation of nuclear weapons and move towards nuclear disarmament.

At the end of each year, the Agency draws a safeguards conclusion for each State with a safeguards agreement in force, based upon the evaluation of all information available to it for that year. For a 'broader conclusion' to be drawn that 'all nuclear material remained in peaceful activities', both a comprehensive safeguards agreement (CSA) and an additional protocol (AP) must be in force, and the Agency must have been able to conduct all necessary verification and evaluation activities. For States that have CSAs in force but no

[12] National participation costs: Member States receiving technical assistance are assessed a charge of 5% of their national programme, including national projects and fellows and scientific visitors funded under regional or interregional activities. At least half of the assessed amount for the programme must be paid before contractual arrangements for the projects may be made.

[13] Footnote-a/: Projects that are awaiting funding or are partially funded by the TCF.

APs, the Agency does not have sufficient tools to draw credible safeguards conclusions regarding the absence of undeclared nuclear material and activities. For such States, the Agency draws a safeguards conclusion, for a given year, with respect to whether declared nuclear material remained in peaceful activities.

For those States for which the broader conclusion has been drawn and a State level integrated safeguards approach has been approved, the Secretariat is able to implement integrated safeguards, the optimum combination of all safeguards measures available to the Agency under CSAs and APs, to achieve maximum effectiveness and efficiency in meeting the Agency's safeguards obligations.

Safeguards Conclusions for 2008

In 2008, safeguards were applied for 163 States with safeguards agreements in force with the Agency.[14] Eighty-four States had both CSAs and APs in force. For 51 of these States,[15] the Agency concluded that *all* nuclear material remained in peaceful activities. For 33 of the States, the Agency had not yet completed all the necessary evaluations under their APs, and concluded that the *declared* nuclear material remained in peaceful activities. For 70 States with CSAs in force but without APs, the Agency was able to draw the conclusion that declared nuclear material remained in peaceful nuclear activities.[16] Integrated safeguards were implemented during 2008 in 25 States.

"In 2008, safeguards were applied for 163 States with safeguards agreements in force with the Agency."

For three States that had safeguards agreements based on INFCIRC/66/Rev. 2 in force in 2008, the Secretariat concluded that the nuclear material, facilities or other items to which safeguards were applied remained in peaceful activities. Safeguards were also implemented with regard to declared nuclear material in selected facilities in four of the five nuclear weapon States under their respective voluntary offer safeguards agreements in force. For these four States, the Agency concluded that nuclear material to which safeguards were applied in selected facilities remained in peaceful activities or was withdrawn as provided for in the agreements.

The Secretariat could not draw any safeguards conclusions for 30 NPT non-nuclear-weapon States without safeguards agreements in force.

During 2008, the Director General submitted four reports to the Board of Governors on the implementation of the NPT safeguards agreement and relevant United Nations Security Council resolutions in the Islamic Republic of Iran (Iran). The Agency was able to verify the non-diversion of the declared nuclear material in Iran in 2008. As Iran has not provided the information and access that would have allowed the Agency to make progress on a number of outstanding issues related to Iran's past nuclear activities, and as Iran has not implemented its AP, the Agency remained unable to draw a conclusion regarding the absence of undeclared nuclear material and activities in Iran. Contrary to the decisions of the Security Council, Iran did not suspend its uranium enrichment related activities and continued its heavy water related projects.

In 2008, the Director General submitted a report to the Board of Governors on the implementation of the Syrian Arab Republic's NPT safeguards agreement. In April 2008, the Agency was provided with information alleging that an installation destroyed by Israel at Dair Alzour in Syria in 2007 had been a nuclear reactor under construction. Syria has stated that the Dair Alzour site was a military site and was not involved in any nuclear activities. The destruction of the building and the subsequent removal of the debris made the Agency's verification work quite difficult and complex. The Agency held discussions with Syria in Damascus and visited the Dair Alzour site in June 2008. At the end of 2008, the Agency's verification work in Syria was continuing.

Conclusion of Safeguards Agreements, Additional Protocols and Small Quantities Protocols (SQPs)

The Secretariat continued to implement, in 2008, its 'Plan of Action to Promote the Conclusion of Safeguards Agreements and Additional Protocols'.

[14] The status with regard to the conclusion of safeguards agreements, APs and small quantities protocols is given in Table A6 in the Annex.

[15] And Taiwan, China.

[16] The 70 States do not include the Democratic People's Republic of Korea, as the Agency was not able to implement safeguards in that State and, therefore, could not draw any conclusion.

Outreach events held in 2008 included: an interregional seminar for SQP States in Vienna; briefings in Geneva on the sidelines of the second meeting of the Preparatory Committee for the 2010 Review Conference of the Parties to the Treaty on the Non-Proliferation of Nuclear Weapons; and a regional seminar in Santo Domingo, Dominican Republic.

Additional protocols entered into force for two States in 2008, bringing the number of States with APs in force to 88. Three States acceded to the safeguards agreement between non-nuclear-weapon States of Euratom, Euratom and the Agency, as well as the AP thereto. SQPs were amended to reflect the revised text for eight States. By the end of the year, there were 61 States with operative SQPs still requiring amendment in accordance with the Board of Governors' September 2005 decision.

Other Verification Activities

As authorized by the Board, the Agency implemented monitoring and verification measures in the Democratic People's Republic of Korea (DPRK) related to the shutdown of the Yongbyon nuclear facilities and one facility at Taechon. These activities were partially discontinued from 22 September to 13 October 2008 at the request of the DPRK, resulting in a lack of access for Agency inspectors to the Yongbyon facilities and in the removal of Agency seals and surveillance equipment at the Radiochemical Laboratory. On 14 October 2008, the Agency resumed its activities as envisaged in the ad hoc monitoring and verification arrangements. The Agency found no indication that these facilities had resumed operation during that period of time.

Strengthening the Effectiveness and Improving the Efficiency of Agency Safeguards

The Agency continued its efforts to strengthen the effectiveness and improve the efficiency of safeguards. For example, integrated safeguards were introduced in 12 States.[17] In addition, safeguards approaches and procedures were developed, and technology, training and quality management were enhanced.

Research and development activities were carried out with the assistance of Member State support programmes for the development of safeguards concepts, information processing and analysis, verification technologies and training. Meetings and workshops were held to identify tools that would be needed by the Agency to carry out its mission in the future.

Designed to increase the effectiveness and efficiency of information processing by replacing the current system with a modern platform, the Integrated Safeguards Information System Re-engineering Project reached its third and last phase. Six of the 16 projects contained therein were finalized at the end of 2008.

In 2008, the Secretariat continued to develop and diversify sources of safeguards relevant information, including — with the cooperation of Member States — information on covert nuclear related trade. It also continued to install digital surveillance systems and unattended monitoring systems, and to expand its capabilities to transmit data directly from the field to Vienna.

The Agency continued to work with State systems of accounting for and control of nuclear material (SSACs) to improve the implementation of safeguards, with a particular emphasis on assistance activities such as SSAC Advisory Service (ISSAS) missions and regional technical meetings.

"... a project on enhancing the capabilities of the safeguards analytical services was presented to the Board of Governors in November 2008."

In light of the deteriorating condition of the Agency's safeguards laboratories, a project on enhancing the capabilities of the safeguards analytical services was presented to the Board of Governors in November 2008. This project is key to the Agency's capability — and independence — with regard to environmental sample and nuclear material sample analysis. The first phase of the project was designed to address the sustainability and enhancement of the Agency's particle analysis capabilities for environmental samples, while the second will address, in parallel, the future of the Nuclear Laboratory at the Safeguards Analytical Laboratory (SAL) at Seibersdorf. The overall cost of strengthening the Agency's safeguards analytical capabilities is estimated at €35 million. The Government of Japan agreed to provide extrabudgetary funding for the acquisition of an ultra-high sensitivity secondary ion mass

[17] See footnote 15.

spectrometer. However, additional funding is needed so that this equipment can be installed and operated at SAL.

Management Issues

The Agency-wide Information System for Programme Support (AIPS) is the centrepiece for increasing efficiency and effectiveness in programme delivery. It will also improve accountability, bring greater transparency and improve internal control of the Agency's financial and procurement operations. The mobilization of resources for AIPS — an Enterprise Resource Planning System for the Agency — continued during 2008, with financial support provided or pledged by 135 Member States. After evaluating software packages, a decision was taken on the most appropriate vendor. A detailed request for proposal was issued at the end of the year to the potential implementation partners. The target date for the beginning of actual implementation is mid-2009.

"The Agency-wide Information System for Programme Support (AIPS) is the centrepiece for increasing efficiency and effectiveness in programme delivery."

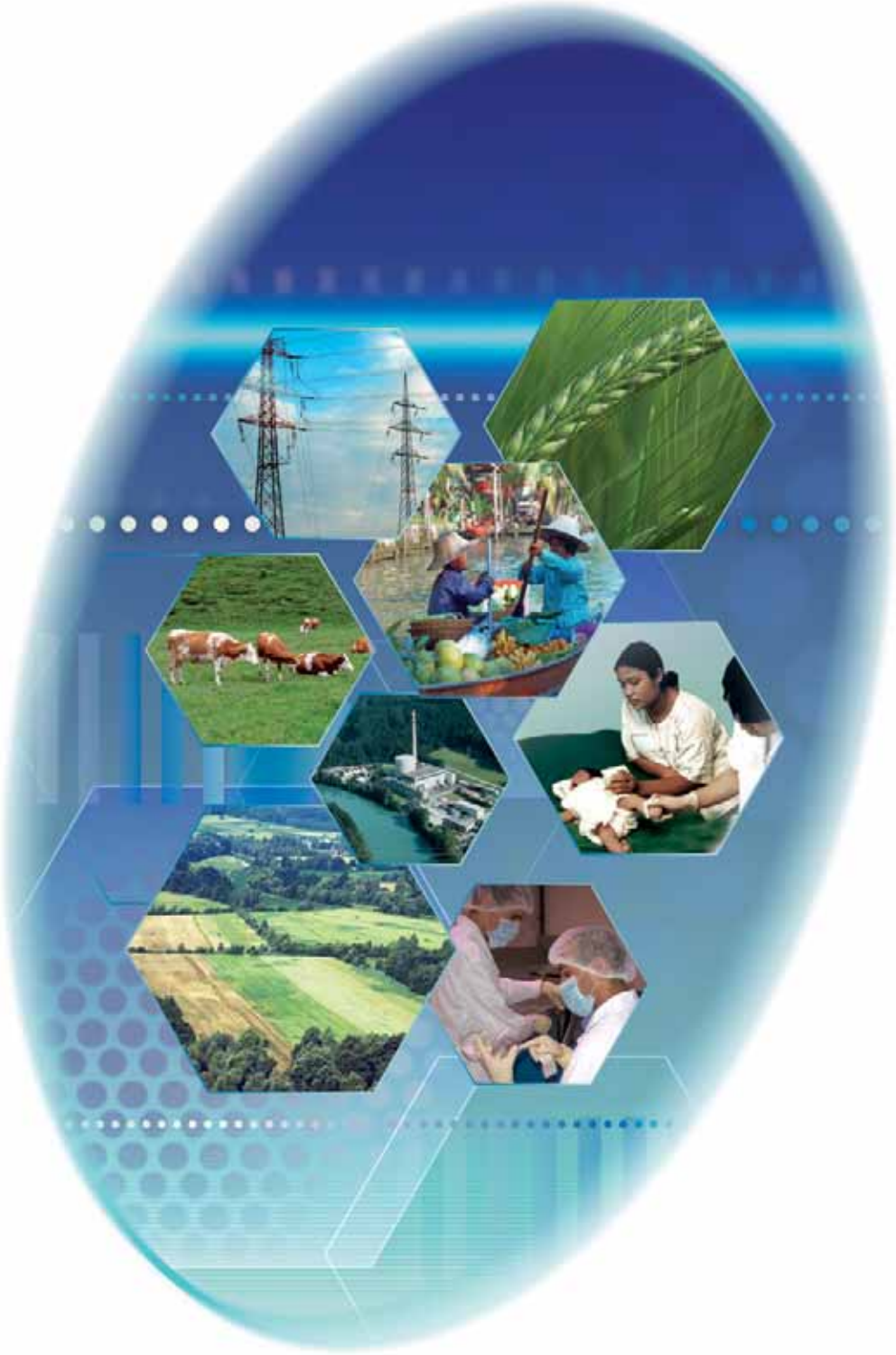
The cost of the first stage of AIPS, which addresses finance and procurement and will provide the capability necessary to implement International Public Sector Accounting Standards (IPSAS), is nearly €10 million.

Looking to the Future

In 2008, the Agency remained active in fostering international cooperation for the peaceful uses of nuclear technologies, and in transferring these technologies to developing countries. It continues to press for a comprehensive and effective nuclear safety regime. And it has been laying the groundwork for a strengthened verification system. For the Secretariat and Member States to be able to continue to move forward on all these fronts, an active partnership and adequate resources are indispensable. The Agency is committed to reinforcing this partnership.

An independent Commission of Eminent Persons (CEP), appointed by the Director General to make recommendations for the future of the Agency up to the year 2020 and beyond, met twice in Vienna under the Chairmanship of Ernesto Zedillo, former President of Mexico. The CEP comprised former heads of government, ministers, top scientists and diplomats, from both developed and developing countries. Its report was published in May, presented to the Board of Governors in June by Chairman Zedillo, and discussed at the September meeting of the Board. Some of the CEP's key recommendations were that the Agency should: work with supplier and donor States to help 'newcomer' States put in place the necessary infrastructure to launch nuclear energy programmes safely, securely and peacefully; give high priority to establishing multilateral fuel cycle arrangements covering both the front and back ends of the cycle; increase the resources of the TCF substantially; address the threat of nuclear terrorism by encouraging States to negotiate binding agreements to set effective global nuclear security standards; lead an international effort to establish a global nuclear safety network, also based on binding agreements; and strengthen its safeguards activities, obtaining better equipment, more staff and funding, as well as more legal authority. The subject of the future work of the Agency is now under consideration by Member States.

Technology



Nuclear Power

Objective

To enhance the capability of interested Member States, in a rapidly changing market environment, to improve nuclear power plant operating performance, life cycle management including decommissioning, human performance, quality assurance and technical infrastructure, through good practices and innovative approaches consistent with global objectives on non-proliferation, nuclear safety and security; to enhance the capacity of Member States for the development of evolutionary and innovative nuclear system technology for electricity generation, actinide utilization and transmutation and for non-electric applications, consistent with sustainability goals; and to facilitate the improvement of public understanding of nuclear power.

Engineering Support for Operation, Maintenance and Plant Life Management

Rising expectations for nuclear power include not only growing interest in building new nuclear power plants, as discussed in the following section, but also increased interest in extending the operating lives of existing plants. The Agency supports the safe long term operation (LTO) of nuclear power plants through comprehensive plant life management (PLiM) (i.e. planning and managing for LTO throughout the life of a plant) by compiling and disseminating information on technological advances, best practices and lessons learned from past experience. In 2008, nine reports were published (see Table A23 on the attached CD-ROM).

Two CRPs were completed in 2008. The first was on the 'Master Curve Approach to Monitor the Fracture Toughness of Reactor Pressure Vessels' (RPVs), while the second was entitled 'Benchmark of Calculation Methods for Structural Integrity Assessment of Pressure Vessels during Pressurized Thermal Shock (PTS)'. These were completed in cooperation with the OECD/NEA and the Joint Research Centre of the European Commission. The first developed alternative ways to handle certain technical issues associated with using the master curve approach to quantify fracture toughness when testing surveillance specimens. Improved understanding of elastic–plastic fracture mechanics allowed the fracture toughness of RPV steels to be determined using fewer and smaller specimens. The second performed benchmark deterministic calculations for a typical PTS regime to compare the effects of different parameters on assessed integrity. Final reports for both CRPs will be published in 2009.

Also important to extending the life and improving the performance of operating nuclear power plants are the modernization and improved use of instrumentation and control (I&C) systems. In 2008, the Agency published *On-line Monitoring for Improving Performance of Nuclear Power Plants: Parts 1 and 2* (IAEA Nuclear Energy Series Nos NP-T-1.1 and NP-T-1.2). In addition, a report on *The Role of Instrumentation and Control Systems in Power Uprating Projects for Nuclear Power Plants* (IAEA Nuclear Energy Series No. NP-T-1.3) was issued.

Launching Nuclear Power Programmes

More than 50 Member States have indicated to the Agency that they are considering or planning to introduce nuclear power. In 2008, the technical cooperation programme for 2009–2011 was approved and included a tripling of the projects supporting countries considering the introduction of nuclear power. The Agency published *Nuclear Energy Basic Principles*, which describes the rationale and vision for the peaceful uses of nuclear energy and identifies the basic principles on which nuclear energy systems should be based to fulfil their potential to meet growing global energy demand (Fig. 1). It also published *Evaluation of the Status of National Nuclear Infrastructure Development* (IAEA Nuclear Energy Series No. NG-T-3.2), which provides guidance for evaluating a country's infrastructure status based on *Milestones in the Development of a National Infrastructure for Nuclear Power* (IAEA Nuclear Energy Series No. NG-G-3.1). The Agency held a workshop in December 2008 to introduce the evaluation method described in this publication.

"More than 50 Member States have indicated to the Agency that they are considering or planning to introduce nuclear power."

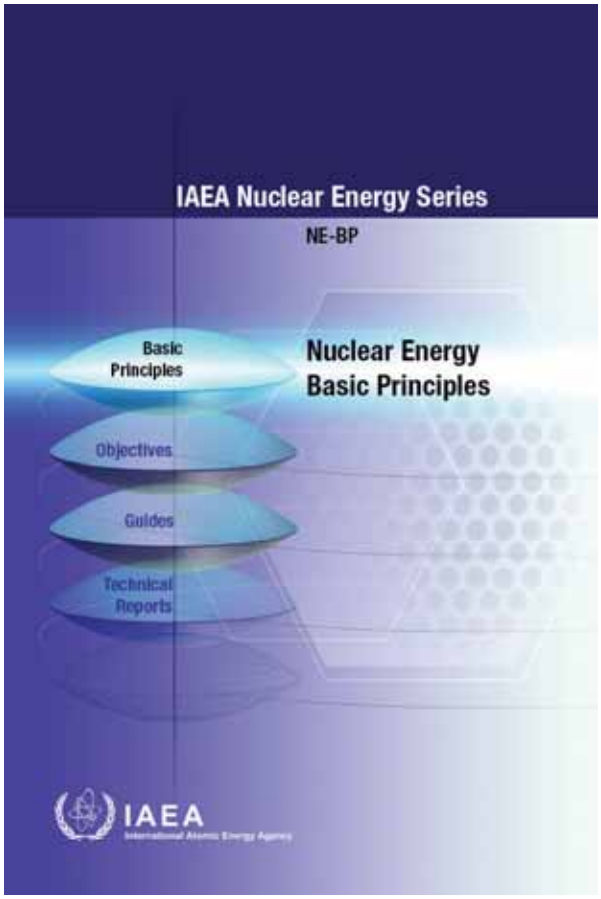


FIG. 1. The apex publication in the IAEA Nuclear Energy Series deals with the basic principles for nuclear energy systems.

The Agency established a new service in 2008 known as Integrated Nuclear Infrastructure Review (INIR). INIR missions are external peer reviews conducted by the Agency at the request of a country, and each is intended to build on a self-evaluation — using the references mentioned previously — already carried out by the country. INIR missions cover all 19 infrastructure issues in the 'milestones' publication, including legal, safety, social, financial, engineering, security and safeguards issues. The first INIR missions are planned for 2009 through the technical cooperation programme.

There is also increased interest in resuming work on nuclear power plants where construction started but has since been delayed. The Agency published *Restarting Delayed Nuclear Power Plant Projects* (IAEA Nuclear Energy Series No. NP-T-3.4), which presents lessons learned from delayed projects that were successfully restarted, completed and brought to commercial operation.

Human Resources

An important challenge for the nuclear power industry, government authorities, research and development organizations, and educational institutions is ensuring that there is a sufficient and skilled workforce for all stages of the nuclear fuel cycle. For countries considering starting nuclear power, human resources are one of the 19 issues for which the Agency has suggested milestones. In 2008, two new reports were published: *Commissioning of Nuclear Power Plants: Training and Human Resource Considerations* (IAEA Nuclear Energy Series No. NG-T-2.2); and *Decommissioning of Nuclear Facilities: Training and Human Resource Considerations* (IAEA Nuclear Energy Series No. NG-T-2.3).

Nuclear Reactor Technology Development

The Agency seeks to stimulate innovation in nuclear power through activities in four areas:

- Technological progress along the main reactor lines: light water, heavy water, fast and gas cooled reactors;
- INPRO;
- Small and medium sized reactors;
- Non-electric applications such as hydrogen generation and desalination using nuclear power.

In the area of water cooled reactors, the Agency published *Advanced Applications of Water Cooled Nuclear Power Plants* (IAEA-TECDOC-1584) and completed a CRP on Natural Circulation Phenomena, Modelling and Reliability of Passive Systems. The CRP brought together 16 institutes from 13 IAEA Member States. They examined the use of natural circulation and passive systems in 20 reference advanced water cooled reactor designs. Twelve phenomena influencing natural circulation were characterized, including liquid behaviour in large pools, the effect of non-condensable gasses on condensation heat transfer, condensation on containment structures, and steam–liquid interactions.

"An important challenge for the nuclear power industry, government authorities, research and development organizations, and educational institutions is ensuring that there is a sufficient and skilled workforce for all stages of the nuclear fuel cycle."

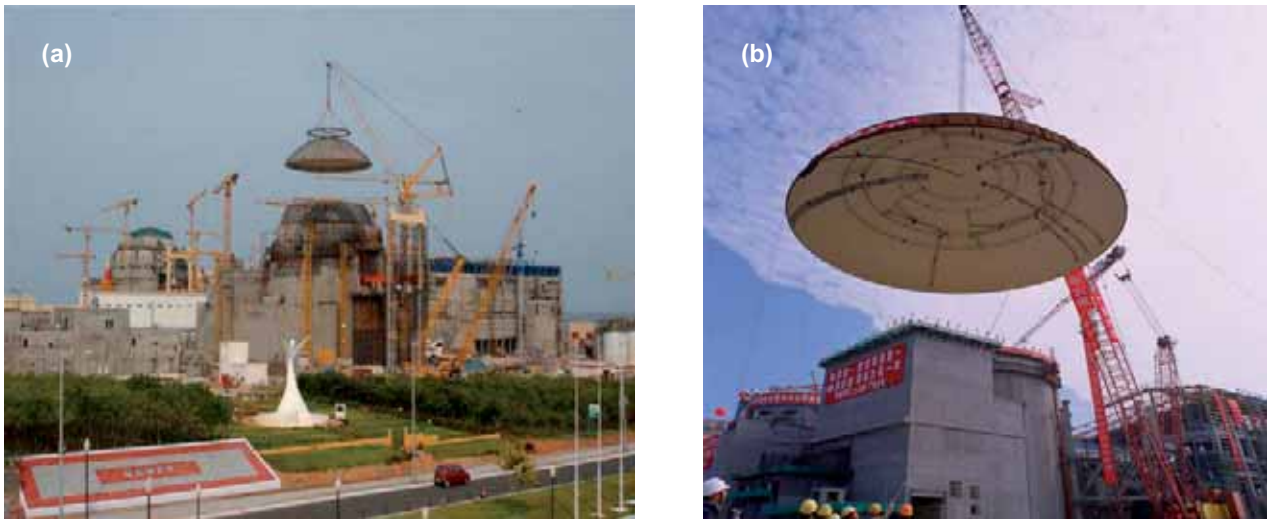


FIG. 2. Lifting the containment dome into position at: (a) the Kudankulam nuclear power plant in India (photograph courtesy of Nuclear Power Corporation of India); and (b) the Lingao-4 plant in China.

Constraints on installing major components inside the reactor and containment building can have a major impact on the construction schedule, and hence cost, of a nuclear power plant. In the past, the walls of the reactor and containment building were constructed with temporary openings to allow the entry of large equipment. A recent technique that has shortened construction time is open top installation (Fig. 2), where the reactor/containment building is built with a temporary roof with an opening through which major pieces of equipment, such as the reactor vessel and steam generators, are lowered into position using very heavy lift cranes.

"INPRO provides a forum in which technology holders and users jointly consider innovation."

The Agency convened workshops on 'Steps for Conducting Nuclear Power Plant Technology Assessments' and 'Best Practices on Heavy Water Reactor Operation', and organized two courses on natural circulation, one in cooperation with the ICTP. The Agency also maintained and updated THERPRO, the Thermophysical Properties of Nuclear Materials Database, available to all Member States.

In the area of fast reactors, the Agency launched two CRPs in 2008 linked to experimental programmes at Japan's MONJU reactor and France's PHÉNIX reactor within the framework of the former reactor's restart and the latter's end of life studies. These CRPs will address natural convection in the coolant in the upper plenum of the reactor vessel of a sodium cooled fast reactor, temperature and power distributions in off-balance situations, and sodium natural circulation phenomena in fast reactor cores. And as part of its activities to coordinate efforts to preserve knowledge about fast reactors, the Agency published *Fast Reactor Knowledge Preservation System: Taxonomy and Basic Requirements* (IAEA Nuclear Energy Series No. NG-T-6.3).

INPRO provides a forum in which technology holders and users jointly consider innovation. As of December 2008, INPRO had 28 members. Since 2001, 34 cost free experts from 17 Member States have contributed to INPRO's work. In 2008, six countries (Argentina, Armenia, Brazil, India, the Republic of Korea and Ukraine) finished assessments of innovative nuclear systems using the method developed by the Agency through INPRO. A progress report on INPRO was published in 2008. Another progress report focused on a joint study of the closed fuel cycle using fast reactors by Canada, China, France, India, Japan, the Republic of Korea, the Russian Federation and Ukraine. A multivolume INPRO manual was also published: *Guidance for the Application of an Assessment Methodology for Innovative Nuclear Energy Systems: INPRO Manual — Overview of the Methodology* (IAEA-TECDOC-1575). In 2008, a two year effort to develop common user considerations was completed. The effort identified commonalities in the expectations held by developing countries considering the introduction of nuclear power. Publication of the results is planned for 2009.

Phase 2 of INPRO, which began in 2006, includes work in three areas: (1) continuous improvement

of the INPRO methodology; (2) institutional and infrastructure activities; and (3) specific collaborative projects among INPRO Members. Of 12 collaborative projects proposed by INPRO members, ten were operational in 2008.

The Agency's cooperation with GIF[1] included organization of a workshop in October to apply software developed by GIF in evaluations of the economics of high temperature gas cooled reactors. The workshop identified improvements needed in the software to better analyse multi-unit, modular and co-generation designs.

In the area of non-electric applications, the Agency released an update of the Desalination Economic Evaluation Program (DEEP), a computer code developed to assess the economic aspects of desalination projects using nuclear energy. The Agency also released the first 'pre-alpha' version of the Hydrogen Economic Evaluation Program (HEEP), a comparable computer code to evaluate the economic aspects of hydrogen production using nuclear energy.

[1] GIF was established to lead the collaborative efforts of the world's leading nuclear technology nations to develop next generation nuclear energy systems to meet future energy needs. The current members of GIF are Argentina, Brazil, Canada, China, France, Japan, the Republic of Korea, the Russian Federation, South Africa, Switzerland, the United Kingdom, the USA and Euratom.

Nuclear Fuel Cycle and Materials Technologies

Objective

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

Uranium Production Cycle and the Environment

Accurate knowledge of uranium resources, production and demand in Member States is essential for planning the supply of uranium fuel for nuclear power plants. The latest update of the biennial Red Book was published jointly by the Agency and the OECD/NEA in 2008. Global uranium production in 2007 was 42 500 tonnes of uranium (t U), an increase of 7% when compared with 2006 (Fig. 1). Production growth in 2008 was similar, and the total expected global production for 2008 is over 45 000 t U. Newly mined uranium provided about two thirds of the world's power reactor requirements of ~68 000 t U. The remainder of the demand was met from secondary sources, including civilian and military stockpiles, down-blending military HEU, reprocessed uranium from spent fuel, mixed oxide (MOX) fuel with uranium-235 partially replaced by plutonium-239 from reprocessed spent fuel and re-enrichment of depleted uranium tails. From the longer term perspective, uranium resources are adequate. The Red Book noted that resources would last 83 years at the current rate of consumption, and preliminary results from a project analysing the supply of uranium to 2060 show enough uranium resources in the ground. However, their accessibility in the future will be a function of market forces and public acceptance.

"Accurate knowledge of uranium resources, production and demand in Member States is essential for planning the supply of uranium fuel for nuclear power plants."

The growing interest in uranium production has increased the demand for skilled labour and information exchange. Meetings were organized in Vienna and Amman, Jordan, on uranium exploration, best practices in uranium mining and processing, advanced mining and milling methods and equipment, mine remediation and environmental issues.

Four technical cooperation projects on the uranium production cycle were implemented in 2008, in Argentina, China, Egypt and Pakistan. A regional project on the same subject focused on the Latin American region.

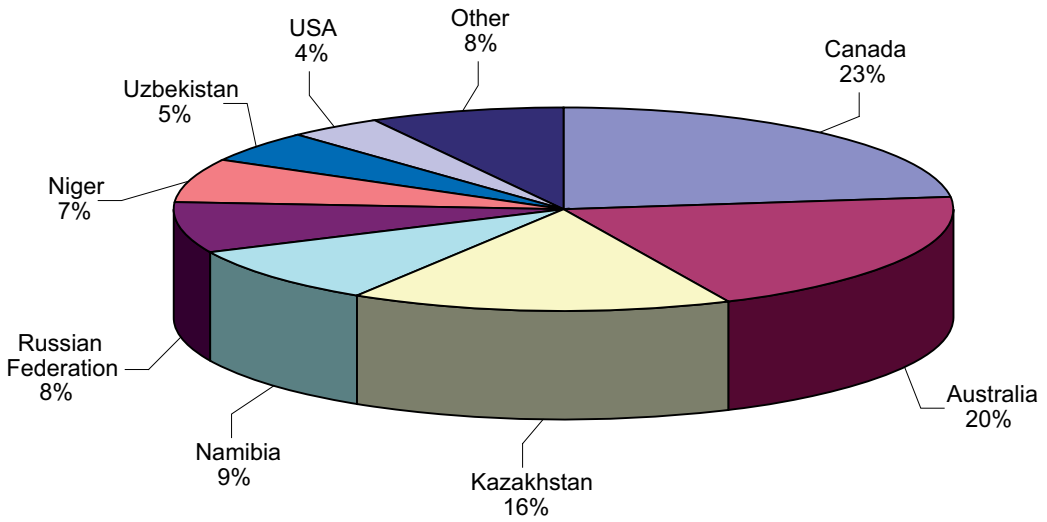


FIG. 1. Distribution of world uranium production in 2007.

Nuclear Power Reactor Fuel Engineering

Two new CRPs started in 2008. The first, Fuel Modelling at Extended Burnup (FUMEX-III), focuses on modelling transient behaviour and mechanical interactions between pellets and cladding. Its scope includes severe transient behaviour, for example during reactivity initiated accidents and loss of coolant accidents, as well as temperature and fission gas release at high burnup. The data to be modelled will be provided by the OECD/NEA and the Halden Reactor Project. The second new CRP is on the use of accelerators to simulate radiation effects in materials. Its objective is to combine accelerator simulation with theoretical modelling of radiation effects to help develop new radiation resistant structural materials for advanced nuclear systems.

Preliminary results were published in the journal *Nuclear Engineering and Technology* from a CRP on delayed hydride cracking (DHC) in zirconium cladding alloys, which held its final Research Coordination Meeting in 2008. During the CRP, the advanced pit-loading tension (PLT) technique developed in the CRP's host laboratory, Studsvik Nuclear AB in Sweden, was transferred to, and used in, the participating institutions in eight other Member States. Its results strengthened confidence in the PLT technique for estimating DHC properties in fuel cladding and provided reliable values of crack velocity as a function of temperature that helped clarify this important mechanism of zirconium alloy degradation.

The Agency completed a review of fuel failures that occurred in water cooled reactors between 1994 and 2006. The final report, which will be published in 2009, contains unique failure statistics covering 96% of the world fleet of LWRs and HWRs. It reflects the current balance between incentives for higher fuel performance and for more reliable operations and presents detailed descriptions of root causes, failure mechanisms and mitigation measures.

Spent Fuel Management

Safe, secure, reliable, economic and environmentally sound technology for the management of spent nuclear fuel arising from power reactors remains a key issue for the sustainable utilization of nuclear energy. The Agency helps strengthen Member State capacities to plan, develop and implement spent fuel management strategies and activities more efficiently. In this connection, the Agency published a report on *Spent Fuel Reprocessing Options* (IAEA-TEC-DOC-1587) in 2008 and completed two additional reports on methods for determining spent fuel storage costs and on managing damaged fuel.

A CRP on spent fuel performance assessment and research (SPAR-II) held its final review of results on compiling and assessing the experience of different countries with both wet and dry spent fuel storage. The main focus was on degradation mechanisms affecting fuel element materials for both undamaged and damaged fuel.

Topical Advanced Nuclear Fuel Cycle Issues

Proliferation resistance for advanced fuel cycles was a major focus for the Agency in 2008. Together with several members of INPRO, the Agency began a collaborative project on proliferation resistance, concentrating on acquisition/diversion pathway analysis, and continued work on protected plutonium production and GIF/INPRO proliferation resistance assessments.

Technical meetings were held on Member State nuclear fuel cycle policies and strategies (in Fukui, Japan) and on structural materials used in liquid metal cooled fast reactor fuel assemblies (in Hyderabad, India). Given increased efforts around the world to develop coated particle fuels for gas cooled reactors, the Agency is developing a training handbook that covers advanced fuel design, fabrication technology, quality assurance and quality control, fuel irradiation qualification, fuel performance, fuel modelling and overall fuel cycle issues.

"Proliferation resistance for advanced fuel cycles was a major focus for the Agency in 2008."

There is strong interest among Member States in developing innovative fuel cycle approaches to minimize waste and environmental impacts. One approach is to use partitioning and transmutation (P&T) techniques to separate the minor actinides (MAs) and plutonium from spent fuel. The MAs could then be incinerated in fast reactors to reduce long term radiological toxicity. In 2008, the Agency completed a CRP on process losses in separation processes in P&T systems to minimize long term environmental impacts. A quantitative relationship was established between the environmental impact of disposed waste and the reduction of transuranic

elements in the waste, taking separation losses into account. Based on this, target values were set for reduction of transuranic elements that are in line with current process losses.

Integrated Nuclear Fuel Cycle Information System

The Agency continued to maintain and update a number of databases and simulation systems in the area of the nuclear fuel cycle to provide the Agency and Member States with reliable and up to date information on worldwide nuclear fuel cycle activities. The databases include the Nuclear Fuel Cycle Information Systems (NFCIS), World Distribution of Uranium Deposits (UDEPO), Post-Irradiation Examination Facilities Database (PIE), Minor Actinide Property Database (MADB) and Nuclear Fuel Cycle Simulation System (NFCSS) (illustrated in Fig. 2 and formerly known as VISTA). The European Commission's HotLab database has been merged into the Agency's PIE database. Also, web based software was developed to enable interested parties to use NFCSS through the Internet. All of these databases are available at *http://www-nfcis.iaea.org/*.

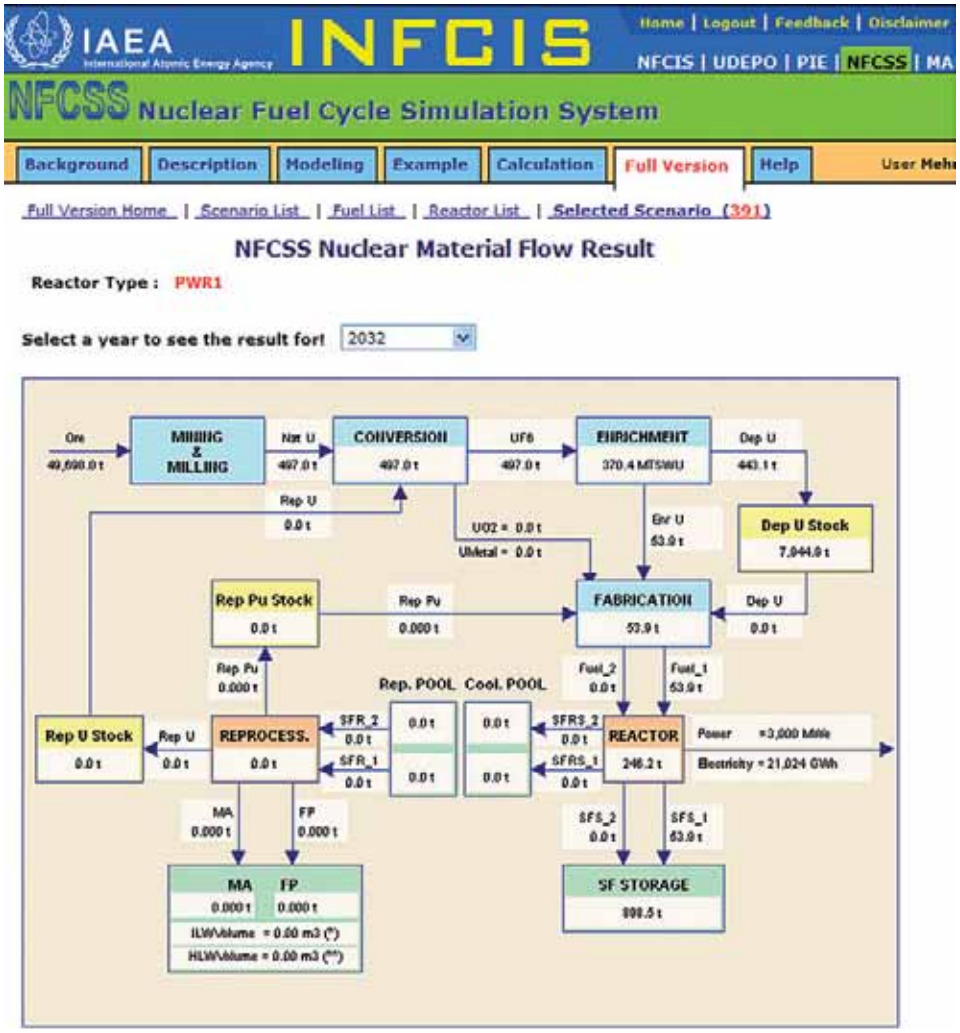


FIG. 2. Screen shot from the web based NFCSS application.

