

IAEA ANNUAL REPORT 2016



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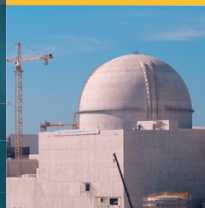
3 GOOD HEALTH AND WELL-BEING



6 CLEAN WATER AND SANITATION



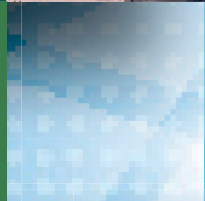
7 AFFORDABLE AND CLEAN ENERGY



9 INDUSTRY, INNOVATION AND INFRASTRUCTURE



13 CLIMATE ACTION



14 LIFE BELOW WATER



15 LIFE ON LAND



17 PARTNERSHIPS FOR THE GOALS



IAEA

60 Years

Atoms for Peace and Development

IAEA Annual Report 2016

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 2016.

Contents

<i>Member States of the International Atomic Energy Agency</i>	iv
<i>The Agency at a Glance</i>	v
<i>The Board of Governors</i>	vi
<i>The General Conference</i>	vii
<i>Notes</i>	viii
<i>Abbreviations</i>	ix

Overview	1
----------------	---

Nuclear Technology

Nuclear Power	27
Nuclear Fuel Cycle and Materials Technologies	34
Capacity Building and Nuclear Knowledge for Sustainable Energy Development	39
Nuclear Science	43
Food and Agriculture	48
Human Health	52
Water Resources	55
Environment	58
Radioisotope Production and Radiation Technology	61

Nuclear Safety and Security

Incident and Emergency Preparedness and Response	67
Safety of Nuclear Installations	71
Radiation and Transport Safety	77
Radioactive Waste Management and Environmental Safety	81
Nuclear Security	84

Nuclear Verification

Nuclear Verification	91
----------------------------	----

Technical Cooperation

Management of Technical Cooperation for Development	101
---	-----

Annex	109
--------------------	-----

Organizational Chart	149
-----------------------------------	-----

Member States of the International Atomic Energy Agency

(as of 31 December 2016)

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

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".

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The Agency at a Glance

(as of 31 December 2016)

- 168** Member States.
- 83** intergovernmental and non-governmental organizations worldwide invited to observe the Agency's General Conference.
- 60** years of international service.
- 2521** staff.
- €357.5 million** total Regular Budget for 2016¹. Extrabudgetary expenditures in 2016 totalled **€96.4 million**.
- €84.5 million** target in 2016 for voluntary contributions to the Agency's Technical Cooperation Fund, supporting projects involving **3777** expert and lecturer assignments, **5820** meeting participants and other project personnel, **3114** participants in **193** regional and interregional training courses and **1701** fellows and scientific visitors.
- 146** countries and territories receiving support through the Agency's technical cooperation programme, including **37** least developed countries.
- 914** active technical cooperation projects at the end of 2016.
- 2** liaison offices (in New York and Geneva) and **2** safeguards regional offices (in Tokyo and Toronto).
- 15** international laboratories (Vienna, Seibersdorf and Monaco) and research centres.
- 11** multilateral conventions on nuclear safety, security and liability adopted under the Agency's auspices.
- 4** regional/cooperative agreements relating to nuclear science and technology.
- 132** Revised Supplementary Agreements governing the provision of technical assistance by the Agency.
- 135** active CRPs involving **1748** approved research, technical and doctoral contracts and research agreements. In addition, **79** Research Coordination Meetings were held.
- 25** active IAEA Collaborating Centres. In 2016, **5** institutions were newly designated as IAEA Collaborating Centres and **9** centres were redesignated as IAEA Collaborating Centres for a period of 4 years.
- 19** national donors to the voluntary Nuclear Security Fund.
- 181** States in which safeguards agreements were being implemented^{2,3} of which **129** States had additional protocols in force, with **2214** safeguards inspections performed in 2016. Safeguards expenditures in 2016 amounted to **€132.9 million** in the operational portion of the Regular Budget and **€29.4 million** in extrabudgetary resources.
- 20** national safeguards support programmes and **1** multinational support programme (European Commission).
- 480 000** visitors a month to the newly launched iaea.org site at the end of 2016, a 12% increase from 2015. The Agency's social media audience increased significantly, with more than **360 000** followers on various channels at the end of 2016, a 50% increase during the year. As of the end of the year, the Agency had social media accounts in Arabic, French, Russian and Spanish, as well as English.
- 4 million** records in the Agency's International Nuclear Information System (INIS) database, with over **500 000** full texts not readily available through commercial channels and **2.7 million** page views in 2016.
- 1.3 million** documents, technical reports, standards, conference proceedings, journals and books in the IAEA Library and over **13 000** visitors to the Library in 2016.
- 145** publications, including newsletters, issued in 2016 (in print and electronic formats).

¹ At the UN average rate of exchange of US \$1.1075 to €1.00. The total Regular Budget was €362.0 million at the US \$1.00 to €1.00 rate.

² These 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.

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, in the course of 2016 the Board considered the *Nuclear Technology Review 2016*.

In the area of safety and security, the Board discussed the *Nuclear Safety Review 2016* and also debated the *Nuclear Security Report 2016*.

As regards verification, the Board considered the *Safeguards Implementation Report for 2015*. It approved one safeguards agreement and one additional protocol. The Board considered the Director General's reports on verification and monitoring in the Islamic Republic of Iran in light of United Nations Security Council resolution 2231 (2015). The Board kept under its consideration 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 2015* and approved the Agency's technical cooperation programme for 2017.

The Board approved the recommendations contained in the *Proposal by the Chair of the Board of Governors on the Agency's Budget Update for 2017*.

The Board discussed and took note of the Agency's *Medium Term Strategy 2018–2023*.

Composition of the Board of Governors (2016–2017)

Chair:

HE Mr. Tebogo Joseph SEOKOLO
Ambassador
Governor from South Africa

Vice-Chairpersons:

HE Mr. Bahtijors HASANS
Ambassador
Governor from Latvia

HE Mr. Gonzalo de SALAZAR SERANTES
Ambassador
Governor from Spain

Algeria
Argentina
Australia
Belarus
Brazil
Canada
China
Costa Rica
Côte d'Ivoire
Denmark
France
Germany
Ghana

India
Japan
Korea, Republic of
Latvia
Namibia
Netherlands
Pakistan
Paraguay
Peru
Philippines
Qatar
Russian Federation
Singapore

Slovenia
South Africa
Spain
Switzerland
Turkey
United Arab Emirates
United Kingdom of
Great Britain and
Northern Ireland
United States of America
Uruguay

The General Conference

The General Conference comprises all Member States of the Agency and meets once a year. It debates the annual report of the Board of Governors on the Agency's activities during the previous year, approves the Agency's 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 2016, the Conference — upon the recommendation of the Board — approved The Gambia, Saint Lucia, and Saint Vincent and the Grenadines for membership of the Agency. At the end of 2016, the Agency's membership was 168.

Notes

- The *IAEA Annual Report 2016* aims to summarize only the significant activities of the Agency during the year in question. The main part of the report, starting on page 25, generally follows the programme structure as given in *The Agency's Programme and Budget 2016–2017* (GC(59)/2 and Mod. 1).
- The introductory chapter, 'Overview', 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 Security Report*, *Nuclear Technology Review*, *Technical Cooperation Report* and the *Safeguards Statement 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*.
- 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.
- All the views expressed by Member States are reflected in full in the summary records of the June Board of Governors meetings. On 12 June 2017, the Board of Governors approved the Annual Report for 2016 for transmission to the General Conference.

Abbreviations

ABACC	Brazilian–Argentine Agency for Accounting and Control of Nuclear Materials
AFRA	African Regional Co-operative Agreement for Research, Development and Training Related to Nuclear Science and Technology
ALMERA	Analytical Laboratories for the Measurement of Environmental Radioactivity
ANENT	Asian Network for Education in Nuclear Technology
AP	additional protocol
ARASIA	Co-operative Agreement for Arab States in Asia 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
CNS	Convention on Nuclear Safety
COP22	22nd session of the Conference of the Parties (UNFCCC)
CPF	Country Programme Framework
CPPNM	Convention on the Physical Protection of Nuclear Material
CRP	coordinated research project
CSA	comprehensive safeguards agreement
CVDs	cardiovascular diseases
DSRS	disused sealed radioactive source
ENEN	European Nuclear Education Network
EPR	emergency preparedness and response
EPREV	Emergency Preparedness Review
EPRIMS	Emergency Preparedness and Response Information Management System
Euratom	European Atomic Energy Community
FAO	Food and Agriculture Organization of the United Nations
HEU	high enriched uranium
ICTP	Abdus Salam International Centre for Theoretical Physics
INIR	Integrated Nuclear Infrastructure Review
INIS	International Nuclear Information System
INLEX	International Expert Group on Nuclear Liability
INPRO	International Project on Innovative Nuclear Reactors and Fuel Cycles
IPPAS	International Physical Protection Advisory Service
IRRS	Integrated Regulatory Review Service
ITDB	Incident and Trafficking Database (IAEA)
JCPOA	Joint Comprehensive Plan of Action
JPA	Joint Plan of Action
JPLAN	Joint Radiation Emergency Management Plan of the International Organizations
LANENT	Latin American Network for Education in Nuclear Technology

LEU	low enriched uranium
LSD	lumpy skin disease
MESSAGE	Model for Energy Supply Strategy Alternatives and their General Environmental Impacts
NESA	Nuclear Energy System Assessment
NGSS	next generation surveillance system
NPCs	National Participation Costs
NPT	Treaty on the Non-Proliferation of Nuclear Weapons
OECD	Organisation for Economic Co-operation and Development
OECD/NEA	OECD Nuclear Energy Agency
ORPAS	Occupational Radiation Protection Appraisal Service
OSART	Operational Safety Review Team
PACT	Programme of Action for Cancer Therapy (IAEA)
RANET	Response and Assistance Network (IAEA)
RCA	Regional Co-operative Agreement for Research, Development and Training Related to Nuclear Science and Technology
ReNuAL	Renovation of the Nuclear Applications Laboratories
RSA	Revised Supplementary Agreement Concerning the Provision of Technical Assistance by the IAEA
SALTO	Safety Aspects of Long Term Operation
SDG	Sustainable Development Goal
SEED	Site and External Events Design
SMR	small and medium sized or modular reactor
SQP	small quantities protocol
SSDL	secondary standards dosimetry laboratory
STAR-NET	Regional Network for Education and Training in Nuclear Technology
TCF	Technical Cooperation Fund
UAV	unmanned aerial vehicle
UHVC	ultra-high vacuum chamber
UNDAF	United Nations Development Assistance Framework
UNEP	United Nations Environment Programme
WHO	World Health Organization

Overview

The Agency's Statute was approved 60 years ago, in October 1956. With its entry into force in July 1957, the International Atomic Energy Agency was officially established with the objective of accelerating and enlarging the "contribution of atomic energy to peace, health and prosperity throughout the world" while ensuring that "assistance provided by it ... is not used in such a way as to further any military purpose". Six decades on, the Agency continues to make tangible contributions in these areas and remains committed to meeting emerging global challenges in order to improve health, prosperity, peace and security around the world, and to help Member States achieve their development goals. By continuously adapting its diverse programmatic activities, within the framework of its Statute, the Agency has maintained the flexibility to address the evolving needs of Member States.

Under the banner '60 Years of IAEA — Atoms for Peace and Development', commemorative events were organized to mark the Agency's 60th anniversary during the Agency's General Conference in 2016. Among them were a photo exhibition, a special issue of the *IAEA Bulletin*, and a series of documentary films highlighting key areas of activities and the Agency's unique contribution to international peace and development, past and present.

This chapter provides an overview of some of the major global nuclear related developments in 2016 and how they were addressed through the Agency's work. During 2016, programmatic activities focused, in a balanced manner, on developing and transferring nuclear technologies for peaceful applications, enhancing nuclear safety and security, and strengthening nuclear verification and non-proliferation efforts worldwide.

NUCLEAR TECHNOLOGY

Nuclear Power

Status and trends

The global generating capacity of nuclear energy reached 391 gigawatts (electrical) (GW(e)) at the end of 2016. Ten new reactors were connected to the grid during the year, bringing the number of operational nuclear power reactors to 448. Construction started on 3 reactors, with a total of 61 reactors under construction around the world; 3 reactors were permanently shut down.

The Agency's 2016 projections for 2030 showed an increase in global nuclear power capacity of 1.9% in the low case scenario and 56% in the high case scenario. The new capacity to be added by 2030 is expected to greatly exceed the net increase in global nuclear capacity, as new nuclear power reactors replace those scheduled for retirement. Near and

"The global generating capacity of nuclear energy reached 391 gigawatts (electrical) (GW(e)) at the end of 2016."

long term growth prospects remained centred in Asia, home to 40 of the 61 reactors under construction, and 47 of the 55 reactors connected to the grid since 2005.

Major conferences

In May, the Agency organized the International Conference on Advancing the Global Implementation of Decommissioning and Environmental Remediation Programmes, the first major event to address both decommissioning and remediation. More than 540 experts from 54 Member States and 4 international organizations discussed progress made in developing programmes and shared examples of successful decommissioning and remediation. Participants committed themselves to scaling up decommissioning and remediation efforts as more facilities around the world reach the end of their operating life.

In November, the Agency, in cooperation with the Nuclear Energy Agency of the Organisation for Economic Co-operation and Development (OECD/NEA), organized the Third International Conference on Nuclear Knowledge Management: Challenges and Approaches. Held in Vienna, the event attracted more than 450 participants from 61 Member States and 10 international organizations, and featured 16 satellite events and 25 exhibitions. Participants focused on practical experience and provided examples of how knowledge management supports operational efficiency, reliability and sustainability.

Climate change and sustainable development

The Paris Agreement on climate change entered into force on 4 November 2016, just before the 22nd session of the Conference of the Parties to the United Nations Framework Convention on Climate Change (COP22), in Marrakesh, Morocco. The Agreement calls for limiting the global temperature rise to below 2°C above pre-industrial levels. At COP22, the Agency highlighted the role of nuclear technology in meeting the 2°C target at a side event held in cooperation with several organizations in the United Nations system. The Agency continued to present technical information about the role nuclear power, as a low carbon energy source, can play in meeting the climate–energy challenge and in contributing to sustainable development.

Energy assessment services

The Agency provided technical support to Member States conducting energy planning studies and assessing the potential role of nuclear power in meeting their future energy needs sustainably. Through national and regional technical cooperation projects, it carried out expert missions and provided energy assessment training and fellowships. The Agency also enhanced and updated its energy planning tools and models, tested a new cloud service for their use, and developed revised projections on global nuclear power capacity for 2030–2050.

Two INPRO (International Project on Innovative Nuclear Reactors and Fuel Cycles) Dialogue Forums held in 2016 drew more than 130 participants from over 35 Member States and 4 international organizations. The first Dialogue Forum, in April, addressed advanced nuclear energy systems; the second, in October, considered legal and institutional issues of global deployment of small modular reactors.

Support to operating nuclear power plants

Wireless technologies for transferring process and diagnostic information offer many potential benefits. To explore their possible adoption by the nuclear sector, the Agency launched a coordinated research project (CRP) aimed at developing and demonstrating advanced wireless communication techniques for use in instrumentation and control

systems of nuclear power plants. The project will address key areas such as relevant codes and standards, nuclear specific environments, computer security and a range of technological issues associated with wireless communication.

Launching nuclear power programmes

The Agency continued to assist some 30 countries that are considering, planning or starting a nuclear power programme. In 2016, Integrated Nuclear Infrastructure Review (INIR) missions were conducted to Kazakhstan and Malaysia, and INIR follow-up missions were conducted to Bangladesh and Poland. The INIR peer review service assists Member States in determining the status of their infrastructure, analysing gaps in the planning process and preparing an Integrated Work Plan for receiving a structured assistance package from the Agency. Since INIR's launch in 2009, 21 missions have been conducted to 15 Member States.

Capacity building, knowledge management and nuclear information

The Agency continued to support Member States with established nuclear power programmes as well as newcomer countries by hosting meetings, workshops, training sessions and schools, and by providing e-learning materials and support to nuclear education networks and master's programmes in nuclear technology management. In 2016, the Agency held courses in the Republic of Korea, Mexico and Tunisia on understanding the physics and technology of advanced reactors using PC based simulators. A new Agency course on the use of computational fluid dynamics for design and safety analysis of nuclear power plants was held in China. The Agency conducted a workshop in Kenya on nuclear technology assessment, designed to assist newcomer countries in evaluating available nuclear power technologies against country specific environments, site requirements and energy needs.

The Agency's International Nuclear Information System (INIS) database, supported by 130 Member States and 24 international organizations, reached a new milestone of 4 million records and 2.7 million views. The IAEA Library continued to coordinate research support and document delivery among the 55 members of the International Nuclear Library Network.

Assurance of supply

Significant progress was made on the IAEA Low Enriched Uranium (LEU) Bank project in 2016. Construction of the IAEA LEU Storage Facility began in early September and is proceeding on schedule. Kazakhstan expects that the IAEA LEU Storage Facility will be commissioned and ready to receive LEU in the second half of 2017. The Agency started activities in preparation for LEU acquisition.

An LEU reserve in Angarsk, established following the Agreement of February 2011 between the Government of the Russian Federation and the Agency, remained operational.

Fuel cycle

The Agency organized over 30 meetings and workshops in 2016 aimed at increasing fuel cycle sustainability. This included four Technical Meetings, four Research Coordination Meetings, two training activities and 25 consultancy meetings on uranium exploration, resources and production; environmental remediation of uranium mining activities; fuel engineering; and spent fuel management. In July, the Agency and the OECD/NEA jointly published *Uranium 2016: Resources, Production and Demand*, commonly referred to as the 'Red Book'.

"The Agency's International Nuclear Information System (INIS) database, supported by 130 Member States and 24 international organizations, reached a new milestone of 4 million records and 2.7 million views."

Technology development and innovation

As a follow-up of the IAEA Action Plan on Nuclear Safety, the Agency organized a Technical Meeting on Phenomenology and Technologies Relevant to In-Vessel Melt Retention and Ex-Vessel Corium Cooling in October. The event provided a forum to exchange the most recent R&D results, and to discuss strategies and measures for retaining molten core material in the reactor or containment vessel. The Agency also released an upgraded version of the Severe Accident Management Guideline Development (SAMG-D) Toolkit and, in December, held a training workshop on understanding the role of severe accident management guidelines.

In September, the Agency held a Technical Meeting on Technology Assessment of Small Modular Reactors for Near Term Deployment, in Beijing, China. The meeting helped Member States to stay informed about advances in small and medium sized or modular reactor (SMR) technology and identify designs available for near term deployment. In December, a Technical Meeting on the Design and Operation Aspects of Pressurized Water Reactor Based Small and Medium Reactors, held in Islamabad, Pakistan, focused on providing developing countries that are launching a nuclear power programme with information on the general design features, system and component descriptions, parameters and integrated plant operation of a 300 MW(e) nuclear power reactor. During the year, the Agency published *Design Safety Considerations for Water Cooled Small Modular Reactors Incorporating Lessons Learned from the Fukushima Daiichi Accident* (IAEA-TECDOC-1785). The report presents common considerations, approaches and measures for enhancing the operational safety performance of SMR designs to cope with extreme natural hazards.

In the area of fast reactors, the Agency concluded a four year CRP entitled 'Benchmark Analyses of an EBR-II Shutdown Heat Removal Test' and launched a new CRP entitled 'Radioactive Release from the Prototype Fast Breeder Reactor under Severe Accident Conditions'. The Abdus Salam International Centre for Theoretical Physics (ICTP) and the Agency held a joint workshop on the physics and technology of innovative nuclear energy systems for sustainable development, in Trieste, Italy, in August and September.

The Agency continued to support work on non-electrical applications of nuclear power. During the year, it held a meeting of the Technical Working Group on Nuclear Desalination and organized Technical Meetings on the user-vendor interface and the socioeconomic aspects of nuclear cogeneration. The Agency also conducted the third Research Coordination Meeting of its CRP on application of advanced low temperature desalination systems to support nuclear power plants and non-electric applications.

Research reactors

The Agency provided training and carried out expert missions and outreach activities to support Member States in various aspects of planning, construction, operation and maintenance, and utilization of research reactors. During the year, it published *History, Development and Future of TRIGA Research Reactors* (Technical Reports Series No. 482) and a brochure entitled *Research Reactors: Purpose and Future*. The Agency continued to assist Member States, upon request, in minimizing the civilian use of high enriched uranium by supporting the conversion of research reactors and of targets for radioisotope production. In September, the last remaining 61 kilograms of high enriched uranium was repatriated from Poland to the Russian Federation.

Radioactive waste management, decommissioning and environmental remediation

In 2016, the Agency held 68 Technical and Consultancy Meetings aimed at helping Member States to strengthen their capabilities and improve practices in radioactive waste

management, decommissioning of installations and remediation of contaminated sites. It also launched 14 new e-learning modules in English and in Russian on decommissioning, disused sealed radioactive sources (DSRSs) and disposal; developed public areas to provide access to basic information on web sites on the IAEA CONNECT platform; conducted 12 field missions on DSRs; and updated guidelines and self-assessment questionnaires in ARTEMIS, the Agency's new Integrated Review Service for Radioactive Waste and Spent Fuel Management, Decommissioning and Remediation.

Nuclear fusion

The 26th IAEA Fusion Energy Conference, held in October in Kyoto, Japan, attracted about 1000 participants — the highest number of attendees in the Conference's history. The Agency continued to lead the coordination of global Demonstration Fusion Power Plant (DEMO) related activities in 2016, including through the fourth DEMO Programme Workshop, held in November in Germany.

Nuclear data

In 2016, the Agency provided the nuclear community with relevant nuclear data: under its leadership, new and improved nuclear data libraries for ^{235}U and ^{238}U were developed for the Collaborative International Evaluated Library Organization (CIELO).

“The 26th IAEA Fusion Energy Conference, held in October in Kyoto, Japan, attracted about 1000 participants — the highest number of attendees in the Conference's history.”

Accelerator applications

The Agency expanded the Accelerator Knowledge Portal in 2016 to include geographic information on the accelerators listed. It also launched a CRP that will focus on the use of ion beams to analyse objects of art and to simulate damage in materials such as fuel cladding and nuclear waste forms. In December, the Agency held an experts meeting to discuss the effects of radiation on cultural heritage objects; the meeting was also used to plan future activities in this area.

Through the IAEA-Elettra Sincrotrone Trieste X ray fluorescence beamline, the Agency provided research time, training and support to research groups from 18 Member States.

Nuclear instrumentation

In April, the Agency installed an X ray fluorescence ultra-high vacuum chamber (UHVC) at its Nuclear Science and Instrumentation Laboratory at Seibersdorf. The UHVC will be used to train researchers in the use of the IAEA-Elettra Sincrotrone Trieste beamline.

The Agency successfully completed its project to develop an unmanned aerial vehicle (UAV) based mobile gamma spectrometry system to monitor radiation levels in Fukushima Prefecture. The new system was handed over to the Fukushima Prefectural Centre for Environmental Creation in July. During the year, the Agency's mobile spectrometry team carried out missions to Argentina, Japan, Nepal and Zambia. Team members used both a backpack detector based system and, in Argentina and Japan, the new UAV based system to monitor radiation levels on the earth's surface.

NUCLEAR SCIENCES AND APPLICATIONS

The Agency continued to develop and transfer nuclear technologies to Member States. Efforts in 2016 focused, in particular, on helping Member States use nuclear and isotopic techniques to achieve the Sustainable Development Goals (SDGs) related to food and agriculture, human health, water resources, environment, and radioisotope production

and radiation technology. The Agency also focused on helping to address emerging and urgent Member State needs by providing nuclear derived techniques to areas affected by the Zika virus to help quickly identify and respond to outbreaks of the disease, and by providing expertise to assess the structural integrity of affected buildings in countries hit by earthquakes. These activities were carried out largely through the Agency's CRPs and Collaborating Centres in Member States, with technology transferred through technical cooperation projects.

The Agency also supported Member States through e-learning platforms such as the Human Health Campus and through human health apps. In 2016, the Agency developed two new tools: FIGO, an app that helps doctors evaluate the extent of cancer in women; and NUCARD, an app designed to help medical practitioners choose the right treatment for patients with cardiovascular disease.

Renovation of the Nuclear Applications Laboratories (ReNuAL)

Work on the Renovation of the Nuclear Applications Laboratories (ReNuAL) project progressed on schedule and within budget in 2016. Construction began in March with the installation of the new electrical infrastructure required to support the new laboratory buildings. This work was completed in June and construction began in July. By the end of 2016, the foundation and concrete structure of the Insect Pest Control Laboratory had been completed and work on the interior had begun.

In September, the Agency met its extrabudgetary funding target of €20.6 million to reach ReNuAL's overall €31 million budget, with bilateral contributions from 25 Member States and a collective contribution from the African Regional Cooperative Agreement for Research, Development and Training Related to Nuclear Science and Technology (AFRA).

Further construction required to complete the modernization of the Nuclear Applications laboratories in Seibersdorf will be addressed under ReNuAL Plus (ReNuAL+), the follow-up of ReNuAL. By the end of 2016, seven Member States had pledged or provided more than €4 million in additional extrabudgetary funds for ReNuAL+.

Food and Agriculture

Diagnosis and control of disease outbreaks

The Agency, in partnership with the Food and Agriculture Organization of the United Nations (FAO), through the Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture, responded rapidly to help Member States fight outbreaks of several zoonotic and transboundary animal diseases in 2016. These included outbreaks of avian influenza HPAI-H5N1 virus in Burkina Faso, Cameroon, Côte d'Ivoire, Niger and Nigeria, and HPAI-H7N9 virus in China; lumpy skin disease in Eastern Europe and the Balkan region (Albania, Bulgaria, Greece, Montenegro, Serbia and the former Yugoslav Republic of Macedonia); and peste des petits ruminants in China and Mongolia. The Agency continued to help countries in Africa build capacity to prepare for and address potential threats from Ebola virus outbreaks. More than 72 veterinary diagnostic staff from 22 Member States were trained in the detection and differentiation of Ebola virus at the animal-human interface. The Agency also provided training courses on nuclear derived techniques for detecting the Zika virus to 31 participants from 20 Member States. Additionally, 9 training courses with 153 trainees were conducted and 15 emergency toolboxes were provided to African Member States for the containment of emerging transboundary animal and zoonotic diseases. These were facilitated through the VETLAB network of veterinary diagnostic laboratories and the technical cooperation programme.

Climate-smart agriculture

The Agency expanded its climate-smart soil and water management project in the Kassala region of the Sudan to include more than 1000 female farmers. Introduced in 2015 through the Joint FAO/IAEA Division and in cooperation with scientists from the Agricultural Research Corporation (ARC) in the Sudan, the project helps rural female farmers use low-cost drip irrigation technology combined with fertilizer to produce vegetables. Scientists from ARC used nuclear and isotopic techniques to determine the nitrogen fertilizer use efficiency and the vegetable water requirement. By applying appropriate levels of fertilizer and using drip irrigation technology to deliver the right amount of water for the hot and water-scarce climate, the women are able to grow vegetables for their families and increase the nutritional value of their diet. As most of the farmers involved are refugees, the project has drawn the support of organizations such as the Sudanese Red Crescent Society, the Talawiet Organization for Development and the Office of the United Nations High Commissioner for Refugees. It is seen as a way to both help empower women and make rural Sudanese communities stronger, and to promote the sustainable use and protection of precious water and soil resources.

Human Health

International Conference on Integrated Medical Imaging in Cardiovascular Diseases

The second International Conference on Integrated Medical Imaging in Cardiovascular Diseases (IMIC 2016) was held in Vienna in October, aimed at improving the understanding of medical imaging's role in the management of cardiovascular diseases. The conference provided clinicians, scientists and professionals with an international forum for reviewing the latest developments in all aspects of integrated medical imaging as applied to cardiovascular diseases, including the importance of quality management as an integral part of clinical practice. Some 350 professionals from 88 Member States attended the conference, and more than 1000 took advantage of the live streaming of conference sessions. Notably, IMIC 2016 had the support of 17 professional organizations in the field of nuclear medicine, cardiology and radiology. The conference fulfilled the rigorous requirements of the European Union of Medical Specialists' European Accreditation Council for Continuing Medical Education, and participants were awarded 27 European Continuing Medical Education Credits.

“Some 350 professionals from 88 Member States attended [IMIC 2016], and more than 1000 took advantage of the live streaming of conference sessions.”

Stable isotope techniques to reduce stunting

Stunting is caused by chronic undernutrition and recurrent infections during the most critical period of childhood growth and development. About 159 million children under five years of age are too short for their age and are considered stunted. In 2016, the Agency established a new four year interregional technical cooperation project entitled 'Contributing to the Evidence Base to Improve Stunting Reduction Programmes', in collaboration with CARE, the Inter-American Development Bank (IADB), the United Nations Children's Fund (UNICEF) and the World Bank. Twelve countries in Africa, Asia and Latin America are taking part in the project. Participants have been trained in using stable isotope techniques to help evaluate interventions to address stunting and are in the process of receiving study supplies and obtaining ethical approval for the different studies. These include studies on the impact of breastfeeding promotion programmes on exclusive breastfeeding rates, and the influence of behaviour change communication, micronutrient supplementation and fortified complementary foods on body composition. The project ultimately aims at

determining the effect of increased rates of exclusive breastfeeding and improved body composition on subsequent stunting prevalence.

Water Resources Management

IWAVE Project pilot phase

The United Nations estimates that more than two billion people around the world are living under water stress — a number that is likely to increase in the coming decades. In 2016, the pilot phase of the IAEA Water Availability Enhancement (IWAVE) Project, funded through the Peaceful Uses Initiative, was completed in Costa Rica, Oman and the Philippines. The Agency helped each State to develop a comprehensive approach to identifying gaps in its national hydrological information, as well as its capacity for sustainable water resources management, through nation-wide institutions with a mandate on water. The Project provided training in approaches to data sharing, and fostered dialogue and collaboration that led to new data collection and an improved understanding of resource availability. The Agency worked with experts in Costa Rica to develop a national ‘Agenda for Water’ outlining the country’s goals. In Oman, it helped develop a scientifically sound assessment of groundwater in the agriculturally important Samail catchment. In the Philippines, it strengthened the capacity of the National Water Resources Board and the Philippine Nuclear Research Institute to assess groundwater resources and their vulnerability to pollution in two of the country’s nine water stressed regions. The IWAVE methodology as tested in the pilot phase, and lessons learned therein, will be integrated into new technical cooperation projects.

