# IAEA ANNUAL REPORT 2011

IAEA
International Atomic Energy Agency

# IAEA Annual Report 2011

**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 2011.**

GC(56)/2

# Contents

# Member States of the International Atomic Energy Agency

*(as of 31 December 2011)*

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

The Agency's Statute was approved on 23 October 1956 by the Conference on the Statute of the IAEA held at United Nations Headquarters, New York; it entered into force on 29 July 1957. The Headquarters of the Agency are 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 2011)*

**152** Member States.

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

**54** years of international service.

**2474** professional and support staff.

**€314 million** total regular budget for 2011.[1] Extrabudgetary expenditures in 2011 totalled **€61.9 million** (including open purchase orders from previous years).

**$70.4 million** target in 2011 for voluntary contributions to the Agency's Technical Cooperation Fund, supporting projects involving **3319** expert and lecturer assignments, **4634** national experts, meeting participants and other project personnel, **3051** participants in training courses and **1397** 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 agreements relating to nuclear science and technology.

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

**130** active CRPs involving **1667** approved research, technical and doctoral contracts and research agreements. In addition, **73** Research Coordination Meetings were held.

**16** national donors and 1 multinational donor (European Union) to the voluntary Nuclear Security Fund.

**178** States in which safeguards agreements were being implemented[2], of which **114** States had additional protocols in force, with **2024** safeguards inspections performed in 2011. Safeguards expenditures in 2011 amounted to **€124.3 million** in regular budget and **€7.6 million** in extrabudgetary resources.

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

**2.7 million** people read more than **17 million** pages on the Agency's *iaea.org* site, and viewed stories on the Agency's Facebook site over **12.7 million** times.

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

**1.1 million** documents, technical reports, standards, conference proceedings, journals and books in the IAEA Library and **15 300** visitors to the Library in 2011.

**324** publications, brochures, leaflets, newsletters and other promotional material issued in 2011 (in print and electronic formats).

---

[1] At the UN average rate of exchange of $1.3893 to €1.00. The total budget was € 331.5 million at the $1.00 to €1.00 rate.

[2] The 178 States do not include the Democratic People's Republic of Korea, where the Agency did not implement safeguards and, therefore, could not draw any conclusion.

# 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 2011.*

In the area of safety and security, the Board met following the accident at TEPCO's Fukushima Daiichi nuclear power plant and subsequently approved an Action Plan on Nuclear Safety and kept its implementation under review throughout the remainder of the year. The Board discussed the *Nuclear Safety Review for the Year 2010* and also debated the *Nuclear Security Report 2011.*

As regards verification, the Board considered the *Safeguards Implementation Report for 2010.* 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 issues of the implementation of the NPT safeguards agreement in the Syrian Arab Republic and the application of safeguards in the Democratic People's Republic of Korea.

The Board discussed the *Technical Cooperation Report for 2011* and approved the Agency's technical cooperation programme for 2012.

## Composition of the Board of Governors (2011–2012)

Chairperson:

HE Mr. Gianni GHISI
Ambassador
Governor from Italy

Vice-Chairpersons:

HE Ms Dana DRÁBOVÁ
President, State Office for Nuclear Safety (SÚJB)
Governor from the Czech Republic

HE Mr Makram Mustafa QUEISI
Ambassador
Governor from Jordan

Argentina
Australia
Belgium
Brazil
Bulgaria
Canada
Chile
China
Cuba
Czech Republic
Ecuador
Egypt
France
Germany
Hungary
India
Indonesia
Italy
Japan
Jordan
Korea, Republic of
Mexico
Netherlands
Niger
Portugal
Russian Federation
Saudi Arabia
Singapore
South Africa
Sweden
Tunisia
United Arab Emirates
United Kingdom of Great Britain and Northern Ireland
United Republic of Tanzania
United States of America

# 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 financial statements 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 2011, the Conference endorsed the Board's decision to approve the IAEA Action Plan on Nuclear Safety. The Conference — upon the recommendation of the Board — approved Dominica, the Lao People's Democratic Republic and Tonga for membership of the Agency. At the end of 2011, the Agency's membership was 152.

# Notes

- The *IAEA Annual Report 2011* aims to summarize only the significant activities of the Agency during the year in question. The main part of the report, starting on page 21, generally follows the programme structure as given in *The Agency's Programme and Budget 2010–2011* (GC(53)/5).

- The introductory chapter, 'The Year in Review', seeks to provide a thematic analysis of the Agency's activities within the 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 2011 and Background to the Safeguards Statement*.

- Additional information covering various aspects of the Agency's programme is available in electronic form only on *iaea.org*, along with the *Annual Report.*

- 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 (NPT). The term 'nuclear-weapon State' is as used in the NPT.

# Abbreviations

| | |
|---|---|
| ABACC | Brazilian–Argentine Agency for Accounting and Control of Nuclear Materials |
| Abdus Salam ICTP | Abdus Salam International Centre for Theoretical Physics |
| 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 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 |
| 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 |
| 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 |
| 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 |
| OSCE | Organization for Security and Co-operation in Europe |
| PAHO | Pan American Health Organization/WHO |
| PHWR | Pressurized heavy water reactor |
| PWR | Pressurized water reactor |
| RBMK | High-power channel-type reactor |
| RCA | Regional Co-operative Agreement for Research, Development and Training Related to Nuclear Science and Technology |
| SQ | Significant quantity |
| UNDESA | United Nations Department of Economic and Social Affairs |
| UNDP | United Nations Development Programme |
| UNEP | United Nations Environment Programme |
| UNESCO | United Nations Educational, Scientific and Cultural Organization |
| 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, water moderated power reactor |

# The Year in Review

The Agency, as a multidisciplinary organization, pursues its statutory objective "to seek to accelerate and enlarge the contribution of atomic energy to peace, health and prosperity throughout the world" by addressing in a balanced manner the global challenges related to nuclear technology, including energy security, human health and food security, water resources management, nuclear safety and security, and non-proliferation.

## NUCLEAR TECHNOLOGY

In the area of nuclear technology, the Agency facilitates the exchange of nuclear information and knowledge, builds capacity, and transfers technology to its Member States, mainly through its technical cooperation programme. The aim is to facilitate, upon request, the use of nuclear science and associated technologies to meet the socioeconomic needs of Member States in a safe, secure and sustainable manner.

### Nuclear Power

#### *Status and trends and projected growth for nuclear power*

At the end of 2011, there were 435 power reactors in operation with a total capacity of 369 gigawatts-electric (GW(e)), 2% less than at the beginning of the year. The decrease was due to the permanent retirement of 13 reactors. Twelve of the 13 retirements were due to the accident at Tokyo Electric Power Company's (TEPCO's) Fukushima Daiichi nuclear power plant (hereinafter referred to as the 'Fukushima Daiichi accident') — four reactors at the Fukushima Daiichi plant itself and eight in Germany — and one was the permanent retirement of an old reactor in the United Kingdom. Seven new reactors were connected to the grid, an increase from five new reactors in 2010, two in 2009 and none in 2008.

The Fukushima Daiichi accident resulted in a slowing of the expansion of nuclear power but did not reverse it. The Agency's post-accident projections of global nuclear power capacity in 2030 were 7–8% lower than what was projected before the accident. Capacity is now expected to grow to 501 GW(e) in 2030 in the low projection and to 746 GW(e) in the high projection. The number of nuclear reactors in operation in 2030 is expected to increase by about 90 in the low projection. Most of the growth will likely occur in countries that already have operating nuclear power plants, and Member States in Asia as well as the Russian Federation are expected to be the centres of expansion. Of the 64 new power reactors under construction at the end of 2011, 26 were in China, 10 in the Russian Federation, 6 in India and 5 in the Republic of Korea. However, some countries, such as Germany, decided to phase out and discontinue the use of nuclear power.

Other States, such as Belgium, Italy and Switzerland, have re-evaluated their nuclear programmes. Several other countries, such as Austria, Denmark, Greece and New Zealand, continued to exclude the nuclear power option.

*"The Agency expanded the scope of its guidance and assistance for long term operation and initiated an annual 'Industry Cooperation Forum' ..."*

#### *Agency support to operating nuclear power plants*

In the wake of the Fukushima Daiichi accident, assessments for long term operation increased their focus on design review, stored equipment and severe accident management. The Agency expanded the scope of its guidance and assistance for long term operation and initiated an annual 'Industry Cooperation Forum', which recommended: increased cooperation with utilities; greater interaction between operating organizations in countries with experience in the nuclear area and those in countries introducing nuclear power; more effective communication; and wider dissemination of best operational practices.

#### *Launching nuclear power programmes*

Nuclear power remains an important option for countries, and interest in nuclear power remains high. Of the countries without nuclear power that, before the Fukushima Daiichi accident, had strongly indicated their intention to proceed with a nuclear

power programme, a few cancelled or revised their plans, while others took a 'wait and see' approach, but most continued their programmes to introduce nuclear power. In the Agency's projections, between 7 and 20 new countries are expected to bring their first reactors on-line before 2030.

Some countries that had been strongly committed to nuclear power continued with their plans, incorporating into them the lessons being learned from the Fukushima Daiichi accident. Turkey and the United Arab Emirates (UAE) made progress in 2011 working with vendors. Belarus signed a contract with the Russian Federation for the construction of two reactors. Bangladesh signed an intergovernmental agreement with the Russian Federation for two 1000 MW(e) reactors, and Vietnam signed a loan agreement with the Russian Federation regarding financing of its first nuclear power plant.

The Agency increased assistance especially for new owner/operator organizations in Member States while continuing to offer a broad range of support services that included guidance, standards, technical assistance, review services, training, capacity building and knowledge networks. In addition, it conducted Integrated Nuclear Infrastructure Review missions in Bangladesh and the UAE.

*"Agency support for nuclear programmes begins at the very front of the fuel cycle, with estimates and analysis of global uranium resources."*

## *Energy assessment services*

The Agency helps interested Member States build their capacities for national energy assessments and planning by training experts and transferring computer models and data. Demand for these services continued to increase, and the Agency's analytical tools are now used in over 125 Member States. In 2011, the Agency trained over 600 energy analysts and planners from 67 countries in the use of these tools. Traditional face to face training was regularly supplemented by web based e-training.

## *Capacity building*

The preservation and management of nuclear knowledge is a high priority for many Member States. In 2011, the Agency conducted 'Knowledge Management Assist Visits' and workshops in Armenia, Belarus, Bulgaria, China, Kazakhstan, the Republic of Korea, the Russian Federation, Ukraine, the UAE, the USA and Vietnam. The goal was to increase awareness of the importance of knowledge management in the daily operations of nuclear organizations and to help managers, using methods developed by the Agency, to identify the staff positions most critical in terms of knowledge. In cooperation with the Abdus Salam ICTP in Trieste, Italy, the Agency conducted its second Nuclear Energy Management School and seventh Nuclear Knowledge Management School.

## *Assurance of supply*

Several developments occurred in 2011 relating to the assurance of supply of nuclear fuel. The first was an agreement between the Government of the Russian Federation and the Agency that established a low enriched uranium (LEU) reserve in Angarsk, Russian Federation, which entered into force in February. The second involved the Board of Governors' approval, in March 2011, of a 'Nuclear Fuel Assurance' mechanism originally proposed by the United Kingdom and co-sponsored by several other States including some European Union Member States, the Russian Federation and the USA. The third, in May, was the Agency's invitation to interested Member States to submit proposals to host the Agency's LEU Bank that was approved by the Board of Governors in December 2010. Kazakhstan submitted a proposal, an Agency technical mission visited Kazakhstan in August to assess two sites, and negotiations on a host State agreement were scheduled to start in early 2012. By the end of 2011, of the approximately $150 million pledged as voluntary contributions for the LEU Bank, more than $105 million had been received by the Agency — from Norway, the USA and the Nuclear Threat Initiative, as well as €10 million from the European Union.

## *Uranium resources*

Agency support for nuclear programmes begins at the very front of the fuel cycle, with estimates and analysis of global uranium resources. Total identified conventional uranium resources recoverable at a cost of less than $130 per kilogram of uranium (kg U), were estimated at 5.4 million tonnes of uranium (Mt U), with an additional 0.9 Mt U recoverable at costs between $130 and $260/kg U. The spot price at the

end of the year was $135/kg U. Uranium production was estimated to have increased by 2.5%, to about 55 500 t U in 2011. Production in Kazakhstan, the world's largest producer, which increased by 27% between 2009 and 2010, was estimated to have increased by another 9% in 2011.

At the 2010 rate of uranium consumption by the world's nuclear power plants, the projected lifetime of 5.4 Mt U is approximately 80 years.

### *Innovation*

Continual innovation is essential for the long term expansion of nuclear power. In 2011, interest continued to increase in small and medium sized reactors and in innovations to mitigate the susceptibility of reactors to extreme natural hazards. The Agency continued to promote the exchange of technical information through Technical Working Groups, CRPs, international conferences, publications and the International Project on Innovative Nuclear Reactors and Fuel Cycles (INPRO). In a series of workshops, advances and experience in power plant construction were shared with countries considering new reactors, particularly the advantages and disadvantages of different approaches under geographical and resource constraints. The Agency's Power Reactor Information System was expanded to include non-electric applications, and INPRO completed a collaborative project that quantified the benefits of international cooperation in a future global transition to fast reactors and closed fuel cycles. Egypt, Israel and Jordan joined INPRO, increasing the membership to 35.

### *Research reactors*

Research reactor coalitions supported by the Agency were strengthened in 2011 to improve utilization, ageing management and training. A new Central African Research Reactor Network was initiated in July, and three training courses were organized by the Eastern European Research Reactor Initiative. The Agency also contributed to the continuing conversion of research reactors from high enriched uranium (HEU) to LEU. Mexico decided to convert its TRIGA research reactor to LEU fuel and, through the Agency, secured the replacement of its HEU fuel with LEU from the USA. The Agency, under a project designed to assist Mexico with research reactor conversion, completed fuel inspections in France and Mexico in support of the first of two LEU fuel shipments. This fuel was received in Mexico in December. As part of the Russian Research Reactor Fuel Return programme, a tripartite contract was signed between the Agency, the Russian Federation and Ukraine in October to return the last fresh HEU fuel stockpile at Ukraine's Kharkov Institute to the Russian Federation before March 2012.

Shortages of molybdenum-99 were less of an immediate concern in 2011 following the 2010 restarts of research reactors in Canada and the Netherlands. The Agency shifted its focus to the transition of molybdenum-99 production away from the use of HEU. It completed a comparative assessment of non-HEU production technologies, organized an international meeting to further international collaboration on conversion to LEU based production and completed a CRP on production using LEU targets.

*"In 2011, interest continued to increase in small and medium sized reactors and in innovations to mitigate the susceptibility of reactors to extreme natural hazards."*

## Applications of Nuclear Technology

### *Trends and developments*

In 2011, the Agency continued to assist Member States in the application of nuclear and isotopic techniques in the areas of food and agriculture, human health, water resources, the environment and industry as related, in particular, to socioeconomic development and the Millennium Development Goals. Capacity building as a cross-cutting priority for all of the above areas in nuclear applications was strengthened through collaboration and partnership with FAO, WHO, ICTP, UNEP and UNESCO, as well as through networks such as ALMERA[1] and IAEA Collaborating Centres. The Agency's coordinated research activities continued to stimulate research in nuclear fields in Member States through more than 130 active CRPs at the end of 2011. Applied R&D, training and capacity building, and provision of analytical

[1] The ALMERA (Analytical Laboratories for the Measurement of Environmental Radioactivity) network currently represents 122 laboratories from 77 countries worldwide (*http://www.iaea.org/nael/page.php?page=2244*).

services to Member States were strengthened at the Agency's laboratories in Seibersdorf and Monaco, thus increasing the impact of Agency programmes in food and agriculture, human health, isotope hydrology and environmental monitoring.

## *Food and agriculture*

Rinderpest, also known as cattle plague, is a highly contagious viral disease of cattle, buffalo, yak and several wildlife species that has caused immense livestock losses over many decades. The Agency, in collaboration with FAO, the World Organisation for Animal Health (OIE) and other partners, has supported Member States for more than 25 years in their efforts to control and eradicate the disease. In early 2011, FAO and OIE officially declared the disease eradicated from the world. This significant event was marked by a special celebration on 21 September during the Agency's 55th regular session of the General Conference.

*"... the Agency's coordinated research activities resulted in the adoption of 14 irradiation treatments pertaining to the health of plants for quarantined pests under the International Plant Protection Convention ..."*

In 2011, the Agency's coordinated research activities resulted in the adoption of 14 irradiation treatments pertaining to plant health and control of quarantine pests under the International Plant Protection Convention to facilitate trade in agricultural commodities such as tropical fruits. Guidelines on the audit and accreditation of facilities that irradiate food were also developed by the Asia and Pacific Plant Protection Commission for adoption as a regional standard.

## *Human health*

A mobile version of the 'Human Health Campus', an educational distance learning web site for health professionals in radiation medicine (*http://humanhealth.iaea.org*) was launched, providing e-learning modules, case studies, audiovisual tutorials and interactive sessions in nuclear medicine, radiation oncology, medical physics and nutrition (*http://humanhealth.iaea.org/M*). This provides a platform for capacity building, in addition to the interactive on-line learning offered by the Human Health Campus.

The Agency continued to emphasize the importance of quality assurance, encouraging Member States to commit to a peer review and educational process. It continued its train the trainer activities for quality management courses, organizing Quality Assurance in Nuclear Medicine (QUANUM) missions as well as conferences, meetings and publications.

An international conference on 'Clinical PET and Molecular Nuclear Medicine' (IPET-2011) was convened in Vienna in November. The current status, challenges and future directions in clinical nuclear medicine were discussed, with an emphasis on oncology, neurology, cardiology and infection, from the 'laboratory to the bedside'.

The Agency continued its efforts to raise awareness of the usefulness of stable isotope techniques in programmes designed to promote good nutritional practices. To assist in this process, the first five e-learning modules on stable isotope techniques in nutrition were launched, and a number of Agency publications on this subject were issued.

## *Programme of Action for Cancer Therapy (PACT)*

In 2011, the Political Declaration of the High-level Meeting of the United Nations General Assembly on the Prevention and Control of Non-communicable Diseases (NCDs) formally recognized the Agency's role in the fight against NCDs, particularly cancer and heart diseases. This invigorated its cancer initiatives and enhanced its collaboration with WHO and other United Nations agencies.

Support for cancer control was intensified, as reflected in Member State requests for integrated missions of PACT (imPACT) reviews and support for the Agency's Advisory Group on Increasing Access to Radiotherapy Technology (AGaRT) in low and middle income (LMI) countries. This support included donations of more than $1 million in contributions and pledges from partner organizations and Member States.

AGaRT continues to act as a facilitator to bring together radiotherapy users in LMI countries and major radiotherapy equipment suppliers, to ensure that the unique radiotherapy service requirements of these countries are met by the technology available. During the second AGaRT meeting, in June 2011, discussions on guidelines were initiated to balance

medical, technical and economic aspects when selecting equipment for a radiotherapy unit.

### *Radioisotopes and radiation technology*

Applications of radioisotopes in diagnosis and therapy continued to grow. A CRP on 'Therapeutic Radiopharmaceuticals Labelled with Rhenium-188 and Yttrium-90' was concluded, while another CRP was initiated to develop an easy to use, freeze-dried kit for the treatment of non-Hodgkin's lymphoma, a type of blood cancer. A major goal was to facilitate the availability of radiolabelled antibodies at reasonable cost to Member States.

In diagnosis, a CRP on 'Accelerator Based Alternatives to non-HEU Production of Molybdenum-99/Technetium-99m' was initiated to help Member States make use of an alternate technology using accelerators to produce technetium-99m, a key diagnostic radiopharmaceutical in nuclear medicine. Gallium-68, available from a generator, was the focus of another CRP to help Member States carry out studies using positron emission tomography without an on-site cyclotron.

Through its technical cooperation programme, the Agency installed a cobalt-60 source in Cuba.

### *Environment*

The Agency strengthened its research activities to monitor radionuclides in the marine and terrestrial environment and to study climate change issues in the oceans — in particular, to study the impact of ocean acidification and global warming on oceanographic processes, ecosystems and associated services. Three new marine certified reference materials for radionuclides, trace elements and organic contaminants were produced according to ISO guides 34 and 35 and distributed to Member States. In addition, the Agency implemented 28 technical cooperation projects to assist over 40 Member States in Africa, the Middle East, the Asia–Pacific region, and Latin America and the Caribbean to develop or to improve national technical and equipment capacity for marine pollution studies and environmental quality assessment.

### *Management of water resources*

The Agency's Global Network of Isotopes in Precipitation, managed in collaboration with the World Meteorological Organization, has been the primary global database since 1961 for isotope applications in hydrology and climate studies. An atlas of isotopes in river waters was completed to aid Member State efforts to monitor the hydrological impacts of climate change, as rivers integrate the spatial and temporal changes in precipitation, water use and land use patterns in a catchment.

Increasing use of groundwater, in part to mitigate the impact of climate change, requires a better understanding of aquifer recharge, for which isotopes of noble gases are a powerful tool. In this context, a portable sampling device for dissolved noble gases was developed in 2011 that allows wider use of isotopes for climate change adaptation studies. The work of the Agency in this area was featured in an article in *The New York Times* in November 2011.

The Agency's Water Availability Enhancement Project (IWAVE), supported by the Peaceful Uses Initiative (PUI), was successfully launched in three pilot countries, Costa Rica, Oman and the Philippines. As the first step in this project, detailed reports on the information needed are being prepared in each Member State. The first of the reports for the Philippines was completed in 2011.[2]

*"The Agency strengthened its research activities to monitor radionuclides in the marine and terrestrial environment and to study climate change issues in the oceans ..."*

An international symposium on 'Isotope Hydrology, Marine Ecosystems, and Climate Change Studies' organized by the Agency in Monaco addressed the role of isotopes in understanding and modelling climate change, marine ecosystems and water cycles The special focus on water resource assessments emphasized the strong link between the application of nuclear and isotope techniques, water resource management and policy decisions.

## NUCLEAR SAFETY AND SECURITY

The Agency's nuclear safety and security programmes promote the worldwide achievement

[2] BARRINGER, F., A rare isotope helps track an ancient water source, The New York Times, 22 November 2011, p. D2.

## GENERAL CONFERENCE SCIENTIFIC FORUM: 'WATER MATTERS'

During the 55th regular session of the General Conference in September, a two day Scientific Forum entitled 'Water Matters: Making a Difference with Nuclear Techniques' highlighted the importance of water on the international agenda and the role that nuclear techniques play in addressing key water and climate issues. The Director General opened the event, introducing the Agency's activities and role in the effective management of water resources.

Over the two days, government ministers joined leading water experts from the fields of agriculture, hydrology and oceanography to highlight global water challenges and to demonstrate the benefits of nuclear techniques in addressing these issues.

The Forum highlighted the need for scientific information on water resources in order to adopt sound management policies. It also emphasized the contribution that new technologies — both isotope and non-isotope — can make in addressing the technical, socioeconomic and political water related challenges that will be faced by the world's population in the future.

The importance of agricultural water management to address food security and sustainable agriculture was addressed in a session on 'Tackling Water Scarcity and Saving Water in Agriculture', which underlined the need for better management of water in both rainfed and irrigated agriculture. This was essential to cover the expected 50% increase in global agriculture water requirements by 2050 to meet additional demand for food for a global population that is expected to grow from the current 7 billion to around 9 billion by 2050.

of high levels of nuclear safety and nuclear security to protect people, society and the environment.

In response to the Fukushima Daiichi accident, the Agency convened a five day Ministerial Conference on Nuclear Safety in Vienna from 20 to 24 June 2011. The objective of the conference was to learn lessons from the accident and strengthen nuclear safety throughout the world. At the conference, a Ministerial Declaration was adopted which, inter alia, requested the Director General to prepare a draft Action Plan on Nuclear Safety. The Action Plan was approved by the Board of Governors and endorsed unanimously by the 55th regular session of the General Conference in September. This plan provides a comprehensive framework of actions to strengthen global nuclear safety. An initial progress report in the implementation of the Action Plan was submitted to the Board of Governors in November 2011.

*"In response to the Fukushima Daiichi accident, the Agency convened a five day Ministerial Conference on Nuclear Safety in Vienna from 20 to 24 June 2011."*

## Status of Nuclear Safety

Despite the Fukushima Daiichi accident, the level of nuclear safety among the 435 operating nuclear power plants in operation around the world remained high in 2011, as indicated by data collected by the Agency and the World Association of Nuclear Operators.

### *Conventions and Codes of Conduct*

In April 2011, Contracting Parties to the Convention on Nuclear Safety (CNS) met in Vienna for the Fifth Review Meeting. The CNS agreed, inter alia, to analyse relevant issues of arising from the Fukushima Daiichi accident at an Extraordinary Meeting to be held in August 2012.

An international meeting on the Code of Conduct on the Safety of Research Reactors was held in May 2011 with the participation of 31 countries. The meeting participants recognized the efforts of the Agency in encouraging Member States to apply the Code. At the meeting, it was concluded that the Code is the principal reference of Member State activities in the area of research reactor safety and provides recommendations to address common safety issues such as regulatory supervision and ageing management.

## *Safety standards*

The IAEA Action Plan on Nuclear Safety requested the Commission on Safety Standards (CSS) and the Secretariat to review and revise the relevant safety standards in a prioritized sequence, as required, using the existing process in a more efficient manner.

The first draft of an action plan for the review of the Agency's safety standards was prepared by the Secretariat and submitted to the CSS at its meeting in November 2011. The draft plan describes the methodology for conducting the review of the safety standards in terms of scope, prioritization, approach, process and timeline, as well as possible options for subsequent revisions of those safety standards where necessary. The Agency offers a range of support services to Member States intending to embark on a nuclear power programme. For example, a new Safety Guide published in 2011, *Establishing the Safety Infrastructure for a Nuclear Power Programme* (IAEA Safety Standards Series No. SSG-16), provides recommendations on how countries can meet the Agency's Safety Requirements for national safety infrastructures. This publication was used in conjunction with workshops, training seminars and self-assessment tools.

## *Peer reviews and advisory services*

The Agency continued to assist States in applying its safety standards and security guidance by providing education and training, promoting information exchange on best safety practices, and rendering a broad range of safety services. The nuclear safety and security services offered by the Agency — such as operational safety reviews, design reviews and regulatory reviews — continued to be in great demand.

For example, nine Integrated Regulatory Review Service (IRRS) missions were conducted in 2011, more than in any previous year. Of these nine, five were first missions, to the Republic of Korea, Romania, Slovenia, Switzerland and the UAE, and four were follow-up missions to Australia, Canada, Germany and Spain.

The Agency's Operational Safety Review Team (OSART) missions are a well-known and important service for nuclear power plants. In 2011, seven OSART missions were conducted: in Armenia, Brazil, the Czech Republic, France, the Russian Federation, South Africa and the USA. In addition, following the Fukushima Daiichi accident, severe accident management was added as an OSART module to further support the enhancement of nuclear safety in Member States.

The Integrated Safety Assessment for Research Reactors (INSARR) service is designed to enhance the safety of research reactors and for promoting the application of the Agency's safety standards. Three INSARR missions were conducted in 2011: to the High Flux Reactor in Petten, the Netherlands, which produces 40% of the world's supply of the medical radioisotope molybdenum-99; to the TRIGA reactor in Piteşti, Romania; and to the 10 MW Huarangal research reactor in Peru.

Following the Fukushima Daiichi accident, the Design and Safety Assessment Review Service was enhanced to identify the impact of extreme events on fundamental safety functions and to develop possible mitigating actions.

There was increased demand for site selection, site assessment and hazard characterization review services by Member States. Nine Siting and External Event Design reviews were conducted in 2011 in Armenia, Bangladesh, Indonesia, Jordan, Malaysia, Morocco, Romania, the UAE and Vietnam. These review services highlighted the continued need for Member States to carry out thorough site specific hazard and design safety reviews consistent with the Agency's safety standards to protect nuclear installations against external hazards.

*"The nuclear safety and security services offered by the Agency — such as operational safety reviews, design reviews and regulatory reviews — continued to be in great demand."*

By the end of 2011, 80% of the 435 nuclear power plants operating in the world were more than 20 years old. The Agency conducted peer review missions under its Safe Long Term Operation service in the Czech Republic, Hungary, the Republic of Korea, the Netherlands, Pakistan, South Africa and Ukraine.

At the request of the Malaysian Government, the Agency organized an expert mission to review the radiation safety aspects of a rare earth processing facility being built near Kuantan, in Pahang state, against Agency safety standards and to draw the relevant conclusions.

## Global knowledge networks

The Regulatory Cooperation Forum (RCF) is a Member State initiative that optimizes regulatory support from Member States with advanced nuclear power programmes to States considering nuclear power or initiating a nuclear power programme ('newcomer countries'). In 2011, the RCF, facilitated and promoted by the Agency, developed and implemented an action plan for Jordan's regulatory body and identified Vietnam and Poland as the next recipients of RCF activities.

## Research, education and training

The Agency further developed its Safety Assessment Education and Training (SAET) project. The training programmes were structured for the specific needs of Member States, based on the SAET syllabus and related safety assessment training modules. This training is available to Member States through the technical cooperation programme, as well as through extrabudgetary funding.

*"In 2011, the Board of Governors approved ... Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards — Interim Edition ..."*

## Strengthening the safety of radioactive sources

The revised *Guidance on the Import and Export of Radioactive Sources* was approved by the Board of Governors and the General Conference in 2011. In July 2011, the Agency organized a meeting on the Code of Conduct on Safety and Security of Radioactive Sources to discuss implementation of the Code. As a result of this meeting, additional States expressed their commitment to use the Code of Conduct as guidance in the development and harmonization of their national laws and regulations, bringing the total number of States making this commitment to 107 as of December 2011.

## Revised Basic Safety Standards for Radiation Protection and the Safety of Radiation Sources

In 2011, the Board of Governors approved a Safety Requirements publication entitled *Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards — Interim Edition* (IAEA Safety Standards Series No. GSR Part 3 (Interim)). This interim edition, which was published in November, is consistent with the 2007 recommendations of the International Commission on Radiological Protection and reflects developments since the 1996 edition in the protection of workers and the public, and in relation to medical exposures.

## Decommissioning

Hundreds of facilities around the world using radioactive and nuclear material are ageing and many will soon reach the end of their projected operational lifetime. A number of operating facilities are being shut down earlier than initially planned. In the short term, this is not expected to significantly increase the number of facilities undergoing immediate dismantling. Instead, many of these facilities are likely to be placed into safe enclosure awaiting deferred dismantling. However, an increased need is expected in Member States for decommissioning resources, both technical and financial. This will result in turn in an increased demand for the Agency's assistance and services.

## Denials of shipment

Reporting of denials of shipment of radioactive material remains sporadic and, as a result, the extent of the problem remains difficult to identify with precision. A revised reporting process was developed which will be implemented in 2012 to improve the quality of reporting. Reducing denials to a level that is no longer of significant concern by the 2013 General Conference continues to be a goal. In this connection, participants at the Agency's international conference on the 'Safe and Secure Transport of Radioactive Material: The Next Fifty Years of Transport — Creating a Safe, Secure and Sustainable Framework', held in October 2011, identified the need to increase support for Member States in the area of denials of shipment.

### *Incident and emergency preparedness and response*

The Agency continued to contribute to the strengthening of global emergency preparedness and response arrangements and capabilities. Shortly after the notification of Japan's International Seismic Safety Centre, the Agency's Incident and Emergency system was activated and its Incident and Emergency Centre (IEC) was placed in 'full response' mode. Since then, the Agency's efforts in 2011 were focused on the response to the Fukushima Daiichi accident. Many lessons have been identified nationally as well as internationally, and these will be taken into account in the future.

### *Civil liability for nuclear damage*

The *IAEA Action Plan on Nuclear Safety* calls specifically for States to work towards the establishment of a global nuclear liability framework that addresses the concerns of all States that might be affected by a nuclear accident, with a view to providing appropriate compensation for nuclear damage, and calls on the Agency's International Expert Group on Nuclear Liability (INLEX) to recommend actions to facilitate the achievement of such a goal.

At its 11th regular meeting, held in May 2011, INLEX discussed, inter alia, developments relating to nuclear liability with the European Union and INLEX's outreach activities. At a special session held in December 2011, INLEX discussed inter alia its role in the implementation of the *IAEA Action Plan on Nuclear Safety*. In particular, the Group agreed on activities to be carried out before the next regular meeting in May 2012, and had a preliminary discussion on ways and means whereby a global nuclear liability framework that addresses the concerns of all States can be established.

## Status of Nuclear Security

The risk of nuclear and other radioactive material being used with malicious intent poses a serious threat to international peace and security. In 2011, the Agency continued to help States in establishing and sustaining effective national security frameworks. Support was given in: meeting commitments under the relevant international legal instruments; the establishment of international guidance; capacity building; the conduct of peer reviews; and the enhancement of international cooperation.

The International Nuclear Security Education Network provides a forum for the Agency and academic and research bodies to collaborate in the area of educational activities dealing with nuclear security. Using the Agency's guidance material, five universities in Europe began development of Master of Science programmes in nuclear security for the autumn 2012 semester. This initiative is being supported by the Agency and the European Commission.

The Agency continued to interact with Member States and relevant United Nations bodies such as the Counter-Terrorism Implementation Task Force and the United Nations Security Council Resolution 1540 Committee (the '1540 Committee'). The aim was to improve cooperation and enhance dialogue among other international nuclear security related initiatives.

The Agency conducted three International Physical Protection Advisory Service missions, in France, Sweden and the United Kingdom. Two of these missions took place in States with advanced nuclear programmes, representing a welcome development. The missions identified good practices and made a number of recommendations.

*"The International Nuclear Security Education Network provides a forum for the Agency and academic and research bodies to collaborate in the area of educational activities dealing with nuclear security."*

## SAFEGUARDS

The Agency's verification programme remains at the core of multilateral efforts to curb the proliferation of nuclear weapons. Through the application of safeguards, the Agency aims to assure the international community that nuclear material and facilities are used only for peaceful purposes. As such, the Agency has an essential verification role under the Treaty on the Non-Proliferation of Nuclear Weapons (NPT), as well as other treaties such as those establishing nuclear-weapon-free zones.

## Implementation of Safeguards in 2011

At the end of each year, based upon an evaluation of all safeguards relevant information available to it for that year, the Agency draws a safeguards conclusion for each State for which safeguards are applied. In 2011, safeguards were applied for 178 States[3] with safeguards agreements in force with the Agency.[4, 5]

For the Agency to be able to conclude that all nuclear material in a State remained in peaceful activities, both a comprehensive safeguards agreement (CSA) and an additional protocol (AP) should be in force, and the Agency must have been able to conduct all necessary verification and evaluation activities. By the end of 2011, of the 109 States with both a CSA and AP in force, the Agency was able to draw such a conclusion for 58 of these States.[6] For the other 51 States, the Agency was only able to conclude that *declared* nuclear material remained in peaceful activities, as all the necessary evaluations had yet to be completed.

For the 61 States with a CSA but with no AP in force, the Agency was only able to conclude that *declared* nuclear material remained in peaceful activities, as the Agency did not have sufficient tools to provide credible assurances regarding the absence of *undeclared* nuclear material and activities.

*"During 2011, the Director General submitted four reports to the Board of Governors on the implementation of the NPT Safeguards Agreement and relevant provisions of United Nations Security Council resolutions in the Islamic Republic of Iran (Iran)."*

Safeguards were also implemented with regard to declared nuclear material in selected facilities in the five nuclear-weapon States under their respective voluntary offer agreements and APs. For these States, the Secretariat concluded that nuclear material to which safeguards had been applied in selected facilities remained in peaceful activities or had been withdrawn from safeguards as provided for in the agreements.

For the three States in which the Agency implemented safeguards pursuant to safeguards agreements based on INFCIRC/66/Rev.2, the Secretariat concluded that the nuclear material, facilities or other items to which safeguards were applied remained in peaceful activities.

The Secretariat could not draw any safeguards conclusions for the 14 NPT non-nuclear-weapon States without safeguards agreements in force.

During 2011, the Director General submitted four reports to the Board of Governors on the implementation of the NPT Safeguards Agreement and relevant provisions of United Nations Security Council resolutions in the Islamic Republic of Iran (Iran). While the Agency continued throughout 2011 to verify the non-diversion of declared nuclear material at the nuclear facilities and locations outside facilities declared by Iran under its Safeguards Agreement, as Iran did not provide the necessary cooperation, including by not implementing its Additional Protocol, as required in the binding resolutions of the Board of Governors and the United Nations Security Council, the Agency was unable to provide credible assurance about the absence of undeclared nuclear material and activities in Iran and, therefore, was unable to conclude that all nuclear material in Iran was in peaceful activities. The Director General decided that the time was right to provide the Board of Governors with the Secretariat's detailed analysis of the information available to the Agency which had given rise to concerns about possible military dimensions to Iran's nuclear programme. This analysis was published in an Annex to the Director General's November 2011 report to the Board. The Secretariat's analysis indicates that Iran has carried out activities relevant to the development of a nuclear explosive device. It also indicates that prior to the end of 2003, these activities took place under a structured programme and that some activities may still be ongoing. On 18 November 2011, the Board of Governors adopted by a vote resolution GOV/2011/69 in which, inter alia, the Board expressed deep and increasing concern about the unresolved issues regarding the Iranian nuclear programme, including those which need to be clarified to exclude the existence of possible military dimensions, and stressed that it is essential

---

3 The 178 States do not include the Democratic People's Republic of Korea, where the Agency did not implement safeguards and, therefore, could not draw any conclusion.

4 And Taiwan, China

5 The status with regard to the conclusion of safeguards agreements, APs and small quantities protocols is given in the annex to this document.

6 And Taiwan, China.

for Iran and the Agency to intensify their dialogue aiming at the urgent resolution of all outstanding substantive issues for the purpose of providing clarifications regarding those issues, including access to all relevant information, documentation, sites, material and personnel in Iran.

During 2011, the Director General submitted two reports to the Board of Governors on the implementation of the NPT Safeguards Agreement in the Syrian Arab Republic (Syria). On 6 June 2011, the Director General reported to the Board of Governors that, based on all the information available to the Agency, it was very likely that a building destroyed at the Dair Alzour site was a nuclear reactor which should have been declared to the Agency by Syria. On 9 June 2011, the Board of Governors adopted by a vote a resolution in which it, inter alia, decided to report, as provided for in Article XII.C of the Statute, through the Director General, Syria's non-compliance with its Safeguards Agreement to all Members of the Agency and to the Security Council and General Assembly of the United Nations. In May 2011, Syria indicated its readiness to fully cooperate with the Agency to resolve issues related to the Dair Alzour site. Following that, in August 2011, Syria informed the Agency of its readiness to have a meeting with the Agency in order to resolve the outstanding issues regarding the Dair Alzour site. In October 2011, a delegation from the Agency visited Damascus with the aim of advancing the Agency's verification mission in Syria. A number of questions, in particular concerning other locations that may be functionally related to the Dair Alzour site, remain to be resolved. In 2011, Syria cooperated with the Agency in addressing the Agency's concerns in relation to previously unreported conversion activities at the Miniature Neutron Source Reactor and the origin of anthropogenic natural uranium particles found there. The Agency decided that the matter would henceforth be addressed in the routine implementation of safeguards. For 2011, the Agency was able to conclude for Syria that declared nuclear material remained in peaceful activities.

Since December 2002, the Agency has not implemented safeguards in the Democratic People's Republic of Korea (DPRK) and, therefore, did not draw any safeguards conclusion for that country. In September 2011, the Director General submitted a report to the Board of Governors and General Conference on the application of safeguards in the DPRK. Since 1994, the Agency has not been able to conduct all necessary safeguards activities provided for in the DPRK's NPT Safeguards Agreement. From the end of 2002 until July 2007, the Agency was not able, and since April 2009 has not been able, to implement any verification measures in the DPRK and, therefore, could not draw any safeguards conclusion regarding the DPRK. Reports received about the construction of a new uranium enrichment facility and of a light water reactor in the DPRK are deeply troubling. Although not implementing any verification activities in the field, the Agency continued to monitor the DPRK's nuclear activities by using open source information, satellite imagery and trade information. The Agency also continued to further consolidate its knowledge of the DPRK's nuclear programme with the objective of maintaining operational readiness to resume safeguards implementation in the DPRK.

*"The Secretariat continued to implement its Plan of Action to Promote the Conclusion of Safeguards Agreements and Additional Protocols ..."*

## Conclusion of Safeguards Agreements and Additional Protocols

The Secretariat continued to implement its *Plan of Action to Promote the Conclusion of Safeguards Agreements and Additional Protocols*, which was updated in September 2010. Outreach events in 2011 included: an interregional seminar on the Agency's safeguards system for States in Southeast and South Asia with limited nuclear material and activities; a regional seminar on the Agency's safeguards system for States in Southeast Asia with significant nuclear activities (both held in Singapore in March 2011); and briefings for a number of Permanent Missions on the Agency's safeguards (in Geneva in May and in New York in October).

In 2011, CSAs entered into force for three States and APs for ten States. Small quantities protocols that reflect the revised text were brought into force in seven States.

## Strengthening Safeguards

In 2011, the Agency prepared to implement the Agency's *Medium Term Strategy 2012–2017* and the *Long-Term Strategic Plan 2012–2023* for safeguards.

The Agency continued to evolve the State level concept for the planning, conduct and evaluation of safeguards. Safeguards implementation, pursued in accordance with the State level concept, is based on a comprehensive evaluation of all safeguards relevant information regarding a State. Efforts during the year focused on ways to better link verification activities at Headquarters and in the field with those related to the evaluation of all safeguards relevant information available to the Agency. All such information regarding a State's nuclear programme, including feedback from inspection related activities, is evaluated, not only to draw safeguards conclusions but also to determine the safeguards activities to be conducted with respect to that State in order to maintain those conclusions. This helps the Agency to customize and focus its verification activities.

*"The construction at the Agency's Seibersdorf Laboratories of an extension to the Clean Laboratory for environmental sample particle analysis was completed, and advanced mass spectrometry equipment was put into service."*

To help States build their capacity to comply with their safeguards obligations, in 2011 the Agency conducted two IAEA SSAC Advisory Service (ISSAS) missions in Kazakhstan and Mexico, as well as seven international, regional and national training courses for personnel implementing systems to comply with the obligations.

A project entitled 'Enhancing Capabilities of the Safeguards Analytical Services (ECAS)' achieved significant progress. The construction at the Agency's Seibersdorf Laboratories of an extension to the Clean Laboratory for environmental sample particle analysis was completed, and advanced mass spectrometry equipment was put into service. Site preparation began for the construction of the new Nuclear Material Laboratory, and progress was made in the concept and design for infrastructure and site reorientation required in order to improve the efficiency and security of the Agency's Safeguards Analytical Laboratories.

## MANAGEMENT OF TECHNICAL COOPERATION FOR DEVELOPMENT

The Agency carries out its mandate "to accelerate and enlarge the contribution of atomic energy to peace, health and prosperity throughout the world" primarily through its technical cooperation programme. Its contribution in addressing a range of socioeconomic and development issues is carefully targeted. Technical cooperation projects, whether on nuclear power, knowledge management, human health, better water management, more accurate identification of pollution sources, or nuclear safety or security, help Member States deal with important challenges.

In 2011, the technical cooperation programme was carried out against a global development backdrop that included the Millennium Development Goals and the approaching 2015 deadline for their achievement; international concern about climate change; and other pressing challenges such as water scarcity, land degradation, food and energy security, and communicable and non-communicable diseases. The 'Green Economy' concept, defined by UNEP as an economy that is low carbon, resource efficient and socially inclusive, continued to gain momentum, and with the United Nations Conference on Sustainable Development (Rio+20) in sight, sustainable development issues were at the forefront of the development agenda.