Capacity Building and Nuclear Knowledge Maintenance for Sustainable Energy Development

Objective

To enhance the capacity of Member States to perform their own analyses of electricity and energy system development, energy investment planning and energy–environment policy formulation and their economic implications; to sustain and effectively manage nuclear knowledge and expertise; to enhance information and knowledge resources for the peaceful use of nuclear science and technology.

Energy Modelling, Databanks and Capacity Building

In 2008, the Agency revised upward its projections for global nuclear power development. The revised high case projects 748 GW(e) of installed nuclear power worldwide in 2030, compared with 372 GW(e) at the end of 2008, that is, a doubling of capacity in 22 years. The low case projects 473 GW(e) in 2030, an increase of only 27%.

These projections are prepared by an expert group convened each year by the Agency. The low case includes: (a) new nuclear construction currently under way or firmly established; and (b) scheduled retirements and planned licence extensions. The high case adds in announced longer term plans of governments and utilities for new reactors. The high case is thus a reasonable possible quantification of what has been labelled the 'nuclear renaissance'.

Successive updates have generally raised projections over the last five years. For the high case, the 2008 projection for nuclear capacity in 2030 is about 30% higher than that made in 2003. For the low case, the 2008 projection for nuclear capacity in 2030 is about 23% higher than that made in 2003. The 2003 low case projection even forecasted a decline in global capacity after 2020.

Demand continued to increase for Agency assistance in analysing different national and regional energy systems and energy strategies. In 2008, French and Spanish versions of the user interface were completed for the energy supply system model MESSAGE, the principal model used in many Agency supported studies. This increases the model's accessibility in French and Spanish speaking countries.

The Agency's analytical tools are now being used in 115 Member States. Their reach is further increased by six international organizations that are also using them for energy assessments in developing countries. During 2008, 402 energy analysts and planners from 58 countries were trained to use the Agency's analytical tools. To expand its ability to meet the increased demand for training, and following a successful pilot project in 2007, the Agency introduced on-line training for distance learning (see box on the next page).

"The Agency's analytical tools are now being used in 115 Member States."

Energy Economic Environment (3E) Analysis

In line with its mandate to provide objective and up to date information about nuclear power, the Agency contributes to international studies and deliberations that provide the context within which nuclear power is assessed compared with other sources of energy. At the 14th Conference of the Parties to the United Nations Framework Convention on Climate Change (UNFCCC) held in Poznan, Poland, in December 2008, the Agency organized two side events with the Polish Nuclear Energy Agency and the OECD/NEA. The Agency also released a special publication, *Climate Change and Nuclear Power 2008*, which provides information on all aspects of nuclear power in the context of current climate change concerns and presents national perspectives from seven countries. The booklet confirms the diversity of reasons to introduce or expand nuclear power (including climate change mitigation, energy supply security, fossil energy price volatility and regional air pollution), as well as concerns that still exist (such as operational safety, proliferation and waste disposal). The Agency further raised

Expanding the Agency's ability to build capacity in Member States

To respond to the increased demand from Member States for training, the Agency introduced in 2008 'Technology Supported Learning', which uses on-line multimedia training packages to facilitate training in conducting distance learning programmes. The sessions using these packages also make use of the cyber platforms of the Asian Network for Education in Nuclear Technology and the Latin American Energy Organization. Human interaction is provided by videoconference sessions and on-line tutors.

Increased demand for technical support prompted the Agency to launch the web based 'Tele-Support Expert Service', which supports users of the Agency's analytical tools. It allows a user to post a question through the Internet, which is routed to an expert inside or outside the Agency. The response is then posted on the web.

its profile, as had been requested by Member States, by providing an on-site information centre, staffed throughout the conference, to distribute publications and answer questions.

At the request of several interested Member States, including Belarus, Chile, Kenya, Malaysia, Poland and Thailand, the Agency provided special presentations on the benefits and concerns associated with nuclear power. The Agency also contributed to three nuclear information workshops: in Bariloche, Argentina; Beijing, China; and Daejeon, the Republic of Korea. The workshops were organized by the World Nuclear University for young nuclear professionals from countries already using nuclear power and those considering starting nuclear power programmes.

A special issue of the *International Journal of Global Energy Issues* on the prospects for nuclear energy in the 21st century was published with significant contributions from the Agency. It included regional and thematic papers reviewing both past experience and the factors now being weighed in regions with interest in nuclear power, for example, West Asia, northern Africa, sub-Saharan Africa, South East Asia and Australia, and provided a major contribution to international deliberations on the role of nuclear power in meeting the world's energy challenges.

Financing the construction of new nuclear power plants continues to be a major concern, particularly in countries considering the introduction of nuclear power. In 2008, the Agency published a report on the *Financing of New Nuclear Power Plants* (Fig. 1). It emphasizes that there is no simple financing

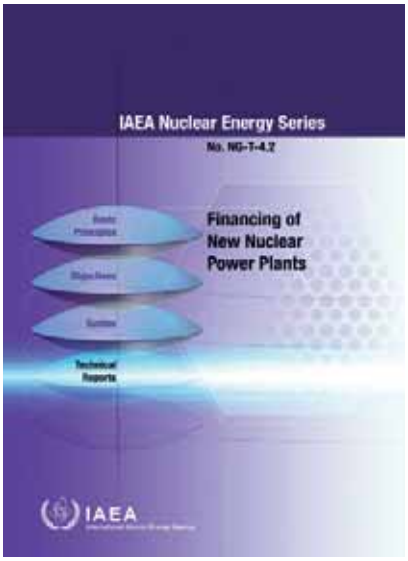


FIG. 1. An Agency report on financing new nuclear power plants emphasizes that, while markets have changed since most of today's plants were built, the underlying importance of the basics remains: stability, long term commitment, sharing of financial risk wisely and ensuring that revenues cover costs.

solution, that markets have changed since most of today's plants were built, but that the underlying importance of the basics remains: stability, long term commitment, sharing financial risk wisely and making sure that revenues cover costs.

A workshop organized jointly by the Agency and the ICTP compared geological disposal of radioactive waste from nuclear energy with the disposal of carbon dioxide from fossil fuel combustion. Carbon dioxide capture and storage (CCS) could reduce emissions of this gas from fossil electricity generation by up to 90% and allow the continued use of fossil fuels even in a highly climate constrained future. The workshop identified similarities between the two waste disposal problems. For example, both carbon dioxide and radioactive waste raise concerns about leakage over very long time spans and about the associated health, liability and intergenerational ethical issues (for example, present generations leaving long lived waste that poses remote but continuing risks to future generations). Adding CCS technology to fossil fuelled plants will add to their upfront and waste disposal costs, making their cost structure more like that of nuclear power. The workshop also outlined a broad comparison of the economic and climate change benefits of nuclear energy versus fossil electricity generation with CCS, and initiated a CRP in which research teams from interested Member States will prepare in-depth comparisons of selected aspects of the geological disposal issue.

Nuclear Knowledge Management

Concerns have been expressed in a number of countries about the possible lack of availability of people with the skills needed by the nuclear power industry. These include countries with established nuclear power programmes and newcomers. Their concerns cover skills associated with all steps in the fuel cycle, from uranium exploration through reactor operation to decommissioning and spent fuel management. Agency activities on nuclear knowledge management address topics across the full range of concerns.

The Agency convened a meeting of senior officials in May to review nuclear knowledge management needs and discuss priorities. Participants agreed that, for the immediate future, education in nuclear science and technology and knowledge transfer to the next generation should be given the highest priority.

"The Agency convened a meeting of senior officials in May to review nuclear knowledge management needs and discuss priorities."

The Agency published guidance on the *Planning and Execution of Knowledge Management Assist Visits for Nuclear Organizations* (IAEA-TECDOC-1586) and conducted three such visits in 2008 to: the Ignalina nuclear power plant in Lithuania; the Zaporozhye nuclear power plant in Ukraine; and the Atomic Energy Commission of Kazakhstan and the Institute of Nuclear Physics in Kazakhstan. As the name implies, assist visits provide assistance, education and advice on best practices and strategies in knowledge management; they reinforce existing strengths; and they offer recommendations on possible improvements.

The Agency also conducts training courses on nuclear knowledge management to reach broader audiences, and supports networks that disseminate information in this area. In cooperation with the ICTP, the European Commission and the World Nuclear University, the Agency conducted the 2008 Knowledge Management School at the ICTP. It also conducted a workshop at the Research Centre Karlsruhe, in Germany, and a regional training course in Vienna on the development of the ANENT cyber platform and distance learning, at which participants from Asia received training in operating the ANENT web portal and cyber platform (*www.anent-iaea.org*).

The Fast Reactor Knowledge Organization System was completed in 2008. It establishes an information structure in the area of fast reactors, provides an open mechanism for introducing new documents or references from owners, and supports information searches. The system contains more than 50 000 records and will be an important resource for countries considering fast nuclear technology. This is a result of the Agency's pilot project on a fast reactor knowledge preservation system that began in 2004. Member States with either extensive experience with fast reactors or active programmes will continue to update the system.

International Nuclear Information System and Library

Member States, in particular those considering the introduction of nuclear power, research

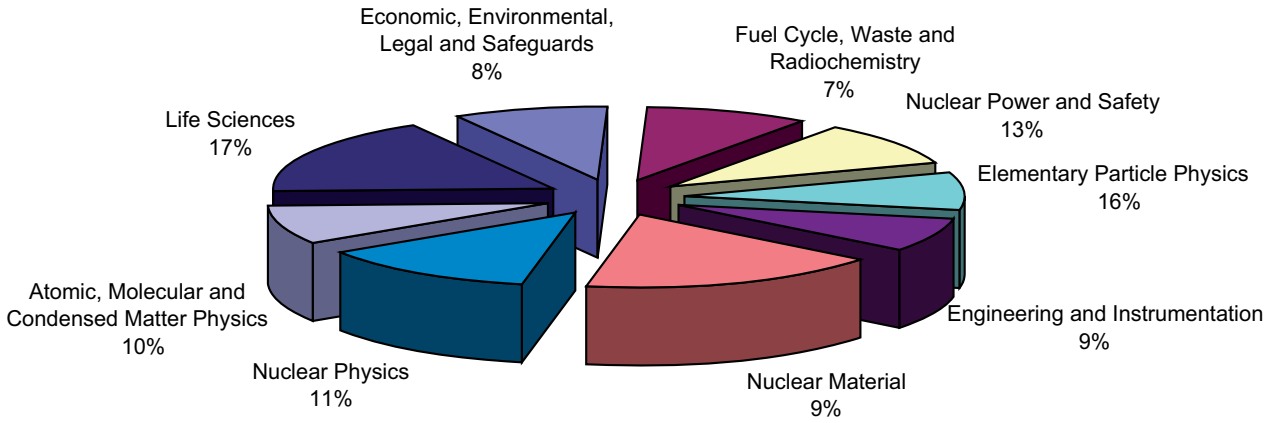


FIG. 2. The range of subjects covered by INIS in areas of the Agency's activities in nuclear science and technology.

reactors or other peaceful applications of nuclear techniques, require easy access to reliable and authoritative information on numerous aspects of nuclear science and technology. The International Nuclear Information System (INIS) provides instant on-line access to such information (Fig. 2). The 34th Consultative Meeting of INIS Liaison Officers endorsed a pilot project for free public access to the INIS on-line database, which would increase accessibility significantly. In 2008, INIS also moved from a bibliographic database of metadata to a searchable full text database. The number of full text records increased to over 650 000, and the total number of bibliographic records rose to over three million.

"The International Nuclear Information System ... provides instant on-line access to ... information [on nuclear science and technology]."

The IAEA Library complements INIS data by coordinating the International Nuclear Libraries Network (INLN). In 2008, the INLN focused on the information needs of newcomers to nuclear power. Membership in INLN increased from ten partners in 2007 to 23 in 2008.

Nuclear Science

Objective

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

Atomic and Nuclear Data

The Agency maintains extensive nuclear, atomic and molecular databases that are available to all Member States through both on-line and traditional services. Improvements to on-line sites in 2008 have resulted in easier browsing and retrieval capabilities for these databases.

Such data are used, for example, in the design of advanced fission reactors like those being considered by the Generation IV International Forum (GIF) and the Agency's International Project on Innovative Nuclear Reactors and Fuel Cycles (INPRO). Their design requires much more comprehensive cross-section databases than were previously needed. The Agency therefore launched a new CRP in 2008 to assess, evaluate and assemble a nuclear data library for advanced systems (the Fusion Evaluated Nuclear Data Library (FENDL-3)).

"The Agency maintains extensive nuclear, atomic and molecular databases that are available to all Member States through both on-line and traditional services."

The Agency also launched a new CRP to characterize the size, composition and origins of dust in fusion devices. The resulting information will be compiled in a database and made available to Member States. Existing fusion devices generate dust particles during operation, and the possibility of an excessive accumulation of dust is a significant safety concern. A major requirement for ITER and subsequent fusion machines will be the reduction and control of such dust.

By the end of 2008, all providers of analytical services based on ion beam techniques had adopted the new Ion Beam Analysis Nuclear Data Library (IBANDL), formulated under the Agency's auspices, as a standard reference database. Both web based and CD-ROM versions are now available to users in Member States.

In cooperation with the ICTP, the Agency organized two training workshops in 2008 entitled 'Nuclear Structure and Decay Data: Theory and Evaluation' and 'Nuclear Reaction Data for Advanced Reactor Systems'. The Agency also held an on-site training course on 'Modelling and Evaluating Nuclear Reaction Data for Transport Calculations'.

Research Reactors

Improving utilization

The Agency promotes regional collaboration to improve the utilization of small and medium size research reactors. In 2008, the Agency organized a technical meeting on strategic planning for research reactor utilization in the Mediterranean region, leading to the creation of the Mediterranean Research Reactor Users Network (M-RRUN). Research reactor coalitions were also formed in Eastern Europe, the Caribbean and Central Asia. In addition to these geographically defined coalitions, one topically oriented research reactor network was also established, on 'Residual Stress and Texture Analysis for Industrial Partners' (STRAINET).

In 2008 there were severe shortfalls in the production of vital medical and industrial radioisotopes, particularly molybdenum-99, owing to the frequent unavailability of some of the research reactors used for production. This highlighted the fragility of the molybdenum-99 supply chain, which relies on a small number of large and ageing research reactors, and the importance of better collaboration. In response, the Agency published *Optimization of Research Reactor Availability and Reliability: Recommended Practices* (IAEA Nuclear Energy Series No. NP-T-5.4) and *Homogeneous Aqueous Solution Nuclear Reactors for the Production of Mo-99 and Other Short Lived Radioisotopes* (IAEA-TECDOC-1601). The first publication compiles lessons learned from the operating experience of diverse heavily utilized research reactors and recommends specific operations and maintenance practices to optimize performance. The second presents the state of the art of homogeneous aqueous solution reactors (AHRs), including past and ongoing activities in China, France, the Russian Federation and the USA, and identifies specific

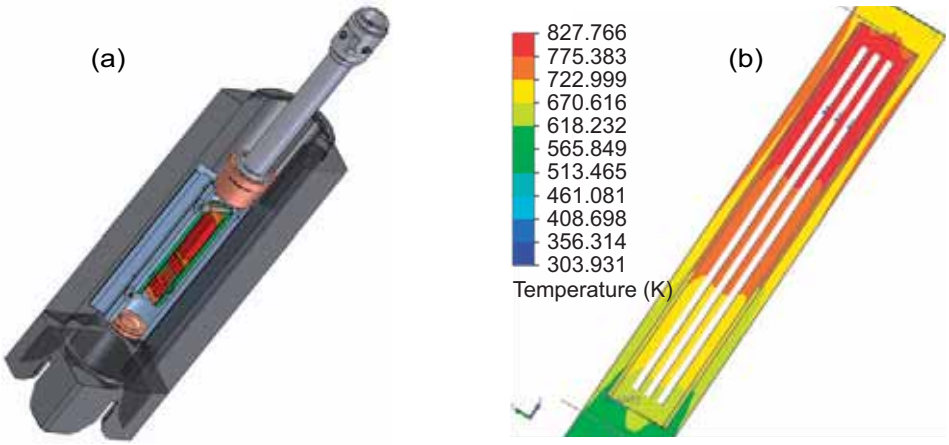


FIG. 1. (a) Design of a new in-pile irradiation rig for structural materials studies of lead–lithium; and (b) modelling of the thermodynamics of the lead–lithium irradiation rig (graphic courtesy of NRI, the Czech Republic).

opportunities and challenges in using them to produce medical isotopes. A follow-up CRP was started in 2008 to study the technical feasibility of using LEU in AHRs, to carry out benchmarking for modelling AHRs and to evaluate the feasibility of producing short lived fission product isotopes such as molybdenum-99. The related topic of molybdenum-99 production from LEU continued to be the focus of an ongoing CRP.

Up to 70% of operating research reactors are over 30 years old. In 2008, the Agency started development of a 'knowledge bank' on research reactor ageing management programmes.

In the area of materials studies for the energy sector, the Agency convened a technical meeting on using research reactors to study materials under high neutron fluence, including initiatives relevant for INPRO and GIF, and including both experimental and modelling studies. Figure 1 illustrates (a) one of the designs and (b) results of modelling the thermodynamics of the lead–lithium irradiation rig. The Agency also published *Neutron Imaging: A Non-Destructive Tool for Materials Testing* (IAEA-TECDOC-1604), which summarizes the use of this technique in industrial applications and research.

Planning new research reactors

In response to increased requests for assistance in evaluating and planning new research reactors, in 2008 the Agency, together with the East European Research Reactor Initiative (EERRI), organized a training course to develop evaluation and planning skills using a combination of theory and hands-on experience. A complementary project was also launched in 2008 to capture the lessons learned from recent and current research reactor construction projects. The project involves experts with experience in such projects, reactor suppliers and representatives from countries considering new reactor projects.

Research reactor fuel

The Agency continued to support Member States participating in international programmes to return research reactor fuel to its country of origin. At the request of Portugal and the US Foreign Research Reactor Spent Nuclear Fuel Acceptance Program, the Agency contracted for the removal from Portugal and repatriation to the USA of 7 kg of spent HEU fuel. As part of the Russian Research Reactor Fuel Return (RRRFR) programme, the Agency assisted in the repatriation to the Russian Federation of spent HEU fuel from Bulgaria, Hungary and Latvia.

"The Agency continued to support Member States participating in international programmes to return research reactor fuel to its country of origin."

In addition to supporting repatriation shipments, the Agency developed and made available to all potential participants in the RRRFR a report on the *Experience of Shipping Russian-Origin Research Reactor Spent Fuel to the Russian Federation*. This report presents guidelines for institutions repatriating spent fuel to the Russian Federation based on experience gained in this area from Bulgaria, the Czech Republic, Hungary, Latvia and Uzbekistan.

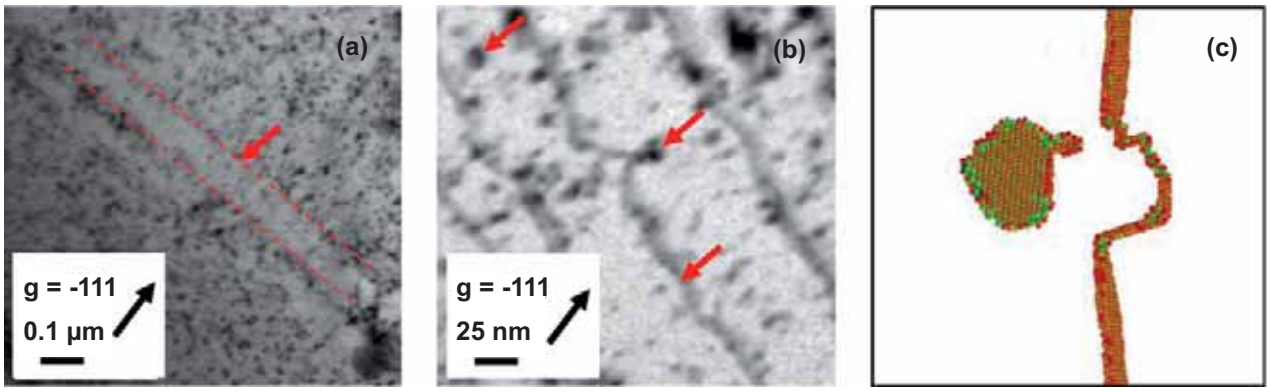


FIG. 2. Accelerator based ion irradiation induced degradation of stainless steel 316L at (a) the micrometre level (strain localization into clear bands) and (b) the nanometre level (interstitial loops dislocation/interactions). Photograph (c) shows the simulation of the molecular dynamics of edge dislocation behaviour under stress at 150 MPa (courtesy of CEA, France)

The Agency also published *Return of Research Reactor Spent Fuel to the Country of Origin: Requirements for Technical and Administrative Preparations and National Experiences* (IAEA-TECDOC-1593), which describes the preparations required for repatriating spent fuel to the USA and summarizes the experience of countries that have already repatriated spent fuel to the USA and the Russian Federation.

A technical cooperation project to repatriate spent fuel from the RA research reactor at the Vinča Institute in Serbia, the largest technical cooperation project in the Agency's history, continued on schedule. Manufacturing began on custom designed equipment to clean and prepare the water in the spent fuel pond for fuel repackaging. All fuel will be transported to the Russian Federation as a single shipment in 2010.

Accelerators for Materials Science and Analytical Applications

In 2008, the Agency initiated new activities on materials research focused on structural materials for advanced fission and fusion reactors. With the Kharkov Institute of Physics and Technology of the National Science Centre of Ukraine, the Agency co-hosted a technical meeting on 'Accelerator Simulation and Theoretical Modelling of Radiation Effects' in June. New technologies for studying materials under high radiation doses as recommended by the meeting encouraged a new CRP aimed at gaining a better understanding of the mechanisms by which radiation causes material damage in order to develop or identify structural materials for new nuclear power plants. The CRP includes both theoretical modelling of radiation induced degradation mechanisms, especially on microstructural and mechanical properties of materials under high irradiation (Fig. 2), and round robin exercises to help develop and test radiation resistant materials.

"In 2008, the Agency initiated new activities on materials research focused on structural materials for advanced fission and fusion reactors."

Nuclear Instrumentation and Spectrometry

Agency activities on nuclear instrumentation focused on strengthening Member State capabilities through training and assistance with quality control. Three regional and three national training courses and two group fellowship training courses were organized at the Agency's Laboratories, Seibersdorf, and Member State laboratories through technical cooperation projects on nuclear electronics and nuclear instrumentation. To support these activities, the Agency published *Quality Control Procedures Applied to Nuclear Instruments* (IAEA-TECDOC-1599), *A Training Module for Quality Management in Calibration, Maintenance and Repair of Nuclear Instrumentation* (IAEA-TCS-33/CD), and guidelines on the role and utilization of regional resource centres in nuclear instrumentation.

The capabilities of the Agency's Laboratories, Seibersdorf, were enhanced with the transfer of a scanning electron microscope from the Safeguards Analytical Laboratory. The microscope will be used to characterize individual particles in support of work on environmental chemistry and to study biological materials for agricultural research.

Support for X ray based techniques included the organization of a worldwide proficiency test for X ray spectrometry laboratories to improve the quality of analytical results in 20 Member States. Through the technical cooperation programme, human resources development was enhanced in one national and four regional training courses on the application of nuclear analytical techniques to environmental pollution monitoring and the conservation of cultural heritage objects. Two technical reports were also prepared on the adaptation of nuclear spectrometry applications for in situ characterization of materials and microanalytical techniques using low energy particle accelerators and synchrotron radiation sources.

Nuclear Fusion

The 22nd IAEA Fusion Energy Conference (FEC 2008) was convened in October, commemorating 50 years of international fusion research. It was held in the Palais des Nations, in Geneva, the site of the second United Nations Conference on the Peaceful Uses of Atomic Energy in 1958 where international cooperation on fusion began.

"The 22nd IAEA Fusion Energy Conference ... was convened in October, commemorating 50 years of international fusion research."

Also in October, the Agency and the ITER International Fusion Energy Organization (ITER Organization) signed a cooperation agreement to facilitate interactions with Member States and to foster fusion energy development through information exchange, training, publications, the organization of scientific conferences, research on plasma physics and modelling, and fusion safety and security. In February, the ITER Organization formally applied for a construction permit to build ITER in Cadarache, France. Massive ground development work is already under way to construct facilities that will house the sophisticated equipment for ITER.

A CRP on joint research using small tokamaks was completed in 2008. It confirmed the importance of small and medium size tokamaks in fusion research, particularly for: developing and testing novel diagnostics; benchmarking new numerical codes, materials and technologies (which cannot be done in large machines without preliminary studies); and broadening education and training. The CRP stimulated cooperation on fusion research in Thailand and led to new research using small tokamaks for joint experiments in developing Member States.

Food and Agriculture

Objective

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

Enhancing Food Security through Mutant Crop Varieties

In 2008, Asia, Africa, Latin America and the Caribbean region, supported by the Agency, saw the introduction of mutant varieties which helped to increase food security (Fig. 1). For example, in India new mungbean mutant varieties with a short cultivation period and enhanced disease resistance are being grown in rice paddy fields during the fallow period, providing additional food for local consumption while boosting the income of farmers.

The Agency supported five regional technical cooperation projects on plant breeding in Africa, Asia and the Pacific, and Europe. These projects facilitated the exchange of germplasm, trained researchers in developing countries in the latest technologies and gave them access to valuable genetic material.

In Cuba, scientists and breeders from the national breeding institute, National Institute of Agricultural Sciences, working with farmers, developed a new line of drought tolerant tomato (R4-300). This new mutant tomato variety, which almost doubled the region's regular tomato yields to 65 tonnes per hectare (t/ha), was sold at $11.38/t in the first year of production, representing an increase of almost $7.78/t.

Fifteen plant breeding specialists from six member countries of the Cooperative Agreement for Arab States in Asia for Research, Development and Training Related to Nuclear Science and Technology (ARASIA) attended a regional technical cooperation training course on plant breeding based on mutation induction and efficiency enhancing biomolecular technologies. The aims of this course were to: create an R&D facility; gain practical experience in implementing a technical cooperation project; and facilitate interaction and cooperation between the key researchers from the participating countries.

"Marking the 80th anniversary of mutation induction in crop plants, the Agency and FAO organized an international symposium in Vienna on the role of this technique in developing improved crop varieties ..."

Marking the 80th anniversary of mutation induction in crop plants, the Agency and FAO organized an international symposium in Vienna on the role of this technique in developing improved

FIG. 1. Mutant varieties of soybean in Vietnam.

crop varieties, including the discovery of genes controlling important traits, and understanding the functions and mechanisms of action of these genes. The symposium participants discussed the application of induced mutations in addressing such challenges as the bio-remediation of contaminated lands, improving crop production systems and crop resilience to climate change and variability.

Soil and Water Management and Crop Nutrition

Nitrogen and phosphorus are essential plant nutrients for food and fibre production. Developing countries use more than 55 million tonnes of nitrogen fertilizers with an estimated annual value of $16 billion. In 2008, the Agency published *Guidelines on Nitrogen Management in Agricultural Systems* to assist Member States in improving fertilizer nitrogen use efficiency and minimizing adverse effects on the environment. The publication describes how isotopic tracers can be used to improve overall nitrogen use efficiency, optimize biological nitrogen fixation and enhance sustainable agriculture.

To address the issue of phosphate deficiencies common in degraded soils, the Agency, in partnership with the International Center for Soil Fertility and Agricultural Development, developed a web based phosphate rock decision support system (PRDSS) as a tool for farmers and land managers to determine the appropriate phosphorous fertilizers to be used to increase crop productivity. This system is being used as part of a crop nutrition management package in Benin, Burkina Faso, Burundi, Chad, the Democratic Republic of the Congo, Mali, Rwanda, Senegal, Uganda and the United Republic of Tanzania.

Use of Isotopic Techniques to Increase Crop Productivity

Developing countries account for 95% of the world's production of rice and over 40% of the world's wheat production. The production of these cereals has recently been severely reduced by drought and a lack of irrigation water. As a result, enhancing water use efficiency has become a priority for rice and wheat cultivation in many parts of the world. Through a network of coordinated research activities involving 12 Member States, the Agency demonstrated the utility of carbon isotope discrimination (CID) to assess plant water use (Fig. 2), in particular the ability to discriminate carbon-13 from carbon-12 and their respective absorption of carbon dioxide in photosynthesis. This

"... enhancing water use efficiency has become a priority for rice and wheat cultivation in many parts of the world."

FIG. 2. Training Agency fellows in the use of the CID technique for evaluating wheat genotypes for greater water use efficiency.

FIG. 3. Soybean farming in Brazil using conservation agriculture to increase crop yield, improve soil quality and enhance land carbon sequestration.

successful CRP led to the CID technique being incorporated into wheat breeding programmes in China, India and Pakistan, in addition to government support in training scientists and supplying isotope ratio mass spectrometers for analysing carbon-13 and carbon-12. The CID technique is also being used by rice breeders in Bangladesh and China, and by the International Rice Research Institute to evaluate rice genotypes for salinity tolerance. CID promises to contribute to a significant saving of resources that would otherwise be used in more time consuming processes for evaluating or screening rice.

Soil Conservation Techniques for Sustainable Agricultural Management

In order to improve soil conservation techniques, the Agency supported a range of field activities in 2008 in Africa, Asia and Latin America. Both fallout radionuclides (caesium-137 and beryllium-7) and stable isotopes (nitrogen-15 and carbon-13) were proven to be essential tools in quantifying the effectiveness of soil conservation measures. The Agency also supported national research institutes in the use of fallout radionuclides, stable isotopes (nitrogen-15 and carbon-13) and soil moisture neutron probes to track soil redistribution (erosion and deposition), carbon, as well as water and nutrient movement under diverse soil conservation techniques in Algeria, Argentina, Australia, Austria, Bangladesh, Brazil, Chile, China, El Salvador, Indonesia, India, Kenya, Madagascar, Malaysia, Mali, Mexico, Mongolia, Morocco, Myanmar, Pakistan, Philippines, Poland, the Russian Federation, Sri Lanka, Tajikistan, Thailand, Turkey, Uganda, the United Kingdom, the United States of America, Uzbekistan and Vietnam.

Conservation agriculture (CA), an agricultural practice covering approximately 100 million hectares around the world, protects soil against erosion and improves soil fertility through the permanent presence of crop residues and crop rotation. In addition, CA reduces energy costs by reducing soil cultivation (tillage). Preliminary results obtained in 2008 from a CRP involving 12 national research institutes in Argentina, Australia, Brazil, Chile, India, Mexico, Morocco, Pakistan, Turkey and Uzbekistan indicated that CA enhances biological nitrogen fixation (as measured by nitrogen-15) by up to 10–15% and increases available soil moisture content by up to 20–30% at harvest (as measured by neutron probes). The research also demonstrated the unique role of nuclear techniques in quantifying the role of CA (Fig. 3) in enhancing soil carbon sequestration (based on carbon-13) and in reducing soil nitrogen losses (based on nitrogen-15 balance studies). CA was able to retain more soil organic carbon compared with conventional tillage because of less soil disturbance. Under rotations — including

"The research ... demonstrated the unique role of nuclear techniques in quantifying the role of CA ... in enhancing soil carbon sequestration ... and in reducing soil nitrogen losses ..."

a winter legume — CA could sequester up to 17 mg of carbon per hectare more than conventional tillage in tropical red soils of the Brazilian semi-arid Cerrado region. Carbon-13 based studies indicated that this increase in soil carbon over 13 years of CA was attributable mainly to the returns of organic matter from crop residues. Soil organic carbon derived from the native vegetation was found to reduce substantially (by 11%) after 13 years of conventional tillage.

Sustainable Control of Major Insect Pests Using the Sterile Insect Technique

Over-reliance on pesticides, together with pre-harvest and post-harvest losses due to the continued incidence of pests, requires the development of improved methods of pest control. These methods involve biologically and ecologically based tactics such as the sterile insect technique (SIT) and related biological controls that can be applied as part of an area-wide integrated pest management (AW-IPM) approach.

FIG. 4. A female cactus moth (photograph courtesy of J. Carpenter).

The Agency achieved a breakthrough in 2008 with the development of rearing techniques for the olive fly, *Bactrocera oleae*, a severe pest of olive trees, resulting in the possibility of using SIT programmes against this pest. Significant improvements were made in streamlining egg collection techniques and in egg and larval handling, leading to a marked improvement in the productivity of female olive fruit flies in the laboratory.

In 2008, the Agency published 26 scientific papers in international peer reviewed journals on the development of SIT for tackling major pest insects.

With the support of FAO, the Agency and other partners, the United States Department of Agriculture (USDA) has been developing the SIT component for integration with other cactus moth control tactics. In Mexico, the establishment of an efficient cactus moth monitoring network allowed the detection of outbreaks of cactus moth on the Yucatan Peninsula. Intensive control activities, which included the shipment of sterile moths from the USA to these areas, resulted in the elimination of these outbreaks in late 2008 (Fig. 4).

"Following six years of Agency technical cooperation activities, Panama declared the Peninsula of Azuero and the southern part of Veraguas Province to be free of the Mediterranean fruit fly in 2008."

In support of the African Union led Pan African Tsetse and Trypanosomiasis Eradication Campaign initiative for the control of tsetse flies, the Agency developed in 2008 a dynamic mathematical model for the design of control strategies and to facilitate day to day decision making in the implementation of AW-IPM. This innovative model, which can be used interactively by both technicians and managers working in operational tsetse management programmes, introduces for the first time insect dispersal and some spatial complexity modelling.

To help African Member States manage tsetse species of economic importance, the Agency transferred the SIT to Ethiopia (*Glossina pallidipes*), Mozambique, South Africa (*G. austeni* and *G. brevipalpis*), and Senegal (*G. palpalis gambiensis*). The project in Senegal aims to eliminate *G. p. gambiensis* from the Niayes, an area located north-east of Dakar with a high density of livestock. In the initial phase of the project, emphasis was placed on training, followed by a feasibility assessment phase.

Following six years of Agency technical cooperation activities, Panama declared the Peninsula of Azuero and the southern part of Veraguas Province to be free of the Mediterranean fruit fly in 2008. Four years of systematic

surveillance confirmed the eradication of the fly, qualifying the region for the export of tomatoes, peppers and papaya without quarantine measures. In addition, this programme supported efforts to eradicate the West Indian fruit fly (*Anastrepha obliqua*) from the area. This is expected to boost the area's ambition to become one of the most important fresh fruit and vegetable exporting areas in Central America.

To support international trade in agricultural commodities, the Agency helped to develop international standards for phytosanitary measures (ISPMs) through the International Plant Protection Convention (which currently has 180 Contracting Parties). Following extensive country reviews, in 2008, a standard on the *Establishment of Areas of Low Pest Prevalence for Fruit Flies (Tephritidae)* (ISPM No. 30, 2008) was approved by the Commission on Phytosanitary Measures. In addition, the Agency provided expertise for the Technical Panel on Pest Free Areas and Systems Approaches for Fruit Flies, which developed several draft ISPMs in 2008.

"To support international trade in agricultural commodities, the Agency helped to develop international standards for phytosanitary measures ..."

A *Model Business Plan for a Sterile Insect Production Facility* was published in 2008 to facilitate private sector involvement in the production of sterile insects in pest control activities. While providing an international perspective on issues such as initial capital costs and recurring operational expenditures for a sterile insect facility, the manual also offers tools to evaluate the feasibility of proceeding with the construction or expansion of a sterile insect production facility.