Environment

Thirtieth anniversary of the Marine Environmental Studies Laboratory (MESL)

“In 2016, the Marine Environmental Studies Laboratory (MESL) in Monaco celebrated its 30th anniversary.”

In 2016, the Marine Environmental Studies Laboratory (MESL) in Monaco celebrated its 30th anniversary. MESL was established to help Member States monitor marine pollution in close collaboration with the Regional Seas Programme of the United Nations Environment Programme (UNEP). Over the years, the Agency, through MESL, has developed a comprehensive approach to strengthening Member State capacities that includes proficiency tests to check laboratory performance, the development of analytical methods and training of scientists in the determination of hazardous contaminants, and the establishment of quality assurance and quality control procedures in laboratories. During 30 years of continuous collaboration with UNEP and the Regional Seas Programme, the Agency has trained more than 400 scientists in 59 training courses at MESL and organized 48 proficiency tests and 31 interlaboratory comparison analyses of contaminants in marine environmental samples, contributing to the generation of quality assured pollution data by Member States.

Proficiency tests and training courses

The Agency organized two training courses on the analysis of trace elements and organic contaminants (chlorinated pesticides, polychlorinated biphenyls and petroleum hydrocarbons) in marine samples. Ten scientists from eight Mediterranean Member States participated in the courses, which were developed in collaboration with the UNEP Mediterranean Action Plan. The training courses included theoretical and practical workshops on sampling techniques at sea, sample preparation and the application of analytical methods for the determination of contaminants. The Agency also organized two

proficiency tests, one on the determination of trace elements in marine biota, with the participation of 31 laboratories from 14 Member States, and one on the determination of organic contaminants in marine sediment, with the participation of 23 laboratories from 13 Member States.

Radioisotope Production and Radiation Technology

The Agency held a Technical Meeting on new ways of producing technetium-99m (^{99m}Tc) and ^{99m}Tc generators. The meeting was part of the Agency's ongoing efforts to assist Member States in the production of ^{99m}Tc , the most widely used radioisotope in nuclear medicine. The meeting presented promising non-reactor based technologies for production of molybdenum-99 (^{99}Mo) — the radioactive parent of ^{99m}Tc — such as through photoactivation of ^{100}Mo targets using linear accelerators, and preparation of generators using low to medium specific activity ^{99}Mo , either with novel high capacity adsorbent materials or in tandem with ^{99m}Tc concentration units.

“a Technical Meeting on new ways of producing technetium-99m (^{99m}Tc) and ^{99m}Tc generators.... presented promising non-reactor based technologies for production of molybdenum-99 (^{99}Mo) — the radioactive parent of ^{99m}Tc ”

NUCLEAR SAFETY AND SECURITY

Nuclear Safety

Identifying priorities to strengthen nuclear safety

The Agency systematically analysed the lessons arising from the Fukushima Daiichi accident, as well as lessons from other relevant sources, to identify priorities for the programme of work to strengthen nuclear, radiation, transport and waste safety, and emergency preparedness and response. These priorities include activities related to, inter alia: external hazards assessment, severe accident management, safety culture, extending the operating life of nuclear power plants, the decommissioning of facilities, the disposal of high level and other radioactive waste, and the safety of radiation sources used in non-power applications.

Safety standards, and peer review and advisory services

The Agency continued its review of the safety standards. In 2016, it published seven Safety Requirements incorporating lessons from the Fukushima Daiichi accident: *Governmental, Legal and Regulatory Framework for Safety* (IAEA Safety Standards Series No. GSR Part 1 (Rev. 1)); *Site Evaluation for Nuclear Installations* (NS-R-3 (Rev. 1)); *Safety of Nuclear Power Plants: Design* (SSR-2/1 (Rev. 1)); *Safety of Nuclear Power Plants: Commissioning and Operation* (SSR-2/2 (Rev. 1)); *Safety Assessment for Facilities and Activities* (GSR Part 4 (Rev. 1)); *Leadership and Management for Safety* (GSR Part 2); and *Safety of Research Reactors* (SSR-3).

Member State requests for the Agency's peer review and advisory services continued to increase and a large number of missions were conducted across all safety areas. The Agency conducted seven Integrated Regulatory Review Service (IRRS) missions; three IRRS follow-up missions; two Emergency Preparedness Review (EPREV) missions; three Operational Safety Review Team (OSART) missions; five OSART follow-up missions; five Site and External Events Design (SEED) missions; four Safety Aspects of Long Term Operation (SALTO) missions; three SALTO follow-up missions; three Integrated Safety Assessment of Research Reactors (INSARR) missions; one INSARR follow-up mission; and three Education and Training Appraisal (EduTA) missions. The Agency also completed three technical safety reviews: two comparing generic reactor design safety documentation against Agency safety standards and one dealing with probabilistic safety assessment.

Major conferences

“The Agency organized four major nuclear safety conferences during the year.”

The Agency organized four major nuclear safety conferences during the year. In February, it held the International Conference on Human and Organizational Aspects of Assuring Nuclear Safety — Exploring 30 Years of Safety Culture, at its Headquarters in Vienna, Austria. The conference was attended by 350 participants from 56 Member States and 7 international organizations. Participants emphasized the benefits of a systemic approach to safety to deal effectively with organizational complexities, and the need to expand work on safety culture to address all nuclear and radiological applications.

In April, the Agency hosted the International Conference on Effective Nuclear Regulatory Systems: Sustaining Improvements Globally, in Vienna, Austria. The conference drew more than 200 participants from 62 Member States and 8 international organizations. Topics of discussion included the lessons and challenges of regulating nuclear installations, radiation sources and radioactive waste. Conference participants noted the importance of increasing Member State adherence to international instruments and highlighted issues for consideration by governments, including ensuring the independence of the regulatory body and providing it with adequate authority, resources and staff.

In May, the International Conference on Advancing the Global Implementation of Decommissioning and Environmental Remediation Programmes took place in Madrid, Spain. The conference, organized by the Agency, was attended by more than 540 experts from 54 Member States and 4 international organizations.

The Agency, in cooperation with the European Commission and the OECD/NEA, organized the International Conference on the Safety of Radioactive Waste Management, held in Vienna in November. The conference drew 276 participants from 63 Member States and 4 international organizations. Participants exchanged information on managing all types of radioactive waste and discussed current and future challenges. Participants also highlighted the need for continued assistance to Member States in building and strengthening the capacities of both regulators and operators.

Improving regulatory effectiveness

Data collected in 2016 on the IRRS follow-up missions showed that Member States with operating nuclear power plants had implemented most of the recommendations and suggestions from the initial IRRS mission. More than 70% of recommendations and 80% of suggestions had been implemented.

In 2016, the Agency completed its Regulatory Infrastructure Development Project, launched in 2013 to strengthen national regulatory infrastructure for the safe use of radiation sources in Member States in North Africa and the Middle East. As a result of this project, the national regulatory infrastructures for radiation safety of the participating Member States, including their authorization processes and inspection programmes, are better aligned with the relevant Agency safety standards. The Agency continued to address the need for improvement of radiation safety infrastructure in those Member States establishing or enhancing their radiotherapy programmes through the Programme of Action for Cancer Therapy (PACT).

Operation of nuclear power plants, research reactors and fuel cycle facilities

The Agency published *OSART Guidelines: 2015 Edition* (IAEA Services Series 12 (Rev. 1)). The revision takes into account lessons arising from the Fukushima Daiichi accident and experience gained from the application of the Agency's safety standards. An increasing number of Member States are requesting Agency safety reviews in the area of long term operation and ageing management; there were nine requests in 2016 compared with four in 2015.

In May, the Agency organized a Technical Meeting on the use of a graded approach in the application of the safety requirements for research reactors at the Agency's Headquarters in Vienna. In July, the Agency published *Safety Reassessment for Nuclear Fuel Cycle Facilities in Light of the Accident at the Fukushima Daiichi Nuclear Power Plant* (Safety Reports Series No. 90), with practical information on performing safety reassessment for all types of nuclear fuel cycle facilities in light of the lessons from the Fukushima Daiichi accident.

Incident and emergency preparedness and response

During 2016, the Agency conducted 13 Convention Exercises involving the active participation of almost 100 Member States and 14 international organizations. Carried out within the framework of the Convention on Early Notification of a Nuclear Accident and the Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency, these 'ConvEx exercises' are held regularly to practise Member State capabilities to respond to a nuclear or radiological emergency. The Agency also conducted 38 training events on various topics of emergency preparedness and response, including four workshops on notification, reporting and requesting assistance, and four workshops on effective public communication in an emergency. A Technical Meeting to review the Agency's assessment and prognosis procedures for nuclear and radiological emergencies was held in Vienna, Austria, in November–December. Participants discussed the assessment and prognosis process and the associated communication procedures. During the meeting, the Agency provided attendees with access to its on-line assessment and prognosis tools and procedures.

“During 2016, the Agency conducted 13 Convention Exercises involving the active participation of almost 100 Member States and 14 international organizations.”

New and expanding nuclear power programmes

Member States embarking on a new nuclear power programme, or expanding an existing programme, continued to request Agency assistance in establishing and strengthening their national safety infrastructures. The Agency conducted around 200 expert missions, workshops and training courses involving participants from 44 Member States with emerging or expanding nuclear power programmes, providing guidance and information on all elements of establishing an effective safety infrastructure. The Agency continued to assist these Member States in establishing and strengthening their national nuclear safety infrastructures through peer reviews, such as the IRRS, and advisory services, such as for site selection and site evaluation.

Leadership and management for safety and safety culture

The Agency issued two publications relating to safety culture assessment during 2016. The first, *Performing Safety Culture Self-assessments* (Safety Reports Series No. 83), provides information on how an organization can develop in-house understanding of, and insights into, its safety culture. Such insights provide opportunities to proactively improve safety awareness and performance. The second, *OSART Independent Safety Culture Assessment (ISCA) Guidelines* (IAEA Services Series 32), provides guidance on how to independently assess safety culture during OSART missions.

Capacity building in nuclear, radiation, transport and waste safety, and emergency preparedness and response

During 2016, the Agency conducted 122 capacity building activities across its programme of work for nuclear, radiation, transport and waste safety, and emergency preparedness and response, with some 2000 participants from over 150 Member States. These training activities were carried out at the national, regional and international levels, and included two Schools of Radiation Emergency Management, held in Austria and Japan. Initiated in

2015, these Schools train qualified professionals from organizations involved in emergency preparedness and response in the basic elements of preparing for and responding to nuclear or radiological emergencies.

Strengthening global, regional and national networks and forums

Member States have increased their interest in and use of the Global Nuclear Safety and Security Network (GNSSN) and its associated networks: in 2016, the web site hosting the GNSSN platform had some 42 000 visitors, compared with 38 000 visitors in 2015. The Agency expanded the GNSSN platform during the year, establishing a portal to provide Member State counterparts secure access to the ARTEMIS peer review service. With the newly established European and Central Asian Safety (EuCAS) Network and Global Nuclear Safety and Security Communicators Network, the GNSSN platform now gathers 22 global, regional and thematic networks, as well as 20 national nuclear safety knowledge platforms.

During the year, the Agency issued *Guidelines on Devising a Programme for Competence Acquisition and Development among Nuclear Regulators* (IAEA-TECDOC-1794) in both English and Spanish. The guidelines were jointly developed with the Ibero-American Forum of Radiological and Nuclear Regulatory Agencies (FORO).

Radiation protection

In 2016, the Agency organized two Technical Meetings on radiation exposure in medicine, providing participants an opportunity to discuss and share experience related to the safety implications of the medical application of radiation. The first meeting, held at the Agency's Headquarters in Vienna in March, addressed justification of medical exposure in diagnostic imaging. The second meeting, held in Vienna in May, focused on patient dose monitoring and the use of diagnostic reference levels for the optimization of protection in medical imaging. Also in May, the Agency, in cooperation with the World Health Organization (WHO) and the National Nuclear Regulator of South Africa, organized a workshop in Cape Town, South Africa, on the Control of Public Exposure in Compliance with the International Basic Safety Standards (IAEA Safety Standards Series No. GSR Part 3).

Radioactive waste management, decommissioning and environmental assessments

In June, the Agency organized a Technical Meeting on remediation techniques and strategies in post-accident situations, in Vienna, Austria. Participants shared knowledge and experience related to the remediation and recovery of contaminated areas and application of the Agency's safety standards. They discussed the identification of appropriate remedial actions to reduce radiation exposures, verification of the results of such actions, and considerations for management of waste generated during remediation activities.

Safety conventions

In relation to the Convention on Nuclear Safety (CNS), several meetings were held in preparation of the upcoming Seventh Review Meeting of the Contracting Parties to the CNS. This included a 'turnover meeting' held in Vienna in March, where the officers of the CNS Sixth Review Meeting shared their experience with the officers elected for the CNS Seventh Review Meeting and provided feedback on the preparation and conduct of the previous review meetings.

In September, a topical meeting of the Contracting Parties to the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management

(Joint Convention) took place at Agency Headquarters on ‘Challenges and Responsibilities of Multinational Radioactive Waste Disposal Facilities’. A meeting to discuss feedback from Contracting Parties to improve the review process for the Joint Convention was held in October.

Civil liability for nuclear damage

The International Expert Group on Nuclear Liability (INLEX) serves as the Agency’s main forum for questions related to nuclear liability. The 16th Meeting of INLEX took place in Vienna, Austria, in May. The Group finalized, inter alia, its discussion on the legal regime applicable to liability for damage caused by radioactive sources and reiterated its recommendation that licences for at least Category 1 and 2 sources should include a requirement that the licensee take out insurance, or other financial security, to cover its potential third party liability. The Group also discussed liability issues relating to long term storage and disposal facilities and to the transport of nuclear material, as well as the scope of application of the Agency’s nuclear liability conventions as regards nuclear fusion installations and SMRs. In this respect, the Group concluded that although international nuclear liability conventions are the relevant instruments for addressing third party liability of SMRs, the low risk involving nuclear fusion installations does not justify their inclusion within the scope of such conventions.

The Fifth Workshop on Civil Liability for Nuclear Damage was held in Vienna in May. The workshop provided participants with an introduction to the international legal regime of civil liability for nuclear damage.

Other outreach activities in 2016 included a joint IAEA–INLEX mission to China to raise awareness of the international legal instruments relevant for achieving a global nuclear liability regime, as well as a Subregional Workshop on Civil Liability for Nuclear Damage for Pacific Island States, held in Sydney, Australia, in March to provide participants with information on the existing international nuclear liability regime and to advise on the development of national implementing legislation.

Nuclear Security

Amendment to the CPPNM

The Amendment to the Convention on the Physical Protection of Nuclear Material (CPPNM) entered into force in May 2016, requiring States Parties to establish, implement and maintain a physical protection regime to protect nuclear facilities and nuclear material in domestic use, storage and transport. The Agency organized the Second Meeting of the Representatives of the States Parties to the CPPNM and its Amendment in December. The meeting was held in Vienna and participants from 71 Parties to the CPPNM discussed the new obligations arising from the entry into force of the Amendment, focusing on issues relating to information sharing. The need to promote universal adherence to the Amendment was also highlighted during the meeting.

“The Amendment to the Convention on the Physical Protection of Nuclear Material (CPPNM) entered into force in May 2016”

International Conference on Nuclear Security

The Agency organized the International Conference on Nuclear Security: Commitments and Actions, held in Vienna, Austria, in December. The conference, comprising a ministerial segment and a scientific and technical programme, was attended by some 2100 participants from 139 Member States, 47 of which were represented at Ministerial level. A Ministerial Declaration¹ was adopted that, inter alia, reasserted national responsibility for nuclear

¹ Available at: https://www.iaea.org/sites/default/files/16/12/english_ministerial_declaration.pdf

security; underlined the importance of keeping pace with the evolving challenges and threats to nuclear security; and recognized the Agency's central role in facilitating and coordinating international cooperation in nuclear security.

IPPAS

To mark the 20th anniversary of the first International Physical Protection Advisory Service (IPPAS) mission, the Agency organized the second International Seminar to Share Experience and Best Practices from Conducting International Physical Protection Advisory Service Missions, held in November in London, United Kingdom. The participants shared the lessons identified and discussed the benefits received from IPPAS missions and their follow-up activities, and considered options for enhancing the service. The Agency carried out six IPPAS missions in 2016, bringing to 75 the total number of IPPAS missions conducted since 1996.

Capacity building

“In 2016, the Agency conducted 92 security related training activities... providing training to more than 1400 participants.”

In 2016, the Agency conducted 92 security related training activities — 39 at the international or regional level and 53 at the national level — providing training to more than 1400 participants. It also launched four new e-learning modules: Introduction to and Overview of IAEA Nuclear Security Series Publications; Radiation Basics and Consequences of Exposure to Radiation; Categorization of Radioactive Material; and Introduction to Radioactive Sources and Their Applications. In addition, the Agency donated 736 handheld radiation detection instruments to States, and assisted the deployment of nine radiation portal monitor systems.

NUCLEAR VERIFICATION ^{2,3}

Implementation of safeguards in 2016

At the end of every year, the Agency draws a safeguards conclusion for each State for which safeguards are applied. This conclusion is based on an evaluation of all safeguards relevant information available to the Agency in exercising its rights and fulfilling its safeguards obligations for that year.

In 2016, safeguards were applied for 181 States^{4,5} with safeguards agreements in force with the Agency. Of the 124 States that had both a comprehensive safeguards agreement (CSA) and an additional protocol (AP) in force⁶, the Agency drew the broader conclusion that all nuclear material remained in peaceful activities for 69 States⁷; for the remaining 55 States, as the necessary evaluation regarding the absence of undeclared nuclear material and activities for each of these States remained ongoing, the Agency concluded only that declared nuclear material remained in peaceful activities. For 49 States with a CSA but

² The designations employed and the presentation of material in this section, including the numbers cited, do not imply the expression of any opinion whatsoever on the part of the Agency or its Member States concerning the legal status of any country or territory or of its authorities, or concerning the delimitation of its frontiers.

³ The referenced number of States Parties to the Treaty on the Non-Proliferation of Nuclear Weapons is based on the number of instruments of ratification, accession or succession that have been deposited.

⁴ These States do not include the Democratic People's Republic of Korea (DPRK), where the Agency did not implement safeguards and, therefore, could not draw any conclusion.

⁵ And Taiwan, China.

⁶ Or an additional protocol being provisionally applied, pending its entry into force.

⁷ And Taiwan, China.

with no AP in force, the Agency concluded only that declared nuclear material remained in peaceful activities. For those States for which the broader conclusion has been drawn, the Agency is able to implement integrated safeguards: an optimized combination of measures available under CSAs and APs to maximize effectiveness and efficiency in fulfilling the Agency's safeguards obligations. During 2016, integrated safeguards were implemented for 57 States^{8,9}.

Safeguards were also implemented with regard to nuclear material in selected facilities in the five nuclear-weapon States party to the Treaty on the Non-Proliferation of Nuclear Weapons (NPT) under their respective voluntary offer agreements. For these five States, the Agency concluded that nuclear material in selected facilities to which safeguards had been applied remained in peaceful activities or had been withdrawn from safeguards as provided for in the agreements.

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

As of 31 December 2016, 12 States Parties to the NPT had yet to bring CSAs into force pursuant to Article III of the Treaty. For these States Parties, the Agency could not draw any safeguards conclusions.

Conclusion of safeguards agreements and APs, and amendment and rescission of small quantities protocols

In 2016, the Agency continued to implement the *Plan of Action to Promote the Conclusion of Safeguards Agreements and Additional Protocols*¹⁰, which was updated in September 2016. During 2016, two APs entered into force.¹¹ Two States¹² amended their operative small quantities protocols (SQPs) to reflect the revised standard text. Additionally, the Board of Governors approved a CSA with an SQP and an AP for one State.¹³ This means that, by the end of 2016, safeguards agreements were in force with 182 States and APs were in force with 129 States. Moreover, 62 had accepted the revised SQP text (which was in force for 56 of these States) and seven States had rescinded their SQPs.

Verification and Monitoring in the Islamic Republic of Iran in light of United Nations Security Council Resolution 2231 (2015)

In 2016, the Agency continued monitoring and verification in the Islamic Republic of Iran (Iran) in relation to the nuclear-related measures set out in the Joint Plan of Action (JPA) until being informed, on 19 January 2016, by China, France, Germany, the Russian Federation, the United Kingdom, the United States of America (E3+3) and Iran, on

⁸ Albania, Andorra, Armenia, Australia, Austria, Bangladesh, Belgium, Bulgaria, Burkina Faso, Canada, Chile, Croatia, Cuba, Czech Republic, Denmark, Ecuador, Estonia, Finland, Germany, Ghana, Greece, Holy See, Hungary, Iceland, Indonesia, Ireland, Italy, Jamaica, Japan, Republic of Korea, Latvia, Libya, Lithuania, Luxembourg, Madagascar, Mali, Malta, Monaco, Netherlands, Norway, Palau, Peru, Poland, Portugal, Romania, Seychelles, Singapore, Slovakia, Slovenia, South Africa, Spain, Sweden, the former Yugoslav Republic of Macedonia, Ukraine, United Republic of Tanzania, Uruguay and Uzbekistan.

⁹ And Taiwan, China.

¹⁰ Available at: <https://www.iaea.org/sites/default/files/16/09/plan-of-action-2015-2016.pdf>

¹¹ Cameroon and Côte d'Ivoire.

¹² Afghanistan and Saint Kitts and Nevis.

¹³ Liberia.

behalf of the E3/EU+3 and Iran, that — with the start of the implementation of the Joint Comprehensive Plan of Action (JCPOA) — the JPA was no longer in effect.¹⁴

On 16 January 2016, the Director General reported to the Board of Governors and in parallel to the United Nations Security Council that the Agency had verified that Iran had taken the actions specified in paragraphs 15.1–15.11 of Annex V of the JCPOA. Implementation Day occurred on the same day.

Also on 16 January 2016, Iran began to provisionally apply the Additional Protocol to its Safeguards Agreement in accordance with Article 17(b) of the Additional Protocol, pending its entry into force, and to fully implement the modified Code 3.1 of the Subsidiary Arrangements to its Safeguards Agreement.

Since Implementation Day, the Agency has been verifying and monitoring Iran's nuclear-related commitments under the JCPOA. During 2016, the Director General submitted six reports to the Board of Governors and in parallel to the United Nations Security Council entitled *Verification and Monitoring in the Islamic Republic of Iran in light of United Nations Security Council Resolution 2231 (2015)* (GOV/INF/2016/1, GOV/2016/8, GOV/2016/23, GOV/2016/46, GOV/2016/55 and GOV/INF/2016/13).

Syrian Arab Republic (Syria)

In August 2016, the Director General submitted a report to the Board of Governors entitled *Implementation of the NPT Safeguards Agreement in the Syrian Arab Republic* (GOV/2016/44) covering relevant developments since the previous report in August 2015 (GOV/2015/51). The Director General informed the Board of Governors that no new information had come to the knowledge of the Agency that would have an impact on the Agency's assessment that it was very likely that a building destroyed at the Dair Alzour site was a nuclear reactor that should have been declared to the Agency by Syria.¹⁵ In 2016, the Director General renewed his call on Syria to cooperate fully with the Agency in connection with unresolved issues related to the Dair Alzour site and other locations. Syria has yet to respond to these calls.

On the basis of the evaluation of information provided by Syria and all other safeguards relevant information available to it, the Agency found no indication of the diversion of declared nuclear material from peaceful activities. For 2016, the Agency concluded for Syria that declared nuclear material remained in peaceful activities.

Democratic People's Republic of Korea (DPRK)

In August 2016, the Director General submitted a report to the Board of Governors and General Conference entitled *Application of Safeguards in the Democratic People's Republic of Korea* (GOV/2016/45–GC(60)/16), which provided an update of developments since the Director General's report of August 2015 (GOV/2015/49–GC(59)/22).

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, the Agency could not draw any safeguards conclusion regarding the DPRK.

¹⁴ In January 2016, the Director General submitted to the Board of Governors a report entitled *Status of Iran's Nuclear Programme in relation to the Joint Plan of Action* (GOV/INF/2016/3).

¹⁵ The Board of Governors, in its resolution GOV/2011/41 of June 2011 (adopted by a vote) had, inter alia, called on Syria to urgently remedy its non-compliance with its NPT Safeguards Agreement and, in particular, to provide the Agency with updated reporting under its Safeguards Agreement and access to all information, sites, material and persons necessary for the Agency to verify such reporting and resolve all outstanding questions so that the Agency could provide the necessary assurance as to the exclusively peaceful nature of Syria's nuclear programme.

On 6 January 2016, the DPRK announced that it had conducted a nuclear test and on 9 September 2016 the DPRK announced that it had conducted another nuclear test.

In 2016, no verification activities were implemented in the field, but the Agency continued to monitor the DPRK's nuclear activities by using open source information, including satellite imagery and trade information. The Agency maintained operational readiness to resume safeguards implementation in the DPRK, and continued to further consolidate its knowledge of the DPRK's nuclear programme.

During 2016, the Agency continued to observe indications which were consistent with the operation of the Yongbyon Experimental Nuclear Power Plant (5 MW(e)) at Yongbyon. This followed a period between mid-October and early December 2015 when there were no such indications. This period was sufficient for the reactor to have been de-fuelled and subsequently re-fuelled. Based on past operational cycles, a new cycle commencing in early December 2015 can be expected to last about two years.

From the first quarter of 2016, there were multiple indications consistent with the Radiochemical Laboratory's operation, including deliveries of chemical tanks and the operation of the associated steam plant. Such indications ceased in early July 2016. In previous reprocessing campaigns, the Radiochemical Laboratory's operation involved the use of the spent fuel discharged from the Yongbyon Experimental Nuclear Power Plant (5 MW(e)).

At the Yongbyon Nuclear Fuel Rod Fabrication Plant there were indications consistent with the use of the reported centrifuge enrichment facility located within the plant. Additional construction work around the building that houses this reported facility has been ongoing.

The Agency has not had access to the Yongbyon site. Without access to the site, the Agency cannot confirm the operational status of the facilities on the site, or the nature and purpose of the activities observed.

The continuation and further development of the DPRK's nuclear programme and related statements by the DPRK, including those about continuing to "boost" its "nuclear force", are a major cause for concern. The DPRK's nuclear activities, including those in relation to the Yongbyon Experimental Nuclear Power Plant (5 MW(e)) and the Radiochemical Laboratory, and the use of the building which houses the reported enrichment facility are deeply regrettable. Such actions are clear violations of relevant United Nations Security Council resolutions, including resolutions 2270 (2016) and 2321 (2016). The DPRK's fourth and fifth nuclear tests, announced on 6 January and 9 September 2016, respectively, are also in clear violation of United Nations Security Council resolutions and deeply regrettable.

Enhancing safeguards

During 2016, the Agency completed updating State-level safeguards approaches for the remaining States in the original group of 53 States that were already under integrated safeguards at the start of 2015. In addition, it developed State-level safeguards approaches for: eight States with a CSA and an AP in force and a broader conclusion; two States with a CSA and AP in force but without a broader conclusion; and one State with a voluntary offer agreement and an AP in force. In developing and implementing a State-level safeguards approach, consultations are held with the relevant State and/or regional authority, particularly on the implementation of in-field safeguards measures.

Cooperation with State and regional authorities

To assist States in building capacity for implementing their safeguards obligations, the Agency conducted nine international, regional and national training courses for those responsible for overseeing and implementing the State and regional systems of accounting for and control of nuclear material. The Agency also participated in several other training

activities organized by Member States on a bilateral basis. In 2016, the Agency carried out two INIR missions that included, inter alia, advice on how to systematically enhance the capabilities necessary for the application of safeguards while embarking on a nuclear power programme.

Safeguards equipment and tools

Throughout 2016, the Agency ensured that the instrumentation and monitoring equipment installed in nuclear facilities around the world vital to effective safeguards implementation continued to function as required. The Agency continued with the next generation surveillance system implementation campaign, replacing outdated surveillance units.

Safeguards analytical services

In 2016, the Agency collected 603 nuclear material samples, all of which were analysed by the Agency's Nuclear Material Laboratory (NML). It also collected 474 environmental samples during the year, which were analysed by the Network of Analytical Laboratories, including at the Agency's Environmental Sample Laboratory and the NML. Proficiency tests and quality procedures were applied to ensure the correctness and accuracy of all results.

Developing the safeguards workforce

In 2016, the Agency conducted over 160 safeguards training courses to provide safeguards inspectors and analysts with necessary technical and behavioural competencies. These included two Introductory Courses on Agency Safeguards held at Agency Headquarters for 23 newly recruited safeguards inspectors, and numerous courses held at nuclear facilities to enhance practical competencies for safeguards implementation in the field.

Information technology: MOSAIC

During 2016, the Agency introduced new IT tools and capabilities, completed the enhancement of all legacy safeguards IT applications and strengthened the information security of safeguards data as part of the Modernization of Safeguards Information Technology (MOSAIC) project. The new and refurbished IT tools have enabled the Agency to increase effectiveness, find efficiencies and enhance security, while meeting the ever increasing demand for its services.

Preparing for the future

In 2016, the Agency published *Development and Implementation Support Programme for Nuclear Verification 2016–2017*. The programme provides a detailed picture of all development work that is expected to take place in 2016–2017. To address the near term development objectives and to support the implementation of its verification activities, the Agency continued to rely on Member State Support Programmes in implementing many of these activities. At the end of 2016, 20 States¹⁶ and the European Commission had formal support programmes with the Agency.

¹⁶ Argentina, Australia, Belgium, Brazil, Canada, China, Czech Republic, Finland, France, Germany, Hungary, Japan, Republic of Korea, Netherlands, Russian Federation, South Africa, Spain, Sweden, United Kingdom and United States of America.