In response to Member State requests, the Agency continued to focus on improving programme quality and transparency. Training to ensure that all technical cooperation project objectives would be specific, measurable, attainable, realistic, and timely was carried out for programme management officers, National Liaison Officers and technical officers, and was completed in early 2011. Cross-cutting efforts were made to ensure early review of the 2012–2013 technical cooperation programme cycle. In addition, special efforts were made to ensure that Member States received information in a timely fashion, through informal briefings, seminars, and the early release of documentation for the meeting of the Technical Assistance and Cooperation Committee.

Since the Agency's contribution to Member State development is specialized and technical in nature, partnerships with relevant actors, from counterparts to other international organizations, are essential if the programme is to meet its strategic goal of promoting tangible socioeconomic impact in Member States by contributing to the achievement

of their sustainable development priorities. In recent years, the Agency has made a particular effort to participate in the United Nations Development Assistance Framework (UNDAF) process and to build on complementarities with other international and regional development agenda.

Specific partnerships in 2011 included cooperation with the UNDP in Asia to promote nuclear imaging technologies, coordinated support with several United Nations agencies and international partners to address the legacy of uranium production sites in Europe, joint activities with the Pan American Health Organization to increase the use of nuclear applications in medicine, and efforts to enhance institutional collaboration and synergies with the African Union Commission's Department of Peace and Security. Significant support to nuclear safety activities was provided under an agreement with the European Commission.

## The Technical Cooperation Programme in 2011

In 2011, the nuclear fuel cycle programme accounted for the highest proportion of 'actuals' through the technical programme, at 27%.[7] It was followed by human health at 18.3%, and by nuclear safety at 16.1% (Fig. 1). By the end of the year, financial implementation of the Technical Cooperation Fund (TCF) stood at 73.9%. Regarding non-financial implementation, the technical cooperation programme supported, inter alia, 3319 expert and lecture assignments, 205 training courses and 1379 fellowships and scientific visits.

At the regional level, meeting basic human needs remained at the top of the agenda for national development plans and international cooperation programmes in many African Member States. Agency assistance in this region therefore focused mainly on the sustainable application of nuclear techniques to achieve increased food security, improved nutrition and health services. In addition, attention focused on better management of groundwater resources, improved energy development planning, quality control in industrial development and a cleaner and safer environment.

In Asia and the Pacific, the focus on strengthening human and institutional capacity to apply nuclear technology in the health, agriculture and industry sectors continued. Other areas of activity included support to infrastructure building for Member States embarking on nuclear power programmes, and developing and strengthening national infrastructure for radiation and nuclear safety.

Acting promptly in response to a request from Member States following the Fukushima Daiichi accident, the Secretariat coordinated the initiation of a new RCA project to enhance national capacities for monitoring radioactive substances in the marine environment in the Asia and the Pacific region. The project aims to harmonize measurements of various radioisotopes to ensure a comparable and verifiable impact assessment across the Pacific Ocean, as well as exchange of information about the potential impact and risks to marine biota and to humans through food consumption. In addition to RCA Member States, seven other countries from the region are participating in this project, including three that are not Agency Member States.

*"Training to ensure that all technical cooperation project objectives would be specific, measurable, attainable, realistic and timely was carried out ... in early 2011."*

In Europe, technical cooperation activities concentrated on support for countries planning a nuclear power programme, and on the use of radiation in health care. Ensuring that appropriate levels of safety and security in all aspects of the peaceful use of nuclear technology are maintained is a key component of the Agency's technical cooperation projects.

In Latin America, special emphasis was placed on promoting technical excellence, leadership and cooperation between Member States, particularly through trilateral cooperation arrangements within regional projects planned for the 2012–2013 technical cooperation programme cycle. There is a renewed interest in the region in promoting strategic alliances and partnerships to multiply the benefits of technical cooperation with Member States.

[7] The financial terminology has changed following implementation of a new enterprise resource planning system, the Agency-wide Information System for Programme Support. 'Actuals' are the equivalent of 'disbursements', which was the term used previously.

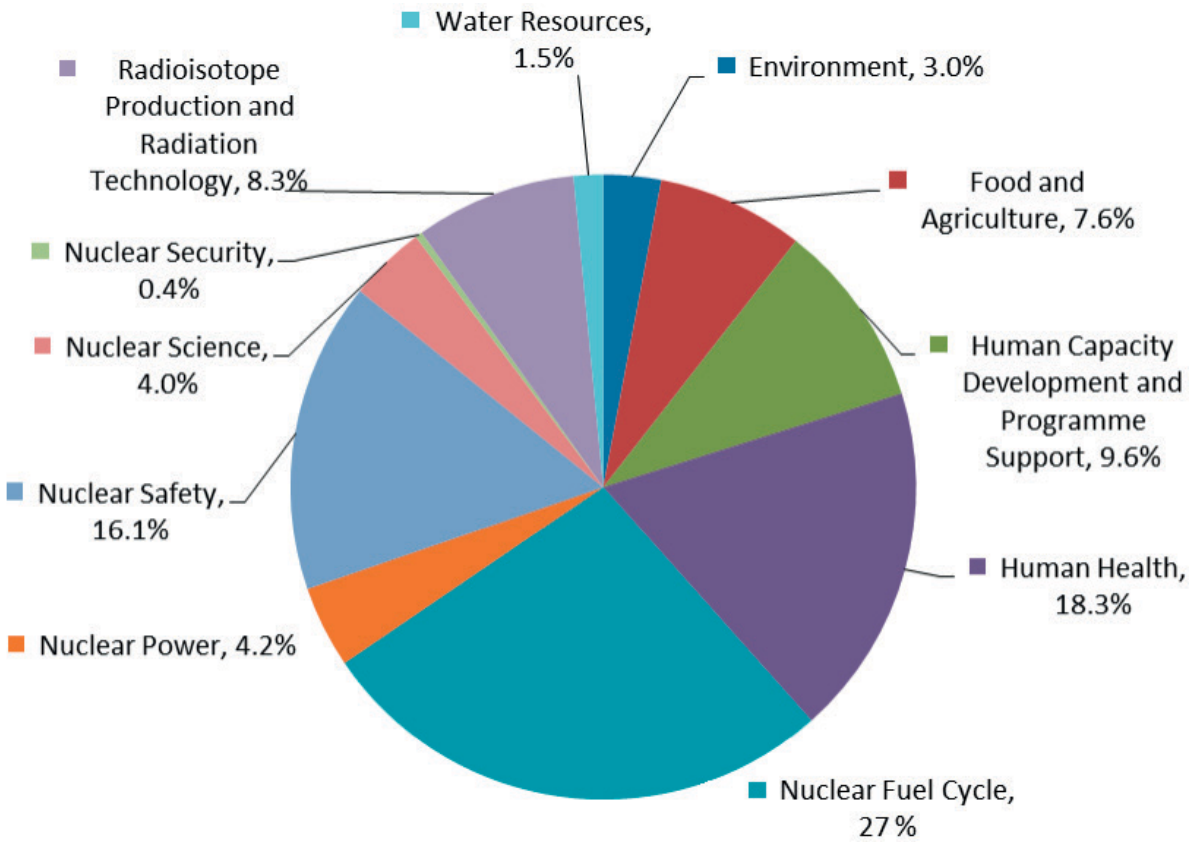



*FIG. 1. Actuals by technical field for 2011 (nuclear safety includes transport safety and safe management of radioactive waste; nuclear fuel cycle includes predisposal and disposal of nuclear fuel waste).*

## Financial Resources of the Technical Cooperation Programme

The technical cooperation programme is funded by voluntary contributions to the TCF, as well as by extrabudgetary contributions, government cost-sharing and contributions in kind. Overall, new resources reached a total of some €81.8 million in 2011, with approximately €62.9 million for the TCF (including previous year payments to the TCF, assessed programme costs, national participation costs[8] (NPCs) and miscellaneous income), €17.7 million in extrabudgetary resources, and about €1.1 million representing in-kind contributions.

The rate of attainment[9] for the TCF stood at 89.3% on pledges and at 86% on payments at the end of 2011, while payment of NPCs totalled €0.2 million. Resources were sufficient to carry out the core technical cooperation programme as planned for 2011.

*"the Secretariat coordinated ... a new RCA project to enhance national capacities for monitoring radioactive substances in the marine environment in the Asia and the Pacific region. "*

### *Actuals*

In 2011, approximately €83.3 million were disbursed to 123 countries or territories, of which 30 were least developed countries, reflecting the Agency's ongoing effort to address the development needs of those States.

[8] *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 can be made.

[9] The rate of attainment is the percentage that results from dividing the total voluntary contributions pledged and paid to the TCF for a particular year 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.

## MANAGEMENT ISSUES

In order to strengthen policy planning and strategy formulation as well as improve policy coordination and implementation, the Director General consolidated various high level management functions into a new office, the Director General's Office for Policy. This reorganization was aimed at improving effectiveness and efficiency in addressing current and emerging priority issues as well as cross-cutting and thematic issues so as to ensure a 'one-house' approach within the Secretariat. Another goal was to enhance communication with Member States.

The Agency recognizes that it operates in a challenging environment and is exposed to threats that may have implications for its performance and reputation. It also regards risk management as an essential element in the framework of good corporate governance and as an integral part of good management practice. To address this issue, a systematic approach to risk management was put in place with the objective of adding value to decision making and providing assurance to stakeholders that important risks for the Agency are appropriately dealt with. Specifically, a cross-departmental Risk Management Group was set up in 2011 to address and mitigate identified risks to the work of the Agency.

The formulation of the 2012–2013 programme and budget was guided by the goals of maximizing efficiency, reflecting changing priorities, striking an appropriate balance among the Agency's activities and, at the same time, taking into account the current financial challenges faced by most Member States and constantly increasing demands for the Agency's services. A two stage budget preparation process using a new methodology was initiated that also considered the guidance given to the Secretariat by Member States and the priorities identified in the *Medium Term Strategy 2012–2017*.

Among the Agency's initiatives to improve efficiency, effectiveness and organizational transparency is the implementation of a new enterprise resource planning system that involves reengineering all of its business processes — the Agency-wide Information System for Programme Support (AIPS). In 2011, the Agency implemented Plateau 1 of AIPS, covering finance, procurement, asset management and programme management. Work continued during the year on Plateau 2, covering the management of contacts (that is, information relating to suppliers, customers and project counterparts, among others) and the planning and monitoring of programmes and projects.

The implementation of Plateau 1 of AIPS served as the platform for the introduction, also in 2011, of IPSAS, the International Public Sector Accounting Standards. IPSAS is central to the reform of United Nations system management practices and the improvement of transparency and accountability.

*"A two stage budget preparation process using a new methodology was initiated that also considered the guidance given to the Secretariat by Member States and the priorities identified in the Medium Term Strategy 2012–2017."*

# The Agency's Response to the Accident at TEPCO's Fukushima Daiichi Nuclear Power Plant

The accident at Tokyo Electric Power Company's (TEPCO's) Fukushima Daiichi nuclear power plant (hereinafter the 'Fukushima Daiichi accident'), following the devastating earthquake and tsunami that struck Japan in March 2011, brought nuclear safety to the forefront of global attention. It underlined the responsibility of Member States and operating organizations in this crucial area.

This chapter briefly describes the Agency's response to the accident. It is based to a large extent on the *Nuclear Safety Review for 2012*, which provides a more detailed description of the accident and the range of the response actions to it.

*"The accident at ... [the] ... Fukushima Daiichi nuclear power plant ... brought nuclear safety to the forefront of global attention. It underlined the responsibility of the Member States and operating organizations in this crucial area."*

## Background

On 11 March 2011, an earthquake of magnitude 9.0 and a subsequent tsunami with an unprecedented run-up height reported to be approximately 14 m occurred off the east coast of Honshu, Japan. The Tokai, Higashi Dori, Onagawa, and Fukushima Daiichi and Daini nuclear power facilities were affected by severe ground motion and multiple large tsunami waves. The operational units at these facilities were successfully shut down by the automatic systems. However, the large tsunami waves affected these facilities to varying degrees, with the most serious consequences occurring at the Fukushima Daiichi nuclear power plant. About 46 minutes after the earthquake, the first of a series of large tsunami waves reached the site and overran the 5.7 m sea wall designed to protect it.

The tsunami inundated the Fukushima Daiichi site, causing the loss of all power sources except for one emergency diesel generator. With no other significant power source available on-site or off-site, the ability to cool the reactors was completely lost. The operators faced a catastrophic and unprecedented emergency scenario, with no power, no reactor control, almost no instrumentation and severely disrupted communications systems. They had to work in darkness to secure the safety of six reactors, six associated fuel pools, a common fuel pool and dry cask storage facilities.

Without backup power, venting and seawater injections could not alleviate the resulting lack of cooling to the active fuel and spent fuel pools. The reactor temperature increased and eventually led to hydrogen explosions at Units 1, 3 and 4, considerably damaging or destroying portions of these reactor buildings; fuel damage was suspected in Units 1, 2 and 3. On 12 April 2011, the Japanese Nuclear and Industrial Safety Agency (NISA) rated the event as Level 7 on the IAEA–OECD/NEA International Nuclear and Radiological Event Scale (INES).[1]

As a result of the release of a wide spectrum of radionuclides to the environment, a large number of people had to be evacuated from the area in order to prevent exposures above predefined reference levels. The Government of Japan established a restricted area of 20 km radius and planned evacuation zones. An emergency evacuation preparedness zone was established between a 20 and 30 km radius, and a deliberate evacuation area was also identified extending beyond the 30 km radius.

The assessment of exposures to the population and the environment, in particular in the Fukushima area, is the subject of studies being carried out by WHO and UNSCEAR, respectively, with the support and involvement of the Agency.

In mid-December 2011, conditions at the Fukushima Daiichi nuclear power plant had improved and stabilized. Plant operators brought the reactors into a "cold shutdown condition".

[1] See *INES: The International Nuclear and Radiological Event Scale User's Manual: 2008 Edition*, IAEA, Vienna (2009).

## The Agency's Response in the Aftermath of the Accident

Following the accident, the Agency's Incident and Emergency Centre (IEC) was placed in 'full response mode', operating 24 hours a day, 7 days a week, from 11 March to 3 May 2011. Designated Agency staff, notably liaison officers, public information officers, emergency response managers, logistics officers, technical specialists, and communication specialists, among others, were called in to discharge critical functions at the IEC.

The Agency kept Member States informed of the evolving situation, promptly notified all international organizations, activated the Joint Radiation Emergency Management Plan of the International Organizations, and began coordinating the inter-agency response to the Fukushima Daiichi accident with regard, in particular, to reaching a common understanding of the accident situation and coordinating public information.

From the early days after the accident, the Director General consulted with the Director General of WHO, the Director General of FAO, the Executive Secretary of the CTBTO and the Secretary General of WMO for effective coordination of activities.

At the first coordination meeting of the Inter-Agency Committee on Radiological and Nuclear Emergencies (IACRNE), relevant international organizations were briefed on the status of the situation, information was exchanged, response activities were coordinated and the public was kept informed through joint press releases.

The Director General visited Tokyo to obtain first-hand information on the accident, to pledge the Agency's full support and expert assistance, and to convey offers of assistance from more than a dozen countries. He met with Japanese Prime Minister Naoto Kan and the Minister of Foreign Affairs, Takeaki Matsumoto, along with senior officials from TEPCO and NISA. He stressed the importance of providing timely official information to the Agency and of maintaining the highest level of transparency.

The Agency sent four radiological monitoring teams to Japan to help validate the results of more extensive measurements made by the Japanese authorities. The Agency also sent a boiling water reactor expert team to Japan for detailed technical discussions with the relevant Japanese authorities.

In view of the accident's progression, the Agency evaluated key issues relating to the accident, coordinated responses, and provided accurate and timely information to Member States, the media and the public. Through its Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture and its laboratories in Seibersdorf, Austria, the Agency gathered and presented food contamination and monitoring data in areas affected by the Fukushima Daiichi accident. The database currently includes more than 100 000 entries based on information provided by the Japanese authorities. In addition, a Joint FAO/IAEA Food Safety Assessment Team went to Japan in March 2011 to provide advice and assistance to the Japanese authorities on food safety and monitoring strategies.

*"... the Agency's Incident and Emergency Centre was placed in 'full response mode', operating 24 hours a day, 7 days a week, from 11 March to 3 May 2011."*

The Agency's Laboratories in Seibersdorf provided analysis, information and methodological advice to laboratories from the ALMERA network.[2] These in turn carried out spectroscopic measurements on nearly 100 samples taken in Japan during various Agency missions.

Because Japan has a very high marine food consumption rate, the marine environment is of special concern to the Japanese population. Therefore, the contamination of the marine environment was continuously monitored both at the discharge areas of the reactors as well as at the offshore stations by TEPCO and by the Japanese authorities.

The Agency's Environment Laboratories in Monaco reviewed information regarding impacts on marine life and seafood resulting from the thousands of tonnes of radioactively contaminated water used to cool the reactors that had been released into the Pacific Ocean. The Agency also advised Japan on the collection of marine samples and reviewed a marine monitoring programme in Japan. It also participated in an analysis campaign initiated by the US Woods Hole Oceanographic Institution to collect water and biota samples between Japanese waters and Hawaii in June 2011.

[2] The Analytical Laboratories for the Measurement of Environmental Radioactivity (ALMERA) network comprises 122 laboratories from 77 States.

A delegation of major shipping lines met with the Agency and the International Maritime Organization in May 2011 to discuss ways of monitoring containers at ports. Support was provided to the shipping companies through the Agency's Denial of Shipment Network.

By agreement with the Government of Japan, the Agency assembled a team of experts who undertook an 'IAEA International Fact Finding Expert Mission' from 24 May to 2 June 2011 to identify initial lessons to be learned from the Fukushima Daiichi accident and to share this information with the world nuclear community. During the mission, the team of international nuclear experts received information from many relevant Japanese ministries, nuclear regulators and operators. The mission also visited three of the affected nuclear power plants — Tokai Daini, Fukushima Daini and Fukushima Daiichi — to gain an appreciation of the status of the plants and the scale of the damage. The visits allowed the experts to talk to the operator staff as well as to view the ongoing restoration and remediation work. The results of this mission were discussed with Japanese experts and officials, and a mission report was submitted to the Ministerial Conference on Nuclear Safety mentioned below.

*"... the Agency assembled ... an 'IAEA International Fact Finding Expert Mission' from 24 May to 2 June 2011 to identify initial lessons to be learned from the Fukushima Daiichi accident ..."*

The Director General convened a Ministerial Conference on Nuclear Safety in Vienna, from 20 to 24 June 2011, to draw on the lessons from the Fukushima Daiichi accident in order to strengthen nuclear safety throughout the world. The conference provided an opportunity to undertake, at the ministerial and senior technical level, a preliminary assessment of the accident and discussed broader issues relating to nuclear safety, emergency preparedness and response, and the international legal framework. The Conference unanimously adopted a Ministerial Declaration, which, inter alia, requested the IAEA Director General to prepare a draft Action Plan on Nuclear Safety.

At the 55th regular session of the Agency's General Conference in September, Member States unanimously endorsed the Board's approval of the IAEA Action Plan on Nuclear Safety, which was prepared in consultation with Member States.

The Director General established a dedicated 'Nuclear Safety Action Team' in the Secretariat to ensure proper coordination among all stakeholders and to oversee the prompt implementation of the Action Plan. This team developed a strategy to implement the activities within the scope of the Action Plan, initiating a detailed schedule of activities covering 12 actions, 39 sub-actions and 170 activities aimed at strengthening global nuclear safety. The Director General submitted a first progress report on the implementation of the Action Plan to the Board of Governors in November 2011.

At the request of the Japanese Government, the Agency sent an international expert mission to Japan from 7 to 14 October 2011 to help develop remediation plans. The mission's final report was issued to the Japanese Government on 15 November 2011 and was made publicly available.

Based on the lessons learned from the Fukushima Daiichi accident, the Agency began to re-evaluate the range of safety and security peer reviews and advisory services it offers to Member States, with a view to strengthening them.

Taking into account existing experience, the Agency developed a methodology for assessing the safety vulnerabilities of a nuclear power plant and made it available for Member States to assist them in completing a systematic analysis of the impact of extreme natural hazards at a nuclear power plant.

The Agency is in the process of extending its design review service to include modules for the peer review of national assessments that have been carried out by Member States. This service focuses on the design and safety assessment aspects of protection against extreme events, including defence in depth.

To strengthen the effectiveness of national regulatory bodies, and to enhance the Integrated Regulatory Review Service (IRRS), a 'Fukushima module' was incorporated into the scope of IRRS missions to take account of the initial regulatory implications of the accident. The Director General proposed closer cooperation with WANO, stating that the two organizations should continue to exchange information regarding the results of their respective peer review activities, where confidentiality constraints permit.

The Secretariat reviewed the Agency's safety standards, covering, as a first priority, the set of Safety Requirements applicable to nuclear power

plants and the storage of spent fuel. The draft Safety Standards Action Plan was approved by the Commission on Safety Standards. The plan will be continuously updated as further lessons continue to be learned in this regard.

The Agency also continued to assist Member States in strengthening and maintaining their capacity building programmes. The main issues considered were education and training, human resources, knowledge management and knowledge networks. The Agency also began development of a self-assessment methodology for capacity building programmes.

Another priority is to enhance the transparency and effectiveness of communication and to improve the dissemination of information. In addition, the Agency initiated a review of the application of INES as a communication tool.

*"The Secretariat reviewed the Agency's safety standards, covering, as a first priority, the set of Safety Requirements applicable to nuclear power plants and the storage of spent fuel."*

# Nuclear Technology

# Nuclear Power

## Objective

*To enhance the capability of interested Member States considering launching nuclear power programmes to plan and build the necessary infrastructure. To enhance the capability of interested Member States with existing and planned nuclear power programmes, 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, for actinide utilization and transmutation, and for non-electric applications, consistent with sustainability goals.*

## Launching Nuclear Power Programmes

Despite the accident at TEPCO's Fukushima Daiichi nuclear power plant (hereinafter the Fukushima Daiichi accident), nuclear power remains an important option not only for countries with existing nuclear programmes, but also for developing countries with growing energy requirements. While some countries indicated that they would defer decisions about introducing nuclear power, others continued with such plans while incorporating emerging lessons from the Fukushima Daiichi accident. Table 1 compares the numbers of Member States at different stages of decision making and planning for nuclear power at year-end in 2010 and 2011, according to their official statements.

Integrated Nuclear Infrastructure Review (INIR) missions were conducted in Bangladesh and the United Arab Emirates in 2011. The INIR process itself was strengthened: an updated brochure on *Guidance on Preparing and Conducting INIR Missions* was published in April, and experts meetings were held to learn lessons from recent missions. Greater emphasis was also placed on preparatory activities, and a meeting in October considered the development of INIR missions to be carried out prior to commissioning, as is called for in the IAEA Action Plan on Nuclear Safety. The Agency began work in 2011 to update the evaluation methodology used in INIR missions.

*Table 1. Member States at Different Stages of Decision Making and Planning to Introduce Nuclear Power in 2010 and 2011*

| | 2010 | 2011 |
|---|---|---|
| First nuclear power plant under construction | 1 | 0 |
| First nuclear power plant ordered | 2 | 3 |
| Decided and started preparing infrastructure | 10 | 6 |
| Active preparation with no final decision | 7 | 6 |
| Considering nuclear power programme | 14 | 14 |

## Engineering Support for Operation, Maintenance and Plant Life Management

The long term operation of nuclear power plants beyond the timeframe originally anticipated for them requires initiatives in education and training of plant personnel. The Fukushima Daiichi accident has focused additional attention, by both operators and regulators, on design reviews, the validity of a plant's original 'design basis' for extended periods, equipment stocks on-site, and non-safety-related structures, systems and components (SSCs) that are nonetheless important for severe accident management.

*"The long term operation of nuclear power plants beyond the timeframe originally anticipated for them requires initiatives in education and training of plant personnel."*

In 2011, the Agency began development of guidelines for approaches and models related to plant life management (PLiM) for long term operation of nuclear power plants and issued two related publications. *Stakeholder Involvement throughout the Life Cycle of Nuclear Facilities* (IAEA Nuclear Energy Series No. NG-T-1.4) offers general guidance and examines the benefits of long term stakeholder involvement in nuclear facilities in

terms of enhanced public confidence. *Stress Corrosion Cracking in Light Water Reactors: Good Practices and Lessons Learned* (IAEA Nuclear Energy Series No. NP-T-3.13) provides general descriptions of damage mechanisms associated with different types of stress corrosion cracking that are of concern to SSCs in light water reactors.

At a 'Nuclear Industry Cooperation Forum', held as a side event during the 55th regular session of the General Conference, about 65 representatives from the nuclear industry and the Agency shared operating experience and management strategies to enhance safety and improve performance in the wake of the Fukushima Daiichi accident.

*"Cybersecurity received increased attention in 2011, in part owing to the critical role of digital systems in modern nuclear facilities."*

To preserve valuable nuclear knowledge and expertise as many experts retire and to consolidate nuclear knowledge for the next generation of nuclear engineers and scientists, the Agency cooperates with the European Union's Joint Research Centre Institute for Energy and Transport (JRC-IET). In 2011, the Agency and JRC-IET began the development of a ten module, web based training course on irradiation embrittlement of WWER reactor pressure vessel material (Fig. 1).

Cybersecurity received increased attention in 2011, in part owing to the critical role of digital systems in modern nuclear facilities. A technical meeting in May on 'Newly Arising Threats in the Cybersecurity of Nuclear Facilities' proposed revisions to international guidance on computer security at nuclear facilities and recommended that the Agency undertake additional reviews of security guidance, start a CRP on the robustness of digital instrumentation and control systems against malicious acts, offer a peer review service on computer security, expand training, establish a 'community of practice' for the field and identify existing best practices in cybersecurity for nuclear facilities. The meeting concluded that while many organizations had worked on cybersecurity, their efforts had emphasized information technology and less work had been done on design requirements, the detection of and recovery from successful attacks, risk assessment, and verification and validation methods.

The successful expansion of a country's nuclear power programme depends on good relationships


*FIG. 1. The WWER reactor pressure vessel embrittlement multimedia training course.*

among the many parties involved. One way to ensure long term, reliable and sustainable relationships is the establishment of 'strategic partnerships', for example between a nuclear power plant operator and the design authority or vendor for the plant, or between a regulatory body and technical support organizations. In November, a technical meeting on 'Strategic Partnerships for the Expansion of a Nuclear Power Programme' brought together representatives from 15 Member States, who agreed that formalized strategic partnerships could significantly strengthen existing expansion capabilities. The participants also supported the Agency's assistance to Member States for the expansion of nuclear power programmes.

## Human Resource Development

Human resource development remained a high priority, particularly for Member States considering launching nuclear power programmes. Two training courses on the topics of leadership and management for countries introducing nuclear power were organized jointly by the Agency and France and the United States of America, respectively. The French course was hosted by the French Alternative Energies and Atomic Energy Commission (CEA) at Saclay, France, in June, and the US course was hosted by Argonne National Laboratories in the USA in November. In October, the Republic of Korea hosted the third mentoring programme to be organized by the Agency and the Korea Hydro & Nuclear Power Company (KHNP), at which future leaders of nuclear power projects in six countries introducing nuclear power were mentored by recently retired KHNP executives.

A technical meeting in November on 'Recruitment, Training and Qualification of Personnel for New Nuclear Power Programmes' provided an opportunity for both newcomers and Member States with established programmes to share experience. Through the technical cooperation programme, workshops on workforce planning and human resource development were organized in Malaysia, Nigeria and Vietnam. The Agency also published *Workforce Planning for New Nuclear Power Programmes* (IAEA Nuclear Energy Series No. NG-T-3.10).

At the 55th regular session of the General Conference, the USA presented the Agency with 'Nuclear Power Human Resources' (NPHR), a software modelling tool that can be adapted for workforce planning for new and expanding nuclear power programmes. The Agency will develop NPHR further to help national decision makers understand the needs of the nuclear power programme for workforce development, based on regulatory frameworks and other factors. NPHR will also potentially help Member States to gather data to contribute to an Agency effort to survey the global human resource requirements of nuclear power programmes, including new programmes.

In parallel, the Agency launched a 'Nuclear Power Industry Workforce Survey' of those Member States with existing nuclear power programmes in an effort to identify the total existing nuclear power programme workforce, as well as the short to medium term human resource requirements of existing programmes. The results of this survey should be available in the first half of 2012.

*"Human resource development remained a high priority, particularly for Member States considering launching nuclear power programmes."*

In the area of capacity building, and as part of the IAEA Action Plan on Nuclear Safety, the Agency is developing a new self-assessment method to enable Member States with existing nuclear power programmes, as well as those considering such programmes, to review the adequacy of their existing national capacity building arrangements and to identify areas to be strengthened.

## Nuclear Reactor Technology Development

At a workshop on 'Technology Assessment of Small and Medium-sized Reactors (SMRs) for Near Term Deployment', held in December, potential buyers and operators of SMRs had the opportunity to learn from reactor designers about the specific design, safety and other features of various SMRs under development (Fig. 2). The workshop participants ranked reactor safety as the most significant consideration, followed by economics, proven technology, plant performance and operability, and constructability.

A new publication, *Construction Technologies for Nuclear Power Plants* (IAEA Nuclear Energy Series No. NP-T-2.5), provides information on conventional and advanced techniques and methods being used in different aspects of the construction phase

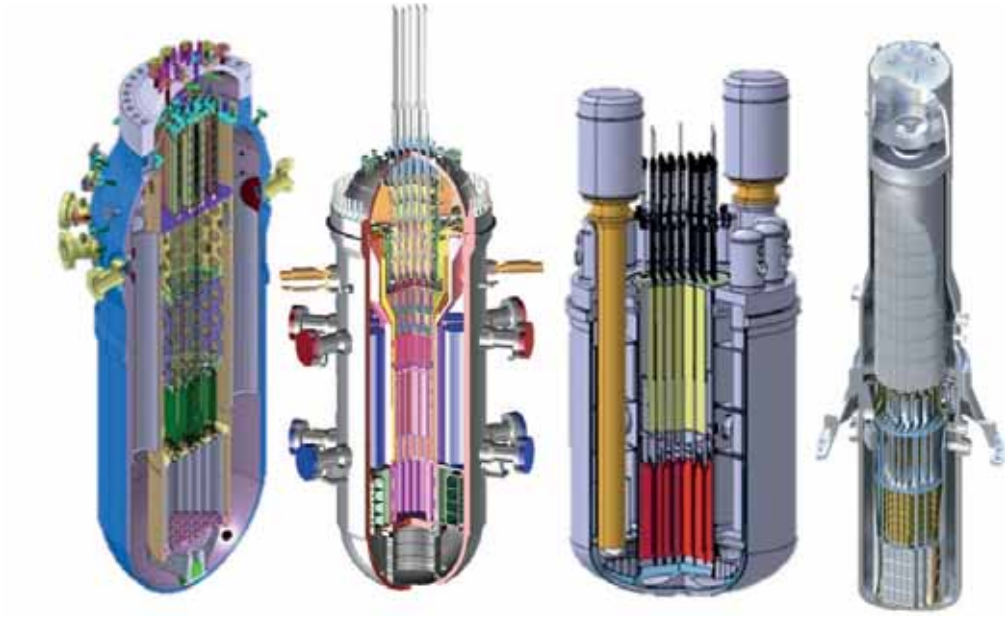


*FIG. 2. Examples of SMRs under development (left to right): CAREM from Argentina, SMART from the Republic of Korea, SVBR-100 from the Russian Federation and mPower from the USA.*

of projects, in both the nuclear and non-nuclear industries. In addition, workshops were held in Shanghai in June for the Asia region and in Paris in December for Africa and Europe. The workshops presented advances in construction techniques and the advantages and disadvantages of each technique.

Another workshop, on 'Non-electric Applications of Nuclear Energy', hosted by the Nuclear Research Institute Řež in the Czech Republic in October, recognized the need for international collaboration to reduce R&D costs. The importance of a pilot plant for hydrogen production using nuclear energy was also underlined.

*"In 2011, the INPRO Steering Committee developed the 'INPRO Development Vision 2012–2017', with the strategic objective of working towards global nuclear energy system sustainability ..."*

Updated versions of the Desalination Economic Evaluation Program (DEEP 4.0) and the Agency tool kit on nuclear desalination were released, with new features for easier use. The Agency also released a complementary new tool, the Desalination Thermodynamic Optimization Program (DE-TOP), for analysing the thermodynamics of co-generation systems, with an emphasis on water desalination. The Thermo-Physical Materials Properties (THERPRO) database for light and heavy water reactors was upgraded to a new web based system available at *http://www.iaea.org/NuclearPower/THERPRO/* (Fig. 3).

## Enhancing Global Nuclear Energy Sustainability through Innovation

The International Project on Innovative Nuclear Reactors and Fuel Cycles (INPRO), which supports Member States in developing and deploying sustainable nuclear energy systems, welcomed three new members in 2011: Egypt, Israel and Jordan. This brought the number of members to 35.[1]

In 2011, the INPRO Steering Committee developed the 'INPRO Development Vision 2012–2017' (Fig. 4), with the strategic objective of working towards global nuclear energy system sustainability by modelling and analysing pathways for nuclear energy growth. The pathways include transition to fast reactors and the closing of the nuclear fuel cycle, promoting technical and institutional innovations, and supporting Member States in developing

[1] The members of INPRO at the end of 2011 were Algeria, Argentina, Armenia, Belarus, Belgium, Brazil, Bulgaria, Canada, Chile, China, Czech Republic, Egypt, France, Germany, India, Indonesia, Israel, Italy, Japan, Jordan, Kazakhstan, Republic of Korea, Morocco, Netherlands, Pakistan, Poland, Russian Federation, Slovakia, South Africa, Spain, Switzerland, Turkey, Ukraine, United States of America and the European Commission.


*FIG. 3. The THERPRO database clickable map of the periodic table of elements.*

national long range nuclear energy strategies that take full advantage of available innovations.

Four Nuclear Energy System Assessments (NESAs) using the INPRO methodology were under way or initiated in 2011 in Belarus, Indonesia, Kazakhstan and Ukraine in support of national long range nuclear energy strategic planning. The NESA Support Package, developed to support a country's assessment, was extended to include sample data and 'e-NESA' software.

The INPRO collaborative project GAINS (Global Architecture of Innovative Nuclear Energy Systems Based on Thermal and Fast Reactors Including a Closed Fuel Cycle) was concluded. It identified and quantified the benefit of transitioning to a globally sustainable nuclear energy system based on fast reactors and closed fuel cycles. A follow-up project, Synergetic Nuclear Energy Regional Group Interactions Evaluated for Sustainability (SYNERGIES), was initiated, with the objective of

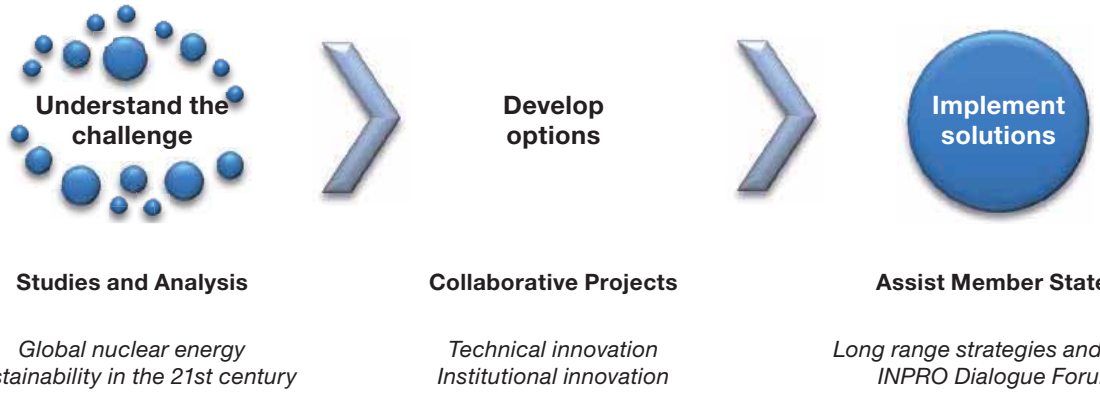



*FIG. 4. Global nuclear energy sustainability and INPRO's contribution.*

quantifying the benefit of collaboration and synergies among countries during this transition.

The 3rd INPRO Dialogue Forum, which promotes strategic discussions between nuclear technology holders, users and other stakeholders, discussed the development and deployment of small and medium sized reactors (SMRs) and initiated an in-depth survey on common user considerations for SMRs as a follow-up to the publication *Common User Considerations (CUC) by Developing Countries for Future Nuclear Energy Systems* (IAEA Nuclear Energy Series No. NP-T-2.1).

# Nuclear Fuel Cycle and Materials Technologies

## Objective

*To enhance and further 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

The projected growth in nuclear power is expected to increase uranium requirements for power reactors from 68 640 tonnes of uranium per year (t U/a) in 2010 to between 107 600 and 136 900 t U/a in 2030, based respectively on the reference and high nuclear growth scenarios of the World Nuclear Association.

The 2010 edition of the joint IAEA–OECD/NEA publication *Uranium 2009: Resources, Production and Demand*, the next edition of which will be published in 2012, divides conventional uranium resources into 'identified resources' and 'undiscovered resources'. According to the report, most current exploration is focused on new areas with estimated undiscovered resources, and much of the effort is in countries with no recent history of uranium exploration.

To address challenges in identifying uranium resources in 'greenfield' areas, i.e. areas that have not been previously investigated, the Agency organized a technical meeting on uranium provinces and mineral potential modeling. At the meeting, held in Vienna in June, some 80 experts from 35 Member States discussed the occurrence, nature and control of economic uranium mineralization in current and potential 'uranium provinces'. Uranium provinces are regions of the Earth's crust with rocks having uranium concentrations above normal abundance, generally as distinct deposits. The participants agreed that the critical application of mineral potential modelling techniques would be essential in locating new uranium deposits. They stressed the relative importance of different mantle and crustal processes and geological cycles in the formation of 'mega-uranium' provinces, for example the Central Asia uranium province and the Middle East–North Africa–Latin America phosphate uranium province. They concluded that further research is needed to globally consolidate the present understanding of the formation of uranium provinces, and that greater attention should be given to mineral potential modelling in mega-uranium provinces that cross national borders.

Unconventional uranium resources and thorium further expand the resource base. These resources include uranium in seawater and resources from which uranium is only recoverable as a minor by-product. Past estimates of potentially recoverable uranium associated with phosphates, non-ferrous ores, carbonatite, black schist and lignite are of the order of 10 Mt U.

In response to rising interest, the Agency organized a technical meeting on uranium extraction from phosphates. The meeting, which was held in Vienna in September and attended by 40 experts from 27 Member States, introduced the concept of 'comprehensive extraction' to optimize the return from any mining and processing operation. The objective is to extract all elements of current and potential value, not just a single target commodity. The meeting also discussed technology, operational efficiency, environmental impacts and sustainability in the context of past experience, as well as current research and priority areas in the phosphoric acid pre-treatment and solvent extraction stages, where further attention could improve overall economics. The meeting strongly endorsed training and professional development in the 'triple bottom line method', comprising economic, social and environmental criteria for measuring and evaluating returns from enterprise performance.

*"The projected growth in nuclear power is expected to increase uranium requirements for power reactors ..."*

The Agency also organized an international training meeting/workshop course on uranium extraction from phosphates and phosphoric acid, in Marrakech, Morocco, in association with the Moroccan Association of Nuclear Engineers (AIGAM)

and with the support of the Moroccan Ministry of Energy, Mines, Water and Environment. The 50 participants from over 30 Member States received training in starting uranium extraction plants in phosphoric acid production facilities (Fig. 1).

World thorium resources are estimated to be about 6 Mt. Although thorium has been used as a nuclear fuel on a demonstration basis, its broader use would depend on the commercial deployment of thorium fuelled reactors, which is currently a gradual process. In 2011, India started the site selection process for an experimental thorium fuelled 300 MW(e) advanced heavy water reactor that is expected to be operational by 2020.

*"The participants noted thorium's promise in extending the global deployment of nuclear power and concluded that the technology is sufficiently mature for initial commercial deployment ..."*

The Agency held a technical meeting on world thorium resources, in October in Thiruvananthapuram, India (Fig. 2). Organized in cooperation with Indian Rare Earths Limited (IREL) and with support from the Atomic Minerals Directorate for Exploration and Research, Hyderabad, and the University of Kerala, Thiruvananthapuram, and with over 50 experts attending from 20 Member States, the meeting focused on resource estimates, exploration, production and the use of thorium in the nuclear fuel cycle, with an emphasis on environmental, health, safety, economic and social licensing aspects. The participants noted thorium's promise in extending the global deployment of nuclear power and concluded that the technology is sufficiently mature for initial commercial deployment, although no one has yet taken that step. It also addressed the co-production of thorium and rare earth elements, and the importance of conserving thorium and defining good practices to store co-produced thorium for future use.

*FIG. 1. Uranium extraction workshop in Marrakech, Morocco.*

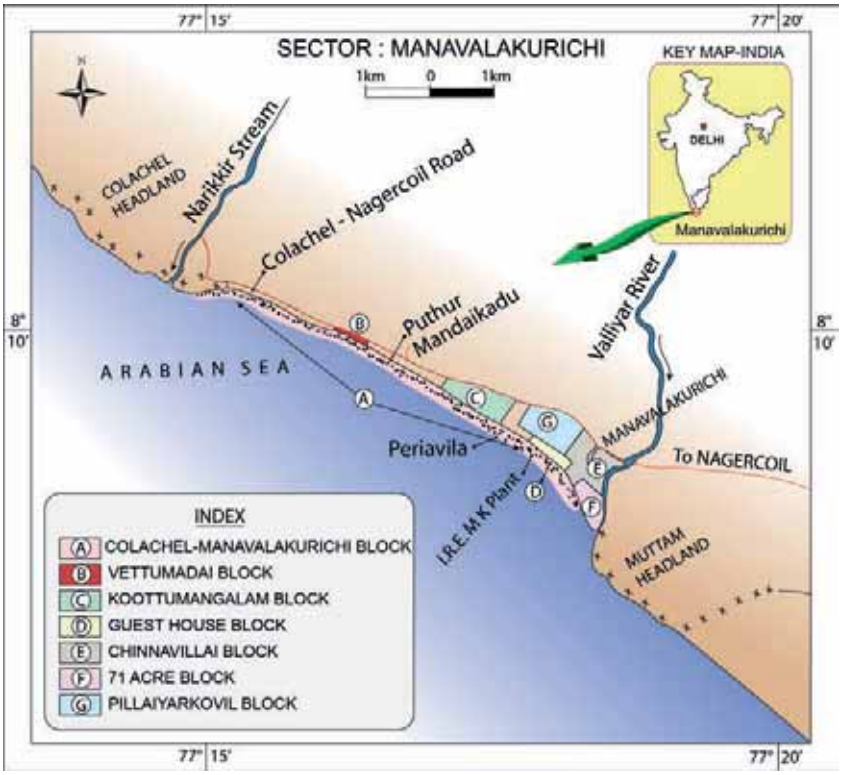



*FIG. 2. Map of the Manavalakurichi beach sand thorium deposit, India.*

## Nuclear Power Reactor Fuel Engineering

The Agency assists Member States in pooling information and undertakes cooperative research on the development, design, manufacture, use in reactors, and performance analysis of nuclear fuel. In 2011, the annual demand for LWR fuel fabrication services remained at about 7000 tonnes of enriched uranium in fuel assemblies, but it is expected to increase to about 9500 t U/a by 2020. For PHWRs, requirements accounted for 3000 t U/a.