Early Diagnosis of Transboundary Animal Diseases

The early, rapid and sensitive diagnosis of transboundary animal diseases and those of a zoonotic nature remained a high priority for Member States in 2008. The Agency supported national efforts in these areas by hiring experts, organizing regional training courses and setting up CRPs on contagious pleuropneumonia, Rift Valley fever and peste des petits ruminants. Techniques using nucleic acid amplification for the detection and differentiation of highly pathogenic avian influenza and human pandemic agent H5N1 now permit diagnosis in one day as compared with one week using classical methods. The inability to stamp out avian influenza during the 2008 campaign highlighted the difficulties of finding it in the field, as it occurs mostly in 'backyard' chickens, which represent 70% of the world's chicken meat. Thus, the ability to perform rapid testing was reconfirmed as a major advantage, and the Agency is assisting in the validation of these technologies for wide scale use in developing Member States.

Gene Based Technologies in Livestock Breeding

Sheep and goats are among the most important livestock species, especially in developing countries. The genetic diversity of these species has not been fully exploited to increase the livelihoods of people due to the lack of organized breeding plans, among other key factors. In 2008, the Agency transferred information and best practices on nuclear and nuclear related DNA techniques and methodologies to several Member States. The Agency also developed an online genetic repository bank on sheep to graphically view the location of samples on Google reference maps, as well as an Internet based application for the Agency to liaise with Member State laboratories.

In a CRP on Gene Based Technologies in Livestock Breeding: Characterization of Small Ruminant Genetic Resources in Asia, results from the analysis of the genes that are responsible for production traits of small ruminants and information on the traits of those animals (i.e. lean meat, good quality milk, heat resistance, big heads, etc.) were collected from about 4000 sheep and goats from 89 breeds/populations, while nearly 40 goat and sheep breeds were genotyped for 15 microsatellite markers in order to search for favourable breeding traits. The collection of these data is important in facilitating the selection of superior animals for improving indigenous and locally adapted breeds with a direct impact on farmer households.

Artificial Insemination

Artificial insemination is the most widely used technique for genetic improvement and for increasing the productivity of livestock. It is associated with improved animal care, enhanced data recording and better livestock feeding in

farms. However, research work using progesterone radioimmunoassay (RIA) data showed that 45% of inseminations are associated with poor 'on-farm' management, thus affecting the efficiency of breeding programmes. In 2008, the Agency supported the establishment of laboratories in nearly 60 Member States for the use of RIA and enzyme linked immunosorbent assay, and developed computer applications to solve problems in farm management. As a result, shorter intercalving periods of three to four months and up to 20% better conception rates were obtained.

In the area of training and capacity building, 53 scientists received two to four months of fellowship training outside their own countries. Additionally, 113 experts in livestock attended Agency training courses or scientific meetings.

Improving Food Quality and Safety

The approval and commercial application of irradiation for food and agricultural commodities continues to gain acceptance worldwide, especially as related to the control of quarantined insect pests. The Agency's research activities contributed to the finalization of International Plant Protection Convention (IPPC) standards allowing the use of irradiation as a phytosanitary (quarantine) treatment.

Countries, such as Chile, Colombia, Egypt, Ghana, Guatemala, India, Indonesia, Jamaica, the Libyan Arab Jamahiriya, Malaysia, Mexico, Mongolia, Morocco, Nigeria, Peru, Sri Lanka, the Syrian Arab Republic and Uruguay, worked with the Agency in 2008 to assess the feasibility of using irradiation as a safe post-harvest phytosanitary treatment. The acceptance and growth of this technology has been demonstrated in part by information in the Agency's newly updated and revised databases on food irradiation clearances and facilities. These databases indicated that as of 2008, irradiation had been approved in over 60 countries to treat an estimated 500 000 t of various kinds of food — including spices, grains, chicken, beef, seafood, fruits and vegetables — in approximately 180 gamma irradiation facilities worldwide.

As part of its efforts to build capacity in Member States in the field of food safety, the Agency completed a technical cooperation project in Panama on the development and transfer of pesticide residue analytical methods utilizing carbon-14 radiotracers. It also assisted Chile in addressing deficiencies in its regulatory systems to satisfy auditors from Canada, China, Mexico, the USA, and the European Union, thereby keeping Chile's export markets open.

The Agency also combined research and capacity building through a CRP on the development of integrated analytical methods to assess the effectiveness of pesticide use, and a regional technical cooperation project on strengthening laboratory capacity to assess the implementation of good agricultural practices in the production of fruit and vegetables in Latin America. This initiative helped 15 countries to develop and optimize effective, economic, safe and environmentally sustainable production practices for fruit and vegetables and other agricultural commodities. Analytical methods for chemical hazards, including trypanocides, antimicrobial drugs, growth promoters and pesticides in foods, were also developed and transferred to Member States in 2008.

"More than 60 scientists and analysts were trained in radiotracer techniques and related analytical procedures by the Agency at its laboratories at Seibersdorf or in Member State laboratories."

More than 60 scientists and analysts were trained in radiotracer techniques and related analytical procedures by the Agency at its laboratories at Seibersdorf or in Member State laboratories. In addition, information on the role of nuclear techniques and analytical laboratories in food safety systems was widely disseminated, for example, through a 'Food Safety Summit' in China attended by more than 50 government scientists and food safety regulators.

Emergency response planning activities included Agency participation in a meeting of the Inter-Agency Committee on Response to Nuclear Accidents, in London in November 2008. The Agency also joined FAO, UNEP and WHO in a United Nations team to respond to a request from Mongolia to carry out field investigations into environmental and food chain contamination affecting human and animal health. Preliminary conclusions indicated that there are a number of possible causes of the observed symptoms in humans and animals, including industrial contamination of the environment and food chain and/or infectious animal disease. A follow-up FAO technical cooperation project was initiated.

Human Health

Objective

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

Quality Management in Nuclear Medicine

In 2008, the Agency introduced guidelines on quality management in nuclear medicine to facilitate self-appraisal and external audits. The *International Basic Safety Standards for Protection against Ionizing Radiation and for the Safety of Radiation Sources*, as well as the Agency's assistance in the area of nuclear medicine, require that radiation medicine centres establish a comprehensive quality assurance programme for medical exposures supported by internal and external audits. The objective of these guidelines is to introduce a culture of annual systematic reviews of the clinical area. The Agency tested these guidelines in a technical cooperation project in Slovenia. Quality management self-assessments have now been adopted by the European Union of Medical Specialists/European Board of Nuclear Medicine for the certification of nuclear medicine processes in nuclear medicine departments.

The quality, safety and efficacy of radiopharmaceuticals are a concern of a large number of States, many of which do not have the means to develop their own quality specifications. To address this issue, the Agency and WHO validated a new chapter of the *International Pharmacopoeia (Ph. Int.)* on radiopharmaceuticals. The approval of this chapter followed four years of collaboration between the Agency and WHO, and is the result of lengthy and detailed reviews by all stakeholders, including numerous WHO collaborating centres and national quality control laboratories.

Capacity Building in Radiation Oncology

Using its Directory of Radiotherapy Centres (DIRAC) — the only global database that describes the current capacity for the delivery of radiation therapy — the Agency provided data to the European Union Network for Information on Cancer. In addition to helping set up a network of databases, the Agency provided the European Union with updated and standardized indicators on cancer burden and care, ensuring the availability of data on cancer in Europe through traditional publications as well as through electronic media.

One goal of the Agency's radiation medicine programme is to enhance the capabilities of Member States to address major health problems such as cancer and cardiovascular disease. One method of achieving this goal is by providing targeted education and training. For example, in 2008 the Agency and the European Society for Therapeutic Radiology and Oncology conducted a pilot training course on best practices in radiation oncology, Selected groups from eight European countries received instruction on how to create their own train the trainers courses for radiation therapy technologists (RTTs) in their respective countries.

"One goal of the Agency's radiation medicine programme is to enhance the capabilities of Member States to address major health problems such as cancer and cardiovascular disease."

The shortage of medical specialists for cancer treatment in developing countries was the driving force behind a new distance learning course launched in 2008 entitled Applied Sciences of Oncology (*http://rpop.iaea.org/RPoP/RPoP/Content/index.htm*). Intended for radiation oncologists, RTTs, medical physicists and radiation biologists, this course can be used as either a self-guided or a tutored programme, complementing the training available in their countries through formal educational programmes. In addition, a new syllabus for the training of radiation oncology nurses was published in the Agency's Training

Course Series, to help Member States establish training programmes in this field.

Quality Assurance and Metrology in Radiation Medicine

Recognizing that both the clinical aspects (diagnosis, treatment decision making, indication for treatment and follow-up) and the procedures related to the physical and technical aspects of patient treatment require careful control and planning to ensure safe, high quality radiotherapy, the Agency published guidelines on *Setting up a Radiotherapy Programme: Clinical, Medical Physics, Radiation Protection and Safety Aspects*. This was complemented by the issue of two other publications on the effective implementation of advanced treatment modalities, such as three dimensional conformal radiotherapy and intensity modulated radiotherapy.

The Agency also trained some 100 medical physicists in the use of these technologies, mainly through technical cooperation workshops and courses, and through partnerships with the ICTP, the American Association of Physicists in Medicine and the European Federation of Organisations for Medical Physics.

"... the Agency implemented a methodology for comprehensive audits of radiotherapy practices in 25 Member States in Asia, Europe and Latin America, mainly through technical cooperation projects."

Coordinated research activities on radioactivity measurements for nuclear medicine applications concluded in 2008 and are expected to lead to improvements in the accuracy with which radiopharmaceuticals are determined before they are administered to patients. This is particularly important for therapeutic nuclear medicine, where unsealed sources with relatively high activity levels are used to treat rather than diagnose disease.

In the framework of its Quality Assurance Team for Radiation Oncology (QUATRO) service, the Agency implemented a methodology for comprehensive audits of radiotherapy practices in 25 Member States in Asia, Europe and Latin America, mainly through technical cooperation projects. The Agency communicated its recommendations for improvements in radiotherapy treatment to the audited hospitals.

A similar external clinical audit programme was formulated in the area of diagnostic radiology. Two pilot audits using the new guidelines, known as Quality Assurance Audit for Diagnostic Radiology Improvement and Learning (QUAADRIL), were implemented in 2008. This audit process reviews the complete clinical range of activities in diagnostic radiology facilities by providing a framework for a structured investigation, a description of acceptable standards, and a format for documenting the status of the audited site. In related work, an audit using QUAADRIL was conducted through a technical cooperation project in a radiology department in Bosnia and Herzegovina. The objective was to evaluate the quality of this department's practices and overall performance in diagnostic radiology, as well as in interactions with external service providers.

The IAEA–WHO thermoluminescent dosimeter (TLD) postal dose audit service focuses on providing dose quality audits to end users, who often have no other means to verify the output of their radiation sources. It provides quality assurance to health professionals and patients, and seeks to improve the quality of treatment. In 2008, the service checked the calibration of 458 clinical beams used to treat cancer patients in Member State hospitals. Twenty-five discrepancies were identified and resolved.

The Agency's dosimetry standards have been used to calibrate 20 national standards from Member States, providing a link from their measurements to the international measurement system (Fig. 1). Once established, these standards are used by national dosimetry laboratories to calibrate instruments used in radiotherapy, diagnostic radiology and radiation protection dosimetry. The international dosimetry comparisons, published in 2008 by the International Bureau of Weights and Measures (BIPM), investigated the degree of equivalence of internationally recognized dosimetry standards, and confirmed the quality of the Agency's dosimetry standards.

Stable Isotope Techniques to Improve Nutrition and Address Communicable Diseases

The Agency's collaboration with WHO and other partners was further strengthened during 2008 through the organization of joint meetings on priority areas in nutrition, including HIV/AIDS. A regional consultation meeting, sponsored jointly by WHO, the US National Institutes of Health, the Agency and other partners, was held in Burkina Faso for 20 francophone African countries. The

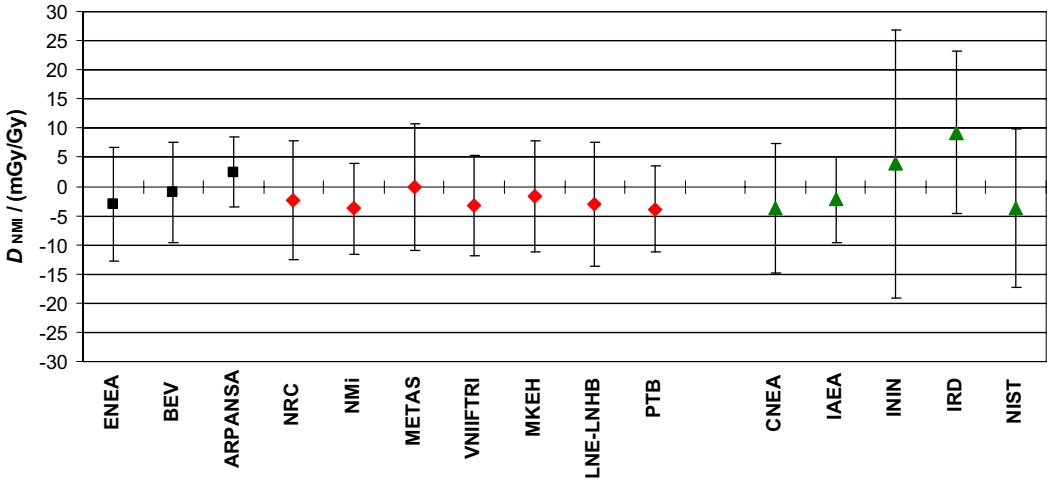


FIG. 1. An international dosimetry comparison showing the degree of equivalence between national dosimetry standards (x axis) with respect to the BIPM reference value (y axis). (The black squares indicate results that are more than ten years old.)

meeting was notable for being the first time that the Agency has been involved in the organization of a regional meeting on this issue and resulted in recommendations to integrate nutrition into a comprehensive response to HIV/AIDS in African countries.

Collaboration with HarvestPlus (a programme of the Consultative Group on International Agricultural Research (CGIAR)) in 2008 included research activities on biofortification as a strategy to improve micronutrient nutrition for infants and young children. A joint technical meeting, organized to review progress in plant breeding to improve the nutritional quality of staple foods in developing countries, concluded that major achievements had been made to establish biofortification as one of the most important sustainable strategies to combat micronutrient malnutrition, also known as 'the hidden hunger' (Fig. 2).

New research activities, as well as the Agency's support to the International Malnutrition Task Force (IMTF), are prominent indicators of the Agency's increased attention to the problem of severe acute malnutrition in children. As a member of the IMTF board of governors, the Agency worked with the International Pediatric Association, the International Union of Nutritional Sciences, UNICEF and WHO to provide leadership and direction to this interagency advisory and advocacy group. As one of its first major activities, the IMTF launched a web site in 2008 to share ideas and experience on the management of acute malnutrition.

In the area of communicable diseases, activities conducted under Agency projects validated new diagnostic tools for national disease control and surveillance programmes. The objective is to counter the spread of drug resistant strains of pathogens of epidemiological significance, and to help integrate these tools into the protocols of national control programmes for malaria and TB.

The Agency's technical cooperation projects contributed to the upgrading of laboratory facilities, capacity building, and the establishment or strengthening of molecular capacity in Burkina Faso, Cameroon, Ethiopia, Ghana, Kenya, Madagascar, Mali, Nigeria, South Africa, Sudan, Uganda, the United Republic of Tanzania and Zambia. These molecular techniques were central to the identification and control of outbreaks of multidrug resistant TB (MDR-TB), and to the detection and monitoring of emerging MDR-TB strains. Results from the studies were used in national policies and strategies to combat malaria.

"In the area of communicable diseases, activities conducted under Agency projects validated new diagnostic tools for national disease control and surveillance programmes."

Programme of Action for Cancer Therapy (PACT)

During 2008, the Agency continued to build partnerships through PACT with leading cancer organizations and agencies. In this regard, an agreement with WHO for a Joint Programme on Cancer Control

FIG. 2. A study in Bangladesh is evaluating the impact of replacing white sweet potatoes with orange sweet potatoes with high provitamin A carotenoid content (biofortified sweet potatoes) to combat vitamin A deficiency (photograph courtesy of K. Jamil, ICDDR,B, Dhaka, Bangladesh).

was finalized during the year. 'Practical Arrangements' were also concluded with the International Agency for Research on Cancer (IARC), the Program for Appropriate Technology in Health (PATH) and the Organisation of European Cancer Institutes–European Economic Interest Grouping (OECI–EEIG). Negotiations for three additional partnership agreements were initiated with the Lance Armstrong Foundation, the Alliance for Cervical Cancer Prevention and Best Medical International.

The Agency made significant progress in building up PACT Model Demonstration Sites (PMDSs) in Albania, Nicaragua, Sri Lanka, the United Republic of Tanzania, Vietnam and Yemen. For example, radiotherapy machines were installed in Nicaragua and the United Republic of Tanzania and, within the framework of a tripartite agreement concluded in 2008, India will supply a 'Bhabhatron' teletherapy machine to Vietnam. In addition, by the end of 2008, PACT had received requests from 60 Member States for imPACT reviews since its implementation in 2006.

More than 20 Member States volunteered their national cancer institutes, cancer centres and hospitals as training resources for PACT programme initiatives in 2008. For example, the Tata Memorial Centre and the Bhabha Atomic Research Centre in India designed a comprehensive training programme offering fellowships in radiation oncology and medical physics, including practical training opportunities, for health professionals from PMDS countries and Africa. And using funds from the IAEA Nobel Peace Prize Cancer and Nutrition Fund, PACT helped train 20 participants from Africa and Latin America in quality assurance procedures in radiotherapy at the Argonne National Laboratory in the USA.

With in-kind support valued at more than $250 000 from the US National Cancer Institute (NCI), 22 health professionals from low and middle income Member States, including 12 from PMDSs, completed the NCI summer curriculum in cancer prevention in the USA. The Agency also supported the participation of seven individuals from PMDS countries in a training course in France on cancer registration and epidemiology organized by the IARC; and three Tanzanian health professionals were awarded medical physics fellowships to study in South Africa. Finally, using resources mobilized by PACT, the Agency helped train over 70 health professionals to strengthen capacity in cancer control and radiotherapy in several developing countries.

Culminating a two year Agency effort, $13.5 million in long term loans were confirmed in 2008 by the OPEC Fund for International Development and the Arab Bank for Economic Development in Africa to strengthen Ghana's national cancer control programme. In addition, PMDS counterparts in Vietnam credited PACT initiatives with facilitating bilateral support by Australia and Austria to train up to 30 professionals and provide up to six radiotherapy machines. In December 2008, HSH Prince Albert II of Monaco hosted a gala dinner in Monte Carlo to generate support for PACT programme activities.

"More than 20 Member States volunteered their national cancer institutes, cancer centres and hospitals as training resources for PACT programme initiatives in 2008."

Water Resources

Objective

To enable Member States to sustainably use and manage their water resources through the use of isotope technology.

Raising Awareness of Water Issues and Improving Dissemination of Isotope Information

In 2008, the Agency made special efforts to disseminate the results of its work in the area of water resources to the public and experts in Member States. For example, it screened a film entitled *Search for Water* at the International Exposition on Water and Sustainable Development (EXPO 2008), held in Zaragoza, Spain. Also available at *http://www.iaea.org/NewsCenter/Multimedia/Videos/Isotopehydrology/index.html*, the film describes challenges in water resources management and introduces the topic of isotope hydrology in a manner that is understandable to both scientists and laypersons. More than 15 000 people visited the Agency's exhibit at Zaragoza, which included displays, posters and other information.

The Agency co-sponsored an international conference in Kampala, Uganda, on Groundwater and Climate in Africa. The Agency's contribution helped elucidate the use of isotopes for understanding the impact of climate change on groundwater recharge. The conference was the first to discuss the role of groundwater in improving livelihoods in Africa under conditions of rapid development and climate change (Fig. 1). The main outcome of the conference was the creation of a roadmap for policy makers on how to adapt to the impacts of climate change on water resources. In addition, the conference emphasized the need for increased regional cooperation in water resources assessment.

"The Agency's contribution helped elucidate the use of isotopes for understanding the impact of climate change on groundwater recharge."

The Agency published two technical documents containing the results of projects that were completed in 2008. The first highlights the results of individual country studies in Latin America conducted within the framework of regional technical cooperation projects and describes the application of isotope methods for characterizing hydrological systems and improved water management decisions. The second, on the characterization of submarine groundwater discharge (SGD) in coastal zones, describes the results of a CRP completed in 2008 jointly with IAEA-MEL. Among the major conclusions: isotope approaches are effective for identifying SGD and for quantifying the rates of discharge. Although SGD is not considered to be significant on a global scale, it

FIG. 1. Access to fresh water is expected to be affected by climate change in many areas. Isotope techniques can be used to map current water resources and assess their sustainability.

can be a large component on a regional scale and an important pathway for coastal pollution from land based activities.

The results of data analysis following an isotope survey (covering radon-222, tritium, stable oxygen, hydrogen and nitrogen isotopes) of the Danube River, conducted in collaboration with the International Commission for the Protection of the Danube River, were published in 2008 in the *Final Scientific Report of Joint Danube Survey 2*. In addition to serving as a baseline for monitoring the impact of climate change on river hydrology, the isotope data reveal that: (a) areas of groundwater input to the rivers can be identified; (b) nitrate pollution is mainly from natural organic matter in the soil and anthropogenic waste, rather than from atmospheric nitrogen and fertilizers; and (c) mixing of tributary waters in the main Danube channel may be relatively slow, occurring over a distance of several kilometres. These findings improved the understanding of river hydrology and nutrient sources, and contributed to more effective cooperation to meet the European Union's Water Framework Directive goals.

Strengthening Capacity and Advancing Isotope Hydrology Applications

The funds available for water resources projects in the Technical Cooperation Fund amounted to over $8.7 million in 2008. With this, the Agency supported over 80 active technical cooperation projects in Africa, Asia, Europe and Latin America to improve the management of groundwater and surface water and to address contamination issues. For instance, the Agency completed a technical cooperation project to characterize the hydrology of the Guarani Aquifer, shared by Argentina, Brazil, Paraguay and Uruguay, in cooperation with the Global Environmental Facility, the World Bank and the Organization of American States. The partners in this project collected new information on the source and movement of groundwater in this extensive aquifer system using isotope and geochemical data. This information led to the construction of a better database for modelling the aquifer system so that appropriate shared resource management policies can be adopted.

"... the Agency supported over 80 active technical cooperation projects in Africa, Asia, Europe and Latin America to improve the management of groundwater and surface water and to address contamination issues."

An important component of the Agency's technical cooperation programme is providing training and building capacity in developing Member States. For example, in 2008 the Agency organized an isotope hydrology regional training course for counterparts from French speaking countries in Africa, in Rabat, Morocco. Another advanced regional course, held in Budapest, on the application of isotope techniques, in cooperation with the Environmental Protection and Water Management Research Institute and the Research Centre for Water Resources Development in

FIG. 2. The availability of isotope data is expected to improve through the routine use of laser based isotope analysers, which are cheaper and easier to use than conventional mass spectrometers.

Hungary, trained participants from south-eastern European countries in isotope hydrology and groundwater flow and transport modelling.

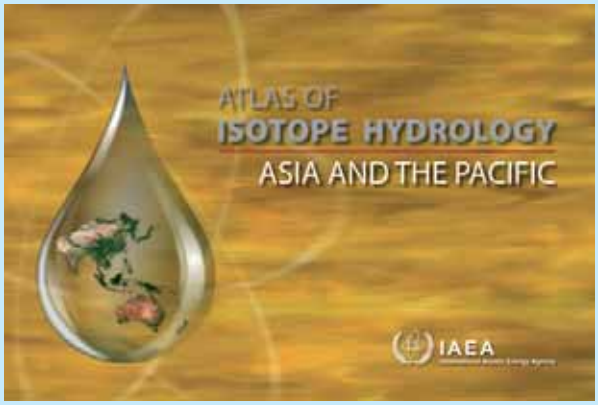
The Agency completed a CRP on the application of isotopes to understand water and carbon cycle dynamics in the atmosphere. Nine countries participated in the collection of over 10 000 samples of atmospheric moisture and plant water at 51 field sites. The results helped to improve the understanding of water and carbon cycle processes, particularly to quantify carbon and evaporation fluxes from land surfaces. Quantification of these fluxes provides a means to validate general circulation models used for simulating the impact of climate change on the water cycle.

The Agency achieved a milestone in building Member State capacity for the isotope analysis of water samples. Eleven Member States[1] received a laser instrument that was tested and adapted by the Agency in a technical cooperation project (Fig. 2). The instruments, which are now operational, were installed by counterparts who had earlier received hands-on training in their installation and operation.

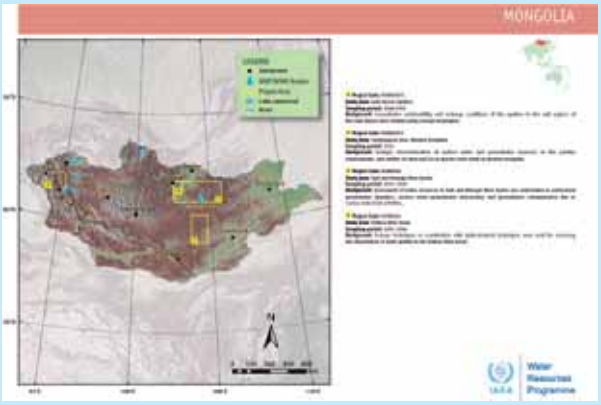
The IAEA Isotope Hydrology Analytical Network (IHAN) supporting the analytical needs of technical cooperation projects, CRPs and global isotope networks was expanded with new laboratories from Mexico and Vietnam.

[1] Albania, Argentina, Croatia, Ethiopia, Lebanon, Mexico, Thailand, Tunisia, Uganda, Venezuela and Vietnam.

New isotope hydrology atlas — Improving water management in Member States



Cover page of the atlas.



Example of a project page in the atlas.

Access to environmental isotope data is critical for expanding the application of isotope methods for improved water management. The release in 2008 of the *Atlas of Isotope Hydrology — Asia and the Pacific* followed the 2007 publication of an atlas covering Africa and is an important step in making existing isotope data available to Member States. These data were compiled from 105 Agency projects in 16 countries in Asia and the Pacific to produce the atlas. Nearly 16 000 isotope records were compiled from technical cooperation projects and CRPs conducted between 1973 and 2007. The atlas features a digital elevation map for each country in the region showing project areas, major water bodies and the locations of stations in the Agency's global network of isotopes in precipitation (GNIP). Summary pages for each project include a higher resolution map of the study area showing sample types and locations as well as isotope data tables and plots. The isotope information presented in the atlas is a valuable reference to scientists, practitioners and policy makers engaged in the field of hydrology. It can be downloaded from *http://www.iaea.org/water.*

Environment

Objective

To enhance the capabilities of Member States in understanding environmental dynamics and the identification and mitigation of marine and terrestrial environment problems caused by radioactive and non-radioactive pollutants using nuclear techniques.

Coastal Marine Environments and the Sustainability of Fisheries and Biodiversity

There is growing concern about the likely effects on the ocean of climate change and increasing levels of contaminants and carbon dioxide, and about how these changes may impact the sustainability of fisheries and biodiversity. In 2008, IAEA-MEL completed a series of experimental radiotracer studies on the potential impact of ocean acidification on the biological processes of three species of commercial seafood. Sea bream, sea bass and cuttlefish were exposed to radiotracers to assess the incorporation into the tissues of these species of trace elements such as cadmium and zinc, which are commonly found in marine ecosystems. Studies suggest that levels of these contaminants may rise in the future owing to a combination of factors such as industrial growth and greater use of nuclear power to mitigate carbon emissions. All three species are of increasing importance to commercial fisheries, given the steep decline of finfish catches in recent years.

The experimental parameters used in the studies were based on scenarios of seawater pH levels derived from various models of future carbon emissions developed by the Intergovernmental Panel on Climate Change (IPCC). Studies of the eggs and larvae of sea bream and cuttlefish showed both morphological and physiological impacts of ocean acidification, as well as increasing accumulation of some metal contaminants, and indicated negative effects on the potential viability or rates of increase of commercial species (Fig. 1). Data of this kind enable the monetary valuation of the costs of carbon dioxide emissions and their application to policy assessment, in the context of the aquaculture and fisheries industries.

In Africa, as part of the second phase of a technical cooperation project on coastal zone management, the Agency supported Angola, Kenya, Mauritius, Namibia and South Africa in applying isotope techniques in national phytoplankton monitoring programmes to address the adverse health and environmental effects of harmful algal blooms. In collaboration with the IOC, the Agency trained participating Member States in the use of the

FIG. 1. An experimental system at IAEA-MEL to assess the impact of exposure of commercial seafood to seawater at the decreased pH levels predicted by climate change models.

receptor binding assay for toxin quantification and in the identification of toxic algae. The aim was to increase levels of expertise in these countries, enabling them to contribute to the sustainable development and management of the marine coastal environment.

In Latin America, an Agency technical cooperation project on the use of nuclear techniques to address management problems of coastal zones in the Caribbean fostered collaboration between 12 Member States in the region as well as with UNEP's Caribbean Regional Coordinating Unit, and France, Italy and Spain. In 2008, samples were collected from the coastal zones of participating Member States, and a regional project was launched to study harmful algal blooms in these areas. Potential sites and counterparts for a study of submarine groundwater discharge were also identified.

The Monaco Declaration

In 2008, the Agency facilitated the signature by over 150 international marine specialists of the Monaco Declaration. The Declaration expresses concern about recent rapid changes in ocean chemistry and their potential, within decades, to severely affect marine organisms, food chains, biodiversity and fisheries. Through the Declaration, scientists urged policy makers to launch initiatives aimed at:

"In collaboration with the IOC, the Agency trained participating Member States in the use of the receptor binding assay for toxin quantification and in the identification of toxic algae."

- Improving understanding of the impacts of ocean acidification by promoting research in this nascent field;
- Building links between economists and scientists to evaluate the socioeconomic impacts of ocean acidification and the potential costs of inaction;
- Improving communication between policy makers and scientists so that new policies are based on current findings and scientific studies address policy based questions;
- Preventing severe damage from ocean acidification by developing plans to rapidly and drastically cut emissions.

Rapid Analysis of Radionuclides in Environmental Samples

As part of its programme on recommended procedures for the rapid analysis of radionuclides in environmental samples, the Agency developed, tested and validated methods for the determination of polonium-210, lead-210 and plutonium isotopes. This work included the development, in cooperation with the Korea Institute of Nuclear Safety (KINS), of a system for the automated separation of radionuclides for radiochemical analysis.

ALMERA Network

In 2008, 11 new laboratories joined the Analytical Laboratories for the Measurement of Environmental Radioactivity (ALMERA) network — which is coordinated by the Agency — bringing the total number of members to 117 from 72 Member States. The Agency continued to organize regular proficiency tests for the members of the network to help them improve their analytical performance. A comparison carried out in 2008 of results obtained from the 2006 and 2007 proficiency tests showed a significant improvement in the accuracy of the results for lead-210 (Fig. 2) and cadmium-107 in environmental samples reported by the laboratories taking part.

To facilitate regional integration of the ALMERA network, the 5th meeting of the network was held in Rio de Janeiro in October 2008. The host institution — Brazil's National Nuclear Energy Commission, Institute of Radiation Protection and Dosimetry — was nominated as the ALMERA focal point for the North American and Latin American regions for the period 2009–2013. KINS was nominated as the focal point for the Asia–Pacific region.

Public Communication in the Uranium Mining Industry

A well conceived communication policy that responds effectively to public concerns regarding environmental issues involving uranium mining is an essential part of good business practices for the industry and is extremely useful for regulators. A report entitled *Communication Strategies in Uranium Mining* was published in 2008. Drafted by communications experts brought together by the Agency to consider best practices, the report provides guidance on stakeholder involvement, the development of a communications plan, and major communication issues that may arise during the life cycle of a mine, including remediation of sites.

Radionuclide Transfer in Terrestrial and Freshwater Environments

Models of radionuclide transfer are widely used to assess the radiological impact of intentional or accidental releases of radionuclides to the environment. The current Agency publication in this field, the *Handbook of Parameter Values for the Prediction of Radionuclide Transfer in Temperate Environments* (Technical Reports Series No. 364) was published in 1994; since that time, a considerable body of data on radionuclide transfer has been collected, in particular from studies carried out following the Chernobyl accident in 1986. These data and models were reviewed, leading to the preparation of two new publications in 2008. *The Quantification of Radionuclide Transfer in Terrestrial and Freshwater Environments for Radiological Assessments* contains the full collection of the reviewed data and the methods used to obtain the tabulated data values, while the updated *Handbook of Parameter Values for the Prediction of Radionuclide Transfer in Terrestrial and Freshwater Environments* provides summaries of parameter values in an easily accessible form for use by modellers and regulators.

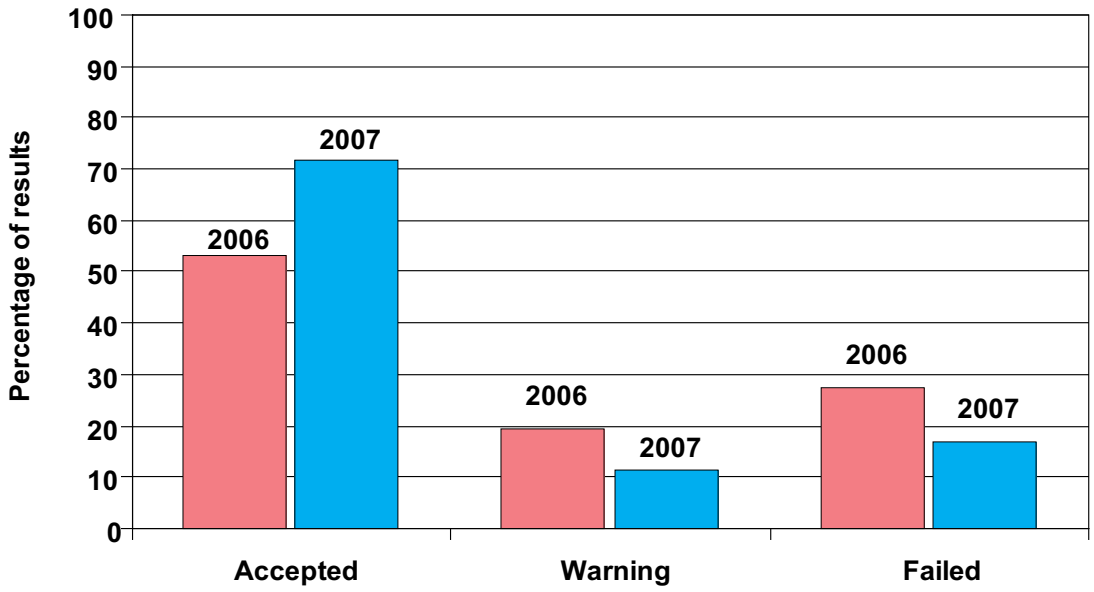


FIG. 2. Improvement in the accuracy of the analytical results for the determination of lead-210 in environmental samples analysed at laboratories participating in the 2006 and 2007 ALMERA proficiency tests.

Radioisotope Production and Radiation Technology

Objective

To contribute to improved health care and safe and clean industrial development in Member States through the use of radioisotopes and radiation technology, and to strengthen national capabilities for producing radioisotope products and utilizing radiation technology for socioeconomic development.

Radioisotopes and Radiopharmaceuticals

There is a continuing increase in the demand for positron emitters for diagnostic studies in developing countries, in particular fluorine-18–fluorodeoxyglucose (FDG) for positron emission tomography (PET)/computed tomography (CT) studies in cancer patients.

To help Member States build and/or strengthen national capabilities, the Agency released in 2008 the first in a series of publications on cyclotron produced radionuclides that covers principles and practices (Technical Reports Series No. 465). The series is intended as a reference for practitioners and regulators, as well as for use in teaching and training of personnel for sustainable, effective and safe operations. In related work, the Agency convened a workshop on the establishment of a cyclotron radiopharmaceutical production facility and implementation of good manufacturing practices in Thailand as part of a regional technical cooperation project.

Responding to a growing demand for support in setting up cyclotron and PET radiopharmaceutical production facilities, the Agency has assisted more than 15 countries through technical cooperation projects. For example, in 2008 one project facilitated the establishment of a 16.5 MeV cyclotron in Belo Horizonte, Brazil, where FDG is being produced for cancer diagnosis. Another cyclotron is being installed in Recife, in north-eastern Brazil.

The application of radioisotopes for therapy in nuclear medicine is also growing, with increased use of beta emitting isotopes such as yttrium-90 and lutetium-177. The development of an automated module for the electrochemical separation of yttrium-90 from strontium-90, demonstrated through a recently concluded CRP, has been taken up by a company specializing in equipment for isotope processing. This will assist many Member States in having access to regular supplies of yttrium-90. The Agency's work in this area was recognized by experts in the field, including Professor H.N. Wagner, Jr., who said:

> "New $^{90}Sr/^{90}Y$ generators for radiotherapeutic applications, developed with funding by the International Atomic Energy Agency (IAEA) in association with investigators… are simple to operate and can be scaled up and automated. This type of collaborative and beneficial work is an example of what the IAEA continues to do for the field of nuclear medicine, particularly in developing countries." (*Journal of Nuclear Medicine*, August 2008, pp. 15N–34N.)

"The application of radioisotopes for therapy in nuclear medicine is also growing, with increased use of beta emitting isotopes such as yttrium-90 and lutetium-177."