“In 2016, the Agency conducted over 160 safeguards training courses to provide safeguards inspectors and analysts with necessary technical and behavioural competencies.”

MANAGEMENT OF TECHNICAL COOPERATION FOR DEVELOPMENT

The technical cooperation programme in 2016

The technical cooperation programme is the Agency's key mechanism for transferring technology and building capacities in the peaceful use of nuclear science and technology, helping Member States to achieve their development goals and to address a range of global challenges. In 2016, health and nutrition accounted for the highest proportion of actuals — that is, disbursements — through the technical cooperation programme, at 25.8%. This was followed by safety at 23.1%, and by food and agriculture at 17.3%. By the end of the year, financial implementation of the Technical Cooperation Fund (TCF) stood at 84.6%. Regarding non-financial implementation, the programme supported, *inter alia*, 3777 expert and lecture assignments, 193 regional and interregional training courses, and 1701 fellowships and scientific visits.

Through its technical cooperation programme, the Agency continued to support Member States in building their human capacity for sustainable development. The programme focused on improving programme and project quality, building partnerships, strengthening regional cooperation, and enhancing radiation safety and security for the peaceful application of nuclear energy. It also increased efforts to enhance governmental and regulatory safety infrastructure, and the radiation protection capacities of end users of ionizing radiation. Demonstrating a high degree of responsiveness and flexibility through the technical cooperation programme, immediate support was provided to Member States in response to outbreaks of disease such as lumpy skin disease in Europe and Zika in Latin America, and to natural disasters such as the earthquake in Ecuador.

The technical cooperation programme is guided by the priorities expressed in individual Country Programme Frameworks and national development plans, as well as by regional programme frameworks and priorities. The programme also aims to contribute to globally agreed development objectives, such as the SDGs. Under the 2016–2017 technical cooperation cycle, nine new Member States have benefited from their first ever national technical cooperation programmes.

Overview of regional activities

In Africa, support for Member States focused on human resource capacity building activities, networking, knowledge sharing and partnership facilitation, and on the procurement of equipment. Interventions concentrated on human health, agriculture and food security, environmental sustainability, and legal and regulatory frameworks.

In human health, significant improvements were made in the establishment, re-establishment or expansion of radiotherapy services in several countries, including Botswana, Madagascar, Senegal and Uganda, where the Agency supported the design and implementation of quality assurance programmes and the establishment of training and education programmes in medical physics as it applies to nuclear medicine. In November, the Agency issued *Enhancing Patient Care in Africa through Safe Medical Imaging* (IAEA Brief No. 2016/1) on the role of the medical physicist in medical imaging. The brief encourages Member States to establish policies to ensure better safety and greater effectiveness in diagnostic imaging.

With Agency support, several national veterinary laboratories enhanced their capacity to detect veterinary drug residues in 2016. This has improved food safety in national markets and is supporting food exports from, for example, Benin, Botswana and Morocco. In the field of animal diseases, improved capacities in molecular diagnostic techniques are contributing to increased food safety and better control of transboundary diseases. In 2016, the Botswana National Veterinary Laboratory was recognized as a reference laboratory for contagious bovine pleuropneumonia by the World Organisation for Animal Health.

*“the [technical cooperation] programme supported, *inter alia*, 3777 expert and lecture assignments, 193 regional and interregional training courses, and 1701 fellowships and scientific visits.”*

In Cameroon, the Yaoundé Annex of the National Veterinary Laboratory (LANAVET) was opened, bringing diagnostic services closer to the animal breeders in the south of the country. LANAVET, a leading national and subregional actor in the fight against emerging zoonotic diseases, is training scientists from other African Member States, under the technical cooperation programme, in biosafety and biosecurity with regard to emerging zoonotic diseases such as Ebola and highly pathogenic avian flu.

Environmental sustainability and water availability are among the priorities in the Africa region. In 2016, the Agency's regional Sahel project completed a first, broad overview of groundwater resources in the Sahel region. The 13 participating Member States produced five transboundary aquifer/basin reports, important for formulating major recommendations to improve water resource management in the Sahel.

In the Asia and the Pacific region, the priority thematic areas for the 2016–2017 technical cooperation cycle were human health and nutrition, safety and security, food and agriculture, industrial applications, and water and the environment. Under human health, the technical cooperation programme helped Member States build capacity and competence in the use of emerging multimodality molecular diagnostic imaging and therapeutic nuclear medicine techniques to manage and treat non-communicable diseases, including cancer. The safe and secure application of nuclear medicine techniques was further emphasized through regional capacity building and support for the application of quality assurance systems.

Regional projects in radiation safety focused on helping Member States in the region to establish and sustain robust national infrastructure for radiation safety via review missions, the development of national plans, and capacity building for regulatory bodies and users of radiation technology. The programme also helped enhance the radiation safety and dosimetry capacities of hospitals to ensure radiation protection of patients and workers in diagnostic and interventional radiology and nuclear medicine.

In Europe and central Asia, technical cooperation activities in 2016 focused on the development of institutional and human resource capacities, and on enhancing cooperation among Member States. Four areas were prioritized: nuclear and radiation safety; nuclear energy; human health; and isotope and radiation technology applications, including environmental, agricultural and industrial applications.

Demand continued to increase in the region for technical cooperation related to nuclear power as an option to supply safe, economical and reliable energy. Requests also increased for cooperation in the areas of radioactive waste management, spent fuel management and the decommissioning of nuclear facilities. Support in connection with nuclear medicine and cancer treatment remained in high demand, as did activities related to stakeholder involvement in regulatory decision making processes.

The Agency was able to provide Member States in the Europe region with emergency assistance in response to an outbreak of lumpy skin disease in 2016. This highly infectious cowpox virus is common in Africa and Asia, and has been spreading through south-eastern Europe since 2013. Through the technical cooperation programme, experts in the region were trained in how to detect the virus quickly and accurately.

In the Latin America and the Caribbean region, the priority thematic areas for the 2016–2017 technical cooperation cycle were health and nutrition (with a focus on cancer), followed by nuclear safety, food and agriculture, and water and the environment. More than 70% of core funding was allocated to these areas.

Ecuador suffered a catastrophic earthquake on its Pacific coast in April 2016. The technical cooperation programme provided immediate assistance in the form of expert advice on the use of non-destructive testing as part of the emergency response, and provided mobile X ray equipment for medical diagnoses.

The outbreak of Zika virus disease also posed a challenge for the region. With Agency assistance, state of the art equipment was procured for the rapid detection of Zika and other vector transmitted viruses. A complementary four year regional technical cooperation project was also approved, which will support implementation of the sterile insect technique

“The Agency was able to provide Member States in the Europe region with emergency assistance in response to an outbreak of lumpy skin disease in 2016.”

to suppress the mosquito population. Eleven Zika affected Member States are benefiting from equipment and training under this project.

The spread of the Mediterranean fruit fly in the Dominican Republic required immediate Agency cooperation through the technical cooperation programme. With firm government intervention and support through the technical cooperation programme, the outbreak was controlled after six months, and commercial activities were restored in 2016.

Programme of Action for Cancer Therapy (PACT)

Through its Programme of Action for Cancer Therapy (PACT), the Agency, in collaboration with key partners, helps low and middle income Member States to improve access to radiation medicine as part of a comprehensive cancer control framework. Activities in 2016 focused on strengthening the skills of health professionals and mobilizing additional resources for quality, safe, effective and sustainable cancer services.

During the year, the Agency established new and intensified existing partnerships with Member State institutions, the private sector, relevant foundations and civil society organizations to support Member States in addressing the global cancer burden effectively and in a cohesive and coordinated manner.

Eight Member States received integrated missions of PACT (imPACT) reviews to assess their national cancer control capacities. The Member States were provided with recommendations for addressing their cancer burdens.

The Agency also facilitated and supported training for health professionals in a broad range of cancer related subjects. Namibia and Rwanda received valuable expert advisory support on the development of their national cancer control plans. In El Salvador and Myanmar, the Agency and WHO convened national workshops to support Member State priorities in, and to cost, cancer control activities. The Agency further developed the courses available on the Virtual University for Cancer Control e-learning platform, including a master's level course in clinical oncology, in preparation for the platform's expansion to additional sub-Saharan countries.

“Eight Member States received integrated missions of PACT (imPACT) reviews to assess their national cancer control capacities.”

Legislative assistance

In 2016, the Agency continued to provide legislative assistance to its Member States through the technical cooperation programme. Country specific bilateral legislative assistance on drafting national nuclear legislation was provided to 19 Member States, while 2 regional and 5 national workshops on nuclear law were organized during the year.

The Agency also organized the sixth session of the Nuclear Law Institute in Baden, Austria, from 10 to 21 October 2016, which is designed to meet the increasing demand by Member States for legislative assistance and to enable participants to acquire a solid understanding of all aspects of nuclear law. Fifty-eight participants from Member States from all four regions attended the training.

Technical cooperation programme management

In 2016, several measures were taken to further improve the programme quality of the current and future technical cooperation cycles. The Agency revised and updated its technical cooperation programme quality criteria, which are applicable across all phases of the programme cycle. It released a new tool for Programme Management Officers, National Liaison Officers and project counterparts, providing guidance to project teams on the requirements for high quality project design. Finally, it conducted a first quality review of project documents for the 2018–2019 programme cycle, providing project teams with feedback and recommendations for enhancing the quality of their projects.

As part of the new framework for monitoring the outcomes of technical cooperation projects, the Agency developed outcome monitoring plans, which are being implemented for selected pilot projects. A tool for the electronic submission of Project Progress Assessment Reports (PPARs), developed to facilitate effective and efficient reporting of project results, was piloted in the 2016 submission round. Agency efforts to build project management capacity focused strongly on new Member States, with the provision of training in results based management using the logical framework approach, monitoring and evaluation. Practical project design workshops were conducted for Programme Management Officers, technical officers, National Liaison Officers and project counterparts. The overall aim was to prepare and implement projects, in line with the guidance of the Agency's Policy-Making Organs, that better respond to Member State needs and priorities, and that are of high quality, with measurable, attainable and timely objectives.

Technical cooperation and the global development context

Following the adoption of the Sustainable Development Goals (SDGs) the Agency has identified nine SDGs where it can support Member States in addressing their development challenges through its technical cooperation projects and a wide range of programmatic activities.

In July, the Agency attended the 2016 United Nations High-level Political Forum on Sustainable Development (HLPF), using the occasion to outline the benefits of nuclear science and technology and its contribution to the attainment of the SDGs, and hosting a side event on food security. During the meeting, the Agency participated in a panel debate on maximizing the impact of SDG 9 (Infrastructure and Industry) on other goals. As part of the lead-up to the 2017 HLPF, the Agency also took part in an expert meeting on 'Readying Institutions and Policies for Integrated Approaches to the 2030 Agenda', held in Vienna in December.

SCIENTIFIC FORUM

'Nuclear Technology for the Sustainable Development Goals' was the theme of the 2016 Scientific Forum, held at the Agency's Headquarters during the 60th regular session of the General Conference. Leading experts, academics and industrial representatives outlined many of the ways that nuclear technology can be used to help achieve the Sustainable Development Goals.

The forum highlighted the importance of global access to radiation medicine, the pursuit of nuclear science partnerships and the use of nuclear technology to boost crop yield. It also outlined the beneficial roles of nuclear energy in the pursuit of low carbon technologies as well as the use of radioactive isotopes in global natural resource management. A key message of the forum was that nuclear technology will bring more tangible benefits if it is integrated into broader development strategies.

The Agency took part in the European Development Days (EDDs) held in Brussels in June, and hosted an Interactive Lab Debate under the EDD topic 'Planet'. The debate focused on water, the energy and food nexus, and climate change, as well as on the connection between global challenges, sustainable development and nuclear technologies. The Agency also participated in the EDD Global Village, showcasing three projects conducted through the Agency's technical cooperation programme and the Joint FAO/IAEA Division.

In November, the Agency participated in the United Nations Convention to Combat Desertification (UNCCD) Committee for the Review of the Implementation of the Convention, in Nairobi, Kenya. The Agency is recognized as a scientific partner of UNCCD and works to coordinate technical cooperation project activities with UNCCD efforts on

the ground and to build relationships with national UNCCD focal points in national environment ministries.

In 2016, the Agency signed a Delegation Agreement with the European Commission, which supports continued work with the European Union on regional and interregional projects to address the development needs of Agency Member States in the area of nuclear safety. It also signed a cooperation agreement with the International Renewable Energy Agency (IRENA) aimed at coordinating joint energy planning capacity building and training, including joint events and the exchange of experts in the field of energy planning.

In response to Member State requests, the Agency issued a document entitled *Addressing the Challenges Facing Least Developed Countries in the Peaceful Application of Nuclear Energy through the Technical Cooperation Programme*. The document, presented at the November meeting of the Technical Assistance and Cooperation Committee, highlighted how the Agency helps countries to address these challenges and their development needs. In December, the Agency brought together several small island developing States from the Asia and the Pacific and the Latin America and the Caribbean regions to discuss how the technical cooperation programme could support addressing their challenges and contribute to their sustainable development.

Twenty Country Programme Frameworks and ten United Nations Development Assistance Frameworks (UNDAFs) were co-signed in 2016.

Financial resources

The technical cooperation programme is funded by contributions to the TCF, as well as through extrabudgetary contributions, government cost sharing and contributions in kind. Overall, new resources reached a total of some €101.1 million in 2016, with approximately €81.6 million for the TCF (including assessed programme costs (APCs), National Participation Costs¹⁷ (NPCs) and miscellaneous income), €18.7 million in extrabudgetary resources, and about €0.8 million representing in kind contributions.

The rate of attainment for the TCF stood at 93.6% on pledges and at 92.9% on payments at the end of 2016, while payment of NPCs totalled €2.8 million.

Actuals

In 2016, approximately €85.2 million was disbursed to 146 countries or territories, of which 37 were least developed countries, reflecting the Agency's ongoing effort to address the development needs of those States.

MANAGEMENT ISSUES

Efficiency gains – Partnership for Continuous Improvement

In 2016, the Agency continued to streamline business processes and eliminate unnecessary bureaucracy through the Partnership for Continuous Improvement initiative. Greater use of off-site arrangements for translation reduced travel and associated costs. Streamlined work processes reduced processing times in procurement and budget and finance.

¹⁷ 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 the assessed amount for the programme must be paid before contractual arrangements for the projects may be made.

Gender equality and gender mainstreaming

“The proportion of women in professional and higher categories reached 29% by the end of 2016, and the percentage of women in senior management positions (D level or higher) reached 28%, the highest in the Agency’s history.”

The proportion of women in professional and higher categories reached 29% by the end of 2016, and the percentage of women in senior management positions (D level or higher) reached 28%, the highest in the Agency’s history. During the year, the Agency implemented a Gender Action Plan that included events to promote gender awareness and activities to build a talent pipeline. Departmental level reporting on gender related staffing and programmatic activities was strengthened, and the gender focal point programme was revitalized.

Agency-wide Information System for Programme Support (AIPS)

The AIPS Plateau 4 systems for Travel, Events and Performance Management were completed in 2016. The Travel system became fully operational in September, with no significant business disruption. At the end of the year, the Agency launched the Events Management system and the new Performance Management system was ready to be used for work plans for 2017. Work continued during 2016 on the final component, a new portal for Member States.

IT information security

In 2016, the Agency began implementing an initiative to strengthen the security of its information systems. The projects include strengthening information security rules and procedures, increasing security awareness through staff training and implementing stronger security controls on the Agency’s information technology infrastructure.

Partnerships and resource mobilization

In 2016, the Agency’s implementation of the *Strategic Guidelines on Partnerships and Resource Mobilization*, approved by the Board of Governors in June 2015, contributed to a more coordinated and comprehensive approach to partnerships and resource mobilization activities. The Agency continued to seek opportunities to mobilize resources and expand its partnerships, including with the private sector.

Nuclear Technology

The background is a solid light blue color with a fine, repeating pattern of small white dots. Overlaid on this are several large, semi-transparent light blue circles of varying sizes. Three thick, solid blue lines curve across the composition, resembling orbital paths or stylized atomic trajectories. Scattered throughout the design are numerous squares of different shades of blue and white, some appearing as if they are floating or attached to the circular elements.

Nuclear Power

Objective

To assist Member States embarking on new nuclear power programmes in planning and building their national nuclear infrastructures. To provide integrated support to Member States with existing nuclear power plants and to those planning new nuclear build in order to help improve operating performance and help ensure safe, secure, efficient and reliable long term operation through the implementation of good practices and innovative approaches, and lessons learned from the Fukushima Daiichi accident. To provide collaborative frameworks for operators of water cooled reactors to benefit from advances in technology, and for Member States to facilitate effective development of fast reactors and gas cooled reactors and to expand the safe use of non-electric applications.

Launching Nuclear Power Programmes

In 2016, around thirty Member States were actively considering or planning a nuclear power programme (Table 1). The Agency supported these embarking countries through Integrated Nuclear Infrastructure Review (INIR) missions; workshops and other training opportunities; and tools such as the Country Nuclear Infrastructure Profile and Integrated Work Plan mechanisms.

TABLE 1. Number of Member States considering or planning a nuclear power programme, according to their official statements (as of 31 December 2016)

First nuclear power plant started construction/under construction	2
First nuclear power plant ordered	2
Decided to introduce nuclear power and started preparing the appropriate infrastructure	6 ^a
Active preparation for a possible nuclear power programme with no final decision	7
Considering a nuclear power programme	10

^a Includes Viet Nam, whose National Assembly in November 2016 endorsed the Government's decision to cancel the country's nuclear power plans.

The Agency's INIR missions remained a key element of its assistance to embarking Member States. In 2016, the Agency conducted INIR Phase 1 missions to Malaysia and Kazakhstan, and INIR follow-up missions to Bangladesh and Poland. Since the service's launch in 2009, the Agency has deployed a total of 21 INIR missions to 15 Member States (Table 2). In December, the Agency published *Evaluation of the Status of National Nuclear Infrastructure Development* (IAEA Nuclear Energy Series No. NG-T-3.2 (Rev. 1)), describing the approach to evaluating national nuclear infrastructure development used in INIR missions. The revision takes into account feedback from past INIR missions and self-evaluations, and the lessons from the accident at the Fukushima Daiichi nuclear power plant.

TABLE 2. Member States that have received INIR missions since the service was introduced in 2009; as of the end of 2016, the Agency had conducted 21 INIR missions

Region	Embarking	Expanding
Africa	Kenya, Morocco, Nigeria	South Africa
Asia and the Pacific	Bangladesh, Indonesia, Jordan, Malaysia, Thailand, Viet Nam, United Arab Emirates	
Europe	Belarus, Kazakhstan, Poland, Turkey	

Activities in 2016 focused on increasing Member State awareness and understanding of the ‘Milestones’ approach to introducing nuclear power, and key issues such as building a national position, road maps for nuclear programme development, management, human resource development, the legal and regulatory framework, and funding and financing. Stakeholder involvement continued to be an important area of attention for countries at all stages of nuclear infrastructure development. The Agency published *Industrial Involvement to Support a National Nuclear Power Programme* (IAEA Nuclear Energy Series No. NG-T-3.4) to assist Member States in establishing national policies and strategies for local industrial involvement and in assessing their available industrial supply options and capabilities, including the national supply chain. A Technical Meeting on the Environmental Impact Assessment Process for Nuclear Power Programmes, organized by the Agency and held in Vienna in May, was attended by 61 participants from 32 Member States. It brought together nuclear and environmental regulators to discuss the challenges in managing the interface between the radiological and non-radiological impact assessment activities ahead of a site licence application.

The Agency standardized the Country Nuclear Infrastructure Profile and Integrated Work Plan mechanisms taking into account the recommendations of INIR missions and the results of technical cooperation projects. The improved mechanisms were used for planning activities in embarking Member States with active nuclear infrastructure development programmes.

Support was provided to Ghana, Kenya, Malaysia, Morocco, Saudi Arabia and the Sudan in conducting studies required for the preparation of a comprehensive report to be used in taking an informed decision on whether to introduce nuclear power into their energy mix. The Agency conducted workshops on nuclear power programme development road maps with Egypt, Saudi Arabia, Sri Lanka and the Sudan, and advised Tunisia and the Sudan on how to prepare the INIR self-evaluation report.

Operating Nuclear Power Plants and Expanding Nuclear Programmes

The number of operating nuclear power reactors grew to 448 in 2016; 270 of these reactors have been in service for over 30 years. As of the end of 2016, 61 reactors were under construction. The Agency continued to support countries with operating nuclear power plants, mainly by disseminating operational experience and good practices in technology, management and human resources, and by sharing new models, methods, tools and processes for efficient and reliable operation and construction.

Agency activities in this area were expanded to include analysis of specific conditions, cost drivers and reasons for economic challenges, and to identify optimized approaches to technology and management and improvements in existing operational programmes, processes and procedures. The Agency held several meetings on these topics throughout the year, including a Technical Meeting on the Economics of Nuclear Power Plant Life Extension and Long Term Operation held in May at the Agency’s Headquarters in Vienna. The meeting drew 23 participants from 18 Member States, who discussed technical and

managerial cost drivers and economic intricacies, and defined major parameters for economic assessment for long term operation of nuclear power plants.

In August, the Agency organized a Technical Meeting on Plant Life Management during the Transition from Operation to Decommissioning of Nuclear Power Plants to help Member States better prepare for planned or premature retirement of nuclear power reactors. Held in Gyeongju, Republic of Korea, the meeting was attended by 75 participants from 13 Member States. Participants identified a number of factors as being critical for a successful transition, including early planning, allocation of dedicated resources in a timely manner, consideration of the significant cultural and organizational changes involved, availability of relevant data and records, and good communication and stakeholder involvement.

At a Technical Meeting on Strengthening Resiliency in Nuclear Power Plant Operations in the Face of Current and Future Challenges held in September in Vienna, 26 executives and leaders of nuclear operating organizations from 10 Member States and 2 international organizations shared experience related to medium and long term challenges in nuclear power plant operation. Participants emphasized the importance of maintaining safety and enhancing the efficiency and effectiveness of nuclear electricity generation. The sixth Nuclear Operating Organization Cooperation Forum, also held in September, during the 60th regular session of the General Conference, gathered together more than 100 industry executives from China, France, the Russian Federation, the United States of America and NUGENIA (Nuclear Generation II & III Association). The participants concluded that, for nuclear power to continue to be sustainable and economically competitive, it is important that operators win and maintain public confidence by paying careful attention to costs and to the management of radioactive waste.

The Agency issued two publications on nuclear power in the IAEA Nuclear Energy Series in 2016. *Technical Challenges in the Application and Licensing of Digital Instrumentation and Control Systems in Nuclear Power Plants* (IAEA Nuclear Energy Series No. NP-T-1.13) presents the technical challenges faced by operators, developers, suppliers and regulators, enabling users, and the industry more broadly, to benefit from shared experience, recent technological developments, and emerging best practices. *Procurement Engineering and Supply Chain Guidelines in Support of Operation and Maintenance of Nuclear Facilities* (IAEA Nuclear Energy Series No. NP-T-3.21) provides an overview of nuclear equipment procurement processes and issues of special concern, as well as guidance on good practices for setting up and managing a high quality procurement organization. A related on-line Nuclear Contracting Toolkit, also published in 2016, was designed to support all levels of procurement activities related to major nuclear power projects, including developing a procurement strategy, proposing and soliciting bids, and negotiating and managing contracts (Fig. 1).



FIG. 1. The Agency's new on-line Nuclear Contracting Toolkit is aimed at supporting Member State procurement activities related to major nuclear power projects.

Integrated Management Systems

The Agency continued to explore and disseminate good practices and potential improvements in the use of integrated management systems in the operation and construction of nuclear power plants. The strong relationship between quality assurance and management systems, including the supply chain, was discussed at a Technical Meeting held in Vienna in June, attended by 65 participants from 26 Member States and 2 international organizations, and at the joint 14th IAEA–FORATOM Management System Workshop, held in Vienna in December, with over 110 experts from 42 Member States. Both meetings emphasized the importance of the role of nuclear leadership in ensuring safe and economical operation through quality management.

Capacity Building and Management Support

A major challenge for the nuclear field is to maintain a reliable supply of personnel in order to ensure that a competent workforce is available for all life cycle phases of a nuclear facility. In April, the Agency organized a Technical Meeting, held at the Ringhals Nuclear Power Plant in Sweden, that offered participants practical guidance on improving plant and human performance, and training programmes at nuclear facilities. At a meeting of the Technical Working Group on Managing Human Resources in the Field of Nuclear Energy held in June in Vienna, 21 participants from nuclear facilities, utilities, regulatory bodies and academia, representing 19 Member States, discussed educational programmes, training procedures, workforce productivity and staffing plans. The participants focused on long term and advance planning for human resources management to ensure that the knowledge of staff who are about to retire is preserved.

In 2016, the Agency added two new modules to its on-line E-learning for Nuclear Newcomers series, designed to explain the Agency's 'Milestones' approach. The new modules, on 'Building a National Position' and 'Culture for Safety', bring to 15 the number of interactive modules available on the Agency's web site.

“In 2016, the Agency added two new modules to its on-line E-learning for Nuclear Newcomers series,.... on ‘Building a National Position’ and ‘Culture for Safety’”

Nuclear Technology Development

Advanced water cooled reactors

As a follow-up of the IAEA Action Plan on Nuclear Safety, the Agency organized a Technical Meeting on Phenomenology and Technologies Relevant to In-Vessel Melt Retention and Ex-Vessel Corium Cooling, held in Shanghai, China, in October. Attended by over 60 experts from 18 Member States, the meeting provided a forum for exchanging the most recent research and development results in this area and for discussing strategies and measures to retain melted core in the reactor or the containment vessel. In December, the Agency held a Workshop on Understanding the Role of Severe Accident Management Guidelines to raise awareness of the importance of establishing reliable and systematic guidance on the mitigative actions to be taken in case of a severe nuclear accident. The workshop was attended by 51 participants from 25 Member States and 3 international organizations.

The Agency conducted several other training activities during the year, including a workshop on nuclear technology assessment held in Kenya to assist newcomer countries in evaluating available nuclear power technologies against country specific environments, site requirements and energy needs. Courses on understanding the physics and technology of advanced reactors using PC based simulators were held in the Republic of Korea, Mexico and Tunisia. The Agency expanded the suite of reactor simulators used in the courses to

include a new generic integral pressurized water reactor simulator. A new course on the use of computational fluid dynamics for nuclear power plant design and safety analysis was held in China. The course was attended by over sixty professionals, from 13 institutes in China and from one each in Brazil and South Africa.

The Agency completed the CRP entitled ‘Understanding and Prediction of Thermal Hydraulics Phenomena Relevant to Supercritical Water Cooled Reactors’, aimed at facilitating collaborative activities to develop the supercritical water cooled reactor concept. This innovative technology was also the focus of two Technical Meetings in 2016: the Technical Meeting on Heat Transfer, Thermal-Hydraulics and System Design for Supercritical Water Cooled Reactors, held in August in Sheffield, United Kingdom, and the Technical Meeting on Materials and Chemistry for Supercritical Water Cooled Reactors, held in October in Řež, Czech Republic.

Small and medium sized or modular reactors

Member State interest in the development of small and medium sized or modular reactors (SMRs) for both electricity generation and non-electric applications continued to grow. To address this growing interest, the Agency held a Technical Meeting on Technology Assessment of Small Modular Reactors for Near Term Deployment in Beijing, China, in September. Using the Agency’s methodology, participants conducted a reactor technology assessment of certain types of small modular reactors in order to understand the design and safety features of these systems, including manufacturing issues of structures, systems and components. In December, the Agency held a Technical Meeting on the Design and Operation Aspects of Pressurized Water Reactor Based Small and Medium Sized Reactors in Islamabad, Pakistan, to inform developing countries about the general design features, systems and components of a 300 MW(e) nuclear power reactor. It also issued *Design Safety Considerations for Water Cooled Small Modular Reactors Incorporating Lessons Learned from the Fukushima Daiichi Accident* (IAEA-TECDOC-1785), presenting the operational safety performance of SMR designs for coping with extreme natural hazards.

Fast reactors

The Technical Working Group on Fast Reactors met in Buenos Aires, Argentina, in May to present recent developments in fast reactor technology and to consider future activities in this area. In November, the Agency presented the findings of its review of the recent Generation IV International Forum (GIF) report on safety design guidelines for sodium cooled fast reactors at the Sixth Joint IAEA–GIF Technical Meeting/Workshop on the Safety of Sodium Cooled Fast Reactors. During the year, the Agency launched the LMFNS (Liquid Metal Cooled Fast Neutron Systems) Facilities Database, offering Member States detailed information on experimental facilities in support of the development of fast neutron systems.

A four year CRP entitled ‘Benchmark Analyses of an EBR-II Shutdown Heat Removal Test’ was concluded at a final Research Coordination Meeting held in April. The CRP contributed to the verification and validation of Member State simulation tools to be used for the design and safety analysis of sodium cooled fast reactors. A new CRP entitled ‘Radioactive Release from the Prototype Fast Breeder Reactor under Severe Accident Conditions’ was launched at a Research Coordination Meeting in May. The CRP will help Member States to better understand the phenomena involved in a severe accident in a sodium cooled fast reactor and to develop the corresponding simulation tools. The Joint ICTP–IAEA Workshop on Physics and Technology of Innovative Nuclear Energy Systems for Sustainable Development conducted in August–September at the Abdus Salam International Centre for Theoretical Physics (ICTP) in Trieste, Italy, attracted 47 participants from 24 Member States. The workshop presented the theoretical foundation of all aspects

of innovative nuclear energy systems and familiarized students with their models and codes for design and safety analysis.

High temperature reactors

Agency activities in the area of high temperature gas cooled reactors included evaluations of technology readiness, safety requirements, high fidelity tools and sustainability aspects. As part of its initiative to preserve the high temperature reactor knowledge developed over many decades at the Jülich Research Centre, Germany, the Agency conducted a mission to assess requirements for transferring knowledge, documents and software from the Centre to the Agency. Most of this knowledge is related to safety aspects of high temperature reactors.

The Agency held its first Technical Meeting on the Status of Molten Salt Reactor Technology in October. The meeting's high attendance — 35 participants from 17 Member States — reflected the strong interest in Agency support in this area.