The Agency published the results of a CRP in a report entitled *Optimization of Water Chemistry to Ensure Reliable Water Reactor Fuel Performance at High Burnup and in Ageing Plants (FUWAC)* (IAEA-TECDOC-1666). The CRP built on improvements from earlier research on data processing technologies and diagnostics for water chemistry and corrosion control in nuclear power plants. These improvements made it possible to better control and monitor water chemistry. The CRP that ended in 2011 reviewed the principles of managing water chemistry, taking into account improvements in control and monitoring, new materials, the impact of more onerous operating conditions, crud induced power shifts and ageing. The final report (IAEA-TECDOC-1666) compiles the principal insights in five areas: corrosion of primary circuit materials, the composition and thickness of deposits on fuel, crud induced power shift, fuel oxide growth and thickness, and radioactivity buildup in the reactor coolant system.

A CRP on 'Fuel Behaviour Modelling: FUMEX-3' was completed in 2011. More than 20 Member States contributed to the CRP and to the joint IAEA–OECD/NEA International Fuel Performance Experiments (IFPE) Database that was created within the FUMEX series of CRPs. The CRP improved fuel modelling codes to better predict the behaviour of fuel at high burnups, in particular the mechanical interactions that occur during transients. And a new CRP on fuel cladding cracking, entitled 'Evaluation of Conditions for Hydrogen-induced Degradation of Zirconium Alloys during Fuel Operation and Storage', was initiated in 2011 in response to the accident at TEPCO's Fukushima Daiichi nuclear power plant.

*"The Agency assists Member States in pooling information and undertakes cooperative research on the development, design, manufacture, use in reactors, and performance analysis of nuclear fuel. "*

The Agency organized a technical meeting in Japan on the behaviour and modelling of fuel for water cooled reactors under severe transient and loss of coolant accident conditions. The specialists, from 19 Member States, identified deficiencies in experimental data and differences in safety criteria, and recommended improved international coordination in testing fuel and comparing different codes used to model fuel behaviour.

## Spent Fuel Management

In 2011, about 10 500 tonnes of heavy metal (t HM) were discharged as spent fuel from all nuclear power reactors. The total cumulative amount of spent fuel that has been discharged globally up to December 2011 is approximately 350 500 t HM. Currently, less

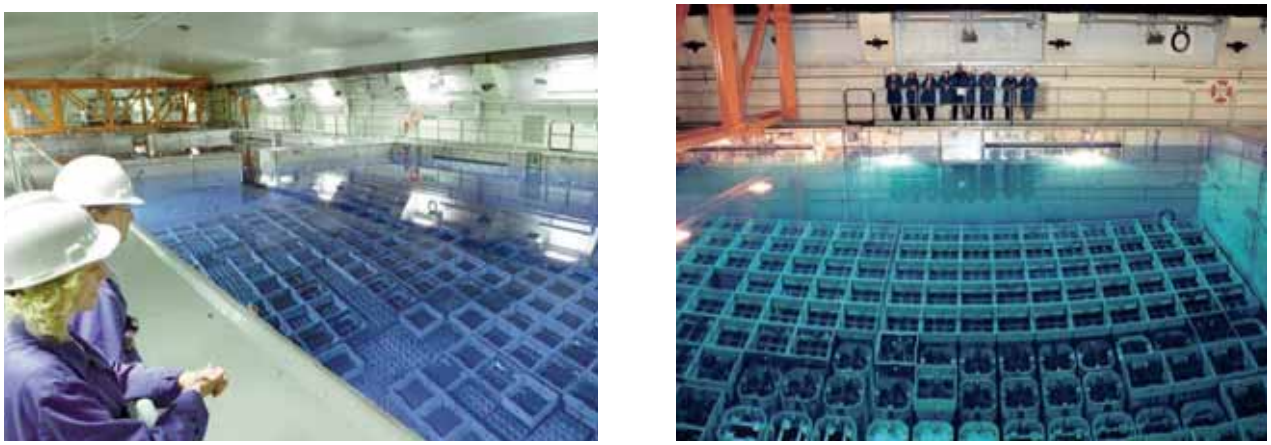


*FIG. 3. The Central Interim Storage Facility for Spent Nuclear Fuel (CLAB) at Oskarshamn, Sweden, an away from the reactor underground wet storage pool facility.*

than 25% of discharged fuel is reprocessed, and the implementation of disposal facilities for spent fuel or high level waste has been delayed in most Member States. Consequently, there are growing inventories of spent nuclear fuel. This fuel will have to be stored for longer periods than initially intended, with storage times possibly extending beyond 100 years (Figs 3 and 4).

In 2011, the Agency initiated a new CRP on demonstrating performance of spent fuel and related storage system components during very long term storage. Its objectives are to: create a network of experts; assemble the necessary models and experimental data; develop a method to demonstrate long term spent fuel performance; develop the capability to assess the impact of high burnup and mixed oxide fuel on long term spent fuel storage, transport and disposal; and document the technical basis for demonstrating long term spent fuel performance to help transfer the knowledge to countries introducing nuclear power programmes.

*"There is continuing interest in the deployment of small and medium reactors (SMRs) given their potential suitability for small electricity grids, remote locations and non-electric applications, and their potentially lower capital costs and simplified infrastructure requirements."*

## Topical Advanced Fuel Cycle Issues

The chemical separation of various constituents of spent nuclear fuel (called 'partitioning') could facilitate the reuse of separated fissile material to obtain extra energy and reduce the radiotoxicity of nuclear waste, and thus the size of geological repositories. The Agency held a technical meeting on 'Advanced Partitioning Processes', in Vienna in June, to review the status and prospects of partitioning and its possible contribution to advanced and proliferation resistant nuclear fuel cycles. The meeting concluded that although hydro- and pyro-metallurgical separation technologies were at advanced stages at the pilot scale, more work was needed for engineering scale development. The meeting identified specific scale-up challenges such as equipment and facility design.

In the area of fuels and fuel cycles for sodium cooled fast reactors, the Agency published *Status and Trends of Nuclear Fuels Technology for Sodium Cooled Fast Reactors* (IAEA Nuclear Energy Series No. NF-T-4.1) and *Status of Developments in the Back End of the Fast Reactor Fuel Cycle* (IAEA Nuclear Energy Series No. NFT4.2). The first publication describes manufacturing processes, out of pile properties, and the irradiation behaviour of mixed uranium plutonium oxide, carbide, nitride and metallic fuels. It also covers minor actinide bearing fuels. The second publication is a comprehensive presentation of partitioning technologies and related issues concerning the back end of the sodium cooled fast reactor fuel cycle.

There is continuing interest in the deployment of small and medium reactors (SMRs), given their

*FIG. 4. The Independent Spent Fuel Storage Installation at the Surry Nuclear Power Plant in Virginia, USA, an at-reactor dry storage cask facility.*

potential suitability for small electricity grids, remote locations and non-electric applications, and their potentially lower capital costs and simplified infrastructure requirements. Research and development of innovative fuels and fuel cycle options for SMRs are under way in several Member States. In response, the Agency organized a technical meeting on fuel and fuel cycles for SMRs for Member States to exchange information and experience on nuclear fuel and fuel cycle technologies related to SMRs for electricity generation, process heat and marine propulsion, and breeding and/or burning transuranic elements. The meeting concluded that fuel discharge burnup and fuel residence in the reactor core needed to be optimized to ensure that SMR fuel cycles were in fact economical.

## Integrated Nuclear Fuel Cycle Information System

Comprehensive information on worldwide nuclear fuel cycle activities is available through the Agency's Integrated Nuclear Fuel Cycle Information System (iNFCIS) (*http://infcis.iaea.org/*). iNFCIS attracts more than 600 000 visits annually from researchers, professionals, policy makers and the general public. The on-line information system includes the Nuclear Fuel Cycle Information System (NFCIS), World Distribution of Uranium Deposits (UDEPO), Post-Irradiation Examination Facilities Database (PIE) and Minor Actinide Property Database (MADB). In 2011, a new database on the World Distribution of Thorium Deposits and Resources (ThDEPO) was added to the system, and iNFCIS was migrated to the NUCLEUS platform, the Agency's common access point for its scientific, technical and regulatory information resources.

iNFCIS makes it possible to analyse the different stages, facilities, capacities, interlinkages and synergies related to various fuel cycle options and approaches. Using the data in iNFCIS, the Agency projects that fuel services such as uranium conversion, enrichment, fuel fabrication and reprocessing, and recycling will experience growth similar to the projected growth in uranium requirements for power reactors noted above (Fig. 5). Currently, most of these service capacities are slightly underutilized, but facility replacements will be required in the near future. iNFCIS enables the early identification of potential bottlenecks in the fuel cycle supply chain for a variety of scenarios, for example the Agency's high and low projections as reported in the next chapter on 'Capacity Building and Nuclear Knowledge Maintenance for Sustainable Energy Development'.

*"Comprehensive information on worldwide nuclear fuel cycle activities is available through the Agency's Integrated Nuclear Fuel Cycle Information System ..."*

*FIG. 5. Uranium ore processing at the Key Lake operation in Canada.*

# 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 information resources for the peaceful uses of nuclear science and technology; to support Member States interested in including nuclear energy in their national energy mixes by providing nuclear information.*

## Energy Modelling, Databanks and Capacity Building

The Agency updates annually its estimates of future nuclear electricity generating capacity in the world. In 2011, the exercise took into account changing perceptions about the future of nuclear power resulting from the accident at TEPCO's Fukushima Daiichi nuclear power plant (hereinafter the Fukushima Daiichi accident) after the earthquake and tsunami that hit Japan on 11 March 2011. The 2011 high estimate projected that global nuclear power capacity would increase from 369 GW(e) at the end of 2011 to 746 GW(e) in 2030 and 1228 GW(e) by 2050. The low estimate projected growth to 501 GW(e) in 2030 and 560 GW(e) in 2050.

*"Demand continued to increase for Agency assistance in capacity building for energy system analysis and planning, and for conducting national and regional studies on future energy strategies and the role of nuclear power."*

The number of operating nuclear reactors is projected to increase by about 90 by 2030 in the low estimate and by about 350 in the high estimate from the total of 435 reactors at the end of 2011. Most of the growth will occur in countries that already have operating nuclear power plants. Projected growth is greatest in the Far East. The nuclear capacity in this region is projected to grow from 79.6 GW(e) at the end of 2011 to 180 GW(e) in 2030 in the low estimate and to 255 GW(e) in the high estimate.

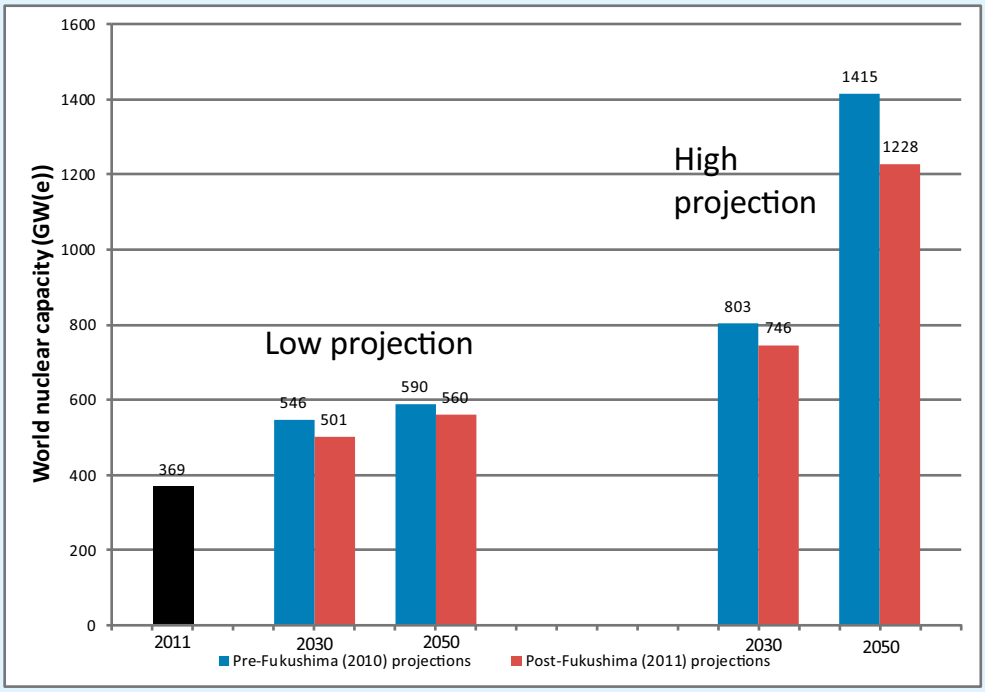
The low and high estimates do not represent extreme situations but cover a plausible range. They are prepared by an international group of experts assembled by the Agency, and are based on a country by country, bottom–up approach, reflecting plans by governments and electric utilities, and the judgement of experts.

Demand continued to increase for Agency assistance in capacity building for energy system analysis and planning, and for conducting national and regional studies on future energy strategies and the role of nuclear power. The Agency's analytical tools developed for this purpose are now being used in more than 125 Member States. During 2011, over 600 energy analysts and planners from 67 countries were trained to use these tools. Traditional face to face training was regularly supplemented by web based e-training courses. For countries introducing nuclear power, the Agency held four regional and five national training workshops on assessing the economic and financial viability of nuclear power projects and establishing national positions on the introduction of nuclear power, which is the first of the 19 infrastructure issues identified in the publication *Milestones in the Development of a National Infrastructure for Nuclear Power* (IAEA Nuclear Energy Series No. NG-G-3.1).

## Energy–Economy–Environment (3E) Analysis

For the 17th Conference of the Parties (CoP-17) to the United Nations Framework Convention on Climate Change, held in December 2011 in Durban, South Africa, the Agency published *Climate Change and Nuclear Power 2011*, which emphasizes the importance of nuclear energy in reducing carbon dioxide emissions in the electricity sector (see Fig. 1) and provides up to date information on a number of issues related to the subject. As in previous years, the Agency maintained an information centre at CoP-17 that provided an opportunity to present

The Fukushima Daiichi accident resulted in a slowing of the expansion of nuclear power, but did not reverse it. As shown in the figure below, the Agency's post-accident projections of global nuclear power capacity in 2030 were 7–8% lower than what was projected before the accident. This continued growth in both the low and high projections suggests that the factors that contributed to increasing interest in nuclear power before the Fukushima Daiichi accident have not changed: these include increasing global demand for energy as well as concerns about climate change, volatile fossil fuel prices and security of energy supply.




*Comparison of projections for nuclear power before and after the Fukushima Daiichi accident.*

its work on the linkages between nuclear power and climate change mitigation, to disseminate relevant publications, and to discuss broader issues pertaining to nuclear energy with government and non-government delegates. In addition to nuclear power's low greenhouse gas emissions, the Fukushima Daiichi accident and the overall safety of nuclear power plants were the most frequent subjects about which questions were asked. Nuclear power continued to be of major interest to delegations from developing countries as they assessed their climate change mitigation options.

Many Member States, especially those with both abundant and cheap coal resources and with the capacity to build and operate nuclear power reactors, must decide on their preferred mix for electricity generation using coal and nuclear power. Key issues include the relative advantages and disadvantages associated with managing the waste products, specifically carbon dioxide in the case of coal based power and radioactive waste in the case of nuclear power. An Agency book published by Springer in 2011, *Geological Disposal of Carbon Dioxide and Radioactive Waste: A Comparative Assessment*, assesses carbon dioxide and radioactive waste disposal and reveals many similarities, including the transformation of the geological environment, safety and monitoring concerns, and regulatory, liability and public acceptance issues. The publication is intended to help policy makers consider, as part of developing national energy strategies, the broad range of issues involved in the disposal of waste from nuclear energy and from fossil based power generation with carbon dioxide capture. The Agency

*"Nuclear power continued to be of major interest to delegations from developing countries as they assessed their climate change mitigation options."*

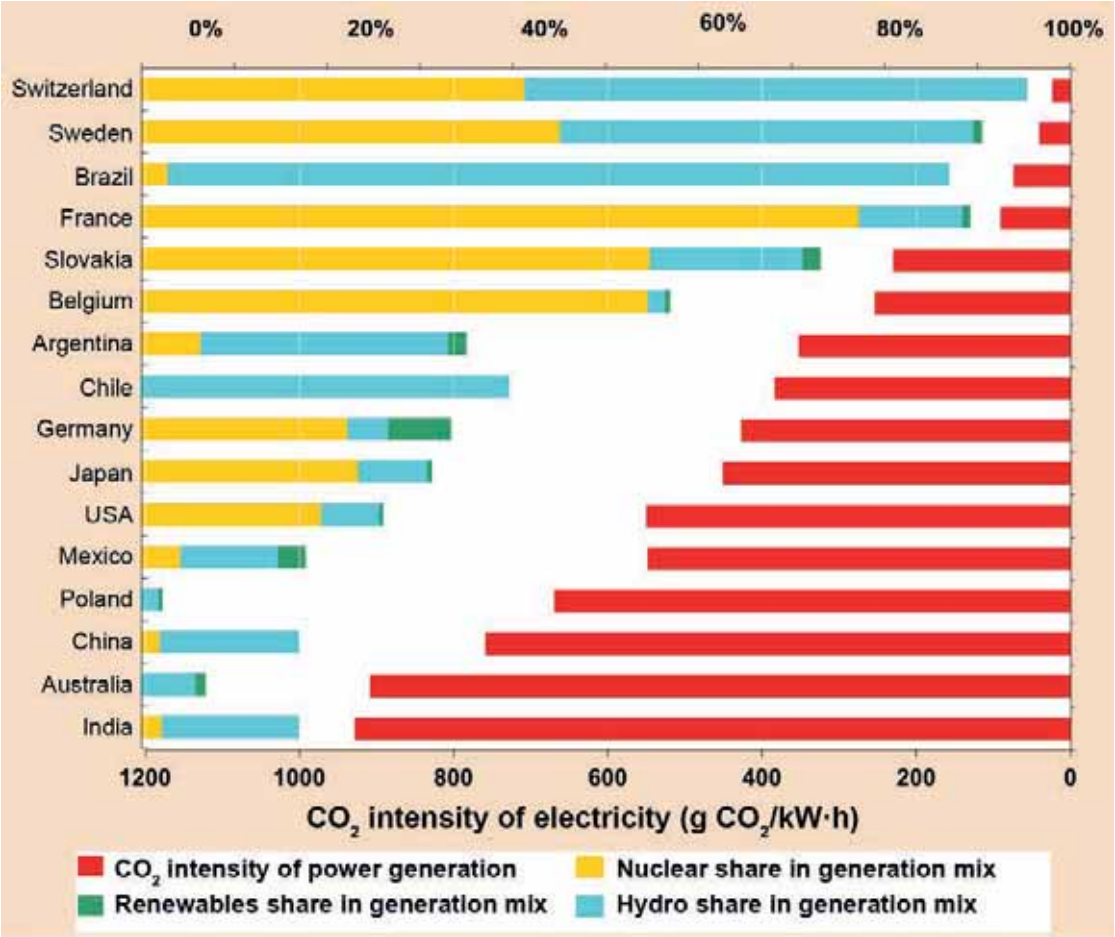



*FIG. 1. Carbon dioxide intensity and the shares of non-fossil sources in the electricity sector of selected countries (Agency calculations based on IEA data).*

also completed a CRP that supported Member States in the preparation of comparative assessments of the geological disposal of carbon dioxide and radioactive waste in the context of their own specific requirements.

In response to the diverse range of privatization and deregulation concepts and programmes across Member States, a series of technical meetings was held to explore the prospects for nuclear power under different electricity market regulatory arrangements. Their preliminary conclusion was that regulated markets generally offer better opportunities for nuclear power, through government support and long term power purchase agreements, compared with pool based deregulated markets with less flexibility for long term power purchase agreements. However, the decisions of investors are influenced strongly by factors unrelated to power market reforms, such as climate change policy, the price of natural gas, feed-in tariffs (which provide a guaranteed revenue per kilowatt-hour to producers), resource abundance and security of supply.

*"The Agency continued to participate in the international debate on the potential role of nuclear power in climate protection and mitigation."*

The Agency continued to participate in the international debate on the potential role of nuclear power in climate protection and mitigation. In addition to publishing *Climate Change and Nuclear Power 2011*, it delivered invited presentations at a number of topical international conferences, prepared a paper on nuclear power and climate change for the Human Development Report of the UNDP Asia–Pacific Regional Centre and contributed to the Fifth Assessment Report of the IPCC. The Agency also expanded the scope of its climate related activities to explore the impacts of climate change and extreme weather events on nuclear energy installations and the energy sector at large; it also

organized a workshop at the Abdus Salam ICTP in Trieste, reported at major international conferences and prepared a special issue of the journal *Climatic Change* on extreme weather events.

## Nuclear Knowledge Management

The Agency continued to be an important source of methods and guidance for nuclear knowledge management activities in Member States. In 2011, it published *Comparative Analysis of Methods and Tools for Nuclear Knowledge Preservation* (IAEA Nuclear Energy Series No. NG-T-6.7), which presents the results of a CRP on the methods and tools used in various nuclear organizations. It concluded that knowledge preservation in nuclear organizations had not reached maturity, that many cost effective methods and tools were available and that knowledge preservation processes could improve operational procedures and overall performance. It recommended that organizations without formal knowledge preservation programmes conduct knowledge loss risk assessments and take knowledge preservation into account in their strategic planning. The Agency also published *Status and Trends in Nuclear Education* (IAEA Nuclear Energy Series No. NG-T-6.1), which provides a general overview of activities regarding nuclear knowledge management, nuclear education, and national and regional needs and expectations. It also presents detailed country reports on the status of nuclear education in Member States and recommendations about best practices in nuclear education.

Through its technical cooperation programme, the Agency conducted knowledge management assist visits to the Shanghai Nuclear Engineering Research and Design Institute in China, the Kozloduy nuclear power plant in Bulgaria, the Atomic Energy Committee of Kazakhstan, the State Atomic Energy Corporation 'Rosatom' and Typhoon Scientific Production Association in the Russian Federation, the South Ukraine and Khmelnitsky nuclear power plants in Ukraine, the Khalifa University of Science, Technology and Research (KUSTAR) in the United Arab Emirates, Texas A&M University in the USA, and several universities in Vietnam.

The Agency continued to facilitate three important regional networks, the Asian Network for Education in Nuclear Technology, the AFRA Network for Education in Nuclear Science and Technology, and the Latin American Network for Education in Nuclear Technology, which was created in December 2010 and held its second General Assembly in Chile in October. A central element of the Agency's support is a 'Cyber Learning Platform for Nuclear Education and Training', which was installed in 2011 in Vienna, the Korea Atomic Energy Research Institute in the Republic of Korea, and KUSTAR in the United Arab Emirates.

In 2011, in cooperation with the Abdus Salam ICTP in Trieste, the Agency conducted its second School of Nuclear Energy Management and seventh School of Nuclear Knowledge Management. The former provided an opportunity for young managers from developing countries to be involved in a nuclear programme management course and to learn from world experts and the Agency's specialists about global nuclear energy development. The latter course targeted young professionals from developing countries and provided training on nuclear knowledge management and its implementation in nuclear organizations.

*"In 2011, in cooperation with the Abdus Salam ICTP in Trieste, the Agency conducted its second School of Nuclear Energy Management and seventh School of Nuclear Knowledge Management."*

In cooperation with the Karlsruhe Institute of Technology in Germany, the Agency conducted a train the trainers course on nuclear knowledge management for university teachers to develop curriculums for Masters level courses in science and engineering.

## Collecting and Disseminating Nuclear Information

In cooperation with 127 countries and 24 international organizations, the International Nuclear Information System (INIS) represents a global information system offering almost 3.4 million bibliographic records and more than 310 000 full-text non-conventional publications. This collection of documents on the peaceful uses of nuclear science and technology is now fully indexed and searchable on the Internet using the INIS Collection Search, a Google based web application developed by the Agency (*http://www.iaea.org/inis*). An average of over 50 000 searches were performed, as well as 3500 downloads, every

month in 2011. Through its technical cooperation programme, the Agency organized a regional training course for Africa in Morocco. In Vienna, it organized a training seminar with 40 participants from Member States. At the end of the year, the joint INIS/Energy Technology Data Exchange (ETDE) thesaurus contained 21 881 valid descriptors and 8675 'forbidden terms', i.e. terms that should no longer be used but should be replaced by a valid term included in the thesaurus.

The Agency has continued to complement its print collection at the IAEA Library with an increasing number of electronic resources. The number of visitors per month increased from 1000 in 2010 to over 1200 in 2011. A total of over 15 000 research requests were processed, while the number of loans to users increased from 14 500 in 2010 to 20 000 in 2011. Membership in the International Nuclear Library Network (INLN), coordinated by the Agency, remained stable with 35 member libraries. The INLN has developed into a 'community of practice', i.e. a network of people with a common interest who work together over time to develop knowledge in a specific area.[1]

[1] The main library web site is: http://www.iaea.org/OurWork/ST/NE/Library/
The library catalogue can be accessed at: *http://library.iaea.org/starweb/IAEA/servlet.starweb?path=IAEA/STARLibraries.web*
The INLN web site is: *http://www.iaea.org/OurWork/ST/NE/Library-INLN/*

# 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 a wide range of databases of nuclear, atomic and molecular data which underpin modern technology applications in fission and fusion energy production as well as medical and analytical applications. The databases are available primarily through on-line services to Member States and, in 2011, received approximately 175 000 hits, an increase of about 16% over the previous year. In addition, more than 11 000 reports, manuals and technical documents were downloaded.

An important activity is the development of software tools that enable data to be retrieved and displayed in ways that make the data more understandable and useful. The Evaluated Nuclear Data File (ENDF) and the Experimental Nuclear Reaction Data (EXFOR) links at *http://www-nds.iaea.org/* have recently acquired new features, including the ability to upload a user's data and to apply a wide range of 'corrections' to the experimental data to allow for changing standards.

Figure 1 shows an example of a cross-section curve used in ion beam analysis and stored in the Ion Beam Analysis Nuclear Data Library (IBANDL). Such data can also be displayed via EXFOR. Another major class of data deals with the static properties of nuclides, such as half-lives, decay modes and energy levels of excited states, as featured in the *Live Chart of Nuclides*, which was significantly extended during 2011 to show a wider range of nuclear properties *(http://www-nds.iaea.org/livechart/)*.

*"The Agency maintains a wide range of databases of nuclear, atomic and molecular data which underpin modern technology applications in fission and fusion energy production as well as medical and analytical applications."*

The XML Schema for Atoms, Molecules and Solids, developed with the Agency's support and guidance, is being widely implemented through the (European) Virtual Atomic and Molecular Data Centre.

The Agency supports relevant code comparison efforts to test the predictive powers of various model codes. A workshop on computation of collisional

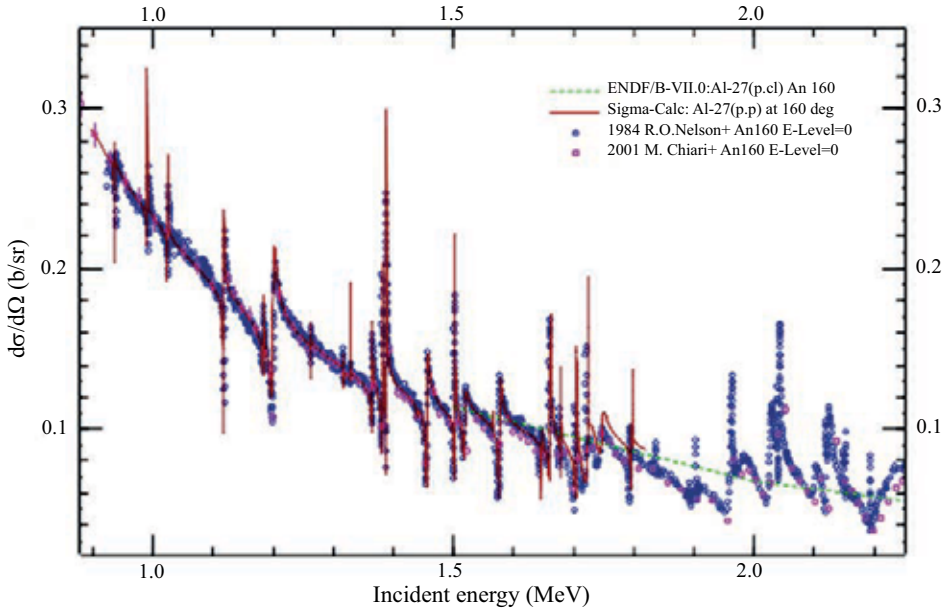



*FIG.1. Experimental data on the elastic scattering of protons on aluminium (shown by the symbols) compared with a theoretical calculation carried out using the tools in IBANDL. Such data are important in ion beam analysis.*

and radiative properties of atoms and ions away from local thermodynamic equilibrium was held in December 2011 in Vienna with Agency support, which provided valuable benchmarking of about twenty calculational codes.

Three training workshops were organized by the Agency in 2011, one in Trieste in cooperation with the Abdus Salam ICTP entitled 'Monte Carlo Radiation Transport and Associated Data Needs for Medical Applications', and the other two in Vienna to train new compilers of EXFOR and to teach the basics of covariances and the use of Global Assessment of Nuclear Data Requirements (GANDR). Approximately 75 participants received training during these events.

*"As part of ongoing efforts to prevent future shortages of molybdenum-99 supplies and to move away from the use of high enriched uranium, the Agency organized an international meeting to further international collaboration on conversion to [LEU] based $^{99}$Mo production."*

## Research Reactors

### *Addressing the shortage of molybdenum-99 supplies*

As part of ongoing efforts to prevent future shortages of molybdenum-99 ($^{99}$Mo) supplies and to move away from the use of high enriched uranium (HEU), the Agency organized an international meeting to further international collaboration on conversion to low enriched uranium (LEU) based $^{99}$Mo production. The December meeting focused on the specific technical and policy challenges confronting major HEU based producers and on advancing opportunities for potential multilateral cooperation that commenced in 2010. The meeting defined the scope of cooperation possible in a commercial $^{99}$Mo production environment and the Agency's role in supporting that conversion. It started a discussion on optimization of a high density LEU target for $^{99}$Mo production. This work — especially on a high density target — is envisaged to continue until all the major producers are converted to LEU in 2015.

The Agency completed its comparative assessment of non-HEU technologies for the production of $^{99}$Mo. The assessment, which will be published in 2012, will supplement reports published by the OECD/NEA High-level Group on the Security of Supply of Medical Radioisotopes, of which the Agency is a member. The report of the CRP related to the production of $^{99}$Mo using LEU targets, which held its final Research Coordination Meeting in December, will also be published in 2012.

### *Improving the utilization of research reactors*

Collaborative efforts between Member States (both with and without research reactors) to improve utilization were further enhanced in 2011 with the creation in July of the Central African Research Reactor Network, a technical meeting in October on access to research reactors by Member States that do not host such facilities, and the December 2011

*FIG. 2. The new very-high-flux PIK research reactor in the Russian Federation attained its first physical criticality on 28 February 2011 (left: reactor hall; right: reactor control room). (Photographs courtesy of PNPI 2011.)*

final coordination meeting of a technical cooperation project on 'Enhancing the Sustainability of Research Reactors and Their Safe Operation through Regional Cooperation, Networking and Coalitions', which proposed the creation of a new coalition covering the Commonwealth of Independent States (CIS).

A further initiative to encourage the development of very-high-flux research reactors (such as CARR in China, JHR in France and PIK in the Russian Federation) as international facilities with potentially shared ownership was launched in 2011 (Fig. 2).

An international conference on 'Research Reactors: Safe Management and Effective Utilization', organized every four years by the Agency, was hosted in Rabat in November 2011 by the Government of Morocco. The more than 200 participants from 42 Member States discussed key issues facing the research reactor community, including safe utilization. These included possible implications of the accident at TEPCO's Fukushima Daiichi nuclear power plant (hereinafter the Fukushima Daiichi accident) for some research reactors, utilization and maintenance issues, and preparations for new research reactors. A number of participants stressed the need for a 'milestones approach' for new research reactors comparable to the Agency's approach for new nuclear power plants.

The development of an integrated approach to routine automation of neutron activation analysis is the aim of a new CRP initiated in 2011. The CRP is expected to result in an increased neutron activation analysis (NAA) service capacity, and thus enhanced research reactor utilization.

Two Agency publications on research reactors were issued in 2011, *Research Reactor Application for Materials under High Neutron Fluence* (IAEA-TECDOC-1659) and a booklet entitled *Research Reactors in Africa.* The first publication focused on research reactor utilization for materials development and testing for both fission and fusion based nuclear power plants. The second highlighted the services available from African reactors to stakeholders in health, research, agriculture and other areas.

## *Research reactors in education and training*

Three Research Reactor Group Fellowship Training Courses, organized by the Eastern European Research Reactor Initiative and supported by the Agency, were held in 2011 to assist Member States interested in either initiating new research reactor projects or improving the utilization of existing research reactors. The six week courses were conducted at research reactors in Austria, the Czech Republic, Hungary and Slovenia. They included theory and practical work and technical visits.

For the past two years, the Abdus Salam ICTP–IAEA School of Nuclear Energy Management has included in its programme a session on the 'Fundamentals of Nuclear Applications', which presents the diverse applications of research reactors for both nuclear power related research and non-power applications. The session also highlighted the role of research reactors in developing the national nuclear infrastructure necessary for introducing nuclear power.

## *Research reactor infrastructure*

The contents and format of the Agency's Research Reactor Database (RRDB), available through the Nucleus web portal (*http://nucleus.iaea.org/RRDB/*), were reviewed in June by a group of external experts. Based on their comments, an updated version of the RRDB was released with advanced capabilities, including a guide to assist experts as they update the database, integrated map displays and a significantly improved revision management system.

*"The session also highlighted the role of research reactors in developing the national nuclear infrastructure necessary for introducing nuclear power."*

## *Research reactor fuel*

The Agency published *Good Practices for Water Quality Management in Research Reactors and Spent Fuel Storage Facilities* (IAEA Nuclear Energy Series No. NP-T-5.2) to assist research reactor managers and operators in implementing water quality programmes. In addition, two meetings relating to the management of spent research reactor fuel were organized. The first covered good practices in management and storage of spent research reactor fuel and guidelines for interim wet and dry storage. The second was a kick-off meeting to elaborate an Agency report on commercial options for the back end management of spent research reactor fuel.

### *Research reactor operation and maintenance*

In parallel with a meeting on research reactor ageing management held in October, the Agency carried out a project to revise and update a database on operating experience related to ageing. This extensive effort yielded over 200 responses from research reactor operators around the world; the information represents a unique collection of operating experience.

## Accelerators for Materials Science and Analytical Applications

The Tenth International Topical Meeting on 'Nuclear Applications of Accelerators', held in April 2011 in Knoxville, USA, brought together 130 experts from 20 countries in a conference co-chaired by representatives of the American Nuclear Society and the Agency. A significant outcome of the meeting was its demonstration of increased international interest in accelerator driven systems (ADSs) (Fig. 3).

Ion beam analysis, in particular applications in material science, cultural heritage and studies of nuclear technology materials, was a key area of work in 2011. Two new CRPs were initiated, one on 'Benchmarking of Structural Materials Pre-selected for Advanced Nuclear Reactors' and the other on the 'Utilization of Ion Accelerators for Studying and Modelling of Radiation Induced Defects in Semiconductors and Insulators'.

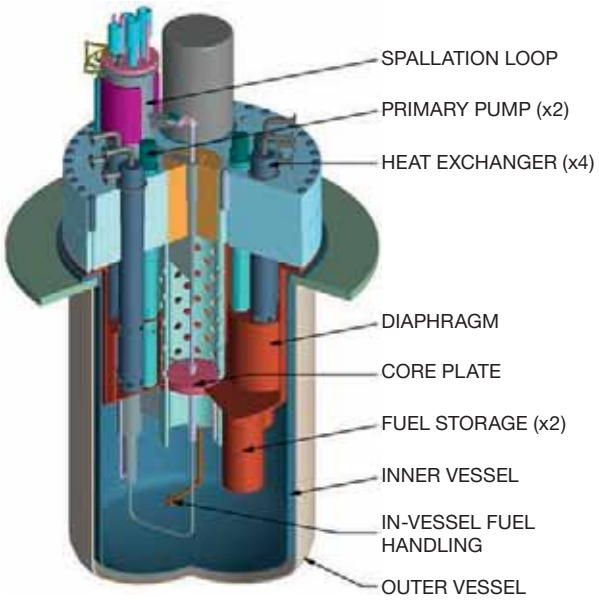



*FIG. 3. Schematic drawing of the MYRRHA ADS.*

## Nuclear Instrumentation and Spectrometry

Following a meeting on 'Future Perspectives for the Nuclear Spectrometry and Applications Laboratory (NSAL)' held in March 2011, two activities proposed at the meeting were initiated: construction of an ultra-high vacuum chamber (UHVC) and mobile gamma spectrometry and environmental mapping activities. Both of these projects are especially significant within the context of the Fukushima Daiichi accident and site remediation.

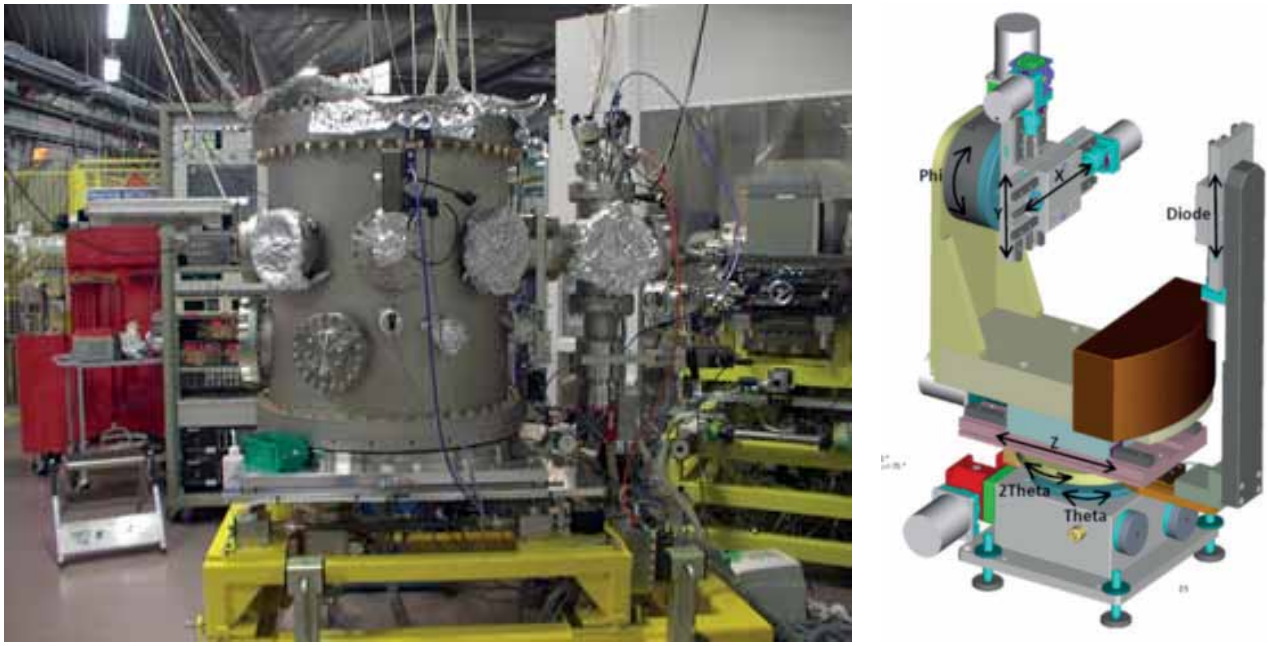



*FIG. 4. The UHVC at the Federal Institute of Physics and Technology, Berlin (left), and the seven axis motorized sample manipulator under construction for the Agency's UHVC (right).*

*FIG. 5. A 16th century Mexican headdress (left) being examined with a hand-held X ray fluorescence spectrometer (right).*

The new UHVC is being designed and constructed in collaboration with the Federal Institute of Physics and Technology, Berlin, and the Technical University of Berlin, and is expected to be installed in 2013 at Elettra, the IAEA Collaborating Centre in Trieste, Italy. The UHVC will significantly expand the capacity of the NSAL for advanced elemental analysis of materials and will allow advanced hands-on training to fellows from Member States (Fig. 4).

In 2011, NSAL conducted a non-invasive analysis of two valuable exhibits from a collection of Mexican artefacts at the Art History Museum in Vienna. The analysis was designed to establish the presence of toxic elements which would suggest the use of pesticides in past treatments of objects for conservation and to establish the authenticity of gold decorations and elements (Fig. 5).

## Nuclear Fusion

Agency cooperation with ITER in Cadarache, France, continued. The past year saw the completion of the first large building on the ITER site, the 257 m long by 49 m wide poloidal field coil hall (Fig. 6), which will house the assembly of part of ITER's magnetic confinement system. With diameters of up to 24 m, the poloidal field coils are too large to be

*"The UHVC will significantly expand the capacity of the NSAL for advanced elemental analysis of materials ..."*

*FIG. 6. The first completed ITER building, the poloidal field coil hall.*

transported in their finished state and will therefore be wound on-site.

In support of fusion energy technology, the Agency focuses on the development and evaluation of data for processes that involve plasma particles interacting with the wall of the fusion confinement device. In 2011, a CRP began on molecular processes in the near-wall plasma, and work continued on tungsten and beryllium as fusion related materials. These are foreseen as the main wall materials for the ITER experimental reactor and a future fusion power plant.

Reflecting the growth of the field of plasma physics and nuclear fusion worldwide in the context of ITER and other research activities for future fusion power stations, two new CRPs were initiated in 2011 on 'Small Magnetic Fusion Devices for Mainstream Fusion Research' and 'Materials under High Repetition and Intense Fusion Pulses'.

# Food and Agriculture

## Objective

*To promote and contribute to the improvement of food security and safety to enhance Member State capabilities in the application of nuclear techniques for sustainable agricultural development.*

## Animal Production and Health

A major event in 2011 was the declaration of global freedom from rinderpest by FAO and the World Organisation for Animal Health (OIE). This significant achievement was celebrated during the Agency's 55th General Conference in September 2011 (Fig. 1). The commitment of the Agency was mentioned by the participants as a critical factor in the effort's success. Officials, including over 50 ministers and ambassadors, as well as dignitaries from FAO, OIE, the African Union–Interafrican Bureau for Animal Resources and the European Union celebrated this achievement.


*FIG. 1. The Director General, Mr. Yukiya Amano with, from left, Mr. Ahmed El Sawalhy (African Union–Interafrican Bureau for Animal Resources), Mr. Kazuaki Miyagishima (OIE), Ms. Ann Tutwiler (FAO), and HE Mr. Gianni Ghisi (Ambassador of Italy and Chairman of the Agency's Board of Governors) during the celebration of the global freedom from rinderpest.*

The Agency, in its joint programme with FAO, continues to develop and implement technologies for animal disease control. The new generation LAMP test to diagnose trypanosomosis, avian influenza, rabies, Rift Valley fever and foot and mouth disease (FMD) builds on the foundation established by the rinderpest programme. Field results indicate that the test kits are robust and do not need cooling of the reagents. Internet or mobile phone connections make it possible to take action immediately after a disease outbreak is detected. This helps Member States shift their efforts from reacting to a disease to detecting the disease at an early stage, even before the appearance of clinical signs (Fig. 2).