In order to provide relevant updates on technetium-99m products, widely used in diagnostic imaging, the Agency published *Technetium-99m Radiopharmaceuticals: Manufacture of Kits* (Technical Reports Series No. 466). The publication details the preparation and testing of these kits and is intended as a reference for practitioners as well as for new entrants in this field.

Radiation Processing Technology

Volatile organic compounds (VOCs) and polycyclic aromatic hydrocarbons (PAHs) are contaminants that are emitted in different — mostly combustion based — processes, for example, in the power, chemical and metallurgical industries, and as a result of municipal waste incineration. A CRP that ended in 2008 demonstrated that electron beam technology is a promising technique to decrease VOC and PAH concentrations in flue gases. The Agency, in cooperation with UNIDO, organized a training course for the European region to disseminate the technology for electron beam flue

FIG. 1. Injection of tritiated water (HTO) as a tracer for interwell study at an oilfield in Indonesia.

gas treatment (EBFGT). The training focused on conducting feasibility studies on EBFGT for coal fired boilers of the size most commonly used in this region.

To demonstrate the use of radiation aided synthesis, modification and characterization of advanced materials by nanoscale control of their properties, the Agency initiated a new CRP in 2008 focusing on potential biomedical applications of this technology. Specifically, this CRP will investigate the application of radiolytic methodologies for the synthesis of nanoparticles and nanoporous membranes. In related work, the Agency published three monographs on radiation processing techniques including *Trends in Radiation Sterilization of Health Care Products*, which details the status of recent developments and also provides comprehensive information on the practical aspects of radiation sterilization.

Industrial Applications of Radioisotopes

The interwell tracer technique is an important engineering tool for the efficient recovery of oil and is also used in geothermal reservoirs. Significant advances in research and field studies were made by 11 Member States through a CRP that ended in 2008, on the validation of tracers and software for interwell investigations. The CRP established methods for the synthesis, analysis and quality control of several radioactive tracers, field tested new radiotracer injection systems and automatic sample collection systems developed in the CRP, and validated processes to analyse low activity interwell radiotracer samples through laboratory intercomparison tests. In addition, the software packages *Anduril* and *Poro* were developed and tested by analysing interwell tracer data from different countries, and were validated through round robin analysis tests and interpretation of data. The results of the CRP enhance the reliability and quality of data in field applications (Fig. 1).

"The interwell tracer technique is an important engineering tool for the efficient recovery of oil and is also used in geothermal reservoirs."

An important component of the Agency's technical cooperation assistance to Member States is the provision of training tools. In this regard, two publications were issued in 2008: *Training Guidelines in Non-destructive Testing Techniques: 2008 Edition*; and *Radiotracer Residence Time Distribution Method for Industrial and Environmental Applications* (Training Course Series No. 31).

African Member States have given high priority to non-destructive testing (NDT), opting for a regional approach to maximize scarce resources

in this field. Currently, most countries rely on the training and certification of NDT personnel at the two AFRA Regional Designated Centres in South Africa (for countries where English is spoken) and in Tunisia (for francophone countries). To support these efforts, the Agency organized several regional training courses in 2008 to certify NDT personnel. In addition, a mutual recognition scheme of NDT certification was put in place as a basis for the promotion of NDT services and mobility of NDT personnel at the regional level. Several NDT practitioners were certified to Level III through this programme and, in turn, national capabilities to train and certify NDT personnel at Levels I and II were established in the region.

Application of Nuclear Techniques for Protecting Cultural Heritage

Scientific studies of art and archaeology can help protect humanity's cultural heritage. Nuclear techniques such as neutron activation analysis, X ray fluorescence and ion beam analysis can help to repair damaged objects, identify fraud and assist archaeologists in the appropriate categorization of historical artefacts. Through a CRP completed in 2008 on the applications of nuclear analytical techniques to investigate the authenticity of art objects, the Agency supported 16 Member States in applying these non-destructive nuclear techniques in their cultural heritage investigations.

For example, pottery shards analysed from an ancient site in Ghana showed that the pottery was produced locally, dispelling an earlier belief that the pottery had been brought by outsiders. In Peru, a combination of techniques applied to Inca pottery samples to distinguish between authentic and fraudulent pieces identified the place of production and shed light on the production process, such as firing temperature and the composition of the paste used. In Croatia, ion microprobe and other complementary techniques were used to select the best strategy for the restoration and conservation of paintings, and to help clarify suspicious attributions, authorships and possible earlier restoration attempts or interventions (Fig. 2).

"... the Agency supported 16 Member States in applying ... non-destructive nuclear techniques in their ... cultural heritage investigations."

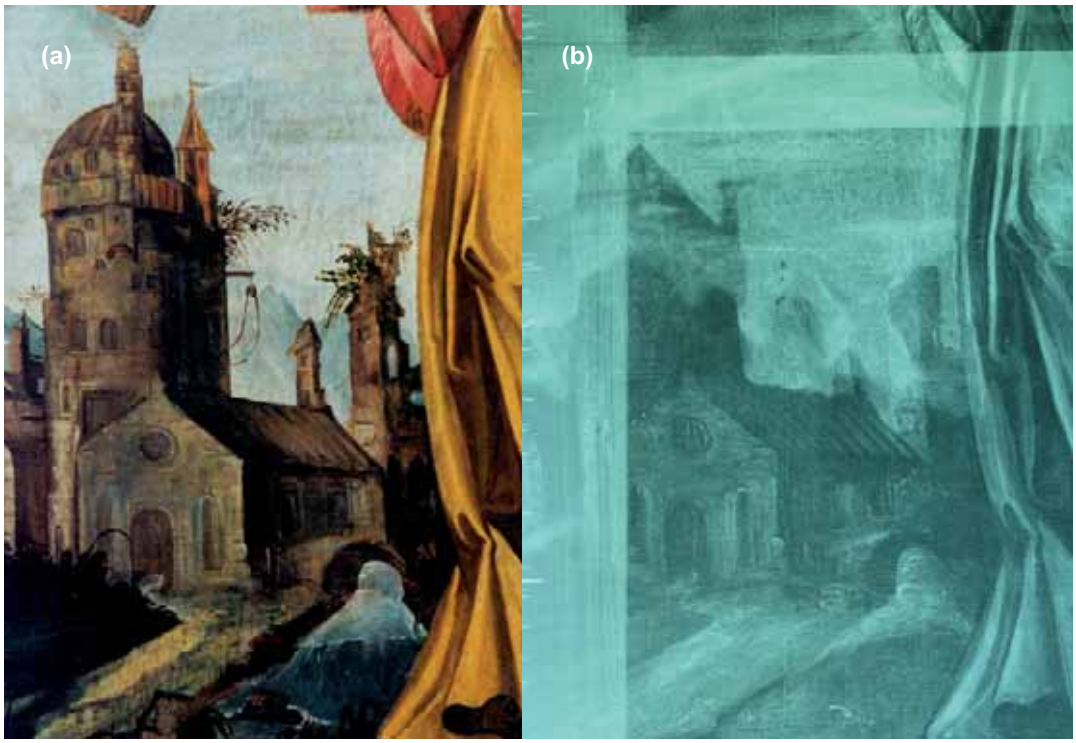
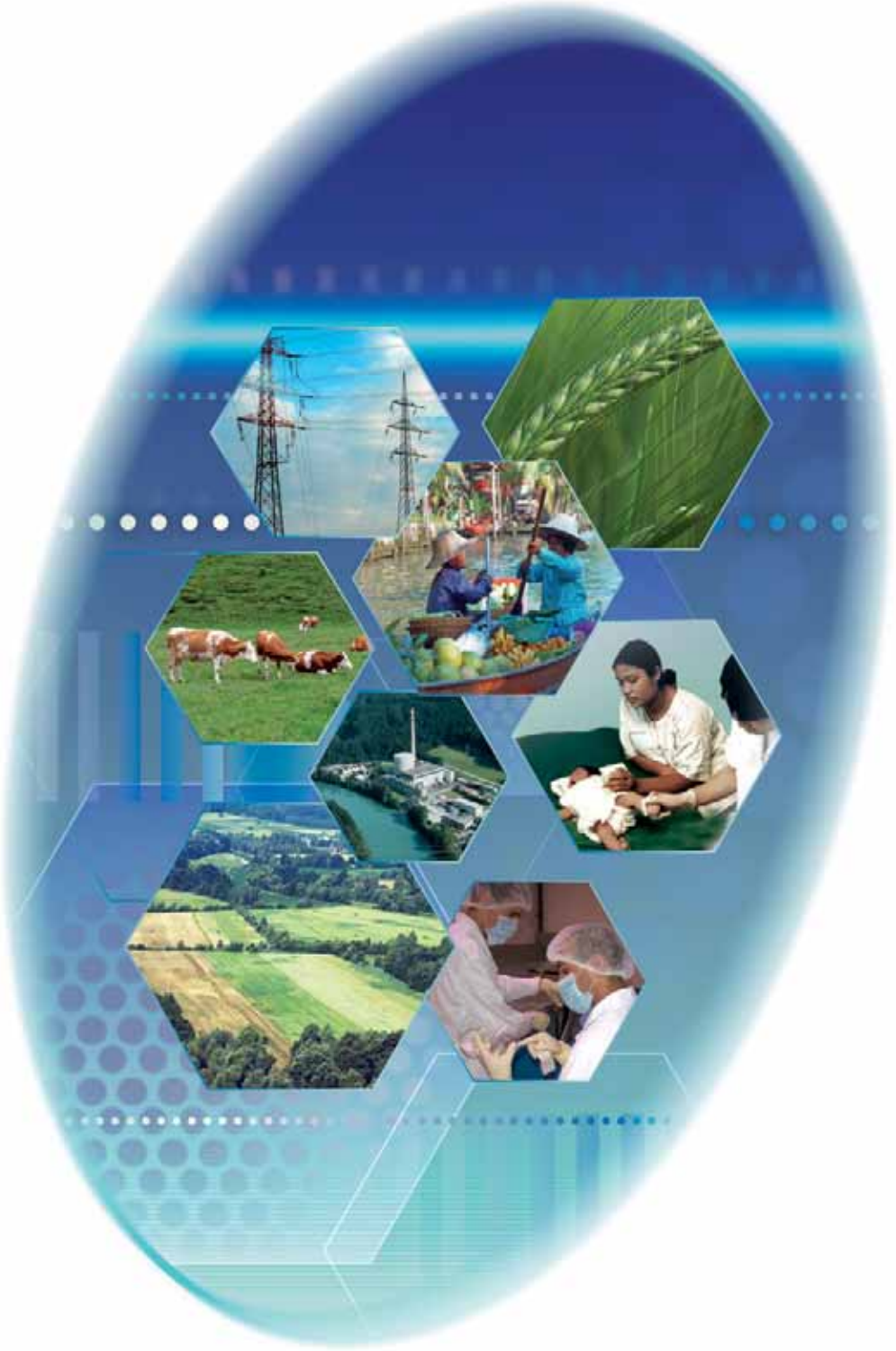


FIG. 2. (a) Detail of the painting of St Michael from Gračani; (b) the X ray image of the same detail. The difference between the church towers indicates that some type of restoration was done in the past (photographs courtesy of the Croatian Conservation Institute).

Safety and Security



Incident and Emergency Preparedness and Response

Objective

To establish effective and compatible national, regional and international capabilities and arrangements for preparedness, early warning, timely response to actual, potential or perceived nuclear or radiological incidents and emergencies independent of whether the incident or emergency arises from an accident, negligence or a deliberate act, and for sharing official, technical and public information among Member States and relevant international organizations.

Status of Emergency Preparedness and Response around the World in 2008

Despite improvements in emergency preparedness and response (EPR) capabilities in 2008, the Agency concluded that many Member States still require assistance in building basic EPR capabilities. Specifically, EPR legislation has to be harmonized with international requirements; national threat assessment analysis needs to be either carried out or updated, since it forms the basis for national EPR systems; and national radiation emergency plans have to be developed. As a result, Agency efforts focused on: improving access to information (Fig. 1); building EPR capacities, particularly in those Member States embarking on nuclear power programmes; testing existing capabilities; and expanding the scope of drills and exercises to include both safety and security related components.

"... the Agency concluded that many Member States still require assistance in building basic EPR capabilities."

FIG. 1. The Agency's Manual for First Responders to a Radiological Emergency *is now available for PDAs and mobile phones.*

In 2008, Denmark ratified the Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency (Assistance Convention). The ratification by Senegal[1] and the accession of Gabon to both the Convention on Early Notification of a Nuclear Accident (102 parties at the end of 2008) and the Assistance Convention (101 parties at the end of 2008) were also noteworthy.

ConvEx-3

In July 2008, the Inter-Agency Committee on Radiological and Nuclear Emergencies (IACRNE)[2] coordinated a 'Convention Exercise' (ConvEx-3) to test the international response to a simulated accident with potential transboundary consequences. The exercise, based on a simulated accident at the Laguna Verde nuclear power plant in Mexico, was conducted over two days in cooperation with 75 countries and 10 international organizations.[3] Its objectives were to: test the response of Member States and international organizations to a severe nuclear accident; test and evaluate the international emergency management system; and identify good practices as well as deficiencies and areas requiring improvement that cannot be identified in national exercises. The exercise scenario included an evolving nuclear safety

[1] The Early Notification and Assistance Conventions entered into force for Senegal on 23 January 2009.

[2] The Inter-Agency Committee on Response to Nuclear Accidents (IACRNA) was established following a meeting of FAO, IAEA, ILO, UNEP, UNSCEAR, WHO and WMO at the Agency's General Conference in September 1986. At the 20th IACRNA Regular Meeting, in November 2008, the Committee adopted a new name — the Inter-Agency Committee on Radiological and Nuclear Emergencies — effective 1 January 2009. The Agency is the secretariat for IACRNE.

[3] Specifically, the European Commission, Europol, FAO, IAEA, ICAO, ICPO-INTERPOL, OECD/NEA, PAHO, WHO and WMO.

situation, radioactive release to the atmosphere, medical and public health issues, and issues concerning commerce, industry and tourism.

The Agency's Incident and Emergency Centre served as the global focal point for international communication and response during the exercise. Key systems that would be required in an actual emergency were tested. The exercise evaluation team made a number of recommendations for improvement, which IACRNE and the Agency are actively pursuing, including increasing the frequency of such full scale exercises and expanding the scope of their scenarios to include security related components.

Assistance to Member States

RANET is a global network of national assistance capabilities that can be called upon under the Assistance Convention. These capabilities include field assistance teams deployed to a requesting State, and external based support, which provides expertise and assessment without deployment to the event site. As of December 2008, 14 Member States had registered capabilities under RANET (Table 1).

"RANET is a global network of national assistance capabilities that can be called upon under the Assistance Convention."

The Agency has already begun to make use of RANET in coordinating timely assistance to requesting States. For example, in 2008 the Agency, in cooperation with other Member States, carried out two field missions in response to requests under the Assistance Convention. One of these, an assistance mission to Benin following a request for safe recovery of a radiation source in a scrap metal shipment, made use of France's capabilities in the areas of source search and recovery and the USA's capabilities in the analysis and interpretation of gamma ray spectra. Experts from the Agency and France were able to locate the source, identify its radioactive content and place it in safe temporary storage. Later, based on the information, photographs and gamma ray spectra provided by the mission, the type, model and origin of the source were determined by experts in the USA. The Agency is coordinating the repatriation of this source to the country of origin.

Emergency Preparedness Review missions assess and evaluate national emergency preparedness and

Table 1. Capabilities of Member States registered with RANET as of December 2008 (EBS: external based support; FAT: field assistance team)

	Aerial survey	Radiation monitoring	Environmental measurements	Source search/recovery	Assessment and advice	Medical support	Public health protection	Biodosimetry	Internal dose assessment	Bioassay	Histopathology	Dose reconstruction
Argentina								FAT/EBS				
Australia		FAT		FAT	FAT							FAT
Finland								EBS				
France			FAT/EBS	FAT	FAT/EBS			EBS	FAT/EBS			EBS
Hungary		FAT	FAT/EBS	FAT	FAT/EBS	FAT	FAT	EBS	EBS	EBS		
Mexico		FAT	FAT	FAT					FAT			
Nigeria	FAT	FAT	FAT	FAT	FAT							FAT
Pakistan		FAT/EBS	FAT/EBS	FAT/EBS	FAT/EBS							
Romania	FAT	FAT/EBS	FAT/EBS		EBS				EBS			EBS
Slovenia		FAT/EBS	FAT/EBS	FAT/EBS	FAT	FAT		FAT	FAT			FAT
Sri Lanka		FAT	FAT	FAT								
Sweden	FAT	FAT	FAT/EBS	FAT	FAT/EBS				EBS			
Turkey		FAT/EBS	FAT/EBS	FAT/EBS				EBS				
USA					EBS							

response programmes. In 2008, the Agency conducted missions to Kyrgyzstan, Montenegro, Tunisia and Uzbekistan to provide an independent assessment of their EPR programmes and capabilities, and their conformance with international standards. The Agency's Integrated Regulatory Review Service missions to Mexico, Spain and Ukraine also included a peer review of the EPR aspects of national regulatory systems.

The missions revealed that awareness of the need for a sound legal basis, properly functioning regulatory system and appropriate infrastructure to cope with the consequences of nuclear or radiological incidents and emergencies is growing in all of these countries. The Agency will continue to work to minimize discrepancies in national and local EPR arrangements and urge Member States to comply with the international standards in place. The mission reports summarized the findings and gave recommendations for mid-term and longer term corrective actions.

Event Reporting

In 2008, 63 Member States endorsed a revised *INES: The International Nuclear and Radiological Event Scale User's Manual* that consolidates previous clarifications and guidance, and harmonizes terminology and criteria across all areas of application. The manual was presented at the Agency's 52nd General Conference in September, where Member States were requested to designate INES national officers and make greater use of the scale (Fig. 2).

"During 2008, the Agency was informed or became aware of 183 events involving, or suspected to involve, ionizing radiation."

During 2008, the Agency was informed or became aware of 183 events involving, or suspected to involve, ionizing radiation. In 43 cases the Agency took action, such as authenticating and verifying information with external counterparts, requesting/receiving information and providing official information or offering the Agency's good offices for potential follow-up and assistance if this was requested by Member States.

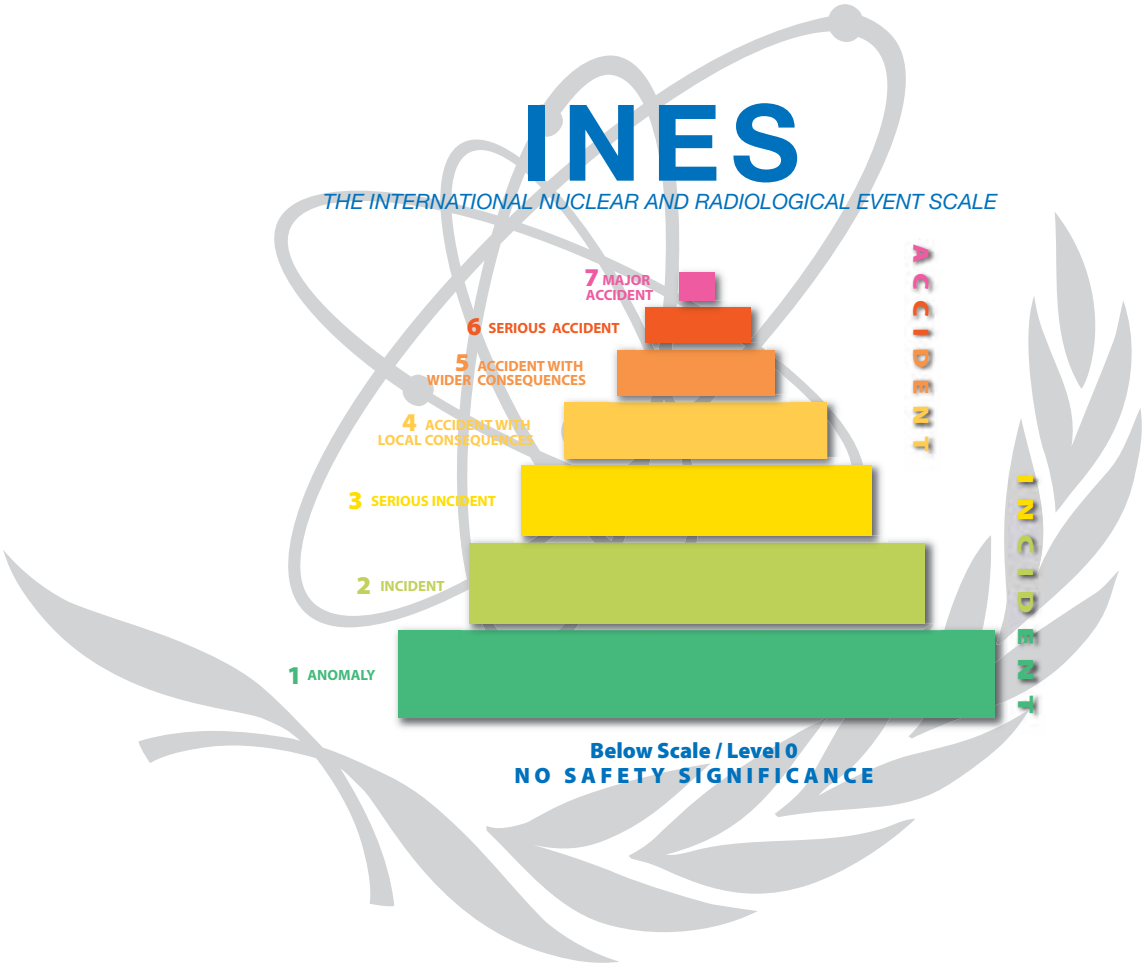


FIG. 2. The International Nuclear and Radiological Event Scale.

Safety of Nuclear Installations

Objective

To enable Member States to ensure appropriate levels of safety during the design, construction and operations throughout their total life cycle of all types of nuclear installations through the availability of a set of safety standards and assistance in their applications; to enable Member States seeking to embark on nuclear power production programmes to develop appropriate safety infrastructures through the availability of Agency guidance and assistance.

State of Nuclear Installation Safety around the World in 2008

Major themes observed in 2008 in nuclear installation safety worldwide include continuous improvements in strengthening safety through international cooperation, activities related to new entrant nuclear power programmes and the expansion of existing nuclear power programmes. There was a continuing focus on operating experience feedback, knowledge networking, self-assessment and peer review.

The international instruments associated with nuclear installation safety include the Convention on Nuclear Safety, which had 62 Contracting Parties at the end of 2008, and the voluntary Code of Conduct on the Safety of Research Reactors.

Enhancing Nuclear Safety Infrastructure for Member States Embarking on Nuclear Programmes

The establishment of a sustainable national safety infrastructure is an essential foundation for ensuring safe siting, design, construction, operation and decommissioning of nuclear power plants. This process involves the development of a strong governmental, legal and regulatory framework, as well as the necessary education and training, technical capacity and an integrated approach to safety. In 2008, the Agency assisted Member States in developing a safe and effective infrastructure by reviewing proposed nuclear legislation and laws, and reviewing safety infrastructure and regulatory body development needs. In this regard, the International Nuclear Safety Group (INSAG) — a high level expert group that provides authoritative advice on nuclear safety issues to the international nuclear community and public through the offices of the Agency — issued two publications that address the importance of the various infrastructure issues which have a bearing on the obligation to ensure nuclear safety: *Nuclear Safety Infrastructure for a National Nuclear Power Programme Supported by the IAEA Fundamental Safety Principles* (INSAG-22) and *Improving the International System for Operating Experience Feedback* (INSAG-23).

In July 2008, the Agency organized a workshop with more than 100 participants from 45 countries to discuss the roles and responsibilities of 'vendor countries' and nuclear power newcomers. It was clearly felt that there were moral responsibilities when transferring nuclear power technology. As a consequence, vendor companies should work more closely with their governments to set up agreements that contribute to long term safety and security in countries seeking to buy their nuclear technology. The concept of 'vendor countries', rather than vendor companies, arose directly from these discussions, since the private sector's focus on profits cannot replace national ownership and commitment to long term safety and security. Regarding a possible nuclear power plant export control regime focusing on long term safety, the participants emphasized the importance of international treaties and conventions as well as compliance with the Agency's safety standards, systematic Agency safety review services applicable at different stages of a State's nuclear power development, and Agency forums such as the review meetings for the Convention on Nuclear Safety.

"The establishment of a sustainable national safety infrastructure is an essential foundation for ensuring safe siting, design, construction, operation and decommissioning of nuclear power plants."

Topical Issues in Nuclear Installation Safety

At an Agency conference on Topical Issues in Nuclear Installation Safety, held in Mumbai in November 2008, the participants agreed on a number of conclusions and recommendations:

- The prevention of accidents requires constant vigilance, a high level of technical competence, strong leadership with a commitment to continuous improvement, and a vision of sustained excellence.
- The participation of all Member States in international nuclear safety instruments, codes of conduct and conventions, including those on liability for nuclear damage, is considered essential for global safety.
- Countries embarking on nuclear power programmes assume crucial safety responsibilities that cannot be delegated. Therefore, the establishment of a sustainable national safety infrastructure is an essential foundation for ensuring safe design, construction, operation and decommissioning of nuclear power plants.
- Operating experience feedback (OEF) is an important element of the continuous safety improvement process for nuclear power plants.
- The synergies between safety and security need to be maximized by integrating the respective requirements.
- The quality of the supply chain is an important issue. Harmonization of safety requirements, design codes and quality standards within the supply chain was recognized as requiring further collaboration among Member States, international organizations and supplier companies.
- Despite high levels of safety at nuclear power plants, emergency preparedness and response is an important issue in the context of developing nuclear energy.
- There is a generation gap in nuclear related education and training that needs to be addressed. In addition, technical capacity needs to be improved.

Operational Safety of Nuclear Power Plants

The work of the Agency's Operational Safety Review Team (OSART) service is well established. Missions in 2008 to Cruas, France; Balakovo, the Russian Federation; Forsmark, Sweden; Rovno, Ukraine; and Arkansas Nuclear One, USA, indicated that OSART is also useful for countries with a mature nuclear power programme (Fig. 1).

Seven OSART preparatory meetings and five follow-up missions were also conducted in 2008. The follow-up mission results showed that about 95% of the recommendations and suggestions raised during OSART reviews have been either resolved or their implementation is making satisfactory progress.

"Countries embarking on nuclear power programmes assume crucial safety responsibilities that cannot be delegated."

After studying the results of the OSART reviews, the Agency in 2008 considered enlarging the scope of the review areas to better match the needs of each Member State. Among the improvements being studied are optional review areas that could be selected by States covering: commissioning; long term operation; transition from operations

FIG. 1. OSART members inspecting equipment at the Forsmark nuclear power plant in Sweden.

to decommissioning; applications of probabilistic safety assessments in decision making; and accident management. The Agency also offers a 'corporate' OSART service to review those centralized functions of the corporate organization of a nuclear utility which affect the operational safety of the nuclear power plants of the utility.

Another Agency service, Peer Review of Operational Safety Performance Experience (PROSPER), provides critical information to nuclear power plant operators in terms of their capability to identify and assess operating experience and implement appropriate corrective actions. In 2008, the Agency conducted a PROSPER mission to a Magnox South plant in the United Kingdom, and a PROSPER follow-up mission to Santa Maria de Garona in Spain.

The Incident Reporting System (IRS) is an international system jointly operated by the Agency and the OECD/NEA. It is used by 31 countries to exchange experience on improving the safety of nuclear power plants by submitting event reports on unusual events considered important for safety. By the end of 2008, the IRS database reached the threshold of 3500 reports; 90 new reports were submitted to the IRS in 2008. The IRS content is improving: the quality of entries has improved, the reports have a better level of detail, and event causes are better substantiated and explained.

"The Incident Reporting System ... is used by 31 countries to exchange experience on improving the safety of nuclear power plants by submitting ... reports on unusual events considered important for safety."

Convention on Nuclear Safety

In April 2008, Contracting Parties to the Convention on Nuclear Safety (CNS) met in Vienna for the 4th Review Meeting. Their national reports took into account a Secretariat report presenting generic information on the significant issues, developments and trends in enhancing nuclear safety.

The Contracting Parties reported the increased application of Agency Safety Standards in their national regulations. They also recognized the value of the Agency's safety services (e.g. OSART and IRRS) and encouraged all Contracting Parties to request such services if they had not already done so.

In addition, the Contracting Parties highlighted nine common issues that should be addressed in the next national reports:

- Legislative and regulatory framework;
- Independence of the regulatory body;
- Safety management and safety culture;
- Staffing and competence;
- Probabilistic safety assessment;
- Periodic safety review;
- Ageing management and life extension;
- Emergency management;
- New nuclear power plants.

The Contracting Parties also recognized the need for a continuous process, with enhanced communication between review meetings. To address that, a new schedule of the review process and the continuity of officers for a three year term was approved.

With regard to more transparency of the review process, the Contracting Parties decided to invite journalists to attend the opening plenary session of the review meeting. In addition, a press event is to be organized at the end of each review meeting.

Finally, the Contracting Parties agreed on outreach measures to promote the CNS by convincing other countries of the benefits of the peer review process. To encourage participation, a recommendation was made that Contracting Parties and the Agency engage with those Parties not taking part. Signatory States that have not yet ratified the CNS should be encouraged to do so, and countries not yet members of the CNS who want to launch a nuclear programme should also be encouraged to ratify it.

Application of the Code of Conduct on the Safety of Research Reactors

A meeting on the application of the Code of Conduct on the Safety of Research Reactors was held by the Agency in October 2008. In addition to exchanging information on the safety status of research reactors and on good practices with respect to the application of the Code, the participants reviewed self-assessments on the application of the Code to identify common safety trends and issues. The participants agreed on a number of recommendations to further enhance the application of the Code, including the organization of periodic regional and international meetings. These recommendations covered:

- Networking between regulatory bodies and operating organizations for improved regulation and safety management;
- Ways to improve ageing management;
- Infrastructure needs for new research reactors;
- Practical application of a graded approach to safety requirements;
- Implementation of activities addressing common safety issues identified from self-assessments.

Based on feedback from earlier meetings on the application of the Code, the Agency held four regional meetings in 2008 on research reactor safety: in South East Asia, the Pacific and the Far East; in Eastern Europe; in Africa; and in Latin America. The participants, drawn from regulatory bodies and research reactor operating organizations, including senior members of safety committees, exchanged information on safety issues and trends; developed action plans for the update, review and assessment of safety documents; and addressed the implementation of periodic safety reviews at research reactors.

"In recent years, renewed attention has been paid worldwide to seismic safety owing to the occurrence of extremely severe earthquakes that have affected some nuclear power plants beyond their original design levels."

The International Seismic Safety Centre and Related Activities

The seismic safety of nuclear installations is a subject that has received substantial attention at the Agency as part of its statutory functions for establishing safety standards. The Agency has been providing services relating to their application to Member States. In recent years, renewed attention has been paid worldwide to seismic safety owing to the occurrence of extremely severe earthquakes that have affected some nuclear power plants beyond their original design levels.

To enhance information and experience sharing among Member States, the Agency in 2008 established the International Seismic Safety Centre (ISSC). The objectives and tasks of this centre include:

- Establishing a focal point for sharing lessons learned from scientific developments and the occurrence of seismic events;
- Providing feedback to improve the Agency's seismic safety standards;
- Supporting Member States through advisory and review services and training courses;
- Enhancing seismic safety by providing advice from top level scientists and experts.

The Agency's seismic safety review services, which are based on the safety standards, started in the 1980s. Since then, more than 110 missions involving interdisciplinary teams of experts have been undertaken in many Member States during the site selection and evaluation phases, and for new and existing nuclear installations. In 2008, the Agency dispatched missions to Armenia and Jordan, and fact finding missions to the Kashiwazaki-Kariwa nuclear power plant in Japan to follow up on the earthquake that occurred in July 2007 (Fig. 2).

A Scientific Committee was established in 2008 to advise the ISSC in its activities. In addition, the ISSC is responsible for developing and maintaining an international roster of experts and a network of associated institutions. Since its formation in October 2008, the following activities have been carried out by the ISSC:

- Reassessment of the seismic hazard;
- Re-evaluation of the seismic safety of existing nuclear power plants;
- Post-earthquake actions and response to emergencies in coordination with the Agency's Incident and Emergency Centre;
- Development of a database on earthquake experience;
- Feedback of experience from extreme events.

FIG. 2. Removal, cleaning and replacement of oil contaminated soil below the pile foundation of a non-safety related structure at the Kashiwazaki-Kariwa nuclear power plant.

Radiation and Transport Safety

Objective

To establish global radiation and transport safety policies, criteria and standards, and to achieve a global harmonization of their application for the safety and security of radiation sources and thereby to raise the levels of protection of people, including Agency staff, against radiation exposure.

Status of Radiation and Transport Safety around the World in 2008

Occupational radiation protection in nuclear installations was generally well managed in 2008. The most significant occupational radiation exposures continued to involve workers handling radioisotopes. Many Member States continued to incorporate the provisions of the *Code of Conduct on the Safety and Security of Radioactive Sources* and its supplementary *Guidance on the Import and Export of Radioactive Sources* (Import/Export Guidance) into their national legislation.

"Occupational radiation protection in nuclear installations was generally well managed in 2008."

Denials and delays of shipment of radioactive material continued to occur in all parts of the world. Although acceptable solutions are difficult to identify, it is clear that effective outreach to and communication with transport industry personnel, whose main activity is not handling radioactive material, is essential to mitigate denials and delays.

Revision of the International Basic Safety Standards

Revision of the *International Basic Safety Standards for Protection against Ionizing Radiation and for the Safety of Radiation Sources* (the BSS) continued, with coordination by the BSS secretariat.[1] Three drafting meetings were held in 2008, and a first draft of the revised BSS was completed in June. This draft was subsequently reviewed by the Agency's four Safety Standards Committees.[2] After refining the draft on the basis of these reviews, the BSS secretariat will send it to Member States for comment in 2009, and publish the revised BSS in 2010.

Education and Training in Radiation, Transport and Waste Safety

As part of the wide range of activities on capacity building for sustainable education and training programmes in Member States, an Education and Training Appraisal mission visited Ghana, a potential regional training centre for English-speaking countries in Africa. Another mission went to Greece, which hosts the Agency's post-graduate educational course in radiation safety and the safety of sources, as well as other specialized courses for Member States in Europe. In 2008, the Agency entered into a long term agreement with Argentina in the area of education and training. Post-graduate educational courses in radiation safety and the safety of radiation sources were held in Argentina, Belarus, Malaysia, Morocco and the Syrian Arab Republic. Also in 2008, the Agency developed training material for radiation protection officers.

Improving the Radiation Safety Infrastructure in Member States

Development of a new information management system (IMSIMS) was completed in 2008. This system will be made available to Member States in 2009 to update the Radiation and Waste Safety Infrastructure Profiles for 107 countries receiving Agency assistance. IMSIMS will provide updated information about the national and regional status of radiation safety infrastructures. This information will help identify needs and priorities in Member States, which will be used when planning future Agency programmes.

The 12th International Congress of the International Radiation Protection Association, which was co-sponsored by the Agency, was held in Buenos Aires from 20 to 25 October 2008. The

[1] Consisting of representatives of eight co-sponsoring and potential co-sponsoring international organizations: the European Commission, FAO, IAEA, ILO, OECD/NEA, PAHO, UNEP and WHO.

[2] Covering nuclear, radiation, transport and waste safety.

FIG. 1. The Agency's RPoP web site recorded more than two million hits in 2008.

objectives were to strengthen radiation protection worldwide by ensuring a broad gathering of professionals directed at the promotion and enhancement of radiation protection. The congress offered an opportunity for feedback from all areas where ionizing radiation is applied; this feedback has been particularly valuable in the revision process of the International Basic Safety Standards.

Safe Transport of Radioactive Material

In 2008, the Board of Governors approved the 2009 edition of *Regulations for the Safe Transport of Radioactive Material* (the Transport Regulations). In addition, the Agency published an updated version of the main guidance on the Transport Regulations, providing a stronger basis for the safe transport of radioactive material worldwide.

As part of the implementation of the Action Plan of the International Steering Committee on Denials of Shipment of Radioactive Material, the Agency convened regional workshops, in China, Italy, Madagascar and the United Republic of Tanzania, to discuss the reasons for denials of shipment, the role of the Agency and the Transport Regulations in reducing denials, and the effect of denials on industry. Participants also made presentations on the instances and effects of denials of shipment in their individual countries. The main outcomes of the workshops included regional plans of action to address instances of denials and regional networks to ensure that communication is facilitated and is ongoing. A database for recording instances of denial was established in collaboration with ICAO and IMO to facilitate understanding of the causes of denials of shipment. By the end of 2008, the database held more than 100 denial reports. During the 52nd regular session of the General Conference, a meeting was convened to provide information to Member States on denials of shipment.

In September 2008, a group of coastal and shipping States held, with Agency participation, a fourth round of informal discussions in Vienna with

a view to maintaining dialogue and consultation aimed at improving mutual understanding, confidence building and communication in relation to safe maritime transport of radioactive material.