Advanced Reactors Information System (ARIS)

In July, the Agency released a new version of its on-line Advanced Reactors Information System (ARIS) database, with a specific section dedicated to SMRs and the incorporation of innovative molten salt reactors. A booklet on advances in SMR technology developments was published in August, as a supplement to ARIS.

Non-electric Applications of Nuclear Power

In line with General Conference resolution GC(58)/RES/12 on “Strengthening of the Agency’s technical cooperation activities” and in response to the growing interest in nuclear cogeneration and process heat for nonelectric applications, the Agency provided support to Member States interested in seawater desalination, hydrogen production, district heating and other industrial applications of nuclear energy. In May, it held the Fifth Meeting of the Technical Working Group on Nuclear Desalination, with 13 participants from 11 Member States. It also organized three Technical Meetings on topics related to the vendor–user interface, techno-economics and socioeconomics of non-electric applications of nuclear energy. A third and final Research Coordination Meeting completed the CRP entitled ‘Application of Advanced Low Temperature Desalination Systems to Support Nuclear Power Plants and Non-electric Applications’. Participants were asked to provide contributions for a TECDOC, which will serve as a collection of best practices and proven methods for strengthening the design and development of advanced low temperature desalination processes coupled to nuclear power reactors.

Enhancing Global Nuclear Energy Sustainability through Innovation

With Mexico joining in 2016, the membership of the International Project on Innovative Nuclear Reactors and Fuel Cycles (INPRO) grew to 42. During the year, Indonesia completed a Nuclear Energy System Assessment (NESA) report on its large light water reactor scenario.

The Agency carried out several INPRO related training activities, including a Regional Training Course on Nuclear Energy System Modelling and Assessment Using the INPRO Methodology, held in April in Rabat, Morocco. The course was attended by 23 participants from 11 Member States. Three Technical Meetings held in Vienna in June, October and

November, with 44 participants from 43 Member States, focused respectively on INPRO collaborative projects on roadmaps to innovative nuclear energy systems, key indicators of innovative nuclear energy systems, and cooperative approaches to the back end of the nuclear fuel cycle. At two Technical Meetings held in Vienna in May and November, involving 47 participants from 35 Member States, experts reviewed updates of the INPRO methodology manuals in the areas of environmental impacts of resource depletion and stressors, and safety of nuclear reactors and fuel cycles. GIF and the Agency held an interface meeting in Vienna in April. The 30 participants from 9 GIF member countries reviewed progress on innovative reactors and related assessment methodologies.

The Agency issued two publications updating the INPRO Manuals: *INPRO Methodology for Sustainability Assessment of Nuclear Energy Systems: Environmental Impact from Depletion of Resources* (IAEA Nuclear Energy Series No. NG-T-3.13) and *INPRO Methodology for Sustainability Assessment of Nuclear Energy Systems: Environmental Impact of Stressors* (IAEA Nuclear Energy Series No. NG-T-3.15). In March, it issued *Modelling Nuclear Energy Systems with MESSAGE: A User's Guide* (IAEA Nuclear Energy Series No. NG-T-5.2), providing detailed guidance on building mathematical models representing complex nuclear energy systems within the framework of the Agency's Model for Energy Supply Strategy Alternatives and their General Environmental Impacts (MESSAGE).

Two INPRO Dialogue Forums were held in 2016. The 12th INPRO Dialogue Forum, held in Vienna in April, provided an opportunity for GIF to present Generation IV nuclear energy systems to Member States. The 13th INPRO Dialogue Forum, held in Vienna in October, considered legal and institutional issues of global deployment of small modular reactors. It presented case studies on how existing frameworks such as international legal instruments and regulatory regimes may relate to the specific case of factory built or factory fuelled reactors. These two Forums attracted more than 130 experts from over 35 Member States and the European Commission, the Nuclear Energy Agency of the Organisation for Economic Co-operation and Development, the International Framework for Nuclear Energy Cooperation and the World Nuclear Association.

Nuclear Fuel Cycle and Materials Technologies

Objective

To advance the development and implementation of an increasingly safe, reliable, efficient, proliferation resistant and environmentally sustainable nuclear fuel cycle (NFC), providing the maximum benefit to Member States. To assist and support Member States in strengthening their capabilities and improving practices in radioactive waste management (RWM), decommissioning and remediation of contaminated sites and to support States embarking on nuclear power and developing countries to develop necessary RWM infrastructure. To collect data on damaged fuel and storage facilities and to assist Member States discuss and share ideas and information on nuclear fuel behaviour under severe conditions. To assist Member States in decommissioning nuclear sites affected by accidents and to remediate off-site contaminated areas.

Uranium Resources and Production

The Agency's UDEPO (World Distribution of Uranium Deposits) database provides reliable, up-to-date information on the technical, geographical and geological characteristics of uranium deposits around the world. It covers not only operational mines but also depleted or dormant uranium mines, in order to provide an overview of past operations and future possibilities, in addition to the information on existing uranium production. Significant progress was made towards updating and expanding UDEPO to include more spatial and statistical data. Information on more than 700 additional uranium deposits was collated and about 800 location coordinates were added to existing deposits, primarily as a result of the UDEPO consultancy meeting held in Vienna in June.

The Agency held two workshops on uranium exploration and assessment methods in Argentina in 2016 — one in Mendoza, in April, with 71 participants from 13 Member States and one in Buenos Aires, with 46 participants from 15 Member States. The workshops highlighted uranium exploration methods and new techniques for quantifying uranium potential. The Agency took part in the 53rd meeting of the Joint OECD/NEA-IAEA Uranium Group, held in Buenos Aires in October with 32 participants from 19 Member States. During the meeting, the OECD Nuclear Energy Agency (OECD/NEA) and Euratom provided an update on uranium production cycle activities in their member countries.

The 26th edition of the joint IAEA-OECD/NEA publication *Uranium 2016: Resources, Production and Demand*, also referred to as the 'Red Book', was published in November (Fig. 1). It reported that, as of 1 January 2015, the annual world uranium production of 55 975 tonnes of uranium provided about 99% of current annual world reactor requirements, with the remainder supplied by previously mined uranium. The uranium resource base is considered to be more than adequate to meet projected requirements for the foreseeable future. The Agency also published *In Situ Leach Uranium Mining: An Overview of Operations* (IAEA Nuclear Energy Series NF-T-1.4), in December. The report provides an overview

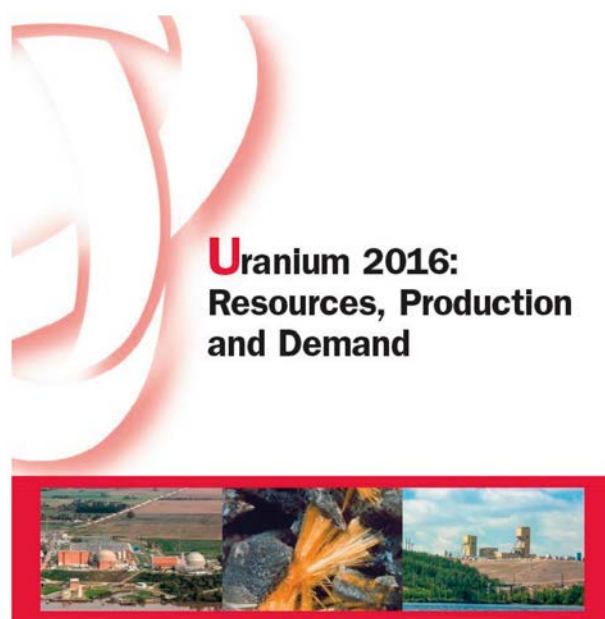


FIG. 1. The joint IAEA–OECD/NEA publication *Uranium 2016: Resources, Production and Demand*, also referred to as the ‘Red Book’, was published in November.

of in situ leaching (ISL) technology and its application, covering operational experience worldwide for a number of active and dormant ISL mines.

The Agency’s technical and training meetings on the uranium production cycle were well attended throughout 2016. In total, more than 500 participants from over 50 Member States attended meetings on uranium and related topics held by the Agency in Argentina, Austria, Brazil, Mongolia, Morocco, Nigeria, Sri Lanka and the United States of America.

Nuclear Power Reactor Fuel

The Agency supported cooperative research and assisted Member States in sharing information on the development, design, manufacture and performance assessment of fuel for all types of nuclear power reactor. Particular emphasis was given to the development of fuels with increased accident tolerance and the analysis of fuel behaviour under accident conditions. In June, the Agency held the second Research Coordination Meeting (RCM) of the coordinated research project (CRP) entitled ‘Fuel Modelling in Accident Conditions’ (FUMAC), launched in 2014 with 21 partners from 17 Member States. The participants presented the results of the activities carried out since the first RCM, demonstrating the capability of existing fuel performance codes to describe fuel behaviour under accident conditions. The CRP entitled ‘Reliability of High Power, Extended Burnup and Advanced PHWR Fuels’, which was started in 2014 with six partners from six Member States, held its second RCM in Buenos Aires, Argentina, in May. Participants discussed fuel performance issues arising from increased power and burnup in fuels for pressurized heavy water reactors, such as increased release of gaseous and volatile fission products, pellet–cladding interaction, and degradation of thermophysical properties of fuel and stress corrosion cracking.

In June, the Agency published *Accident Tolerant Fuel Concepts for Light Water Reactors*, the proceedings of a Technical Meeting held at Oak Ridge National Laboratory, United States of America (IAEA-TECDOC-1797). *High Burnup Fuel: Implications and Operational Experience*, the proceedings of a Technical Meeting held in Buenos Aires, Argentina, was published in August (IAEA-TECDOC-CD-1798).

“more than 500 participants from over 50 Member States attended meetings on uranium and related topics held by the Agency in Argentina, Austria, Brazil, Mongolia, Morocco, Nigeria, Sri Lanka and the United States of America.”

In October, the Agency held a consultancy meeting in Vienna to begin drafting a review of fuel failures from 2006 to 2015. The report will be an update of *Review of Fuel Failures in Water Cooled Reactors* (IAEA Nuclear Energy Series No. NF-T-2.1), published in 2010 and covering the period from 1994 to 2006.

Management of Spent Fuel from Nuclear Power Reactors

The CRP entitled ‘Demonstrating Performance of Spent Fuel and Related Storage System Components during Very Long Term Storage’ was concluded in 2016. The project’s third and final RCM was held in April in Santander, Spain, followed in June by a consultancy meeting held in Vienna to finalize a report on the findings. In October, the first RCM of a CRP entitled ‘Spent Fuel Performance Assessment and Research — Phase IV’ (SPAR-IV) was held in Vienna. This new CRP is aimed at developing a technical knowledge base on the long term behaviour of power reactor spent fuel and storage system materials. Eleven partner institutions from nine Member States will provide input on operating experience and research.

The Agency held consultancy meetings on management strategies for separated plutonium, lessons learned in the development of fuel cycles, and heat removal in spent fuel storage. Experts attending the meetings shared information and best practices on these topics. At two other consultancy meetings, held in Vienna in April and December, experts finalized the technical content of seven e-learning modules covering the various steps of spent fuel management prior to disposal, including reprocessing.

At a Technical Meeting on Advanced Fuel Cycles for Waste Burden Minimization, held in Vienna in June, 15 participants from 7 Member States discussed spent fuel processing technologies in terms of waste strategies, and assessed the technological readiness of various fuel cycle options and their related implementation challenges. At another Technical Meeting held in Vienna in June, 21 experts from 13 Member States and the European Commission shared best practices in applying the concept of ‘design extension conditions’ to operating spent fuel storage facilities.

Radioactive Waste Management, Decommissioning and Environmental Remediation

The Agency addressed the wide range of radioactive waste challenges across its Member States through more than 70 technical cooperation projects in 2016. In November, the Agency conducted a peer review of the project to build and operate France’s first deep geological disposal facility for high and intermediate level radioactive waste. During the year, it further developed draft guidelines and a self-assessment module for ARTEMIS, the Agency’s new Integrated Review Service for Radioactive Waste and Spent Fuel Management, Decommissioning and Remediation. In 2016, the Agency received three requests from Member States for an ARTEMIS mission.

New e-learning materials on decommissioning, radioactive waste management, environmental remediation and the management of disused sealed radioactive sources (DSRSs) were added to the learning management system on the Cyber Learning Platform for Network Education and Training (CLP4NET).

Radioactive waste management

In November, the Agency organized the International Conference on the Safety of Radioactive Waste Management, held in cooperation with the European Commission and the OECD Nuclear Energy Agency (OECD/NEA). The meeting was attended by

276 participants from 63 Member States. Conference participants highlighted the need for continued assistance to Member States for building and strengthening the capacities of both regulators and operators.

In response to Member State interest in multinational disposal facilities, the Agency published *Framework and Challenges for Initiating Multinational Cooperation for the Development of a Radioactive Waste Repository* (IAEA Nuclear Energy Series No. NW-T-1.5), in March.

To further promote the benefits of reporting inventories of spent nuclear fuel and radioactive waste, the Agency continued its close cooperation with the European Commission and the OECD/NEA on preparing the tripartite report 'Status and Trends in Spent Fuel and Radioactive Waste Management'. This report incorporates authorized submissions from 47 Member States, covering over 90% of the nuclear power plants ever constructed, and is supported by the Agency's Net Enabled Waste Management Database.

The Agency continued to operate and improve its waste benchmarking system for water cooled, water moderated reactors. This benchmarking is aimed at helping Member States share best practices between waste management operators of this type of nuclear power plant in order to minimize waste arising during operation.

In May, the Agency published *Processing of Irradiated Graphite to Meet Acceptance Criteria for Waste Disposal* (IAEA-TECDOC-1790), the final report of a CRP bearing the same name.

Decommissioning and environmental remediation

Over 540 participants from 54 Member States and four international organizations attended the International Conference on Advancing the Global Implementation of Decommissioning and Environmental Remediation Programmes, held by the Agency in Madrid, Spain. Conference participants raised awareness of the growing need to address the legacy of past nuclear activities, identified priority areas and recommended strategies for improving the safe and effective implementation of decommissioning and environmental remediation programmes.

During 2016, the Agency published two reports on topics in this area: *Managing the Unexpected in Decommissioning* (IAEA Nuclear Energy Series No. NW-T-2.8), in March, and *Advancing Implementation of Decommissioning and Environmental Remediation Programmes — CIDER Project: Baseline Report* (IAEA Nuclear Energy Series No. NW-T-1.10), in April.

Management of disused sealed radioactive sources

The Agency provided support for assessments of the available options for the management of DSRs, including co-disposal with other waste at suitable facilities, recycling and repatriation, and disposal in dedicated boreholes. Borehole disposal projects were at various stages of development in several countries, including Ghana, Malaysia and the Philippines.

A number of successful operations were conducted in 2016 to remove DSRs from user premises and to bring them under proper storage conditions. The repatriation of four French origin Category 1 DSRs — one each from Lebanon and Tunisia and two from Cameroon — was completed during the year. One Category 1 disused source was removed from a teletherapy head in Uganda and transferred to safe and secure storage. Two Category 1 disused sources were removed from a hospital and placed into safe and secure storage in Jordan. The Agency initiated removals of Category 1 and 2 sources in several Member States, including Albania, Burkina Faso, Lebanon and the former Yugoslav Republic of Macedonia, with removals scheduled for completion in 2017 (Fig. 2). Agency-supported operations to train local personnel and to condition DSRs were completed in Indonesia, Malaysia, Nepal, the Philippines, Thailand and Viet Nam.

"A number of successful operations were conducted in 2016 to remove DSRs from user premises and to bring them under proper storage conditions."

The Agency extended access to the International Catalogue of Sealed Radioactive Sources and Devices to many nominees in Member States, making the identification of DSRs found in the field easier. Efforts to add more details on sources and devices were initiated in 2016, to further improve the usefulness of the catalogue.



FIG. 2. Preparing for removal of a Category 1 disused sealed radioactive source from Lebanon.

Capacity Building and Nuclear Knowledge for Sustainable Energy Development

Objective

To strengthen Member State capacities in energy and nuclear power planning to elaborate sustainable energy strategies and conduct studies for energy system and electricity supply options, energy investment planning, and energy environment policy formulation. To build Member State capacities to manage nuclear knowledge and provide knowledge management services and assistance. To procure and provide printed and electronic information in the area of nuclear science and technology to the IAEA Secretariat and Member States.

Energy Modelling, Databanks and Capacity Building

During 2016, the Agency updated, enhanced and disseminated its energy planning tools and databanks; the number of Member States using its energy models grew to 138. The Agency and the International Renewable Energy Agency (IRENA) signed a cooperation agreement to coordinate joint capacity building and training in energy planning. Multi-criteria decision analysis capabilities were added to the Model for Energy Supply Strategy Alternatives and their General Environmental Impacts (MESSAGE) to enable assessment of energy options for sustainable development and climate change mitigation. Regional training events on energy planning tools were conducted with local experts in Africa, Eastern Europe and Latin America. Training of trainers was organized to extend the pool of experts in developing countries. In total, over 600 professionals from 86 countries were trained through distance training and face-to-face training events.

Energy–Economy–Environment (3E) Analysis

In advance of the 60th regular session of the Agency's General Conference, the Agency issued two publications on nuclear power as a sustainable energy option: *Climate Change and Nuclear Power 2016* and *Nuclear Power and Sustainable Development*. The publications present information on how nuclear energy, as one of the low carbon energy sources available today, can help meet the 'climate–energy challenge' and contribute to sustainable development. Linkages between nuclear technology and sustainable development were also highlighted in the Scientific Forum held during the 60th General Conference, covering 'Nuclear Technology for the Sustainable Development Goals', one of the sessions of which focused on 'Energy for the Future: The Role of Nuclear Power' (Fig. 1).

At the 22nd session of the Conference of the Parties to the United Nations Framework Convention on Climate Change (COP22), held in November in Marrakesh, Morocco, the Agency participated in a side event on energy, in cooperation with several organizations in the United Nations system, and hosted an exhibit on nuclear power and nuclear

applications. The Agency also had greater scientific engagement in climate change science through participation in the drafting of the Intergovernmental Panel on Climate Change special report on the 1.5°C scenario.

Scoping missions for CLEW (climate, land, energy and water), a framework for integrated assessment of resource systems, were conducted in Ghana and Nicaragua to assist those countries in achieving the Sustainable Development Goals. Under CLEW, the Agency, in collaboration with the United Nations Department of Economic and Social Affairs, United Nations Development Programme and the World Bank, helps Member States assess the cross-sectoral impact of policy decisions and promote robust and cohesive policy formulation.

Work continued on several coordinated research projects focusing on national and regional macroeconomic effects of nuclear power programmes, financing nuclear investments, and the potential role of nuclear energy in national climate change mitigation strategies. The Agency published seven technical reports from these projects in 2016, on topics such as sustainable development, addressing the impacts of climate change, financing and electricity market reforms.



FIG. 1. Fiona Reilly of Atlantic Superconnection speaks on financing nuclear power projects at the Scientific Forum held during the 60th General Conference.

Nuclear Knowledge Management

The Agency continued to assist Member States in maintaining and preserving nuclear knowledge by developing methodology and guidance documents and facilitating sustainable education, training and information exchange in nuclear science and technology. In 2016, the Moscow Engineering Physics Institute (MEPhI) became the second institution — after the University of Manchester — to implement the International Nuclear Management Academy (INMA) programme, with 15 enrolled students. At the end of the year, some ten

universities across the world were in the process of implementing programmes that would meet the competency requirements of the Agency's INMA initiative, aimed at improving the availability and accessibility of master's level courses for nuclear sector managers.

In 2016, the Agency carried out three Knowledge Management Assist Visits: to the Nuclear Power Production and Development Company of the Islamic Republic of Iran in April; to the Leningrad nuclear power plant in the Russian Federation in June; and to the Shanghai Nuclear Engineering Research and Design Institute in China in October. The visits focused on the importance, shared responsibilities and challenges of maintaining nuclear knowledge for high levels of safety, and on sharing best practices and experience.

Interest in the Agency's Nuclear Energy Management (NEM) and Nuclear Knowledge Management (NKM) Schools continued to increase. The Agency held four NEM Schools and one NKM School during the year: the fourth annual IAEA–Japan NEM School, in July, at the University of Tokyo; the first IAEA–Rosatom Regional NEM School, in September, in St. Petersburg; the seventh annual Joint ICTP–IAEA NEM School, in October, at the Abdus Salam International Centre for Theoretical Physics (ICTP) in Trieste, Italy; the first Joint South Africa–IAEA NEM School, in October, in Cape Town; and the 12th annual ICTP–IAEA NKM School in September, at the ICTP in Trieste.

The Agency continued to support the activities of and collaboration among the four regional nuclear education networks it has helped establish — the Regional Network for Nuclear Education and Training in Nuclear Technology (STAR-NET), the AFRA Network for Education in Science and Technology (AFRA-NEST), the Asian Network for Education in Nuclear Technology (ANENT) and the Latin American Network for Education in Nuclear Technology (LANENT). In 2016, the Agency supported the development of educational materials and e-learning courses. It also organized an annual 'Networking Networks' workshop, where the regional networks exchanged information on their activities and on existing resources in the field of nuclear knowledge management. Close collaboration with the European Nuclear Education Network (ENEN) continued during the year.

In 2016, the Cyber Learning Platform for Network Education and Training (CLP4NET) was established as the Agency's official learning management system (LMS) platform for e-learning resources. The number of CLP4NET users surpassed 13 500, and more than 300 courses are now hosted in the self-directed (open) LMS and the instructor-led (protected) LMS. The platform has improved accessibility to the Agency's education and training resources and made delivery of training to Member States more efficient.

The IAEA CONNECT platform serves as the gateway to the networks run by the Agency. Such networks are important, as they promote capacity building, as well as facilitate collaboration and sharing of information and experience among their members. Improvements to IAEA CONNECT in 2016 included the development of public areas to provide access to basic information on web sites on the platform.

“The number of CLP4NET users surpassed 13 500, and more than 300 courses are now hosted in [CLP4NET].”

Collection and Dissemination of Nuclear Information

The membership of the International Nuclear Information System (INIS) comprises 130 Member States and 24 international organizations. INIS reached a milestone of 4 million records, with over half a million full texts that are not readily available through commercial channels. The Agency added over 127 000 bibliographic records and 8620 full texts to the INIS Repository, which had over 2.7 million page views during the year. In addition, a major upgrade was introduced to the INIS Repository Search. The INIS Thesaurus continued to serve the international community and was maintained through intensive collaboration with Member States. The Thesaurus is available in eight languages, with almost 31 000 well defined descriptors.

In cooperation with the Japan Atomic Energy Agency (JAEA), which serves as the National INIS Centre of Japan, over 1600 Fukushima Nuclear Accident Archive records

were made publicly available through the INIS Repository. During the year, new automated technology was developed and digital harvesting of more than 15 000 records containing nuclear information was completed.

The 38th Consultative Meeting of INIS Liaison Officers was held in October, attended by 69 participants from 60 Member States and 5 international organizations. The meeting provided Member States with information on INIS activities. Participants shared experience and provided recommendations on the further development and future operation of INIS.

The IAEA Library continued to ensure that information resources and services remained current, cost effective and easily accessible. The number of electronic journals available through the Library increased from 50 000 in 2015 to over 53 000 in 2016. More than 13 400 people visited the Library in 2016, and over 16 000 items were loaned out. The Library fulfilled over 1530 interlibrary loan and document delivery requests.

In response to customer requests for tailored packaging of nuclear information products and services, the Agency created 1810 personalized Library user profiles. It also offered over 30 training sessions covering general aspects of the Library for newcomers as well as personalized sessions responding to the specific needs of Agency staff members.

During the year, the Agency, through the IAEA Library, coordinated the International Nuclear Library Network (INLN) —comprising 55 libraries and research institutes — by sharing knowledge, resources and best practices.

“In response to customer requests for tailored packaging of nuclear information products and services, the Agency created 1810 personalized Library user profiles.”

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. To assist Member States in the management and effective utilization of research reactors.

Nuclear Data

Physics at entirely different scales of magnitude are currently being bridged by an innovative approach to radiation damage analysis. With the help of current computing power, it is now possible to estimate damage response functions — such as displacements per atom, and kinetic energy released in matter (kerma) and gas production — on a stronger scientific basis, including a quantitative expression of the uncertainties. These developments will shed new light on the shielding of accelerators and of fission and fusion reactors. To support work in this area, the Agency held a Technical Meeting on Nuclear Reaction Data and Uncertainties for Radiation Damage in Vienna in June, with 16 participants from 11 Member States.

The coordinated research project (CRP) entitled ‘Nuclear Data for Charged-particle Monitor Reactions and Medical Isotope Production’ was concluded at the third Research Coordination Meeting, held in Vienna in June with 14 participants from 13 countries. The project led to improvements in evaluations of decay data and in the charged-particle monitor (standard) reaction database for proton, deuteron, helium-3 and alpha induced reactions relevant for medical isotopes. The related medical radioisotopes production portal on the Agency’s web site was updated accordingly.

Research Reactors

Utilization and applications of research reactors

In 2016, the Agency developed a comprehensive set of e-learning tools for neutron activation analysis, including case studies, quizzes and other learning materials. In October, it held a workshop in Vienna attended by 28 participants from 25 Member States, to review and test the new e-learning tools. The participants’ comments and other feedback will be used to further improve the quality of the tool before its final release for public use in 2017 (Fig. 1).

In December, the Agency conducted a workshop to assist research reactor managers in reviewing their strategic plans for research reactor utilization. The event, held in Vienna,

“In 2016, the Agency developed a comprehensive set of e-learning tools for neutron activation analysis, including case studies, quizzes and other learning materials.”

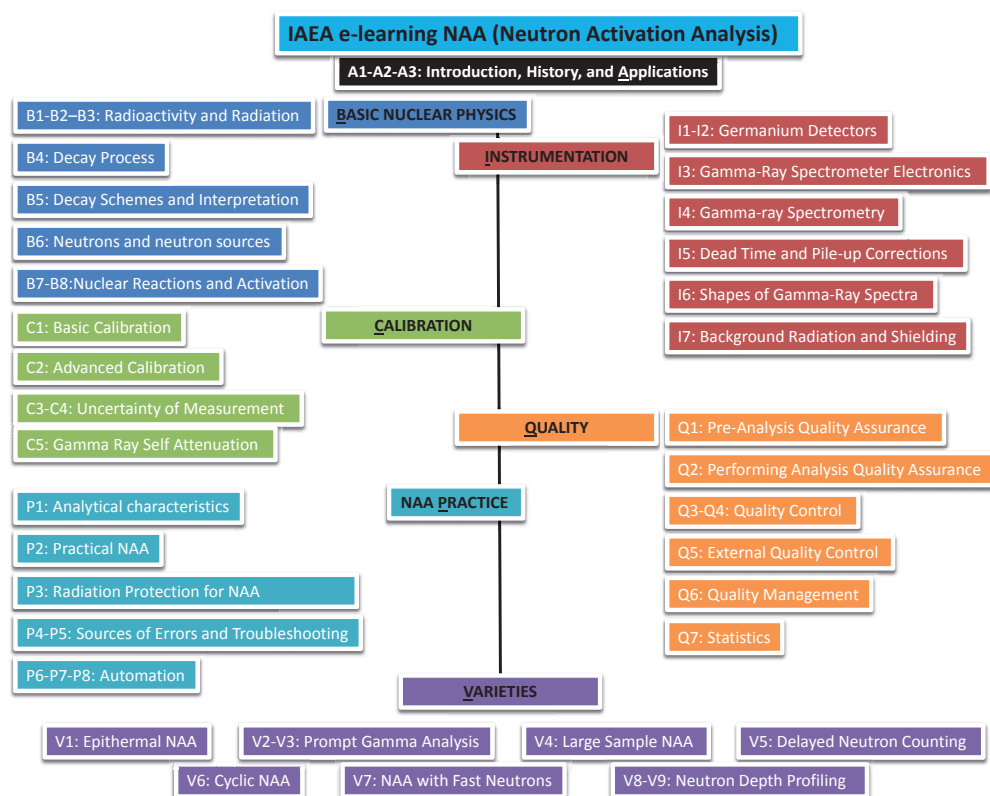


FIG. 1. The Agency's e-learning tools for neutron activation analysis currently comprise 45 modules, including lectures and self-directed learning exercises.

Austria, was attended by 37 participants from 30 Member States and resulted in the review of 26 strategic plans.

Two research reactor organizations were designated as IAEA Collaborating Centres in 2016. The Australian Nuclear Science and Technology Organisation will assist the Agency in implementing selected programmatic activities focused on multi-analytical techniques for materials research, environmental studies and industrial applications. The Reactor Institute Delft, in the Netherlands, will focus on activities related to neutron activation and neutron beam based methodologies of research reactors.

The Agency's Research Reactor Database (RRDB) provides comprehensive technical information on some 770 research reactors in 67 Member States, including their utilization. Based on inputs from Member States, information on some 95 facilities was updated in the RRDB in 2016.

In July, the Agency published *History, Development and Future of TRIGA Research Reactors* (Technical Report Series No. 482), summarizing the information available on TRIGA reactors and providing an overview of the potential challenges to be addressed by TRIGA operating organizations in the near future. It also issued a revision of its brochure *Research Reactors: Purpose and Future*.

New research reactor projects, infrastructure development and capacity building

At a Technical Meeting on the Role of Research Reactors in Providing Support for Nuclear Power Programmes, held in Vienna in June, 32 meeting participants from 24 Member States concluded that research reactors can play an important role in supporting new and ongoing nuclear power programmes, and identified areas where these reactors can make important contributions. At a workshop on the Agency's 'Milestones' approach for research reactors, held in Vienna in October, the Agency provided practical information and related

knowledge to 20 participants from 17 Member States. A preparatory Integrated Research Reactor Infrastructure Assessment (IRRIA) mission was undertaken to Mongolia in April, to provide guidance on planning for a new research reactor.

The Agency's Internet Reactor Laboratory project was fully implemented in Latin America, Europe and Africa in 2016. Live transmissions were carried out from two host facilities: Argentina's RA-6 reactor and the French Alternative Energies and Atomic Energy Commission (CEA) ISIS reactor.