Technology transfer continued to be a priority in 2011. Member States received support through technical cooperation projects in the control or eradication of animal diseases, including those affecting people. For example, during the FMD outbreak in Mongolia, strategic vaccination guided by a surveillance programme was implemented. To help Mongolia control FMD, 200 000 doses of vaccine were delivered to the counterpart through a technical cooperation project. The action proved effective and the spread of FMD was contained. Over one million animals were saved directly, and another ten million indirectly. The Agency is assisting Mongolia in the development of a pilot facility for production of irradiated vaccines. Additionally, the Agency

*"The commitment of the Agency was mentioned by the participants as a critical factor in the effort's success"*

*FIG. 2. On the spot diagnostic tools have significantly improved the early and rapid response to animal diseases.*

is cooperating with FAO, OIE and neighbouring countries to establish a regional network for animal disease control.

In 2011, technology transfer in the field of animal production was directed towards four areas: (1) improved feeding practices; (2) improved reproduction through artificial insemination; (3) evaluation of genetic profiles to improve animal production; and (4) selection of other measures to improve animal production. In the tropics, climatic variations reduce plant growth and feed availability,

*FIG. 3. Zambian farmer in a field of locally available feed.*

leading to reduced productivity. Farmers in Zambia have traditionally kept animals on marginal pastures. Through a technical cooperation project, the nutritional value of locally available feed is being assessed to evaluate its ability to provide sufficient energy and/or protein for animals (Fig. 3). Results suggest that supplementing low quality diets with velvet bean is comparable to the use of commercial concentrates.

*"Approved in over 60 countries, food irradiation supports sustainable agricultural production by virtue of its ability to control spoilage, food borne pathogenic microorganisms and insect pests without significantly affecting sensory or other organoleptic attributes of the food."*

In Niger and Cameroon, artificial insemination centres are utilizing local breeds. Improved reproduction has resulted in an increase in milk production of three litres per cow per day.

## Food Safety and Food Control

In 2011, a CRP on 'Integrated Analytical Approaches to Assess Indicators of the Effectiveness of Pesticide Management Practices at the Catchment Scale' established and strengthened a network of analytical laboratories in Latin America (Argentina, Brazil, Chile, Costa Rica and Ecuador) and in Bulgaria, China, Kenya and the Philippines. The laboratories identified a series of biological and chemical indicators to assess the presence of selected high impact pesticides in surface water, sediments and foods. These indicators were subsequently integrated into a monitoring strategy to assess the effectiveness of pesticide management practices at the microcatchment scale, resulting in enhanced communication and effective feedback mechanisms between laboratories and agricultural producers.

More specifically, laboratory capacity was improved in nine laboratories, resulting in the validation of 24 analytical methods, the publication of 17 papers in scientific journals, 46 poster presentations at conferences, one book chapter, 34 keynote speeches, and the mentoring and training of 11 BSc and 6 MSc candidates. Further benefits included the improvement of quality assured procedures and the generation of local data on environmental pesticide applications, which are being used to establish and improve good agricultural practices, as well as more effective and targeted campaigns on the safe use of pesticides in the field. The pesticide contamination data generated by the CRP are being used by national regulatory authorities to support a holistic approach to food production through the use of nuclear and complementary technologies that improve food safety and environmental protection.

Approved in over 60 countries, food irradiation supports sustainable agricultural production by virtue of its ability to control spoilage, food borne pathogenic microorganisms and insect pests without significantly affecting sensory or other organoleptic attributes of the food. In 2011, a relatively small but growing proportion of food produced worldwide was irradiated to help minimize the risk of food borne illnesses or to maintain post-harvest product quality, making it possible to keep food longer while at the same time ensuring a higher level of food safety and quality.

## Sustainable Management of Major Insect Pests

The international trade in agricultural commodities provides food, consumer goods and a livelihood to millions of people, but also promotes the spread of pests that damage commercial crops and the environment. Tephritid fruit flies cause severe damage to fruits and vegetables and are major quarantine pests that interfere with the export of horticultural commodities. The most cost effective management of fruit flies combines pre-harvest and post-harvest pest risk management measures. In support of these strategies, the Agency and FAO have developed guidelines that outline how the exporting country can integrate measures at the time of pre-harvest, harvest, post-harvest, export and transport, or/and at entry and distribution in the importing country.

Over the years, FAO/IAEA projects have assisted Guatemala in implementing the sterile insect technique (SIT) to suppress or contain pest fruit flies. In 2011, two areas comprising 300 000 hectares were officially declared free of the Mediterranean fruit fly, facilitating exports of fresh fruit and vegetables from these areas without the need for costly post-harvest treatments (Fig. 4).

A CRP on the 'Development of Standardized Mass-Rearing Systems for Male *Anopheles arabiensis* Mosquitoes' was completed in 2011. During the five year CRP, significant progress was made in developing and validating new mass rearing and sterilization procedures for mosquitoes. Among the equipment developed was: a larval tray–rack system; a device with the capacity to separate a mixture of one million larvae–pupae per hour; and a new larval diet to facilitate the establishment of colonies. Knowledge gained and several practical procedures that were developed are being transferred to Member States.

*FIG. 4. Earnings in Guatemala from the export of non-traditional crops such as bell peppers, tomatoes and papayas (picture above) have increased several-fold due to Agency technology transfer that has enabled phytosanitary trade barriers to be overcome and thousands of rural jobs to be created.*

A special issue of the journal *Genetica* on 'Molecular Technologies to Improve the Effectiveness of the Sterile Insect Technique' was published, representing the outcome of a CRP. The issue, which contains 15 scientific papers from leading researchers in the field of classical and modern biotechnology, reviews the state of the art in the use of genetics and molecular biology to generate improved strains for the application of SIT that produce only male insects for sterilization and release, or that carry identifiable markers to discriminate released and wild insects in the field.

*"During the five year CRP, significant progress was made in developing and validating new mass rearing and sterilization procedures for mosquitoes."*

Efficient mass rearing of the target insect is fundamental for SIT, but its complexity for moth pests is often underestimated. A joint FAO/IAEA textbook, *Rearing Codling Moth for the Sterile Insect Technique* (FAO Plant Production and Protection Paper 199), was published in 2011. The book compiles information on the rearing of the codling moth in relation to the SIT. The integration of SIT with other control tactics offers great potential for the codling moth, and the book aims to support ongoing and future management programmes.

## Crop Improvement through Mutation Breeding

A major achievement in 2011 was the development of ten advanced mutant wheat lines (some induced at the Agency's Laboratories in Seibersdorf) resistant to the black stem rust, race Ug99, by an interregional technical cooperation project that included 18 Member States and three international and two national institutions. The virulent race Ug99 appeared in East Africa in 1999 and quickly spread to Ethiopia, Kenya, Sudan and Uganda, overcoming the stem rust resistant genes that were protecting

breeding programmes. Recently, Ug99 caused 80% yield loss in Kenya, with outbreaks occurring in parts of Asia and in the Islamic Republic of Iran and Yemen. According to FAO, annual losses could reach $3 billion. As the plague may spread globally, new resistance is urgently required. The radiation induced mutant lines show promise in national yield trials in Kenya, where the disease is endemic (Fig. 5).

*FIG. 5. Demonstration of Ug99 resistant wheat mutant lines in Eldoret, Kenya, at the second technical meeting of an interregional technical cooperation project.*

In 2011, 14 new mutant varieties were officially released to farmers, most of which were produced directly with support from the Agency through the technical cooperation programme and CRPs. Data on these and on a further 132 mutant varieties (released in previous years) were added to the mutant varieties database in 2011 (see *http://mvgs.iaea.org*). The database now contains 3424 entries for 224 plant species. The latest additions were two mutant Egyptian safflower varieties, 'Insha 10' and 'Insha 11', released in 2011. An oil crop rich in linoleic acid (an essential fatty acid), safflower is used in cooking and has medicinal properties such as lowering cholesterol.

*"A low cost mutation detection kit was developed by the Joint FAO/IAEA Programme for use in developing countries."*

In 2011, the Agency distributed low cost kits to Austria, Bulgaria, Poland, the Philippines and the Syrian Arab Republic for mutation detection in banana, lupin and wheat. In Poland, they were used for rapid selection of lupin mutants for anthracnose disease resistance. The kit contains a positive control, is quick, does not require specialized equipment and, most significantly, is very inexpensive.

A low cost mutation detection kit was developed by the Joint FAO/IAEA Programme for use in developing countries. This has been distributed to ten countries and applied to 12 crop species. In addition, over 100 fellows were trained.

## Soil and Water Management and Crop Nutrition

The compound-specific stable isotope analysis (CSIA) technique, supported by methods using naturally abundant stable isotopes such as nitrogen-15 and carbon-13, has been used to identify critical hotspots of land degradation (Fig. 6). Such information is crucial in order to implement appropriate and cost effective on-farm conservation strategies. Results obtained in a 2011 CRP showed that mulch based cropping systems can reduce soil erosion by 90% in the mountainous uplands of northern Vietnam, while still retaining sufficient runoff water for lowland rice production.

*FIG.6. Innovative isotope techniques identify hotspots of land degradation in mountainous northern Vietnam.*

Through another CRP, farm ponds, on-farm wetlands and riparian buffer zones, all covering an area of 1–3% of the catchments studied, were found to be effective at capturing more than 90% of water originating from rainfall and surface runoff from these catchments during the rainy season. The water captured was shown by isotopic signatures of

oxygen-18, hydrogen-2 and nitrogen-15 to be a major source of nitrogen (up to 50% for plant growth) and was found to save up to $200/ha/year on fertilizer alone.

A technical document entitled *Impact of Soil Conservation Measures on Erosion Control and Soil Quality* was published in 2011. The report provides information on the use of fallout radionuclides in 16 countries in efforts to minimize soil erosion/degradation and develop sustainable watershed management strategies.

Through a regional technical cooperation project, the radionuclides caesium-137, lead-210, beryllium-7, potassium-40 and radium-226 have been used effectively as fingerprints to identify sources of sediment delivery to water bodies in forested catchments in south-central Chile. Information obtained in this project is currently being used to improve management practices in the Chilean forestry sector, which was valued at $5.5 billion in 2008 and accounts for 7.3% of Chile's exports.

Under a regional technical cooperation project, the isotope nitrogen-15 was successfully used to show that green manure application could increase rice yield by 20%, reduce mineral nitrogen fertilizer requirements by 50% and increase fertilizer nitrogen use efficiency by 25–45%. In Cuba, this translated into an additional income of $450/hectare to resource poor farmers.

For the first time in the Agency's history, a two week expedition to Antarctica was carried out by Chilean and Agency experts within the context of a regional technical cooperation project to assess the impact of climate change on soil degradation and soil quality in Antarctic ecosystems (Fig. 7). Information obtained through the use of stable and radioisotope tracers will be particularly useful in understanding the impacts of climate change on land degradation in the high Andes and elsewhere.

*FIG. 7. Soil sampling in Antarctica (Ardley Island) for fallout radionuclide analysis will help to assess the impact of climate change on soil redistribution.*

*"For the first time in the Agency's history, a two week expedition to Antarctica was carried out by Chilean and Agency experts within ... the context of a regional technical cooperation project to assess the impact of climate change on soil degradation and soil quality in Antarctic ecosystems ..."*

# 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.*

## Training and Education for Successful Radiotherapy

Radiation oncology, radiology and nuclear medicine are three disciplines in radiation medicine that are heavily dependent on technology and require competent professional staff to ensure safe and effective patient diagnosis, treatment and management. The Agency has identified a shortage of radiation medicine professionals and a lack of training in Member States as two of the main obstacles to the successful implementation of national radiotherapy strategies. In 2011, the Agency addressed the problem by: (1) producing learning and educational materials; (2) making materials available to centres with limited resources, in their local languages; (3) organizing and conducting courses and workshops; and (4) planning long term training and education at the national or regional scale.

*"Applications in radiation medicine continue to increase in importance as new imaging and treatment modalities are introduced and existing technologies are enhanced."*

The Agency also identified the need for suitable guidelines on appropriate staffing levels when seeking to initiate, expand or upgrade services. In 2011, the Agency developed three calculation tools for the areas of radiation oncology, radiology and nuclear medicine that help predict staffing requirements for radiation medicine departments in hospitals. The tools are based on the input of statistics that are commonly known or can be easily estimated.

## Nuclear Medicine

The Agency strengthened its efforts to promote a sustainable and cost effective nuclear medicine and diagnostic imaging programme for Member States. This was done through the initiation of two CRPs. Involving 20 Member States, the CRPs focus on the early detection of breast cancer through imaging and on the detection of coronary artery disease (CAD) through myocardial perfusion imaging (MPI) and coronary computed tomography angiography. In addition, a publication completed in 2011, *Nuclear Cardiology: Its Role in Cost Effective Care*, issued in the IAEA Human Health Series, offers an overview of CAD as a public health problem in developing countries, the role of nuclear cardiology methods within a scenario of unprecedented technological advances, and the evidence behind the appropriateness of recommendations to apply nuclear techniques in the diagnostic process for cardiac patients. The potential expanding role of non-invasive functional imaging is also discussed in the publication, as is the need for solid training, education and quality assurance (QA) in nuclear cardiology practice.

A number of Agency publications issued in 2011 examined trends in diagnostic and therapeutic nuclear medicine. For example, *Atlas of Bone Scintigraphy in the Developing Paediatric Skeleton: The Normal Skeleton Variants and Pitfalls* was issued in the IAEA Human Health Series.

## Dosimetry and Medical Radiation Physics

Applications in radiation medicine continue to increase in importance as new imaging and treatment modalities are introduced and existing technologies are enhanced. Comprehensive QA and independent dosimetry audits are thus required to ensure appropriate clinical outcomes and to reduce the likelihood of errors, accidents and misdiagnoses. In this regard, the increased use of small photon fields in stereotactic and intensity modulated radiotherapy has highlighted the need to standardize the dosimetry of such fields using procedures consistent with those for conventional radiotherapy. An expert group, established by the Agency in collaboration with the American Association of Physicists in Medicine and the Institute of Physics

and Engineering in Medicine in the United Kingdom, completed work on an international code of practice for the dosimetry of small static photon fields. The code provides procedures for reference dosimetry, including correction factors based either on experiments or on Monte Carlo simulations. The factors are tabulated for various detectors in specific machines such as the CyberKnife, the Gamma Knife and the TomoTherapy system, as well as for generic rectangular fields defined by multi-leaf collimators and circular fields defined by cones used for radiosurgery. The code also defines procedures for determining the beam quality in non-reference conditions. For the measurement of beam output factors in small fields, procedures for connecting large field measurements using ionization chambers to small field measurements using high resolution detectors are given (Fig. 1).

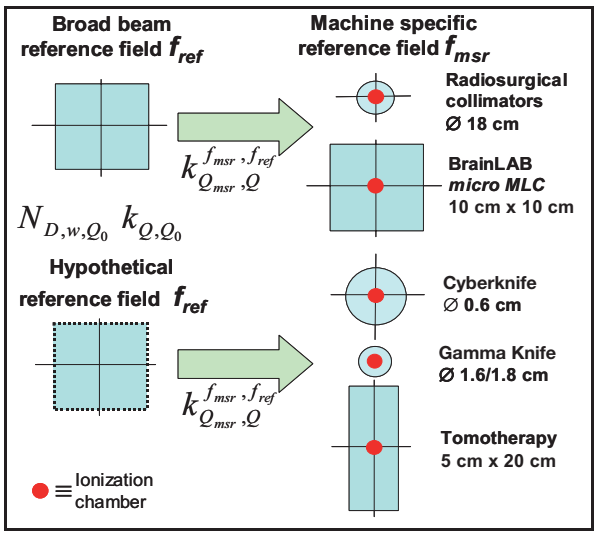



*FIG. 1. Schematic overview of the dosimetry of small static fields with reference to a machine specific reference field according to the procedure of the new code of practice.*

In 2011, the Agency issued a publication in the Training Course Series on the clinical training of medical physicists in nuclear medicine. With this publication, the Agency now offers a complete package of clinical training material for medical physicists in radiation oncology, diagnostic radiology and nuclear medicine.

## Applied Radiation Biology and Radiotherapy

It is likely that many teachers of radiation biology in low and middle income Member States may not be radiation biologists themselves, because of the scarcity of such specialists. In such cases, radiation oncologists and medical physicists end up teaching radiobiology. To assist these teachers in conveying important radiobiological principles to their students, a series of 634 educational slides was added to the publication *Radiation Biology: A Handbook for Teachers and Students* (Training Course Series No. 42). The slides can also be downloaded from the Human Health Campus web site at *http://nucleus.iaea.org/HHW/Home/index.html.*

During 2011, a workshop was organized to consolidate the experience gained from the second cycle of train the trainers sessions for radiation therapists (RTs) in Europe. The workshop was conducted in collaboration with the European Society for Radiotherapy and Oncology. These activities generated a number of local courses for RTs in Europe. The methodology of this process has generated great interest and has become a potential model for radiotherapy technologists in other regions and even for other professional groups.

## Stable Isotope Techniques in Nutrition for Improved Health

Malnutrition remains the single largest cause of child mortality. Over one third of all child deaths are due to malnutrition. Malnourished mothers often produce malnourished children, who are more likely to die before the age of five. If these children survive, they tend to start school late, are more likely to drop out and are less likely to learn in school. They are also more likely to become malnourished adults, continuing this cycle of deprivation.

*"... the Agency ... offers a complete package of clinical training material for medical physicists in radiation oncology, diagnostic radiology and nuclear medicine."*

Considerable capacity has been established over the past few years in Africa in the use of deuterium dilution techniques to assess body composition and human milk intake by breastfed infants (Fig. 2). These techniques use low cost, low maintenance instrumentation (such as Fourier transform infrared spectrometry), which is particularly useful in areas with limited resources. In 2011, Botswana and Morocco were officially selected for the first two

AFRA Regional Designated Centres in the use of deuterium dilution techniques in human nutrition. Laboratories in these countries will provide on the job training, verification of calibration standards and expert services to coordinate interlaboratory tests for QA purposes.

*FIG. 2. Collecting saliva samples to non-invasively quantify human milk consumption by a breastfed baby in Morocco.*

A technical meeting in September 2011 sought to identify potential obstacles to, and suggest solutions for, the effective scaling up of food fortification strategies. Participants from Africa, Asia, Latin America and the Middle East gathered in Vienna to share experience from national and regional fortification programmes. They also discussed the expansion of programmes designed to improve nutritional status and health during the first two years of age.

*"A technical meeting in September 2011 sought to identify potential obstacles to, and suggest solutions for, the effective scaling up of food fortification strategies."*

## Programme of Action for Cancer Therapy (PACT)

The adoption in 2011 of the Political Declaration of the High-level Meeting of the General Assembly on the Prevention and Control of Non-communicable Diseases (resolution A/RES/66/2) was the second time in the history of the United Nations that a high level resolution on health issues was adopted (the first being on HIV/AIDS). The declaration highlights the importance of international cooperation in addressing the challenges of non-communicable diseases (NCDs) and calls for United Nations funds, programmes and agencies and other international organizations to work together in a coordinated manner to support national efforts to prevent and control NCDs, and to provide technical assistance and capacity building to developing countries.

The first meeting on the implementation of the political declaration recognized the ongoing efforts of the Agency relevant to NCDs, notably PACT, the technical cooperation programme, the WHO/IAEA Joint Programme on Cancer Control and the PACT Model Demonstration Sites (PMDSs). Two areas of collaboration were identified for the Agency: first, to scale up technical assistance to strengthen national cancer control strategies in developing countries, and second, to increase PMDS projects in selected countries. The Agency is also contributing to the Action Plan for the Global Strategy for the Prevention and Control of Noncommunicable Diseases (2013–2018), which is being developed for the United Nations system organizations.

The Virtual University for Cancer Control and Regional Training Network (VUCCnet) Africa pilot project entered its second year in 2011. The VUCCnet Annual Stakeholders Coordination Meeting concluded with 15 Member States recognizing VUCCnet as both a vehicle and a facilitating mechanism to enhance cancer control education and training in Africa, extending VUCCnet endorsement beyond the six Member States currently participating in the project. Member States agreed to work together under a regional cooperative approach to allow, in the short term, capacity building within

*FIG. 3. An imPACT mission in the Philippines to assess cancer control capacity.*

the pilot countries and, in the longer term, to pave the way for subregional cancer control workforce training hubs.

The Agency, through PACT, and in cooperation with its partners such as WHO, continues to deliver comprehensive cancer control to Member States. In 2011, 13 additional Member States officially requested an integrated mission of PACT (imPACT), and eight imPACT reviews were planned and conducted (four of them in response to new requests) to assess the national capacity and needs in Algeria, Bolivia, Colombia, Lesotho, Nigeria, Paraguay, the Philippines and Uganda (Fig. 3). All but one of the eight PMDSs in Albania, Ghana, Nicaragua, Mongolia, Sri Lanka, United Republic of Tanzania, Vietnam and Yemen have received PACT missions to follow up on the recommendations for a comprehensive cancer control approach through partnerships.

After six years of operation, assessing the outcomes of the PACT initiative in Member States is a priority, and an evaluation and monitoring methodology is being developed, notably for PMDSs, in collaboration with partners and Member States.

*"In 2011, 13 additional Member States officially requested an integrated mission of PACT (imPACT), and eight imPACT reviews were planned and conducted ..."*

# Water Resources

## Objective:

*To enable Member States to sustainably use and manage their water resources through the application of isotope techniques for hydrology.*

The Agency continued to implement the IAEA Water Availability Enhancement (IWAVE) project in three pilot countries: Costa Rica, Oman and the Philippines. The IWAVE project aims at assisting Member States in conducting sound water resources assessments at national or regional levels, leading to the establishment of water policies for a more rational allocation of surface and groundwater resources. The pilot studies in the three countries have advanced through a preliminary phase involving the main stakeholders in each country aimed at identifying gaps in the current hydrological information and understanding. A number of activities, including seminars and workshops, were held to initiate actions addressing the gaps.

*"The IWAVE project aims at assisting Member States in conducting sound water resources assessments at national or regional levels, leading to the establishment of water policies for a more rational allocation of surface and groundwater resources."*

In 2011, testing and development of the use of long lived radionuclides and noble gases continued on selected large transboundary aquifers including the Guarani aquifer in South America and the Mekong River aquifer in Vietnam, among others. Several field sampling campaigns were conducted in Argentina and Brazil involving revision of previous isotope work in the area. The use of carbon-14 to determine the age of groundwater was also facilitated in many national and regional technical cooperation projects (Figs 1 and 2).

The operation of isotope monitoring stations around the world for the collection of precipitation and river isotope data continues to be a major activity for the Agency. The Global Network of Isotopes in Precipitation (GNIP), managed by the Agency in collaboration with WMO, is the primary isotope database used in hydrology and climate studies. The network has reached 50 years of operation and has collected isotope data for more than 1000 meteorological stations. A new on-line platform for facilitating access to global isotope data and maps is being developed. In addition, the ability to use precipitation isotope data in global climate models was improved through a new interpolation map of GNIP data.

A CRP on 'Quantification of Hydrological Fluxes in Irrigated Lands Using Isotopes for Improved Water Use Efficiency' was completed in 2011. The objective of the CRP was to enhance the application of water

*FIG. 1. Sampling for carbon-14 dating of groundwater in Niger.*

*FIG. 2. Testing groundwater in rural areas of the Central African Republic.*

use efficiency techniques for irrigated lands at the field and basin scales in Member States. The focus was on the development and implementation of isotope methods for quantification of deep percolation and evaporation, two of the major fluxes that control the water balance of irrigated lands and thus can be used to measure the degree of water use efficiency. Research projects collected isotope data from precipitation, soil water, percolation water, groundwater, atmospheric vapour and plant water samples as well as related meteorological data. The results of the CRP clearly indicate the large effect irrigation practices have on water use efficiency, affecting both deep percolation pulses and the potential transport of fertilizers and other contaminants to groundwater. Irrigation via flooding was shown to lead to higher evaporative losses than other methods. In addition, isotope results show how strongly evaporation varies under different crop types.

*"The results of the CRP clearly indicate the large effect irrigation practices have on water use efficiency, affecting both deep percolation pulses and the potential transport of fertilizers and other contaminants to groundwater."*

## Strengthening Analytical Capabilities in Member States

Recent developments in laser spectroscopy systems have led to instruments which can more simply and inexpensively measure stable isotopes of water with the analytical precision required for isotope hydrology applications. Today, the use of such laser analysers has become standard practice and many Member States have acquired commercially available units with the assistance of the Agency through its technical cooperation programme, resulting in easier and faster access to isotope results for hydrological investigations. The Agency contributed to the adaptation of these instruments for use by Member States.

Over the past five years, the Agency has organized nine one-week training courses, involving a total of 64 participants. The Agency has also provided assistance to Member States by developing tools for processing isotope data, and by organizing meetings of laser analyser users to exchange experience, compile tips, and offer trouble-shooting advice as well as tools for analysing in-house isotope standards.

The fourth interlaboratory comparison exercise for laboratories engaged in the analysis of the hydrogen and oxygen stable isotope composition of water samples was completed in 2011. More than 135 laboratories from 53 countries submitted their isotope data sets to the Agency and had their performance assessed. The results of the exercise are expected to help stable isotope laboratories to identify analytical problems and improve their overall performance.

*An Agency training course on the installation and operation of laser isotope analysers.*

Another CRP, on 'Isotopic Techniques for the Assessment of Hydrological Processes in Wetlands', was completed in 2011. A number of methodologies integrating isotope and hydrological tools were applied and evaluated to assess the role of groundwater in maintaining the supply of water, dissolved salts and nutrients to wetlands. Various isotope dating tools were used to obtain insights on the temporal scale of water fluxes, while stable isotopes were mainly used to track the sources of water and solutes as well as to delineate mixing processes. Several participants of the CRP made presentations on this issue at the European Geosciences Union General Assembly in 2011.

*"The findings of this project will contribute to sustainable development and management of the scarce water resources of this predominantly desert country."*

An Agency technical cooperation project in Mauritania utilized stable water isotopes, tritium and carbon isotopes, as well as hydrochemistry, to investigate the coastal Trarza aquifer, where the capital Nouakchott is located. The project showed that there were different water bearing layers, namely the shallow horizons recharged from direct infiltration of rainwater and surface water runoff, and a confined aquifer isolated from the influence of nearby surface waters. The findings of this project will contribute to sustainable development and management of the scarce water resources of this predominantly desert country.

A technical cooperation project dealing with the assessment of groundwater resources in the Santa Elena Peninsula, in Ecuador, was completed in 2011. A conceptual hydrogeological model, based on hydrogeological, hydrochemical and isotopic information, was developed. The project identified important differences in hydrological functioning between the northern and southern sectors of the study area. Tritium and carbon-14 were used to date shallow groundwater and assess the recharge processes in both areas. The northern sector is characterized by a more active groundwater flow than the southern sector, which has lower groundwater potential. The conceptual model has also served as a basis for identifying areas where it is necessary to undertake in-depth studies with a view to assessing the feasibility of artificial recharge.

In Thailand, an Agency project on the use of isotope hydrology for the management of groundwater resources supported the introduction and application of isotope hydrology techniques in integrated water resources management, which is a top priority for the socioeconomic development of the country. As a result of the project, an isotope hydrology laboratory was established for national research services. Hydrological processes in the Upper Chi watershed and Lower Nan River basin were assessed using isotope techniques combined with other relevant techniques, and a national database of isotopic data on the groundwater of Thailand was established. Regulations for water resources management were proposed, and human resource capacity in the field of isotope hydrology was significantly strengthened.

# Environment

## Objective

*To enhance the capacity for understanding environmental dynamics, and the identification and mitigation of problems in the marine and terrestrial environments caused by radioactive and nonradioactive pollutants using nuclear techniques.*

## Application of Isotopes to Understand the Impact of Ocean Acidification on Organisms

In the future, the acidification of the ocean due to carbon dioxide accumulation in seawater is expected to dramatically reduce the calcification and physiology of many marine organisms. Moreover, changes in ocean carbonate chemistry and decreasing pH will alter the chemical speciation of trace elements and modify their bioavailability to marine biota. In this connection, radioisotope analysis provides valuable data for understanding the mechanisms of toxicity in marine organisms and for assessing the risk of contaminant levels in seafood for human consumption. In 2011, such experimental studies at the Agency identified contrasting interactions among contaminants and species, resulting from combined chemical and biological effects caused by climate change.

Isotope techniques facilitate our understanding of carbon driven effects on marine organisms and reduce the uncertainty that exists concerning biological outcomes of changing ocean chemistry. Data collected by the Agency in 2011 highlighted how ocean warming synergistically increases the effect of ocean acidification on the calcification capacity of most species studied. However, not all organisms display the same response to environmental changes, and results obtained in the Agency's laboratories helped identify tolerant organisms that could be considered as key species for adaptation of ecosystems and for maintenance of associated ecosystemic research in the future. The results of these studies are essential for the production of accurate models of effects on fisheries and estimates of the socioeconomic impacts of ocean acidification.

## Building the Technical Capacity of Regional Laboratories for Assessing Marine Pollution

In 2011, three new marine certified reference materials for radionuclides, trace elements and organic contaminants were produced according to ISO Guides 34 and 35. They were distributed to Member States to be used in national and regional laboratories for quality control, validation of analytical methods, and assessment of data quality and methods development.

The Agency provided technical support for the quality assurance of data for UNEP's Programme for the Assessment and Control of Pollution in the Mediterranean Region (MED POL) by completing two interlaboratory comparisons and two analytical performance studies, and by conducting two training courses on analytical techniques and basic metrological principles for the determination of organic contaminants and trace elements. Four methods for the determination of trace elements and organic contaminants in marine samples were also revised and provided to MED POL laboratories.

*"Isotope techniques facilitate our understanding of carbon driven effects on marine organisms and reduce the uncertainty that exists concerning biological outcomes of changing ocean chemistry."*

With the aim of improving quality assurance and management of laboratories in Member States, the Agency organized three proficiency tests for the determination of radionuclides, trace elements and organic contaminants for the Regional Organization for the Protection of the Marine Environment (ROPME). A proficiency test for radionuclides was also organized for the Contracting Parties to the Convention for the Protection of the Marine Environment of the North-East Atlantic (OSPAR Convention). In addition, the Agency conducted three worldwide interlaboratory quality assurance comparisons for radionuclides, trace elements and methyl mercury in the marine environment. Over 120 laboratories participated in these comparisons.

*FIG. 1. An example of an HAB (left). (Photograph courtesy of B. Suarez.) The radiobinding assay technique permits the detection of HAB outbreaks at an early stage (right).*

The Agency implemented 28 technical cooperation projects to assist over 40 Member States in Africa, the Middle East, the Asia–Pacific region, and Latin America and the Caribbean in developing or improving national technical capacity for marine pollution studies and environmental quality assessment. The Agency also provided support to develop tools and techniques for assessing levels of organic and inorganic contaminants, radionuclides and stable isotopes in the marine environment, and for setting up sustainable regional monitoring programmes. Member States received assistance in generating data on contaminants in seafood, and in assessing the relevance of using experimentally derived and field based data for establishing regulatory threshold levels of contaminants in seafood. Five technical cooperation projects and one CRP focused on the assessment of harmful algal blooms (HABs), toxin concentrations in the environment and toxin transfer to human consumers. In related work, the Agency and its international counterparts in Member States, including the IAEA Collaborating Centre in the Philippines, used nuclear techniques to develop and refine a radioassay technique that detects and warns more quickly and precisely of an HAB outbreak, thus saving lives and protecting fisheries (Fig. 1).

*"The Agency also supported studies that combined laboratory experiments ... using radioisotopes and work in the field that focused on carbon dioxide vents that naturally decrease seawater pH. These studies help demonstrate and validate contrasts in tolerance among species to changing environmental conditions."*

## The Agency's Contributions to Climate Change Studies

Climate change is a major challenge for the Earth's future. The world's oceans absorb over 25% of the increasing carbon dioxide emissions released into the atmosphere by human activities. Global warming will further accelerate carbon dioxide release from natural sources into the atmosphere. Recent research has provided evidence that rising levels of carbon dioxide are causing acidification of ocean water. Nuclear and isotopic methods are major tools to study climate change effects on the environment. The Agency is playing a significant role in addressing these issues.

One example of the Agency's work is its collaboration with researchers around the world to study how the rising acidity of ocean water disrupts the ecophysiology of organisms that are of high economic value or that provide the foundation of the marine food chain, as well as of the corals that serve as coastal protection and act as an essential habitat for countless marine species. The Agency also supported studies that combined laboratory experiments (as described above) using radioisotopes

and work in the field that focused on carbon dioxide vents that naturally decrease seawater pH. These studies help demonstrate and validate contrasts in tolerance among species to changing environmental conditions.

Recognizing that an interdisciplinary approach is necessary for climate change studies, the Agency facilitated discussions and collaboration between experts in geochemistry, biology, fisheries and economics. The aim is to build connections between the different disciplines and to target priority support for Member States dependent upon marine resources in a time of rapid environmental change.

As part of its collaboration in the Malina project, jointly organized by Canada, France and the USA to assess the impact of climate change in the coastal Arctic Sea, the Agency carried out experiments on the identification of the terrestrial, marine and bacterial sources of carbon and the processes of transport and degradation in the water column of the Beaufort Sea off the Mackenzie River delta (Fig. 2). This work involves the assessment of particle export from surface waters and water mass exchanges between shelf and offshore areas, as well as downward particle flux at several depths and in several areas. The data generated will assist field observations monitoring the complex and rapidly changing Arctic environment and increase the information available to climate change modellers.

*"The data generated will assist field observations monitoring the complex and rapidly changing Arctic environment and increase the information available to climate change modellers."*

*FIG. 2. As part of the Malina project, the Agency carried out experiments to measure natural radionuclides in the Arctic Sea.*

# Radioisotope Production and Radiation Technology

## Objective

*To contribute to improved health care and to safe and clean industrial development in Member States by strengthening national capabilities in the production of radioisotope products and in the use of radioisotopes and radiation technology.*

## Radioisotopes and Radiopharmaceuticals

Research in the field of therapeutic radiopharmaceuticals is growing, with a large number of specific antibodies being used as carrier molecules to target cancers. In recent years, several radiolabelled antibodies (for example, rituximab and ibritumomab tiuxetane) labelled with beta emitting radionuclides such as yttrium-90 ($^{90}$Y), lutetium-177 ($^{177}$Lu) and iodine-131 ($^{131}$I) have proved to be very effective in the treatment of non-Hodgkin's lymphomas (NHLs). Generally, these radiopharmaceuticals are very expensive and are not readily available in all Member States.

*"The use of positron emission tomography (PET) continues to grow owing to its excellent diagnostic images."*

To facilitate affordable antibody based therapeutic treatments, a CRP to investigate the feasibility of developing a kit for labelling the antibody rituximab with $^{177}$Lu/$^{90}$Y was launched in 2011 with the participation of 18 Member States. A meeting was also organized to explore the possibility of labelling rituximab with $^{131}$I in hospital radiopharmacies.

Another CRP, on therapeutic radiopharmaceuticals labelled with rhenium-188 ($^{188}$Re) and $^{90}$Y, concluded in 2011. An important outcome of this project was the preparation of new agents labelled with $^{188}$Re and $^{90}$Y for targeted therapy, of which a biotin radioconjugate for the treatment of breast cancer and two labelled antibodies for the therapy of neuroblastoma and small cell lung cancer were highly promising. A variety of $^{90}$Y labelled particulates such as hydroxyapatite aggregates, human serum albumin microspheres, plastic microparticles and colloids of citrate, ferric hydroxide, antimony sulphide and chromic phosphate were developed and employed in radiosynovectomy to alleviate pain in swollen joints resulting from conditions such as haemophilia and rheumatoid arthritis. An earlier CRP, on the development of therapeutic radionuclide generator systems, was successful in developing an electrochemical $^{90}$Sr/$^{90}$Y generator system, which was produced as an automated system by a commercial vendor. With the Agency's help, the first such generator, installed in Cuba, is yielding $^{90}$Y with adequate radionuclidic purity and was recently approved for human use by the national regulatory authorities.

Two of the radioisotopes most frequently used in medicine are molybdenum-99 ($^{99}$Mo) and technetium-99m ($^{99m}$Tc). Interruptions in the supply of $^{99}$Mo over the past few years have had an impact on patient care, particularly after the facilities of the two largest producers in the world were shut down. While the supply situation of $^{99}$Mo has improved somewhat, efforts have intensified to explore the use of alternative methods of producing $^{99m}$Tc. Several Member States that have cyclotrons or are planning to build them have embarked on research programmes for the production of $^{99}$Mo or $^{99m}$Tc using accelerators. Recognizing that this approach could be an option for producing $^{99m}$Tc for Member States, either for limited local use or as a fallback option if there is another supply crisis, a new CRP focusing on the development of accelerator based alternatives to the $^{99}$Mo/$^{99m}$Tc generator was initiated. Twelve Member States have expressed interest in participating in this CRP.

The use of positron emission tomography (PET) continues to grow owing to its excellent diagnostic images. While production of fluorine-18 ($^{18}$F), the most widely used PET radionuclide, requires a cyclotron, gallium-68 ($^{68}$Ga), another PET radionuclide, can be produced from $^{68}$Ge/$^{68}$Ga generators without the need for a cyclotron. The 68 minute half-life of $^{68}$Ga and the long one-year shelf life of the generator, together with the well known chemistry of gallium, make it an attractive PET radionuclide. Recognizing the important role of $^{68}$Ga radiopharmaceuticals,


*FIG. 1. A $^{68}Ge/^{68}Ga$ generator.*

a new CRP was started aimed at developing $^{68}Ga$ labelled somatostatin analogues for the management of neuroendocrine tumours, as well as other potential $^{68}Ga$ based radiopharmaceuticals. The CRP, in which 17 Member States are participating, will also address the quality assurance/quality control issues related to these developments (Fig. 1).

Carbon-11 ($^{11}C$) plays a unique role both in the diagnosis, monitoring and research of human disease and as a tool in drug discovery. Its short half-life (20.4 minutes) allows repeated studies to be conducted on the same subject within a day, yet is long enough to permit study of the fate of the isotope for a few hours after administration. The Agency hosted a technical meeting in September at which the status of $^{11}C$ radiopharmaceuticals in clinical research and future trends in labelling, automation and instrumentation were discussed. The experts identified areas where support was required for timely and optimum utilization of $^{11}C$ radiopharmaceuticals in Member States.

## Radiation Technology Applications

Composite materials combine properties of the individual components synergistically in an efficient and cost effective manner and have various applications, from sports equipment to the automotive and aerospace industries to food packaging and artificial organs (Fig. 2). Materials reinforced with nanoscale components have improved functional and structural properties. While utilizing the full potential of such nanofillers is challenging, these obstacles can be overcome by the radiation grafting of appropriate monomers/polymers onto the nanofiller surface. Radiation techniques also enable simultaneous synthesis of the nanofiller and cross-linking of the matrix of the composite, which is not possible with other techniques. Furthermore, the use of natural polymers in composites opens new possibilities for the development of affordable, high value, non-toxic, radiation processed composites. To investigate this potential further, a new CRP was started that is linked to a European Union project on polymer nanocomposites with novel structural and functional properties.

*"... a joint Abdus Salam ICTP–IAEA workshop ... focused on radiation treatment for the sterilization of single use medical devices as well as biodegradable food packaging materials, cable insulators, and adhesives and sealants for use in nuclear power plants."*

Addressing the need of developing Member States for training in this area, a joint Abdus Salam ICTP–IAEA workshop on 'Radiation Resistant Polymers' focused on radiation treatment for the sterilization of single use medical devices as well as biodegradable food packaging materials, cable insulators, and adhesives and sealants for use in nuclear power plants. The workshop consisted

of lectures, discussions and a visit to the Elettra synchrotron facility in Italy.

*FIG. 2. Demonstration of a test of a composite absorbent.*

To promote radiation technology applications in Member States, an Agency technical cooperation project assisted in the installation of a 24 000 curie (888 TBq) cobalt-60 gamma radiation source. The source was installed through a technical cooperation project at the Centre for Technology Applications and Nuclear Development in Cuba.

*"... a CRP on potential radionuclide generators for industrial tracer applications ... resulted in an improvement in the availability of industrial radiotracers and radiotracer services, especially in developing Member States that do not have radioisotope production facilities."*

Through another technical cooperation project, an institute in Bangladesh was supported in the production of biodegradable packaging materials from locally available natural polysaccharides, and in synthesizing 'super water' absorbents by combining indigenous and synthetic monomers and polymers. In addition, through combined governmental and Agency support, a new irradiation facility became operational. The facility uses locally available resources for the industrial scale production of oligochitosan, a potential plant growth promoter in agriculture.

Short lived radiotracers are used for quick trouble-shooting of complex problems in industrial fluidic systems. However, the timely access of such radiotracers from nuclear reactors is a major impediment. One solution is to use radionuclide generators that can produce tracers at the site. In this context, a CRP on potential radionuclide generators for industrial tracer applications was concluded in 2011. The project resulted in an improvement in the availability of industrial radiotracers and radiotracer services, especially in developing Member States that do not have radioisotope production facilities. Two generators, one using caesium-137 ($^{137}$Cs) and barium-137m ($^{137m}$Ba), and the other using $^{68}$Ge and $^{68}$Ga, were tested and validated. Case studies were performed in various fields at the laboratory and industrial scales (Fig. 3).

*FIG. 3. Industrial single photon emission computed tomography system for the radiotracer visualization of $^{68}$Ga and $^{137m}$Ba from generators.*

The Agency published *Nuclear Techniques for Cultural Heritage Research* in the IAEA Radiation Technology Series. This publication provides an understanding of the application of nuclear techniques — for example, neutron activation analysis, X ray fluorescence analysis and ion beam analysis — for non-destructive investigation of precious artefacts and materials such as ceramics, stones, metals and pigments from paintings.

# Nuclear Safety and Security

# Incident and Emergency Preparedness and Response

## Objective

*To establish effective and compatible national, regional and international emergency preparedness and response capabilities and arrangements for early warning and 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 malicious act. To improve provision/sharing of information on incidents and emergencies among Member States, international organizations and the public/media.*

## Safety Standards and Guidelines

In the area of emergency preparedness and response, a number of Agency guidelines were developed or refined. These included *Criteria for Use in Preparedness and Response for a Nuclear or Radiological Emergency* (IAEA Safety Standards Series No. GSG-2) and three publications in the Emergency Preparedness and Response (EPR) Series: *EPR-Research Reactor: Generic Procedures for Response to a Nuclear or Radiological Emergency at Research Reactors*; *EPR-Triga Research Reactor: Generic Procedures for Response to a Nuclear or Radiological Emergency at Triga Research Reactors*; and *EPR-Biodosimetry: Cytogenetic Dosimetry: Applications in Preparedness for and Response to Radiation Emergencies*. The Agency also released training material entitled *EPR-Research Reactor: Generic Procedures for Response to a Nuclear or Radiological Emergency at Research Reactors – Training Material.*

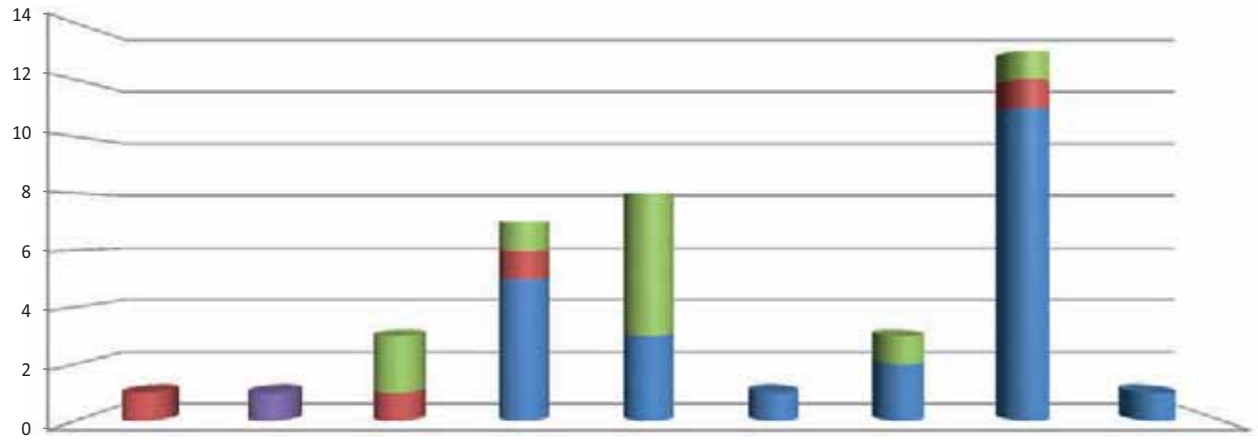
## Compliance with Current Standards

The Emergency Preparedness Review (EPREV) service, offered to Member States since 1999, focuses on independent assessments of national preparedness for responding to radiation incidents and emergencies, and of compliance with Agency Safety Requirements, such as *Preparedness and Response for a Nuclear or Radiological Emergency* (IAEA Safety Standards Series No. GS-R-2), and relevant Safety Guides. The scope of EPREV covers preparedness for all radiological and nuclear incidents and emergencies that may affect a Member State, whether or not the country has nuclear facilities.