Radiation Protection of Patients

The medical use of ionizing radiation is growing around the world. At the same time, new and advanced medical radiation technologies are being introduced at a rapid pace. The increasingly innovative uses of radiation in the medical area, while of great benefit, are creating new radiation protection challenges. Whereas other exposures to ionizing radiation have remained at a constant level or have decreased over the past decade, medical exposures have increased markedly. Medical uses constitute the largest human-made source of ionizing radiation to the world's population; in some countries they are now a larger source of exposure than natural background radiation.

"The increasingly innovative uses of radiation in the medical area, while of great benefit, are creating new radiation protection challenges."

In response to this challenge, the Agency continues to provide comprehensive guidance on the radiation protection of patients. The Radiation Protection of Patients (RPoP) web site (*http://rpop.iaea.org/ RPoP/RPoP/Content/index.htm*) (Fig. 1) is one source of information on the medical uses of radiation. In addition, three Safety Reports Series publications were produced in 2008 focusing on new technologies (Fig. 2). Training materials for health professionals using new imaging and radiotherapy technology were also issued on CD-ROM.

Radiation Protection of Workers

In addition to ensuring individual and workplace monitoring of its staff, including experts and trainees, the Agency supported several projects on the radiation protection of workers. As an example, measures were taken in 2008 to assist Chile in implementing the recommendations from the occupational radiation protection appraisal that the Agency conducted in 2007. Information on occupational radiation protection issues was also presented at regional training courses and workshops organized by the Agency's technical cooperation programme. The Agency provided guidance to Member States on the procurement of equipment, for example to Belarus for monitoring radiation exposure to radon. It also gave advice on procurement and delivery of a thyroid measurement system to Uruguay.

The third meeting of the Steering Committee of the international Action Plan for Occupational Radiation Protection was held in 2008. Four actions of the 14 were closed as fully completed, four were considered complete but requiring follow-up and six were still in progress. Recommendations by

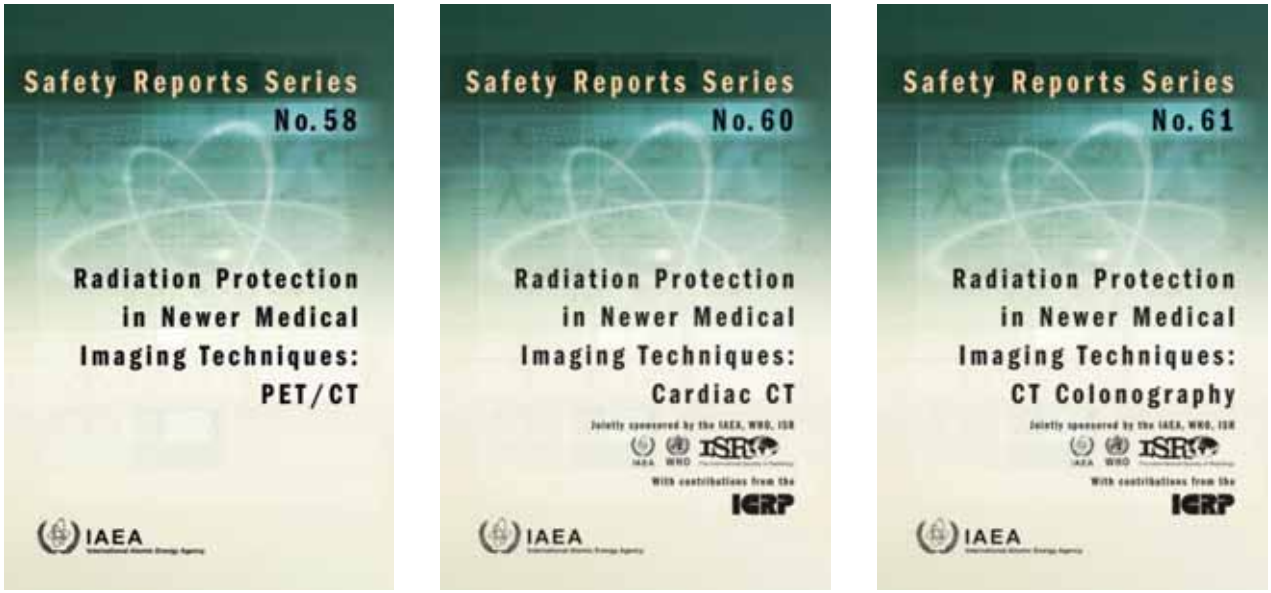


FIG. 2. Three new publications issued in 2008 on radiation protection in the use of newer imaging technologies.

the Steering Committee are related to the impact of new technologies on occupational exposure in the medical sector, radiation protection criteria for workers in existing exposure situations, the increasing lack of skilled workers and the impact of new scientific developments on the radiation protection of workers. In addition, a new project on the Information System on Occupational Exposure in the Medical, Industrial and Research Areas was initiated to improve the availability and adequacy of radiation protection data in these areas, and thus help to identify trends and future needs.

Code of Conduct on the Safety and Security of Radioactive Sources

In May 2008, 167 technical and legal experts from 88 Member States and two non-Member States, and observers from the European Commission, the Organization for Security and Co-operation in Europe and the International Source Suppliers and Producers Association met in Vienna to exchange lessons learned from the implementation by States of the Import/Export Guidance. Significant issues came to light, such as difficulties in the provision of information to exporting States on the regulatory and technical capacity of importing States. Participants requested international assistance in developing regional networks and the use of existing networks to discuss implementation of the Import/Export Guidance. They also called for a general review of the guidance at the next information exchange meeting, planned for 2010.

Radiation Monitoring and Protection Services at the Vienna International Centre

With no interruption of its daily services, the individual radiation monitoring and protection services laboratories (comprising the whole body counter, urine analysis and external dosimetry) moved from the Agency's Laboratories, Seibersdorf to the Vienna International Centre (VIC) in 2008, resulting in savings of time and financial resources for the Agency (Fig. 3). Accredited at the international level since 2006, the services laboratories are recognized by the Agency's radiation safety regulator as a technical service provider for individual and workplace monitoring. Since they comply fully with the Agency's safety standards, Member States can use these services as a model to implement the standards dealing with occupational exposure control.

FIG. 3. The whole body counter in its new location at the VIC.

Management of Radioactive Waste

Objective

To achieve global harmonization in policies, criteria and standards governing waste safety and public and environmental protection, together with provisions for their application including state of the art technologies and methods for demonstrating their adequacy.

Status of Radioactive Waste Management around the World in 2008

The Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management (Joint Convention) is the main international instrument associated with the management of radioactive waste. With the addition of Senegal[1] and Tajikistan, the Joint Convention had 46 Contracting Parties at the end of 2008. The organizational meeting for the 3rd Review Meeting for the Joint Convention (scheduled for May 2009) took place in 2008.

"Confidence in the safety of spent fuel and radioactive waste management is an important factor in the public acceptance of nuclear energy."

Confidence in the safety of spent fuel and radioactive waste management is an important factor in the public acceptance of nuclear energy. However, difficulties in siting and putting into operation waste disposal facilities in many Member States led to a situation in which arrangements for extended storage had to be made.

As existing nuclear installations and other facilities using radioactive material continue to age, the time for their eventual decommissioning is approaching. Even though, from a technological perspective, there are a number of options available for safe decommissioning, in many cases decommissioning planning is far from complete. For a large number of facilities worldwide, decommissioning activities continue to be underfunded.

[1] The Joint Convention entered into force for Senegal on 24 March 2009.

Revised Classification of Radioactive Waste

The Agency updated a safety standard on the classification of radioactive waste. This standard covers all radioactive waste types and recognizes the clearance concept for identifying the boundary between waste that needs to be managed as radioactive waste and that which can be removed from regulatory control for management as conventional waste (Fig. 1).

Development of National Policy and Strategies for Radioactive Waste Management

The Joint Convention implies that States must have a policy related to the management of spent nuclear fuel and radioactive waste and strategies to implement the policy. These issues are also discussed in several Agency safety standards. In 2008, the Agency organized a series of regional workshops to explain to decision makers and technical experts the importance of having a national policy and related strategies in place for the safe management of radioactive waste and spent fuel. It also organized appraisals of policies and strategies in Bolivia, Costa Rica, Cuba, Namibia, Spain, Ukraine and Venezuela.

Safety Demonstration of Geological Disposal

The Agency launched the International Project on Demonstrating the Safety of Geological Disposal (GEOSAF) in 2008 to provide a forum for the exchange of experience and opinions in demonstrations of the safety of geological disposal. It also aims to provide a platform for knowledge transfer in view of the increasing number of countries contemplating nuclear power. The inaugural meeting took place in Paris in June 2008 and was hosted by the French Institute for Radiation Protection and Nuclear Safety. The project structure comprises two working groups, the first dealing primarily with safety demonstration methodology, and the second focusing on the regulatory process.

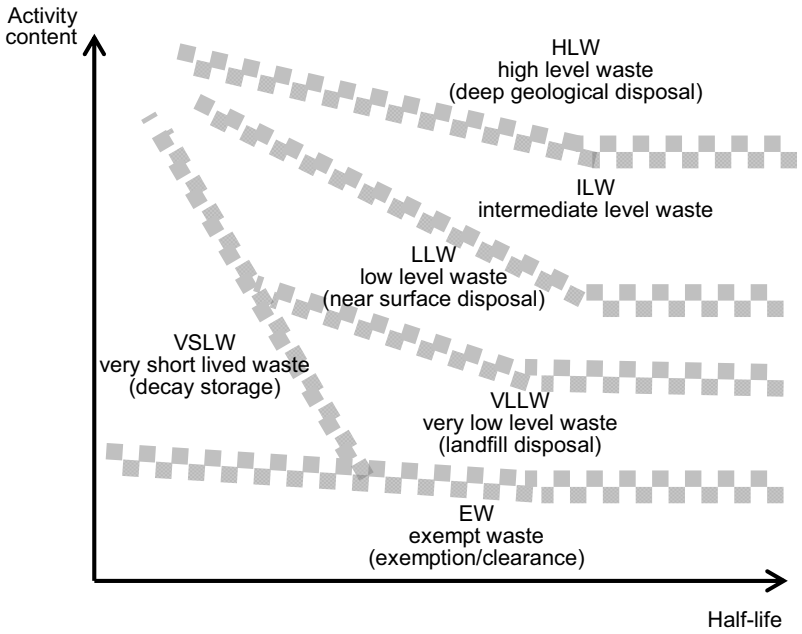


FIG. 1. Classification showing types of radioactive waste.

Several tasks for the two working groups have been identified, including a review of a report on a European pilot study on regulatory expectations for demonstrating the safety of geological disposal and carrying out a critical review of test cases.

The Radioecological Situation at Thule

At the request of the National Institute of Radiation Protection of Denmark, the Agency performed an international peer review of 'Project Thule 2007 — Investigations of Radioactive Contamination on Land'. This project refers to the crash in 1968 of a US Air Force bomber carrying four nuclear weapons onto the frozen ocean approximately 10 km west of Thule Air Force Base in Greenland (Fig. 2). In the ensuing decades, several scientific campaigns monitored the long term fate of the plutonium dispersed during the accident, with an emphasis on the marine environment. However, since only a few monitoring activities had been performed in the terrestrial environment, Project Thule 2007 was intended to fill this gap. The Agency review team analysed the proposal and supporting documentation, and prepared a technical report with advice and recommendations on optimizing the proposed

FIG. 2. The former Thule Air Force Base in Greenland.

monitoring programme. The team concluded that the proposal had achievable goals and that the project was supported by qualified experts, proper equipment and resources.

Agency Review Services in 2008

At the request of the Nuclear Agency of Romania, the Agency reviewed the radiological situation of workers, the population and the environment surrounding the Cernavoda nuclear power plant. The general conclusion was that the plant has a radiation protection programme in place for workers, the public and the environment which is consistent with the recommendations of international safety standards. With regard to the protection of the public and the environment, the Agency concluded that the assessed dose results were below the dose limits, and the models and parameters adopted provided a high degree of conservatism. Based on the information available, the population and environment surrounding the Cernavoda nuclear power plant were not exposed to significant risk due to radioactive discharges, particularly of tritium, and that the levels of received doses were acceptable and consistent with the system for radiological protection defined by the ICRP and the Agency's safety standards. With regard to the protection of workers, the review found that the relevant regulations and documentation of the nuclear power plant complied with ICRP recommendations as well as the safety standards of the Agency and the European Union, ensuring that doses were below the international accepted limits. Efforts were also being made to reduce occupational exposure.

The Agency conducted a peer review of the 'Technical Programme for the Development of the Slovenian National Repository for Low and Intermediate Level Radioactive Waste' at the request of Slovenia's national radioactive waste management agency. The review focused on three main areas: the repository design bases and the suitability of the basic engineering design for low and intermediate level waste disposal at the proposed site; the site selection process, site assessment criteria and site characterization; and the waste management agency's future activities that are intended to lead to a detailed engineering design and licence application.

Decommissioning Peer Review

In 2008, the Agency conducted an International Peer Review of the Magnox Decommissioning Programme in the United Kingdom, focusing on the Bradwell nuclear power plant. The achievements and issues from the peer review were examined at an international meeting in November 2008. Magnox South valued the benchmarking process and encouraged other decommissioning operators to take advantage of it. The Agency will improve the review service using the lessons learned during this pilot case.

Assistance to Iraq

The Agency project to assist the Government of Iraq in the evaluation and decommissioning of the former facilities that used radioactive material has continued in 2008, with support from France, Germany, Italy, Ukraine, the United Kingdom and the USA. Decommissioning started at the first facility identified by the prioritization system agreed to in 2007, the lightly contaminated LAMA building at Al-Tuwaitha, with the clearance of unexploded ordnance and scrap material from around the facility itself. These efforts were facilitated by the practical training given to the team at a contaminated site in the Chernobyl exclusion zone in Ukraine.

"The IDN ... acted as a focal point for integrating complementary efforts in decommissioning — both within the Agency and with external groups."

The International Decommissioning Network

Following its launch in 2007, the International Decommissioning Network (IDN) expanded its activities in 2008. For example, two hands-on workshops were held — one in Belgium on size reduction of components and one in Spain on materials management and clearance. Participants were able to examine working equipment in detail and interact with technical staff. The IDN also acted as a focal point for integrating complementary efforts in decommissioning — both within the Agency and with external groups.

The Contact Expert Group

International cooperation in solving nuclear legacy issues in the Russian Federation made

FIG. 3. Removal of submarine spent nuclear fuel from the former naval base at Gremikha for reprocessing at the Mayak plant in the Russian Federation.

substantial progress in 2008 through the Contact Expert Group (CEG). The CEG, with 13 participating Member States, supports and coordinates these activities, particularly those dealing with radioactive waste and spent nuclear fuel management, dismantling of nuclear submarines and remediation of nuclear sites. Recent projects completed by the Russian Federation and international partners include: a storage facility for submarine reactor compartments; storage for spent nuclear fuel that cannot be reprocessed; dismantling of the bulk of decommissioned nuclear submarines; technical solutions to their safe towing; and removal of the first part of spent nuclear fuel from the former Gremikha Naval Base (Fig. 3). In addition, participants at a CEG workshop made recommendations on the complex issue of the safe and secure management of radioactive waste at coastal sites in the north-west of the Russian Federation. Another workshop was devoted to decommissioning, and the replacement and disposal of radioisotope thermoelectric generators (RTGs). Following the CEG's recommendations, an international coordination group for RTGs was established to address the most urgent issues on a more regular basis. In 2008, Japan joined the CEG, highlighting the growing significance of the programme in Asia. The members also agreed to extend the term of the CEG for another two years (2010–2011).

The Uranium Mining and Production Industry

The increase in world demand for uranium was discussed at a round table event during the 52nd regular session of the General Conference in 2008. The discussion identified key safety and environmental issues associated with the recent increase in the uranium mining and production industry, legacy issues in the industry arising from poor past practices (Fig. 4), the shortage of experienced industry professionals in the areas of radiation protection, uranium exploration and mining engineering, and the lack of an adequate regulatory structure in many countries which are now involved in the exploitation of uranium for the first time. The Agency initiated several programmes to assist Member States involved in uranium exploration and production. The industry, in conjunction with the Agency, has also developed its own initiatives to assist operators in moving towards the goal of consistent global best practices and social responsibility in the uranium production industry.

Safe Use of Phosphogypsum in Agriculture, Construction, Roads and Landfills

Phosphate products, by-products and residues produced by the industry are widely used in

FIG. 4. A tailings pile and acid leach facility at an abandoned site in Taboshar, Tajikistan (note the village and school in the distance).

agriculture, building construction, roads and landfills. The global phosphate industry is also one of the largest producers of residues containing low levels of naturally occurring radioactive material such as phosphogypsum. In 2008, a collaborative approach coordinated by the Agency was adopted for a project to develop databases, demonstration projects and centres of excellence. Other important aspects of the project are the development and use of realistic radiological assessment models and a global best practices model providing for an optimized approach to safety, regulation, residue and waste management in the phosphate industry.

Nuclear Security

Objective

To improve the worldwide security of nuclear material, other radioactive material and their associated nuclear facilities, in use, storage and transport, through support and assistance to Member States for the establishment of effective national nuclear security regimes.

State of Nuclear Security around the World in 2008

Malicious acts involving nuclear or other radioactive material are a continuing worldwide threat. Existing data indicate circumstances in which nuclear and other radioactive material is vulnerable to theft, is uncontrolled or is in unauthorized circulation. Related facilities and transports are at risk from acts of sabotage. In the course of 2008, a number of Member States took concrete steps — with Agency assistance — to address identified weaknesses. Through human resource and other development programmes, Agency efforts were focused on ensuring the sustainability of nuclear security improvements.

"Malicious acts involving nuclear or other radioactive material are a continuing worldwide threat."

Nuclear Security Assessments

The Agency continued to consolidate the nuclear security needs of States into Integrated Nuclear Security Support Plans (INSSPs), which serve as a framework for implementing nuclear security activities and improvements. In 2008, an additional ten States approved their INSSPs, while a further 28 INSSPs are in various stages of development and discussion.

To help States assess the status of their technical and administrative arrangements, the Agency conducted nuclear security advisory and evaluation missions as well as fact finding and technical visits. There were 21 missions during the year which produced recommendations for nuclear security improvements in the requesting State focusing on: physical protection of nuclear and other radioactive material and associated facilities and transports in States; nuclear security legislative and regulatory frameworks; detection and response to the illicit trafficking of nuclear and other radioactive material; and planning and preparedness for nuclear security at major public events and for responding to malicious acts.

Guidance on Nuclear Security for Member States

Three new guides were issued in 2008 in the IAEA Nuclear Security Series (Fig. 1). Upcoming publications deal with the security of radioactive sources, cyber security and the protection of information sensitive for nuclear security.

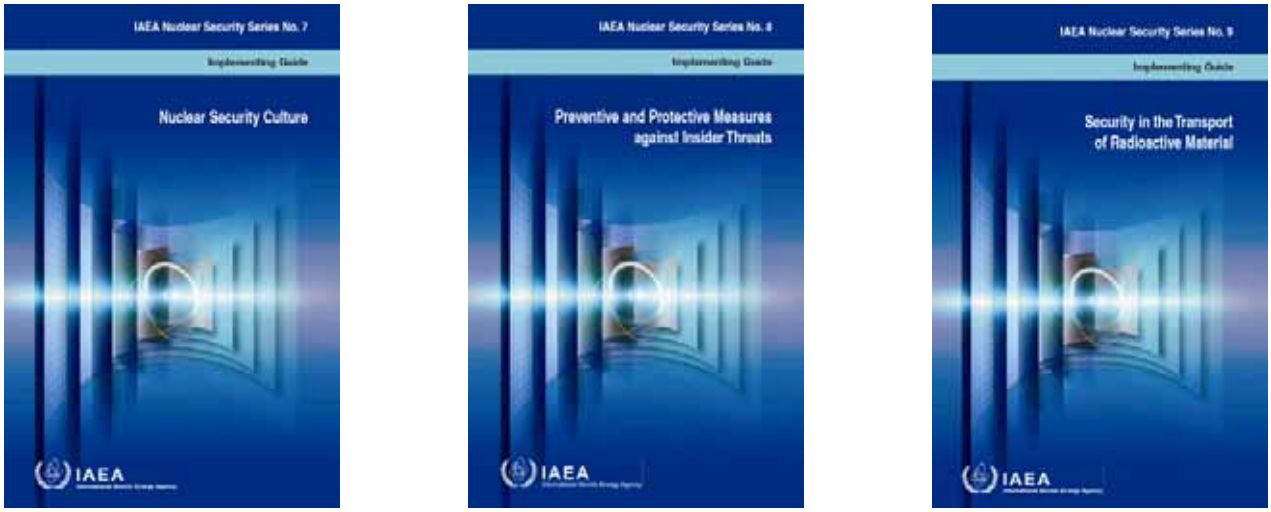


FIG. 1. Three publications issued by the Agency in 2008 covering nuclear security culture, insider threats and the transport of radioactive material.

Risk Reduction

The Agency assisted States in upgrading, or preparing to upgrade, physical protection at nuclear facilities in 12 States. Upgrades were also prepared for or implemented to the physical protection of radioactive material in nine States. More than 1500 disused radioactive sources were moved to secure storage. The Agency also continued its involvement in projects to repatriate disused HEU research reactor fuel. Supported by the US Global Threat Reduction Initiative, the Agency assisted in the shipment to the Russian Federation of 6.3 kg of spent HEU fuel from Bulgaria, 154.4 kg of spent HEU fuel from Hungary and 14.4 kg of spent HEU fuel from Latvia. In August 2008, the removal and repatriation of 7 kg of US origin spent HEU fuel from a research reactor in Portugal was prepared and managed under an Agency contract. This was the first time the Agency played a hands-on role in repatriating such material to the USA.

Nuclear Security Equipment Laboratory

During 2008, the Agency provided 24 States with 592 items of equipment to improve detection and response capabilities. Through its Nuclear Security Equipment Laboratory (NSEL), the Agency helped to ensure that border detection instruments met relevant technical and functional specifications by conducting acceptance tests on 689 portable and two fixed installed radiation detection instruments, and by evaluating 31 new detection systems. In 2007, the Agency was concerned about a 27% rejection rate of equipment tested by the NSEL. A comprehensive strategy to improve the quality of procured equipment was developed and, as a result, the rate of rejection was reduced to 5% in 2008. Following several improvements to hardware and software, five remote monitoring units passed NSEL acceptance testing (Fig. 2). Two units were deployed at research reactors to demonstrate the utility of the system in pilot installations.

"... through its Nuclear Security Equipment Laboratory (NSEL), the Agency helped to ensure that border detection instruments met relevant technical and functional specifications ..."

The Agency played a direct role in the deployment of radiation detection equipment at entrances to the Vienna based international organizations. It also provided inputs for the development of design documentation and specifications, assisted in the selection and procurement of the hand-held equipment and contributed to the development of operating procedures.

FIG. 2. Installation of remote monitoring equipment to improve the physical protection of a nuclear facility.

Nuclear Security at Major Public Events

The Agency continued to help States meet the nuclear security challenges associated with major public events. Assistance included security information, detection equipment and training, in addition to facilitating peer based sharing of knowledge and expertise. In cooperation with the Chinese authorities, the Agency conducted a project to ensure the nuclear security of the Summer Olympic Games in Beijing in August 2008 (Fig. 3). It also assisted the Government of Peru in establishing nuclear security arrangements for the Latin American and Caribbean–European Union Summit; and the Asia–Pacific Economic Cooperation CEO Summit. The Agency also facilitated assistance to Peru from the Brazilian Government, including the provision of experts for training activities and the loan of detection equipment that the Agency provided to Brazil for the Pan-American Games security project. And the Agency participated in initial discussions on providing assistance for future major public events to take place in China (the 2010 Shanghai EXPO), South Africa (the 2010 World Cup), the United

FIG. 3. Checkpoint at the entrance of the 2008 Summer Olympic Games, Beijing.

Kingdom (the 2012 Olympic Games) and Poland–Ukraine (the 2012 Eurocup).

Human Resources Development

To strengthen the capacity of States in the area of prevention, the Agency organized 14 national and 16 regional training courses focusing on the physical protection of nuclear material in use, storage and transport and associated facilities, including State systems of accounting for and control of nuclear material. More than 750 participants from more than 90 States received prevention training. The Agency also provided training to enhance State capabilities for detecting, interdicting and responding to illegal acts involving nuclear and other radioactive material and associated facilities. During 2008, training courses of this kind, including 18 national, 12 regional and three international courses, were convened for more than 870 individuals from more than 80 States. The Agency continued to increase its efforts to improve nuclear security information and coordination through human resources development. To this end, three regional workshops on illicit trafficking information and two regional workshops on information and computer security were conducted during the year, involving nearly 150 participants from 42 States.

"The Agency organized 14 national and 16 regional training courses focusing on the physical protection of nuclear material in use, storage and transport and associated facilities."

In 2008, the Agency held meetings with Brazilian and Malaysian authorities on establishing national Nuclear Security Support Centres (NSSCs). It also supported Pakistan in providing nuclear security training courses through Pakistan's NSSC.

The Agency also continued to give priority to the development of nuclear security education mechanisms. For example, it supported educational programmes at the Sevastopol National University of Nuclear Energy and Industry, in Ukraine, and at the Interdepartmental Special Training Centre in Obninsk, the Russian Federation. In addition, it enhanced cooperation with the Naif Arab University for Security Sciences, established by the League of Arab States and located in Saudi Arabia. These efforts are aimed at promoting institutional exchanges, exchanging information and organizing symposia, meetings and training courses on nuclear security issues.

The Illicit Trafficking Database

The Agency's Illicit Trafficking Database (ITDB) contains data on illicit trafficking and other unauthorized activities from 1993 onward. The membership of the Agency's ITDB programme continued to expand, now numbering 103 Member States and one non-member State. By 31 December 2008, States had reported, or otherwise confirmed, 1562 incidents to the database; 222 incidents were reported by States in 2008, of which 119 had occurred during the year (the others had occurred earlier). Of those which had occurred during the year, 15 involved illegal or unauthorized possession and related criminal activities, 16 involved thefts or losses of material, and 86 incidents involved the recovery or discovery of uncontrolled or orphan material, unauthorized disposals and other unauthorized activities. In two cases, there was insufficient information to categorize the incident. The continued reporting by States of incidents — whether criminal, unauthorized or inadvertent in nature — points to the need for further improvement of measures to control and secure nuclear and other radioactive material, wherever used or located, and of capabilities to detect illicit trafficking and other unauthorized acts involving such material.

Cooperation with International Organizations

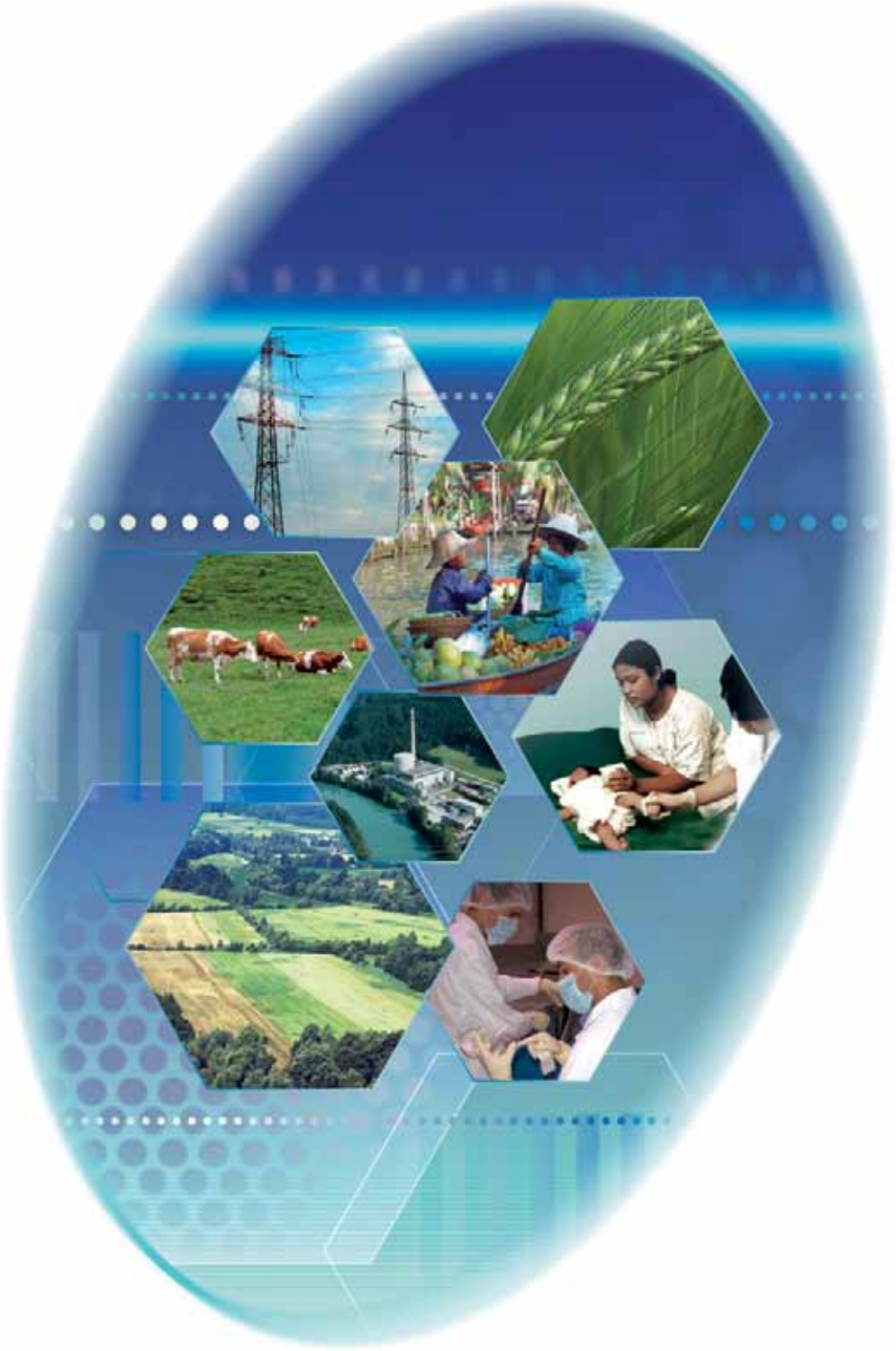
The Agency continued to work with other international and regional organizations, including the European Commission, Europol, ICPO-INTERPOL, International Maritime Organization, Organization for Security and Co-operation in Europe, United Nations Interregional Crime and Justice Research Institute, United Nations Office on Drugs and Crime, Universal Postal Union, and World Customs Organization, in such areas as information sharing and training.

Support to the Nuclear Security Fund

The implementation of the Agency's nuclear security programme continued to depend largely on the donation of extrabudgetary funds by Member States and others to the Nuclear Security Fund (NSF). In 2008, financial contributions with a cumulative value in excess of €7.6 million were received from 20 Member States and the European Union. In addition, a number of States made contributions in kind through the donation of equipment and services. The continued emphasis on programme delivery resulted in disbursements of over €18.2 million during the year, a significant increase over 2007.

The NSF continued to rely on the contributions of relatively few donors. Coordination with these donors and other multilateral initiatives continued to ensure optimal use of resources.

Verification



Safeguards

Objective

To provide credible assurance to the international community that nuclear material and other items placed under safeguards are not diverted or misused; for States with comprehensive safeguards agreements, to provide credible assurance that all nuclear material remains in peaceful activities; and to support the efforts of the international community in connection with nuclear disarmament.

Safeguards Conclusions for 2008

At the end of each year, the Agency draws a safeguards conclusion for each State with a safeguards agreement in force, based upon the evaluation of all information available to it for that year. With regard to States with comprehensive safeguards agreements (CSAs), the Agency seeks to conclude that all nuclear material has remained in peaceful activities.

To draw such a conclusion, the Secretariat must ascertain that: (i) there are no indications of diversion of declared nuclear material from peaceful activities (including no misuse of declared facilities or other locations to produce undeclared nuclear material); and (ii) there are no indications of undeclared nuclear material or activities for the State as a whole.

In order to ascertain that there are no indications of undeclared nuclear material or activities in a State, and ultimately to be able to draw the broader conclusion that all nuclear material has remained in peaceful activities, the Secretariat considers the results of its verification activities under CSAs and the results of its evaluation and verification activities under additional protocols (APs) (Figs 1 and 2). Therefore, for the Agency to draw such a broader conclusion, both a CSA and an AP must be in force, and the Agency must have been able to conduct all necessary verification and evaluation activities. For States that have CSAs in force but no APs, the Agency does not have sufficient tools to provide credible assurance regarding the absence of undeclared nuclear material and activities in a State, and therefore only draws a conclusion for a given year with respect to whether declared nuclear material remained in peaceful activities.

"At the end of each year, the Agency draws a safeguards conclusion for each State with a safeguards agreement in force, based upon the evaluation of all information available to it for that year."

FIG. 1. Sealing of nuclear material by Agency inspectors.

FIG. 2. Verification of spent fuel using a digital Cerenkov viewing device.

In 2008, safeguards were applied for 163 States with safeguards agreements in force with the Agency. Eighty-four States had both CSAs and APs in force. For 51 of these States,[1] the Agency concluded that all nuclear material remained in peaceful activities. For 33 of the States, the Agency had not yet completed all the necessary evaluations and could therefore only conclude that the declared nuclear material remained in peaceful activities. Similarly, for 70 States with CSAs in force but without APs, the Agency was only able to draw that conclusion.[2]

Three States had in force item specific safeguards agreements which require the application of safeguards to specified nuclear material, facilities and other items or material. For these States, the Secretariat concluded that nuclear material, facilities or other items to which safeguards had been applied remained in peaceful activities.

Five nuclear weapon States had voluntary offer safeguards agreements in force. Safeguards were implemented with regard to declared nuclear material in selected facilities in four of the five States. For these four States, the Agency concluded that nuclear material to which safeguards had been applied in selected facilities remained in peaceful activities or had been withdrawn as provided for in the agreements.

As of 31 December 2008, 30 non-nuclear-weapon States party to the NPT had yet to bring CSAs into force pursuant to the Treaty. For these States, the Secretariat could not draw any safeguards conclusions.

A broader conclusion was drawn for the first time for four States and was reaffirmed for 47 States.[3]

Conclusion of Safeguards Agreements, Additional Protocols and Small Quantities Protocols

The Agency continued to facilitate the conclusion of safeguards agreements and APs, and the amendment of small quantities protocols (SQPs). APs entered into force for two States during 2008, bringing the number of States with APs in force to 88 by the end of the year (Fig. 3). One State signed a CSA and three States signed APs in 2008, and the Board of Governors approved a CSA for one State and APs for four States.

In order to implement the Board's 2005 decision on SQPs[4], the Agency continued to communicate

1 And for Taiwan, China.

2 The 70 States do not include the DPRK as the Agency was not able to implement safeguards in that State and, therefore, could not draw any conclusion.

3 See footnote 1.

4 Many States with minimal or no nuclear activities have concluded a small quantities protocol to their CSA. Under SQPs, the implementation of most of the safeguards procedures of CSAs is held in abeyance as long as certain criteria are met. In 2005, the Board of

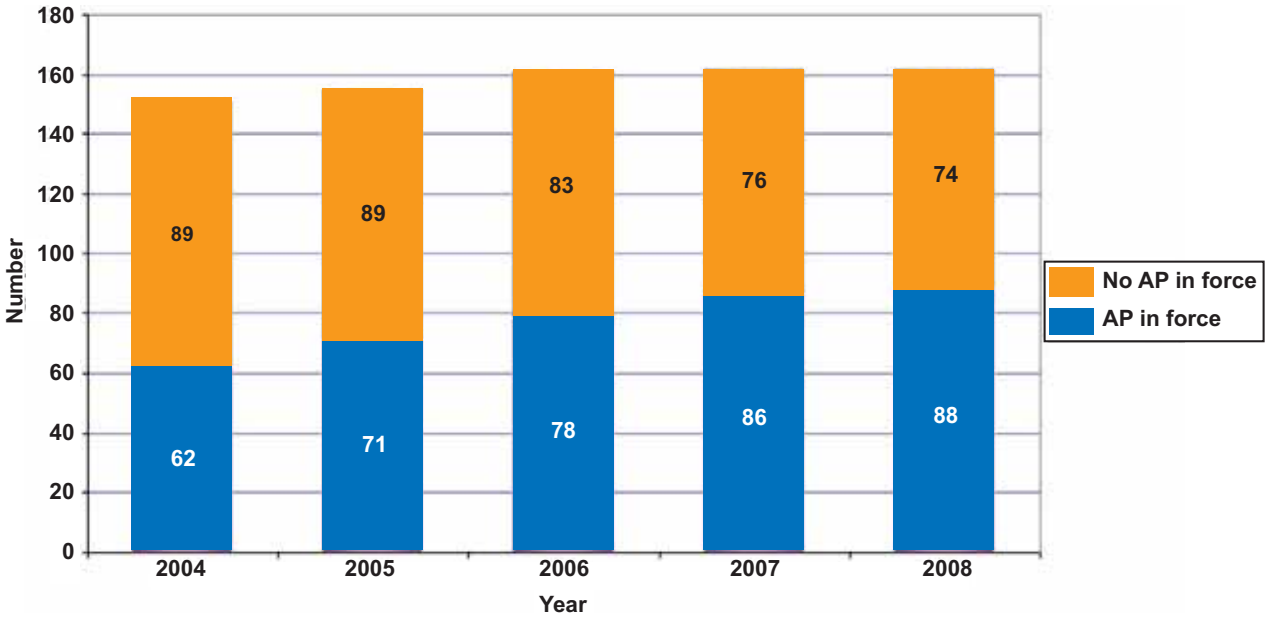


FIG. 3. Status of APs for States with safeguards agreements in force, 2004–2008 (the DPRK is not included).

with States with a view to amending or rescinding their SQPs. During 2008, SQPs were amended to reflect the modified text for eight States and an operative SQP was rescinded for one State.