During the 60th regular session of the Agency's General Conference, the Research Institute of Atomic Reactors in the Russian Federation was designated as an IAEA-designated International Centre based on Research Reactor.

Research reactor fuel cycle

The Agency supported Ghana's efforts to convert its miniature neutron source reactor from high enriched uranium (HEU) fuel to low enriched uranium (LEU) fuel. In July, it held an international meeting in China, in cooperation with the China Institute of Atomic Energy (CIAE), for high level delegates from all Member States operating a miniature neutron source reactor to witness the first criticality test of the LEU core for the Ghana Research Reactor.

In September, the last 61 kilograms of HEU remaining in Poland was repatriated to the Russian Federation.

Research reactor operation and maintenance

In 2016, the Agency initiated several activities to help Member States address challenges related to ageing management and lifetime extension of research reactors and the optimization of their operational performance. In January, it held the first Research Coordination Meeting of the CRP entitled 'Condition Monitoring and Incipient Failure Detection of Rotating Equipment at Research Reactors' at its Headquarters in Vienna. Project participants are investigating the latest advances in rotating equipment monitoring and diagnostic techniques, including the use of state of the art rotational monitoring sensors and data transmission techniques such as wireless technologies. In April, the Agency undertook two expert missions: the first, to Indonesia, provided advice on the design of an instrumentation and control system for a research reactor; the second, to Pakistan, provided advice concerning an ageing management programme for the country's PARR-1 research reactor.

The Agency conducted a Workshop on Safety Reassessment of Research Reactors following the Feedback from the Accident at the Fukushima Daiichi Nuclear Power Plant, in Vienna in September, with 40 participants from 34 Member States. In November, it organized a training workshop on integrated management systems for research reactors in Vienna, attended by 31 participants from 29 Member States. Workshop participants exchanged knowledge and experience on developing, implementing and continuously improving management systems, which are essential for ensuring safe and effective operation of research reactors.

During the year, the Agency's Research Reactor Ageing Database (RRADB) was migrated to a new platform offering more advanced features such as extended criteria for filtering to generate more detailed reports for selected combinations of ageing mechanisms and affected structures, systems and components. The RRADB now includes both the legacy database and new information provided by Member States during the year.

"During the year, the Agency's Research Reactor Ageing Database (RRADB) was migrated to a new platform offering more advanced features"

Accelerator Applications

The Agency's Accelerator Knowledge Portal, launched in 2014, offers a database of particle accelerators in the world and includes several networking features. In 2016, the Agency introduced several upgrades to the Portal: the platform now has geographic capabilities, and support was augmented for environmental applications such as pollution monitoring and provenance studies using synchrotrons and ion beam accelerators.

During the year, researchers from Member States participating in the CRP entitled 'Experiments with Synchrotron Radiation for Modern Environmental and Industrial Applications' made use of the Agency's X ray fluorescence beamline at the Elettra synchrotron in Trieste to carry out 12 experiments focused on environmental science and industrial applications.

In its work on materials modification and analysis using accelerator based techniques, the Agency focused predominantly on three areas in 2016. The first area of focus was development of ion beam analytical methods and high precision fingerprinting of trace elements using accelerators. In September, the Agency held a Technical Meeting on Enhancing Nuclear Technologies to Meet the Needs of Forensic Science at the University of Surrey, Guildford, United Kingdom, that resulted in the proposal, and subsequent approval, of a new CRP on this subject. The second area of focus was radiation damage, including studies to determine the effects of analytical ion beams on materials of cultural heritage. In 2016, research by members of the 'Utilization of Ion Accelerators for Studying and Modelling of Radiation Induced Defects in Semiconductors and Insulators' CRP was published in a special section of *Nuclear Instruments and Methods in Physics Research*. The third area of focus was the use of accelerators to emulate damage and gas build-up in structural materials such as fuel cladding for fast reactors, and long term damage processes in nuclear waste forms. A new CRP entitled 'Accelerator Simulation and Theoretical Modelling of Radiation Effects — SMORE-II' was approved in support of research in this area.

“researchers from Member States...made use of the Agency's X ray fluorescence beamline at the Elettra synchrotron in Trieste to carry out 12 experiments focused on environmental science and industrial applications.”



FIG. 2. As part of the Agency's unmanned aerial vehicle system for rapid environmental monitoring, drones mounted with sensors and cameras are used to remotely collect data in preparation for environmental remediation.

Nuclear Instrumentation

The Agency's unmanned aerial vehicle system for rapid environmental mapping — developed for monitoring hard to reach areas where the level of contamination is unknown — was handed over to Fukushima Prefecture in July (Fig. 2). During the year, the system, which can help Member States to monitor radiation after mining or remediation activities, was successfully deployed for training and modelling assessment in Japan and at a uranium mine in Argentina; and mobile gamma spectrometry with backpack detectors was used for site assessments related to copper mining activities in Zambia, and for radiation mapping in Nepal.

Installation of the ultra-high vacuum chamber (UHVC) at the Nuclear Science and Instrumentation Laboratory in Seibersdorf was

completed in April (Fig. 3). The installation provides a much needed complementary ‘mirror’ endstation for training users on the experimental apparatus prior to experimentation at the IAEA XRF beamline at the Elettra synchrotron facility in Trieste, Italy. The new training facility will be used to expand the pool of trained experimenters in Member States and to support the use of this important technology.

Nuclear Fusion

The Agency hosted numerous workshops and meetings of the world’s fusion community in 2016. Among them was the 26th IAEA Fusion Energy Conference, held in October in Kyoto, Japan. The FEC is the world’s leading event on fusion science and technology; this year’s FEC attracted almost 1000 participants and had a record number of conference contributions. Updates on all major projects were presented in about 90 plenary talks and over 600 posters. The fourth DEMO (Demonstration Fusion Power Plant) Programme Workshop, held in November in Karlsruhe, Germany, was attended by 78 participants from 11 Member States and representatives of ITER. The workshop provided an opportunity to review the status of different DEMO related projects and to present results on aspects such as materials science and power extraction. During the year, construction of ITER continued and the Wendelstein 7-X stellarator in Germany was commissioned.

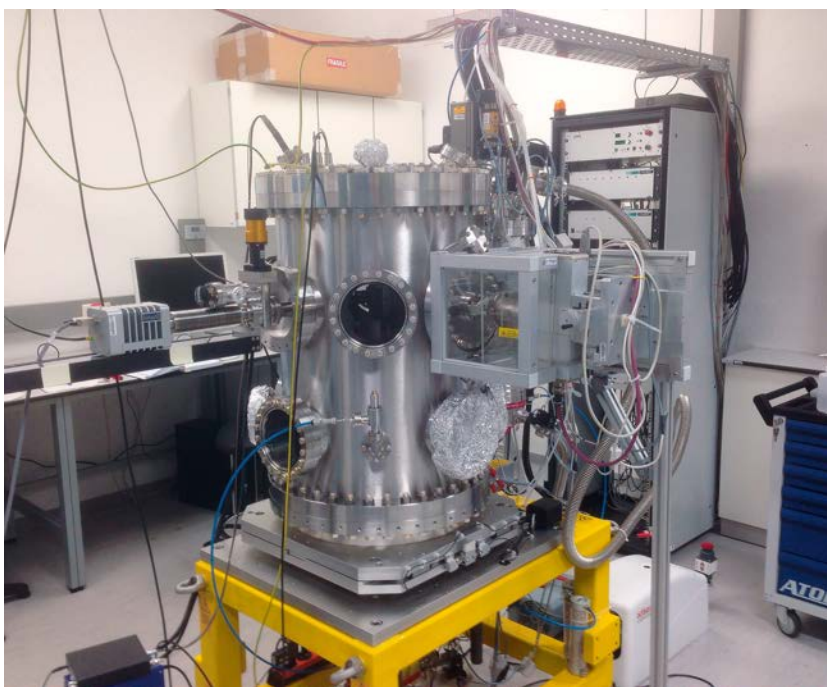


FIG. 3. The ultra-high vacuum chamber at the Agency’s Seibersdorf laboratory will be used to train scientists to carry out experiments at the IAEA XRF beamline at the Elettra synchrotron in Trieste, Italy.

Joint Activities with the ICTP

In 2016, the Agency and International Centre for Theoretical Physics (ICTP) conducted 11 joint activities for 578 participants from 100 Member States, 352 of whom were from developing Member States. The Agency supported ten PhD students from developing countries through the STEP (Sandwich Training Educational Programme) fellowship, enabling them to carry out research at institutes having state of the art equipment. Over the past 13 years, STEP fellowships have been awarded to 180 students from all over the world. Throughout this time, the fellowship has promoted gender balance, and of the current 35 STEP students, 18 are women.

“the Agency and International Centre for Theoretical Physics (ICTP) conducted 11 joint activities for 578 participants from 100 Member States, 352 of whom were from developing Member States.”

Food and Agriculture

Objective

To contribute to the sustainable intensification of agricultural production and the improvement of global food security by addressing the challenges of food production, food protection and food safety through capacity building and technology transfer to Member States. To increase resilience of livelihoods to threats and crises in agriculture by improving assessment and mitigation of threats and crises in agriculture, including impact of climate change and nuclear or radiological accidents on agriculture, as well as food safety risks. To improve efficient agricultural and food systems for sustainable management and conservation of natural resources, and to enhance the conservation and application of plant and animal biodiversity.

Animal Production and Health

The Agency helps Member States to safely use nuclear and related technologies to improve animal production and health through the early and rapid detection and control of animal and zoonotic diseases. In 2016, it responded quickly to emerging outbreaks of

avian influenza in Europe and Africa, and of lumpy skin disease (LSD) in cattle in Eastern Europe and the Balkan region, providing immediate assistance in emergency preparedness for sampling, detection of the pathogen and containment of the disease.

LSD is a highly contagious disease of cattle caused by the LSD virus and is transmitted rapidly both by contact between animals and by vector insects such as stable flies. Although until recently LSD was present only in Africa and parts of Asia, in 2016 the disease emerged in Europe, spreading rapidly across the Balkan region (Albania, Bulgaria, Greece, Montenegro, Serbia and the former Yugoslav Republic of Macedonia).

As the first step in combating the outbreak, the Agency provided Bulgaria and Serbia with technical guidance and a toolkit of emergency laboratory reagents and consumables to reinforce their laboratory capacities to prevent further spread. It organized a workshop on the integration of harmonized early detection protocols into country control



FIG. 1. European veterinary diagnostic staff participating in a training course on lumpy skin disease held at the Agency's Laboratories in Seibersdorf.

plans for LSD, with 59 participants from 33 Member States, and two training courses on the use of nuclear derived techniques for the detection and differentiation of the LSD virus, with 37 participants from 22 European and Balkan Member States. Emergency diagnostic toolkits with reagents for virus detection and a set of harmonized standard operating protocols were delivered to all training course participants. Genetic sequencing services were also provided to all the laboratories involved, enabling an in-depth understanding of the molecular epidemiology of the LSD virus.

“[The Agency organized] two training courses on the use of nuclear derived techniques for the detection and differentiation of the [lumpy skin disease] virus, with 37 participants from 22 European and Balkan Member States.”

Improving Livestock Performance

In 2016, the Agency initiated a coordinated research project (CRP) entitled ‘Application of Nuclear and Genomic Tools to Enable for the Selection of Animals with Enhanced Productivity Traits’ to assist Member States in evaluating livestock for disease resistance and tolerance, and breeding potential. During the year, participants used a nuclear technique involving cobalt-60 to construct a radiation hybrid panel for the camel genome; the panel will undergo further analysis and sequencing to prove its use as a genomic tool in animal breeding. In addition, the Agency assisted 19 Member States in building their capacities in molecular and conventional genetic evaluation technologies and in the selection of superior animals for breeding through guidance and implementation of validated technologies and procedures.

Food Authenticity and Traceability to Support Food Safety and Security

The Agency completed the CRP entitled ‘Implementation of Nuclear Techniques to Improve Food Traceability’ in 2016. The project generated a number of novel food authenticity and traceability datasets. Participants developed new analytical methods and standard operating procedures, and successfully demonstrated the feasibility of using stable isotope analysis to establish the geographical origins of several important food products produced in developing Member States. Government and industry linkages were successfully initiated in a number of Member States, enabling future capacity building in food safety and control.

Developing Generic Irradiation Procedures for Quarantine Treatments of Food Commodities

The results of a CRP on developing new and improving existing phytosanitary irradiation treatments were published in a special issue of *Florida Entomologist* in 2016. New phytosanitary irradiation treatments against specific pests were reported, and generic dose treatments were proposed for moths, butterflies, mealy bugs and weevils. The new irradiation methods are expected to help prevent the spread of pest species and enable trade in fresh agricultural produce that would otherwise be banned. The data generated will also be useful in the implementation of International Plant Protection Convention standards.

Mutation Breeding for Crop Improvement

In 2016, Member States released nine improved mutant varieties of different crops, developed with support from Agency CRPs and technical cooperation projects.

As part of a CRP entitled 'Efficient Screening Techniques to Identify Mutants with Disease Resistance for Coffee and Banana', with a grant from the OPEC Fund for International Development, the Agency is supporting Member States in developing mutation induction methods to increase resistance to coffee leaf rust. In April, six experts attended a workshop on using radiation to develop plant varieties that are resistant to the deadly fungus. Participants were provided with a training manual on coffee mutation induction developed by the Agency.

The Agency published two books containing protocols for mutation breeding of plants in 2016. The first, *Biotechnologies for Plant Mutation Breeding*, offers a wide range of protocols for the use of induced mutation in crop breeding and functional genomics studies using both forward and reverse genetic approaches. The second, *Protocols for Pre-Field Screening of Mutants for Salt Tolerance in Rice, Wheat and Barley*, presents techniques required for mutation breeding to develop crop varieties adaptable to temperature variations and climate change.

Increasing the Efficiency of the Lepidoptera Sterile Insect Technique

In 2016, the results of the CRP entitled 'Increasing the Efficiency of Lepidoptera Sterile Insect Technique by Enhanced Quality Control' were published in a special issue of *Florida Entomologist*. The project led to significant improvements in the identification of factors affecting the field performance of sterile male moths, and in developing quality control methods for the rearing and handling of moths.

Emergency Assistance for Mediterranean Fruit Fly Outbreak in the Caribbean

The Agency, in cooperation with the Food and Agriculture Organization of the United Nations (FAO), InterAmerican Institute for Cooperation on Agriculture, International Regional Organization for Plant and Animal Health and United States Department of Agriculture, continued to support efforts to manage an outbreak of Mediterranean fruit fly in the Dominican Republic. After the country lost an estimated US \$40 million in horticultural exports, it began a campaign of country-wide surveillance, followed by containment, suppression and eradication actions using an area-wide integrated approach including the aerial release of sterile male Mediterranean fruit fly pupae shipped from the Moscamed Programme in Guatemala.

In 2016, the pest was confined to the east of the country, where eradication actions were conducted over a 300 square kilometre area (Fig. 2). During the year, the export ban by the United States Department of Agriculture was lifted in 23 of 30 provinces.

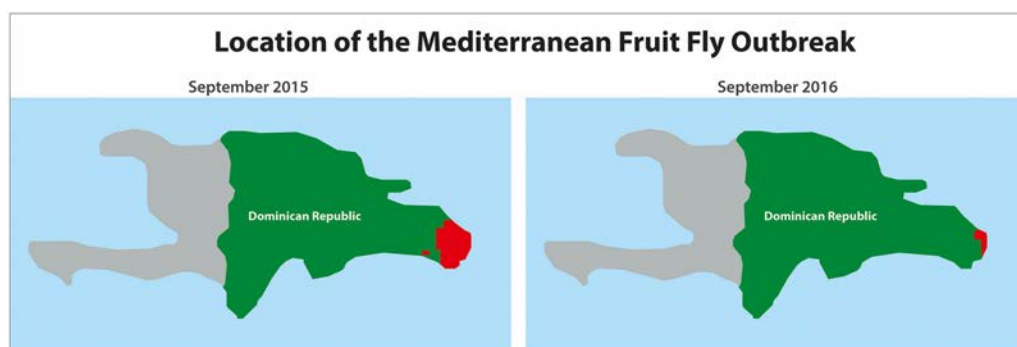


FIG. 2. Area of the Dominican Republic affected by the Mediterranean fruit fly (shown in red) in September 2015 (left) and September 2016 (right).

Managing Irrigation Water to Enhance Crop Productivity in the Sudan

In 2016, the Agency helped female farmers in the eastern region of the Sudan to increase vegetable production and improve food supply, despite the region's increasing water scarcity. An international research network established under a CRP entitled 'Managing Irrigation Water to Enhance Crop Productivity under Water-limiting Conditions: A Role for Isotopic Techniques' provided the technology to help rural female farmers in the Kassala region to use low cost drip irrigation combined with fertilizer to optimize vegetable production. Experts from the Agency and FAO trained scientists from Sudan's Agricultural Research Corporation in the use of nuclear and isotopic techniques to determine crop water requirements and to optimize nitrogen fertilizer use. The scientists then trained female farmers in the region to use the low cost drip irrigation system and to properly apply fertilizer (Fig. 3). To date, this drip irrigation technology has been adopted by more than 1000 family farmers. In 2016, the Sudanese Red Crescent, in collaboration with the United Nations High Commissioner for Refugees (UNHCR), joined the initiative to assist in scaling up the technology for climate change adaptation to improve rural livelihoods and alleviate poverty in the Sudan.



FIG. 3. Female farmers in the Kassala region of the Sudan harvest vegetables grown using a low cost drip irrigation system introduced as part of a CRP entitled 'Managing Irrigation Water to Enhance Crop Productivity under Water-limiting Conditions: A Role for Isotopic Techniques'.

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 and related techniques within a quality assurance framework.

International Conference on Integrated Medical Imaging in Cardiovascular Diseases (IMIC 2016)

The World Health Organization (WHO) estimates that, by 2030, 23.6 million people will die each year from cardiovascular diseases (CVDs). Low and middle income countries face the highest burden, with more than 75% of all CVD deaths occurring in these countries. Advances in medical imaging have revolutionized health care in recent decades, providing valuable information on diagnosis, prognosis, risk assessment and therapy assessment of many diseases, including CVDs.

In 2016, the Agency continued to work with key global players — including professional organizations, health institutions and WHO — to improve the management of CVDs through medical imaging. In October, the Agency organized the International Conference on Integrated Medical Imaging in Cardiovascular Diseases (IMIC 2016), attended by 350 participants from 94 Member States. Held at the Agency's Headquarters, the conference provided clinicians, scientists and other professionals with an opportunity to review and exchange insights on the latest developments in various aspects of integrated medical imaging as applied to CVDs. Participants also discussed future trends in medical imaging as applied to the management of patients with CVDs.

United Nations Joint Global Programme on Cervical Cancer Prevention and Control

In 2012, 266 000 women died of cervical cancer worldwide; 90% of these deaths were in low and middle income countries. Most such deaths could be avoided if all adolescent girls were immunized against the human papillomavirus, and if cervical screening and treatment of precancerous lesions were available to all women. Even more advanced cases of cervical cancer have a high rate of curability when treated with radiotherapy combined with chemotherapy.

The Agency has joined six United Nations agencies in a five year Joint Global Programme on Cervical Cancer Prevention and Control under the United Nations Interagency Task Force on the Prevention and Control of Non-communicable Diseases. The Joint Global Programme aims at reducing cervical cancer mortality in participating

countries by 25% by 2025. The Agency will play a pivotal role in this new endeavour by providing technical expertise in radiation medicine. The programme will work with global and national partners, initially in six low and middle income countries, to ensure that each participating country has a functioning, sustainable, high quality national cervical cancer control programme in place at the end of the five years. In November, the Agency participated in the first inception mission to Morocco organized under this programme.

Quality Assurance and Metrology in Radiation Medicine

To provide an internationally consistent framework for the management of uncertainties throughout the radiotherapy process, the Agency collaborated with the American Association of Physicists in Medicine, the American Society for Radiation Oncology, the European Federation of Organisations for Medical Physics and the European Society for Radiotherapy and Oncology on a publication entitled *Accuracy Requirements and Uncertainties in Radiotherapy* (IAEA Human Health Series No. 31). The report, published in 2016, provides a description of the entire radiotherapy process, addressing accuracy issues from radiobiological, clinical, dosimetric and technical perspectives, and discusses the management of uncertainties.

During the year, the Agency organized several training activities for clinical medical physicists, on a national, regional and interregional basis. This included a Joint ICTP–IAEA Workshop on Internal Dosimetry for Medical Physicists Specializing in Nuclear Medicine, held in Trieste, Italy, in November with the support of the International Centre for Theoretical Physics. The workshop, supported by the American Association of Physicists in Medicine and the European Federation of Organisations for Medical Physics, provided participants with a comprehensive review of the basics and recent developments in the fields of nuclear medicine image quantification and internal dosimetry. It was attended by 38 participants from 24 Member States.

The Agency organized a second train the trainer workshop on medical physics support for nuclear or radiological emergencies, held in Atlanta, United States of America, in May, in cooperation with the Argonne National Laboratory. The workshop was designed to provide participants with a good understanding of their potential roles in nuclear or radiological emergency situations, and to prepare them to contribute effectively to the response, as identified in emergency preparedness plans. The workshop, attended by 19 participants from 17 Member States, was hosted by the Centers for Disease Control and Prevention and supported by the Radiation Emergency Assistance Center/Training Site and the Emory University School of Medicine (Fig. 1).

The Agency provides dosimetry calibrations, comparisons and audits to secondary standards dosimetry laboratories (SSDLs) and audits to radiotherapy centres worldwide. In 2016, it performed calibrations of national dosimetry standards for 22 SSDLs and conducted 12 bilateral comparisons. Since the beginning of this activity, the Agency's auditing services have checked over 12 000 radiotherapy beam calibrations in 132 countries. In 2016, over 600 hospital beam audits were completed, with 21 repeat checks to follow up discrepancies that otherwise might not have been discovered, which could have led to incorrect treatment.

A high dose rate brachytherapy unit was commissioned in 2016. The unit will be used for dosimetry calibrations for SSDLs, contributing to increased consistency in

“During the year, the Agency organized several training activities for clinical medical physicists, on a national, regional and interregional basis.”



FIG. 1. Simulation of medical management of patients at the train the trainer workshop on medical physics support for nuclear or radiological emergencies, held in Atlanta, United States of America, in May.

brachytherapy dosimetry internationally.

In November, a Regional Training Course on Protection Level Calibrations Performed at Secondary Standards Dosimetry Laboratories, with 20 participants from the Co-operative Agreement for Arab States in Asia for Research, Development and Training related to Nuclear Science and Technology (ARASIA), was held at the Agency's

Dosimetry Laboratory (Fig. 2). Participants brought their dosimetry instruments to compare their measurements with the Agency's reference standards.



FIG. 2. Calibration setup during a Regional Training Course on Protection Level Calibrations Performed at Secondary Standards Dosimetry Laboratories held at the Agency's Dosimetry Laboratory, in Seibersdorf, Austria, in November.

Assessing Dietary Intake and Energy Expenditure in Low Resource Settings

Comprehensive, reliable data on individual dietary intake and energy expenditure are extremely important for establishing recommendations for optimal nutrition and for designing nutrition policies and programmes. In December 2016, the Agency organized an experts meeting in Vienna with seven experts from three Member States, the Food and Agriculture Organization of the United Nations (FAO) and WHO to explore recent innovations in the field of quantifying dietary energy intake and energy expenditure, and the use of nuclear technology to validate these new methods. The experts made recommendations on future work to validate technological advances in the field of dietary intake and energy expenditure against the doubly labelled water technique (Fig. 3). This technique is a stable isotope reference method for accurate measurement of the amount of energy a person uses each day for everyday activities (total daily energy expenditure). Validating these advances will clarify their strengths and limitations before they are used in large scale surveys in low resource settings.



FIG. 3. An example from Mozambique of a traditional dietary intake assessment by quantitative 24-hour dietary recall using pen and paper. Efforts are under way to develop a tablet based application for conducting such assessments, which will be validated using the doubly labelled water technique.

Water Resources

Objective

To enable Member States to use isotope hydrology for the assessment and management of their water resources, including the characterization of climate change impacts on water availability.

Water Resource Assessment

Many important aquifers have experienced a lowering of water tables and progressive deterioration of water quality as a result of overexploitation. In 2016, the Agency completed the coordinated research project (CRP) entitled ‘The Use of Environmental Isotopes to Assess Sustainability of Intensively Exploited Aquifer Systems’, which utilized isotope hydrology tools to assess groundwater hydrology and evaluate long term aquifer sustainability. The project’s 14 participants from ten Member States reviewed the results of assessments carried out on aquifers located under different climatic and hydrological settings and produced a synthesis report of their findings. A comparison of the results obtained in the CRP enabled the participants to identify the tracers most suitable for assessing hydrological processes affecting intensively exploited aquifers.

During the year, the Agency launched a CRP entitled ‘Use of Isotope Hydrology to Characterize Groundwater Systems in the Vicinity of Nuclear Power Plants’, aimed at developing guidelines for using environmental isotopes and conventional techniques to improve the hydrogeological characterization of local and regional groundwater systems in the vicinity of nuclear power plants. During the first Research Coordination Meeting, held in October in Vienna, six participants from six Member States developed plans for studies of the use of newly available methods — such as noble gas isotope analysis — to provide better information on the dynamics of very fast or very slow moving groundwater in the vicinity of plant sites.

To develop more effective means of building Member State capacity in isotope hydrology, the Agency conducted an interregional training course with 16 participants from 14 Member States. The course, held in October in Vienna, covered the use of multiple stable isotopes and radionuclides, and an isotope-enabled water balance model for estimating water availability at basin and sub-basin scales.

A Technical Meeting on the use of isotopes for characterizing water source, transport and pollution in relation to hydraulic fracturing (fracking) and mining operations was held in December in Vienna. The meeting’s 14 participants, from 10 Member States, highlighted the potential for hydrocarbon and other gases from deep geological formations to migrate into shallow aquifers and potentially contaminate drinking water sources.

An agreement to initiate a new project entitled ‘Study of Simple and Rapid Analysis Methods for Radionuclides’ was signed in October within the framework of Practical Arrangements between the Agency and Fukushima Prefecture, Japan. This new project

“A Technical Meeting on the use of isotopes for characterizing water source, transport and pollution in relation to hydraulic fracturing (fracking) and mining operations....highlighted the potential for hydrocarbon and other gases from deep geological formations to migrate into shallow aquifers and potentially contaminate drinking water sources.”

aims to expand and improve the Prefecture's analytical capacity for measuring tritium and strontium-90 in water, fish and other media.

The Agency continues to work with Japan to address the issue of the inflow of groundwater into reactor and turbine buildings at the Fukushima Daiichi nuclear power plant. In cooperation with Japan's Ministry of Economy, Trade and Industry (METI), the Agency organized an experts meeting on groundwater modelling. The meeting was held in Tokyo, Japan, in February, with financial support from the Government of Japan. Participants included Agency experts and representatives of METI and the Tokyo Electric Power Company (TEPCO). The meeting reviewed TEPCO's achievements and future plans for understanding and managing groundwater inflow, and participants made recommendations for improvements to models used for simulating groundwater flow. These recommendations were also disseminated to nearly 20 participants from various Japanese academic and research institutions through a seminar organized by METI immediately after the conclusion of the experts meeting.

The final coordination meeting of the regional technical cooperation project entitled 'Integrated and Sustainable Management of Shared Aquifer Systems and Basins of the Sahel Region' was held in Accra, Ghana, in December. The aquifer synthesis reports presented at the meeting provided the conclusions and recommendations jointly prepared by project counterparts and experts for improving the use and protection of each of the transboundary aquifers of the Sahel region. Based on new hydrological information acquired using hydrochemical and isotope tracers, project participants concluded that most of the shallow aquifers contained good quality, recently recharged, partly untapped groundwater, but that some were locally affected by various sources of pollution.

A regional technical cooperation project entitled 'Mainstreaming Groundwater Considerations into the Integrated Management of the Nile River Basin' was completed in 2016. Nine of the 11 Member States sharing the Nile Basin — Burundi, Democratic Republic of the Congo, Egypt, Ethiopia, Kenya, Rwanda, Sudan, United Republic of Tanzania and Uganda — participated in the project. The project assisted the nine Member States in building capacity for incorporating and assessing groundwater bodies in the management of the Nile basin water resources. The Agency, in collaboration with Colorado State University (United States of America), developed a new model called IWBMIso (IAEA Water Balance Modelling with Isotopes) that was used in the framework of the project for improved estimation of catchment scale water balance using isotope data. The model has been made freely available on the Agency's web site.

Climate Change Impacts

In 2016, the Agency developed new isotopic methods to improve understanding of climate change impacts on precipitation using data collected since 1961 within the Global Network of Isotopes in Precipitation (GNIP). While these data have long been used to characterize climate changes in the Earth's history, the newly developed methods allow them to be used for understanding precipitation changes that have occurred over the past 50 years. This greatly expands the usefulness of GNIP data for Member States, allowing an improved understanding of both short term, weather related processes, and long term, climate related processes. At a Technical Meeting on Reappraising the Use of Data on Isotopes in Precipitation, held in Vienna in September, experts reviewed these developments and recommended more intensive collection of high frequency isotope and atmospheric radar measurements to reach a robust understanding of climate-isotope relationships.

The Agency completed the CRP entitled 'Environmental Isotope and Age Dating Methods to Assess Water Quality in Rivers Affected by Shallow Groundwater Discharges' in 2016. Project participants used isotopic methods to assess how groundwater discharges impact river water quality, particularly in the light of climate change impacts on rainfall patterns

and groundwater recharge. Participants used oxygen-18, deuterium and radioisotopes to identify areas of nitrate contaminated groundwater discharge to rivers; locate the flow of nitrate contaminated groundwater towards the Volta River; and identify sources of hydrocarbons or natural organic pollution resulting from aquifer discharge entering rivers used for municipal water supplies. Results of individual studies were published in peer reviewed journals in 2016 and will be used as references for future technical cooperation projects.