*FIG. 1. Members of an EPREV mission team visiting the Arkhangelsk region of the Russian Federation.*

In 2011, EPREV missions were conducted in Albania, Estonia, Georgia, Latvia, Pakistan and the Russian Federation (Fig. 1), while the regulatory aspects of the national radiation emergency preparedness systems were assessed in the Republic of Korea, Slovenia, Switzerland and the United Arab Emirates within the framework of Integrated Regulatory Review Service (IRRS) missions. The Agency also conducted 22 missions to assist Member States in developing and strengthening different aspects of national emergency preparedness and response systems. A number of conclusions arose from these missions, for example, that national plans for nuclear and radiological emergencies at the local and national levels needed to be established or improved in Member States; that better coordination between the various relevant governmental bodies with responsibilities in the area of emergency

*"The Emergency Preparedness Review (EPREV) service, ... focuses on independent assessments of national preparedness for responding to radiation incidents and emergencies, and of compliance with Agency Safety Requirements ..."*




| | Emergency monitoring | Embarking States | Exercise preparation, conduction, evaluation | Medical response | National capabilities | Nuclear response | Public information | Radiological response | Research reactors response |
|---|---|---|---|---|---|---|---|---|---|
| Interregional | | 1 | | | | | | | |
| Regional | | | 2 | 1 | 5 | | 1 | 1 | |
| Subregional | 1 | | 1 | 1 | | | | 1 | |
| National | | | | 5 | 3 | 1 | 2 | 11 | 1 |

*FIG. 2. Workshops and courses devoted to emergency preparedness and response in 2011, by subject area.*

preparedness and response was essential; and that the infrastructure and capability of regulatory bodies in several Member States required strengthening.

## Capacity Building in Member States

Training and exercises are a key element of building capacity and competence in Member States. The Agency has focused on supporting the establishment of EPR capacity building centres (CBCs). Three countries (in the Africa, Europe and Latin America regions) have been identified as having the capability to perform the functions foreseen for these CBCs and the willingness to act as partners in this joint effort.

*"In 2011, the Agency organized 38 training events, including workshops and courses on various aspects of emergency preparedness and response."*

In 2011, the Agency organized 38 training events, including workshops and courses on various aspects of emergency preparedness and response. Activities aimed at strengthening capacity in Member States are also in line with the IAEA Action Plan on Nuclear Safety. Figure 2 illustrates the areas in which the training events were held and the geographical coverage of these activities. The Agency also continued to assist Member States in reviewing and upgrading their national EPR capabilities.

## Incident and Emergency Communications

On its protected Unified System for Information Exchange in Incidents and Emergencies (USIE) web site, the Agency published a draft of a new operations manual for Member States and States Parties to the Convention on Early Notification of a Nuclear Accident (the 'Early Notification Convention') and the Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency (the 'Assistance Convention'). This manual will supersede the *Emergency Notification and Assistance Technical Operations Manual (EPR-ENATOM 2007)*, and has been renamed *Incident and Emergency Communication Manual* to better reflect its purpose of dealing with incidents and emergencies, not just events linked to the Early Notification Convention and the Assistance Convention. In addition, the manual includes guidance on reporting for International Nuclear and Radiological Event Scale (INES) national officers, who can input INES reports through the USIE web site. The manual also describes additional response procedures for INES emergency contact points and provides details of new exercises that were developed with a wider scope.

## Response and Assistance Network

The Agency continued to encourage Member States to join the Response and Assistance Network (RANET). While no new RANET registrations were received during 2011, a number of Member States have indicated their interest in joining the network. The lessons learned from the accident at TEPCO's Fukushima Daiichi nuclear power plant (hereinafter referred to as the Fukushima Daiichi accident) identified several areas where RANET can be enhanced. Consequently, a number of activities related to RANET have been included in the IAEA Action Plan on Nuclear Safety.

In 2011, two projects were launched to assist in the harmonization of response and assistance capabilities provided under RANET. The first involved development of the assistance products that are currently defined in Appendix F to *IAEA Response and Assistance Network (EPR-RANET 2010)*. The aim is to provide more detailed specification of the products arising from monitoring and assessment activities conducted during RANET activities. The second project focused on development of a RANET operations manual, which will be used by RANET Field Assistance Teams and Joint Assistance Teams to ensure interoperability and consistency in responding to a request for assistance in the case of a nuclear accident or radiological emergency.

## Strengthening In-house Preparedness and Response Capabilities

Plans for in-house training were developed early in the year, with a view to providing as many on the job training sessions as possible. These training sessions were designed to complement exercises aimed at testing the performance of the main response functions of the Agency's Incident and Emergency System (IES). In the first quarter of 2011, this in-house training led to the conduct of a full scale activation exercise focusing on the functioning of the IES Technical Team and the actions to be taken under the severe accident scenario of a total blackout at a nuclear power plant. However, the need for the Agency to respond urgently to the Fukushima Daiichi accident led to the discontinuation of the exercise part of the in-house training plan after the first quarter of the year.

*"The lessons learned from the accident at TEPCO's Fukushima Daiichi nuclear power plant ... identified several areas where RANET can be enhanced."*

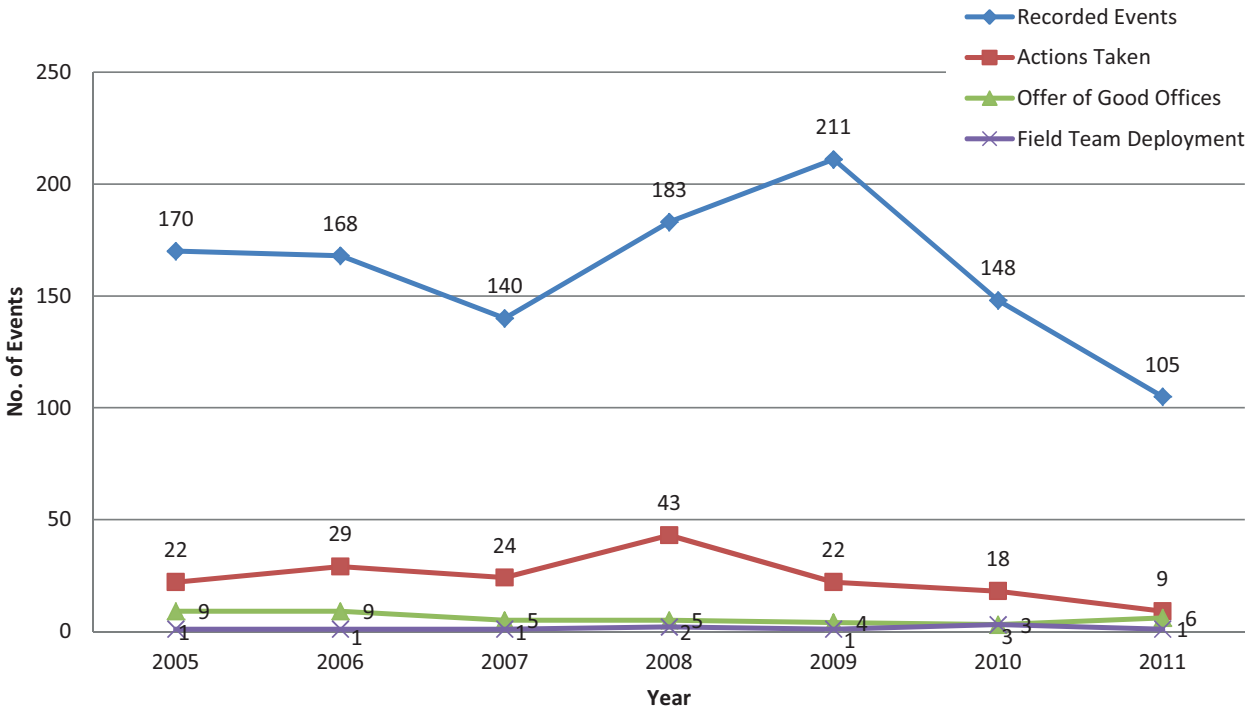



*FIG. 3. Events recorded and responses by the Agency between 2005 and 2011 (the Field Team Deployment figure for 2011 does not include Japan).*

The Agency's response to the accident, as well as subsequent actions taken, is described in a separate chapter in this report.

## Other Radiation Events

In 2011, the Agency was directly informed or indirectly became aware of 105 events involving or suspected to involve ionizing radiation. The Agency took action in nine cases for the purpose of authenticating and verifying information with external counterparts, or providing and sharing official information, and offered its service in six cases (Fig. 3).

*"In 2011, the Agency was directly informed or indirectly became aware of 105 events involving or suspected to involve ionizing radiation."*

In one case in 2011, the Agency received a request for assistance from the Government of Bulgaria under the auspices of the Assistance Convention in relation to the overexposure of workers at a gamma irradiation facility in the town of Stamboliysky. An Agency RANET Assistance Mission, supported by a designated centre in France, was quickly deployed to Bulgaria to undertake a medical evaluation of the exposed workers and assess the doses they had incurred. The Assistance Mission also advised the Bulgarian counterpart organization on the medical follow-up for the workers. Through a bilateral arrangement between the authorities in Bulgaria and France, the overexposed workers were treated in a specialized medical care facility in France.

# Safety of Nuclear Installations

## Objective

*To enhance the global nuclear safety regime and to ensure appropriate levels of safety throughout the total lifetime of all types of nuclear installations in Member States by ensuring the availability of a consistent, needs-based and up to date 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, assistance and networking. To enable Member States to build improved competence frameworks for the safety of nuclear installations and to enhance their capabilities for capacity building as the foundation for strong safety infrastructure.*

## Nuclear Safety Infrastructure

The Agency continued to focus on promoting and supporting the strengthening of global nuclear safety, primarily by assisting in the enhancement of governmental and regulatory frameworks and other safety infrastructure elements in Member States. Its Integrated Regulatory Review Service (IRRS) was widely used by Member States for an objective evaluation of their nuclear and radiation safety regulatory activities in line with the Agency's safety standards. In 2011, five IRRS missions were conducted in the Republic of Korea, Romania, Slovenia, Switzerland and the United Arab Emirates.

FIG. 1. IRRS mission to the Republic of Korea.

In addition, four follow-up IRRS missions were conducted in Australia, Canada, Germany and Spain. As a result of the accident at TEPCO's Fukushima Daiichi nuclear power plant (hereinafter referred to as the Fukushima Daiichi accident), a special IRRS module addressing early lessons learned from the accident was developed for all subsequent IRRS missions (Fig. 1).

IRRS recommendations and suggestions related to regulatory practices, policy and technical issues faced by nuclear regulatory bodies, as well as lessons learned, were collected, analysed and shared with the international community. Related to this work, a report entitled *Highlights of the Lessons Learned from the IAEA Integrated Regulatory Review Service in 2006–2010* was prepared by the Agency and presented at the Third Workshop on Lessons Learned from IRRS Missions, hosted by the Nuclear Regulatory Commission in Washington, D.C., in October. The report addresses areas needing improvement such as the governmental, legal and regulatory framework, certain areas of the core regulatory practices, and the efficiency and effectiveness of the missions themselves.

*"IRRS recommendations and suggestions related to regulatory practices, policy and technical issues faced by nuclear regulatory bodies, as well as lessons learned, were collected, analysed and shared with the international community."*

A new Safety Guide on *Establishing the Safety Infrastructure for a Nuclear Power Programme* (IAEA Safety Standards Series No. SSG-16) was used to assist countries embarking on nuclear power in developing the necessary safety infrastructure using a phased approach. This Guide contributes to the building of leadership and management for safety and of a safety culture by all organizations involved. Several workshops were organized on the application of the Guide. Related to these activities, Member State access to Agency training material was improved, and a dedicated web site on safety infrastructure for nuclear power was developed (*http://www-ns.iaea.org/tech-areas/safety-infrastructure/default.asp?s=0&l=94*).

## Convention on Nuclear Safety

The Agency facilitated the Fifth Review Meeting of the Contracting Parties to the Convention on Nuclear Safety, convened in Vienna in April. The meeting was the first major international nuclear safety meeting following the Fukushima Daiichi accident. It was agreed to make a specific statement by Contracting Parties in response to the accident. The statement reaffirmed the objectives of the Convention; included a commitment to identify and act on the lessons learned; supported the Agency's continuing role in the area of nuclear safety, specifically noting the Ministerial Conference held in June at Agency Headquarters; and included a commitment to hold an Extraordinary Meeting in August 2012 to share lessons learned from, and actions taken in response to, the Fukushima Daiichi accident, and to review the effectiveness and, if necessary, the continued suitability of the provisions of the Convention.

*"The Agency facilitated the Fifth Review Meeting of the Contracting Parties to the Convention on Nuclear Safety ..."*

## Safety Management and Capacity Building

The Agency continued to promote an integrated approach to nuclear safety focusing on management systems, effective leadership and safety culture (Fig. 2). Training for the application of management systems in the regulatory framework was offered at both the national and the regional level. For example, a regional workshop for the European region was conducted specifically on management systems. In addition, several training courses were held on leadership and management for the introduction of nuclear power and on the establishment of safety infrastructure.

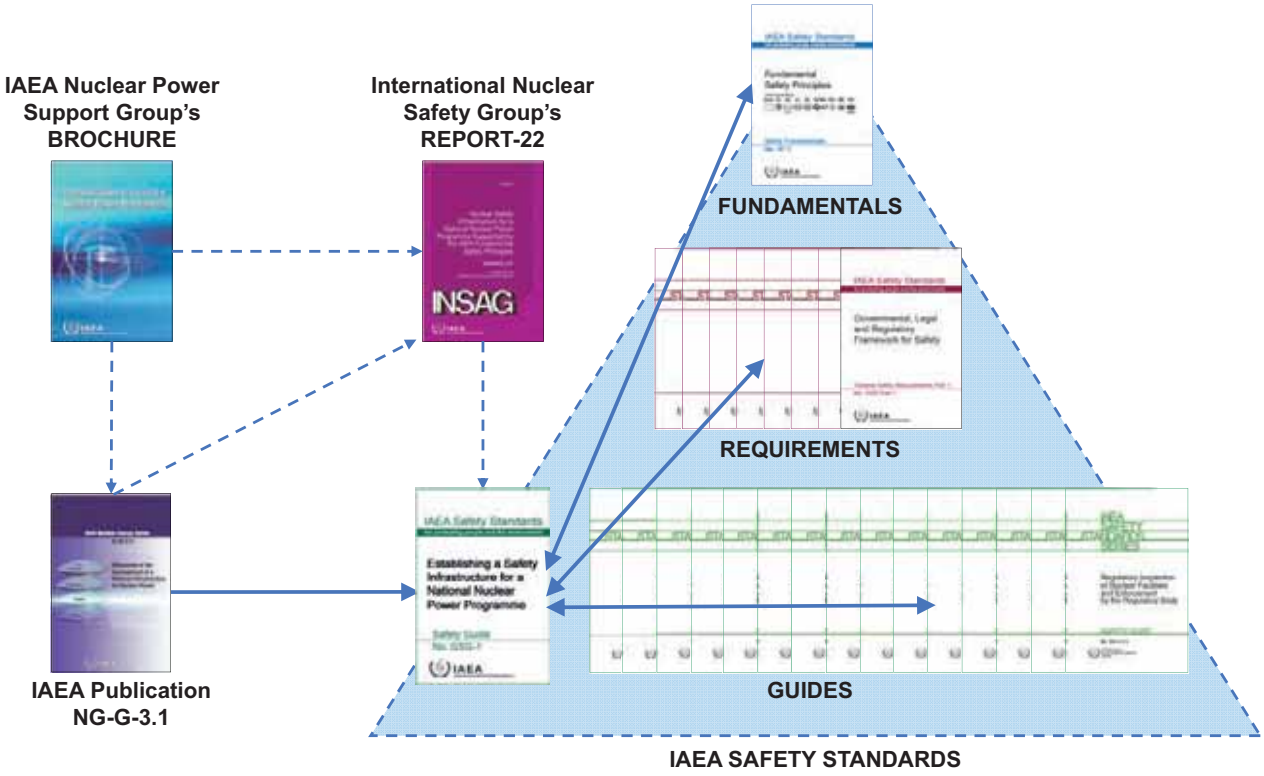



*FIG. 2. Developing safety infrastructure for nuclear power using the Agency's documentation.*

In a letter report[1] to the IAEA Director General, the International Nuclear Safety Group (INSAG) noted that "there are many countries without experience with nuclear power that have launched programs to

[1] *Communication dated 26 July 2011 from the Chairman of the International Nuclear Safety Group (INSAG)*, issued as GOVINF/2011/11.

construct a plant or are advancing in that direction." In this context, INSAG recommended that "the IAEA should reach out to these countries to provide both the education about the necessary infrastructure that must be established and the services to monitor and assist their progress in complying with international standards."

## Safety Assessment of Sites and Installations

The renewed interest of some Member States in building nuclear power plants and research reactors significantly increased the demand for assessments of siting and associated external hazards. After the Fukushima Daiichi accident, Member State demand for site safety services and related capacity building increased significantly, with nine siting missions being conducted by the Agency. In related work, IAEA Safety Standards Series No. SSG-18, on *Meteorological and Hydrological Hazards in Site Evaluation for Nuclear Installations*, was published. The Agency's External Events Notification System, used in response to the Fukushima Daiichi accident, was continuously improved using extrabudgetary resources (Fig. 3).

The Agency developed a comprehensive plan as part of an extrabudgetary project to address issues identified in implementing IAEA safety standards in Member States, including lessons learned after the Fukushima Daiichi accident. These activities have been incorporated into the IAEA Action Plan on Nuclear Safety.

In response to the Fukushima Daiichi accident, *A Methodology to Assess the Safety Vulnerabilities of Nuclear Power Plants against Site Specific Extreme Natural Hazards* was published in November as one of the activities under the Action Plan. The methodology was made available for Member States that may wish to use it in carrying out their national assessments of the safety vulnerabilities of nuclear power plants in the light of lessons learned to date from the accident.

The Global Safety Assessment Network (GSAN) (*http://san.iaea.org/*) links experts around the world and facilitates their cooperation and collaboration on safety assessments in support of international efforts to support nuclear safety. In 2011, the Agency upgraded GSAN by providing a discussion forum and a 'frequently asked questions' page related to safety assessment topics for countries embarking on nuclear power.

*"After the Fukushima Daiichi accident, Member State demand for site safety services and related capacity building increased significantly, with nine siting missions being conducted by the Agency."*

The Agency's Safety Assessment Education and Training (SAET) project is a part of GSAN. Training modules for deterministic and probabilistic safety assessment were developed and piloted in Malaysia, Poland and Vietnam. SAET activities tailored for these countries were refined, and workshops and training courses were held. Two webinars were conducted to provide distance learning training

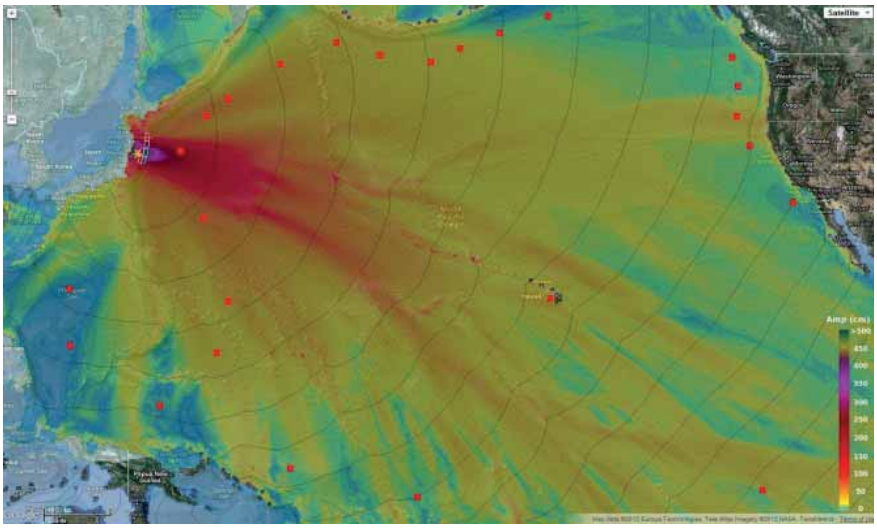


*FIG. 3. Real time tsunami forecasting system under development at the Agency.*

through the Asian Nuclear Safety Network and to link regional lecturers and students across the Asian region with Agency experts.

## Operational Safety and Experience Feedback

The Agency's Operational Safety Review Team (OSART) service coordinates internationally based teams of experts who conduct reviews of operational safety performance at nuclear power plants. In 2011, the IAEA carried out seven OSART and four follow-up missions (Fig. 4). In the area of Safety Aspects of Long Term Operation of Water Moderated Reactors (SALTO), two peer review missions and one follow-up mission were performed, indicating an increased interest in these services on the part of Member States. Both OSART and SALTO attempt to identify gaps between practices of nuclear power plants and relevant IAEA safety standards. These gaps represent potential vulnerabilities that can be resolved through the implementation of appropriate corrective actions.

*"The most important recommendation from this evaluation was that severe accident management be introduced as a separate review area within the standard scope of OSART missions."*

Through a technical meeting, the Agency reviewed the lessons learned from the Fukushima Daiichi accident concerning the OSART service, the effectiveness of other operational safety review services and experience from OSART missions carried out between 2008 and 2011. The most important recommendation from this evaluation was that severe accident management be introduced as a separate review area within the standard scope of OSART missions. The meeting endorsed the integration of the different types of operational safety services (SALTO, Peer Review of Operational Safety Performance Experience (PROSPER) and Safety Culture Assessment Review Team (SCART)) under the umbrella of OSART to improve the use of available resources and harmonize the methodologies of these services.

*FIG. 4. OSART reviewers accompanied by plant staff observing a local instrumentation and control panel at the Smolensk nuclear power plant in the Russian Federation.*

The Agency continued to operate two event reporting systems for nuclear power reactors and for research reactors: the International Reporting System for Operating Experience (IRS) and the Incident Reporting System for Research Reactors (IRSRR). Eighty event reports were shared with the international nuclear community using the IRS, including reports from almost all 29 Member States with operating nuclear power reactors. In addition, updated guidelines related to the coding of the causes and associated attributes of nuclear safety related events were issued. In 2011, 53 Member States contributed to IRSRR incident reports. Additionally, a technical meeting for the IRSRR national coordinators was held in Romania to share research reactor related operating experience through the collection and analysis of information on events and the dissemination of lessons learned.

In the area of long term operation of nuclear power plants, three working groups, a clearing group and a steering committee focusing on ageing management began the development of the International Generic Ageing Lessons Learned (IGALL) database, a comprehensive source of information on ageing mechanisms and related ageing management techniques for nuclear safety related structures, systems and components. The database will help to identify effective ageing management programmes to maintain the reliability of nuclear safety related equipment.

## Safety of Research Reactors and Fuel Cycle Facilities

Two significant Agency activities — one an international meeting on application of the Code of Conduct on the Safety of Research Reactors, held in Vienna in May, and the other an international

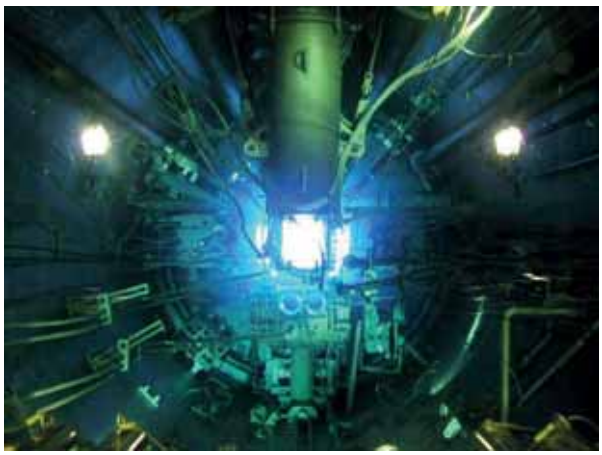


*FIG. 5. Looking down into Egypt's ETRR-2 research reactor, the site of a safety review mission undertaken in 2011.*

conference on the safe management and utilization of research reactors, held in Rabat, Morocco, in November — provided a forum for the exchange of experience and good practices. These activities also contributed to improving Member State self-assessment capabilities, establishing safety infrastructure for countries building their first research reactor and enhancing emergency preparedness and response.

Other meetings involved ageing management, periodic safety reviews and safety performance indicators for research reactors under Agency agreements. The Agency also conducted workshops on operational radiation safety, training and qualification, use of a graded approach in the application of safety requirements, and synergy between safety and security. Three Safety Guides were approved, on safety analysis, utilization and modification, and use of a graded approach, which provide additional guidance on application of the Code of Conduct.

A number of safety review missions were undertaken at research reactors in Egypt, Jordan and Morocco, and three INSARR missions were conducted in the Netherlands, Peru and Romania. These missions provided recommendations for further safety improvements at these facilities concerning mainly the operational organization, the quality of the safety analyses and reactor safety documents, fire protection and radiological safety (Fig. 5).

The Agency continued to enhance the operational safety of fuel cycle facilities. For example, six reports were prepared in 2011 through the Fuel Incident Notification and Analysis System (out of 144 total reports currently in the system database). Training courses were held on application of the safety standards for fuel cycle facilities involving safety culture and criticality safety. And a Safety Evaluation During Operation of Fuel Cycle Facilities (SEDO) mission was conducted at a fuel fabrication facility in Romania.

## Activities Funded by Extrabudgetary Contributions

Two significant extrabudgetary projects funded by Norway were completed in 2011. Carried out within the framework of another extrabudgetary project on 'Safe Nuclear Energy — Regional Excellence', the first project was initiated in 2009 with Romania, and the second project was initiated in 2010 with Bulgaria. One of the primary outcomes of these projects was that over 300 individuals from regulatory authorities and operating organizations were trained. The projects also supported an international emergency response exercise between the two countries, as well as IRRS and EPREV peer review missions to Romania. Operating and regulatory review procedures were developed through the development of safety and capacity building documents to support future assistance to Member States. In addition, a new methodology for assessing safety culture was developed and subsequently tested during OSART missions to Brazil and South Africa.

*"The Agency also conducted workshops on operational radiation safety, training and qualification, use of a graded approach in the application of safety requirements, and synergy between safety and security."*

# Radiation and Transport Safety

## Objective

*To achieve global harmonization of the development and application of the Agency's radiation and transport safety standards, and to increase the safety and security of radiation sources and thereby raise the levels of protection of people, including Agency staff, against the harmful effects of radiation exposure.*

## Radiation Protection of Patients

Approximately 180 million X ray examinations of children are performed annually. At its 55th General Conference in September, the Agency hosted a side event on 'Children and Radiation in Medicine — Protecting Young Patients'. The need to further develop and disseminate information and training material on radiation protection of children was highlighted (Fig. 1). A Safety Report on radiation protection for modern paediatric radiology was completed for publication.

The IAEA safety standards state that the justification of medical exposure for an individual patient shall be carried out through consultation between the radiological medical practitioner and the referring medical physician. However, there is limited awareness among referring medical physicians, including general practitioners and primary care physicians, about radiation exposure and the risks involved regarding different procedures, making it essential to reach this group. To address this issue, the Agency organized a technical meeting on radiation protection for referring physicians. At the meeting, held in Vienna in September, recommendations were made to national medical societies on training and promotion of best practices.

Safety in radiotherapy remained an important issue during the year, with the Agency continuing its work on the 'Safety in Radiation Oncology' (SAFRON) reporting system. SAFRON is a web based, voluntary reporting system for radiotherapy that can be used to report, share and learn from incidents and near incidents. It is expected to be

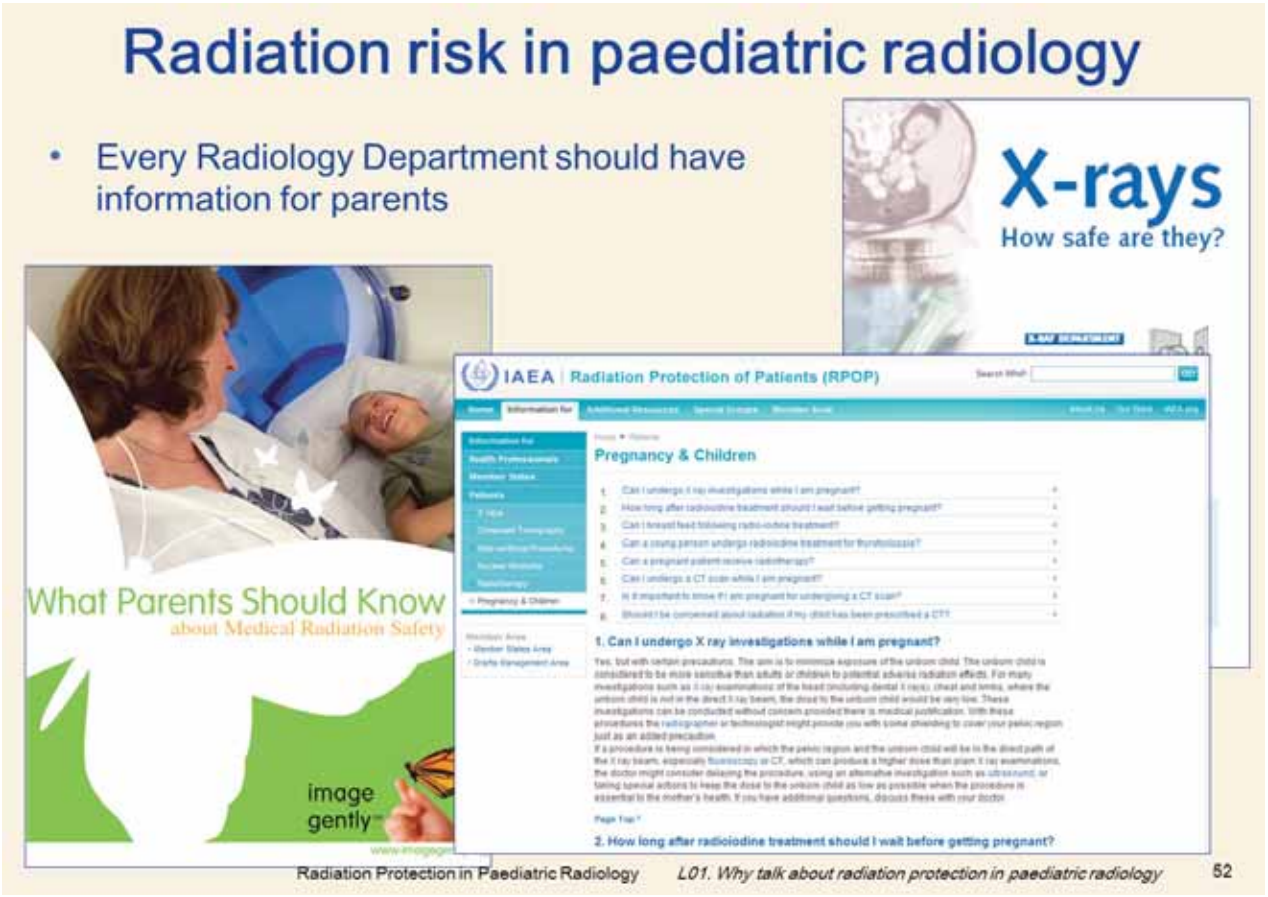



*FIG. 1. Training material for health professionals on the radiation protection of children is available on the Agency's patient protection web site:* rpop.iaea.org.

released for general use in 2012, following a pilot study involving selected hospitals around the world.

## International Basic Safety Standards

The Agency's Safety Requirements on *Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards — Interim Edition* (IAEA Safety Standards Series No. GSR Part 3 (Interim)) were approved by the Board of Governors in September 2011. The revision of the BSS was carried out in collaboration with the co-sponsoring organizations — the European Commission, FAO, ILO, OECD/NEA, PAHO, UNEP and WHO. An interim edition of the BSS was published in November 2011. The final edition will be published after the co-sponsoring organizations have formally endorsed the revised BSS.

The estimates of the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) as well as the 2007 recommendations of the International Commission for Radiological Protection (ICRP) are fully taken into account in the new BSS. Requirements relating to the safety of radiation sources, the protection of patients undergoing medical exposures and the imaging of persons for non-medical purposes have been considerably strengthened. In addition, new requirements have been included on exposure of the public due to radon, exposure of aircrew to cosmic radiation, the remediation of areas contaminated by residual radioactive material and protection of the environment. A new reduced dose limit for the lens of the eye for occupational exposure of workers has been added.

## Enhancing Occupational Radiation Protection

The Agency developed guidance on radiation protection in industries processing naturally occurring radioactive material (NORM), publishing a report entitled *Radiation Protection and NORM Residue Management in the Production of Rare Earths from Thorium Containing Minerals* (Safety Reports Series No. 68). It also developed criteria for the NORM industry for determining which materials need to be considered for regulatory control, as well as additional guidance entitled *Exposure of the Public from Large Deposits of Mineral Residues* (IAEA TECDOC-1660). The Agency also published the proceedings of the Sixth International Conference on Naturally Occurring Radioactive Material (NORM VI).

The Fifth Meeting of the Steering Committee of the International Action Plan for Occupational Radiation Protection was held in Vienna in June. Achievements in the implementation of the action plan include the setting up of regional and international ALARA (as low as reasonably achievable) networks; the development of education and training material; and the creation of an Occupational Radiation Protection Networks (ORPNET) web site as a focal point for occupational radiation protection matters. The Steering Committee evaluated these outputs and proposed that the action plan be concluded. It also suggested that the Agency consider a new mechanism to coordinate occupational radiation protection, and the Secretariat was encouraged to organize a second international conference on occupational radiation protection.

*"The Agency developed guidance on radiation protection in industries processing naturally occurring radioactive material (NORM) ..."*

The Agency's testing laboratory for radiation protection is required to maintain its ISO-17025 accreditation for radiation protection services. The external audit was conducted in November, with the testing laboratory successfully passing the re-accreditation by the Austrian authority. The experience of the re-accreditation will be shared with radiation protection monitoring service laboratories in Member States.

## Code of Conduct on the Safety and Security of Radioactive Sources

Following the recommendations of the 2010 open-ended meeting of technical and legal experts on the implementation of the Code of Conduct on the Safety and Security of Radioactive Sources (the Code), the Agency organized the review and revision of the Guidance on the Import and Export of Radioactive Sources (the Guidance). The revised version, based on five years of experience in implementing the Guidance, was approved by the Board of Governors and endorsed by the General Conference in September 2011. The Agency also organized regional workshops on the implementation of the Code in Africa and Latin America to facilitate regional cooperation and harmonization of regulatory practices.

An open-ended meeting of technical and legal experts took place in July to discuss the development of a non-binding instrument on the transboundary movement of scrap metal that may inadvertently contain radioactive material. The meeting made progress on drafting the instrument and recommended that it be developed as a 'code of conduct' so that it can be easily identified but is also understood to be non-binding, following the well established process for other codes of conduct.

*"Public awareness of measures to achieve the safe and secure transport of radioactive material was also noted as being important."*

## Strengthening Radiation Safety Infrastructures

Following a Thematic Safety Area structure, the Agency provided technical support — including appraisal and advisory missions, procurement of equipment, training courses and fellowships — to more than 120 Member States, with the specific aim of strengthening: regulatory infrastructure; protection of workers; protection of patients; protection of the public; and waste safety. In each case, information about the national infrastructure was recorded and evaluated in the Agency's Radiation Safety Information Management System (RASIMS), in coordination with Member States.

Agency efforts to build competence in this area included evaluating national infrastructure for education and training in radiation protection through Education and Training Appraisal (EduTA) missions to Belarus, the Republic of Korea and Malaysia, and conducting a regional postgraduate educational course in radiation protection and the safety of sources in Argentina, Greece, Malaysia and Morocco. Additionally, more than 30 specialized training events were held for regulators, operators, and scientific and technical staff. A 'Long-Term Agreement' related to education and training in radiation safety was signed between the Agency and Greece, and memoranda of understanding on the same subject were concluded between AFRA and Algeria, Ghana and Morocco, respectively.

## Transport of Radioactive Material

At an international conference on the safe, secure and sustainable transport of radioactive material, held in Vienna in October, participants reviewed current practice and examined issues of importance for the future. The major conclusions of the conference included the need for harmonization, at all levels, of safety and security requirements as well as of Member State regulatory requirements. Harmonization of activities between the Agency and other United Nations organizations was also considered to be important. Participants also felt that consistency between Agency, IMO and ICAO regulations, as well as IATA and national regulations, was necessary to avoid denials of shipment and to foster greater compliance. The participants concluded that harmonizing how regulations were implemented was just as important in preventing denials of shipment. For example, the Agency's Regulations for the Safe Transport of Radioactive Material were being implemented by Member States in very different ways, with different editions of the regulations being used. Conference attendees also pointed out that communication continues to be an issue of interest to a number of coastal States, and they proposed that best practice guidelines be developed for systematic and timely government-to-government communication. Public awareness of measures to achieve the safe and secure transport of radioactive material was also noted as being important. Finally, concerns were expressed about the appropriateness, practicality and legal aspects of prior notification, which was noted as being an issue that required the involvement of IMO.

# 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.*

## Radioactive Waste Management

In November, the Agency, in collaboration with the Swedish Radiation Safety Authority, organized an international workshop in Stockholm on 'High Level Radioactive Waste and Spent Fuel Management — Storage and Disposal'. The workshop emphasized that while storage was a management step, disposal was a management solution for radioactive waste. The workshop participants also recommended that comprehensive strategies for high level radioactive waste and spent fuel management be developed, with clearly defined end-points, including disposal.

The need continues to grow for increased storage capacity for the management of spent nuclear fuel after its removal from the reactor core. One option is to use dual purpose casks designed for both transport and storage. However, there are separate transport and storage regulations that need to be complied with, and the safety performance of these casks during both storage and transport has to be considered in a holistic manner. Following discussions at the international conference on 'Management of Spent Fuel from Nuclear Power Reactors', held in 2010, the Agency initiated a two year international working group to develop guidance on an integrated safety case for dual purpose casks for the transport and storage of spent fuel.

The International Project on Demonstrating the Safety of Geological Disposal (GEOSAF) was finalized at a meeting in May 2011. The project members shared experience on the demonstration of the safety of geological disposal. The project also focused on post-closure safety, and a pilot study on operational safety was initiated. The pilot study concluded that it is essential to develop an integrated safety case addressing both operational and post-closure safety. The participating Member States requested that this work be continued, and a follow-up project is to be launched in March 2012. GEOSAF also prepared a questionnaire, based on the IAEA safety standards, to facilitate review of post-closure safety.

## Decommissioning and Remediation

The International Project on Use of Safety Assessment in Planning and Implementation of Decommissioning of Facilities using Radioactive Material (FaSa), which began in 2008, was completed in 2011 (Fig. 1). All of the working groups completed their work on the development of recommendations for decommissioning safety assessments. The final meeting of the project, held in Vienna in November,

*"The need continues to grow for increased storage capacity for the management of spent nuclear fuel after its removal from the reactor core."*

*FIG. 1. Decommissioning of a glove box in a fuel fabrication facility.*

reviewed the progress achieved in 2011. The main output of the project was recommendations on the use of decommissioning safety assessments in the planning and implementation of decommissioning, with an emphasis on a phased approach to the development of the safety assessment.

The Agency continued to assist Member States with the decommissioning of research reactors. In July, a workshop was held in Romania to demonstrate the review process for development of a decommissioning plan; a draft of the decommissioning plan for the Magurele research reactor was used as the test case. In 2011, the 'planning' phase of the Research Reactor Decommissioning Demonstration Project ($R^2D^2P$) was completed and preparations for the implementation phase began.

Significant progress was made in 2011 under the Iraq Decommissioning Project (IDP). Phase two of the IDP was initiated, with planning for decommissioning of five additional facilities and sites, including the IRT 5000 and Tammuz 2 research reactors. Experts reviewed a draft decommissioning plan that was subsequently submitted to the regulatory body for review. The Agency continued to provide expert advice, building upon a national policy and strategy for radioactive waste management that was drafted in November 2009.

*"Work began on reviewing and updating the Agency's technical reports dealing with decommissioning and remediation ... in the light of lessons learned from the accident at TEPCO's Fukushima Daiichi nuclear power plant."*

The International Working Forum on Regulatory Supervision of Legacy Sites (RSLS) is aimed at strengthening regulatory supervision and remediation of legacy sites. RSLS covers activities such as facility decommissioning, remediation of contaminated lands and development of waste management related facilities. In 2011, a three year work plan for RSLS was finalized that focuses on: enhancing the regulatory regime, professional development of regulators, and applications of methods for safety and environmental assessments.

Three new technical reports on detailed aspects of decommissioning were published as part of the IAEA Nuclear Energy Series: *Selection and Use of Performance Indicators in Decommissioning* (NW-T-2.1), *Redevelopment and Reuse of Nuclear Facilities and Sites: Case Histories and Lessons Learned* (NW-T-2.2) and *Decommissioning of Small Medical, Industrial and Research Facilities: A Simplified Stepwise Approach* (NW-T-2.3). A guide on decommissioning policies and strategies, to be published in the IAEA Nuclear Energy Series, was also completed. Work began on reviewing and updating the Agency's technical reports dealing with decommissioning and remediation following a nuclear accident in the light of lessons learned from the accident at TEPCO's Fukushima Daiichi nuclear power plant.

The International Decommissioning Network (IDN) is an important mechanism for the exchange of information on good international practice in decommissioning and in organizing training activities to aid the development of expertise, especially among young professionals. Several courses, workshops and group scientific visits, involving more than 80 participants from more than 28 Member States, were conducted in conjunction with the technical cooperation programme. In the future, the scope of the IDN will be increased to include collaborative projects in which participants will work together more intensively to share information on good practices in specific areas of decommissioning.

The Network of Environmental Management and Remediation (ENVIRONET) supports Member States in dealing with environmental remediation issues. In 2011, the network created a group in LinkedIn called ENVIRONET. Activities organized within ENVIRONET included mainly training events, panel sessions at international conferences and the annual meeting in Vienna.