Implementation of Integrated Safeguards

Integrated safeguards are defined as the optimum combination of all safeguards measures available to the Agency under CSAs and APs to achieve maximum effectiveness and efficiency in meeting the Agency's safeguards obligations. They are implemented in a State for which the Agency has drawn the broader conclusion. Integrated safeguards were implemented during the whole of 2008 in 25 States.[5] Safeguards implementation activities were carried out for these States in accordance with the State level safeguards approaches and annual implementation plans approved for each individual State.

The Secretariat concluded that the evaluation and verification activities planned for 2008 for the 25 States under integrated safeguards had been satisfactorily implemented and that the State specific technical objectives had been achieved.

Owing to the size and complexity of the fuel cycles in Canada and Japan, integrated safeguards are being introduced in a phased manner in those States. The use of low frequency unannounced inspections has substantially decreased the inspection effort needed in both States and it is further anticipated that the transition to full implementation of integrated safeguards will result in additional savings in the inspection effort.

"The Secretariat concluded that the evaluation and verification activities planned for 2008 for the 25 States under integrated safeguards had been satisfactorily implemented ..."

Safeguards Implementation Issues

Implementation of Safeguards in the Islamic Republic of Iran (Iran)

During 2008, the Director General submitted four reports to the Board of Governors on the implementation of Iran's Comprehensive Safeguards Agreement and relevant provisions of United

Governors took the decision to revise the standardized text of the SQP and change the eligibility criteria for an SQP, making it unavailable to a State with an existing or planned facility and reducing the number of measures held in abeyance. The Agency initiated exchanges of letters with all States concerned in order to give effect to the revised SQP text and the change in the criteria for an SQP.

[5] Australia, Austria, Bangladesh, Bulgaria, Canada, the Czech Republic, Ecuador, Ghana, Greece, the Holy See, Hungary, Indonesia, Ireland, Jamaica, Japan, Latvia, Lithuania, Mali, Norway, Peru, Poland, Portugal, Romania, Slovenia and Uzbekistan.

Nations Security Council resolutions. Iran provided the Agency with access to declared nuclear material and submitted the required nuclear material accounting reports in connection with declared nuclear material and facilities. The Agency was able to verify the non-diversion of the declared nuclear material in Iran in 2008.

Since March 2007, Iran has not implemented the modified text of its Subsidiary Arrangements on the early provision of design information and has continued to object to the Agency carrying out design information verification at the Iran Nuclear Research Reactor.

In 2008, Iran and the Agency continued to address issues related to Iran's past nuclear activities. By the end of 2008, there remained a number of outstanding issues regarding possible military dimensions to Iran's nuclear programme. These issues relate to the alleged studies on the green salt project, high explosives testing, the design of a missile re-entry vehicle; procurement and R&D activities of military related institutes and companies that could be nuclear related; and the production of nuclear equipment and components by companies belonging to defence industries. Iran has not provided the access to information, locations or individuals that would have allowed the Agency to make substantive progress on these issues. As Iran did not implement the AP as required by the Security Council, the Agency remained unable to provide credible assurance about the absence of undeclared nuclear material and activities in Iran. Also, in this context, and contrary to the decisions of the Security Council, in 2008 Iran did not suspend its enrichment related activities, having continued with the operation of the Pilot Fuel Enrichment Plant and the construction and operation of the Fuel Enrichment Plant at Natanz. It also continued its work on heavy water related projects, including the construction of the IR-40 heavy water moderated research reactor at Arak. There was no indication of reprocessing related activities at any declared facilities in Iran.

Implementation of Safeguards in the Syrian Arab Republic (Syria)

In November 2008, the Director General submitted a report to the Board of Governors on the implementation of the NPT safeguards agreement in Syria. In April 2008, the Agency was provided with information alleging that an installation destroyed by Israel at Dair Alzour in Syria in September 2007 had been a nuclear reactor under construction. In June 2008, the Agency held discussions with Syria in Damascus and visited the Dair Alzour site, where it took environmental samples. Syria informed the Agency that Dair Alzour was a military site and was not involved in any nuclear activities. While this cannot be excluded, the features of the building and site were similar to what may be found in connection with a reactor site. By the end of 2008, Syria had not provided the requested documentation in support of its declarations concerning the nature or function of the destroyed building.

Analysis of environmental samples from the Dair Alzour site revealed a significant number of natural uranium particles that had been produced as a result of chemical processing. By the end of 2008, the Agency was still investigating Syria's explanations about the possible origin of the uranium particles and had requested Syria to provide further access to the Dair Alzour site and any other locations where the debris and equipment from the building had been stored. Also, the Agency suggested — as a matter of transparency — a visit to other locations that might help it in its verification activities. At the end of 2008, the Agency's verification work in Syria was continuing. For 2008, the Agency found no indication of the diversion of declared nuclear material in Syria. Therefore, the Agency was able to conclude for Syria that all declared nuclear material remained in peaceful activities.

Implementation of Safeguards in the Libyan Arab Jamahiriya (Libya)

Following Libya's disclosure of its undeclared nuclear activities, the Director General submitted to the Board of Governors — for the first time — in December 2003, a report on the implementation of Libya's CSA. Several progress reports were submitted thereafter. In 2008, the Director General reported to the Board that the issues which had been previously reported were no longer outstanding. For 2008, the Agency found no indication of the diversion of declared nuclear material or of undeclared nuclear material or activities in Libya. Therefore, the Agency was able to conclude for Libya that all nuclear material remained in peaceful activities.

Implementation of Safeguards in Egypt

Following Agency enquiries, Egypt, between 2004 and 2005, disclosed past undeclared nuclear

activities and material to the Agency, as reported to the Board in February 2005. Between 2004 and 2006, Egypt made available to the Agency nuclear material that it had failed to report. It also submitted design information for three additional facilities. Egypt gave the Agency access to information, such as logbooks and operating records, as well as access to personnel and locations related to its conversion and irradiation experiments and its preparatory activities related to reprocessing.

Once its State system of accounting for and control of nuclear material was given the required authority through Presidential and Ministerial decrees in 2006, Egypt undertook a State-wide investigation of its nuclear material holdings, during which additional, previously unreported, nuclear material was identified. The Agency received relevant nuclear material accounting reports, and has been able to verify all declared nuclear material in Egypt. Egypt has also clarified issues relating to its past undeclared activities. The Agency concluded that Egypt's statements are consistent with the Agency's findings, and that the issues raised in the report to the Board are no longer outstanding. For 2008, the Agency found no indication of the diversion of declared nuclear material in Egypt. Therefore, the Agency was able to conclude for Egypt that all declared nuclear material remained in peaceful activities.

"Key to the process by which safeguards conclusions are drawn is the State evaluation process, including the preparation of a State evaluation report and its evaluation by the Agency ..."

Other Verification Activities

Democratic People's Republic of Korea

Since December 2002, the Agency has not implemented safeguards in the DPRK and, therefore, cannot draw any safeguards conclusion. In the context of the ad hoc monitoring and verification arrangement as agreed between the Agency and the DPRK and foreseen in the Initial Actions agreed at the Six-Party Talks, in 2008 the Agency continued implementing monitoring and verification measures related to the shutdown of four installations located at the Yongbyon nuclear facility and one in Taechon. These activities were partially discontinued at the request of the DPRK from 22 September to 13 October 2008, resulting in a lack of access for Agency inspectors to the Radiochemical Laboratory (reprocessing plant) and in the removal of Agency seals and surveillance equipment at this facility. When the Agency resumed its verification activities on 14 October 2008, including the monitoring of fuel discharge from the 5 MW(e) reactor, such activities revealed no indication that the Radiochemical Laboratory had processed nuclear material during the period when monitoring and verification activities had been suspended.

The Nuclear Fuel Fabrication Plant, the 5 MW(e) Experimental Nuclear Power Plant, the 50 MW(e) Nuclear Power Plant and the 200 MW(e) Nuclear Power Plant remained shut down in 2008.

Implementation of Information Driven Safeguards and Development of Safeguards Approaches

Key to the process by which safeguards conclusions are drawn is the State evaluation process, including the preparation of a State evaluation report (SER) and its evaluation by the Agency's internal Information Review Committee. The process of preparing and updating State evaluation reports continued in 2008. During the year, SERs covering 98 States[6] were completed and reviewed. A full description of the State evaluation process is given in the description of the Agency's safeguards system (*http://www.iaea.org/OurWork/SV/Safeguards/safeg_system.pdf*).

The Agency continued to develop and implement more efficient approaches for verification of spent fuel transfers, approaches involving unattended monitoring and surveillance systems, and approaches based on verification through short notice and unannounced inspections. During 2008, integrated safeguards approaches for facilities in European Union non-nuclear-weapon States, including LWRs, spent fuel storage, research reactors and critical assemblies and depleted, natural and low enriched uranium (DNLEU) conversion and fuel fabrication plants were implemented. A safeguards approach for the transfer of spent fuel from Kazakhstan's shutdown BN350 fast breeder reactor to temporary storage has been completed and all equipment tested and installed. Two integrated safeguards approaches

[6] See footnote 1 at the beginning of this section.

for specific nuclear facility types in Japan (DNLEU conversion and fabrication and LWRs without MOX fuel) were updated and approved. An integrated safeguards procedure for conversion and fuel fabrication plants in Canada was approved. A site level integrated safeguards approach was introduced at the Tokai complex in Japan, which comprises several large scale plutonium processing facilities. As part of another site level approach in Japan, an integrated safeguards approach for the Rokkasho Reprocessing Plant (RRP) was approved in 2008. The RRP approach will be evaluated as the plant moves from its commissioning phase to commercial operation, and will be reviewed in 2011.

In September 2008, an expert group meeting on the application of safeguards to geological repositories was conducted to address comments from States on model integrated safeguards approaches for spent fuel conditioning plants and geological repositories.

Detecting Undeclared Nuclear Material and Activities: Improved Technical Capabilities and Methods

Development of Safeguards Equipment

In 2008, development activities included a non-destructive assay (NDA) system combining a plutonium neutron coincidence collar with high resolution gamma spectrometry developed for a MOX fuel fabrication plant, an optical fibre probe system, an upgrade of the cascade header enrichment meter system, a UF_6 cylinder verifier with portable electrically cooled high purity germanium detectors, a portable low resolution gamma spectrometer and a tunable diode laser spectrometry system. The feasibility of another system, UF_6 laser spectroscopy, for accurate enrichment determination was demonstrated as an efficient alternative to destructive analysis. Significant financial and human resources were spent in preventive maintenance and equipment upgrades to ensure the reliability of the Agency's standard equipment systems. During 2008, 50 digital surveillance systems were installed as part of the ongoing effort to replace old surveillance systems. Phase 3 of the Next Generation Surveillance System (NGSS) was completed in September 2008 (Fig. 4). The final camera and system prototypes were delivered to the Agency, with development of the NGSS entering its final phase.

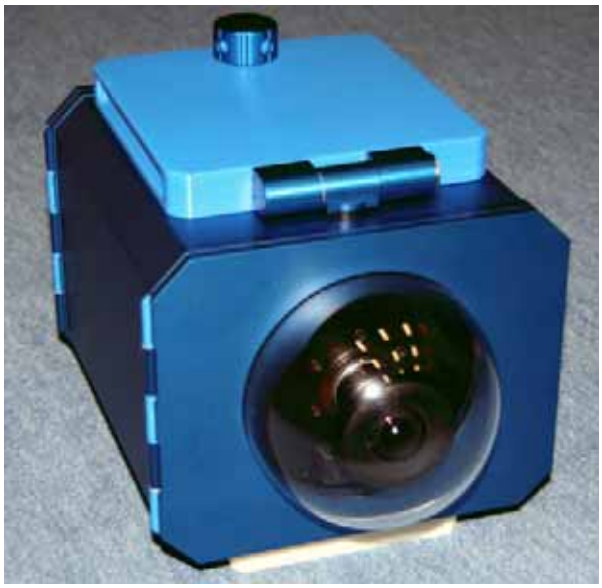


FIG. 4. The camera for the Next Generation Surveillance System.

The Agency made significant progress in 2008 in feasibility studies and implementation of new sealing systems and containment verification techniques. Development of the VOID-3 adhesive seal is continuing. Electronic optical sealing system implementation arrangements were finalized and are being implemented to replace old generation electronic (VACOSS) seals in most applications.

"The Agency made significant progress in 2008 in feasibility studies and implementation of new sealing systems and containment verification techniques."

By the end of 2008, there were 118 unattended monitoring systems (UMSs) installed in 21 States and 46 facilities. In the area of UMSs, new systems and component configurations for applications in future installations were designed, developed and tested.

Sample Analysis

The safeguards analytical services organize the analysis of nuclear material and environmental samples, and other samples collected by inspectors. The service involves the provision of sampling devices, transport of samples from the field to Agency Headquarters, analysis of samples, evaluation of analytical results and quality control. Samples are analysed by the Agency's Safeguards Analytical Laboratory (SAL) and the other 14 laboratories of the Network of Analytical Laboratories (NWAL) (Fig. 5). The Secretariat

is expanding NWAL for the analysis of nuclear material samples. Some Member States (Belgium, the Czech Republic, Finland, France, Hungary and the Russian Federation) have informed the Agency of their wish to provide additional support in this regard. Laboratories in Brazil, China and the Republic of Korea are currently undergoing qualification to become part of NWAL for environmental sample analysis. The average shipping and evaluation time has improved; however, analysis times are still higher than planned goals. In order to improve process performance, additional laboratories are undergoing qualification in order to enlarge NWAL.

Design Information Verification

During 2008, in States[7] with CSAs and significant nuclear activities, the Agency exercised its continuing right to verify design information throughout the life cycle of a facility. Design information verification (DIV) was conducted at facilities under construction and in operation, and at shutdown facilities and facilities being decommissioned, for the purposes described in paragraph 46 of INFCIRC/153 (Corr.) and improves the Agency's ability to provide assurance that no undeclared activities are taking place at declared facilities (Fig. 6). During 2008, 640 DIVs were performed.

Remote Monitoring

Twenty-two new safeguards systems with remote monitoring mode were implemented during 2008. The IAEA Remote Monitoring Data Centre was enhanced by upgrading communication lines and enhancing 'state of health' reporting. The centre is now able to monitor the systems on a near real time basis. Safeguards approaches using remote monitoring systems for safeguards data transmission result in enhanced effectiveness and efficiency of safeguards implementation (Fig. 7).

At the end of 2008, 168 surveillance and radiation monitoring systems with remote transmission capabilities (comprising 106 surveillance and 62 unattended radiation monitoring systems) were authorized for inspection use. By the end of 2008, remote monitoring systems installed at 84 facilities

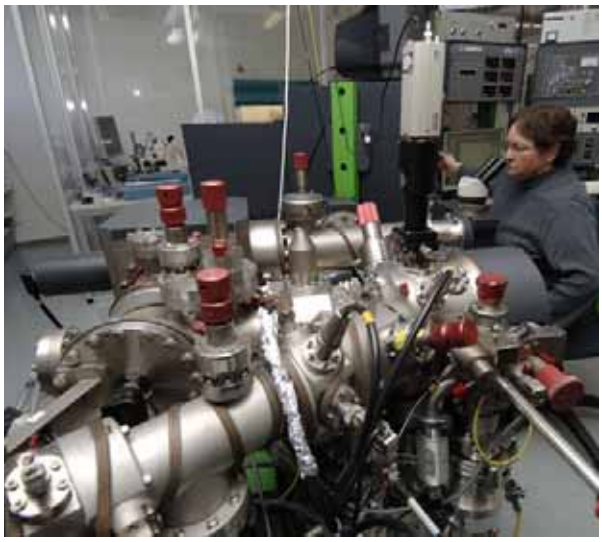


FIG. 5. The secondary ion mass spectrometer at SAL.

FIG. 6. Inspectors observing the design features of an empty reactor core.

FIG. 7. Remote monitoring data satellite receiving station at Agency Headquarters.

[7] See footnote 1 at the beginning of this section.

in 18 States[8] (in 12 of them[9] with full transmission of safeguards data) were transmitting to Headquarters or to an Agency regional office data required for the timely detection of the diversion of nuclear material during interim inspections.

Research and Development Programme

The Research and Development Programme for Nuclear Verification 2008–2009 reflects high priority needs for further enhancement of the efficiency and effectiveness of safeguards activities. These needs are addressed by 24 essential projects in such areas as the development of verification technologies, safeguards concepts, information processing and analysis, and training. Member State Support Programmes (MSSPs) continued to make substantial contributions to Agency safeguards. As of 31 December 2008, 20 States and 1 organization had formal support programmes.[10]

"Information from open sources, commercial satellite imagery, in-house databases and other sources has been collected, analysed and used extensively to support the evaluation of State nuclear activities in 2008."

Information Management and Analysis

The objective of the Agency's Integrated Safeguards Information System Re-engineering Project (IRP) is to increase the effectiveness and efficiency of information processing by replacing the current obsolete systems with a modern integrated one. The project will ensure better support and accessibility of data, including remote access by field offices and inspectors. Phase III of the IRP continued in 2008 with implementation of the reengineered, redeveloped and custom developed applications. The implementation projects are grouped into four streams consisting of related applications grouped by business area (State supplied data, analysis, verification and support). This phase has been revised to take into consideration Agency needs and to ensure the integration and consistency of the IRP. The first task in this phase is to analyse and review the business processes in each stream before developing the new system. Phase III comprises 16 projects, including six that were closed at the end of 2008. The years 2009 and 2010 will be dedicated to developing and testing the new software.

Information from open sources, commercial satellite imagery, in-house databases and other sources has been collected, analysed and used extensively to support the evaluation of State nuclear activities in 2008. The Agency continued to analyse safeguards relevant information on possible covert trade in nuclear material. In addition, the procurement outreach programme gathered information, provided on a voluntary basis, on procurement enquiries and export denials of nuclear related equipment, materials and technology in order to detect early proliferation indicators.

In 2008, the Agency continued to receive reports from Member States on incidents of illicit trafficking and related unauthorized activities involving nuclear and other radioactive material.

Proliferation Resistant Nuclear Energy Systems

Progress was made during the year by INPRO and the GIF Proliferation Resistance and Physical Protection Expert Group in addressing the compatibility and use of the INPRO and GIF assessment methodologies with regard to proliferation resistance in order to understand more fully the range of applicability and the potential for synergy in their application. In addition, the Agency participated in a collaborative project on acquisition/diversion pathway analysis. It also hosted a workshop on 'safeguards by design' to facilitate the inclusion of proliferation resistant features in future facilities.

Neptunium and Americium

In 1999, the Board of Governors endorsed the implementation of a scheme to monitor separated neptunium and decided that the Director General should report to the Board, when appropriate, on information from States regarding separated americium. This information complements the initial

8 See footnote 1 at the beginning of this section.

9 See footnote 1 at the beginning of this section.

10 Argentina, Australia, Belgium, Brazil, Canada, China, the Czech Republic, Finland, France, Germany, Hungary, Japan, the Republic of Korea, the Netherlands, the Russian Federation, South Africa, Spain, Sweden, the United Kingdom and the USA, and the European Commission.

reports and the annual export reports received from relevant States under the neptunium and americium voluntary reporting scheme. By the end of 2008, six States had still not responded to the Secretariat's requests for information about neptunium or americium. The Secretariat received information from ten States, Euratom and Taiwan, China, about exports of neptunium or americium. Evaluation of the information provided by States under the monitoring scheme indicates that the quantities of separated neptunium and americium in the non-nuclear-weapon States remain small and only small quantities are being exported. This evaluation, therefore, does not indicate that a proliferation risk currently exists. Flow sheet verification (FSV) for neptunium was carried out at a European Commission laboratory to confirm that the facility was operating in accordance with the design information and with its annual operating plan. FSV activities were performed during 2008 at large scale reprocessing plants in Japan.

Significant Safeguards Projects

Japan MOX fuel fabrication plant

A draft safeguards approach was developed for the Japan MOX fuel fabrication plant (JMOX) in 2008. The approach is designed to ensure effective safeguards while achieving greater efficiency. A Joint Technical Committee, comprising representatives from the Agency and Japanese bodies, was established to coordinate development of JMOX safeguards systems across the plant. Construction of the facility has not yet commenced.

"Evaluation of the information provided by States under the monitoring scheme indicates that the quantities of separated neptunium and americium in the non-nuclear-weapon States remain small and only small quantities are being exported."

Chernobyl

Surveillance and radiation detection equipment was upgraded in 2008. This equipment will be used to monitor the transfer of spent fuel from Chernobyl units 1–3 to the existing spent fuel wet storage facility and new conditioning facility. A new spent fuel monitoring system was installed at the Chernobyl spent fuel wet storage facility. Procurement and installation of Phase 1 of the Chernobyl site data integration programme was completed. The surveillance and radiation detection data from Chernobyl units 1–3, unit 4 shelter and spent fuel wet storage facility were integrated to a central location for ease of access by the inspectors. The conditioning of irradiated fuel from Chernobyl units 1–3 reactors and the wet storage facility for long term dry storage has been delayed until at least 2013.

Enhancing the Capability of the Safeguards Analytical Services

The Agency needs to strengthen its capability to provide independent and timely analysis of safeguards samples. The Agency has developed an overall plan with two phases. Phase 1 will address the sustainability and enhancement of the Agency's particle analysis capabilities for environmental samples and Phase 2 will address, in parallel, the future of the Nuclear Laboratory at SAL. The progress of the project was presented to the Board of Governors in November 2008. The new laboratory could be constructed at Seibersdorf on land for which the Agency holds a lease option. The estimated overall cost of strengthening the Agency's safeguards analytical capabilities is about €38 million. For Phase 1, the acquisition and installation of the ultrahigh sensitivity secondary ion mass spectrometer (UHS-SIMS) for the Clean Laboratory at SAL, and the building of a Clean Laboratory Extension to accommodate the UHS-SIMS, would require approximately €4.5 million and €3.5 million, respectively. For Phase 2 — the construction of the new laboratory — the current financial plan shows the conceptual design in 2010 followed by the engineering design and construction starting in 2011. The site development will occur in 2010–2011. The Government of Japan has agreed to provide extrabudgetary funding for the acquisition of the UHS-SIMS.

Novel Technology Project

The Agency project for the identification and development of effective and appropriate advanced technologies for the detection of undeclared nuclear activities continued. The Novel Technology Project is currently identifying strong indicators and signatures associated with specific nuclear fuel cycle processes. These will be used to facilitate nuclear safeguards technology gap analyses, allowing

prioritization and identification of technologies for development for future safeguards applications.

Assistance to State Systems of Accounting and Control

The effectiveness and efficiency of Agency safeguards depend, to a large extent, on the effectiveness of State systems of accounting for and control of nuclear material (SSACs) and regional systems of accounting for and control of nuclear material (RSACs), and on the level of their cooperation with the Agency. The Secretariat continued to work with SSACs and RSACs on safeguards implementation issues such as the quality of operator systems for the measurement of nuclear material, the timeliness and accuracy of State reports and declarations, and support for the Agency's verification activities. The Secretariat continues to experience problems in the timeliness and quality of reports and declarations from a number of States. At the same time, improved quality and timeliness by a number of other States demonstrated the effectiveness of the Agency's efforts to improve cooperation with SSACs. Several ISSAS missions and training courses were held. Nevertheless, a few States with CSAs in force had still not established either SSACs or contact points as of the end of 2008.

"... improved quality and timeliness by a number of other States demonstrated the effectiveness of the Agency's efforts to improve cooperation with SSACs."

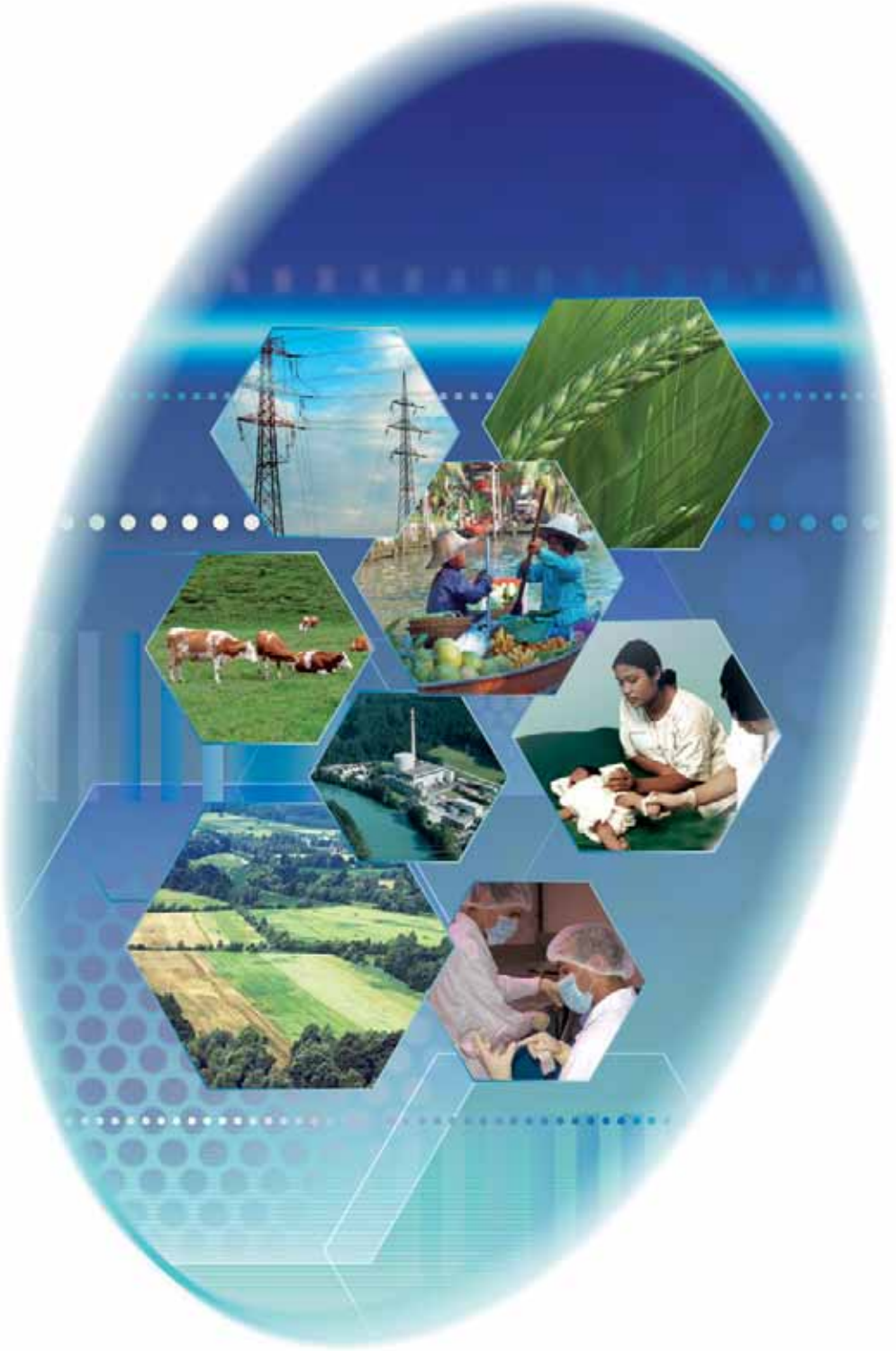
Quality Management

During 2008, the Agency continued to implement a quality management system (QMS) in its safeguards programme. All of the key processes in the programme were identified and responsibility for the process and its results was assigned to process owners. The performance of the QMS was formally reviewed on a regular basis by management. Staff training was given to raise awareness of the QMS and to increase the use of the Corrective Action Report (CAR) and Continual Process Improvement (CPI). CPI working groups were established to evaluate and make recommendations to improve processes. Five internal quality audits were conducted in the areas of corrective action, environmental sampling, procurement, complementary access, and information security.

Standing Advisory Group on Safeguards Implementation

The Standing Advisory Group on Safeguards Implementation (SAGSI) held two plenary meetings in 2008. The main safeguards implementation issues considered by SAGSI were: integrated safeguards approaches for geological repositories and centrifuge enrichment plants; State level technical objectives; and State level safeguards implementation and documentation.

Technical Cooperation



Management of Technical Cooperation for Development

Objective

To contribute to sustainable social and economic benefits in Member States and their increased self-reliance in the application of nuclear techniques.

The Agency, through its technical cooperation programme, aims to promote tangible socioeconomic impacts in its Member States, by supporting the use of appropriate nuclear science and technology to address major sustainable development priorities at the national, regional and interregional levels. The programme concentrates on six thematic areas — human health, agricultural productivity and food security, water resources management, environmental protection, physical and chemical applications, and sustainable energy development, together with a cross-cutting thematic area, safety and security — and supports the achievement of the Millennium Development Goals.

"Consisting of 551 core funded projects in 129 countries and territories, the programme identifies human health, nuclear safety, and food and agriculture as the top three areas of Member State concern, with radioisotope production and radiation technology in fourth place."

Strengthening the Technical Cooperation Programme

In 2008, Member States approved the technical cooperation programme for 2009–2011. Consisting of 551 core funded projects in 129 countries and territories, the programme identifies human health, nuclear safety, and food and agriculture as the top three areas of Member State concern, with radioisotope production and radiation technology in fourth place. Projects related to nuclear power have increased in Europe and Asia and the Pacific, while increases in projects concerning food and agriculture and isotope hydrology are evident in the Latin America region. In Africa, meeting basic human needs remains the main priority. Funding for regional projects has increased to over 40% of the TCF.

The 2009–2011 programme was developed over the year, taking into account the central criterion of government commitment and using Country Programme Frameworks (CPFs) as the basis for cooperation. To maximize efficiency, Member States were invited to submit fewer projects — which were screened at both the concept and design phases — and all projects were reviewed for conformity with the Agency's Statute, INFCIRC/267[1] and relevant decisions of the Agency's Policy-Making Organs and the United Nations Security Council. Lastly, the projects underwent a quality assessment to ensure that they met predefined quality standards.

Programme Cycle Management Framework

Project classifications were simplified during 2008, with the former classifications of 'new', 'extension' and 'continuation' becoming simply 'new' and 'ongoing'. This change was implemented in the preparation of the 2009–2011 technical cooperation programme. New projects were presented separately from ongoing projects and related budgetary amounts that had previously been approved by the Board of Governors, thus simplifying the programme documents produced for the Technical Assistance and Cooperation Committee and the Board. In practice, the new classifications mean that all projects are now approved by the Board for the full life cyce of the project without the need for reapproval. Further improvements to the system were also made in the areas of reporting.

Country Programme Frameworks

Six new CPFs were signed in 2008, by Bangladesh, the Central African Republic, Indonesia, Madagascar, Montenegro and Uganda, with Bangladesh, the Central African Republic and Montenegro signing CPFs for the first time.

[1] *The Revised Guiding Principles and General Operating Rules to Govern the Provision of Technical Assistance by the Agency* (1979).

Fellowship Issues

The Agency participated in the biennial meeting organized by the United Nations for those agencies, programmes and offices that have fellowship programmes or that play a key role in reviewing and determining the entitlements of fellows. Recognizing the Agency's active engagement and commitment, the meeting participants unanimously elected it to chair the 17th Senior Fellowship Officer Meeting, which was held in November 2008.

Regional Programming

Regional programming strengthened over the course of 2008 as the various regional frameworks for Africa, Asia and the Pacific, Europe and Latin America were used to guide the submission and selection of regional project concepts for the 2009–2011 technical cooperation programme cycle. European Member States also agreed on a Common Position Paper in relation to the preparation of a regional technical cooperation strategy, recognizing that regional cooperation is the best mechanism to promote effective and open exchange of know-how and experience.

In Latin America, linkages between regional and national activities were strengthened by comparing the regional profile with national CPFs. This was particularly true in the area of environmental management. For example, a project on the 'Use of Nuclear Techniques to Address the Management Problems of Coastal Zones in the Caribbean Region' is fostering collaboration between 12 Member States and with UNEP's Caribbean Regional Coordinating Unit, as well as with France, Italy and Spain.

Environmental Considerations

Following the recommendations of an internal focus group, regarding the development of a systematic approach to environmental issues in the technical cooperation programme, criteria for selecting projects requiring environmental screening and an environmental checklist were drafted and tested on a pilot basis. The checklist will be used during project assessments a year after project implementation. Counterparts will now be formally required to report on progress and the results achieved through the Programme Cycle Management Framework, including relevant environmental information.

"... criteria for selecting projects requiring environmental screening and an environmental checklist were drafted and tested on a pilot basis."

Coordination with Other United Nations Organizations

Participation during 2008 in the United Nations 'Delivering as One' initiative[2] has demonstrated that the process for Agency engagement in the dialogue is complex. Some of the challenges the Agency faces include: lack of representation at the national level; a gap between the policy approach of the United Nations and the Agency's project focus; and the specialized nature of the Agency's mandate and its limited participation in the development debate. The Secretariat's main role in the pilot countries at present is to: continue monitoring the process; promote Agency activities, particularly technical cooperation activities; share information with the United Nations Country Teams (UNCTs) on Agency programmes and activities in order to identify synergies; and engage in dialogue.

The United Republic of Tanzania is one of the pilot countries for the 'Delivering as One' initiative. The Agency is actively monitoring developments at the country level, and is participating in other relevant activities with the UNCT. Following the exchange of information on the technical cooperation programme for that country, the Agency provided inputs for the capacity assessment exercise conducted by the UNCT, participated in the exercise to outline Agency technical cooperation projects in the United Republic of Tanzania and indicated existing linkages with priorities identified under the United Nations Development Assistance Framework.

Financial Highlights

Pledges and payments against the 2008 TCF totalled $75.9 million against the target of $80 million, with the rate of attainment at the end of 2008 standing at 94.7% (Fig. 1), reflecting unpaid pledges of slightly less than $0.1 million.

[2] *Delivering as One: Report of the High-level Panel on United Nations System-wide Coherence in the Areas of Development, Humanitarian Assistance and the Environment*, A/61/583, United Nations, New York (2006).

For the programme as a whole, new resources stood at $91.5 million (including assessed programme costs and national participation costs). Implementation, measured against the adjusted programme for 2008, reached a rate of 72.9%.

Communication and Resource Mobilization

A modular communication strategy was conceptualized in 2007, and the strategic approach was piloted over the course of 2008. The approach focused on the development of key messages and the establishment of a suite of information products that were used to reach out to major stakeholders in the United Nations system (especially UNDP and United Nations coordinators in Agency Member States), the European Commission, the African Development Bank and selected bilateral development agencies, to advance the establishment of formal partnerships. Negotiations with the European Commission to significantly increase extrabudgetary contributions to Agency programmes were advanced during the second half of 2008.

"... the strategic approach ... focused on the development of key messages and the establishment of a suite of information products that were used to reach out to major stakeholders in the United Nations system ..."

Legislative Assistance

During 2008, the Agency intensified its legislative assistance activities.

In particular, the Agency organized seven international and regional workshops and seminars both at Agency Headquarters and abroad. Further, the Agency provided country specific bilateral legislative assistance — by means of written comments and advice in drafting national nuclear legislation — to 23 Member States.

At the request of Member States, individual training on issues related to nuclear legislation was also provided to individuals, notably through short term scientific visits organized at Agency Headquarters and long term programmes where fellows gain practical experience in international nuclear law.

The Agency continued to take part in academic activities organized at the World Nuclear University and the International School of Nuclear Law by providing lecturers and funding for participants through appropriate technical cooperation projects.

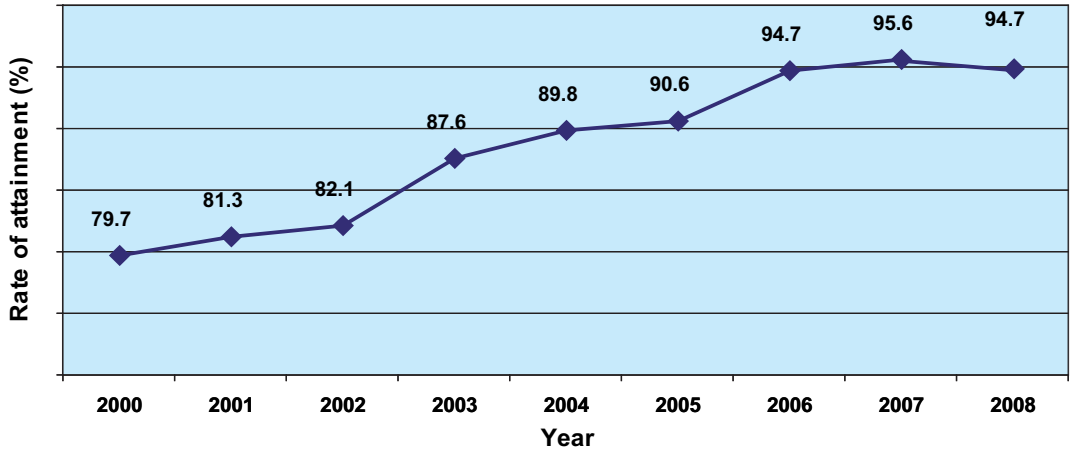


FIG. 1. Rate of attainment of the TCF between 2000 and 2008.