Analytical Capacity and Services

The number of Member State laboratories equipped through the technical cooperation programme to use isotope measurement techniques based on laser spectroscopy increased by ten in 2016. A total of 65 laboratories in 54 Member States now have operational laser spectroscopic instruments to measure stable oxygen and hydrogen isotopes (Fig. 1). Also during the year, three laboratories in Bangladesh, Peru and the Philippines were equipped with lower cost and easy to use tritium enrichment units developed by the Agency. Training in the use of laser spectroscopy and tritium methods has been provided to 174 participants since 2008. As a result, more than 60 Member States are now self-sufficient in the key aspects of isotope hydrology for water resources management.

As Member States increase their capacity for tritium analysis, accurate and precise measurements remain a challenge for many laboratories. To better assist Member States, the Agency developed a new database software system known as TRIMS (Tritium Information Management System), which is freely available to Member States on-line. TRIMS has a user friendly interface and helps laboratories achieve the precision and accuracy required of low level tritium measurements for groundwater age purposes.



FIG. 1. As part of a technical cooperation project, Bolivian counterparts collect groundwater samples in the field (left), which are then analysed to measure the isotope ratios using a laser analyser provided by the Agency (right).

Environment

Objective

To identify environmental problems caused by radioactive and non-radioactive pollutants and climate change, using nuclear, isotopic and related techniques, and to propose mitigation/adaptation strategies and tools. To enhance the capability of Member States to develop strategies for the sustainable management of terrestrial, marine and atmospheric environments and their natural resources in order to address effectively and efficiently their environment related development priorities.

Assessing Marine Pollution

The Agency continued to support Member States in accurately monitoring contaminants and biotoxins in the marine environment. In collaboration with the United Nations Environment Programme Mediterranean Action Plan (UNEP/MAP), it conducted two training courses on analysis of contaminants for marine pollution monitoring studies. Held in Monaco in October–November, the courses were attended by ten scientists from eight Mediterranean Member States (Fig. 1). The Agency furthered the development of the receptor binding assay, a nuclear based technique for rapidly measuring harmful algal bloom (HAB) toxins in seafood, by validating a new ciguatoxin. It also completed more than ten experimental studies aimed at characterizing the transport and trophic transfer of contaminants and biotoxins, and assessing the impact of multiple stressors in the context of climate change. The results will be used to help Member States enhance the capacity of their national seafood safety programmes. During the year, the Agency conducted 14 training activities on these topics, involving 29 Member States. The training was aimed at improving the participating Member States' capacity to assess bioaccumulation, bioavailability and bioaccessibility of contaminants and biotoxins in marine organisms in order to enhance seafood safety.

The Agency has signed Practical Arrangements with three Regional Seas Conventions and Action Plans (RSCAPs): the Commission on the Protection of the Black Sea Against Pollution; the Regional Organization for the Conservation of the Environment of the Red Sea and Gulf of Aden (PERSGA); and the Secretariat of the Pacific Regional Environment Programme (SPREP). Under these arrangements, the Agency is assisting Member States party to these RSCAPs in analysing radionuclides, trace elements, chlorinated pesticides, polychlorinated biphenyls, petroleum hydrocarbons and HAB related biotoxins in marine samples. In 2016, new Practical Arrangements were signed with the South Asia Co-operative Environment Programme for collaboration in the area of data quality assurance in the analysis of contaminants in the South Asia marine and terrestrial environment. At the end of 2016, the Agency had established cooperation agreements with 63 Member States to support capacity building for monitoring and assessing marine pollution.



FIG. 1. Participants in an IAEA–UNEP/MAP training course organized by the Agency in Monaco prepare fish samples for analysis.

Assessing the Impact of Multiple Stressors on Ecosystems

Agency research activities contribute to an improved understanding of the impacts of multiple concurrent stressors on ecosystems (Fig. 2). These include stressors that have direct and sometimes immediate deleterious effects — such as organic solvents, petroleum by-products, radioisotopes and heavy metals — as well as those that are potentially equally important but are more difficult to measure — such as habitat loss, rising air and water temperatures, ocean acidification, ocean deoxygenation and overfishing. In 2016, the Agency conducted research on the effects of multiple stressors on coastal and marine ecosystems using nuclear tracer techniques developed to provide essential information to resource managers. This included field surveys to evaluate the role of various stressors in wholesale ecosystem degradation; laboratory experiments focused on the trophic transfer and bioaccumulation of diverse contaminants and biotoxins; and studies of the effects of ocean acidification on the physiology and metabolic function of key marine species.

To support accurate analyses of short-lived radionuclides in the terrestrial environment, the Agency provided analytical laboratories with milk powder and water samples to simulate conditions after an unexpected release of radionuclides to the environment. These samples were used in proficiency tests to strengthen the analytical techniques needed for decision making by the responsible authorities.

In 2016, the Agency released a new carbonate reference material that will constitute the basis for proper calibration of all carbon isotope measurements worldwide. Such calibration is particularly important in the framework of climate change studies. These isotope measurements are performed by global networks to improve the assessment of carbon sources and sinks in the global carbon cycle.

In close cooperation with the affected countries, the Agency finalized recommendations



FIG. 2. Agency research is contributing to improved understanding of the impacts of multiple concurrent environmental stressors, such as widespread coral bleaching near the Marshall Islands.

for environmental management and supported ongoing environmental monitoring of areas abandoned after the Chernobyl accident.

Performance of Analytical Laboratories

In 2016, the Agency supported more than 450 laboratories in over 80 Member States in efforts to test and improve their analytical performance through comprehensive proficiency tests for radionuclides, stable isotopes, trace elements and organic compounds in materials of terrestrial and marine origin. Two new proficiency tests for radionuclides were started for surface contamination, gross alpha/beta counting, short-lived radionuclides and aerosol filters. The Agency released ten new reference materials and began efforts to bring old reference materials in line with current quality standards. Over 2150 units of 96 different reference materials were provided to Member State laboratories through the Agency's on-line portal during the year.

The global network of Analytical Laboratories for the Measurement of Environmental Radioactivity (ALMERA) grew to 160 members in 87 Member States in 2016. Led by the Agency, the network's laboratories collaborated on the development and validation of rapid analytical methods for the measurement of strontium-89/strontium-90 in soil and seawater in 2016. An ALMERA Training Workshop on the Determination of Organically Bound Tritium in Food Samples Using Liquid Scintillation Counting was hosted by the Canadian Nuclear Safety Commission in Ottawa in September, with 13 participants from 13 Member States. In October, the network held its annual coordination meeting in Sydney, Australia, hosted by the Australian Nuclear Science and Technology Organisation, with 50 participants from 31 countries. Together with the Agency, ALMERA supports a regional African capacity building project entitled 'Promoting Technical Cooperation among Radio-Analytical Laboratories for the Measurement of Environmental Radioactivity'. Two training courses to support analytical quality were organized in 2016 within the framework of this project, with 46 participants from environmental radioactivity laboratories in over 20 African Member States.

In 2016, the Agency continued to assist the Government of Japan in ensuring the quality and reliability of data obtained as part of the sea area monitoring plan. Two sampling missions, involving experts from Japan and the Agency, were organized to collect seawater, sediment and fish samples for interlaboratory comparisons on radionuclides (Fig. 3). For the third consecutive year, a proficiency test for tritium, strontium-90, caesium-134 and caesium-137 in seawater was carried out in addition to the regular interlaboratory comparisons. The results obtained in both the interlaboratory comparisons and the proficiency tests demonstrate a high level of accuracy and competence on the part of the Japanese laboratories involved.



FIG. 3. Seawater samples from five stations within a 10 km radius of the Fukushima Daiichi nuclear power plant have been collected regularly since 2014 for interlaboratory comparisons between Japanese laboratories and the IAEA Environment Laboratories in Monaco. In 2016, interlaboratory comparisons were also organized for radionuclides in sediment and fish collected from the same area.

“The global network of Analytical Laboratories for the Measurement of Environmental Radioactivity (ALMERA) grew to 160 members in 87 Member States in 2016.”

Radioisotope Production and Radiation Technology

Objective

To strengthen national capabilities to produce radioisotope products and radiopharmaceuticals and to apply radiation technology, thus contributing to improved health care and sustainable industrial development in Member States.

Radioisotopes and Radiopharmaceuticals

The Agency continued to assist Member States in the production of technetium-99m (Tc-99m), the most widely used radioisotope in nuclear medicine. In March, it hosted a Technical Meeting on New Ways of Producing Tc-99m and Tc-99m Generators attended by 16 experts from 12 Member States. Participants discussed various options for producing molybdenum-99 (Mo-99), the radioactive parent of Tc-99m, including the relatively new photo-neutron reaction (i.e. the (γ, n) reaction on Mo-100). In this process, a beam of electrons (typically in the energy range of 20–50 MeV) from a high power electron linear accelerator is impinged on a dense target to produce high energy photons through bremsstrahlung radiation. These photons, in turn, strike the Mo-100 target to produce Mo-99 of low to medium specific activity (see Fig. 1). Another important topic of discussion at the meeting was the development of suitable generator systems using low to medium specific activity Mo-99. Participants reviewed ongoing efforts to develop high capacity sorbents for molybdenum. These would allow preparation of compact column generators, presenting new options for producing Tc-99m and Tc-99m generators at the national level.

In 2016, the Agency launched two new coordinated research projects (CRPs) on radiopharmaceuticals. The first, entitled 'Therapeutic Radiopharmaceuticals Labelled with New Emerging Radionuclides', involves 14 institutes from 13 Member States. The project aims at providing guidelines on producing new beta emitters of interest for therapeutic applications in nuclear medicine. The production routes considered will cover the use of cyclotrons, linear accelerators and, to a lesser extent, research reactors. The second CRP,



FIG. 1. A linear accelerator used for producing molybdenum-99 using the (γ, n) reaction on molybdenum-100. (Photograph courtesy of R. Galea, National Research Council Canada; Canadian Crown Copyright.)

entitled ‘Copper-64 Radiopharmaceuticals for Theranostic Applications’, focuses on copper-64 (Cu-64), one of the most promising radioisotopes for theranostic applications. Cu-64 emits both positrons, used in positron emission tomography, and beta particles and Auger electrons, used for therapeutic applications, making it suitable for both diagnosis and therapy. The CRP, which also involves 14 institutes from 13 Member States, aims at studying radiopharmaceuticals suitable for labelling with Cu-64. It follows on an earlier CRP on the topic, the results of which were published by the Agency in 2016 in *Cyclotron Produced Radionuclides: Emerging Positron Emitters for Medical Applications: ⁶⁴Cu and ¹²⁴I* (IAEA Radioisotopes and Radiopharmaceuticals Reports No. 1).

Radiation Technology Applications

Radiation technologies have immense potential in a variety of areas, including reducing the impact of pollutants in the environment. In August, a Technical Meeting on Radiation Technologies for Degradation of Contaminants of Emerging Concern was held in Budapest, Hungary, to assess the present status of radiation technologies and to formulate a work plan for exploring their potential uses. The Agency completed the CRP entitled ‘Radiation Treatment of Wastewater for Reuse with Particular Focus on Wastewaters Containing Organic Pollutants’ in 2016. The CRP, which involved 16 participants from 14 Member States, demonstrated that radiation technology can be successfully integrated with current technologies to treat pollutants that are currently problematic for the industrial and municipal wastewater industry.

“The Agency undertook a number of activities in 2016 aimed at ensuring the safe use of radiation processing facilities, particularly with regard to facility safety and the secure transport of radioactive sources.”

The Agency undertook a number of activities in 2016 aimed at ensuring the safe use of radiation processing facilities, particularly with regard to facility safety and the secure transport of radioactive sources. In late May and early June, a Technical Meeting on Enhancing Safety and Control Features of Existing Radiation Processing Facilities was held at the Institute of Nuclear Chemistry and Technology, an IAEA Collaborating Centre located in Warsaw, Poland. The meeting’s 20 participants from 16 Member States shared their experience of upgrading radiation facilities, and the resulting safety enhancements and economic benefits owing to faster processes and higher throughput. The Agency also hosted an experts meeting on the topic of Challenges Facing Gamma Radiation Sources: Emerging Scenarios, at its Headquarters in May. The meeting brought together five experts from five Member States, who evaluated recent issues related to the use of gamma irradiators. The participants concluded that current and foreseeable demand for cobalt can be met by anticipated supplies, and noted that industry was working with international and national organizations to enhance facility safety and the security of radioactive sources during transport.

The Agency completed its CRP entitled ‘Application of Radiation Technology in the Development of Advanced Packaging Materials for Food Products’ in 2016. Participants assessed the effects of ionizing radiation on commercial and emerging food packaging materials, and provided Member States with guidelines on developing new packaging materials based on natural and synthetic polymers using radiation techniques.

Radiometric techniques are essential tools in industrial processes and in the assessment of environmental changes. In 2016, the Agency concluded the CRP entitled ‘Radiometric Methods for Measuring and Modelling Multiphase Systems towards Process Management’, which involved 18 institutes from 18 Member States. The CRP focused on integrating two or more radiometric methods — each providing essential information complementary to that obtained from the other methods — with advanced modelling techniques to obtain the most valuable information on the multiphase system.

The first meeting of a new CRP entitled ‘Development of Radiometric Methods and Modelling for Measurement of Sediment Transport and Dispersion of Particles and Pollutants from Outfalls’ was held in 2016 in Quebec, Canada, with the participation of ten

institutes from ten Member States. This topic is particularly important in the light of the growing impact of climate change and human activities on coastal areas. The CRP is aimed at developing or improving technologies, methods and models to enhance the Member States' coastline protection capabilities.

In 2016, the Agency undertook emergency actions in response to the earthquake that affected Ecuador in April. As part of this response, it provided technical expertise in the use of non-destructive testing to evaluate the integrity of affected buildings and bridges.

Nuclear Safety and Security

The background of the slide is a light blue color with a fine, repeating dot pattern. Overlaid on this are several abstract elements: a collection of squares in various shades of blue (light, medium, and dark) scattered across the lower half; and several thick, smooth, swirling blue lines that create a sense of motion and flow, primarily concentrated in the center and right side of the image.

Incident and Emergency Preparedness and Response

Objective

To maintain and further enhance efficient Agency, national and international emergency preparedness and response (EPR) capabilities and arrangements for effective response to nuclear/radiological emergencies independent of their cause. To improve provision/sharing of information on nuclear or radiological incidents and emergencies among Member States, international stakeholders and the general public/media in preparedness stage and during response.

Strengthening Emergency Preparedness Arrangements

The Agency assists Member States in strengthening their emergency preparedness and response (EPR) arrangements and capabilities through Emergency Preparedness Review (EPREV) missions and EPR training events and workshops. In 2016, the Agency conducted a preparatory mission to Indonesia and two EPREV missions to Hungary and Indonesia. It also reviewed specific aspects of Member State EPR arrangements through the Integrated Regulatory Review Service (IRRS) and the Operational Safety Review Team (OSART) service.

The number of Member States using the Agency's Emergency Preparedness and Response Information Management System (EPRIMS) increased in 2016: by the end of the year, 88 Member States had appointed EPRIMS national coordinators and there were a total of 198 national EPRIMS users. EPRIMS, which was launched by the Agency in September 2015, enables Member States to assess their preparedness for nuclear and radiological emergencies and to share information with other countries. It provides structured self-assessment templates based on the requirements established in *Preparedness and Response for a Nuclear or Radiological Emergency* (IAEA Safety Standards Series No. GSR Part 7).

The Agency published an e-learning course entitled 'Communication with the Public in a Nuclear or Radiological Emergency'. This on-line training tool provides examples of good practice for public communication, including the selection of spokespersons, management of media relationships and organization of public communication within a command and control structure. To increase the reach of its EPR guidance, in June the Agency publication *Actions to Protect the Public in an Emergency due to Severe Conditions at a Light Water Reactor* (EPR-NPP-PUBLIC PROTECTIVE ACTIONS 2013) was made available in Spanish.

The Agency organized a total of 38 training events and workshops to assist Member States in implementing the requirements of GSR Part 7 and to increase knowledge and understanding of the Agency's EPR guidance. This included two Schools of Radiation Emergency Management organized to address the need for comprehensive training in Member States on all relevant EPR topics, including general EPR framework requirements, hazard assessment, protective strategy, protection of emergency workers, public communication, international assistance and early notification (Fig. 1). In May, the Agency

"The Agency organized a total of 38 training events and workshops to assist Member States in implementing the requirements of GSR Part 7 and to increase knowledge and understanding of the Agency's EPR guidance."



FIG. 1. Participants in the School of Radiation Emergency Management held in Traiskirchen, Austria, in October (photograph courtesy of S. Schoenhacker).

“More than 190 participants from over 45 Member States and 11 international organizations took part in a total of 12 events... related to communication with the public in nuclear or radiological emergencies.”

and the International Labour Organization jointly organized a webinar on protection criteria for emergency workers and helpers in a nuclear or radiological emergency. The webinar was aimed at participants from relevant authorities — including both employers and emergency workers — having responsibilities, rights and duties in relation to occupational radiation protection in a nuclear or radiological emergency. Around 110 people took part worldwide. Two new capacity building centres for EPR were designated in 2016, in Austria and the Republic of Korea.

More than 250 health care professionals from 45 Member States participated in 11 national, regional and interregional events related to medical preparedness and response to a nuclear or radiological emergency. These events covered basic and specialized training, and described

radiological health hazards and approaches to putting these hazards into perspective when communicating with the public.

The Agency organized four workshops on effective public communication in an emergency: two in the Russian Federation, one in South Africa and one hosted by the RANET Capacity Building Centre in Fukushima Prefecture, Japan, for the Asia and the Pacific region.

More than 190 participants from over 45 Member States and 11 international organizations took part in a total of 12 events, including Technical Meetings, workshops and training courses, related to communication with the public in nuclear or radiological emergencies. These events covered, for example, the drafting of a safety guide on public communication during emergencies and the revision of guidance on the use of the International Nuclear and Radiological Event Scale (INES) as a communication tool.

Response Arrangements with Member States

During 2016, the Agency organized 13 Convention Exercises (ConvEx) with Member States and international organizations. Carried out in the framework of 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), the exercises were used to test emergency communication channels and the Agency's assessment and prognosis process. Member State capabilities were also tested regarding: requesting assistance during a nuclear or radiological emergency and preparing for its receipt; exchanging emergency information on appropriate protective actions; and communicating with the public. An exercise version of the International Radiation Monitoring Information System (IRMIS) that allows the use of simulated radiation monitoring data was developed and successfully used for the first time during a ConvEx exercise in 2016. The Agency organized four workshops on notification, reporting and requesting assistance, involving 50 participants from 20 Member States.

A Technical Meeting to Review the IAEA's Assessment and Prognosis Procedures for Nuclear and Radiological Emergencies was held in Vienna, Austria, in late November and early December. The meeting was attended by 77 participants from 53 Member States and 3 international organizations, who reviewed and discussed the Agency's assessment and prognosis process and associated communication procedures. On-line assessment and

prognosis tools developed by the Agency, including the Reactor Assessment Tool, the Protective Actions Assessment Tool and the Radiological Source Assessment Tool, were made available to Member States at the Technical Meeting.

The Agency expanded its Unified System for Information Exchange in Incidents and Emergencies (USIE) web site in 2016. Enhanced functionalities were introduced, including automatic exchange of information among national and international bodies, such as information to be displayed on relevant Agency and European Commission web sites. Another new functionality enables the Agency and those States Parties to the Assistance Convention that have registered their National Assistance Capabilities (NAC) in the Agency's Response and Assistance Network (RANET) to update their existing registrations directly through USIE.

In 2016, Denmark, Spain and Ukraine registered their NAC in RANET, while Canada added additional resources under its registered NAC resources. A total of 31 States Parties to the Assistance Convention have registered their NAC resources in the Agency's RANET. The Agency continued to organize RANET workshops on radiation monitoring during nuclear or radiological emergencies at the RANET Capacity Building Centre in Fukushima Prefecture, Japan.

The Eighth Meeting of the Representatives of Competent Authorities Identified under the Early Notification Convention and the Assistance Convention was held in Vienna, Austria, in June. The representatives discussed matters such as information exchange, international assistance, communicating with the public, training and exercises. The meeting's conclusions covered the utilization of IRMIS, operationalization of the assessment and prognosis process, implementation of the ConvEx exercise regime and sharing of lessons from exercises. During the year, one State became a Party to each Convention; by the end of the year, there were 120 Parties to the Convention on Early Notification of a Nuclear Accident and 113 Parties to the Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency.

Response to Events

In 2016, the Agency was directly informed by the competent authorities, or indirectly became aware based on earthquake alerts from the Agency web site or information from the media, of 234 events involving or suspected to involve ionizing radiation (Fig. 2). It took

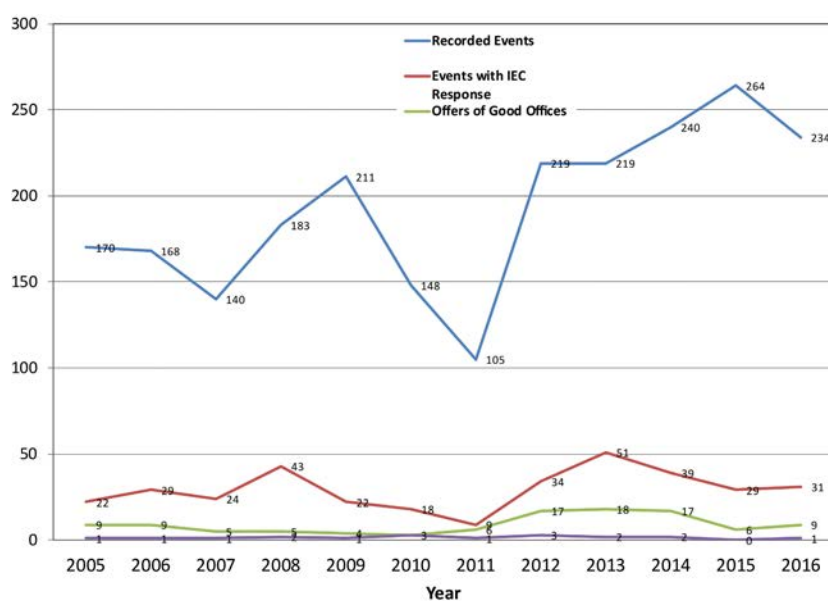


FIG. 2. Number of radiation events the Agency became aware of, and Agency responses, since 2005.

response actions in 31 of these events. Nine offers of good offices were made, including for events involving the loss of radioactive sources and those triggered by earthquakes. In 2016, in response to a request from Georgia, the Agency sent an assistance mission to support the relevant authorities by providing medical advice on managing the radiation injury of a patient affected by the radiological accident that occurred in Lilo, Georgia, in 1997.

Inter-Agency Coordination

In December, the Agency conducted a tabletop exercise to test and improve the public communication procedures based on the Joint Radiation Emergency Management Plan of the International Organizations (JPLAN). The exercise involved public information officers from seven member organizations of the Inter-Agency Committee on Radiological and Nuclear Emergencies (IACRNE). The lessons learned from the exercise will contribute to further improvements of the IACRNE procedures for the inter-agency coordination of public communication during an emergency.

In the context of the JPLAN, the Agency signed Practical Arrangements with the Preparatory Commission for the Comprehensive Nuclear-Test-Ban Treaty Organization (CTBTO) in 2016. The arrangements describe cooperation that may be pursued subject to the Parties' respective mandates, governing regulations, rules, policies and procedures in the case of a nuclear or radiological emergency, particularly with an actual or potential atmospheric release of radioactive materials. The Agency also signed Practical Arrangements with the World Association of Nuclear Operators (WANO) to cooperate in the area of response to radiation incidents and emergencies in WANO member nuclear installations.

In-house Preparedness and Response

The Agency organized a comprehensive programme of training, drills and exercises in 2016 to enhance the skills and knowledge of those Agency staff members who serve as qualified responders under the Incident and Emergency System (Fig. 3). The programme offered approximately 150 hours of training during the year, including 84 training classes delivered to nearly 200 Agency staff responders.



FIG. 3. Agency staff responders during an internal exercise in 2016.

Safety of Nuclear Installations

Objective

To continuously improve the safety of nuclear installations during site evaluation, design, construction and operation through the availability of safety standards and their application. To support Member States in developing and implementing the appropriate safety infrastructure. To assist adherence to, and implementation of, the Convention on Nuclear Safety (CNS) and the Code of Conduct on the Safety of Research Reactors and to strengthen international cooperation.

Nuclear Safety Infrastructure

The Agency's Integrated Regulatory Review Service (IRRS) assists Member States in strengthening and enhancing the effectiveness of their national regulatory infrastructure. IRRS peer reviews consider both technical and policy issues of a regulatory nature against Agency safety standards and, where appropriate, against good practice elsewhere. In 2016, the Agency conducted five IRRS missions to Member States with operating nuclear power plants: two IRRS missions to Japan and South Africa, and three IRRS follow-up missions to Bulgaria, China (Fig. 1) and Sweden.



FIG. 1. IRRS team members and staff of the Chinese National Nuclear Safety Authority visit the Fuqing nuclear power plant as part of an Agency led peer review of China's regulatory framework for nuclear and radiation safety.

“The Agency also organized 25 capacity and competency building activities based on the Agency’s Safety Assessment Education and Training Programme, involving over 400 participants from 15 Member States.”

The Agency continued to assist Member States with emerging or expanding nuclear power programmes. During the year, it organized around 200 expert missions, workshops and training courses, involving 44 Member States, to provide guidance and information on all elements of establishing an effective nuclear safety infrastructure. The activities focused predominantly on the development of national nuclear safety regulations; the establishment of a management system at the regulatory body; and the preparation of a national plan for human resource development, particularly for the regulatory body. The Agency also organized 25 capacity and competency building activities based on the Agency’s Safety Assessment Education and Training Programme, involving over 400 participants from 15 Member States. These activities were aimed at providing staff of regulatory bodies, future nuclear power plant owner/operator organizations, and technical and scientific support organizations with essential knowledge and practical training in safety assessment.

The Agency placed increased importance on the coordination of support for regulatory bodies in Member States embarking on a new nuclear power programme through, for example, the Regulatory Cooperation Forum (RCF). Support plans were identified for the current RCF recipient countries (Belarus, Jordan, Poland and Viet Nam) for 2016 and beyond. These plans included coordination with other regional networks such as the Asian Nuclear Safety Network (ANSN), the Arab Network of Nuclear Regulators (ANNuR) and the Forum of Nuclear Regulatory Bodies in Africa (FNRBA).

The Agency also established the European and Central Asian Safety Network (EuCAS Network), involving the regulatory bodies and technical support organizations of 21 Member States. The new network is expected to focus initially on addressing the management of radioactive waste resulting from nuclear power plants and other nuclear applications. Other areas identified for future activities include environmental remediation and the decommissioning of power and research reactors. The first EuCAS Steering Committee meeting was held in Vienna, Austria, in December.

The Agency organized four national workshops to assist Member States in strengthening and enhancing the effectiveness of their national regulatory infrastructure. These workshops were conducted in Indonesia, on establishing a communication strategy to build public confidence in the regulatory body, involving 17 participants; in Viet Nam, on project management of a safety evaluation report, with 20 participants; and in Egypt and Turkey, on construction and vendor inspections for new nuclear power plants, involving 22 and 20 participants, respectively. The Agency also conducted four regional workshops: on review and assessment by the regulatory body, held in Vienna, Austria, involving 25 participants from 6 Member States; on knowledge management at the regulatory body and its technical support organization and on information and communication technology interfaces, held in the Republic of Korea, involving 14 participants from 8 Member States; on drafting nuclear safety regulations, held in Viet Nam, involving 16 participants from 9 Member States; and on communication by the regulatory body, held in Pakistan, involving 20 participants from 9 Member States. In addition, the Agency organized two hands-on training courses for regulatory inspectors at Zwentendorf, Austria, involving 30 participants from 12 Member States.

Convention on Nuclear Safety

The Agency hosted several preparatory meetings at its Headquarters in Vienna, Austria, in support of the Seventh Review Meeting of Contracting Parties to the Convention on Nuclear Safety (CNS), to take place in March–April 2017. In particular, a working group was established to prepare templates for the Country Review Reports and national presentations to be used during the forthcoming review meeting. Also, an Officer’s ‘turnover meeting’ was convened in March to share experience and lessons learned among incoming and outgoing CNS Officers.

Design Safety and Safety Assessment

In February, the Agency published the revised Safety Requirements publication *Safety of Nuclear Power Plants: Design* (IAEA Safety Standards Series No. SSR-2/1 (Rev. 1)), which takes into account lessons from the accident at the Fukushima Daiichi nuclear power plant. To support Member States in the practical application of the design principles and requirements established in SSR-2/1, the Agency issued *Considerations on the Application of the IAEA Safety Requirements for the Design of Nuclear Power Plants* (IAEA-TECDOC-1791), aimed at facilitating understanding of new topics and terminology introduced in SSR-2/1 (Rev. 1), and organized workshops in China, involving 90 participants, and in Jordan, involving 23 participants. It also issued *Design of Instrumentation and Control Systems for Nuclear Power Plants* (IAEA Safety Standards Series No. SSG-39). This revised Safety Guide takes into account ongoing developments in instrumentation and control, including the development of computer applications and the evolution of the methods necessary for their safe, secure and practical use, developments in human factors engineering and the need for computer security.

The Agency facilitated meetings of the Small Modular Reactor (SMR) Regulators' Forum Steering Committee and its three Working Groups, held in March in Vienna, Austria. The Working Group meetings were used to prepare reports relating to the size of emergency planning zones and the application of the concepts of defence in depth and the graded approach. The Agency also organized two workshops on SMR safety and licensing in Vienna, Austria: one for members of ANNuR, involving 18 participants from 10 Member States, and one for members of FNRBA, involving 20 participants from 15 Member States.

Protection against External Hazards

In February, the Agency issued *Site Evaluation for Nuclear Installations* (IAEA Safety Standards Series No. NS-R-3 (Rev. 1)), which establishes the requirements for a site evaluation for a nuclear installation that fully characterizes the site specific conditions pertinent to the safety of the installation. Three other publications were issued on protection against external hazards. *Diffuse Seismicity in Seismic Hazard Assessment for Site Evaluation of Nuclear Installations* (Safety Reports Series No. 89) describes procedures that can be used to estimate the seismic hazard in diffuse seismicity regions. *Seismic Hazard Assessment in Site Evaluation for Nuclear Installations: Ground Motion Prediction Equations and Site Response* (IAEA-TECDOC-1796) provides information on the state-of-the-art practice and detailed technical elements related to ground motion evaluation by ground motion prediction equations and site response. *Volcanic Hazard Assessments for Nuclear Installations: Methods and Examples in Site Evaluation* (IAEA-TECDOC-1795) provides information on detailed methodologies for, and examples of the application of, volcanic hazard assessment for nuclear installation site evaluation.