## Connecting the Network of Networks for Enhanced Communication and Training (CONNECT)

CONNECT is an Internet based platform for interconnecting Agency networks in the area of radioactive waste management, with the aim of increasing the participation of individuals and organizations and making available additional sources of information that complement existing training events (e.g. technical workshops, training courses, scientific visits). CONNECT also provides a mechanism for the continuous sharing of international best practices and lessons learned, and for professionals in the networks to receive timely and direct advice about possible solutions based on the collective experience of network participants. It

was initiated in 2011 with assistance from Sandia National Laboratories in the USA.

## Contact Expert Group for International Radioactive Waste Projects in the Russian Federation (CEG)

The CEG was established in 1996 under the auspices of the Agency to promote international cooperation and assistance in addressing legacy spent nuclear fuel and radioactive waste management challenges. It comprises 13 Member States. By the end of 2011, the Russian Federation and international partners had defuelled and dismantled 196 decommissioned nuclear submarines (out of 200). One third of this work was funded by international partners, who also funded many key facilities for defuelling and for radioactive waste management at Russian shipyards. The defuelled reactor units are currently being placed in a storage facility. The transfer of spent fuel from submarines currently in storage facilities at former navy bases to reprocessing plants is now the priority of CEG members, and initial shipments of spent fuel from these bases were made in 2011. Another priority is management of legacy radioactive waste at former navy bases and the construction of a regional centre for conditioning and storage of radioactive waste. International programmes for recovering radioisotope thermoelectric generators (RTGs) that were used for navigation purposes along the coastline of the Russian Federation are being successfully implemented. Most of the 1007 RTGs have been recovered (with 119 remaining). In 2011, the Baltic Sea was completely cleared of RTGs.

## Countries Embarking on Nuclear Power

Assistance to countries considering embarking upon nuclear power is organized through the Agency's Integrated Nuclear Infrastructure Group (INIG). The assistance is delivered through technical cooperation projects, Integrated Nuclear Infrastructure Review (INIR) missions, workshops and publications. In 2011, INIR missions were undertaken in Bangladesh and the United Arab Emirates. The missions' recommendations to both Governments focused on establishing a suitable radioactive waste management infrastructure and on incorporating all nuclear fuel cycle issues into plans for the introduction of nuclear power.

An ASEAN regional workshop provided instructions to newcomer countries on the development of a policy and strategy for radioactive waste and spent fuel management. And a national workshop on planning for radioactive waste and spent fuel management was held in Vietnam. Workshop participants indicated that major challenges faced by embarking countries included obtaining practical guidance on establishing national radioactive waste management infrastructure, selecting optimal waste processing and disposal technologies, and developing the required facilities. Capacity building, including the training of local staff to run waste management programmes, was also seen as a challenge.

*"Assistance to countries considering embarking upon nuclear power is organized through the Agency's Integrated Nuclear Infrastructure Group (INIG)."*

## Expert Review Activities

The Agency organized several expert review missions related to waste management, decommissioning and environmental remediation. For example, proposed design options for a near surface repository for short lived radioactive waste, to be located in the vicinity of the former Ignalina nuclear power plant in Lithuania, were reviewed. In Malaysia, a review was undertaken of the ongoing site selection programme for a near surface repository for short lived radioactive waste. A separate mission to Malaysia reviewed a project concerned with the construction of a rare earths processing facility. The safety case for a planned near surface repository near the Cernavoda nuclear power plant in Romania was also reviewed. A review of the decommissioning programme being implemented for the United Kingdom's fleet of first generation gas cooled reactors was completed, in which the review team noted significant advances in the decommissioning programme since an initial review mission in 2008.

# Nuclear Security

## Objective

*To contribute to global efforts to achieve worldwide, effective security wherever nuclear or other radioactive material is in use, storage and/or transport, and of associated facilities, by supporting States, upon request, in their efforts to establish and maintain effective nuclear security through assistance in capacity building, guidance, human resource development, sustainability and risk reduction. To assist adherence to and implementation of nuclear security related international legal instruments; and to strengthen the international cooperation and coordination of assistance given through bilateral programmes and other international initiatives in a manner which also would contribute to enabling a broader use of nuclear energy and of applications with radioactive substances.*

## Nuclear Security Assessments

Nuclear security peer reviews and advisory services continued to be the Agency's main tools for helping States to assess their nuclear security effectiveness, identify needs and provide a basis for formulating plans for continuous improvement. In 2011, three International Physical Protection Advisory Service (IPPAS) missions were undertaken in France, Sweden and the United Kingdom. With a total of 54 missions, IPPAS has become an important tool to build confidence within the international community with regard to the effectiveness of national nuclear security programmes. Some of the output from these missions provided input to the Integrated Nuclear Security Support Plans (INSSPs) drawn up by the Agency together with States to identify areas where improvements are needed in their nuclear security programmes. In the course of 2011, five States approved their INSSPs, bringing the total number to 30, with five additional INSSPs awaiting formal approval. Fourteen other missions were conducted focusing on legal, regulatory and practical measures for controlling nuclear and other radioactive material.

*"Nuclear security peer reviews and advisory services continued to be the Agency's main tools for helping States to assess their nuclear security effectiveness, identify needs and provide a basis for formulating plans for continuous improvement. "*

The Agency undertook other expert missions, at the request of States, to examine arrangements to detect illicit trafficking and respond to nuclear security incidents. It also conducted a number of technical visits, which addressed security needs at locations including border crossings, medical facilities, scientific institutes and industrial sites.

## Strengthening Global Safety and Security

The Advisory Group on Nuclear Security (AdSec) provides advice to the Director General on the Agency's activities related to the prevention and detection of and response to malicious acts involving nuclear or other radioactive material and facilities. The joint AdSec–Commission on Safety Standards (CSS) task force explored ways to improve the process of reviewing and approving draft IAEA Nuclear Security Series publications in the short term as well as the feasibility of a long term objective of developing an integrated series of safety and security standards. In pursuit of the short term objective of improving the process for the review and approval of draft IAEA Nuclear Security Series publications, the task force recommended to the Director General the establishment of a standing Nuclear Security Guidance Committee (NSGC), open to all Member States, to make recommendations on the development and review of nuclear security publications. It was proposed that the NSGC would also cooperate with the CSS and safety standards committees to ensure that safety and security interface issues are properly addressed and reviewed in the Agency's safety and security publications. As a long term vision for structuring the review and approval of draft nuclear safety and security publications, the joint task force recommended that the establishment of a new Safety and Security Series Commission be considered. The joint task force noted that such a long term vision should be revised, if necessary, in the light of experience acquired with the NSGC.

The primary publication in the IAEA Nuclear Security Series, which deals with the fundamentals

of a State's nuclear security regime, was sent for final approval to the relevant authorities in Member States. Three Recommendations level publications, which were completed in 2010 and published in 2011, present best practices in the application of the nuclear security fundamentals.

## Provision of Equipment to Member States

A major element of the Agency's nuclear security assistance to States is the provision of equipment for detecting and responding to the unauthorized movement of nuclear and other radioactive material, including illicit trafficking, as well as the provision of equipment for physical protection upgrades. For example, four remote monitoring systems were deployed and made operational in four facilities to secure Category I–III radioactive sources. The Agency also donated 256 handheld monitors to Member States and lent an additional 588 radiation detection instruments.

## Building Capacity

Investing in human resource development and capacity building continues to be vital to maintaining effective and sustainable nuclear security programmes in States. To this end, the Agency conducted 52 training events covering all aspects of nuclear security, reaching more than 1300 people from 120 States.

The International Nuclear Security Education Network (INSEN) has been expanding and now comprises over 50 academic institutions. During the second annual INSEN meeting in Vienna, members reviewed the activities of the working groups, focusing on the three action plans of the main areas necessary for the establishment of nuclear security education: exchange of information and development of nuclear security education materials; faculty development and cooperation among educational institutions; and promotion of nuclear security education. The action plans were reviewed to ensure that there was continuous support for nuclear security education. Using the Agency's guide *Educational Programme in Nuclear Security* (IAEA Nuclear Security Series No. 12), five universities in Europe began development of Master of Science programmes in nuclear security for the autumn 2012 semester. This initiative is being supported by the Agency and the European Commission.

The Agency established a network among the nuclear security training community to facilitate collaboration among Nuclear Security Support Centres (NSSCs) and to promote the concept of national NSSCs. This resulted in States signing 'Practical Arrangements' with the Agency. To date, the concept has been successfully implemented in several countries, such as Ghana, Morocco and Pakistan (Fig. 1).

*FIG. 1. A nuclear security training session.*

## Illicit Trafficking Database (ITDB)

The membership of the Agency's Illicit Trafficking Database (ITDB) has continued to expand, with two States joining in 2011, bringing the total number of participating States to 112 Member States and one non-Member State. The first web based version of the ITDB was launched, featuring information on all incidents confirmed to the ITDB and solely accessible to ITDB Points of Contact.

*"Investing in human resource development and capacity building continues to be vital to maintaining effective and sustainable nuclear security programmes in States."*

As of the end of 2011, States had reported — or otherwise confirmed via the ITDB — 2164 incidents since the database was established in 1995. A total of 147 incidents were reported in 2011. Twenty of these incidents involved illegal possession of and attempts

to sell nuclear material or radioactive sources. In 31 cases, thefts or losses of radioactive sources were reported. The remaining 96 incidents involved discoveries of uncontrolled material, unauthorized disposals and the inadvertent, unauthorized movement or storage of nuclear material, radioactive sources and/or radioactively contaminated material. During 2011, there were four incidents involving HEU, one related to an attempted sale and three related to other unauthorized activities. There were also seven incidents involving Category I–III radioactive sources, five of which were thefts.

## Coordinated Research Projects

The Agency started a new three year CRP entitled 'Identification of High Confidence Nuclear Forensics Signatures for the Development of National Nuclear Forensics Libraries'. The objective is to identify relevant nuclear forensic signatures and to track their incorporation and modification across the stages of the nuclear fuel cycle. By comparing the nuclear forensic signature of a sample encountered out of regulatory control with those of known materials organized within a national nuclear forensics library, Member States can better ensure the security of nuclear or other radioactive materials manufactured, used or stored within the country. The CRP also aims to provide technical guidance and scientific solutions to assist Member States in the development of a national nuclear forensics library.

*"The Agency started a new three year CRP ... to identify relevant nuclear forensic signatures and to track their incorporation and modification across the stages of the nuclear fuel cycle."*

Another CRP on the 'Development and Implementation of Instruments and Methods for the Detection of Unauthorized Acts Involving Nuclear and Other Radioactive Material' was completed.

## International Cooperation and Coordination

The Agency, in cooperation with Member States, continued to play a role in nuclear security related initiatives such as the Global Initiative to Combat Nuclear Terrorism (GICNT) and to work jointly, as appropriate, with relevant international and regional organizations and institutions. The first information exchange meeting was held in May 2011, with the purpose of exchanging information at the working level.

The Agency engaged Member States and relevant United Nations bodies such as the Counter-Terrorism Implementation Task Force (CTITF) and the Security Council's 1540 Committee to establish a basis for improving cooperation and enhancing dialogue among other international nuclear security related initiatives. The GICNT recognized the leading role of the Agency and has secured an agreement for regular information exchange.

## Nuclear Security Fund

In 2011, the implementation of the nuclear security programme continued to rely on extrabudgetary contributions. Revenue to the Nuclear Security Fund amounted to some €18 million in 2011. Financial contributions were received from 16 Member States and the European Union as extrabudgetary funding.[1] In addition, a number of Member States made contributions in kind through the donation of equipment and expert services. Extrabudgetary resources provide 85% of the nuclear security programme's funding.

[1] Canada, China, Estonia, Finland, France, Germany, Italy, Japan, Republic of Korea, the Netherlands, Norway, Spain, Sweden, the Russian Federation, the United Kingdom, the United States of America and the European Union.

# Safeguards

# Safeguards

## Objective

*To draw independent, impartial and timely safeguards conclusions, in order to provide credible assurances to the international community that States are abiding by their safeguards obligations. To contribute, as appropriate and as requested, to verifying nuclear arms control and reduction agreements.*

## Implementation of Safeguards in 2011

At the end of each year, the Agency draws a safeguards conclusion for each State for which safeguards are applied. This conclusion is based on a continuous, iterative State evaluation process that integrates and assesses all safeguards relevant information available to the Agency. By basing the planning, conduct and evaluation of safeguards on an ongoing analysis of all such information, the Agency is able to more effectively focus verification activities in the field and at Headquarters.

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: first, there are no indications of diversion of declared nuclear material from peaceful activities (including no misuse of declared facilities or other declared locations to produce undeclared nuclear material); and second, there are no indications of undeclared nuclear material or activities in the State as a whole.

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 Agency assesses the results of its verification and evaluation activities under CSAs and additional protocols (APs). Thus, for the Agency to draw such a broader conclusion, both a CSA and an AP must be in force in the State, and the Agency must have completed all necessary verification and evaluation activities.

For States that have a CSA but with no AP in force, the Agency draws a conclusion for a given year only with respect to whether *declared* nuclear material remained in peaceful activities, as the Agency does not have sufficient tools to provide credible assurances regarding the absence of undeclared nuclear material and activities in a State as a whole.

For those States for which the broader conclusion has been drawn and a State level integrated safeguards approach has been approved, the Agency implements integrated safeguards: an optimized combination of measures available under CSAs and APs to maximize effectiveness and efficiency in fulfilling the Agency's safeguards obligations. In accordance with the State level safeguards approach and annual implementation plan approved for each individual State, by the end of 2011 integrated safeguards were implemented for 51 States.[1]

*"In 2011, safeguards were applied for 178 States ... with safeguards agreements in force with the Agency ..."*

In 2011, safeguards were applied for 178 States[2] with safeguards agreements in force with the Agency.[3,4] Of the 109 States that had both a CSA and an AP in force, the Agency concluded that *all* nuclear material remained in peaceful activities in 58 States[5]; for the remaining 51 States, as all the necessary evaluations had yet to be completed, the Agency was unable to draw the same conclusion. For these 51 States, and for the 61 States with a CSA but with no AP in force, the Agency concluded only

---

1 Armenia, Australia, Austria, Bangladesh, Belgium, Bulgaria, Burkina Faso, Canada, Chile, Croatia, Cuba, the Czech Republic, Denmark, Ecuador, Estonia, Finland, Germany, Ghana, Greece, the Holy See, Hungary, Iceland, Indonesia, Ireland, Italy, Jamaica, Japan, the Republic of Korea, Latvia, Libya, Lithuania, Luxembourg, Madagascar, Mali, Malta, Monaco, the Netherlands, Norway, Palau, Peru, Poland, Portugal, Romania, Seychelles, Singapore, Slovakia, Slovenia, Spain, Sweden, Uruguay and Uzbekistan.

2 The 178 States do not include the Democratic People's Republic of Korea, where the Agency did not implement safeguards and, therefore, could not draw any conclusion.

3 And Taiwan, China.

4 The status with regard to the conclusion of safeguards agreements, APs and small quantities protocols (SQPs) is given in the Annex to this report.

5 And Taiwan, China.

that *declared* nuclear material remained in peaceful activities.

Safeguards were also implemented with regard to declared nuclear material in selected facilities in the five nuclear-weapon States under their respective voluntary offer agreements. For these five States, the Agency concluded that nuclear material to which safeguards were applied in selected facilities remained in peaceful activities or had been withdrawn from safeguards as provided for in the agreements.

For the three States in which the Agency implemented safeguards pursuant to safeguards agreements based on INFCIRC/66/Rev.2, the Secretariat concluded that the nuclear material, facilities or other items to which safeguards were applied remained in peaceful activities.

*"... consultations on the amendment of SQPs and the conclusion and entry into force of safeguards agreements and APs were held throughout the year with representatives from Member and non-Member States ..."*

As of 31 December 2011, 14 non-nuclear-weapon States party to the Treaty on the Non-Proliferation of Nuclear Weapons (NPT) had yet to bring CSAs into force pursuant to Article III of the Treaty. For these States, the Secretariat could not draw any safeguards conclusions.

## Conclusion of Safeguards Agreements and APs, and Amendment of SQPs

The Agency continued to facilitate the conclusion of safeguards agreements and APs, and the amendment or rescission of small quantities protocols (SQPs)[6]. During 2011, CSAs entered into force for three States[7], and APs entered into force for ten States[8]. The status of safeguards agreements and APs as of 31 December 2011 is shown in Table A6. During the year, one State[9] signed a CSA and an AP.

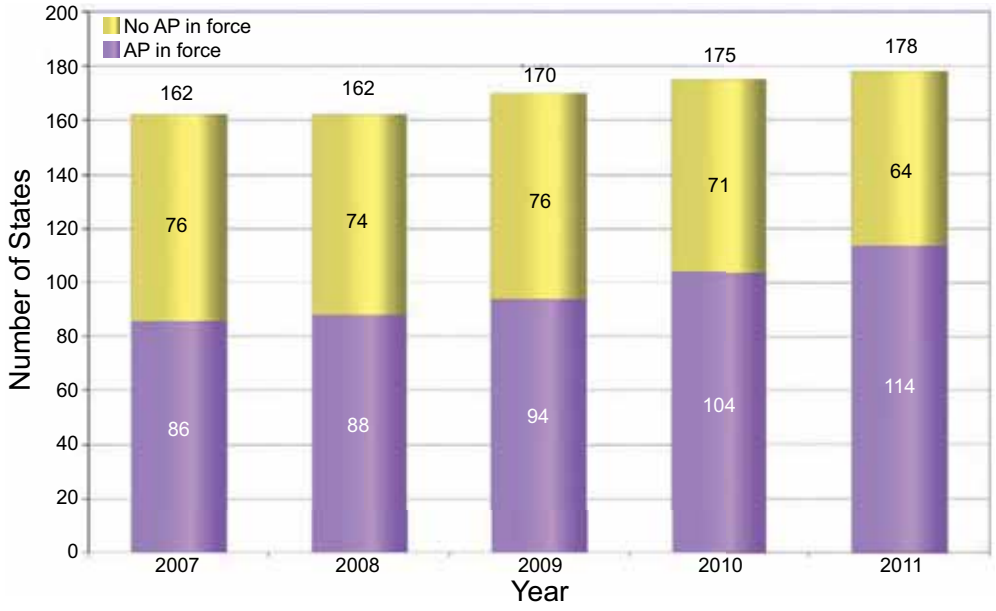



*FIG. 1. Number of APs for States with safeguards agreements in force, 2007–2011 (the Democratic People's Republic of Korea is not included).*

---

6 Many States with minimal or no nuclear activities have concluded an SQP to their CSA. Under an SQP, the implementation of most of the safeguards procedures in Part II of a CSA is held in abeyance as long as certain criteria are met. In 2005, the Board of 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 (GOV/INF/276/Mod.1 and Corr.1). 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.

7 Republic of the Congo, Montenegro and Mozambique.

8 Andorra, Bahrain, Republic of the Congo, Costa Rica, Gambia, Kyrgyzstan, Mexico, Montenegro, Morocco and Mozambique.

9 Guinea.

The Secretariat continued to implement the Plan of Action to Promote the Conclusion of Safeguards Agreements and Additional Protocols, which was updated in September 2010. During the year, the Secretariat convened four outreach events on the subject of Agency safeguards: an interregional seminar for States in Southeast and South Asia with limited nuclear material and activities, and a regional seminar for States in Southeast Asia with significant nuclear activities (both held in Singapore in March 2011); and briefings for a number of Permanent Missions (in Geneva in May and in New York in October). In addition, consultations on the amendment of SQPs and the conclusion and entry into force of safeguards agreements and APs were held throughout the year with representatives from Member and non-Member States in Berlin, Geneva, New York and Vienna, and also during training events organized in Vienna and elsewhere by the Secretariat.

### *Amendment of SQPs*

The Secretariat continued to communicate with States in order to implement the Board's 2005 decisions regarding the amendment or rescission of SQPs to reflect the revised standardized text and changed eligibility criteria. During the year, SQPs with seven States[10] were amended and three States[11] brought into force SQPs based on the revised text.

## Implementing Safeguards in the Islamic Republic of Iran (Iran)

During 2011, the Director General submitted four reports to the Board of Governors entitled *Implementation of the NPT Safeguards Agreement and relevant provisions of Security Council resolutions in the Islamic Republic of Iran* (GOV/2011/7, GOV/2011/29, GOV/2011/54 and GOV/2011/65).

In 2011, contrary to the relevant binding resolutions of the Board of Governors and the United Nations Security Council, Iran did not: implement the provisions of its Additional Protocol; implement the modified Code 3.1 of the Subsidiary Arrangements General Part to its Safeguards Agreement; suspend its enrichment related activities; suspend its heavy water related activities; or address the Agency's serious concerns about possible military dimensions to Iran's nuclear programme, in order to establish international confidence in the exclusively peaceful nature of Iran's nuclear programme.

While the Agency continued throughout 2011 to verify the non-diversion of declared nuclear material at the nuclear facilities and locations outside facilities (LOFs) declared by Iran under its Safeguards Agreement, as Iran did not provide the necessary cooperation, including not implementing its Additional Protocol, as required in the binding resolutions of the Board of Governors and the United Nations Security Council, the Agency was unable to provide credible assurance about the absence of undeclared nuclear material and activities in Iran and, therefore, was unable to conclude that all nuclear material in Iran was in peaceful activities.

*"During the year, the Secretariat convened four outreach events on the subject of Agency safeguards ..."*

The Director General decided that the time was right to provide the Board of Governors with the Secretariat's detailed analysis of the information available to the Agency which had given rise to concerns about possible military dimensions to Iran's nuclear programme. This analysis was published in an Annex to the Director General's November 2011 report to the Board. The Secretariat's analysis indicates that Iran has carried out activities relevant to the development of a nuclear explosive device. It also indicates that prior to the end of 2003, these activities took place under a structured programme and that some activities may still be ongoing.

On 18 November 2011, the Board of Governors adopted by a vote resolution GOV/2011/69 in which, inter alia, the Board expressed deep and increasing concern about the unresolved issues regarding the Iranian nuclear programme, including those which need to be clarified to exclude the existence of possible military dimensions, and stressed that it is essential for Iran and the Agency to intensify their dialogue aiming at the urgent resolution of all outstanding substantive issues for the purpose of providing clarifications regarding those issues, including access to all relevant information, documentation, sites, material and personnel in Iran.

[10] El Salvador, Gambia, Guatemala, Panama, Republic of Moldova, San Marino and Zimbabwe.

[11] Republic of the Congo, Montenegro and Mozambique.

## Implementing Safeguards in the Syrian Arab Republic (Syria)

During 2011, the Director General submitted two reports to the Board of Governors on the implementation of Syria's NPT Safeguards Agreement. On 6 June 2011, the Director General reported to the Board of Governors that, based on all the information available to the Agency, it was very likely that a building destroyed at the Dair Alzour site was a nuclear reactor which should have been declared to the Agency by Syria.

On 9 June 2011, the Board of Governors adopted by a vote a resolution in which it, inter alia, decided to report, as provided for in Article XII.C of the Statute, through the Director General, Syria's non-compliance with its Safeguards Agreement to all Members of the Agency and to the Security Council and General Assembly of the United Nations.

In May 2011, Syria indicated its readiness to fully cooperate with the Agency to resolve issues related to the Dair Alzour site. Following that, in August 2011, Syria informed the Agency of its readiness to have a meeting with the Agency in order to resolve the outstanding issues regarding the Dair Alzour site. In October 2011, a delegation from the Agency visited Damascus with the aim of advancing the Agency's verification mission in Syria. A number of questions, in particular concerning other locations that may be functionally related to the Dair Alzour site, remain to be resolved.

In 2011, Syria cooperated with the Agency in addressing the Agency's concerns in relation to previously unreported conversion activities at the Miniature Neutron Source Reactor and the origin of anthropogenic natural uranium particles found there. The Agency decided that the matter would henceforth be addressed in the routine implementation of safeguards.

For 2011, the Agency was able to conclude for Syria that declared nuclear material remained in peaceful activities.

## Implementing Safeguards in the Democratic People's Republic of Korea (DPRK)

In September 2011, the Director General submitted a report to the Board of Governors and General Conference on the application of safeguards in the DPRK, which provided a historical overview and update on those recent developments of direct relevance to the Agency, along with information on the DPRK's nuclear programme (GOV/2011/53-GC(55)/24).

Since 1994, the Agency has not been able to conduct all necessary safeguards activities provided for in the DPRK's NPT Safeguards Agreement. From the end of 2002 until July 2007, the Agency was not able, and since April 2009 has not been able, to implement any verification measures in the DPRK and, therefore, could not draw any safeguards conclusion regarding the DPRK.

Since April 2009, the Agency has not implemented any measures under the ad hoc monitoring and verification arrangement agreed between the Agency and the DPRK and foreseen in the Initial Actions agreed at the Six-Party Talks. Reports received about the construction of a new uranium enrichment facility and of a light water reactor in the DPRK are deeply troubling.

Although not implementing any verification activities in the field, the Agency continued to monitor the DPRK's nuclear activities by using open source information, satellite imagery and trade information. The Agency also continued to further consolidate its knowledge of the DPRK's nuclear programme with the objective of maintaining operational readiness to resume safeguards implementation in the DPRK.

## State Level Concept for the Planning, Conduct and Evaluation of Safeguards

In 2011, the Agency continued to evolve the State level concept for the planning, conduct and evaluation of safeguards. Safeguards implementation, pursued in accordance with the State level concept, is based on a comprehensive evaluation of all safeguards relevant information regarding a State.

Efforts during the year focused on ways to better link verification activities at Headquarters and in the field with those related to the evaluation of all safeguards relevant information available to the Agency. All such information regarding a State's nuclear programme, including feedback from inspection related activities, is evaluated, not only to draw safeguards conclusions but also to determine the safeguards activities to be conducted with respect to that State in order to maintain those conclusions. This helps the Agency to customize and focus its verification activities.

### *Cooperation with State and regional safeguards authorities*

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, where relevant, regional systems of accounting for and control of nuclear material, and on the level of cooperation of State and regional safeguards authorities with the Agency. The Secretariat routinely meets State and regional authorities to address 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.

To help States build their capacity to comply with their safeguards obligations, the Agency in 2011 conducted two IAEA SSAC Advisory Service (ISSAS) missions in Kazakhstan and Mexico. It also held seven international, regional and national training courses for personnel responsible for oversight and implementation of the SSAC, and participated in meetings supporting development of national infrastructures.

### *Information analysis*

Throughout 2011, the Agency continued to enhance and diversify its capabilities to acquire and process data, analyse and evaluate information, generate knowledge, and securely distribute information to contribute to an effective safeguards system. The analysis of all safeguards relevant information has become an essential part of evaluating a State's nuclear activities and drawing safeguards conclusions.

In drawing its safeguards conclusions, the Agency processes, evaluates and conducts a consistency analysis between State declarations, verification data, and open source information. In support of this process, the Agency draws on a diverse range of open sources, including satellite imagery and nuclear trade related procurement data. It continues to invest in new tools and methods to streamline and prioritize workflows and processes.

Information analysts are also responsible for evaluating an increasing amount of field data, including non-destructive assay (NDA) measurement results, as well as laboratory analysis of destructive assay and environmental samples — essential contributions to the State evaluations.

In an effort to continuously improve the quality of reporting, Agency staff: monitored laboratory and measurement systems performance; organized international technical meetings; and provided training and workshops to States on nuclear material accounting, including measurement and material balance evaluation concepts. Workshops on the procurement outreach programme yielded reports on suspicious procurement attempts and current procurement trends. Ongoing reviews of technical cooperation projects and procurements provided relevant safeguards input to decision making. Information analysts made important contributions to ongoing State evaluations using State files, satellite imagery analysis, material balance evaluations, safeguards approaches, environmental sample analysis, trade analysis, and the analysis of scientific and technical literature.

In 2011, in response to the earthquake and tsunami in Japan, the Agency acquired and analysed imagery of the Fukushima Daiichi nuclear power plant on a daily basis and provided extensive analysis of radionuclide inventories. This information played a critical role in helping to inform Member States, as well as the public, about the crisis.

*"To help States build their capacity to comply with their safeguards obligations, the Agency ... held seven international, regional and national training courses for personnel responsible for oversight and implementation of the SSAC, and participated in meetings supporting development of national infrastructures. "*

### *Information systems*

In 2011, the Agency made improvements to the overall performance, stability and security of its safeguards information systems. The software for all desktops was modernized, and laptops were reconfigured to provide more secure alternatives for remote computing. The information technology (IT) service desk processed an average of 530 service requests per month. Industry standard best practices and process improvements were implemented.

To deliver a secure collaborative platform for information analysis, an Integrated Safeguards Environment (ISE) was designed, and the Safeguards

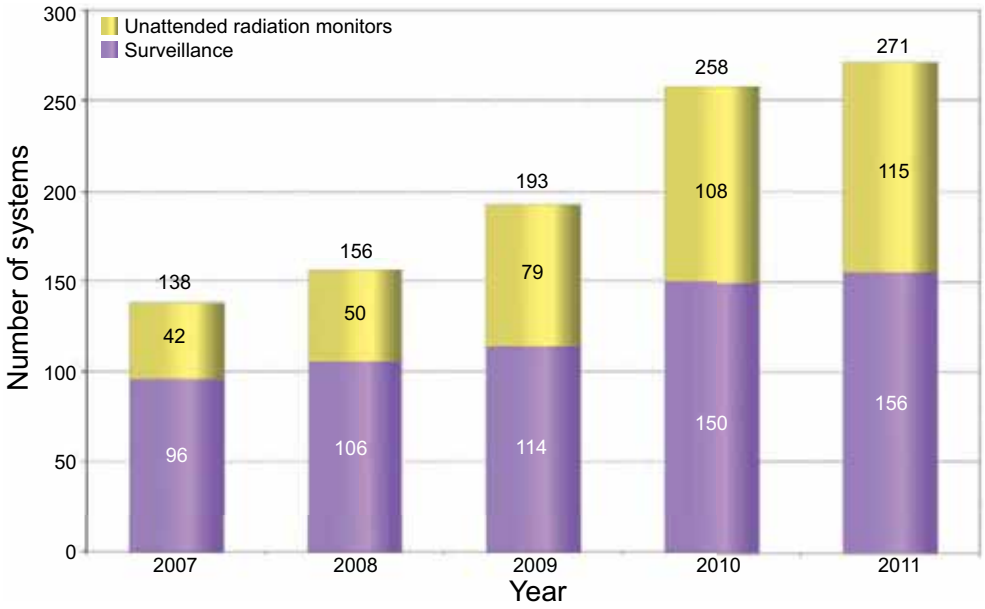



*FIG. 2. Implementation of safeguards systems in remote monitoring mode, 2007–2011.*

Analytical Laboratory IT network was integrated with the rest of the safeguards area. Upgrades were implemented to the IT systems at the safeguards regional offices.

During 2011, numerous other software related upgrades were implemented, including the provision of new capabilities for the dedicated safeguards internet portal, an internal communication tool to support information sharing and collaboration, and the email infrastructure. Other areas of improvement included expanding internal IT forensics capabilities and strengthening system monitoring tools to ensure high availability.

*"In 2011, the Agency made improvements to the overall performance, stability and security of its safeguards information systems."*

Significant improvements were made to IT governance, standards and quality assurance policies. A role based access control solution was designed to facilitate access to safeguards data, and architectural documents were updated to promote standard software development best practices.

The safeguards area's portal site was deployed to facilitate access to all State related data for collaborative analysis, a search engine to retrieve data in any format was deployed, and a new system to manage follow-up actions was developed. The latter will track key activities for the annual implementation plan and State evaluation.

## *Equipment development and provision*

A significant technical support effort was required as part of the recovery efforts following the major earthquake and tsunami in Japan and the Fukushima Daiichi accident.

In measurable terms, achievements in the area of equipment provision are best illustrated by the following statistical data, which reflect both current status and major trends. In the area of NDA, during 2011, 2254 separate pieces of equipment were prepared and assembled into 897 portable and attended NDA systems. By the end of 2011, a total of 154 unattended monitoring systems were in operation worldwide and the Agency had 1199 cameras connected to 589 systems operating at 252 facilities in 33 States. The total number of electronic seals transmitting remote data to IAEA Headquarters in 2011 increased to 172 (from 147 in 2010). In 2011, 271 safeguards systems with remote monitoring were installed at 109 facilities in 21 States[12]. Figure 2 illustrates the increased use of remote monitoring over the past five years.

In the provision of equipment for field applications, 2011 saw a concentration on the maintenance and upgrade of existing installations. For instance, the Agency began to prepare for

[12] And Taiwan, China.

*FIG. 3. CAMECA IMS 1280-HR Large Geometry Secondary Ion Mass Spectrometer in service in the Clean Laboratory extension, Seibersdorf.*

the replacement of instrumentation with the next generation surveillance system (NGSS).

Member States Support Programmes (MSSPs) continued to provide major resources to safeguards equipment innovations. During 2011, this contributed, inter alia, towards the successful completion of the NGSS project, along with numerous improvements and upgrades aimed at achieving better standardization of safeguards instrumentation.

The equipment development programme, as part of its work to support international cooperation, held a workshop in Vienna on possible alternatives to neutron detection technologies, and a practical seminar on advanced sealing technologies. Numerous technical meetings were also hosted, addressing novel approaches to safeguards techniques in areas such as image processing and inertial navigation.

In terms of infrastructure support services, activity in 2011 focused primarily on maintaining proper logistical support to inspections and refurbishing laboratory and testing premises.

### *Enhancing sample analysis*

The Network of Analytical Laboratories (NWAL) consists of the Safeguards Analytical Laboratory (SAL) and laboratories in 18 other Member States and the European Commission. Additional laboratories in the area of environmental and/or nuclear material sample analysis are now in the process of qualification in the following countries: Argentina, Australia, Belgium, China, France, Hungary, the Republic of Korea and the USA. The entry into service of the Large Geometry Secondary Ion Mass Spectrometer (LG-SIMS) at SAL in 2011 (Fig. 3) is indicative of more widespread implementation of this technique for safeguards sample analysis throughout the NWAL.

## Support

### *Developing the safeguards workforce*

As demands on its workforce evolve, so does the Agency's training curriculum. In 2011, the Agency conducted 114 safeguards training courses and, in line with its development of the State level approach

*"In the provision of equipment for field applications, 2011 saw a concentration on the maintenance and upgrade of existing installations."*

to safeguards implementation, began to restructure its training programme accordingly. Training courses were developed, improved or updated in order to provide all safeguards staff with the necessary competencies, particularly those required for conducting collaborative analysis. Examples of such training included a complementary access exercise, an analytical skills workshop, a nuclear fuel cycle indicators course and advanced training in fuel cycle facilities supporting State evaluation. Advanced training on a range of more specialized areas was also organized, including proliferation indicators for different types of nuclear fuel cycle facilities. Training on safeguards activities at facilities was complemented by a new course involving an advanced comprehensive inspection exercise at light water reactors and CANDU reactors.

### *Quality management*

In 2011, the Agency continued to implement a quality management system in the safeguards programme. Training was provided on management system tools, such as the corrective action report system, continual process improvement methodology and document management system. Knowledge management efforts focused on retaining the critical knowledge of retiring staff. The Agency conducted internal audits on the reporting of analytical results from SAL, computer authority files and the use of remote monitoring. The cost calculation methodology was applied to enable the Agency to estimate the cost of implementing safeguards in each State.

*"In 2011, the Agency conducted 114 safeguards training courses ..."*

### *Standing Advisory Group on Safeguards Implementation*

The Standing Advisory Group on Safeguards Implementation held two series of meetings in 2011, at which, inter alia, it considered: efforts to further the application of the State level concept for all States; guidelines for States implementing safeguards agreements and APs; the *Long-term R&D Plan 2012–2023* and the *Development and Implementation Support Programme for Nuclear Verification 2012–2013*; safeguards at the front end of the nuclear fuel cycle; as well as guidelines for determining the decommissioned status of nuclear facilities under safeguards.

## Significant Safeguards Projects

### *ECAS*

To maintain and strengthen its capabilities to provide independent and timely analysis of environmental and nuclear material samples, the Agency continued with the project on Enhancing Capabilities of the Safeguards Analytical Services (ECAS).

In April 2011, construction of the extension of the Clean Laboratory to accommodate the LG-SIMS was completed and the spectrometer installed. Partially funded by the Agency's regular budget and with generous contributions from a number of Member States, this extension of the Environmental Sample Laboratory has afforded the Agency an independent capability in particle analysis equivalent to the best measurement methods available.

During 2011, the detailed design for the 'shell and core' of the new Nuclear Material Laboratory (NML) was completed, the lead contractor began excavating the site in preparation for the construction scheduled to begin in 2012, and the detailed design for the equipment and inner workings of the laboratory was completed. A site plan to help estimate project infrastructure and security cost requirements was further developed. The design phase of the NML and of related infrastructure and security components has been partially funded by the Agency's Regular Budget, with additional extrabudgetary contributions from certain Member States.

### *Integrated analysis*

In 2011, the milestones, delivery schedules and master programme plan regarding the ISIS Re-engineering Project (IRP) had to be revised following cancellation of the contract with the main supplier. Nonetheless, some of the main project components, such as the design of the key components of the ISIS application and data migration from the mainframe to the ISE, have been largely completed.

The Agency formally accepted a geospatial exploitation system (GES) in 2011, a solution aimed at supporting the analysis of imagery and the

secure dissemination of geospatial data within the safeguards programme. The primary objective of the GES is for the imagery analysts to benefit from up to date tools supporting effective special analysis. GES is the first application specifically developed to deploy into the Agency's ISE.

### *MOX Fuel Fabrication Plant in Japan*

The construction of the MOX Fuel Fabrication Plant in Japan (J-MOX), which began in October 2010, has been suspended following the major earthquake and resultant tsunami of March 2011. In 2011, through extensive design information examination and review, the Agency consolidated the safeguards approach and design information verification plan for J-MOX, and also started testing some of the prototype equipment that will be required at the plant.

### *Chernobyl*

The objective of the Chernobyl safeguards project is to develop safeguards approaches and instrumentation for routine safeguards implementation at the Chernobyl facilities. The new spent fuel conditioning plant and new safe confinement over the damaged Reactor Unit 4 are expected to be in operation in 2015. Construction of the spent fuel conditioning plant (part of the new dry spent fuel storage) has been delayed due to a revision of the facility's design. The Agency is directly involved in the early design stages in order to integrate appropriate safeguards systems. During 2011, discussions took place with the Chernobyl site operator and State Authority concerning the construction schedule for the safe confinement and for the spent fuel conditioning plant, and the submission of revised design information for the latter. The conceptual safeguards approach for the spent fuel conditioning plant was drafted on the basis of the existing design information.

## Preparing for the Future

In 2011, implementation began of the Agency's *Medium Term Strategy 2012–2017* and the safeguards *Long-Term Strategic Plan 2012–2023*. The latter addresses the conceptual framework for safeguards implementation, legal authority, technical capabilities (expertise, equipment and infrastructure) as well as the human and financial resources necessary for the Agency's verification efforts. It also considers communication, cooperation and partnerships with the Agency's stakeholders and sets in motion various improvements.

Research and development are essential to meet the safeguards needs of the future. The Agency prepared a *Long-term R&D Plan 2012–2023* that addresses the Agency's R&D requirements in areas such as equipment, information technology, physics and chemical analysis, satellite imagery, statistical analysis and workforce skills.

*"The Agency formally accepted a geospatial exploitation system (GES) in 2011, a solution aimed at supporting the analysis of imagery and the secure dissemination of geospatial data ..."*

To address near term development objectives and to support the implementation of its verification activities, the Agency continued to rely on MSSPs in implementing its *Research and Development Programme for Nuclear Verification 2010–2011.* At the end of 2011, there were 21 formal support programmes[13] with the Agency, supporting over 300 tasks, valued at over €20 million per annum. In preparation for the next biennium, the Agency drafted the *Development and Implementation Support Programme for Nuclear Verification 2012–2013*,[14] which consists of 24 projects in such areas as verification technology development, safeguards concepts, information processing and analysis, and training.

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

[14] The Research and Development Programme for Nuclear Verification has been renamed and, starting in 2012, will be known as the Development and Implementation Support Programme for Nuclear Verification, as it was recognized that this biennial programme addresses, to a large extent, development and implementation support rather than actual research.

# 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.*

## Country Programme Frameworks, UNDAFs and RSAs

Country Programme Frameworks (CPFs) provide a comprehensive context for technical cooperation activities at the national level. In 2011, 14 CPFs were signed.[1] In addition, the Agency continued to strengthen alignment with the development activities of the United Nations at all levels, and participated in the United Nations Development Assistance Framework (UNDAF) process in 81 Member States. As of the end of 2011, the Agency had signed 24 UNDAFs in total.

By year end, a total of 117 Member States had signed a Revised Supplementary Agreement Concerning the Provision of Technical Assistance by the IAEA (RSA).

## Managing the Technical Cooperation Programme

The third and final year of the 2009–2011 technical cooperation programme cycle ended. Three new off-cycle core projects were initiated, as were three Reserve Fund projects. During the course of the year, 244 projects were closed, of which one was cancelled. Active projects at the end of 2011 totalled 681, with an additional 80 in the process of being closed. Member State priorities, as reflected in programme disbursements, were the nuclear fuel cycle, human health and nuclear safety, with some variations in emphasis across regions.

[1] With Afghanistan, Algeria, Bulgaria, Burkina Faso, Cambodia, the Democratic Republic of the Congo, Gabon, Guatemala, Nicaragua, Slovenia, Thailand, the United Arab Emirates, the United Republic of Tanzania and Vietnam.

### Financial highlights

Pledges against the 2011 Technical Cooperation Fund (TCF) totalled €62.9 million (not including national participation costs (NPCs) and assessed programme costs (APCs)), against the target of €70 434 000, with the rate of attainment on payments at the end of 2011 standing at 86.0%. The use of TCF resources resulted in an implementation rate of 73.9%.

### Improving the quality of the technical cooperation programme

A systematic project quality review framework was developed to measure the quality of projects submitted for the 2012–2013 technical cooperation programme cycle. Lessons learned and areas for improvement were identified for further improvements to following cycles.

*"Member State priorities, as reflected in programme disbursements, were the nuclear fuel cycle, human health and nuclear safety, with some variations in emphasis across regions."*

The Programme Cycle Management Framework (PCMF) IT platform was adapted to support the streamlined project design process for the 2012–2013 cycle. As a result, more detailed project design information was collected and the new Field of Activity Code structure was implemented.

### Monitoring and evaluating technical cooperation projects

A strategy to improve the monitoring of technical cooperation projects was prepared in 2011. The strategy identifies tools to be applied by stakeholders to enhance the implementation of projects. These include the Periodic Progress Reporting (PPR) mechanism — a mandatory monitoring tool for technical cooperation projects — and a self-evaluation methodology.

The format of project progress reports was revised following a review and consultation with counterparts and National Liaison Officers (NLOs). The new format will be used for future project progress reporting and closure.

At a meeting in August in Vienna, a self-evaluation guide for technical cooperation projects was drafted. The methodology and tools support the conduct of thorough assessments of outputs and of the progress made in achieving expected project outcomes. They can also be utilized to compile lessons learned.

### *Best practices in project design and management*

The Agency developed a best practices methodology for programme and project management for sharing with stakeholders. The methodology will be validated with Member State NLOs and counterparts, after which it will be made available to stakeholders.

## Coordination with the United Nations and Other International Organizations

The Agency contributed to several global development reports, including two reports by the United Nations, a report by the OECD for the Steering Group on Governance of International Cooperation on Science, Technology and Innovation for Global Challenges, and various reports related to the United Nations Conference on Sustainable Development (Rio+20) and the UN Conference on the Least Developed Countries, as well as regional human development reports on food security (Africa) and climate change (Asia–Pacific). For the 2012–2013 programme cycle, three projects on nuclear technologies for cleaner industrial production were developed with UNIDO.