Annex

Note: Tables A19–A23 are available on the attached CD-ROM.

Table A1. Allocation and utilization of regular budget resources in 2008 (unless otherwise indicated, the amounts in this table are in euros)

Major Programme/Programme	Budget			Expenditures		Unused
	Original at $1.0000	Adjusted at $1.4643[a]	Transfers[b]	Amount	% rate of utilization (4) / (2)	(overexpended) adjusted budget (2) + (3) – (4)
	(1)	(2)	(3)	(4)	(5)	(6)
Operational and Recurrent Portion of the Regular Budget						
1. Nuclear Power, Fuel Cycle and Nuclear Science						
Overall Management, Coordination and Common Activities	901 233	837 916		802 375	95.8%	35 541
Nuclear Power	5 655 513	5 194 239	(249)	5 010 284	96.5%	183 706
Nuclear Fuel Cycle and Materials Technologies	2 543 593	2 337 577		2 304 471	98.6%	33 106
Capacity Building and Nuclear Knowledge Maintenance for Sustainable Energy Development	10 278 727	9 568 019		9 559 552	99.9%	8 467
Nuclear Science	9 057 720	8 560 024		8 608 496	100.6%	(48 472)
Subtotal – Major Programme 1	**28 436 786**	**26 497 775**	**(249)**	**26 285 178**	**99.2%**	**212 348**
2. Nuclear Techniques for Development and Environmental Protection						
Overall Management, Coordination and Common Activities	903 350	835 497		1 002 565	120.0%	(167 068)
Food and Agriculture	12 199 485	11 457 089		11 479 588	100.2%	(22 499)
Human Health	8 630 322	8 059 488		8 083 767	100.3%	(24 279)
Water Resources	3 386 477	3 144 698		2 975 899	94.6%	168 799
Environment	5 405 195	5 090 823		5 085 889	99.9%	4 934
Radioisotope Production and Radiation Technology	1 969 056	1 816 012		1 775 899	97.8%	40 113
Subtotal – Major Programme 2	**32 493 885**	**30 403 607**	**0**	**30 403 607**	**100.0%**	**0**
3. Nuclear Safety and Security						
Overall Management, Coordination and Common Activities	913 158	846 395	13 719	886 268	104.7%	(26 154)
Incident and Emergency Preparedness and Response	1 429 642	1 326 984		1 175 998	88.6%	150 986
Safety of Nuclear Installations	8 378 811	7 792 958		7 571 296	97.2%	221 662
Radiation and Transport Safety	5 359 314	4 987 407		5 127 654	102.8%	(140 247)
Management of Radioactive Waste	6 327 422	5 832 801		5 893 360	101.0%	(60 559)
Nuclear Security	1 107 381	1 026 345		1 172 033	114.2%	(145 688)
Subtotal – Major Programme 3	**23 515 728**	**21 812 890**	**13 719**	**21 826 609**	**100.1%**	**0**
4. Nuclear Verification						
Overall Management, Coordination and Common Activities	1 057 670	988 281		951 485	96.3%	36 796
Safeguards	112 614 837	104 803 113	(11 170)	95 299 643	90.9%	9 492 300
Subtotal – Major Programme 4	**113 672 507**	**105 791 394**	**(11 170)**	**96 251 128**	**91.0%**	**9 529 096**
5. Policy, Management and Administration						
Public Information and Communications	3 422 558	3 199 152		2 768 903	86.6%	430 249
Information and Communication Technology (ICT)	8 973 243	8 498 444		8 117 197	95.5%	381 247
Conference, Languages and Publishing Services	5 294 169	5 020 631		5 011 400	99.8%	9 231
Executive Leadership, Policy and Legal Services	14 399 712	13 274 030		12 905 833	97.2%	368 197
Financial Management and Services, Human Resources Management and General Services	40 701 601	39 498 724	(1 958)	39 135 507	99.1%	361 259
Oversight Services	1 677 992	1 549 650		1 429 496	92.2%	120 154
Subtotal – Major Programme 5	**74 469 275**	**71 040 631**	**(1 958)**	**69 368 336**	**97.6%**	**1 670 337**
6. Management of Technical Cooperation for Development						
Management of Technical Cooperation for Development	16 241 201	15 286 181	(342)	14 994 105	98.1%	291 734
Subtotal – Major Programme 6	**16 241 201**	**15 286 181**	**(342)**	**14 994 105**	**98.1%**	**291 734**
Total operational and recurrent budget	**288 829 382**	**270 832 478**	**0**	**259 128 963**	**95.7%**	**11 703 515**
Essential Investments Portion of the Regular Budget						
1. Nuclear Power, Fuel Cycle and Nuclear Science	50 000	44 625		39 136	87.7%	5 489
2. Nuclear Techniques for Development and Environmental Protection	810 000	722 928		722 928	100.0%	0
3. Nuclear Safety and Security	210 000	187 426		186 215	99.4%	1 211
4. Nuclear Verification	1 315 000	1 173 642		169 030	14.4%	1 004 612
5. Policy, Management and Administration	1 314 000	1 254 266		1 127 928	89.9%	126 338
6. Management of Technical Cooperation for Development	312 000	267 182		265 651	99.4%	1 531
Total essential investments	**4 011 000**	**3 650 069**	**0**	**2 510 888**	**68.8%**	**1 139 181**
Total Agency programmes	**292 840 382**	**274 482 547**	**0**	**261 639 851**	**95.3%**	**12 842 696[c]**
Reimbursable work for others	2 490 805	2 309 206		2 991 023	129.5%	(681 817)[d]
Grand total	**295 331 187**	**276 791 753**	**0**	**264 630 874**	**95.6%**	**12 160 879**

[a] Appropriations in General Conference resolution GC(51)/RES/7 of September 2007 were revalued at the UN average rate of exchange of $1.4643 to €1.00.

[b] Based on the decision of the Board of Governors in document GOV/1999/15, an amount of €13 719 was transferred to Major Programme 3 'Nuclear Safety and Security' in order to cover the cost of emergency assistance provided in Belgium, Benin, Canada, Chile, Japan, Mexico and Tunisia in 2008. To cover this advance, the year end unencumbered balance in the Regular Budget of Major Programmes 1, 4, 5 and 6 was used.

[c] €12 842 696 represents the unobligated balances of the 2008 Regular Budget to be carried over into 2009 to meet programmatic needs.

[d] (€681 817) represents the costs of additional services provided to: (i) other VIC based organizations; and (ii) projects financed from the Technical Cooperation Fund and extrabudgetary resources.

Table A2. Extrabudgetary funds in support of the regular budget 2008 (unless otherwise indicated, the amounts in this table are in euros)

Major Programme/Programme	Extrabudgetary budget figures 2008* (1)	Resources: Unused balance as of 1 Jan. 2008 (2)	Resources: New resources in 2008 (3)	Resources: Total available in 2008 (2) + (3) (4)	Expenditure as of 31 Dec. 2008 (5)	Unused balance (4) – (5) (6)
1. Nuclear Power, Fuel Cycle and Nuclear Science						
Overall Management, Coordination and Common Activities	0	0	0	0	0	0
Nuclear Power	1 932 929	2 415 501	1 695 579	4 111 080	2 072 517	2 038 563
Nuclear Fuel Cycle and Materials Technologies	397 177	246 545	320 826	567 371	306 193	261 178
Capacity Building and Nuclear Knowledge Maintenance for Sustainable Energy Development	0	52 707	103 100	155 807	21 008	134 799
Nuclear Science	462 747	160 001	319 943	479 944	388 785	91 159
Subtotal – Major Programme 1	**2 792 853**	**2 874 754**	**2 439 448**	**5 314 202**	**2 788 503**	**2 525 699**
2. Nuclear Techniques for Development and Environmental Protection						
Overall Management, Coordination and Common Activities	0	180 431	112 000	292 431	164 457	127 974
Food and Agriculture	2 222 267	100 502	1 517 085	1 617 587	1 420 661	196 926
Human Health	796 454	715 479	298 016	1 013 495	398 038	615 457
Water Resources	0	98 251	0	98 251	0	98 251
Environment	699 042	124 458	431 968	556 426	436 851	119 575
Radioisotope Production and Radiation Technology	0	3 773	0	3 773	0	3 773
Subtotal – Major Programme 2	**3 717 763**[a]	**1 222 894**	**2 359 069**	**3 581 963**	**2 420 007**	**1 161 956**
3. Nuclear Safety and Security						
Overall Management, Coordination and Common Activities	2 621 943	3 125 631	1 070 544	4 196 175	1 230 682	2 965 493
Incident and Emergency Preparedness and Response	1 226 389	1 171 725	492 886	1 664 611	711 727	952 884
Safety of Nuclear Installations	3 336 793	2 422 638	3 902 389	6 325 027	3 603 042	2 721 985
Radiation and Transport Safety	2 240 114	1 835 260	254 680	2 089 940	1 497 478	592 462
Management of Radioactive Waste	1 313 869	473 191	812 290	1 285 481	534 284	751 197
Nuclear Security	15 500 042	13 637 090	7 119 729	20 756 819	16 776 049	3 980 770
Subtotal – Major Programme 3	**26 239 150**[b]	**22 665 535**	**13 652 518**	**36 318 053**	**24 353 262**	**11 964 791**
4. Nuclear Verification						
Overall Management, Coordination and Common Activities	0	1 944 845	12 187	1 957 032	4 797	1 952 235
Safeguards	20 912 339	17 084 243	10 542 637	27 626 880	10 646 712	16 980 168
Subtotal – Major Programme 4	**20 912 339**	**19 029 088**	**10 554 824**	**29 583 912**	**10 651 509**	**18 932 403**
5. Policy, Management and Administration						
Public Information and Communications	309 840	298 028	209 039	507 067	292 025	215 042
Information and Communication Technology (ICT)	0	321 341	740 387	1 061 728	97 170	964 558
Conference, Languages and Publishing Services	66 554	0	0	0	0	0
Executive Leadership, Policy and Legal Services	0	535 222	223 614	758 836	198 593	560 243
Financial Management and Services, Human Resources Management and General Services	324 941	448 389	1 005 318	1 453 707	313 875	1 139 832
Oversight Services	0	0	0	0	0	0
Subtotal – Major Programme 5	**701 335**	**1 602 980**	**2 178 358**	**3 781 338**	**901 663**	**2 879 675**
6. Management of Technical Cooperation for Development						
Management of Technical Cooperation for Development	0	253 019	234 104	487 123	260 539	226 584
Subtotal – Major Programme 6	**0**	**253 019**	**234 104**	**487 123**	**260 539**	**226 584**
Total extrabudgetary programme fund	**54 363 440**	**47 648 270**	**31 418 321**	**79 066 591**	**41 375 483**	**37 691 108**

* Column (1): Extrabudgetary budget figures include: [a] €2 406 851 from United Nations organizations; and [b] €16 200 967 for the Nuclear Security Fund.

Table A3. Technical cooperation disbursements by Agency programme and region in 2008

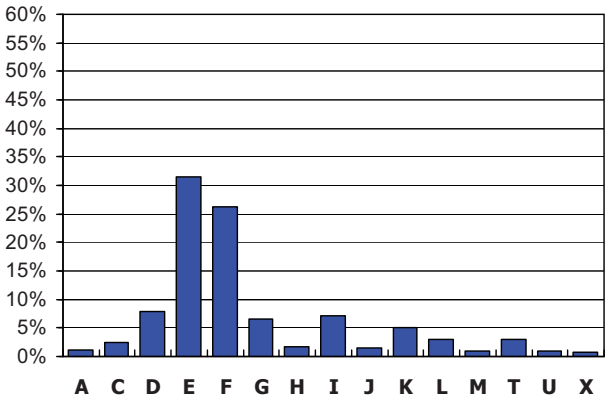
I. Summary of all regions (in thousands of dollars)

	Programme	Africa	Asia and the Pacific	Europe	Latin America	Global/ interregional	Total
A	Nuclear Power	298.7	1273.8	1119.0	682.9	497.4	3871.8
B	Nuclear Fuel Cycle and Materials Technologies	11.9	131.0	44.7	315.0	0.0	502.7
C	Capacity Building and Nuclear Knowledge Maintenance for Sustainable Energy Development	666.8	621.4	594.3	387.0	0.0	2269.5
D	Nuclear Science	2077.6	1465.4	1481.6	654.5	50.7	5729.7
E	Food and Agriculture	8517.3	2374.1	535.8	1969.8	141.2	13 538.3
F	Human Health	7074.7	3113.9	10 969.7	4670.8	1.8	25 830.8
G	Water Resources	1767.3	1205.8	368.9	1171.5	0.0	4513.5
H	Environment	441.1	1431.4	926.5	1305.1	5.0	4109.0
I	Radioisotope Production and Radiation Technology	1940.1	2952.1	1456.1	1183.3	0.0	7531.6
J	Safety of Nuclear Installations	390.2	719.0	2479.6	304.4	33.9	3927.1
K	Radiation and Transport Safety	1354.8	2441.4	2383.2	1248.5	0.0	7427.9
L	Management of Radioactive Waste	795.6	1119.4	6251.4	822.3	137.2	9125.9
M	Nuclear Security	278.4	143.8	302.9	122.8	0.0	847.9
P	Public Information and Communications	14.0	0.0	6.7	0.0	0.0	20.7
T	Management of Technical Cooperation for Development	905.0	1138.7	785.0	1605.6	1265.2	5699.5
U	Executive Management, Policy Making and Coordination	249.7	16.5	53.6	13.6	0.0	333.4
X	Emergency Preparedness	223.9	239.8	377.4	280.8	0.0	1121.9
	Total	27 007.1	20 387.6	30 136.5	16 737.9	2132.3	96 401.4

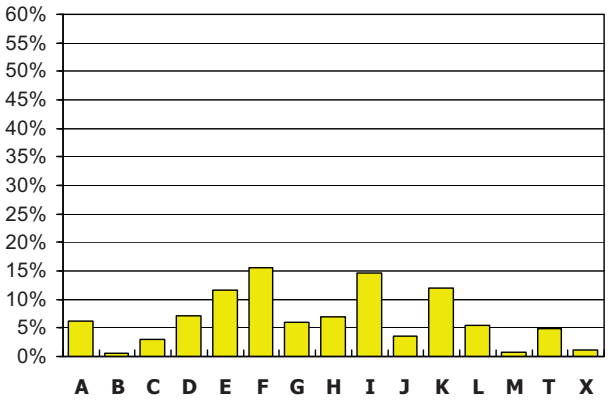
Table A3. Technical cooperation disbursements by Agency programme and region in 2008 (cont.)

II. Distribution by region (in thousands of dollars)

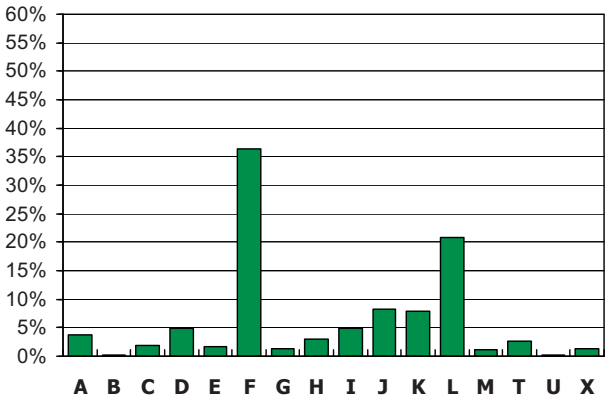
Africa: $27 007.1



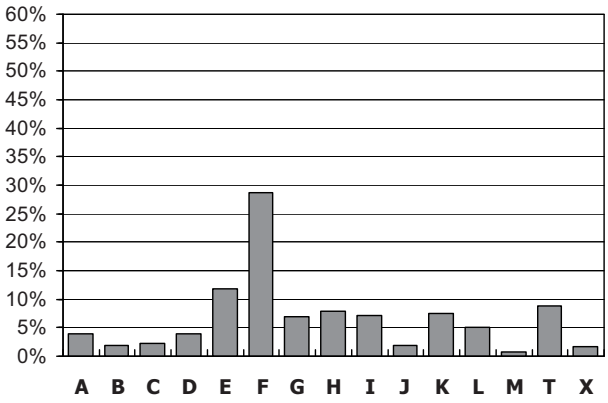
Asia and the Pacific: $20 387.6



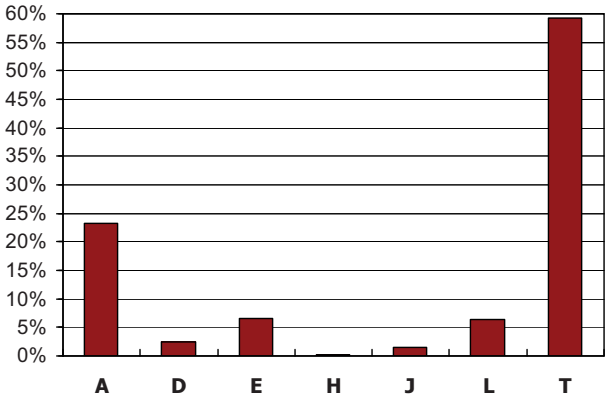
Europe: $30 136.5



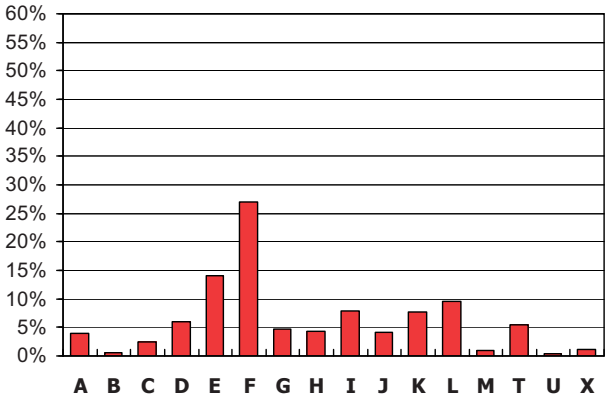
Latin America: $16 737.9



Global/interregional: $2 132.3



Total: $96 401.4



Note: Letters denote Agency programmes, which are explained in the previous summary.

Table A4. Approximate quantities of material subject to Agency safeguards at the end of 2008

Type of material	Quantity of material (SQs)[a]			Quantity in SQs
	Comprehensive safeguards agreements[b]	INFCIRC/66[c] type agreement	Voluntary offer agreements	
Nuclear material				
Plutonium[d] contained in irradiated fuel and in fuel elements in reactor cores	105 657	1 070	15 154	121 881
Separated plutonium outside reactor cores	1 429	5	10 009	11 443
HEU (equal to or greater than 20% ^{235}U)	267	1	49	317
LEU (less than 20% ^{235}U)	15 006	146	795	15 947
Source material[e] (natural and depleted uranium and thorium)	7 576	108	1 379	9 063
U-233	19	—	—	19
Total significant quantities	**129 954**	**1 330**	**27 386**	**158 670**
Non-nuclear material[f]				
Heavy water (tonnes)	0.7	449.3	—	—

[a] SQ: significant quantity. Defined as the approximate amount of nuclear material for which the possibility of manufacturing a nuclear explosive device cannot be excluded. Significant quantities take into account unavoidable losses due to conversion and manufacturing processes and should not be confused with critical masses. They are used in establishing the quantity component of the Agency's inspection goal.

[b] Covering safeguards agreements pursuant to the NPT and/or the Treaty of Tlatelolco and other CSAs; includes facilities in Taiwan, China.

[c] Covering facilities in India, Israel and Pakistan.

[d] The quantity includes an estimated 11 520 SQs of plutonium in irradiated fuel, which is not yet reported to the Agency under the reporting procedures agreed to (the non-reported plutonium is contained in irradiated fuel assemblies to which item accountancy and containment/surveillance measures are applied), and plutonium in fuel elements loaded into cores.

[e] This table does not include material within the terms of subparagraphs 34(a) and (b) of INFCIRC/153 (Corrected).

[f] Non-nuclear material subject to Agency safeguards under INFCIRC/66/Rev.2 type agreements.

Table A5. Number of facilities under safeguards or containing safeguarded material on 31 December 2008

Facility type	Number of facilities			
	Comprehensive safeguards agreements[a]	INFCIRC/66[b] type agreements	Voluntary offer agreements	Total
Power reactors	226	5	1	232
Research reactors and critical assemblies	151	4	1	156
Conversion plants	20	0	0	20
Fuel fabrication plants	42	3	1	46
Reprocessing plants	11	1	1	13
Enrichment plants	13	0	3	16
Separate storage facilities	111	2	6	119
Other facilities	84	0	0	84
Subtotals	**659**	**14**	**13**	**686**
Other locations	444	1	0	445
Totals	**1103**	**15**	**13**	**1131**

[a] Covering safeguards agreements pursuant to the NPT and/or the Treaty of Tlatelolco and other CSAs; includes facilities in Taiwan, China.
[b] Covering facilities in India, Israel and Pakistan.

Table A6. Status with regard to the conclusion of safeguards agreements, additional protocols[a, b] and small quantities protocols[c] (as of 31 December 2008)

State	SQP[c]	Status of safeguards agreement(s)	INFCIRC	Additional protocol status
Afghanistan	X	In force: 20 February 1978	257	In force: 19 July 2005
Albania[1]		In force: 25 March 1988	359	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[2]	X	In force: 9 September 1996	528	
Argentina[3]		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[4]		Accession: 31 July 1996	193	In force: 30 April 2004
Azerbaijan	Amended: 20 November 2006	In force: 29 April 1999	580	In force: 29 November 2000
Bahamas[2]	Amended: 25 July 2007	In force: 12 September 1997	544	
Bahrain	*Signed: 19 September 2007*	*Signed: 19 September 2007*		
Bangladesh		In force: 11 June 1982	301	In force: 30 March 2001
Barbados[2]	X	In force: 14 August 1996	527	
Belarus		In force: 2 August 1995	495	Signed: 15 November 2005
Belgium		In force: 21 February 1977	193	In force: 30 April 2004
Belize[5]	X	In force: 21 January 1997	532	
Benin	*Amended: 15 April 2008*	*Signed: 7 June 2005*		*Signed: 7 June 2005*
Bhutan	X	In force: 24 October 1989	371	
Bolivia[2]	X	In force: 6 February 1995	465	
Bosnia and Herzegovina[6]		In force: 28 December 1973	204	
Botswana		In force: 24 August 2006	694	In force: 24 August 2006
Brazil[7]		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	Amended: 18 February 2008	In force: 17 April 2003	618	In force: 17 April 2003
Burundi	In force: 27 September 2007	In force: 27 September 2007	719	In force: 27 September 2007
Cambodia	X	In force: 17 December 1999	586	
Cameroon	X	In force: 17 December 2004	641	Signed: 16 December 2004
Canada		In force: 21 February 1972	164	In force: 8 September 2000
Cape Verde	*Amended: 27 March 2006*	*Signed: 28 June 2005*		*Signed: 28 June 2005*
Central African Republic	*Approved: 7 March 2006*	*Approved: 7 March 2006*		*Approved: 7 March 2006*

Table A6. Status with regard to the conclusion of safeguards agreements, additional protocols[a, b] and small quantities protocols[c] (as of 31 December 2008) (cont.)

State	SQP[c]	Status of safeguards agreement(s)	INFCIRC	Additional protocol status
Chad	*Approved: 22 November 2007*	*Approved: 22 November 2007*		*Approved: 22 November 2007*
Chile[8]		In force: 5 April 1995	476	In force: 3 November 2003
China		In force: 18 September 1989	369*	In force: 28 March 2002
Colombia[8]		In force: 22 December 1982	306	Signed: 11 May 2005
Comoros	*Signed: 13 December 2005*	*Signed: 13 December 2005*		*Signed: 13 December 2005*
Congo, Republic of the				
Costa Rica[2]	Amended: 12 January 2007	In force: 22 November 1979	278	Signed: 12 December 2001
Côte d'Ivoire		In force: 8 September 1983	309	Signed: 22 October 2008
Croatia	Amended: 26 May 2008	In force: 19 January 1995	463	In force: 6 July 2000
Cuba[2]		In force: 3 June 2004	633	In force: 3 June 2004
Cyprus[9]		Accession: 1 May 2008	193	Accession: 1 May 2008
Czech Republic[10]		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[11]		In force: 21 February 1977	193	In force: 30 April 2004
Djibouti				
Dominica[5]	X	In force: 3 May 1996	513	
Dominican Republic[2]	Amended: 11 October 2006	In force: 11 October 1973	201	Signed: 20 September 2007
Ecuador[2]	Amended: 7 April 2006	In force: 10 March 1975	231	In force: 24 October 2001
Egypt		In force: 30 June 1982	302	
El Salvador[2]	X	In force: 22 April 1975	232	In force: 24 May 2004
Equatorial Guinea	*X*	*Approved: 13 June 1986*		
Eritrea				
Estonia[12]		Accession: 1 December 2005	193	Accession: 1 December 2005
Ethiopia	X	In force: 2 December 1977	261	
Fiji	X	In force: 22 March 1973	192	In force: 14 July 2006
Finland[13]		Accession: 1 October 1995	193	In force: 30 April 2004
France	X	In force: 12 September 1981 In force: 26 October 2007[14]	290* 718	In force: 30 April 2004
Gabon	*X*	*Signed: 3 December 1979*		*Signed: 8 June 2005*
Gambia	X	In force: 8 August 1978	277	
Georgia		In force: 3 June 2003	617	In force: 3 June 2003
Germany[15]		In force: 21 February 1977	193	In force: 30 April 2004
Ghana		In force: 17 February 1975	226	In force: 11 June 2004

Table A6. Status with regard to the conclusion of safeguards agreements, additional protocols[a, b] and small quantities protocols[c] (as of 31 December 2008) (cont.)

State	SQP[c]	Status of safeguards agreement(s)	INFCIRC	Additional protocol status
Greece[16]		Accession: 17 December 1981	193	In force: 30 April 2004
Grenada[2]	X	In force: 23 July 1996	525	
Guatemala[2]	X	In force: 1 February 1982	299	In force: 28 May 2008
Guinea				
Guinea-Bissau				
Guyana[2]	X	In force: 23 May 1997	543	
Haiti[2]	X	In force: 9 March 2006	681	In force: 9 March 2006
Holy See	Amended: 11 September 2006	In force: 1 August 1972	187	In force: 24 September 1998
Honduras[2]	Amended: 20 September 2007	In force: 18 April 1975	235	Signed: 7 July 2005
Hungary[17]		Accession: 1 July 2007	193	Accession: 1 July 2007
Iceland	X	In force: 16 October 1974	215	In force: 12 September 2003
India		In force: 30 September 1971 In force: 17 November 1977 In force: 27 September 1988 In force: 11 October 1989 In force: 1 March 1994 *Approved: 1 August 2008*	211 260 360 374 433	
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	Signed: 9 October 2008
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[2]	Rescinded: 15 December 2006	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	In force: 9 May 2007
Kenya				
Kiribati	X	In force: 19 December 1990	390	Signed: 9 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	629	Signed: 29 January 2007
Lao People's Democratic Republic	X	In force: 5 April 2001	599	
Latvia[18]		Accession: 1 October 2008	193	Accession: 1 October 2008
Lebanon	Amended: 5 September 2007	In force: 5 March 1973	191	
Lesotho	X	In force: 12 June 1973	199	Approved: 24 September 2008
Liberia				

Table A6. Status with regard to the conclusion of safeguards agreements, additional protocols[a, b] and small quantities protocols[c] (as of 31 December 2008) (cont.)

State	SQP[c]	Status of safeguards agreement(s)	INFCIRC	Additional protocol status
Libyan Arab Jamahiriya		In force: 8 July 1980	282	In force: 11 August 2006
Liechtenstein		In force: 4 October 1979	275	Signed: 14 July 2006
Lithuania[19]		Accession: 1 January 2008	193	Accession: 1 January 2008
Luxembourg		In force: 21 February 1977	193	In force: 30 April 2004
Madagascar	Amended: 29 May 2008	In force: 14 June 1973	200	In force: 18 September 2003
Malawi	Amended: 29 February 2008	In force: 3 August 1992	409	In force: 26 July 2007
Malaysia		In force: 29 February 1972	182	Signed: 22 November 2005
Maldives	X	In force: 2 October 1977	253	
Mali	Amended: 18 April 2006	In force: 12 September 2002	615	In force: 12 September 2002
Malta[20]		Accession: 1 July 2007	193	Accession: 1 July 2007
Marshall Islands		In force: 3 May 2005	653	In force: 3 May 2005
Mauritania	X	*Signed: 2 June 2003*		*Signed: 2 June 2003*
Mauritius	Amended: 26 September 2008	In force: 31 January 1973	190	In force: 17 December 2007
Mexico[21]		In force: 14 September 1973	197	Signed: 29 March 2004
Micronesia, Federated States of				
Monaco	Amended: 27 November 2008	In force: 13 June 1996	524	In force: 30 September 1999
Mongolia	X	In force: 5 September 1972	188	In force: 12 May 2003
Montenegro	*Signed: 26 May 2008*	*Signed: 26 May 2008*		*Signed: 26 May 2008*
Morocco	Rescinded: 15 November 2007	In force: 18 February 1975	228	Signed: 22 September 2004
Mozambique	*Approved: 22 November 2007*	*Approved: 22 November 2007*		*Approved: 22 November 2007*
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	X	In force: 5 June 1975 In force: 21 February 1977	229[14] 193	In force: 30 April 2004
New Zealand[22]	X	In force: 29 February 1972	185	In force: 24 September 1998
Nicaragua[2]	X	In force: 29 December 1976	246	In force: 18 February 2005
Niger		In force: 16 February 2005	664	In force: 2 May 2007
Nigeria		In force: 29 February 1988	358	In force: 4 April 2007
Norway		In force: 1 March 1972	177	In force: 16 May 2000
Oman	X	In force: 5 September 2006	691	

Table A6. Status with regard to the conclusion of safeguards agreements, additional protocols[a, b] and small quantities protocols[c] (as of 31 December 2008) (cont.)

State	SQP[c]	Status of safeguards agreement(s)	INFCIRC	Additional protocol status
Pakistan		In force: 5 March 1962 In force: 17 June 1968 In force: 17 October 1969 In force: 18 March 1976 In force: 2 March 1977 In force: 10 September 1991 In force: 24 February 1993 In force: 22 February 2007	34 116 135 239 248 393 418 705	
Palau	Amended: 15 March 2006	In force: 13 May 2005	650	In force: 13 May 2005
Panama[8]	X	In force: 23 March 1984	316	In force: 11 December 2001
Papua New Guinea	X	In force: 13 October 1983	312	
Paraguay[2]	X	In force: 20 March 1979	279	In force: 15 September 2004
Peru[2]		In force: 1 August 1979	273	In force: 23 July 2001
Philippines		In force: 16 October 1974	216	Signed: 30 September 1997
Poland[23]		Accession: 1 March 2007	193	Accession: 1 March 2007
Portugal[24]		Accession: 1 July 1986	193	In force: 30 April 2004
Qatar	*Approved: 24 September 2008*	*Approved: 24 September 2008*		
Republic of Moldova	X	In force: 17 May 2006	690	Approved: 13 September 2006
Romania		In force: 27 October 1972	180	In force: 7 July 2000
Russian Federation		In force: 10 June 1985	327*	In force: 16 October 2007
Rwanda				
Saint Kitts and Nevis[5]	X	In force: 7 May 1996	514	
Saint Lucia[5]	X	In force: 2 February 1990	379	
Saint Vincent and the Grenadines[5]	X	In force: 8 January 1992	400	
Samoa	X	In force: 22 January 1979	268	
San Marino	X	In force: 21 September 1998	575	
Sao Tome and Principe				
Saudi Arabia	X	*Signed: 16 June 2005*		
Senegal	X	In force: 14 January 1980	276	Signed: 15 December 2006
Serbia[25]		In force: 28 December 1973	204	
Seychelles	Amended: 31 October 2006	In force: 19 July 2004	635	In force: 13 October 2004
Sierra Leone	X	*Signed: 10 November 1977*		
Singapore	Amended: 31 March 2008	In force: 18 October 1977	259	In force: 31 March 2008
Slovakia[26]		Accession: 1 Dec. 2005	193	Accession: 1 December 2005
Slovenia[27]		Accession: 1 September 2006	193	Accession: 1 September 2006
Solomon Islands	X	In force: 17 June 1993	420	
Somalia				
South Africa		In force: 16 September 1991	394	In force: 13 September 2002

Table A6. Status with regard to the conclusion of safeguards agreements, additional protocols[a, b] and small quantities protocols[c] (as of 31 December 2008) (cont.)

State	SQP[c]	Status of safeguards agreement(s)	INFCIRC	Additional protocol status
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[2]	X	In force: 2 February 1979	269	
Swaziland	X	In force: 28 July 1975	227	Approved: 4 March 2008
Sweden[28]		Accession: 1 June 1995	193	In force: 30 April 2004
Switzerland		In force: 6 September 1978	264	In force: 1 February 2005
Syrian Arab Republic		In force: 18 May 1992	407	
Tajikistan	Amended: 6 March 2006	In force: 14 December 2004	639	In force: 14 December 2004
Thailand		In force: 16 May 1974	241	Signed: 22 September 2005
The Former Yugoslav Rep. of Macedonia	X	In force: 16 April 2002	610	In force: 11 May 2007
Timor-Leste	*Approved: 11 September 2007*	*Approved: 11 September 2007*		*Approved: 11 September 2007*
Togo	X	*Signed: 29 November 1990*		*Signed: 26 September 2003*
Tonga	X	In force: 18 November 1993	426	
Trinidad and Tobago[2]	X	In force: 4 November 1992	414	
Tunisia		In force: 13 March 1990	381	Signed: 24 May 2005
Turkey		In force: 1 September 1981	295	In force: 17 July 2001
Turkmenistan		In force: 3 January 2006	673	In force: 3 January 2006
Tuvalu	X	In force: 15 March 1991	391	
Uganda	X	In force: 14 February 2006	674	In force: 14 February 2006
Ukraine		In force: 22 January 1998	550	In force: 24 January 2006
United Arab Emirates	X	In force: 9 October 2003	622	
United Kingdom	X	In force: 14 December 1972 In force: 14 August 1978 *Approved: 16 September 1992*[14]	175[29] 263* 	In force: 30 April 2004
United Republic of Tanzania	X	In force: 7 February 2005	643	In force: 7 February 2005
United States of America	X	In force: 9 December 1980 In force: 6 April 1989	288* 366[14]	Signed: 12 June 1998
Uruguay[2]		In force: 17 September 1976	157	In force: 30 April 2004
Uzbekistan		In force: 8 October 1994	508	In force: 21 December 1998
Vanuatu				
Venezuela[2]		In force: 11 March 1982	300	
Vietnam		In force: 23 February 1990	376	Signed: 10 August 2007
Yemen, Republic of	X	In force: 14 August 2002	614	
Zambia	X	In force: 22 September 1994	456	Approved: 27 November 2008
Zimbabwe	X	In force: 26 June 1995	483	

Key

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.

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[a] This table 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 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 that conclude CSAs, provided that they fulfil certain conditions (including that the quantities of nuclear material do not exceed the limits of paragraph 37 of INFCIRC/153), have the option to conclude a so-called "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 which, as far as the Secretariat is aware, these conditions continue to apply. For those States that have accepted the modified standard SQP text, which was approved by the Board of Governors on 20 September 2005, the current status is reflected.

[1] 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. (INFCIRC 359/Mod.1)

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

[3] Date refers to the safeguards agreement concluded between Argentina, Brazil, ABACC and the Agency. On 18 March 1997, upon approval by the Board of Governors, an exchange of letters entered into force between Argentina and the Agency confirming that the safeguards agreement 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.

[4] The application of safeguards in Austria under the NPT bilateral 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 between the non-nuclear weapon States of Euratom, Euratom and the Agency (INFCIRC/193), to which Austria had acceded, entered into force for Austria.

[5] Date refers to a safeguards agreement pursuant to Article III of the NPT. Upon approval by the Board of Governors, an exchange of letters entered into force (for Saint Lucia on 12 June 1996 and for Belize, Dominica, Saint Kitts and Nevis, and Saint Vincent and the Grenadines on 18 March 1997) confirming that the safeguards agreement satisfies the requirement of Article 13 of the Treaty of Tlatelolco.

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

[7] Date refers to the safeguards agreement concluded between Argentina, Brazil, ABACC and the Agency. On 10 June 1997, upon approval by the Board of Governors, an exchange of letters entered into force between Brazil and the Agency confirming that the safeguards agreement 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.

[8] Date refers to a safeguards agreement pursuant to Article 13 of the Treaty of Tlatelolco. Upon approval by the Board of Governors an exchange of letters entered into force (for Chile on 9 September 1996; for Colombia on 13 June 2001; for Panama on 20 November 2003) confirming that the safeguards agreement satisfies the requirement of Article III of the NPT.