The Agency's Site and External Events Design (SEED) review service provides an independent review of the site evaluation and the designed safety of the nuclear installation against the demands of external hazards. In 2016, the Agency conducted three preparatory SEED missions, to Belarus, France and the Islamic Republic of Iran, and five SEED peer review missions, to Japan, Jordan, Pakistan, Poland and Tunisia. It also organized six SEED training workshops involving a total of 115 participants from 19 Member States. The Agency conducted two expert missions to Egypt: in January to assist the Egyptian Nuclear and Radiological Regulatory Authority (ENRRA) in reviewing regulations on siting; and in May to assist ENRRA in reviewing the population distribution at the El-Dabaa site.

In November, the Agency organized a Technical Meeting on Lessons Learned and Safety Improvements Related to External Hazards Based on the IAEA Fukushima Report, attended

by more than 50 participants from 30 Member States. The participants shared their experience concerning the actions taken after the Fukushima Daiichi accident to strengthen nuclear safety with regard to protection against external hazards. The participants also shared best practices in the identification of potential safety issues and areas for improvement related to external hazards and how these issues were addressed.

Operational Safety

The Operational Safety Review Team (OSART) programme has provided advice and assistance to Member States for over 30 years, to enhance the safety of nuclear power plants during construction, commissioning and operation. Under the OSART programme, international teams of experts conduct in-depth reviews of operational safety performance at a nuclear power plant, reviewing the factors affecting the management of safety and the performance of personnel. The Agency conducted three missions in 2016, to Canada, France and Romania. It also conducted five OSART follow-up missions, including two to France, and one each to Hungary, the Netherlands and the Russian Federation.

In 2016, the Agency published *OSART Guidelines: 2015 Edition* (IAEA Services Series 12 (Rev. 1)). The revised guidelines take into account the lessons arising from the Fukushima Daiichi accident and the experience gained from application of the Agency's safety standards. Two new modules were incorporated into the OSART service: one on the assessment of leadership and management for safety, and one on the technological, human and organizational interfaces.

The Agency issued *Leadership and Management for Safety* (IAEA Safety Standards Series No. GSR Part 2), establishing requirements concerning effective leadership and management for safety in organizations concerned with, and facilities and activities that give rise to, radiation risks.

The Agency conducted four Safety Aspects of Long Term Operation (SALTO) missions, to Argentina, Armenia, Bulgaria and Sweden, and three SALTO follow-up missions, to Belgium, the Czech Republic and Sweden. It also made available to Member State regulatory bodies and nuclear utilities a SALTO mission highlights report summarizing the results of 22 SALTO missions and 6 SALTO follow-up missions conducted from 2005 to 2015. The Agency conducted SALTO workshops and seminars, workshops on long term operations and ageing management, and support missions to Argentina, Armenia, Brazil, China, the Czech Republic, Finland, France, Mexico, Pakistan, Romania, the Russian Federation, Slovenia, South Africa, Sweden, Ukraine and the United States of America. The third phase of the Agency's International Generic Ageing Lessons Learned (IGALL) programme was initiated in 2016, with the participation of 29 Member States having operating nuclear power plants.

In April, the Agency held the fourth annual IAEA Workshop for Senior Managers on Leadership and Culture for Safety. The workshop provided an international forum for senior executive managers to share their experience and learn more about how leadership and culture for safety can be continuously improved. The Agency launched a new series of training workshops on a systemic approach to safety for middle managers. The workshops focus on how a systemic approach to safety is achieved in practice. During the year, the Agency issued two publications relating to safety culture assessment: *Performing Safety Culture Self-assessments* (Safety Reports Series No. 83) and *OSART Independent Safety Culture Assessment (ISCA) Guidelines* (IAEA Services Series 32)).

The Agency organized a Technical Meeting to Share Lessons Learned from Recent Human Performance Related Events at Nuclear Power Plants and Considerations for Performance Improvement in Vienna, Austria, in late May and early June, involving 30 participants from 22 Member States. In October, it organized a Technical Meeting of the Technical Committee of the International Reporting System for Operating Experience National Coordinators in

“The Agency launched a new series of training workshops on a systemic approach to safety for middle managers.”

Vienna, Austria. The meeting was attended by 40 participants from 25 Member States, who shared experience and information on significant events at nuclear power plants.

The Agency conducted four national training courses on the International Reporting System for Operating Experience and root cause analysis techniques: one in Ukraine, with 40 participants; one in Slovakia, with 30 participants; and two in Pakistan, with a total of 100 participants. A joint Agency–WANO Moscow Centre meeting was held in Belarus, attended by 33 participants from 8 Member States. Participants discussed the lessons from recent nuclear events and ways to improve the effectiveness of operating experience programmes. The Agency conducted one Peer Review of Operational Safety Performance Experience (PROSPER) mission, to the Russian Federation.

“The Agency conducted four national training courses on the International Reporting System for Operating Experience and root cause analysis techniques”

Safety of Research Reactors

The Agency issued *Safety of Research Reactors* (IAEA Safety Standards Series No. SSR-3), establishing requirements on a range of aspects for safety and safety assessment for all stages in the lifetime of a research reactor. It also published *Management of the Interface between Nuclear Safety and Security for Research Reactors* (IAEA-TECDOC-1801), providing technical guidelines and practical information for aligning the safety–security interface at research reactor sites.

In 2016, the Agency conducted Integrated Safety Assessment of Research Reactors (INSARR) missions to Jordan, the Netherlands and Portugal, and a follow-up INSARR mission to Malaysia. It conducted advisory missions to Indonesia, Jamaica, Malaysia, Peru and Poland, to assist research reactor operating organizations in implementing safety enhancements based on the recommendations of previous INSARR missions. An Agency expert mission to Ghana conducted in late June and early July provided recommendations to ensure the safe conversion of the core of its Miniature Neutron Source Reactor from high enriched uranium to low enriched uranium fuel.

The Agency organized a Technical Meeting on the Use of a Graded Approach in the Application of the Safety Requirements for Research Reactors, held in May. The meeting was attended by 54 participants from 38 Member States, who shared information and exchanged knowledge and experience and provided feedback on related Agency safety standards. The Agency also organized a regional meeting on application of the Code of Conduct on the Safety of Research Reactors, held in Egypt in November, and involving 18 participants from seven Member States in Africa. The meeting provided support to participating Member States in strengthening their programmes for preparing safety documentation for research reactors.

Safety of Fuel Cycle Facilities

In July, the Agency issued *Safety Reassessment for Nuclear Fuel Cycle Facilities in Light of the Accident at the Fukushima Daiichi Nuclear Power Plant* (Safety Reports Series No. 90). The publication provides information on carrying out safety reassessments for nuclear fuel cycle facilities based on Agency safety standards and current international experience, taking into account the available feedback from the Fukushima Daiichi accident. The Agency also organized a workshop on the topic, held in April in Vienna, Austria, with 29 participants from 21 Member States. The workshop participants exchanged information on experience acquired since the Fukushima Daiichi accident relevant to fuel cycle facilities, including regulatory aspects of safety reassessments, design reviews and the application of a graded approach.

The Agency organized a workshop on safety analysis and safety documents for nuclear fuel cycle facilities, held in November in Vienna, Austria, with 19 participants from

17 Member States. Participants received practical information on performing safety analyses for fuel cycle facilities, and on preparing, updating and assessing safety documents for such facilities based on the Agency's safety standards.

The Agency and the OECD Nuclear Energy Agency jointly organized the biennial Technical Meeting for the National Coordinators of the Joint IAEA–OECD/NEA Fuel Incident Notification and Analysis System (FINAS). Held in Paris, France, in October, the meeting was attended by 24 participants from 19 Member States. Participants exchanged operating experience and discussed the events reported to FINAS in the previous two years, including their root causes and actions taken to prevent their recurrence.

Radiation and Transport Safety

Objective

To achieve global harmonization of the development and application of the Agency's safety standards in this area, and to increase the safety of radiation sources, and thereby raise the levels of protection of people against the harmful effects of radiation.

Regulatory Infrastructure

Member States without nuclear installations continued to make use of the Agency's Integrated Regulatory Review Service (IRRS) in 2016. The Agency conducted IRRS missions to five Member States without operating nuclear power plants — Belarus, Estonia, Italy, Kenya and Lithuania. It also conducted an IRRS training course in Vienna, Austria, in December, specifically for radiation safety reviewers taking part in IRRS missions. The training course was attended by more than 40 participants from 18 Member States. The Agency conducted radiation safety advisory missions to Antigua and Barbuda, Cambodia, Ecuador, El Salvador, Liberia, Madagascar, Morocco, Qatar and Sri Lanka, to assess and provide expert guidance on strengthening national regulatory infrastructures.

The Agency organized four national workshops on regulatory infrastructure self-assessment, held in Georgia, Kenya, Nigeria and Spain. It also held two regional workshops on this topic: in Vienna, Austria, attended by 15 participants from 12 Member States, and in Amman, Jordan, attended by 15 participants from 5 Member States. Twenty-seven Member States in the Africa region participating in a regional project entitled 'Enhancing and Sustaining the National Regulatory Bodies for Safety (AFRA)' used the Self-Assessment of Regulatory Infrastructure for Safety (SARIS) methodology to develop and implement national action plans for improving their national regulatory body. These action plans are being used to strengthen their regulatory infrastructure in line with the requirements established in *Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards* (IAEA Safety Standards Series No. GSR Part 3).

Two Schools for Drafting Regulations on Radiation Safety were organized by the Agency for Member States in Europe and in Africa, involving 43 participants from 22 Member States. The Agency used its Control of Sources Network platform to prepare and implement these activities.

An Open-ended Meeting of Technical and Legal Experts to Share Information on States' Implementation of the Code of Conduct on the Safety and Security of Radioactive Sources and Its Supplementary Guidance on the Import and Export of Radioactive Sources was held in Vienna, Austria, from 30 May to 3 June. The meeting served as a forum for the exchange of information on national implementation of the Code of Conduct and its additional guidance. It included plenary sessions devoted to, inter alia, the international and regional initiatives related to safety and security of radioactive sources, synergies between the Code

of Conduct and the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management, and ongoing and new initiatives to assist States in the implementation of the safety and security principles of the Code.

The Agency also organized the third Open-ended Meeting of Legal and Technical Experts to Develop Internationally Harmonized Guidance for Implementing the Recommendations of the Code of Conduct on the Safety and Security of Radioactive Sources in Relation to the Management of Disused Radioactive Sources.

The Agency started one regional project for Member States in the Caribbean region and one interregional project on the control of radioactive sources throughout their life cycle, focusing on the management of sources at the end of their life. The projects have been designed to support the development of regulatory frameworks and operations for conditioning disused sealed radioactive sources.

Radiation Protection

The International Basic Safety Standards (GSR Part 3) require governments to provide information on levels of radon indoors and, if necessary, to establish and implement an appropriate action plan. In May, the Agency assisted Member States in evaluating the need for a national action plan through a Workshop on the Control of Public Exposure in Compliance with the International Basic Safety Standards. Organized in cooperation with the World Health Organization and the National Nuclear Regulator of South Africa, the workshop was attended by 31 participants from 16 Member States and an international organization. The participants shared experience with the management of land contaminated from past practices, radionuclides in food and drinking water in non-emergency situations, and radon in buildings.

In March, the Agency held a Technical Meeting on Justification of Medical Exposure in Diagnostic Imaging, in Vienna, Austria, attended by 56 participants from 28 Member States and 5 international organizations. Participants shared experience with the medical diagnostic applications of ionizing radiation and identified opportunities for strengthening the justification of its use. The Agency also organized a Technical Meeting on Patient Dose Monitoring and the Use of Diagnostic Reference Levels for the Optimization of Protection in Medical Imaging, in Vienna, Austria, in late May and early June. The meeting was attended by more than 60 participants from 35 Member States and 8 international organizations and professional bodies. Participants focused on identifying strengths and weaknesses in the use of diagnostic reference levels for optimization of patient safety and improving medical practice.

During the year, e-learning courses on Safety and Quality in Radiotherapy and on Radiation Dose Management in Computed Tomography were made available on the Agency web site to assist radiology professionals in the safe and appropriate use of these technologies (Fig. 1). The Agency also conducted seven webinars on radiation protection in medicine in 2016, involving 1350 participants from 90 Member States.

In April, the Agency issued *Criteria for Radionuclide Activity Concentrations for Food and Drinking Water* (IAEA-TECDOC-1788). The publication considers the various international standards to be applied at the national level for the assessment of radionuclides in food and drinking water under different circumstances for the purposes of control, other than in a nuclear or radiological emergency.

The Agency's Occupational Radiation Protection Appraisal Service (ORPAS) provides Member States, on request, with an independent assessment and evaluation of their national occupational radiation protection programme. In 2016, the Agency conducted ORPAS missions to Costa Rica and Ghana, an ORPAS follow-up mission to Uruguay, and preparatory ORPAS missions to Malaysia, Morocco and Paraguay.

“The Agency also conducted seven webinars on radiation protection in medicine in 2016, involving 1350 participants from 90 Member States.”

The Agency, in collaboration with the Regional European and Central Asian ALARA Network, organized a regional training course on occupational radiation protection programmes and safety culture in late May and early June, in Vilnius, Lithuania. The training course was attended by 23 participants from 19 Member States, who received training in occupational exposure monitoring and the dosimetry and technical services necessary for workplace monitoring. The Agency organized two regional workshops on the implementation of the International Basic Safety Standards (GSR Part 3). The first workshop was held in Vienna, Austria, in August, attended by 36 participants from 17 Member States in the Asia and the Pacific region. The second workshop was held in Chisinau, Republic of Moldova, in December, attended by 32 participants from 18 Member States in the Europe region.

In the framework of a regional project entitled 'Enhancing National Capabilities on Occupational Radiation Protection in Compliance With Requirements of the New International Basic Safety Standards', Member States in Africa assessed the capabilities of their dosimetry services to measure the quantity of a radiation dose in a person's body (Fig. 2). The project participants also developed guidelines to help Member States improve the performance of existing dosimetry services, thereby strengthening occupational radiation protection in Africa.

The Agency and Fukushima Prefecture, Japan, continued to cooperate on activities relating to off-site decontamination, management of radioactive waste, and radiation monitoring and assistance in environmental mapping using unmanned aerial vehicles. In 2016, the Agency provided technical assistance and support to Fukushima Prefecture, including the development of methodologies for decontamination of publicly accessed areas, remediation of water ecosystems, safety assessment of temporary storage sites and assessment of the results of radiation monitoring.

Transport Safety

The Agency continued to support capacity building for regulatory oversight of transport of radioactive material in over 80 Member States in the Africa, Asia and the Pacific, Europe, and Latin America and the Caribbean regions in 2016. As part of a regional project entitled 'Enhancing Governmental and Regulatory Safety Infrastructure to Meet the Requirements of the New IAEA Basic Safety Standards', the Agency assisted Latin American and Caribbean Member States in strengthening competencies for the safe transport of radioactive material



FIG. 1. The Agency provided training in the safe and effective use of new equipment to staff of the Nuclear Medicine Department at Yangon General Hospital in Yangon, Myanmar.



FIG. 2. Experts from Member States in Africa participated in a meeting in Accra, Ghana, to present and discuss the results of the 2016 regional dosimetry intercomparison exercise to assess the capabilities of their dosimetry services.

in the region. Participating Member States shared information on the status of their national transport regulations and identified opportunities for further harmonization of national transport regulations in the region.

The Agency continued to develop an e-learning platform for a transport safety training programme on the Cyber Learning Platform for Network Education and Training (CLP4NET). In 2016, the modular structure of this training programme was completed and modules on radiation protection, regulatory infrastructure, international transport safety regulations, transport package inspection, and others were filled with relevant training materials.

Radiation Safety Information Management System

The web based Radiation Safety Information Management System (RASIMS) platform is a tool that enables Member States to monitor the status and level of implementation of their radiation safety infrastructure in line with the Agency's safety standards. The Agency organized two regional workshops for RASIMS National Coordinators at the Agency's Headquarters in Vienna, Austria. The first workshop took place in April, attended by RASIMS National Coordinators from 20 Member States in the Europe region. The second workshop took place in November, attended by RASIMS coordinators from 16 Member States in the Latin America and the Caribbean region. The workshops allowed the coordinators to update RASIMS with information on radiation safety infrastructure in their countries, as well as providing an opportunity for identifying improvements to RASIMS.

Radioactive Waste Management and Environmental Safety

Objective

To achieve harmonization in policies and standards governing waste safety and public and environmental protection, together with provisions for their application, including sound technologies and good practices.

Radioactive Waste and Spent Fuel Management

International projects on the safety of high level radioactive waste disposal continued during 2016. A Technical Meeting was held in May, in Vienna, Austria, to follow up on the International Project on Demonstration of the Operational and Long-Term Safety of Geological Disposal Facilities for Radioactive Waste (GEOSAF Part II). The meeting was attended by 26 participants from 17 Member States, who agreed on the terms of reference for the follow-up project, GEOSAF III, and discussed the project plan of work. GEOSAF III will focus on the link between operational and long term safety of geological disposal facilities and on how to demonstrate the safety of such facilities. The first Plenary Meeting of the second phase of the International Project on Human Intrusion in the Context of Disposal of Radioactive Waste (HIDRA II) was held in Vienna, Austria, in January and was attended by 29 participants from 16 Member States. The participants exchanged information on recent national and international activities related to human intrusion in relation to the disposal of radioactive waste, and discussed and agreed on the work programme for HIDRA II. This work included the application of the general approaches and concepts described in HIDRA I, such as inadvertent human intrusion and deliberate human intrusion, and how they may be applied to the safety of disposal facilities.

The Agency assists Member States that are actively pursuing borehole disposal as an option for disused sealed radioactive sources (Fig. 1). In 2016, the Agency assisted Member States in building capacities for the development of borehole disposal. A dedicated School for Drafting Regulations on Waste Disposal, including borehole disposal, was organized for Ghana, Malaysia and the Philippines in October to assist those Member States in developing regulations prior to the implementation of borehole disposal.



FIG. 1. A specially designed canister, or disposal package, for borehole disposal of disused sealed radioactive sources.

Assessment and Management of Environmental Releases

In 2016, the Agency launched the second phase of the Modelling and Data for Radiological Impact Assessments (MODARIA) programme. MODARIA II focuses on applications of radiological impact assessments to support implementation of the Agency's safety standards. The first Technical Meeting for MODARIA II was held in late October–early November, in Vienna, Austria, involving 145 participants from 47 Member States. Participants discussed topics related to radiological impact assessment, including: risk informed decision making for environmental clean-up activities; Agency safety standards addressing protection of people and the environment and the need for radiological impact assessments; and remediation of radioactive contamination in agriculture.

Decommissioning and Remediation Safety

In June, the Agency organized a Technical Meeting on Remediation Techniques and Strategies in Post-Accident Situations. The meeting was held in Vienna, Austria, and attended by 55 participants from 35 Member States and 2 international organizations. Participants shared knowledge and experience related to the remediation and recovery of contaminated areas and the application of the relevant Agency safety standards. They also considered the application of radiation protection principles in post-accident situations, the identification of appropriate remedial actions, strategies for communication with the public and considerations on management of waste generated during remediation activities.

The Agency's International Project on Managing the Decommissioning and Remediation of Damaged Nuclear Facilities (DAROD Project) entered its final phase in 2016. Parallel meetings of the three DAROD Project working groups were held in Vienna, Austria, in late August–early September. The working group meetings involved 25 participants from 14 Member States, who shared and discussed experience on the decommissioning and remediation of damaged nuclear facilities. Participants also identified gaps and the need for additional guidance to address issues related to strategic planning, technical and regulatory aspects of decommissioning and remediation.

The Agency's Coordination Group for Uranium Legacy Sites (CGULS) continued to play a pivotal role in coordinating the many different organizations working toward the goal of sustainable remediation of uranium legacy sites in Central Asia. The Agency held the CGULS annual meeting in Vienna, Austria, in June–July involving 42 participants from 10 Member States, 5 international organizations and 1 non-governmental organization. The meeting participants discussed the development of a strategic master plan for remediation of uranium legacy sites in Central Asia. Participants also presented the current status of planning for remediation of legacy uranium production sites in their countries and discussed the perception of radiation risks by persons living near legacy uranium production sites.

Many Member States are participating in the Agency's International Working Forum on Regulatory Supervision of Legacy Sites (RSLs), reflecting the need for enhanced coordination and knowledge transfer concerning the remediation of these sites. The annual meeting of the Agency's RSLs was held in Vienna, Austria, in late November–early December, involving 29 participants from 21 Member States. The meeting participants summarized the training programmes conducted in their respective regulatory body and the challenges they face in ensuring that regulatory personnel are appropriately trained to supervise legacy sites.

The Agency completed the development of a comprehensive, seven module training course on the safety and regulatory aspects of uranium production. A substantial portion of this training course addresses the remediation of legacy uranium production sites. The course includes an overview of the safety of uranium production activities; decommissioning and closure of uranium production facilities; practical intervention

“The Agency completed the development of a comprehensive, seven module training course on the safety and regulatory aspects of uranium production.”



FIG. 2. The development of a strategic master plan for remediation of legacy uranium sites such as the former Min-Kush uranium production site in Kyrgyzstan was discussed by CGULS Members, in Vienna, in June.

techniques to reduce public doses at uranium legacy sites; remediation of uranium sites; review of remediation plans and activities for uranium sites; and authorization and inspection of uranium production activities. The Agency conducted three such training courses in 2016, involving 55 participants from 34 Member States.

Joint Convention Meeting

The Contracting Parties to the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management (the Joint Convention) organized a Topical Meeting on the safety challenges and responsibilities of multinational radioactive waste disposal facilities, held in September at the Agency's Headquarters in Vienna. The Topical Meeting included sessions on, inter alia, the current status of the initiatives for multinational radioactive waste disposal, roles and responsibilities in the context of multinational disposal, and the liability and financial issues of such facilities.

A Meeting to Discuss Feedback from Contracting Parties to Improve the Review Process for the Joint Convention was held in October; its outcome will be discussed at the Third Extraordinary Meeting of the Contracting Parties to the Joint Convention scheduled to take place in May 2017.

Nuclear Security

Objective

To contribute to global efforts to achieve effective nuclear security, by establishing comprehensive nuclear security guidance and providing for its use through peer reviews and advisory services and capacity building, including education and training. To assist in adherence to, and implementation of, relevant international legal instruments, and to strengthen the international cooperation and coordination of assistance in a way that underpins the use of nuclear energy and applications. To play the central role and enhance international cooperation in nuclear security, in response to General Conference resolutions and Board of Governors directions.

Promotion of the Nuclear Security Framework

The Amendment to the Convention on the Physical Protection of Nuclear Material (CPPNM) entered into force on 8 May 2016, following its ratification by Uruguay and Nicaragua, on 8 April 2016. While the CPPNM covers physical protection of nuclear material during international transport, the Amendment requires States Parties to establish, implement and maintain an appropriate physical protection regime, including a legislative and regulatory framework, for the physical protection of nuclear facilities and nuclear material in peaceful domestic use, storage and transport. It expands the existing offences identified in the CPPNM and establishes new ones, such as the ‘smuggling’ of nuclear material and ‘sabotage’ of nuclear facilities. It also provides for expanded cooperation between and among States Parties regarding, inter alia, rapid measures to locate and recover stolen or ‘smuggled’ nuclear material. During the year, 16 States ratified the Amendment to the CPPNM; at the end of 2016, 48 States Parties to the CPPNM still had to ratify the Amendment, and the Agency’s Secretariat continued to direct its efforts towards ‘universalization’ of the Amendment.

In December, the Agency organized the Second Meeting of the Representatives of the States Parties to the CPPNM and the CPPNM Amendment to discuss the new obligations under the CPPNM Amendment, focusing on issues relating to information sharing. The participants shared their national experience in adhering to and implementing the CPPNM Amendment. The need to promote universal adherence to the Amendment was highlighted during the meeting, which was attended by 119 participants from 71 States Parties to the CPPNM.

Nuclear Security Guidance

The Agency continued to develop comprehensive guidance on nuclear security, with the active involvement of experts from Member States. The Nuclear Security Guidance

Committee met twice during 2016; since its inception in 2012, 67 Member States have nominated representatives to the Committee.

Capacity Building in Nuclear Security

The Agency organized a total of 97 international, regional and national nuclear security related training courses and workshops in 2016, addressing all areas of nuclear security and providing training to more than 2100 participants from 128 States.

The sixth Joint IAEA–ICTP International School on Nuclear Security was held at the Abdus Salam International Centre for Theoretical Physics (ICTP) in Trieste, Italy, in April, providing a comprehensive introduction to the field of nuclear security to 47 participants from 47 Member States. Regional Schools using the same curriculum were held in Jakarta, Indonesia, with 36 participants from 13 Member States; and the first course in Arabic was held in Cairo, Egypt, with 33 participants from 14 States. In 2016, as part of a fellowship programme, the Agency supported seven students from five developing countries in a master’s programme in nuclear security established at the University of National and World Economy, in Sofia, Bulgaria, in 2015.

The Agency continued to coordinate education and training efforts through its networks. The annual meeting of the International Network for Nuclear Security Training and Support Centres (NSSC Network) was held in Islamabad, Pakistan, in March. In August, the Agency hosted the annual meeting of the International Nuclear Security Education Network (INSEN).

The Agency continued to implement activities under the Nuclear Security Plan 2014–2017 to enhance national capacities to protect nuclear and other radioactive material, and to detect material outside of regulatory control. In doing so, it worked with States to upgrade the security of medical and industrial facilities, and to securely manage disused sources through recycling, repatriation, storage and disposal activities. The Agency donated 736 hand-held radiation detection instruments, including associated software packages, and deployed nine radiation portal monitors in Member States.

International Conference on Nuclear Security: Commitments and Actions

The Agency organized the International Conference on Nuclear Security: Commitments and Actions, held in Vienna, Austria, in December (Fig. 1). The conference was attended by some 2100 participants from 139 Member States, 47 of which were represented at Ministerial level. A Ministerial Declaration¹ was adopted that, inter alia, reasserted that responsibility for nuclear security within a State rests entirely with that State; underlined the importance of keeping pace with evolving challenges and threats to nuclear security; and recognized the central role of the Agency in facilitating and coordinating international cooperation. Conference participants underscored the commitment of the international community to nuclear security and the unique platform the Agency offers to assist States in further strengthening a global response to a global threat.

The conference’s scientific and technical sessions addressed a range of topics, including: evolving challenges and threats to nuclear security; identifying gaps in and strategies for the secure management of radioactive material; international instruments for nuclear security; nuclear forensics; computer security for industrial control systems in nuclear facilities; public engagement on nuclear security; and nuclear security education.

“the International Conference on Nuclear Security: Commitments and Actions....was attended by some 2100 participants from 139 Member States, 47 of which were represented at Ministerial level.”

¹ Available at: https://www.iaea.org/sites/default/files/16/12/english_ministerial_declaration.pdf



FIG. 1. Director General Yukiya Amano and Mr. Yun Byung-se, Foreign Minister of the Republic of Korea and Conference President, preside over the International Conference on Nuclear Security: Commitments and Actions, held in Vienna in December.

Improving the Advisory Services

“Since....1996, the Agency has conducted a total of 75 IPPAS missions for 47 States and the Agency’s Laboratories in Seibersdorf, Austria.”

Since the first International Physical Protection Advisory Service (IPPAS) mission was conducted to Bulgaria in 1996, the Agency has conducted a total of 75 IPPAS missions for 47 States and the Agency’s Laboratories in Seibersdorf, Austria. In 2016, the Agency conducted IPPAS missions to Albania, Malaysia, Poland, Sweden, the United Arab Emirates and the United Kingdom.

To improve the sharing of best nuclear security practices among Member States, the Agency established a database of good practices identified in Member States during the conduct of IPPAS missions. The Agency organized the second International Seminar to Share Experience and Best Practices from Conducting International Physical Protection Advisory Service Missions, in November, in London, United Kingdom. The seminar was attended by 87 participants from 36 Member States, who shared the lessons learned and discussed the benefits of IPPAS missions and their follow-up activities, and considered options for enhancing the service.

Incident and Trafficking Database

In 2016, Gabon, Libya and Swaziland joined the Incident and Trafficking Database (ITDB) programme. States confirmed 189 incidents to the ITDB. While most of these incidents involved radioactive sources and radioactively contaminated material, States confirmed 33 incidents involving nuclear material. The proportion of these incidents that involved a confirmed or likely act of trafficking or malicious use was small, with a total of nine incidents of this type reported. A new conceptual framework, approved in 2015 at the meeting of Points of Contacts to the ITDB, was implemented in order to improve the reporting, classification and analysis of incidents.

Nuclear Security Fund

In the course of 2016, financial pledges to the Nuclear Security Fund were accepted by the Agency in the amount of €47.4 million. These pledges included financial contributions from Belgium, Canada, China, Estonia, Finland, France, Germany, India, Italy, Japan, the Republic of Korea, New Zealand, Romania, the Russian Federation, Spain, Switzerland, the United Arab Emirates, the United Kingdom, the United States of America and other contributors. The Agency received in-kind contributions of €134 873 from Germany pertaining to training delivered to experts from Lebanon on chemical, biological, radiological and nuclear material, and of US \$42 000 from Israel for 14 portable radiation detectors.

Nuclear Verification

The background is a solid light blue color with a fine, repeating pattern of small white dots. Overlaid on this are several large, semi-transparent light blue circles and three thick, dark blue curved lines that sweep across the page. Scattered throughout the design are numerous squares of varying sizes and shades of blue, including light blue, medium blue, and dark blue. Some squares are solid, while others are semi-transparent, creating a layered, geometric effect.