*"The Agency contributed to several global development reports, including two reports by the United Nations, a report by the OECD ... and various reports related to the United Nations Conference on Sustainable Development (Rio+20) and the UN Conference on the Least Developed Countries ..."*

Water resources management remains a high priority issue in the African region. Given the transboundary nature of groundwater management, an integrated, regional approach is essential. An important regional focus over the past two years, in collaboration with the UNDP-GEF, was support to the integrated management of the Nubian Aquifer. Significant progress was made under a technical cooperation project, including the development of a strategic framework for the future management of the aquifer and a review of the existing legal framework for use of this shared water resource. In addition, a three dimensional model simulating the Nubian Aquifer's response to significant drawdown and other related parameters was developed. The model test runs did not reveal any immediate and significant transboundary effects. However, Chad, Egypt and Sudan — the Member States involved — are now reviewing and adapting the models to suit national needs.

A project by the Joint Authority for the Study and Development of the Nubian Sandstone Aquifer System to develop a regional legal framework continued to receive the support of the Agency, UNESCO, UNDP and national counterparts within the Nubian Aquifer catchment area until its completion in 2011. An advocacy document has been completed, and efforts are under way to have this formally endorsed by the Nubian Aquifer countries (Chad, Egypt, Libya and Sudan).

In the Asia–Pacific region, cooperation with UNDP through the RCA Regional Office in the Republic of Korea resulted in an extrabudgetary contribution from UNDP of $300 000 to implement an RCA project on single photon emission computed tomography/positron emission tomography imaging technologies in the region.

The Agency collaborated with several United Nations agencies and international partners in supporting the countries in Europe affected by uranium production legacy sites. The main contribution was related to risk assessment and planning of countermeasures to reduce existing exposure and to minimize environmental risk.

In the Latin American region, new joint activities were developed with the Pan American Health Organization to improve quality in medical applications, strengthen the regulatory capabilities of Ministries of Health in the region and increase the use of nuclear applications in medicine. The United States Nuclear Regulatory Commission provided $375 000 in support of regional regulatory authorities.

At the global level, cooperation with intergovernmental organizations continued in the area of nuclear safety, supported by the European Union's contribution of €2.3 million. A further agreement signed in 2011 is currently financing five technical cooperation projects.

## Regional Agreements and Programming

Regional agreements and other Member State groups promote 'horizontal' cooperation and further self-reliance and sustainability. Agency collaboration with these groups led to stronger regional technical cooperation programmes that are focused on priorities identified at the regional level.

In 2011, the Agency supported follow-up actions to the AFRA High Level Policy Review Seminar. The emphasis was on implementation of the AFRA Regional Strategic Cooperative Framework (RCF), the AFRA strategy on human resource development and nuclear knowledge management, the operational functioning of the AFRA Fund and the implementation of AFRA's strategy for partnership development and resource mobilization.

In the Asia–Pacific region, the RCA adopted its strategic priorities for 2012–2017, focusing on four thematic areas: agriculture, environment, human health and industry. RCA members also agreed to the Fifth Extension of the RCA Agreement, effective June 2012, a date which also marks the RCA's 40th anniversary.

The Co-operative Agreement for Arab States in Asia for Research, Development and Training related to Nuclear Science and Technology (ARASIA) also adopted a strategic profile and is working on the designation of regional resource centres within the ARASIA Member States.

In the European region, a major effort was put into strengthening regional cooperation in line with the strategy for technical cooperation in the region adopted in 2010. The strategy was used in designing a focused regional programme for 2012–2013 that addresses Member State priorities identified in the Europe Regional Profile (medium term plan for 2009–2013).

*"In preparing the new technical cooperation programme, emphasis was placed on promoting technical networks as a means of sustaining the collaboration achieved so far and ensuring that continuous outcomes are realized after the conclusion of the projects."*

In the Latin American region, a process to update the Regional Strategic Profile for Latin America and the Caribbean was initiated by ARCAL, with the objective of strengthening the strategic focus for the region and achieving closer harmonization with Agency goals and the objectives reflected in the *Medium Term Strategy 2012–2017*. In preparing the new technical cooperation programme, emphasis was placed on promoting technical networks as a means of sustaining the collaboration achieved so far and ensuring that continuous outcomes are realized after the conclusion of the projects.

*FIG. 1. Technical cooperation exhibition at the Agency's 55th General Conference in September.*

## Outreach and Communication

Outreach to the international development community was strengthened by Secretariat participation in the UN Conference on the Least Developed Countries (in May 2011), and the conference on The Water, Energy and Food Security Nexus – Solutions for the Green Economy (in November 2011), as well as meetings and working groups related to food security. The Agency's work in this area was presented to raise awareness among potential partners of the technical cooperation programme and to build understanding of the contribution of nuclear science and technology.

*"The Agency also expanded its use of social media, using Twitter and Flickr, and a wide range of new outreach and exhibition materials was produced."*

The Secretariat provided several briefings to Member States in 2011 on preparations for the 2012–2013 technical cooperation programme cycle. A second 'Seminar on Technical Cooperation', designed to provide Permanent Missions with a comprehensive overview of the technical cooperation programme, was held in October 2011.

Outreach to the general public continued to make extensive use of the Agency's web site (*http://www.iaea.org*). In addition, extensive radio coverage, photo essays and video material were arranged. A photo exhibition on water issues and on Agency projects were organized in support of the theme of the Scientific Forum at the General Conference (Fig. 1).

## Programme Cycle Management Framework and TC-PRIDE

The Agency's TC Project Information Dissemination Environment (TC-PRIDE) web site has existed in its present form since 1998, and the technology used to develop the site is now obsolete. In tandem with the deployment of a new enterprise resource planning system, the Agency-wide Information System for Programme Support, TC-PRIDE functions are now being incorporated into the existing PCMF IT platform. The merger of sites will provide, in one web site, a consolidated view of technical cooperation projects from concept submission through to project closure, including historic data. The first phase of migration allows the retrieval of monthly reports on

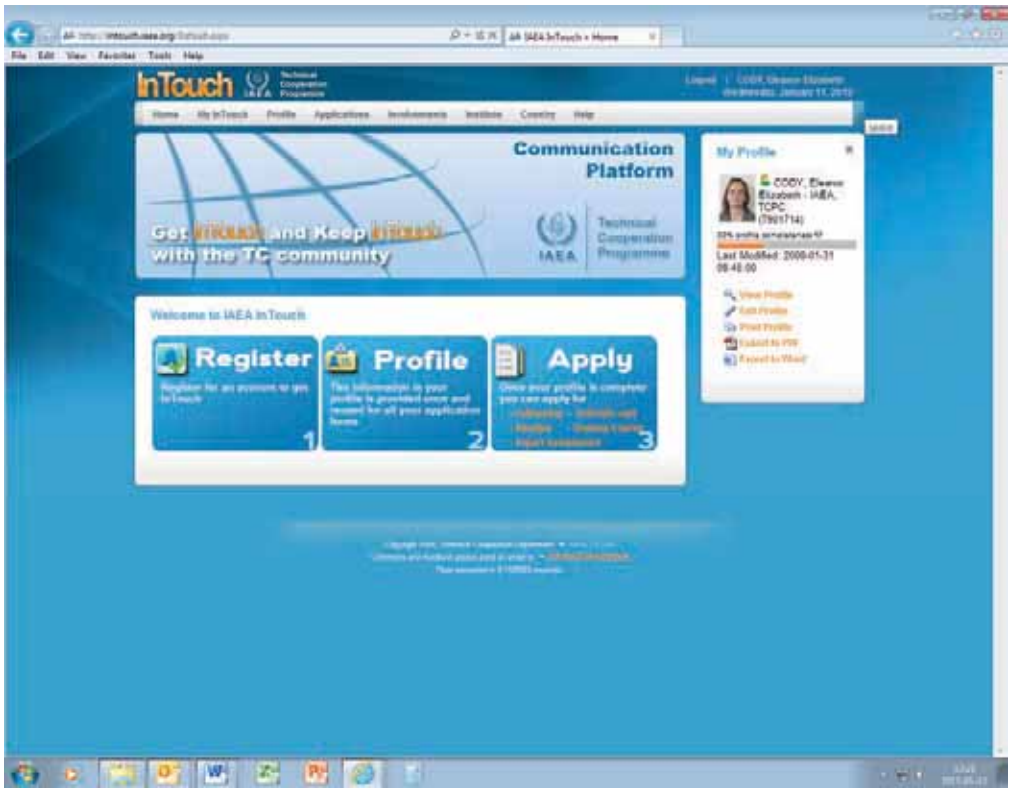



*FIG. 2. Screen shot of the InTouch communication page.*

*Table 1. Submission of nominations to the Agency in 2011 through InTouch*

| | Fellowships | Meetings | Scientific visits | Training courses | Grand total |
|---|---|---|---|---|---|
| Africa | 20 | 21 | 16 | 36 | 93 |
| Asia–Pacific | 54 | 20 | 41 | 9 | 124 |
| Europe | 12 | 19 | 1 | 21 | 53 |
| Latin America | 81 | 249 | 38 | 266 | 634 |
| Total | 167 | 309 | 96 | 332 | 904 |

*Table 2. Submission of profiles for expert/lecturer assignments to the Agency in 2011 through InTouch*

| | |
|---|---|
| Africa | 41 |
| Asia–Pacific | 52 |
| Europe | 113 |
| Latin America | 59 |
| North America | 26 |
| Total | 291 |

the financial status of ongoing technical cooperation projects by country and by project.

## InTouch

InTouch (*http://intouch.iaea.org*), an interactive on-line communication platform was piloted in 2010 and began full operation in 2011 (Fig. 2).

Nine hundred and four nominations for fellowships, meetings, scientific visits and training courses were submitted through InTouch last year, and 291 expert and lecturer profiles were added. The highest number of nominations was received from the Latin American region, while the largest number of expert profiles was submitted from the European region (Tables 1 and 2).

## Legislative Assistance

During 2011, the Agency continued to provide legislative assistance through the technical cooperation programme in response to requests from Member States. Country specific bilateral legislative assistance was provided to 20 Member States, mainly through written comments and advice on drafting national nuclear legislation. At the request of Member States, the Agency also organized short term scientific visits to Headquarters for a number of individuals, enabling them to gain further practical experience in nuclear law.

The Agency continued to contribute to academic activities organized at the World Nuclear University and the International School of Nuclear Law by providing lecturers and funding participants through appropriate technical cooperation projects. In particular, the Agency organized the first annual session of the Nuclear Law Institute in Vienna from 19 November to 3 December 2011. This comprehensive two week course was established to meet the increasing demand for legislative assistance by Member States, as well as to enable participants to acquire an understanding of all aspects of nuclear law and to draft, amend or review national nuclear legislation. A total of 84 representatives from 61 Member States participated in the course.

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

The first IAEA 'Treaty Event' was organized by the Secretariat on the sidelines of the 55th regular session of the General Conference. The event was designed to promote the universal adoption of international treaties related to nuclear safety, security and liability for nuclear damage for which the Director General is depositary.

# Annex



---

**Note:** Tables A19–A24 are available on the attached CD-ROM.

*Table A1. Regular budget allocation and utilization of resources in 2011 by Programme and Major Programme (in euros)*

| Programme / Major Programme | Budget | | | | Expenditure | Unused |
|---|---|---|---|---|---|---|
| | Original at $1.0000 | Adjusted at $1.3893[a] | Transfers[b] | Adjusted budget after transfers | | (over-expended) adjusted budget |
| | (1) | (2) | (3) | (2) + (3) (4) | (5) | (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 | 1 057 909 | 993 603 | – | 993 603 | 1 062 310 | (68 707) |
| Nuclear Power | 6 824 600 | 6 343 746 | – | 6 343 746 | 6 344 865 | (1 119) |
| Nuclear Fuel Cycle and Materials Technologies | 3 192 703 | 2 947 216 | – | 2 947 216 | 2 962 082 | (14 866) |
| Capacity Building and Nuclear Knowledge Maintenance for Sustainable Energy Development | 11 341 668 | 10 673 220 | (6 840) | 10 666 380 | 10 199 322 | 467 058 |
| Nuclear Science | 9 838 590 | 9 339 378 | – | 9 339 378 | 9 551 496 | (212 118) |
| **Subtotal — Major Programme 1** | **32 255 470** | **30 297 163** | **(6 840)** | **30 290 323** | **30 120 075** | **170 248** |
| **2. Nuclear Techniques for Development and Environmental Protection** | | | | | | |
| Overall Management, Coordination and Common Activities | 4 573 892 | 4 364 557 | – | 4 364 557 | 4 223 082 | 141 475 |
| Management of the Coordinated Research Activities | 697 025 | 661 721 | – | 661 721 | 704 807 | (43 086) |
| Food and Agriculture | 11 108 475 | 10 573 836 | – | 10 573 836 | 10 541 995 | 31 841 |
| Human Health | 9 304 379 | 8 790 237 | (37 618) | 8 752 619 | 8 105 372 | 647 247 |
| Water Resources | 3 374 766 | 3 177 699 | – | 3 177 699 | 3 110 393 | 67 306 |
| Environment | 5 891 894 | 5 559 722 | – | 5 559 722 | 5 436 905 | 122 817 |
| Radioisotope Production and Radiation Technology | 2 138 069 | 1 995 215 | – | 1 995 215 | 1 974 147 | 21 068 |
| **Subtotal — Major Programme 2** | **37 088 500** | **35 122 987** | **(37 618)** | **35 085 369** | **34 096 701** | **988 668** |
| **3. Nuclear Safety and Security** | | | | | | |
| Enhancing the Global Nuclear Safety and Security Regime | 758 936 | 711 817 | – | 711 817 | 762 882 | (51 065) |
| Fostering Safety and Security Infrastructure and Improving Capacity Building | 232 405 | 223 662 | – | 223 662 | 239 341 | (15 679) |
| Strengthening Communication and Knowledge Management | 242 686 | 235 376 | – | 235 376 | 144 307 | 91 069 |
| Incident and Emergency Preparedness and Response | 3 621 881 | 3 364 598 | – | 3 364 598 | 3 284 000 | 80 598 |
| Safety of Nuclear Installations | 9 533 729 | 8 946 412 | 113 995 | 9 060 407 | 9 119 314 | (58 907) |
| Radiation and Transport Safety | 5 785 697 | 5 458 224 | – | 5 458 224 | 5 447 451 | 10 773 |
| Management of Radioactive Waste | 6 822 659 | 6 388 254 | – | 6 388 254 | 6 402 289 | (14 035) |
| Nuclear Security | 4 043 439 | 3 808 291 | – | 3 808 291 | 3 851 045 | (42 754) |
| **Subtotal — Major Programme 3** | **31 041 432** | **29 136 634** | **113 995** | **29 250 629** | **29 250 629** | **–** |
| **4. Nuclear Verification** | | | | | | |
| Overall Management, Coordination and Common Activities | 1 382 221 | 1 300 269 | – | 1 300 269 | 1 762 679 | (462 410) |
| Safeguards | 121 761 707 | 114 647 665 | (55 857) | 114 591 808 | 113 022 958 | 1 568 850 |
| **Subtotal — Major Programme 4** | **123 143 928** | **115 947 934** | **(55 857)** | **115 892 077** | **114 785 637** | **1 106 440** |
| **5. Policy, Management and Administration Services** | 78 098 252 | 74 746 270 | (4 560) | 74 741 710 | 74 275 637 | 466 073 |
| **Subtotal — Major Programme 5** | **78 098 252** | **74 746 270** | **(4 560)** | **74 741 710** | **74 275 637** | **466 073** |
| **6. Management of Technical Cooperation for Development** | | | | | | |
| Management of Technical Cooperation for Development | 18 773 821 | 17 782 463 | (9 120) | 17 773 343 | 17 595 268 | 178 075 |
| **Subtotal — Major Programme 6** | **18 773 821** | **17 782 463** | **(9 120)** | **17 773 343** | **17 595 268** | **178 075** |
| **Total Operational Budget** | **320 401 403** | **303 033 451** | **–** | **303 033 451** | **300 123 947** | **2 909 504** |
| **Major Capital Investment Funding Requirements** | | | | | | |
| 1. Nuclear Power, Fuel Cycle and Nuclear Science | – | – | – | – | – | – |
| 2. Nuclear Techniques for Development and Environmental Protection | 919 219 | 919 219 | – | 919 219 | 175 714 | 743 505 |
| 3. Nuclear Safety and Security | – | – | – | – | – | – |
| 4. Nuclear Verification | 3 630 629 | 3 630 629 | – | 3 630 629 | 3 453 562 | 177 067 |
| 5. Policy, Management and Administration Services | 3 566 518 | 3 516 549 | – | 3 516 549 | 3 452 034 | 64 515 |
| 6. Management of Technical Cooperation for Development | – | – | – | – | – | – |
| **Total Capital Budget** | **8 116 366** | **8 066 397** | **–** | **8 066 397** | **7 081 310** | **985 087** |
| **Total Agency Programmes** | **328 517 769** | **311 099 848** | **–** | **311 099 848** | **307 205 257** | **3 894 591** |
| Reimbursable Work for Others | 2 998 916 | 2 808 000 | – | 2 808 000 | 2 923 194 | (115 194)[c] |
| **Grand Total** | **331 516 685** | **313 907 848** | **–** | **313 907 848** | **310 128 451** | **3 779 397** |

[a] General Conference Resolution GC(54)/RES/3 of September 2010 — revalued at the UN average rate of exchange of $1.3893 to €1.00.

[b] Based on the decision of the Board of Governors in document (GOV/1999/15), an amount of €113 995 was transferred to Major Programme 3, Nuclear Safety and Security, in order to cover the costs of emergency assistance provided in Japan subsequent to the accident at TEPCO's Fukushima Daiichi nuclear power plant. To recover this amount, year-end unencumbered balances in the operational portion of the 2011 Regular Budget Appropriation Sections were used.

[c] The amount of (€115 194) represents the costs of additional services provided to other VIC based organizations and to projects financed from the TCF and from extrabudgetary resources.

*Table A2. Extrabudgetary regular programme fund resource utilization in 2011 by Programme and Major Programme, and Fund (in euros)*

| Programme / Major Programme | Extrabudgetary expenditures by fund | | | | |
|---|---|---|---|---|---|
| | Regular Programme Fund (1) | Nuclear Security Fund (2) | LEU Fuel Bank (3) | Peaceful Uses Initiative (4) | Total extrabudgetary expenditure (1)+(2)+(3)+(4) (5) |
| **1. Nuclear Power, Fuel Cycle and Nuclear Science** | | | | | |
| Overall Management, Coordination and Common Activities | – | – | – | – | – |
| Nuclear Power | 2 799 844 | | | 101 009 | 2 900 853 |
| Nuclear Fuel Cycle and Materials Technologies | 337 873 | 198 400 | 188 037 | 53 817 | 778 127 |
| Capacity Building and Nuclear Knowledge Maintenance for Sustainable Energy Development | 271 058 | – | – | – | 271 058 |
| Nuclear Science | 906 933 | – | – | – | 906 933 |
| **Subtotal — Major Programme 1** | **4 315 708** | **198 400** | **188 037** | **154 826** | **4 856 971** |
| **2. Nuclear Techniques for Development and Environmental Protection** | | | | | |
| Overall Management, Coordination and Common Activities | – | – | – | – | – |
| Management of the Coordinated Research Activities | – | – | – | – | – |
| Food and Agriculture | 1 750 738 | – | – | 312 280 | 2 063 018 |
| Human Health | 904 455 | – | – | – | 904 455 |
| Water Resources | 182 872 | – | – | 105 594 | 288 466 |
| Environment | 343 287 | – | – | 27 428 | 370 715 |
| Radioisotope Production and Radiation Technology | – | – | – | – | – |
| **Subtotal — Major Programme 2** | **3 181 352** | **–** | **–** | **445 302** | **3 626 654** |
| **3. Nuclear Safety and Security** | | | | | |
| Enhancing the Global Nuclear Safety and Security Regime | 139 141 | – | – | – | 139 141 |
| Fostering Safety and Security Infrastructure and Improving Capacity Building | 107 245 | – | – | – | 107 245 |
| Strengthening Communication and Knowledge Management | 1 801 964 | – | – | – | 1 801 964 |
| Incident and Emergency Preparedness and Response | 341 993 | – | – | – | 341 993 |
| Safety of Nuclear Installations | 6 208 514 | – | – | – | 6 208 514 |
| Radiation and Transport Safety | 685 878 | 181 410 | – | – | 867 288 |
| Management of Radioactive Waste | 860 654 | – | – | – | 860 654 |
| Nuclear Security | – | 13 946 123 | – | – | 13 946 123 |
| **Subtotal — Major Programme 3** | **10 145 389** | **14 127 533** | **–** | **–** | **24 272 922** |
| **4. Nuclear Verification** | | | | | |
| Overall Management, Coordination and Common Activities | – | – | – | – | – |
| Safeguards | 27 841 851 | – | – | – | 27 841 851 |
| **Subtotal — Major Programme 4** | **27 841 851** | **–** | **–** | **–** | **27 841 851** |
| **5. Policy, Management and Administration Services** | 1 290 252 | – | – | – | 1 290 252 |
| **Subtotal — Major Programme 5** | **1 290 252** | **–** | **–** | **–** | **1 290 252** |
| **6. Management of Technical Cooperation for Development** | | | | | |
| Management of Technical Cooperation for Development | 6 584 | | | | 6 584 |
| **Subtotal — Major Programme 6** | **6 584** | **–** | **–** | **–** | **6 584** |
| **Total Extrabudgetary Expenditure[a]** | **46 781 136** | **14 325 933** | **188 037** | **600 128** | **61 895 234** |
| Commitments (unliquidated obligations)[b] | 12 003 814 | 3 225 728 | 12 189 | 216 441 | 15 458 172 |
| **Actual Charges in 2011[a, b]** | **34 777 322** | **11 100 205** | **175 848** | **383 687** | **46 437 062** |

[a] Represents total expenditure by fund activity.

[b] Represents amounts committed for open contracts for goods and services which were not disbursed by the Agency in 2011.

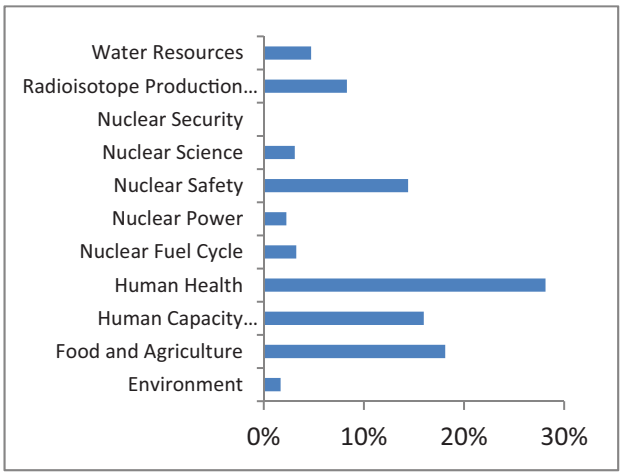
*Table A3(a). Disbursements by technical field and region in 2011*

***Summary of all regions (in thousands of euros)***

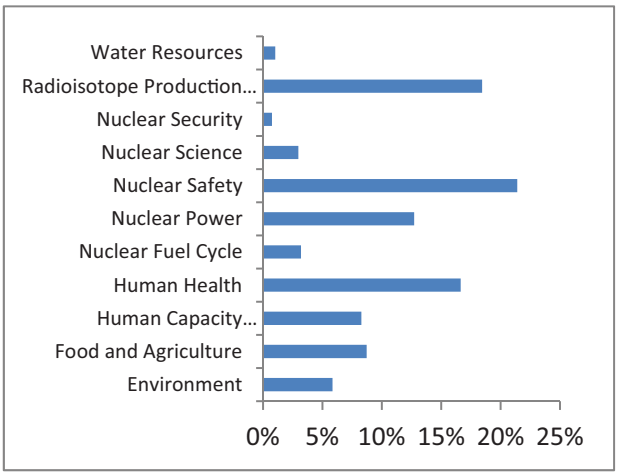
| | Technical field | Africa | Asia and the Pacific | Europe | Latin | Global/ Inter-regional | Total |
|---|---|---|---|---|---|---|---|
| 1 | Environment | 257 604 | 903 730 | 310 657 | 846 677 | 162 071 | 2 480 739 |
| 2 | Food and Agriculture | 2 766 038 | 1 349 165 | 523 758 | 1 498 602 | 174 764 | 6 312 327 |
| 3 | Human Capacity Development and Programme Support | 2 438 723 | 1 280 460 | 1 094 888 | 1 360 194 | 1 819 398 | 7 993 663 |
| 4 | Human Health | 4 295 678 | 2 572 242 | 5 718 896 | 2 591 230 | 21 735 | 15 199 780 |
| 5 | Nuclear Fuel Cycle | 495 590 | 493 350 | 21 241 351 | 313 727 | | 22 544 019 |
| 6 | Nuclear Power | 343 766 | 1 966 895 | 358 280 | 536 798 | 314 313 | 3 520 053 |
| 7 | Nuclear Safety | 2 201 937 | 3 309 356 | 6 365 074 | 1 535 155 | | 13 411 522 |
| 8 | Nuclear Science | 473 289 | 458 659 | 2 133 077 | 135 104 | 95 669 | 3 295 799 |
| 9 | Nuclear Security | | 115 650 | 163 264 | 28 702 | | 307 615 |
| 10 | Radioisotope Production and Radiation Technology | 1 268 417 | 2 851 533 | 1 868 229 | 946 470 | | 6 934 649 |
| 11 | Water Resources | 723 070 | 159 477 | 149 204 | 238 278 | | 1 270 030 |
| | **Total** | **15 264 113** | **15 460 516** | **39 926 680** | **10 030 936** | **2 587 951** | **83 270 196** |

*Table A3(b). Graphical representation of the information in Table A3(a)*

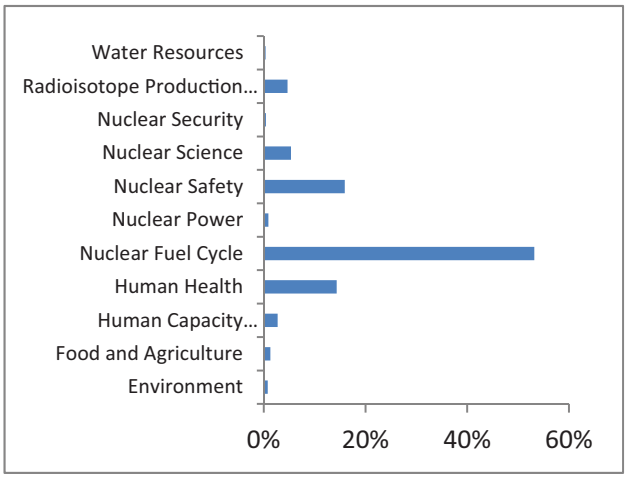
**Africa: €15 264 113**



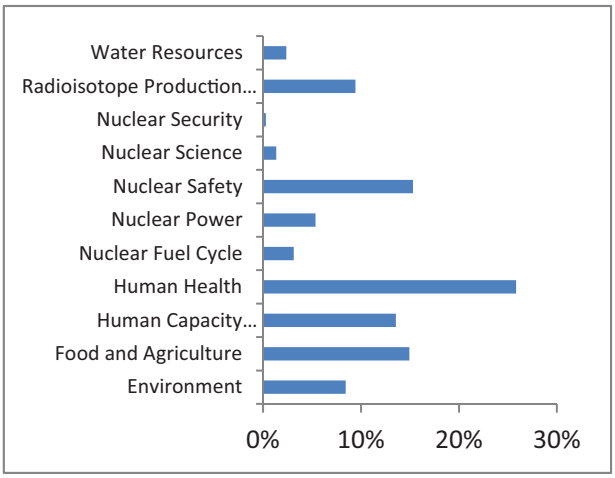

**Asia and the Pacific: €15 460 516**



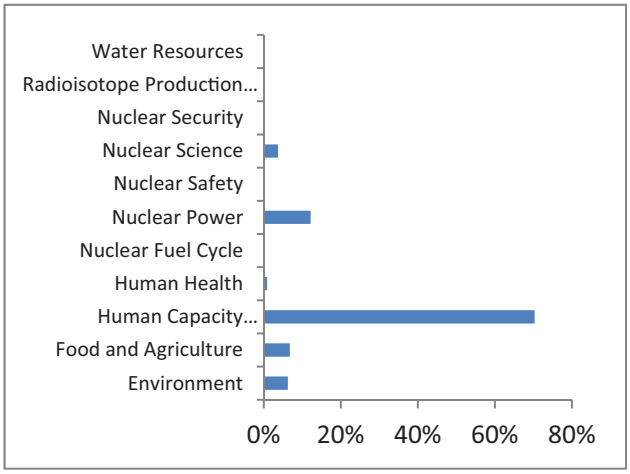

**Europe: €39 926 680**




**Latin America: €10 030 936**




**Global/Interregional: €2 587 951**




**Total: €83 270 196**

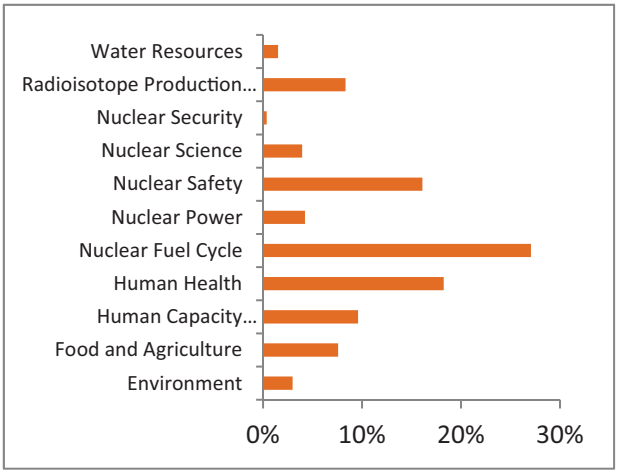


*Table A4. Amount of nuclear material at the end of 2011 by type of agreement*

| Nuclear material | Comprehensive safeguards agreement[1] | INFCIRC/66[2] type agreement | Voluntary offer agreement | Quantity in SQs |
|---|---|---|---|---|
| Plutonium[3] contained in irradiated fuel and in fuel elements in reactor cores | 117 905.961 | 1594.875 | 17 244.026 | 136 744.862 |
| Separated plutonium outside reactor cores | 1310.544 | 5.016 | 10 643.843 | 11 959.403 |
| HEU (equal to or greater than 20% uranium-235) | 213.231 | 1.129 | 0.251 | 214.611 |
| LEU (less than 20% uranium-235) | 16 074.737 | 202.749 | 936.093 | 17 213.579 |
| Source material[4] (natural and depleted uranium and thorium) | 9033.069 | 386.557 | 1902.773 | 11 322.399 |
| Uranium-233 | 17.551 | 0.001 | 0 | 17.552 |
| **Total SQs** | **144 555.093** | **2190.327** | **30 726.986** | **177 472.406** |

*Amount of heavy water at the end of 2011 by type of agreement*

| Non-nuclear material[5] | Comprehensive safeguards agreement[6] | INFCIRC/66[7] type agreement | Voluntary offer agreement | Quantity |
|---|---|---|---|---|
| **Heavy water (tonnes)** | **0.719**[8] | **439.122** | **0** | **439.841** |

1 Covering safeguards agreements pursuant to NPT and/or Treaty of Tlatelolco and other CSAs; including facilities in Taiwan, China.

2 Covering facilities in India, Israel and Pakistan.

3 The quantity includes an estimated amount (10 998.375 SQs) of plutonium (Pu) in irradiated fuel, which has not yet been reported to the Agency under the reporting procedures agreed to (the non-reported Pu is contained in irradiated fuel assemblies to which item accountancy and containment/surveillance measures are applied) and Pu in fuel elements loaded into the core.

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

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

6 Covering safeguards agreements pursuant to NPT and/or Treaty of Tlatelolco and other CSAs; including facilities in Taiwan, China.

7 Covering facilities in India, Israel and Pakistan.

8 In Taiwan, China.

*Table A5. Number of facilities under safeguards during 2011*

| Facility type | Number of facilities | | | |
|---|---|---|---|---|
| | Comprehensive safeguards agreements (CSAs)[a] | INFCIRC/66[b] type agreements | Voluntary offer agreements | Total |
| Power reactors | 227 | 9 | 1 | **237** |
| Research reactors | 148 | 3 | 1 | **152** |
| Conversion plants | 18 | 0 | 0 | **18** |
| Fuel fabrication plants | 42 | 2 | 1 | **45** |
| Reprocessing plants | 11 | 1 | 1 | **13** |
| Enrichment plants | 17 | 0 | 3 | **20** |
| Separate storage facilities | 115 | 1 | 5 | **121** |
| Other facilities | 74 | 0 | 0 | **74** |
| **Subtotals** | **652** | **16** | **12** | **680** |
| Material balance areas outside facilities[c] | 528 | 1 | 0 | **529** |
| **Totals** | **1180** | **17** | **12** | **1209** |

[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.

[c] Excludes the two material balance areas outside facilities at the Agency and one material balance area outside facilities in Euratom.

*Table A6. Conclusion of safeguards agreements, additional protocols and small quantities protocols (as of 31 December 2011)*

| State | SQP [a] | Safeguards agreements [b] | INFCIRC | Additional protocols (APs) |
|---|---|---|---|---|
| Afghanistan | X | In force: 20 Feb. 1978 | 257 | In force: 19 July 2005 |
| Albania[1] | | In force: 25 March 1988 | 359 | In force: 3 Nov. 2010 |
| Algeria | | In force: 7 Jan. 1997 | 531 | Approved: 14 Sept. 2004 |
| Andorra | X | In force: 18 October 2010 | 808 | In force: 19 Dec 2011 |
| Angola | In force: 28 April 2010 | In force: 28 April 2010 | 800 | In force: 28 April 2010 |
| Antigua and Barbuda[2] | X | In force: 9 Sept. 1996 | 528 | |
| Argentina[3] | | In force: 4 March 1994 | 435 | |
| Armenia | | In force: 5 May 1994 | 455 | In force: 28 June 2004 |
| Australia | | In force: 10 July 1974 | 217 | In force: 12 Dec. 1997 |
| Austria[4] | | Accession: 31 July 1996 | 193 | In force: 30 April 2004 |
| Azerbaijan | Amended: 20 Nov. 2006 | In force: 29 April 1999 | 580 | In force: 29 Nov. 2000 |
| The Bahamas[2] | Amended: 25 July 2007 | In force: 12 Sept. 1997 | 544 | |
| Bahrain | In force: 10 May 2009 | In force: 10 May 2009 | 767 | In force: 20 July 2011 |
| Bangladesh | | In force: 11 June 1982 | 301 | In force: 30 March 2001 |
| Barbados[2] | X | In force: 14 Aug. 1996 | 527 | |
| Belarus | | In force: 2 Aug. 1995 | 495 | Signed: 15 Nov. 2005 |
| Belgium | | In force: 21 Feb. 1977 | 193 | In force: 30 April 2004 |
| Belize[5] | X | In force: 21 Jan. 1997 | 532 | |
| *Benin* | *Amended: 15 April 2008* | *Signed: 7 June 2005* | | *Signed: 7 June 2005* |
| Bhutan | X | In force: 24 Oct. 1989 | 371 | |
| Bolivia[2] | X | In force: 6 Feb. 1995 | 465 | |
| Bosnia and Herzegovina[6] | | In force: 28 Dec. 1973 | 204 | |
| Botswana | | In force: 24 Aug. 2006 | 694 | In force: 24 Aug. 2006 |
| Brazil[7] | | In force: 4 March 1994 | 435 | |
| Brunei Darussalam | X | In force: 4 Nov. 1987 | 365 | |
| Bulgaria[8] | | Accession: 1 May 2009 | 193 | Accession: 1 May 2009 |
| Burkina Faso | Amended: 18 Feb. 2008 | In force: 17 April 2003 | 618 | In force: 17 April 2003 |
| Burundi | In force: 27 Sept. 2007 | In force: 27 Sept. 2007 | 719 | In force: 27 Sept. 2007 |
| Cambodia | X | In force: 17 Dec. 1999 | 586 | |
| Cameroon | X | In force: 17 Dec. 2004 | 641 | Signed: 16 Dec. 2004 |
| Canada | | In force: 21 Feb. 1972 | 164 | In force: 8 Sept. 2000 |
| *Cape Verde* | *Amended: 27 March 2006* | *Signed: 28 June 2005* | | *Signed: 28 June 2005* |
| Central African Republic | In force: 7 Sept. 2009 | In force: 7 Sept. 2009 | 777 | In force: 7 Sept. 2009 |
| Chad | In force: 13 May 2010 | In force: 13 May 2010 | 802 | In force: 13 May 2010 |
| Chile[9] | | In force: 5 April 1995 | 476 | In force: 3 Nov. 2003 |

*Table A6. Conclusion of safeguards agreements, additional protocols and small quantities protocols (as of 31 December 2011) (cont.)*

| State | SQP [a] | Safeguards agreements [b] | INFCIRC | Additional protocols (APs) |
|---|---|---|---|---|
| China | | In force: 18 Sept. 1989 | 369* | In force: 28 March 2002 |
| Colombia[9] | | In force: 22 Dec. 1982 | 306 | In force: 5 March 2009 |
| Comoros | In force: 20 Jan. 2009 | In force: 20 Jan. 2009 | 752 | In force: 20 Jan. 2009 |
| Congo, Republic of the | In force: 28 Oct. 2011 | In force: 28 Oct. 2011 | | In force: 28 Oct. 2011 |
| Costa Rica[2] | Amended: 12 Jan. 2007 | In force: 22 Nov. 1979 | 278 | In force: 17 June 2011 |
| Côte d'Ivoire | | In force: 8 Sept. 1983 | 309 | Signed: 22 Oct. 2008 |
| Croatia | Amended: 26 May 2008 | In force: 19 Jan. 1995 | 463 | In force: 6 July 2000 |
| Cuba[2] | | In force: 3 June 2004 | 633 | In force: 3 June 2004 |
| Cyprus[10] | | Accession: 1 May 2008 | 193 | Accession: 1 May 2008 |
| Czech Republic[11] | | Accession: 1 Oct. 2009 | 193 | Accession: 1 Oct. 2009 |
| Dem. Rep. of the Congo | | In force: 9 Nov. 1972 | 183 | In force: 9 April 2003 |
| Denmark[12] | | In force: 21 Feb. 1977 | 193 | In force 30 April 2004 |
| *Djibouti* | *Signed: 27 May 2010* | *Signed : 27 May 2010* | | *Signed : 27 May 2010* |
| Dominica[5] | X | In force: 3 May 1996 | 513 | |
| Dominican Republic[2] | Amended: 11 Oct. 2006 | In force: 11 Oct. 1973 | 201 | In force: 5 May 2010 |
| D.P.R.K. | | In force: 10 April 1992 | 403 | |
| Ecuador[2] | Amended: 7 April 2006 | In force: 10 March 1975 | 231 | In force: 24 Oct. 2001 |
| Egypt | | In force: 30 June 1982 | 302 | |
| El Salvador[2] | Amended: 10 June 2011 | In force: 22 April 1975 | 232 | In force: 24 May 2004 |
| *Equatorial Guinea* | *Approved: 13 June 1986* | *Approved: 13 June 1986* | | |
| *Eritrea* | | | | |
| Estonia[13] | | Accession: 1 Dec. 2005 | 193 | Accession: 1 Dec. 2005 |
| Ethiopia | X | In force: 2 Dec. 1977 | 261 | |
| Fiji | X | In force: 22 March 1973 | 192 | In force: 14 July 2006 |
| Finland[14] | | Accession: 1 Oct. 1995 | 193 | In force: 30 April 2004 |
| France | X | In force: 12 Sept. 1981<br>In force: 26 Oct. 2007[15] | 290*<br>718 | In force: 30 April 2004 |
| Gabon | X | In force: 25 March 2010 | 792 | In force: 25 March 2010 |
| Gambia | Amended: 17 October 2011 | In force: 8 Aug. 1978 | 277 | In force: 18 October 2011 |
| Georgia | | In force: 3 June 2003 | 617 | In force: 3 June 2003 |
| Germany[16] | | In force: 21 Feb. 1977 | 193 | In force: 30 April 2004 |
| Ghana | | In force: 17 Feb. 1975 | 226 | In force: 11 June 2004 |
| Greece[17] | | Accession: 17 Dec. 1981 | 193 | In force: 30 April 2004 |
| Grenada[2] | X | In force: 23 July 1996 | 525 | |
| Guatemala[2] | Amended: 26 April 2011 | In force: 1 Feb. 1982 | 299 | In force: 28 May 2008 |

*Table A6. Conclusion of safeguards agreements, additional protocols and small quantities protocols (as of 31 December 2011) (cont.)*

| State | SQP [a] | Safeguards agreements [b] | INFCIRC | Additional protocols (APs) |
|---|---|---|---|---|
| *Guinea* | *Signed: 13 Dec 2011* | *Signed: 13 Dec 2011* | | *Signed: 13 Dec 2011* |
| *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 Sept. 2006 | In force: 1 Aug. 1972 | 187 | In force: 24 Sept. 1998 |
| Honduras[2] | Amended: 20 Sept. 2007 | In force: 18 April 1975 | 235 | Signed: 7 July 2005 |
| Hungary[18] | | Accession: 1 July 2007 | 193 | Accession: 1 July 2007 |
| Iceland | Amended: 15 March 2010 | In force: 16 Oct. 1974 | 215 | In force: 12 Sept. 2003 |
| **India** | | In force: 30 Sept. 1971<br>In force: 17 Nov. 1977<br>In force: 27 Sept. 1988<br>In force: 11 Oct. 1989<br>In force: 1 March 1994<br>In force: 11 May 2009 | 211<br>260<br>360<br>374<br>433<br>754 | Signed: 15 May 2009 |
| Indonesia | | In force: 14 July 1980 | 283 | In force: 29 Sept. 1999 |
| Iran, Islamic Republic of | | In force: 15 May 1974 | 214 | Signed: 18 Dec. 2003 |
| Iraq | | In force: 29 Feb. 1972 | 172 | Signed: 9 Oct. 2008[19] |
| Ireland | | In force: 21 Feb. 1977 | 193 | In force: 30 April 2004 |
| **Israel** | | In force: 4 April 1975 | 249/Add.1 | |
| Italy | | In force: 21 Feb. 1977 | 193 | In force: 30 April 2004 |
| Jamaica[2] | Rescinded: 15 Dec. 2006 | In force: 6 Nov. 1978 | 265 | In force: 19 March 2003 |
| Japan | | In force: 2 Dec. 1977 | 255 | In force: 16 Dec. 1999 |
| Jordan | X | In force: 21 Feb. 1978 | 258 | In force: 28 July 1998 |
| Kazakhstan | | In force: 11 Aug. 1995 | 504 | In force: 9 May 2007 |
| Kenya | In force: 18 Sept. 2009 | In force: 18 Sept. 2009 | 778 | In force: 18 Sept. 2009 |
| Kiribati | X | In force: 19 Dec. 1990 | 390 | Signed: 09 Nov. 2004 |
| Korea, Republic of | | In force: 14 Nov. 1975 | 236 | In force: 19 Feb. 2004 |
| Kuwait | X | In force: 7 March 2002 | 607 | In force: 2 June 2003 |
| Kyrgyzstan | X | In force: 3 Feb. 2004 | 629 | In force: 10 Nov. 2011 |
| Lao P.D.R. | X | In force: 5 April 2001 | 599 | |
| Latvia[20] | | Accession: 1 Oct. 2008 | 193 | Accession: 1 Oct. 2008 |
| Lebanon | Amended: 5 Sept. 2007 | In force: 5 March 1973 | 191 | |
| Lesotho | Amended: 8 Sept. 2009 | In force: 12 June 1973 | 199 | In force: 26 April 2010 |
| *Liberia* | | | | |
| Libya | | In force: 8 July 1980 | 282 | In force: 11 Aug. 2006 |
| Liechtenstein | | In force: 4 Oct. 1979 | 275 | Signed: 14 July 2006 |
| Lithuania[21] | | Accession: 1 Jan. 2008 | 193 | Accession: 1 Jan. 2008 |