[9] The application of safeguards in Cyprus under the NPT safeguards agreement INFCIRC/189, in force since 26 January 1973, was suspended on 1 May 2008, on which date the agreement of 5 April 1973 between the non-nuclear-weapon States of Euratom, Euratom and the Agency (INFCIRC/193) to which Cyprus had acceded, entered into force for Cyprus.

[10] 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.

[11] The application of safeguards in Denmark under the bilateral NPT safeguards agreement INFCIRC/176, in force since 1 March 1972, was suspended on 5 April 1973, on which date the agreement of 5 April 1973 (INFCIRC/193) between the non-nuclear-weapon States of Euratom, Euratom and the Agency (INFCIRC/193), to which Denmark had acceded, entered into force for Denmark. 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.

[12] The application of safeguards in Estonia under the NPT safeguards agreement INFCIRC/547, in force since 24 November 1997, was suspended on 1 December 2005, on which date the agreement of 5 April 1973 between the non-nuclear-weapon States of Euratom, Euratom and the Agency (INFCIRC/193), to which Estonia had acceded, entered into force for Estonia.

[13] The application of safeguards in Finland under the bilateral 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 between the non-nuclear-weapon States of Euratom, Euratom and the Agency (INFCIRC/193), to which Finland had acceded, entered into force for Finland.

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

[15] 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.

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

[17] The application of safeguards in Hungary under the bilateral NPT safeguards agreement INFCIRC/174, in force since 30 March 1972, was suspended on 1 July 2007, on which date the agreement of 5 April 1973 between the non-nuclear-weapon States of Euratom, Euratomand the Agency (INFCIRC/193), to which Hungary had acceded, entered into force for Hungary.

[18] The application of safeguards in Latvia under the bilateral NPT safeguards agreement INFCIRC/434, in force since 21 December 1993, was suspended on 1 October 2008, on which date the agreement of 5 April 1973 between the non-nuclear-weapon States of Euratom, Euratom and the Agency (INFCIRC/193), to which Latvia had acceded, entered into force for Latvia.

[19] The application of safeguards in Lithuania under the bilateral NPT safeguards agreement INFCIRC/413, in force since 15 October 1992, was suspended on 1 January 2008, on which date the agreement of 5 April 1973 between the non-nuclear-weapon States of Euratom, Euratom and the Agency (INFCIRC/193), to which Lithuania had acceded, entered into force for Lithuania.

[20] The application of safeguards in Malta under the bilateral NPT safeguards agreement INFCIRC/387, in force since 13 November 1990, was suspended on 1 July 2007, on which date the agreement of 5 April 1973 between the non-nuclear-weapon States of Euratom, Euratom and the Agency (INFCIRC/193), to which Malta had acceded, entered into force for Malta.

[21] 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.

[22] Whereas the NPT safeguards agreement and SQP with New Zealand (INFCIRC/185) also apply to Cook Islands and Niue, the AP thereto (INFCIRC/185/Add.1) does not apply to those territories.

[23] The application of safeguards in Poland under the NPT safeguards agreement INFCIRC/179, in force since 11 October 1972, was suspended on 1 March 2007, on which date the agreement of 5 April 1973 between the non-nuclear-weapon States of Euratom, Euratom and the Agency (INFCIRC/193), to which Poland had acceded, entered into force for Poland.

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

[25] 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 (formerly Serbia and Montenegro) to the extent relevant to the territory of Serbia.

[26] The application of safeguards in Slovakia under the bilateral NPT safeguards agreement with the Czechoslovak Socialist Republic (INFCIRC 173), in force since 3 March 1972, was suspended on 1 December 2005, on which date the agreement of 5 April 1973 between the non-nuclear-weapon States of Euratom, Euratom and the Agency (INFCIRC/193), to which Slovakia had acceded, entered into force for Slovakia.

[27] The application of safeguards in Slovenia under the NPT safeguards agreement INFCIRC/538, in force since 1 August 1997, was suspended on 1 September 2006, on which date the agreement of 5 April 1973 between the non-nuclear-weapon States of Euratom, Euratom and the Agency (INFCIRC/193) to which Slovenia had acceded, entered into force for Slovenia.

[28] 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 between the non-nuclear-weapon States of Euratom, Euratom and the Agency (INFCIRC/193), to which Sweden had acceded, entered into force for Sweden.

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

Table A7. Participation by States in multilateral treaties for which the Director General is depositary, conclusion of Revised Supplementary Agreements and acceptance of amendments to Articles VI and XIV.A of the Agency's Statute (status as of 31 December 2008)

	STATE	P&I	VC	CPPNM	CPPNM-AM	ENC	AC	JP	NS	RADW	PAVC	SUPP	RSA	VI	XIV.A
*	AFGHANISTAN			P		Sr	Sr						S	P	
*	ALBANIA	P		P		P	P						S	P	P
*	ALGERIA			Pr	CS	Pr	Pr		S				S	P	P
	ANDORRA			Pr											
*	ANGOLA					P							S		
	ANTIGUA BARBUDA			P											
*	ARGENTINA	P	P	Pr		Pr	Pr	S	P	P	P	CS	S	P	P
*	ARMENIA		P	P		P	P		P				S		
*	AUSTRALIA	P		P	CS	Pr	Pr		P	P		S			
*	AUSTRIA			Pr	CS	P	Pr		Pr	P				P	P
*	AZERBAIJAN			Pr									S		
	BAHAMAS			Pr											
	BAHRAIN														
*	BANGLADESH			P		P	P		P				S		
	BARBADOS														
*	BELARUS	Pr	P	Pr		Pr	Pr		P	P	P		S	P	P
*	BELGIUM	Pr		Pr		P	P	S	P	P					
*	BELIZE												S		
*	BENIN	P											S		
	BHUTAN														
*	BOLIVIA	P	P	P		Pr	Pr						S		
*	BOSNIA AND HER.		P	P		P	P								
*	BOTSWANA			P									S		
*	BRAZIL	P	P	P		P	P		P	P			S	P	P
	BRUNEI														
*	BULGARIA	P	P	P	CS	P	P	P	P	P			S	P	P
*	BURKINA FASO			P									S		
	BURUNDI														
	CAMBODIA			P											
*	CAMEROON	P	P	P		P	P	P					S		
*	CANADA	Pr		P		Pr	Pr		P	P				P	P

Table A7. Participation by States in multilateral treaties for which the Director General is depositary, conclusion of Revised Supplementary Agreements and acceptance of amendments to Articles VI and XIV.A of the Agency's Statute (status as of 31 December 2008) (cont.)

	STATE	P&I	VC	CPPNM	CPPNM-AM	ENC	AC	JP	NS	RADW	PAVC	SUPP	RSA	VI	XIV.A
	CAPE VERDE			P											
*	CENT. AFR. REP.			P											
*	CHAD														
*	CHILE	Pr	Pr	P		P	P	P	P				S		
*	CHINA	Pr		Pr		Pr	Pr		P	Pr			S		
*	COLOMBIA	P	S	P		P	Pr						S		
	COMOROS			P											
	CONGO														
*	COSTA RICA			P		P	P						S		
*	CÔTE D'IVOIRE					S	S						S		
*	CROATIA	P	P	P	CS	P	P	P	P	P			S	P	P
*	CUBA	Pr	P	Pr		Pr	Pr		S				S		
*	CYPRUS	P		Pr		P	P		P				S		
*	CZECH REPUBLIC	P	P	P		P	P	P	P	P	S	S	S	P	P
	DPRK					Sr	Sr								
*	D. REP. CONGO	P		P		S	S						S		
*	DENMARK	Pr		P		P	Pr	P	Pr	Pr					
	DJIBOUTI			P											
	DOMINICA			P											
*	DOMINICAN REP.			S									S		
*	ECUADOR	P		P									S		
*	EGYPT	P	P			Pr	Pr	P	S				S		
*	EL SALVADOR			P		Pr	Pr						S	P	
	EQ. GUINEA			P											
*	ERITREA														
*	ESTONIA	P	P	P		P	P	P	P	P			S		
*	ETHIOPIA												S	P	
	FIJI			P	CS										
*	FINLAND	P		Pr		P	Pr	P	P	P				P	P
*	FRANCE			Pr		Pr	Pr	S	P	P				P	P
*	GABON			P	CS	P	P								

Table A7. Participation by States in multilateral treaties for which the Director General is depositary, conclusion of Revised Supplementary Agreements and acceptance of amendments to Articles VI and XIV.A of the Agency's Statute (status as of 31 December 2008) (cont.)

	STATE	P&I	VC	CPPNM	CPPNM-AM	ENC	AC	JP	NS	RADW	PAVC	SUPP	RSA	VI	XIV.A
	GAMBIA														
*	GEORGIA			P									S		
*	GERMANY	Pr		Pr		Pr	Pr	P	P	P				P	P
*	GHANA	P		P					S				S		
*	GREECE	P		Pr		Pr	Pr	P	P	P			S	P	P
	GRENADA			P											
*	GUATEMALA			Pr		P	P						S		
	GUINEA			P											
	GUINEA-BISSAU			P											
	GUYANA			P											
*	HAITI			S									S		
*	HOLY SEE	P				S	S							P	P
*	HONDURAS			P									S		
*	HUNGARY	Pr	P	P	CS	P	P	P	P	P	S		S	P	P
*	ICELAND	P		P		P	P		P	P			S	P	P
*	INDIA	P		Pr	CS	Pr	Pr		P						
*	INDONESIA	Pr		Pr		Pr	Pr		P	S	S	S	S		
*	IRAN, ISL. REP.	P				Pr	Pr						S		P
*	IRAQ	P				Pr	Pr						S		
*	IRELAND	P		Pr		P	Pr		P	P			S	P	P
*	ISRAEL		Sr	Pr		Pr	Pr		S				S		
*	ITALY	Pr		Pr		Pr	Pr	P	P	P	S	S		P	P
*	JAMAICA	P		P									S		
*	JAPAN	P		P		P	Pr		P	Pr				P	P
*	JORDAN	Pr				P	P		S				S		
*	KAZAKHSTAN	P		P					S	S			S		
*	KENYA			P	CS								S		P
	KIRIBATI														
*	KOREA, REP. OF	Pr		Pr		P	Pr		P	P			S	P	P
*	KUWAIT	P		Pr		P	P		P				S		
*	KYRGYZSTAN									P			S		

Table A7. Participation by States in multilateral treaties for which the Director General is depositary, conclusion of Revised Supplementary Agreements and acceptance of amendments to Articles VI and XIV.A of the Agency's Statute (status as of 31 December 2008) (cont.)

	STATE	P&I	VC	CPPNM	CPPNM-AM	ENC	AC	JP	NS	RADW	PAVC	SUPP	RSA	VI	XIV.A
	LAO P. DEM. REP.														
*	LATVIA	P	P	P		P	P	P	P	P	P		S	P	P
*	LEBANON		P	P		P	P		P	S	S	S	S		
	LESOTHO														
*	LIBERIA														
*	LIBYAN ARAB J.			P	CS		P						S	P	
*	LIECHTENSTEIN			P		P	P							P	P
*	LITHUANIA	P	P	P		P	P	P	P	P	S	S	S	P	P
*	LUXEMBOURG	Pr		Pr		P	P		P	P				P	P
*	MADAGASCAR			P									S		
*	MALAWI														
*	MALAYSIA					Pr	Pr						S		
	MALDIVES														
*	MALI			P		P	P		P				S		
*	MALTA			P									S	P	P
*	MARSHALL IS.			P											
*	MAURITANIA			P	CS										
*	MAURITIUS	P				Pr	Pr						S		
*	MEXICO	Pr	P	P		P	P		P				S	P	
	MICRONESIA														
*	MONACO			P		Pr	Pr		S					P	P
*	MONGOLIA	P		P		P	P						S		
*	MONTENEGRO	P	P	P		P	P						S		
*	MOROCCO	Pr	S	P		P	P	S	S	P	P	CS	S	P	
*	MOZAMBIQUE			Pr											
*	MYANMAR					Pr							S	P	P
*	NAMIBIA			P									S		
	NAURU			P											
*	NEPAL														
*	NETHERLANDS	P		Pr		Pr	Pr	P	P	P				P	P
*	NEW ZEALAND	P		P		P	Pr								

Table A7. Participation by States in multilateral treaties for which the Director General is depositary, conclusion of Revised Supplementary Agreements and acceptance of amendments to Articles VI and XIV.A of the Agency's Statute (status as of 31 December 2008) (cont.)

	STATE	P&I	VC	CPPNM	CPPNM-AM	ENC	AC	JP	NS	RADW	PAVC	SUPP	RSA	VI	XIV.A
*	NICARAGUA	P		P		Pr	Pr		S				S		
*	NIGER	P	P	P		S	S						S		
*	NIGERIA	P	P	P	CS	P	P		P	P			S		
*	NORWAY	P		Pr		P	Pr	P	P	P					
	OMAN			Pr											
*	PAKISTAN	Pr		Pr		Pr	Pr		P				S	P	P
*	PALAU			P											
*	PANAMA			P		P	P						S	P	
	PAPUA N. GUINEA														
*	PARAGUAY			P		S	S						S		
*	PERU		P	Pr		Pr	Pr		P	S	S	S	S	P	P
*	PHILIPPINES	P	P	P		P	P	S	S	S	S	S	S		
*	POLAND	P	P	P	CS	P	P	P	P	P	S		S	P	P
*	PORTUGAL	Pr		Pr		P	P	S	P				S		
*	QATAR			Pr		P	P						S		
*	REP. OF MOLDOVA	Pr	P	P	CS	P	P		P				S		
*	ROMANIA	Pr	P	Pr	CS	Pr	Pr	P	P	P	P	CS	S	P	P
*	RUSSIAN FED.	Pr	P	Pr	CS	Pr	Pr		P	P					
	RWANDA														
	ST KITTS NEVIS			P											
	SAINT LUCIA														
	ST VINCT GRN.		P			P	P	P							
	SAMOA														
	SAN MARINO														
	SAO TOME PRN.														
*	SAUDI ARABIA					Pr	Pr						S		
*	SENEGAL	P		P		S	S						S		
*	SERBIA	P	P	P		P	P						S		
*	SEYCHELLES			P	CS								S		
*	SIERRA LEONE					S	S						S		
*	SINGAPORE	Pr				P	P		P				S		

Table A7. Participation by States in multilateral treaties for which the Director General is depositary, conclusion of Revised Supplementary Agreements and acceptance of amendments to Articles VI and XIV.A of the Agency's Statute (status as of 31 December 2008) (cont.)

	STATE	P&I	VC	CPPNM	CPPNM-AM	ENC	AC	JP	NS	RADW	PAVC	SUPP	RSA	VI	XIV.A
*	SLOVAKIA	P	P	P		Pr	Pr	P	P	P			S	P	P
*	SLOVENIA	P		P		P	P	P	P	P			S	P	P
	SOLOMON ISLANDS														
	SOMALIA														
*	SOUTH AFRICA	Pr		Pr		Pr	Pr		P	P			S		
*	SPAIN	P	S	Pr	CS	Pr	Pr	S	P	P			S	P	P
*	SRI LANKA					Pr	Pr		P				S		
*	SUDAN			P		S	S		S				S		
	SURINAME														
	SWAZILAND			P											
*	SWEDEN	P		Pr		P	Pr	P	P	P				P	P
*	SWITZERLAND	Pr		Pr	CS	P	P	S	P	P				P	P
*	SYRIAN ARAB REP.	P				S	S		S				S		
*	TAJIKISTAN			P									S		
*	THAILAND	Pr				Pr	Pr						S		
*	TFYR MACEDONIA		P	P		P	P		P				S		
	TIMOR LESTE														
	TOGO			P											
	TONGA			P											
	TRINIDAD TOBAGO		P	P											
*	TUNISIA	P		P		P	P		S				S		P
*	TURKEY	Pr		Pr		Pr	Pr	P	P				S	P	P
	TURKMENISTAN			P	CS										
	TUVALU														
*	UGANDA			P									S		
*	UKRAINE	Pr	P	P	CS	Pr	Pr	P	Pr	P	S	S	S	P	P
*	UTD ARAB EMR.			P		Pr	Pr						S		
*	UNITED KINGDOM	P	S	Pr		Pr	Pr	S	P	P				P	P
*	UTD REP. TANZ.			P		P	P						S		
*	USA			P		Pr	Pr		P	P		CS			
*	URUGUAY		P	P		P	P		P	P			S		

Table A7. Participation by States in multilateral treaties for which the Director General is depositary, conclusion of Revised Supplementary Agreements and acceptance of amendments to Articles VI and XIV.A of the Agency's Statute (status as of 31 December 2008) (cont.)

	STATE	P&I	VC	CPPNM	CPPNM-AM	ENC	AC	JP	NS	RADW	PAVC	SUPP	RSA	VI	XIV.A
*	**UZBEKISTAN**			P									S		
	VANUATU														
*	**VENEZUELA**												S		
*	**VIETNAM**	P				Pr	Pr						S		
*	**YEMEN**			P											
*	**ZAMBIA**												S		
*	**ZIMBABWE**					S	S						S		

P&I	Agreement on the Privileges and Immunities of the IAEA
VC	Vienna Convention on Civil Liability for Nuclear Damage
CPPNM	Convention on the Physical Protection of Nuclear Material
CPPNM-AM	Amendment to the Convention on the Physical Protection of Nuclear Material
ENC	Convention on Early Notification of a Nuclear Accident
AC	Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency
JP	Joint Protocol Relating to the Application of the Vienna Convention and the Paris Convention
NS	Convention on Nuclear Safety
RADW	Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management
PAVC	Protocol to Amend the Vienna Convention on Civil Liability for Nuclear Damage
SUPP	Convention on Supplementary Compensation for Nuclear Damage (not yet entered into force)
RSA	Revised Supplementary Agreement Concerning the Provision of Technical Assistance by the IAEA
VI	Acceptance of Amendment to Article VI of the IAEA Statute
XIV.A	Acceptance of Amendment to Article XIV.A of the IAEA Statute
*	Agency Member State
P	Party
S	Signatory
r	Existing reservation/declaration
CS	Contracting State

Table A8. Conventions negotiated and adopted under the auspices of the Agency and/or for which the Director General is the depositary (status and relevant developments)

Agreement on the Privileges and Immunities of the IAEA (reproduced in INFCIRC/9/Rev.2). In 2008, one State accepted the Agreement. By the end of the year, there were 79 Parties.

Vienna Convention on Civil Liability for Nuclear Damage (reproduced in INFCIRC/500). Entered into force on 12 November 1977. In 2008, one State adhered to the Convention. By the end of the year, there were 35 Parties.

Optional Protocol Concerning the Compulsory Settlement of Disputes (reproduced in INFCIRC/500/Add.3). Entered into force on 13 May 1999. In 2008, the status remained unchanged with two Parties.

Convention on the Physical Protection of Nuclear Material (reproduced in INFCIRC/274/Rev.1). Entered into force on 8 February 1987. In 2008, seven States adhered to the Convention. By the end of the year, there were 138 Parties.

Amendment to the Convention on the Physical Protection of Nuclear Material. Adopted on 8 July 2005. In 2008, nine States adhered to the Amendment, bringing the total to 22 States.

Convention on Early Notification of a Nuclear Accident (reproduced in INFCIRC/335). Entered into force on 27 October 1986. In 2008, two States adhered to the Convention. By the end of the year, there were 102 Parties.

Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency (reproduced in INFCIRC/336). Entered into force on 26 February 1987. In 2008, three States adhered to the Convention. By the end of the year, there were 101 Parties.

Joint Protocol Relating to the Application of the Vienna Convention and the Paris Convention (reproduced in INFCIRC/402). Entered into force on 27 April 1992. In 2008, the status remained unchanged with 25 Parties.

Convention on Nuclear Safety (reproduced in INFCIRC/449). Entered into force on 24 October 1996. In 2008, two States adhered to the Convention. By the end of the year, there were 62 Parties.

Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management (reproduced in INFCIRC/546). Entered into force on 18 June 2001. In 2008, one State adhered to the Convention. By the end of the year, there were 46 Parties.

Protocol to Amend the Vienna Convention on Civil Liability for Nuclear Damage (reproduced in INFCIRC/566). Entered into force on 4 October 2003. In 2008, the status remained unchanged with five Parties.

Convention on Supplementary Compensation for Nuclear Damage (reproduced in INFCIRC/567). Opened for signature on 29 September 1997. In 2008, 1 State adhered to the Convention. By the end of the year, there were 4 Contracting States and 13 Signatories.

Revised Supplementary Agreement Concerning the Provision of Technical Assistance by the IAEA (RSA). In 2008, the status remained unchanged with 109 states that concluded RSA Agreements.

Fourth Agreement to Extend the 1987 Regional Co-operative Agreement for Research, Development and Training Related to Nuclear Science and Technology (RCA) (reproduced in INFCIRC/167/Add.22). Entered into force on 26 February 2007 with effect from 12 June 2007. In 2008, the status remained unchanged with 13 Parties.

African Regional Co-operative Agreement for Research, Development and Training Related to Nuclear Science and Technology (AFRA) (Third Extension) (reproduced in INFCIRC/377). Entered into force on 4 April 2005. In 2008, the status remained unchanged with 30 Parties.

Table A8. Conventions negotiated and adopted under the auspices of the Agency and/or for which the Director General is the depositary (status and relevant developments) (cont.)

Co-operation Agreement for the Promotion of Nuclear Science and Technology in Latin America and the Caribbean (ARCAL) (reproduced in INFCIRC/582). Entered into force on 5 September 2005. In 2008, one State adhered to the Agreement. By the end of the year, there were 15 Parties.

Co-operative Agreement for Arab States in Asia for Research, Development and Training Related to Nuclear Science and Technology (ARASIA) (First Extension) (reproduced in INFCIRC/613/Add.2). Entered into force on 29 July 2008. In 2008, there were seven Parties.

Agreement on the Establishment of the ITER International Fusion Energy Organization for the Joint Implementation of the ITER Project (reproduced in INFCIRC/702). Entered into force on 24 October 2007. In 2008, the status remained unchanged with seven Parties.

Agreement on the Privileges and Immunities of the ITER International Fusion Energy Organization for the Joint Implementation of the ITER Project (reproduced in INFCIRC/703). Entered into force on 24 October 2007. In 2008, the status remained unchanged with six Parties.

Table A9. Integrated Regulatory Review Service (IRRS) missions in 2008

Type	Country
IRRS information meeting and self-assessment seminar	Islamic Republic of Iran
Preparatory IRRS	Canada
Preparatory IRRS	Germany
Preparatory IRRS	Lebanon
Preparatory IRRS	Peru
Preparatory IRRS	Russian Federation
Preparatory IRRS	Ukraine
Preparatory IRRS	Vietnam
Preparatory meeting for Follow-up IRRS	France
IRRS	Botswana
IRRS	Côte d'Ivoire
IRRS	Germany
IRRS	Guatemala
IRRS	Madagascar
IRRS	Namibia
IRRS	Sierra Leone
IRRS	Spain
IRRS	Ukraine

Table A10. Operational Safety Review Team (OSART) missions in 2008		
Type	**Nuclear power plant**	**Country**
Preparatory OSART	Armenia	Armenia
Preparatory OSART	Fessenheim	France
Preparatory OSART	Vandellos II	Spain
Preparatory OSART	Oskarshamn	Sweden
Preparatory OSART	Rovno	Ukraine
OSART	Cruas	France
OSART	Balakovo	Russian Federation
OSART	Forsmark	Sweden
OSART	Rovno	Ukraine
OSART	Arkansas Nuclear One	USA
Follow-up OSART	Loviisa	Finland
Follow-up OSART	St. Laurent	France
Follow-up OSART	Ignalina	Lithuania
Follow-up OSART	Mochovce	Slovakia

Table A11. Peer Review of Operational Safety Performance Experience (PROSPER) missions in 2008		
Type	**Organization/Nuclear power plant**	**Country**
PROSPER	Magnox	United Kingdom
Follow-up PROSPER	Santa Maria de Garona	Spain

Table A12. Review of Accident Management Programme (RAMP) missions in 2008	
Type	**Country**
RAMP	China

Table A13. Integrated Safety Assessment of Research Reactors (INSARR) missions in 2008		
Type	**Location**	**Country**
Pre-INSARR	Almaty	Kazakhstan
Pre-INSARR	Tashkent	Uzbekistan
INSARR	Almaty	Kazakhstan
INSARR	Tashkent	Uzbekistan

Table A14. Emergency Preparedness Review (EPREV) missions in 2008	
Type	**Country**
EPREV	Kyrgyzstan
EPREV	Montenegro
EPREV	Tunisia
EPREV	Uzbekistan

Table A15. Safety review service and expert missions in 2008	
Type	**Country**
Advisory mission in relation to site selection and evaluation studies for nuclear power plants	Algeria
Seismic Safety Review Missions (2)	Armenia
Advisory mission for the preparation of the national emergency exercise Aragats 2008	Armenia
Expert mission to observe and evaluate the national emergency exercise Aragats 2008	Armenia
Expert mission to review the current infrastructure for the introduction of a nuclear power programme	Bangladesh
Advisory mission in relation to nuclear power plant site selection and evaluation	Belarus
Advisory mission in relation to geotechnical investigations for nuclear power plant site selection project	Belarus
Advisory mission on further upgrading of emergency notification system of the Ministry of Emergencies	Belarus
Advisory mission on notification procedures and information exchange in case of radiation emergency	Belarus
Expert mission to evaluate the radiation protection programme and the status of implementation of the national dose records register	Belarus
Expert mission to assist in an emergency response	Benin
Expert mission to establish a verified source inventory and an orphan source search plan	Botswana
Expert mission to review the new technical design of BNCT facility and provide assistance in the equipment specification	Bulgaria
Seismic review service follow-up mission to Kozloduy nuclear power plant	Bulgaria
Expert mission to provide practical expertise on individual internal monitoring	Bulgaria
Expert mission to develop the regulatory body inspection programme	Burkina Faso
Advisory mission on national regulatory infrastructure for the control of radiation sources	Burundi
Expert mission to analyse the situation of regulatory controls at radiotherapy centres	Cameroon
Expert mission to review the integrated safety review process of Pickering B nuclear power plant	Canada
Advisory mission on national regulatory infrastructure for the control of radiation sources	Central African Republic
Expert mission to discuss projects and deliver lectures on energy options, and regulatory infrastructure	Chile
Advisory mission on national regulatory infrastructure for the control of radiation sources	Chile
Advisory mission on implementation programme for the optimization of dose to patients in interventional paediatric cardiology	Chile
Safety review mission on development of ageing management programme and methodology	China
Advisory mission on demonstrating the safety of geological disposal	China

Table A15. Safety review service and expert missions in 2008 (cont.)	
Type	**Country**
Expert mission to assist radiological protection of patients in medical exposure from interventional cardiology and methodology to follow up on radiation injuries, including potential lens opacities	Colombia
Advisory mission on public exposure control including waste management and decommissioning	Costa Rica
Expert mission to assist in conducting a national emergency exercise	Cuba
Expert mission to support the regulatory body with its responsibilities in the industrial area	Cuba
Expert mission to support the establishment of a national programme for the radiological protection of patients and protection in medical exposure areas	Cuba
Expert mission to assist in radiation protection of patients in computed tomography	Cuba
Expert mission for long term operation of Dukovany nuclear power plant	Czech Republic
Expert mission concerning technical cooperation and nuclear safety and security	Democratic Republic of the Congo
Expert mission to follow up on implementation of action plan	Democratic Republic of the Congo
Expert mission to review inspection procedures and results	Democratic Republic of the Congo
Expert mission to establish a verified source inventory and an orphan source search plan	Democratic Republic of the Congo
International peer review of the technical content of project proposal 'Thule-2007 – Investigations of radioactive contamination on land'	Denmark
Expert mission on exclusion and external area requirements	Egypt
Expert mission to review regulatory requirements for site selection and evaluation for nuclear power plants	Egypt
Expert mission to finalize the technical requirements related to the Greece research reactor modification programme	Greece
Expert mission to review draft national radiological emergency plan	Guatemala
Expert mission to resolve comments on Paks nuclear power plant structural ageing management programme and maintenance rule implementation	Hungary
Expert mission for long term operation of the Paks nuclear power plant	Hungary
Expert mission to review radiation protection programme at the Kartini research reactor	Indonesia
Expert mission on development of radiation protection programme in BATAN	Indonesia
Expert mission to review the radiation protection programme and the instrumentation and control system for the Bandung research reactor	Indonesia
Expert mission to review Indonesian site evaluation activities for selecting a location for a radioactive waste disposal facility in Java Island	Indonesia
Expert mission to follow up on training plan for INRA	Islamic Republic of Iran
Expert mission to review the final safety analysis report	Islamic Republic of Iran

Table A15. Safety review service and expert missions in 2008 (cont.)	
Type	**Country**
Expert mission to assess the radiation protection programme for the Bushehr nuclear power plant	Islamic Republic of Iran
Advisory mission in relation to developing the competencies necessary for regulatory authorization of radioactive waste management activities	Islamic Republic of Iran
Expert mission to review the safety issues for Slowpoke core conversion	Jamaica
Seismic safety review missions and follow-ups (4)	Japan
Advisory mission in relation to site selection and evaluation studies for nuclear power plants	Jordan
Advisory mission in relation to the installation of a local micro-earthquake network	Jordan
Expert mission to assist Iraq in the evaluation and decommissioning of former facilities that used radioactive material	Jordan
Expert mission to evaluate the status of needs and achievements concerning the monitoring of occupationally exposed workers	Kazakhstan
Expert mission to assist in the implementation of the patient protection project	Kazakhstan
Peer review of the Kyrgyzstan disaster hazard mitigation project	Kyrgyzstan
RaSSIA follow-up mission	Latvia; Montenegro
Expert mission on implementation of research reactor operator certification programme	Malaysia
Expert mission to review research reactor commissioning results in preparation for the regulatory authority for the licencing for operation of the Triga reactor	Morocco
Advisory mission on national regulatory infrastructure for the control of radiation sources	Mozambique
Expert mission to establish a verified source inventory and an orphan source search plan	Namibia
Expert mission to monitor progress under project NIR/4/008	Nigeria
Expert mission to review Chapter 2 of the PSAR for the Chashma 3 nuclear power plant	Pakistan
Advisory mission on national regulatory infrastructure for the control of radiation sources	Paraguay
Expert mission to support the self-assessment in preparation for the IRRS mission	Peru
Expert mission on regulatory activities	Philippines
Expert mission to appraise the radiation protection programmes for workers, members of the public and the environment	Romania
Expert mission for discussions with the Gulf Cooperation Council	Saudi Arabia
Expert missions (2) regarding Vinča Institute Nuclear Decommissioning	Serbia
Expert mission to provide technical expertise on nuclear safety and radiation aspects of fuel management	Serbia
International WATRP mission for the Slovenian national repository for low and intermediate level radioactive waste	Slovenia
Expert mission to advise on training strategy	Spain

Table A15. Safety review service and expert missions in 2008 (cont.)	
Type	**Country**
Expert mission to assist CIEMAT on quality management system for dosimetry services	Spain
Expert mission to assist TECNATOM for an internal dosimetry service for in vitro measurements	Spain
Expert mission to assist in drafting the national emergency preparedness project workplan	Sri Lanka
Expert mission to assist in radiation protection in cardiology	Sri Lanka
Expert mission to assist in the establishment of an effective national system (infrastructure) for radiation protection of workers	Tajikistan
Expert mission on the evaluation of the structure of Thai Research Reactor-1/Modification 1	Thailand
Seismic Safety Review Mission	Turkey
Consultations on finalization of the CPF mission	Uganda
Expert missions (2) in the framework of a joint IAEA–EC–Ukraine project (Zaporozhye and Rovno nuclear power plants)	Ukraine
Joint Project Expert Design Safety Review Mission to the Khmelnitsky nuclear power plant	Ukraine
Advisory mission for establishment of national capabilities for response to radiological and nuclear emergencies	United Arab Emirates
Advisory mission for defining technical specifications of the early warning network	United Arab Emirates
International peer review for the decommissioning activities of Magnox South Ltd	United Kingdom
Expert mission to assess implementation of project on strengthening and updating technical capabilities for the protection of health and safety of workers from occupational exposure to ionizing radiation	Uruguay
Advisory mission on national regulatory infrastructure for the control of radiation sources	Venezuela
Expert mission for training needs assessment	Vietnam

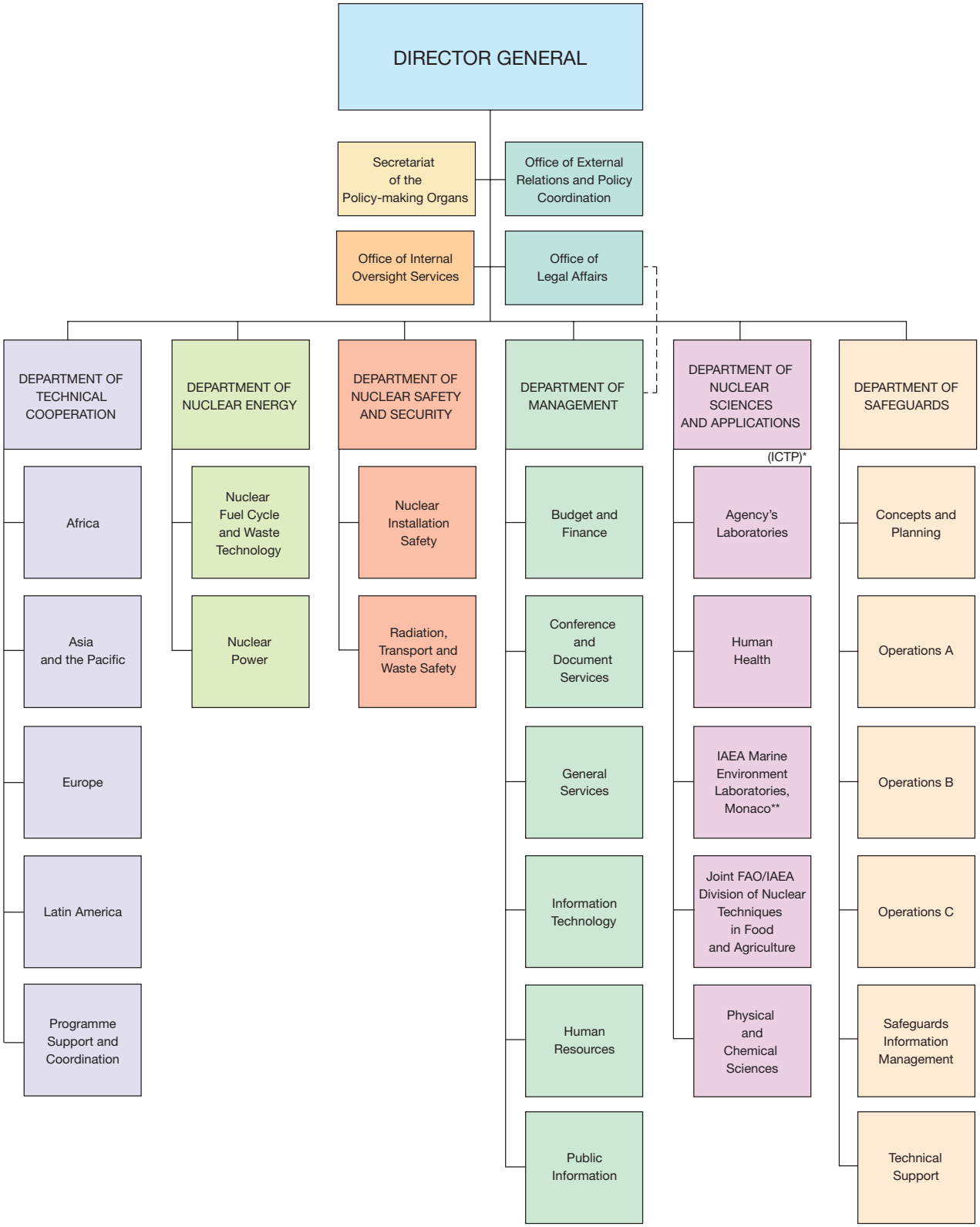
Table A16. International Nuclear Security Advisory Service (INSServ) missions in 2008	
Type	**Country**
INSServ	Cambodia
INSServ	Ecuador
INSServ	Mexico
INSServ	Niger
INSServ	Philippines
INSServ	Sri Lanka

Table A17. International Physical Protection Advisory Service (IPPAS) missions in 2008	
Type	**Country**
IPPAS	Georgia
IPPAS	Netherlands
International Team of Experts (ITE) mission	Azerbaijan
International Team of Experts (ITE) mission	Cape Verde
International Team of Experts (ITE) mission	Eritrea
International Team of Experts (ITE) mission	Ethiopia
International Team of Experts (ITE) mission	Rwanda

Table A18. IAEA SSAC Advisory Service (ISSAS) missions in 2008	
Type	**Country**
ISSAS	Georgia
ISSAS	Niger
ISSAS	Romania

Organizational Chart

(as of 31 December 2008)



* 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.

"The Agency shall seek to accelerate and enlarge the contribution of atomic energy to peace, health and prosperity throughout the world."

Article II of the IAEA Statute

IAEA

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