*Table A6. Conclusion of safeguards agreements, additional protocols and small quantities protocols (as of 31 December 2011) (cont.)*

| State | SQP [a] | Safeguards agreements [b] | INFCIRC | Additional protocols (APs) |
|---|---|---|---|---|
| Luxembourg | | In force: 21 Feb. 1977 | 193 | In force: 30 April 2004 |
| Madagascar | Amended: 29 May 2008 | In force: 14 June 1973 | 200 | In force: 18 Sept. 2003 |
| Malawi | Amended: 29 Feb. 2008 | In force: 3 Aug. 1992 | 409 | In force: 26 July 2007 |
| Malaysia | | In force: 29 Feb. 1972 | 182 | Signed: 22 Nov. 2005 |
| Maldives | X | In force: 2 Oct. 1977 | 253 | |
| Mali | Amended: 18 April 2006 | In force: 12 Sept. 2002 | 615 | In force: 12 Sept. 2002 |
| Malta[22] | | Accession: 1 July 2007 | 193 | Accession: 1 July 2007 |
| Marshall Islands | | In force: 3 May 2005 | 653 | In force: 3 May 2005 |
| Mauritania | X | In force: 10 Dec. 2009 | 788 | In force: 10 Dec. 2009 |
| Mauritius | Amended: 26 Sept. 2008 | In force: 31 Jan. 1973 | 190 | In force: 17 Dec. 2007 |
| Mexico[23] | | In force: 14 Sept. 1973 | 197 | In force: 4 March 2011 |
| *Micronesia, Fed. States* | | | | |
| Monaco | Amended: 27 Nov. 2008 | In force: 13 June 1996 | 524 | In force: 30 Sept. 1999 |
| Mongolia | X | In force: 5 Sept. 1972 | 188 | In force: 12 May 2003 |
| Montenegro | In force: 4 March 2011 | In force: 4 March 2011 | 814 | In force: 4 March 2011 |
| Morocco | Rescinded: 15 Nov. 2007 | In force: 18 Feb. 1975 | 228 | In force: 21 April 2011 |
| Mozambique | In force: 1 March 2011 | In force: 1 March 2011 | 813 | In force: 1 March 2011 |
| 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 [15]<br>In force: 21 Feb. 1977 | 229<br>193 | In force: 30 April 2004 |
| New Zealand[24] | X | In force: 29 Feb. 1972 | 185 | In force: 24 Sept. 1998 |
| Nicaragua[2] | Amended: 12 June 2009 | In force: 29 Dec. 1976 | 246 | In force: 18 Feb. 2005 |
| Niger | | In force: 16 Feb. 2005 | 664 | In force: 2 May 2007 |
| Nigeria | | In force: 29 Feb. 1988 | 358 | In force: 4 April 2007 |
| Norway | | In force: 1 March 1972 | 177 | In force: 16 May 2000 |
| Oman | X | In force: 5 Sept. 2006 | 691 | |
| **Pakistan** | | In force: 5 March 1962<br>In force: 17 June 1968<br>In force: 17 Oct. 1969<br>In force: 18 March 1976<br>In force: 2 March 1977<br>In force: 10 Sept. 1991<br>In force: 24 Feb. 1993<br>In force: 22 Feb. 2007<br>In force: 15 April 2011 | 34<br>116<br>135<br>239<br>248<br>393<br>418<br>705<br>816 | |

*Table A6. Conclusion of safeguards agreements, additional protocols and small quantities protocols (as of 31 December 2011) (cont.)*

| State | SQP [a] | Safeguards agreements [b] | INFCIRC | Additional protocols (APs) |
|---|---|---|---|---|
| Palau | Amended: 15 March 2006 | In force: 13 May 2005 | 650 | In force: 13 May 2005 |
| Panama[9] | Amended: 4 March 2011 | In force: 23 March 1984 | 316 | In force: 11 Dec. 2001 |
| Papua New Guinea | X | In force: 13 Oct. 1983 | 312 | |
| Paraguay[2] | X | In force: 20 March 1979 | 279 | In force: 15 Sept. 2004 |
| Peru[2] | | In force: 1 Aug. 1979 | 273 | In force: 23 July 2001 |
| Philippines | | In force: 16 Oct. 1974 | 216 | In force: 26 Feb. 2010 |
| Poland[25] | | Accession: 1 March 2007 | 193 | Accession: 1 March 2007 |
| Portugal[26] | | Accession: 1 July 1986 | 193 | In force: 30 April 2004 |
| Qatar | In force: 21 Jan. 2009 | In force: 21 Jan. 2009 | 747 | |
| Republic of Moldova | Amended: 1 September 2011 | In force: 17 May 2006 | 690 | Signed: 14 Dec 2011 |
| Romania[27] | | Accession: 1 May 2010 | 193 | Accession: 1 May 2010 |
| Russian Federation | | In force: 10 June 1985 | 327* | In force: 16 Oct. 2007 |
| Rwanda | In force: 17 May 2010 | In force: 17 May 2010 | 801 | In force: 17 May 2010 |
| St Kitts & Nevis[5] | X | In force: 7 May 1996 | 514 | |
| Saint Lucia[5] | X | In force: 2 Feb. 1990 | 379 | |
| St V. & the Grenadines[5] | X | In force: 8 Jan. 1992 | 400 | |
| Samoa | X | In force: 22 Jan. 1979 | 268 | |
| San Marino | Amended: 13 May 2011 | In force: 21 Sept. 1998 | 575 | |
| *São Tomé and Príncipe* | | | | |
| Saudi Arabia | X | In force: 13 Jan. 2009 | 746 | |
| Senegal | Amended: 6 Jan. 2010 | In force: 14 Jan. 1980 | 276 | Signed: 15 Dec. 2006 |
| Serbia[28] | | In force: 28 Dec. 1973 | 204 | Signed: 3 July 2009 |
| Seychelles | Amended: 31 Oct. 2006 | In force: 19 July 2004 | 635 | In force: 13 Oct. 2004 |
| Sierra Leone | X | In force: 4 Dec. 2009 | 787 | |
| Singapore | Amended: 31 March 2008 | In force: 18 Oct. 1977 | 259 | In force: 31 March 2008 |
| Slovakia[29] | | Accession: 1 Dec. 2005 | 193 | Accession: 1 Dec. 2005 |
| Slovenia[30] | | Accession: 1 Sept. 2006 | 193 | Accession: 1 Sept. 2006 |
| Solomon Islands | X | In force: 17 June 1993 | 420 | |
| *Somalia* | | | | |
| South Africa | | In force: 16 Sept. 1991 | 394 | In force: 13 Sept. 2002 |
| Spain | | Accession: 5 April 1989 | 193 | In force: 30 April 2004 |
| Sri Lanka | | In force: 6 Aug. 1984 | 320 | |
| Sudan | X | In force: 7 Jan. 1977 | 245 | |
| Suriname[2] | X | In force: 2 Feb. 1979 | 269 | |

*Table A6. Conclusion of safeguards agreements, additional protocols and small quantities protocols (as of 31 December 2011) (cont.)*

| State | SQP [a] | Safeguards agreements [b] | INFCIRC | Additional protocols (APs) |
|---|---|---|---|---|
| Swaziland | Amended: 23 July 2010 | In force: 28 July 1975 | 227 | In force: 8 Sept. 2010 |
| Sweden[31] | | Accession: 1 June 1995 | 193 | In force: 30 April 2004 |
| Switzerland | | In force: 6 Sept. 1978 | 264 | In force: 1 Feb. 2005 |
| Syrian Arab Republic | | In force: 18 May 1992 | 407 | |
| Tajikistan[32] | Amended: 6 March 2006 | In force: 14 Dec. 2004 | 639 | In force: 14 Dec. 2004 |
| Thailand | | In force: 16 May 1974 | 241 | Signed: 22 Sept. 2005 |
| The F.Y.R. of Macedonia | Amended: 9 July 2009 | In force: 16 April 2002 | 610 | In force: 11 May 2007 |
| *Timor-Leste* | *Signed: 6 Oct. 2009* | *Signed: 6 Oct. 2009* | | *Signed: 6 Oct. 2009* |
| *Togo* | *Signed: 29 Nov. 1990* | *Signed: 29 Nov. 1990* | | *Signed: 26 Sept. 2003* |
| Tonga | X | In force: 18 Nov. 1993 | 426 | |
| Trinidad and Tobago[2] | X | In force: 4 Nov. 1992 | 414 | |
| Tunisia | | In force: 13 March 1990 | 381 | Signed: 24 May 2005 |
| Turkey | | In force: 1 Sept. 1981 | 295 | In force: 17 July 2001 |
| Turkmenistan | | In force: 3 Jan. 2006 | 673 | In force: 3 Jan. 2006 |
| Tuvalu | X | In force: 15 March 1991 | 391 | |
| Uganda | Amended: 24 June 2009 | In force: 14 Feb. 2006 | 674 | In force: 14 Feb. 2006 |
| Ukraine | | In force: 22 Jan. 1998 | 550 | In force: 24 Jan. 2006 |
| United Arab Emirates | X | In force: 9 Oct. 2003 | 622 | In force: 20 Dec. 2010 |
| United Kingdom | X | In force: 14 Dec. 1972[33]<br>In force: 14 Aug. 1978<br>Signed: 6 Jan. 1993[15] | 175<br>263* | In force: 30 April 2004 |
| United Rep. of Tanzania | Amended: 10 June 2009 | In force: 7 Feb. 2005 | 643 | In force: 7 Feb. 2005 |
| United States of America | X | In force: 9 Dec. 1980<br>In force: 6 April 1989 | 288*<br>366[15] | In force: 6 Jan. 2009 |
| Uruguay[2] | | In force: 17 Sept. 1976 | 157 | In force: 30 April 2004 |
| Uzbekistan | | In force: 8 Oct. 1994 | 508 | In force: 21 Dec. 1998 |
| *Vanuatu* | *Approved: 8 Sept. 2009* | *Approved: 8 Sept. 2009* | | *Approved: 8 Sept. 2009* |
| Venezuela[2] | | In force: 11 March 1982 | 300 | |
| Vietnam | | In force: 23 Feb. 1990 | 376 | Signed: 10 Aug. 2007 |
| Yemen, Republic of | X | In force: 14 Aug. 2002 | 614 | |
| Zambia | X | In force: 22 Sept. 1994 | 456 | Signed: 13 May 2009 |
| Zimbabwe | Amended: 31 August 2011 | In force: 26 June 1995 | 483 | |

*Table A6. Conclusion of safeguards agreements, additional protocols and small quantities protocols (as of 31 December 2011) (cont.)*

**Key**

**States:** States not party to the NPT whose safeguards agreements are of INFCIRC/66-type.
*States*: Non-nuclear-weapon States that are party to the NPT but have not yet brought into force comprehensive safeguards agreements (CSAs) pursuant to Article III of that Treaty (grey shading).
*: Voluntary offer safeguards agreement for NPT nuclear-weapon States.

*NB:* This document does not aim at listing all safeguards agreements that the Agency has concluded. Not included are agreements under which the application of safeguards has been suspended in light of the conclusion of a CSA. Unless otherwise indicated, the safeguards agreements referred to are CSAs concluded pursuant to the NPT.

[a] Provided that they fulfil certain conditions (including that the quantities of nuclear material do not exceed the limits set out in paragraph 37 of INFCIRC/153), States with CSAs have the option to conclude a 'small quantities protocol' (SQP) that holds in abeyance the implementation of most of the safeguards procedures of the CSA as long as these conditions are met. This column contains States whose SQP has been approved by the Board and for which, as far as the Secretariat is aware, these conditions continue to apply. For those States that have accepted the revised standard SQP text (approved by the Board of Governors on 20 September 2005) the current status is reflected.

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

[1] Sui generis comprehensive safeguards agreement. 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.

[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 & Nevis and Saint Vincent & 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] The application of safeguards in Bulgaria under the NPT safeguards agreement INFCIRC/178, in force since 29 February 1972, was suspended on 1 May 2009, 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 Bulgaria had acceded, entered into force for Bulgaria.

[9] The 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.

[10] 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.

[11] The application of safeguards in the Czech Republic under the NPT safeguards agreement INFCIRC/541, in force since 11 September 1997, was suspended on 1 October 2009, 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 the Czech Republic had acceded, entered into force for the Czech Republic.

[12] 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.

[13] 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.

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

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

[16] 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.

[17] 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.

[18] 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, EURATOM and the Agency (INFCIRC/193), to which Hungary had acceded, entered into force for Hungary.

[19] Pending entry into force, the additional protocol is applied provisionally for Iraq as of 17 February 2010.

[20] 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.

[21] 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.

[22] 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.

[23] 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.

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

[25] 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.

[26] 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.

[27] The application of safeguards in Romania under the NPT safeguards agreement INFCIRC/180, in force since 27 October 1972, was suspended on 1 May 2010, 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 Romania had acceded, entered into force for Romania.

[28] 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.

[29] 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.

[30] 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.

[31] 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.

[32] The SQP ceased to be operational upon entry into force of the amendments to the SQP.

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

*Table A7. Participation 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 2011)*

| | STATE | P&I | VC | CPPNM | CPPNMAM | ENC | AC | JP | NS | RADW | PAVC | SUPP | RSA | VI | XIV.A |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| * | Afghanistan | | | P | | Sr | Sr | | | | | | P | X | |
| * | Albania | P | | P | | P | P | | P | P | | | P | X | X |
| * | Algeria | | | Pr | CS | Pr | Pr | | S | | | | P | X | X |
| | Andorra | | | Pr | | | | | | | | | | | |
| * | Angola | | | | | P | | | | | | | P | | |
| | Antigua Barbuda | | | P | CS | | | | | | | | | | |
| * | Argentina | P | P | Pr | CS | Pr | Pr | S | P | P | P | CS | P | X | X |
| * | Armenia | | P | P | | P | P | | P | | | | P | | |
| * | Australia | P | | P | CS | Pr | Pr | | P | P | | S | | | |
| * | Austria | | | Pr | CS | P | Pr | | Pr | P | | | | X | X |
| * | Azerbaijan | | | Pr | | | | | | | | | S | | |
| | Bahamas | | | Pr | | | | | | | | | | | |
| * | Bahrain | | | Pr | CS | Pr | | | P | | | | | | |
| * | Bangladesh | | | P | | P | P | | P | | | | P | | |
| | Barbados | | | | | | | | | | | | | | |
| * | Belarus | Pr | P | Pr | | Pr | Pr | | P | P | P | | P | X | X |
| * | Belgium | Pr | | Pr | | P | P | S | P | P | | | | | |
| * | Belize | | | | | | | | | | | | P | | |
| * | Benin | P | | | | | | | | | | | P | | |
| | Bhutan | | | | | | | | | | | | | | |
| * | Bolivia | P | P | P | | Pr | Pr | | | | | | P | | |
| * | Bosnia and Herzogovina | Pr | P | P | CS | P | P | | P | | | | P | | |
| * | Botswana | | | P | | P | P | | | | | | P | | |
| * | Brazil | P | P | P | | P | P | | P | P | | | P | X | X |
| | Brunei | | | | | | | | | | | | | | |
| * | Bulgaria | Pr | P | P | CS | P | P | P | P | P | | | P | X | X |
| * | Burkina Faso | | | P | | | | | | | | | P | | |
| * | Burundi | | | | | | | | | | | | | | |
| * | Cambodia | | | P | | | | | | | | | P | | |
| * | Cameroon | P | P | P | | P | P | P | | | | | P | | |
| * | Canada | Pr | | P | | Pr | Pr | | P | P | | | | X | X |

*Table A7. Participation 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 2011) (cont.)*

| | STATE | P&I | VC | CPPNM | CPPNMAM | ENC | AC | JP | NS | RADW | PAVC | SUPP | RSA | VI | XIV.A |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Cape Verde | | | P | | | | | | | | | | | |
| * | Cent. Afr. Rep. | | | P | | | | | | | | | | | |
| * | Chad | | | | | | | | | | | | P | | |
| * | Chile | Pr | Pr | P | CS | P | P | P | P | P | | | P | | |
| * | China | Pr | | Pr | CS | Pr | Pr | | P | Pr | | | P | | |
| * | Colombia | P | S | P | | P | Pr | | | | | | P | | |
| | Comoros | | | P | | | | | | | | | | | |
| * | Congo | | | | | | | | | | | | | | |
| * | Costa Rica | | | P | | P | P | | | | | | P | | |
| * | Côte d'ivoire | | | | | S | S | | | | | | P | | |
| * | Croatia | P | P | P | CS | P | P | P | P | P | | | P | X | X |
| * | Cuba | Pr | P | Pr | | Pr | Pr | | S | | | | P | | |
| * | Cyprus | P | | Pr | | P | P | | P | P | | | P | | |
| * | Czech Republic | P | P | P | CS | P | P | P | P | P | S | S | P | X | X |
| | Dprk | | | | | Sr | Sr | | | | | | | | |
| * | D. Rep. Congo | P | | P | | S | S | | | | | | P | | |
| * | Denmark | Pr | | P | CSr | P | Pr | P | Pr | Pr | | | | X | X |
| | Djibouti | | | P | | | | | | | | | | | |
| | Dominica | | | P | | | | | | | | | | | |
| * | Dominican Rep. | | | P | | P | | | | | | | P | | |
| * | Ecuador | P | | P | | | | | | | | | P | | |
| * | Egypt | P | P | | | Pr | Pr | P | S | | | | P | | |
| * | El Salvador | | | Pr | | Pr | Pr | | | | | | P | X | |
| | Eq. Guinea | | | P | | | | | | | | | | | |
| * | Eritrea | | | | | | | | | | | | | | |
| * | Estonia | P | P | P | CS | P | P | P | P | P | | | P | X | X |
| * | Ethiopia | | | | | | | | | | | | P | X | |
| | Fiji | | | P | CS | | | | | | | | | | |
| * | Finland | P | | Pr | CS | P | Pr | P | P | P | | | | X | X |
| * | France | | | Pr | | Pr | Pr | S | P | P | | | | X | X |
| * | Gabon | | | P | CS | P | P | | | P | | | P | | |

*Table A7. Participation 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 2011) (cont.)*

| | STATE | P&I | VC | CPPNM | CPPNMAM | ENC | AC | JP | NS | RADW | PAVC | SUPP | RSA | VI | XIV.A |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Gambia | | | | | | | | | | | | | | |
| * | Georgia | | | P | | P | | | | P | | | P | | |
| * | Germany | Pr | | Pr | CS | Pr | Pr | P | P | P | | | | X | X |
| * | Ghana | P | | P | | | | | P | P | | | P | | |
| * | Greece | P | | Pr | CS | Pr | Pr | P | P | P | | | P | X | X |
| | Grenada | | | P | | | | | | | | | | | |
| * | Guatemala | | | Pr | | P | P | | | | | | P | | |
| | Guinea | | | P | | | | | | | | | | | |
| | Guinea-Bissau | | | P | | | | | | | | | | | |
| | Guyana | | | P | | | | | | | | | | | |
| * | Haiti | | | S | | | | | | | | | P | | |
| * | Holy See | P | | | | S | S | | | | | | | X | X |
| * | Honduras | | | P | | | | | | | | | P | | |
| * | Hungary | Pr | P | P | CS | P | P | P | P | P | S | | P | X | X |
| * | Iceland | P | | P | | P | P | | P | P | | | P | X | X |
| * | India | P | | Pr | CS | Pr | Pr | | P | | | S | | | |
| * | Indonesia | Pr | | Pr | CS | Pr | Pr | | P | P | S | S | P | | |
| * | Iran, Isl. Rep. | P | | | | Pr | Pr | | | | | | P | | X |
| * | Iraq | P | | | | Pr | Pr | | | | | | P | | |
| * | Ireland | P | | Pr | | P | Pr | | P | P | | | P | X | X |
| * | Israel | | Sr | Pr | | Pr | Pr | | S | | | | P | | |
| * | Italy | Pr | | Pr | | Pr | Pr | P | P | P | S | S | | X | X |
| * | Jamaica | P | | P | | | | | | | | | P | | |
| * | Japan | P | | P | | P | Pr | | P | Pr | | | | X | X |
| * | Jordan | Pr | | Pr | CS | P | P | | P | | | | P | | |
| * | Kazakhstan | P | P | P | CS | P | P | | P | P | P | | P | | |
| * | Kenya | | | P | CS | | | | | | | | P | | X |
| | Kiribati | | | | | | | | | | | | | | |
| * | Korea, Rep. | Pr | | Pr | | P | Pr | | P | P | | | P | X | X |
| * | Kuwait | P | | Pr | | P | P | | P | | | | P | | |
| * | Kyrgyzstan | | | | | | | | | P | | | P | | |

*Table A7. Participation 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 2011) (cont.)*

| | STATE | P&I | VC | CPPNM | CPPNMAM | ENC | AC | JP | NS | RADW | PAVC | SUPP | RSA | VI | XIV.A |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| * | Lao P. Dem. Rep. | | | Pr | | | | | | | | | | | |
| * | Latvia | P | P | P | CS | P | P | P | P | P | P | | P | X | X |
| * | Lebanon | | P | P | | P | P | | P | S | S | S | P | | |
| * | Lesotho | | | P | | | | | | | | | P | | |
| * | Liberia | | | | | | | | | | | | | | |
| * | Libya | | | P | CS | P | P | | P | | | | P | X | |
| * | Liechtenstein | | | P | CS | P | P | | | | | | | X | X |
| * | Lithuania | P | P | P | CS | P | P | P | P | P | S | S | P | X | X |
| * | Luxembourg | Pr | | Pr | | P | P | | P | P | | | | X | X |
| * | Madagascar | | | P | | | | | | | | | P | | |
| * | Malawi | | | | | | | | | | | | | | |
| * | Malaysia | | | | | Pr | Pr | | | | | | P | | |
| | Maldives | | | | | | | | | | | | | | |
| * | Mali | | | P | CS | P | P | | P | | | | P | | |
| * | Malta | | | P | | | | | P | | | | P | X | X |
| * | Marshall Is. | | | P | | | | | | | | | | | |
| * | Mauritania | | | P | CS | P | P | | | P | | | P | | |
| * | Mauritius | P | | | | Pr | Pr | | | | | | P | | |
| * | Mexico | Pr | P | P | | P | P | | P | | | | P | X | |
| | Micronesia | | | | | | | | | | | | | | |
| * | Monaco | | | P | | Pr | Pr | | S | | | | | X | X |
| * | Mongolia | P | | P | | P | P | | | | | | P | | |
| * | Montenegro | P | P | P | | P | P | | | P | P | | P | | |
| * | Morocco | Pr | S | P | | P | P | S | S | P | P | CS | P | X | |
| * | Mozambique | P | | Pr | | P | P | | | | | | P | | |
| * | Myanmar | | | | | Pr | | | | | | | P | X | X |
| * | Namibia | | | P | | | | | | | | | P | | |
| | Nauru | | | P | CS | | | | | | | | | | |
| * | Nepal | | | | | | | | | | | | | | |
| * | Netherlands | P | | Pr | CS | Pr | Pr | P | P | P | | | | X | X |
| * | New Zealand | P | | P | | P | Pr | | | | | | | | |

*Table A7. Participation 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 2011) (cont.)*

| | STATE | P&I | VC | CPPNM | CPPNMAM | ENC | AC | JP | NS | RADW | PAVC | SUPP | RSA | VI | XIV.A |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| * | Nicaragua | P | | P | | Pr | Pr | | S | | | | P | | |
| * | Niger | P | P | P | CS | S | S | | | | | | P | | |
| * | Nigeria | P | P | P | CS | P | P | | P | P | | | P | | |
| | Niue | | | P | | | | | | | | | | | |
| * | Norway | P | | Pr | CS | P | Pr | P | P | P | | | | | |
| * | Oman | Pr | | Pr | | Pr | Pr | | | | | | P | | |
| * | Pakistan | Pr | | Pr | | Pr | Pr | | P | | | | P | X | X |
| * | Palau | | | P | | | | | | | | | | | |
| * | Panama | | | P | | P | P | | | | | | P | X | |
| | Papua N. Guinea | | | | | | | | | | | | | | |
| * | Paraguay | | | P | | S | S | | | | | | P | | |
| * | Peru | | P | Pr | | Pr | Pr | | P | S | S | S | P | X | X |
| * | Philippines | P | P | P | | P | P | S | S | S | S | S | P | | |
| * | Poland | P | P | P | CS | P | P | P | P | P | P | | P | X | X |
| * | Portugal | Pr | | Pr | CS | P | P | S | P | P | | | P | | |
| * | Qatar | | | Pr | | P | P | | | | | | P | | |
| * | Rep. of Moldova | Pr | P | P | CS | P | P | | P | Pr | | | P | | |
| * | Romania | Pr | P | Pr | CS | Pr | Pr | P | P | P | P | CS | P | X | X |
| * | Russian Fed. | Pr | P | P | CS | Pr | Pr | | P | P | | | | | |
| | Rwanda | | | P | | | | | | | | | | | |
| | St Kitts Nevis | | | P | | | | | | | | | | | |
| | Saint Lucia | | | | | | | | | | | | | | |
| | St Vinct Grn. | | P | | | P | P | P | | | | | | | |
| | Samoa | | | | | | | | | | | | | | |
| | San Marino | | | | | | | | | | | | | | |
| | Sao Tome Prn. | | | | | | | | | | | | | | |
| * | Saudi Arabia | | P | Pr | CS | Pr | Pr | | P | P | Pr | | P | | |
| * | Senegal | P | P | P | | P | P | | P | P | | S | P | | |
| * | Serbia | P | P | P | | P | P | | | | | | P | | |
| * | Seychelles | | | P | CS | | | | | | | | P | | X |
| * | Sierra Leone | | | | | S | S | | | | | | P | | |

*Table A7. Participation 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 2011) (cont.)*

| | STATE | P&I | VC | CPPNM | CPPNMAM | ENC | AC | JP | NS | RADW | PAVC | SUPP | RSA | VI | XIV.A |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| * | Singapore | Pr | | | | P | P | | P | | | | P | | |
| * | Slovakia | P | P | P | | Pr | Pr | P | P | P | | | P | X | X |
| * | Slovenia | P | | P | CS | P | P | P | P | P | | | P | X | X |
| | Solomon Islands | | | | | | | | | | | | | | |
| | Somalia | | | | | | | | | | | | | | |
| * | South Africa | Pr | | Pr | | Pr | Pr | | P | P | | | P | X | X |
| * | Spain | P | S | Pr | CS | Pr | Pr | S | P | P | | | P | X | X |
| * | Sri Lanka | | | | | Pr | Pr | | P | | | | P | | |
| * | Sudan | | | P | | S | S | | S | | | | P | | |
| | Suriname | | | | | | | | | | | | | | |
| | Swaziland | | | P | | | | | | | | | | | |
| * | Sweden | P | | Pr | | P | Pr | P | P | P | | | | X | X |
| * | Switzerland | Pr | | Pr | CS | P | P | S | P | P | | | | X | X |
| * | Syrian Arab Rep. | P | | | | S | S | | S | | | | P | | X |
| * | Tajikistan | P | | P | | P | P | | | P | | | P | | |
| * | Thailand | Pr | | | | Pr | Pr | | | | | | P | | |
| * | Tfyr Macedonia | | P | P | CS | P | P | | P | P | | | P | | |
| | Timor Leste | | | | | | | | | | | | | | |
| | Togo | | | P | | | | | | | | | | | |
| | Tonga | | | P | | | | | | | | | | | |
| | Trinidad Tobago | | P | P | | | | | | | | | | | |
| * | Tunisia | P | | P | CS | P | P | | P | | | | P | X | X |
| * | Turkey | Pr | | Pr | | Pr | Pr | P | P | | | | P | X | X |
| | Turkmenistan | | | P | CS | | | | | | | | | | |
| | Tuvalu | | | | | | | | | | | | | | |
| * | Uganda | | | P | | | | | | | | | P | | |
| * | Ukraine | Pr | P | P | CS | Pr | Pr | P | Pr | P | S | S | P | X | X |
| * | Utd Arab Emr. | | | P | CS | Pr | Pr | | P | P | | | P | | |
| * | United Kingdom | P | S | Pr | CS | Pr | Pr | S | P | P | | | | X | X |
| * | Utd Rep. Tanz. | | | P | | P | P | | | | | | P | | |
| * | Usa | | | P | | Pr | Pr | | P | P | | CSr | | | |

*Table A7. Participation 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 2011) (cont.)*

| | STATE | P&I | VC | CPPNM | CPPNMAM | ENC | AC | JP | NS | RADW | PAVC | SUPP | RSA | VI | XIV.A |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| * | Uruguay | | P | P | | P | P | P | P | P | | | P | | |
| * | Uzbekistan | | | P | | | | | | P | | | P | | |
| | Vanuatu | | | | | | | | | | | | | | |
| * | Venezuela | | | | | | | | | | | | P | | |
| * | Vietnam | P | | | | Pr | Pr | | P | | | | P | | |
| * | Yemen | | | P | | | | | | | | | | | |
| * | Zambia | | | | | | | | | | | | P | | |
| * | Zimbabwe | | | | | S | S | | | | | | P | | |
| | Euratom | | | Pr | | Pr | Pr | | Pr | P | | | | | |
| | Fao | | | | | Pr | Pr | | | | | | | | |
| | Who | | | | | Pr | Pr | | | | | | | | |
| | Wmo | | | | | Pr | Pr | | | | | | | | |

| | |
|---|---|
| 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 (not yet in force) |
| 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 in 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 |
| X | Accepting 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 2011, 1 State became Party to the Agreement. By the end of the year, there were 83 Parties. |
| *Vienna Convention on Civil Liability for Nuclear Damage* (reproduced in INFCIRC/500). Entered into force on 12 November 1977. In 2011, 2 States became Party to the Convention. By the end of the year, there were 38 Parties. |
| *Optional Protocol Concerning the Compulsory Settlement of Disputes* (reproduced in INFCIRC/500/Add.3). Entered into force on 13 May 1999. In 2011, the status remained unchanged with 2 Parties. |
| *Convention on the Physical Protection of Nuclear Material* (reproduced in INFCIRC/274/Rev.1). Entered into force on 8 February 1987. In 2011, the status remained unchanged with 145 Parties. |
| *Amendment to the Convention on the Physical Protection of Nuclear Material*. Adopted on 8 July 2005. In 2011, 7 States adhered to the Amendment bringing the total to 52 States. |
| *Convention on Early Notification of a Nuclear Accident* (reproduced in INFCIRC/335). Entered into force on 27 October 1986. In 2011, 4 States became Party to the Convention. By the end of the year, there were 113 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 2011, 3 States became Party to the Convention. By the end of the year, there were 108 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 2011, the status remained unchanged with 26 Parties. |
| *Convention on Nuclear Safety* (reproduced in INFCIRC/449). Entered into force on 24 October 1996. In 2011, 3 States became Party to the Convention. By the end of the year, there were 74 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 2011, 6 States became Party to the Convention. By the end of the year, there were 63 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 2011, 3 States became Party to the Protocol. By the end of the year, there were 9 Parties. |
| *Convention on Supplementary Compensation for Nuclear Damage* (reproduced in INFCIRC/567). Opened for signature on 29 September 1997. In 2011, 1 State signed the Convention. By the end of the year, there were 4 Contracting States and 15 Signatories. |
| *Revised Supplementary Agreement Concerning the Provision of Technical Assistance by the IAEA (RSA).* In 2011, 3 States concluded a RSA. By the end of the year, there were 117 States party to a RSA Agreement. |
| *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 2011, the status remained unchanged with 15 Parties. |
| *African Regional Co-operative Agreement for Research, Development and Training Related to Nuclear Science and Technology (AFRA) (Fourth Extension)* (reproduced in INFCIRC/377). Entered into force on 4 April 2010. In 2011, 10 States became Party to the Agreement. By the end of the year, there were 31 Parties. |
| *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 2011, 1 State became Party to the Agreement. By the end of the year, there were 21 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 2011, the status remained unchanged with 9 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 2011, the status remained unchanged with 7 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 2011, the status remained unchanged with 6 Parties. |

*Table A9. Nuclear power reactors in operation and under construction in the world (as of 31 December 2011)*[a]

| Country | Reactors in operation | | Reactors under construction | | Nuclear electricity supplied in 2011 | | Total operating experience through 2011 | |
|---|---|---|---|---|---|---|---|---|
| | No. of units | Total MW(e) | No. of units | Total MW(e) | Terawatt-hours (TW·h) | % of total | Years | Months |
| Argentina | 2 | 935 | 1 | 692 | 5.9 | 5.0 | 66 | 7 |
| Armenia | 1 | 375 | | | 2.4 | 33.2 | 37 | 8 |
| Belgium | 7 | 5 927 | | | 45.9 | 54.0 | 247 | 7 |
| Brazil | 2 | 1 884 | 1 | 1 245 | 14.8 | 3.2 | 41 | 3 |
| Bulgaria | 2 | 1 906 | 2 | 1 906 | 15.3 | 32.6 | 151 | 3 |
| Canada | 18 | 12 604 | | | 88.3 | 15.3 | 618 | 2 |
| China | 16 | 11 816 | 26 | 26 620 | 82.6 | 1.9 | 125 | 6 |
| Czech Republic | 6 | 3 766 | | | 26.7 | 33.0 | 122 | 10 |
| Finland | 4 | 2 736 | 1 | 1 600 | 22.3 | 31.6 | 131 | 4 |
| France | 58 | 63 130 | 1 | 1 600 | 423.5 | 77.7 | 1816 | 4 |
| Germany | 9 | 12 068 | | | 102.3 | 17.8 | 782 | 9 |
| Hungary | 4 | 1 889 | | | 14.7 | 43.3 | 106 | 2 |
| India | 20 | 4 391 | 7 | 4 824 | 29.0 | 3.7 | 357 | 3 |
| Iran, Islamic Republic of | 1 | 915 | | | 0.1 | | 0 | 4 |
| Japan | 50 | 44 215 | 2 | 2 650 | 156.2 | 18.1 | 1546 | 4 |
| Korea, Republic of | 21 | 18 751 | 5 | 5 560 | 147.8 | 34.6 | 381 | 1 |
| Mexico | 2 | 1 300 | | | 9.3 | 3.6 | 39 | 11 |
| Netherlands | 1 | 482 | | | 3.9 | 3.6 | 67 | 0 |
| Pakistan | 3 | 725 | 2 | 630 | 3.8 | 3.8 | 52 | 8 |
| Romania | 2 | 1 300 | | | 10.8 | 19.0 | 19 | 11 |
| Russian Federation | 33 | 23 643 | 10 | 8 188 | 162.0 | 17.6 | 1058 | 4 |
| Slovakia | 4 | 1 816 | 2 | 782 | 14.3 | 54.0 | 140 | 7 |
| Slovenia | 1 | 688 | | | 5.9 | 41.7 | 30 | 3 |
| South Africa | 2 | 1 830 | | | 12.9 | 5.2 | 54 | 3 |
| Spain | 8 | 7 567 | | | 55.1 | 19.5 | 285 | 6 |
| Sweden | 10 | 9 326 | | | 58.1 | 39.6 | 392 | 6 |
| Switzerland | 5 | 3 263 | | | 25.7 | 40.9 | 184 | 11 |
| Ukraine | 15 | 13 107 | 2 | 1900 | 84.9 | 47.2 | 398 | 6 |
| United Kingdom | 18 | 9 953 | | | 62.7 | 17.8 | 1495 | 2 |
| United States of America | 104 | 101 465 | 1 | 1 165 | 790.4 | 19.3 | 3707 | 11 |
| **Total**[b, c] | **435** | **368 791** | **65** | **61 962** | **2 518.0** | **12.5%**[d] | **14 792** | **3** |

[a] Data are from the Agency's Power Reactor Information System (PRIS) (http://www.iaea.org/pris)

[b] Note: The total figures include the following data from Taiwan, China:
6 units, 5018 MW(e) in operation; 2 units, 2600 MW(e) under construction;
40.37 TW·h of nuclear electricity generation, representing 19.02% of the total electricity generated.

[c] The total operating experience also includes shutdown plants in Italy (81 years), Kazakhstan (25 years, 10 months), Lithuania (43 years, 6 months) and Taiwan, China (182 years, 1 month).

[d] Represents the global percentage of nuclear energy supplied in 2011.

*Table A10. Emergency Preparedness Review (EPREV) missions in 2011*

| Type | Country |
|---|---|
| EPREV | Albania; Estonia; Latvia; Georgia; Pakistan; Russian Federation |

*Table A11. Integrated Regulatory Review Service (IRRS) missions in 2011*

| Type | Country |
|---|---|
| IRRS mission | Republic of Korea; Romania; Slovenia; Switzerland; United Arab Emirates |
| IRRS Follow-up | Australia; Canada; Germany; Spain |

*Table A12. Safe Long Term Operation (SALTO) missions in 2011*

| Type | Location/nuclear power plant | Country |
|---|---|---|
| SALTO | Paks | Hungary |
| SALTO Limited Scope | Koeberg | South Africa |
| SALTO Follow-up | Dukovany | Czech Republic |

*Table A13. Operational Safety Review Team (OSART) missions in 2011*

| Type | Location/nuclear power plant | Country |
|---|---|---|
| OSART | Angra 2 | Brazil |
| OSART | Armenia | Armenia |
| OSART | Dukovany | Czech Republic |
| OSART | Seabrook | USA |
| OSART | Smolensk | Russian Federation |
| OSART | Koeberg | South Africa |
| OSART | Cattenom | France |
| OSART Follow-up | Vandellos 2 | Spain |
| OSART Follow-up | Fessenheim | France |
| OSART Follow-up | South Ukraine | Ukraine |
| OSART Follow-up | Ling Ao | China |
| OSART Follow-up | Ringhals | Sweden |

*Table A14. Integrated Safety Assessment of Research Reactors (INSARR) missions in 2011*

| Type | Country |
|---|---|
| Pre-INSARR mission, Piteşti Research Reactor | Romania |
| Pre-INSARR mission, High Flux Reactor | Netherlands |
| INSARR mission, High Flux Reactor | Netherlands |
| INSARR mission, Piteşti Research Reactor | Romania |
| INSARR mission, Huarangal Research Reactor | Peru |

*Table A15. Safety Evaluation During Operation for Fuel Cycle Facilities (SEDO) missions in 2011*

| Type | Country |
|---|---|
| SEDO mission to fuel fabrication facility | Romania |

*Table A16. Integrated Site Safety Review Service missions in 2011*

| Type | Country |
|---|---|
| Advisory mission | Armenia; Bangladesh; Indonesia; Jordan; Malaysia; Morocco; Romania; United Arab Emirates; Vietnam |

*Table A17. International Physical Protection Advisory Service (IPPAS) missions in 2011*

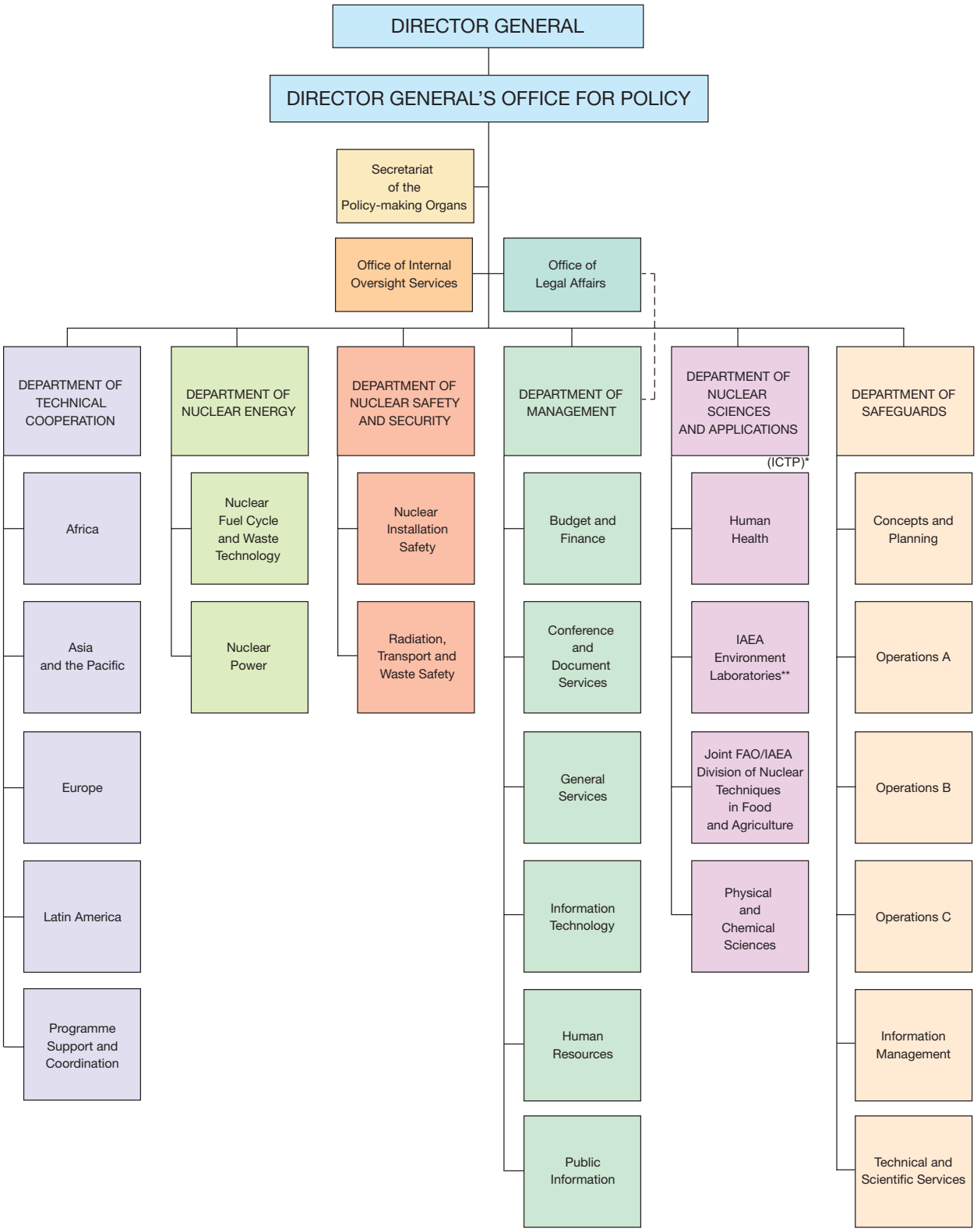
| Type | Country |
|---|---|
| IPPAS | France; Sweden; United Kingdom |

*Table A18. IAEA State System of Accounting for and Control of Nuclear Material Advisory Service (ISSAS) missions in 2011*

| Type | Country |
|---|---|
| ISSAS | Kazakhstan; Mexico |

# Organizational Chart

*(as of 31 December 2011)*




* The Abdus Salam International Centre for Theoretical Physics (Abdus Salam ICTP), legally referred to as the "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.

** 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

www.iaea.org

International Atomic Energy Agency
PO Box 100, Vienna International Centre
1400 Vienna, Austria
Telephone: (+43-1) 2600-0
Fax: (+43-1) 2600-7
Email: Official.Mail@iaea.org