Nuclear Verification^{1,2}

Objective

To deter the proliferation of nuclear weapons by detecting early the misuse of nuclear material or technology, and by providing credible assurances that States are honouring their safeguards obligations. To remain ready to assist with verification tasks, in accordance with the Agency's Statute, in connection with nuclear disarmament or arms control agreements, as requested by States and approved by the Board of Governors.

Implementation of Safeguards in 2016

At the end of every year, the Agency draws a safeguards conclusion for each State for which safeguards are applied. This conclusion is based on an evaluation of all safeguards relevant information available to the Agency in exercising its rights and fulfilling its safeguards obligations for that year.

With regard to States with comprehensive safeguards agreements (CSAs), the Agency seeks to conclude that all nuclear material has remained in peaceful activities. To draw such a conclusion, the Agency must ascertain, firstly, that 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, secondly, that 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 in that State, the Agency assesses the results of its verification and evaluation activities under the State's CSA and additional protocol (AP). Thus, for the Agency to draw such a broader conclusion, both a CSA and an AP must be in force for the State, and the Agency must have completed all necessary verification and evaluation activities and found no indication that, in its judgement, would give rise to a proliferation concern.

For a State that has a CSA but not an AP in force, the Agency draws a conclusion only with respect to whether *declared* nuclear material remained in peaceful activities, as the

¹ The designations employed and the presentation of material in this section, including the numbers cited, do not imply the expression of any opinion whatsoever on the part of the Agency or its Member States concerning the legal status of any country or territory or of its authorities, or concerning the delimitation of its frontiers.

² The referenced number of States Parties to the NPT is based on the number of instruments of ratification, accession or succession that have been deposited.

Agency does not have sufficient tools to provide credible assurances regarding the absence of undeclared nuclear material and activities in the State.

In 2016, safeguards were applied for 181 States^{3,4} with safeguards agreements in force with the Agency. Of the 124 States that had both a CSA and an AP in force⁵ the Agency concluded that *all* nuclear material remained in peaceful activities for 69 States⁶; for the remaining 55 States, as the necessary evaluation regarding the absence of undeclared nuclear material and activities for each of these States remained ongoing, the Agency concluded only that declared nuclear material remained in peaceful activities. For 49 States with a CSA but with no AP in force, the Agency concluded that *declared* nuclear material remained in peaceful activities.

For those States for which the broader conclusion has been drawn, the Agency is able to implement integrated safeguards: an optimized combination of measures available under CSAs and APs to maximize effectiveness and efficiency in fulfilling the Agency's safeguards obligations. During 2016, integrated safeguards were implemented for 57 States^{7,8}.

Safeguards were also implemented with regard to nuclear material in selected facilities in the five nuclear-weapon States party to the Treaty on the Non-Proliferation of Nuclear Weapons (NPT) under their respective voluntary offer agreements. For these five States, the Agency concluded that nuclear material in selected facilities to which safeguards had been applied remained in peaceful activities or had been withdrawn from safeguards as provided for in the agreements.

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

As of 31 December 2016, 12 States Parties to the NPT had yet to bring CSAs into force pursuant to Article III of the Treaty. For these States Parties, the Agency could not draw any safeguards conclusions.

Conclusion of safeguards agreements and APs, and amendment and rescission of SQPs

The Agency continued to facilitate the conclusion of safeguards agreements and APs (Fig. 1), and the amendment or rescission of small quantities protocols (SQPs)⁹. The status

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

⁴ And Taiwan, China.

⁵ Or an additional protocol being provisionally applied, pending its entry into force.

⁶ And Taiwan, China.

⁷ Albania, Andorra, Armenia, Australia, Austria, Bangladesh, Belgium, Bulgaria, Burkina Faso, Canada, Chile, Croatia, Cuba, Czech Republic, Denmark, Ecuador, Estonia, Finland, Germany, Ghana, Greece, Holy See, Hungary, Iceland, Indonesia, Ireland, Italy, Jamaica, Japan, Republic of Korea, Latvia, Libya, Lithuania, Luxembourg, Madagascar, Mali, Malta, Monaco, Netherlands, Norway, Palau, Peru, Poland, Portugal, Romania, Seychelles, Singapore, Slovakia, Slovenia, South Africa, Spain, Sweden, the former Yugoslav Republic of Macedonia, Ukraine, United Republic of Tanzania, Uruguay and Uzbekistan.

⁸ And Taiwan, China.

⁹ 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.

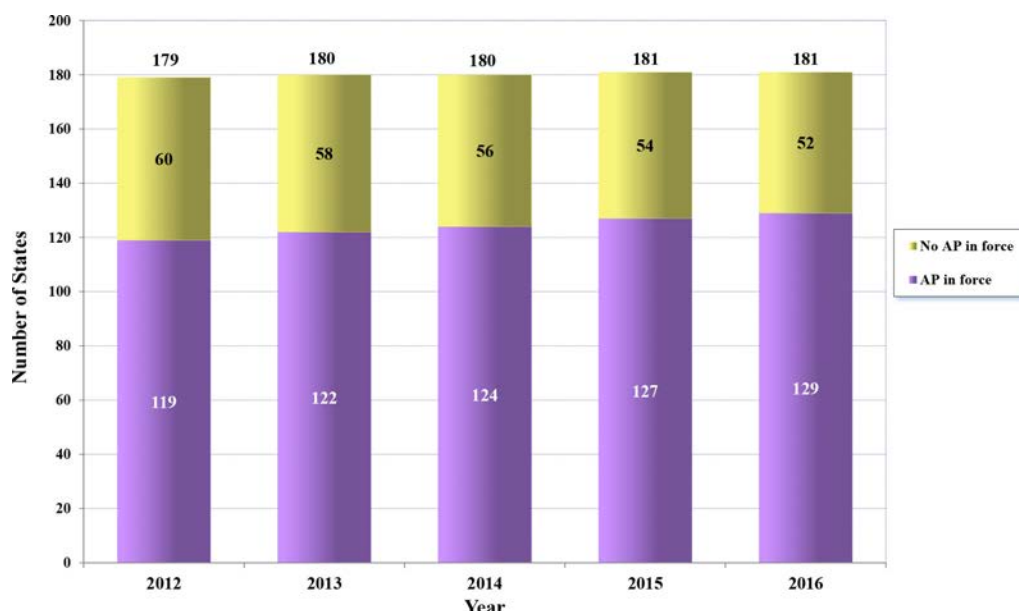


FIG. 1. Number of APs for States with safeguards agreements in force, 2012–2016 (the Democratic People's Republic of Korea is not included).

of safeguards agreements and APs as of 31 December 2016 is shown in Table A6 in the Annex to this report. During 2016, the Board of Governors approved a CSA with an SQP and an AP for one State¹⁰. In addition, two States¹¹ brought an AP into force. An AP has been provisionally applied pending its entry into force for one State¹². By the end of 2016, safeguards agreements were in force with 182 States and APs were in force with 129 States.

The Agency continued to implement the *Plan of Action to Promote the Conclusion of Safeguards Agreements and Additional Protocols*¹³, which was updated in September 2016. The Agency organized a subregional event for States in West Africa, held in Niamey, Niger, in May, at which the Agency encouraged the participating States to conclude CSAs and APs, and to amend their SQPs. In addition, the Agency held consultations with representatives of a number of Member and non-Member States in New York and Vienna at various times throughout the year.

The Agency continued to communicate with States in order to implement the Board of Governors' 2005 decision regarding SQPs, with a view to rescinding such protocols or amending them to reflect the revised standard text. During 2016, two States¹⁴ amended their operative SQP to reflect the revised standard text. This means that, by the end of 2016, 62 States had accepted the revised SQP text (which was in force for 56 of these States).

Verification and Monitoring in the Islamic Republic of Iran in light of United Nations Security Council Resolution 2231 (2015)

In 2016, the Agency continued monitoring and verification in the Islamic Republic of Iran (Iran) in relation to the nuclear-related measures set out in the Joint Plan of Action (JPA) until being informed, on 19 January 2016, by China, France, Germany, the Russian

¹⁰ Liberia.

¹¹ Cameroon and Côte d'Ivoire.

¹² Islamic Republic of Iran.

¹³ Available at: <https://www.iaea.org/sites/default/files/16/09/plan-of-action-2015-2016.pdf>.

¹⁴ Afghanistan and Saint Kitts and Nevis.



FIG. 2. The Director General reports that Iran has taken the actions specified in Annex V of the JCPOA, thereby paving the way for implementation of the JCPOA to begin.

Federation, the United Kingdom, the United States of America (E3+3) and Iran, on behalf of the E3/EU+3 and Iran, that — with the start of the implementation of the Joint Comprehensive Plan of Action (JCPOA) — the JPA was no longer in effect.¹⁵

On 16 January 2016, the Director General reported to the Board of Governors and in parallel to the United Nations Security Council that the Agency had verified that Iran had taken the actions specified in paragraphs 15.1–15.11 of Annex V of the JCPOA (Fig. 2). Implementation Day occurred on the same day.

Also on 16 January 2016, Iran began to provisionally apply the Additional Protocol to its Safeguards Agreement in accordance with Article 17(b) of the Additional Protocol, pending its entry into force, and to fully implement the modified Code 3.1 of the Subsidiary Arrangements to its Safeguards Agreement.

Since Implementation Day, the Agency has been verifying and monitoring Iran's nuclear related commitments under the JCPOA. During 2016, the Director General submitted six reports to the Board of Governors and in parallel to the United Nations Security Council entitled *Verification and Monitoring in the Islamic Republic of Iran in light of United Nations Security Council Resolution 2231 (2015)* (GOV/INF/2016/1, GOV/2016/8, GOV/2016/23, GOV/2016/46, GOV/2016/55 and GOV/INF/2016/13).

Syrian Arab Republic (Syria)

In August 2016, the Director General submitted a report to the Board of Governors entitled *Implementation of the NPT Safeguards Agreement in the Syrian Arab Republic* (GOV/2016/44) covering relevant developments since the previous report in August 2015 (GOV/2015/51). The Director General informed the Board of Governors that no new information had come to the knowledge of the Agency that would have an impact on the Agency's assessment

¹⁵ In January 2016, the Director General submitted to the Board of Governors a report entitled *Status of Iran's Nuclear Programme in relation to the Joint Plan of Action* (GOV/INF/2016/3).

that it was very likely that a building destroyed at the Dair Alzour site was a nuclear reactor that should have been declared to the Agency by Syria.¹⁶ In 2016, the Director General renewed his call on Syria to cooperate fully with the Agency in connection with unresolved issues related to the Dair Alzour site and other locations. Syria has yet to respond to these calls.

On the basis of the evaluation of information provided by Syria and all other safeguards relevant information available to it, the Agency found no indication of the diversion of declared nuclear material from peaceful activities. For 2016, the Agency concluded for Syria that declared nuclear material remained in peaceful activities.

Democratic People's Republic of Korea (DPRK)

In August 2016, the Director General submitted a report to the Board of Governors and General Conference entitled *Application of Safeguards in the Democratic People's Republic of Korea* (GOV/2016/45-GC(60)/16), which provided an update of developments since the Director General's report of August 2015 (GOV/2015/49-GC(59)/22).

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, the Agency could not draw any safeguards conclusion regarding the DPRK.

On 6 January 2016, the DPRK announced that it had conducted a nuclear test and on 9 September 2016 the DPRK announced that it had conducted another nuclear test.

In 2016, no verification activities were implemented in the field, but the Agency continued to monitor the DPRK's nuclear activities by using open source information, including satellite imagery and trade information. The Agency maintained operational readiness to resume safeguards implementation in the DPRK, and continued to further consolidate its knowledge of the DPRK's nuclear programme.

During 2016, the Agency continued to observe indications which were consistent with the operation of the Yongbyon Experimental Nuclear Power Plant (5 MW(e)) at Yongbyon. This followed a period between mid-October and early December 2015 when there were no such indications. This period was sufficient for the reactor to have been de-fuelled and subsequently re-fuelled. Based on past operational cycles, a new cycle commencing in early December 2015 can be expected to last about two years.

From the first quarter of 2016, there were multiple indications consistent with the Radiochemical Laboratory's operation, including deliveries of chemical tanks and the operation of the associated steam plant. Such indications ceased in early July 2016. In previous reprocessing campaigns, the Radiochemical Laboratory's operation involved the use of the spent fuel discharged from the Yongbyon Experimental Nuclear Power Plant (5 MW(e)).

At the Yongbyon Nuclear Fuel Rod Fabrication Plant there were indications consistent with the use of the reported centrifuge enrichment facility located within the plant. Additional construction work around the building that houses this reported facility has been ongoing.

¹⁶ The Board of Governors, in its resolution GOV/2011/41 of June 2011 (adopted by a vote), had, inter alia, called on Syria to urgently remedy its non-compliance with its NPT Safeguards Agreement and, in particular, to provide the Agency with updated reporting under its Safeguards Agreement and access to all information, sites, material and persons necessary for the Agency to verify such reporting and resolve all outstanding questions so that the Agency could provide the necessary assurance as to the exclusively peaceful nature of Syria's nuclear programme.

The Agency has not had access to the Yongbyon site. Without access to the site, the Agency cannot confirm the operational status of the facilities on the site, or the nature and purpose of the activities observed.

The continuation and further development of the DPRK's nuclear programme and related statements by the DPRK, including those about continuing to "boost" its "nuclear force", are a major cause for concern. The DPRK's nuclear activities, including those in relation to the Yongbyon Experimental Nuclear Power Plant (5 MW(e)) and the Radiochemical Laboratory, and the use of the building which houses the reported enrichment facility are deeply regrettable. Such actions are clear violations of relevant United Nations Security Council resolutions, including resolutions 2270 (2016) and 2321 (2016). The DPRK's fourth and fifth nuclear tests, announced on 6 January and 9 September 2016, respectively, are also in clear violation of United Nations Security Council resolutions and deeply regrettable.

Enhancing Safeguards

Evolving safeguards implementation

During 2016, the Agency completed updating State-level safeguards approaches for the remaining States in the original group of 53 States that were already under integrated safeguards at the start of 2015. In addition, it developed State-level safeguards approaches for: eight States with a CSA and an AP in force and a broader conclusion; two States with a CSA and AP in force but without a broader conclusion; and one State with a voluntary offer agreement and an AP in force. As described in *Supplementary Document to the Report on the Conceptualization and Development of Safeguards Implementation at the State Level* (GOV/2013/38) (GOV/2014/41 and Corr.1), in developing and implementing a State-level safeguards approach consultations are held with the relevant State and/or regional authority, particularly on the implementation of in-field safeguards measures.

A State-level safeguards approach is developed in accordance with a State's safeguards agreement, through the conduct of acquisition or diversion path analysis, identification and prioritization of technical objectives, and selection of safeguards measures to address them. In those States where State-level safeguards approaches are not implemented, safeguards activities are conducted at declared facilities and locations outside facilities where nuclear material is customarily used (LOFs) as specified in the Safeguards Criteria, and new techniques and technologies are implemented, as applicable and in accordance with the States' safeguards agreements, to strengthen effectiveness and improve efficiency.

In 2016, to continue to ensure consistency and non-discrimination in the implementation of safeguards for States with the same type of safeguards agreements, the Agency continued to improve internal work practices, including the better integration of the results of safeguards activities conducted in the field with those carried out at Headquarters, and introduced further advances in the handling of safeguards-relevant information to facilitate its evaluation. The Agency also prepared new guidance documentation and improved its internal review mechanisms for safeguards implementation.

Cooperation with State and regional authorities

To assist States in building capacity for implementing their safeguards obligations, the Agency conducted nine international, regional and national training courses for those responsible for overseeing and implementing the State and regional systems of accounting for and control of nuclear material, and participated in several other training activities organized by Member States on a bilateral basis. In total, more than 225 participants from some 70 countries were trained on safeguards related topics. The Agency also provided targeted assistance to facility operators to improve the performance of their measurement

system for nuclear material accounting and control at bulk facilities, and piloted a regional training course on safeguards and nuclear security for States with little or no nuclear material. The Agency also conducted two Safeguards Implementation Practices Workshops in Vienna, in which safeguards practitioners from State authorities and facilities discussed challenges and shared lessons learned and good practices in relation to establishing safeguards infrastructure and facilitating Agency verification activities.

In June, the Agency published the *Safeguards Implementation Practices Guide on Provision of Information to the IAEA* (IAEA Services Series 33). A preparatory IAEA State System of Accounting for and Control of Nuclear Material Advisory Service (ISSAS) mission was conducted to Jordan, in advance of implementation of the ISSAS mission in 2017. In 2016, the Agency conducted Integrated Nuclear Infrastructure Review (INIR) missions to Kazakhstan and Malaysia providing, inter alia, advice to the host countries on how to systematically enhance the capabilities necessary for the application of safeguards while embarking on a nuclear power programme.

Safeguards equipment and tools

Throughout 2016, the Agency ensured that the instrumentation and monitoring equipment vital to effective safeguards implementation around the world continued to function as required. During the year, 1057 portable and resident non-destructive assay systems comprising 2168 separate pieces of equipment were prepared and assembled for inspection use. By the end of 2016, a total of 164 unattended monitoring systems were in operation in 24 States and the Agency had 872 video surveillance systems with 1436 individual cameras operating at 266 facilities in 35 States¹⁷. In addition, the Agency is responsible for maintaining approximately 120 cameras used jointly with regional or State authorities. By the end of 2016, remote data transmission infrastructure ensured the collection of 887 unattended safeguards data streams from 122 facilities in 25 States¹⁸. Of these, 299 data streams were produced by surveillance systems, 111 by unattended monitoring systems and 477 by electronic seals.

The Agency continued with implementation of the next generation surveillance system (NGSS), replacing outdated surveillance units (DCM-14 based technology). By the end of 2016, 597 NGSS cameras had been installed in 29 States.

In 2016, cooperative efforts with Member States, the European Commission and the Brazilian–Argentine Agency for Accounting and Control of Nuclear Materials (ABACC) continued for procurement, acceptance testing, installation, and maintenance of safeguards equipment designated for joint use and for training of relevant staff.

In 2016, the Agency continued to undertake activities aimed at identifying and evaluating emerging instrumentation technologies that could lead to the deployment of new instruments in support of safeguards implementation. These activities were performed in close cooperation with Member State Support Programmes (MSSPs).

Safeguards analytical services

The Agency's Network of Analytical Laboratories (NWAL) consists of the Agency's Safeguards Analytical Laboratories (SAL) and 20 other qualified laboratories in Australia, Brazil, France, Hungary, Japan, the Republic of Korea, the Russian Federation, the United Kingdom, the United States of America and the European Commission. Additional laboratories in the areas of environmental and/or nuclear material sample analysis were in

“By the end of 2016, a total of 164 unattended monitoring systems were in operation in 24 States and the Agency had 872 video surveillance systems with 1436 individual cameras operating at 266 facilities in 35 States”

¹⁷ And Taiwan, China.

¹⁸ And Taiwan, China.

the process of qualification in Argentina, Belgium, Canada, China, Germany, Hungary, the Netherlands and the United States of America.

In 2016, the Agency collected 603 nuclear material samples that were analysed by the Agency's Nuclear Material Laboratory (NML). The Agency also collected 474 environmental samples, which resulted in analysis of 916 subsamples. Two hundred sixteen of these subsamples were analysed at the Agency's Environmental Sample Laboratory and the NML, with the remainder analysed by other laboratories in the NWAL.

Support

Developing the safeguards workforce

In 2016, the Agency conducted over 160 safeguards training courses to provide safeguards inspectors and analysts with the necessary technical and behavioural competencies. These included two Introductory Courses on Agency Safeguards for 23 newly recruited inspectors and courses held at nuclear facilities to enhance practical competencies for safeguards implementation in the field. New training courses were also developed in 2016, including a course on safeguards issues regarding Pyroprocessing at an Engineering Scale Demonstration Facility. The Agency continued to engage with MSSPs in the development of tools for training and in the conduct of courses at nuclear facilities.

Significant Safeguards Projects

Information technology: MOSAIC

“as part of the Modernization of Safeguards Information Technology (MOSAIC) project, the Agency introduced new IT tools and capabilities, completed the enhancement of all legacy safeguards IT applications and strengthened the information security of safeguards data.”

During 2016, as part of the Modernization of Safeguards Information Technology (MOSAIC) project, the Agency introduced new IT tools and capabilities, completed the enhancement of all legacy safeguards IT applications and strengthened the information security of safeguards data. These tools and applications include the Electronic Verification Package (eVP) and Field Activity Reporting (FAR) applications for use by inspectors in the field, and the Safeguards Implementation Report Analytical Tool (SANT) for streamlining the production of the Safeguards Implementation Report. The new and refurbished IT tools have enabled the Agency to increase effectiveness, find efficiencies and enhance security, while meeting an ever increasing demand for its services.

Preparing for the Future

In early 2016, the Agency published the *Development and Implementation Support Programme for Nuclear Verification 2016–2017* to address near term development objectives and to support the implementation of its verification activities. The Agency continued to rely on MSSPs in implementing work in pursuit of the objectives and key achievement targets described therein. At the end of 2016, 20 States¹⁹ and the European Commission had formal support programmes with the Agency.

¹⁹ Argentina, Australia, Belgium, Brazil, Canada, China, Czech Republic, Finland, France, Germany, Hungary, Japan, Republic of Korea, Netherlands, Russian Federation, South Africa, Spain, Sweden, United Kingdom and United States of America.

Technical Cooperation

The background is a light blue color with a fine, repeating dot pattern. Overlaid on this are several abstract elements: a collection of squares in various shades of blue (light, medium, and dark) scattered across the page; and several thick, flowing, light blue lines that curve and loop around the squares, creating a sense of movement and interconnectedness. The overall aesthetic is clean, modern, and technical.

Management of Technical Cooperation for Development

Objective

To enhance the relevance, socioeconomic impact and efficiency of technical cooperation support to Member States by planning and implementing a needs based, responsive and sustainable technical cooperation programme (TCP), and by seeking continuously increasing effectiveness.

The Technical Cooperation Programme

The technical cooperation programme is the Agency's major vehicle for transferring nuclear technology to Member States. The programme builds capacities to support the peaceful application of nuclear science and technology, helping Member States to address key development priorities in areas such as health and nutrition, food and agriculture, water and the environment, industrial applications, and nuclear knowledge development and management. The technical cooperation programme also helps Member States to identify and meet future energy needs, and assists in improving radiation safety worldwide, including through the provision of legislative assistance. The programme aims to achieve tangible socioeconomic impact by contributing directly in a cost effective manner to the achievement of the major sustainable development priorities of each country, including relevant nationally identified targets under the Sustainable Development Goals (SDGs). The technical cooperation programme also facilitates regional and interregional cooperation among Member States and partners.

Country Programme Frameworks and Revised Supplementary Agreements

Country Programme Frameworks (CPFs) provide a frame of reference for technical cooperation between a Member State and the Agency. They define mutually agreed development needs and priorities that can be supported through technical cooperation programming.

The Agency continued to strengthen the role of the CPF as the main strategic planning tool for the development of national technical cooperation programmes for Member States. Efforts to strengthen the connection between technical cooperation activities and the larger development context also continued. A number of recently developed CPFs have already identified linkages, as appropriate, between national technical cooperation activities and the SDGs.

In 2016, 20 CPFs were signed by Member States – Burkina Faso, Burundi, China, Costa Rica, Ecuador, Estonia, Ghana, Malawi, Malaysia, Myanmar, Nepal, Niger, Oman, Poland,

Qatar, Senegal, Seychelles, Singapore, Uzbekistan and Zambia. There were, in total, 91 valid CPFs by the end of the year.

Revised Supplementary Agreements Concerning the Provision of Technical Assistance by the International Atomic Energy Agency (RSAs) govern the provision of technical assistance by the Agency. Seven Member States signed an RSA in 2016. As of 31 December 2016, 132 Member States had signed an RSA.

United Nations Development Assistance Frameworks

The United Nations Development Assistance Framework (UNDAF) is a structure for coordinating United Nations system actions in support of national development goals. In 2016, the Agency continued to focus on greater involvement in the development and implementation of UNDAFs in relevant countries. This process has enabled the Agency to raise awareness about its work and facilitated access to the main national development coordination and planning bodies. In addition, it has assisted in coordination and collaboration with United Nations and other partners.

In 2016, the Agency co-signed a total of ten UNDAFs — for Albania, Azerbaijan, Bangladesh, Georgia, Honduras, Lao People's Democratic Republic, Mongolia, Montenegro, Tajikistan and the United Republic of Tanzania. The Agency is currently a co-signatory of 45 valid UNDAFs.

Partnership Agreements and Practical Arrangements

The Agency signed a new Delegation Agreement with the European Commission in 2016. The new agreement focuses on support for Member States in the area of radiation and nuclear safety. The Agency also signed a cooperation agreement with the International Renewable Energy Agency (IRENA) to support the coordination of joint energy planning capacity building and training.

In 2016, the Agency signed two Practical Arrangements for cooperation on the IAEA Curricula for Nuclear Medicine Professionals, with the Osaka University Graduate School of Medicine and Osaka University Hospital, Japan, and with the Dubai Health Authority, Dubai Hospital, United Arab Emirates. Under Practical Arrangements signed with the Agency, the General Council of Official Medical Associations of Spain and the Foundation for International Cooperation of Spanish Medical Associations provided expertise to regional projects in Latin America on radiotherapy during the year.

The Agency also signed Practical Arrangements with the Organisation of Islamic Cooperation and the Islamic Development Bank on Cooperation in the Area of Comprehensive Cancer Control in Common Member States. The Arrangements set out a framework for non-exclusive cooperation to support the efforts of common Member States in the area of comprehensive cancer control through the technical cooperation programme, and in particular through the Programme of Action for Cancer Therapy (PACT).

Managing the Agency's Technical Cooperation Programme

Member State priorities in 2016, as reflected in programme disbursements, were health and nutrition, safety, and food and agriculture (Fig. 1), with some variations in emphasis across regions. By the end of the year, 914 projects were active. During the course of the year, 417 projects were closed, of which 4 were cancelled in consultation with the relevant Member States, and an additional 450 projects were in the process of being closed. Nine national Programme Reserve projects were implemented, in Costa Rica, El Salvador,

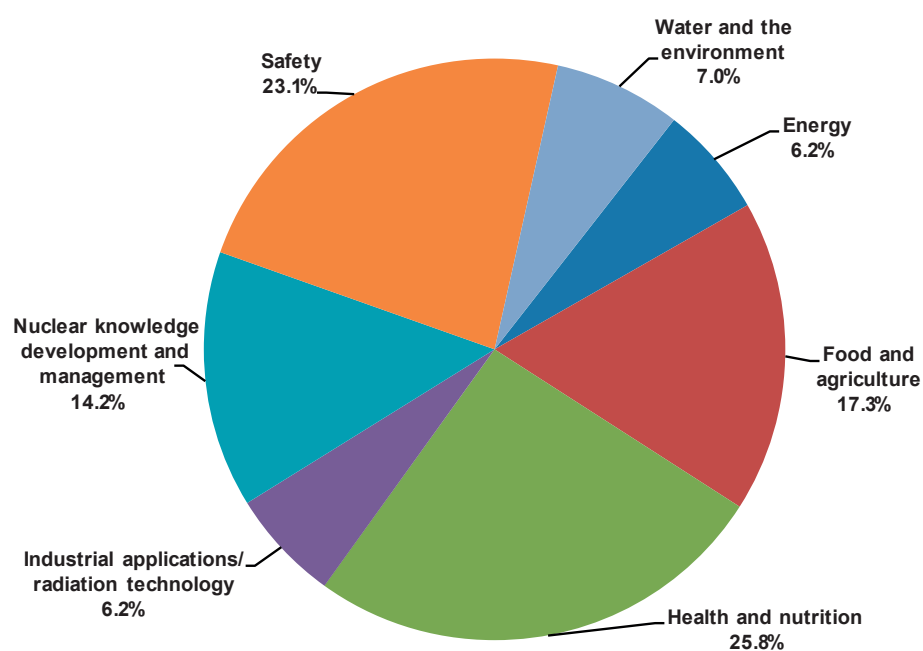


FIG. 1. Actuals by technical field for 2016. (Percentages do not add up to 100% owing to rounding.)

Guatemala, Haiti, Honduras, Marshall Islands, Nicaragua, Panama and Swaziland, and two regional projects were implemented in the Latin America and the Caribbean region.

Financial Highlights

Payments against the 2016 Technical Cooperation Fund (TCF) totalled €78.5 million (not including National Participation Costs (NPCs) and assessed programme cost (APC) arrears), against the target of €84.5 million, with the rate of attainment on payments at the end of 2016 standing at 92.9% (Fig. 2). The use of these resources resulted in a TCF implementation rate of 84.6%.

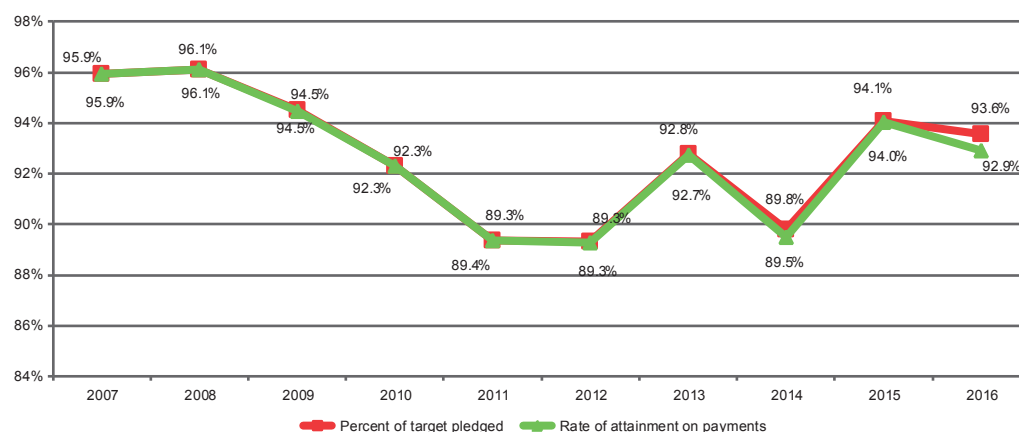


FIG. 2. Trends in the rate of attainment, 2007–2016.

Improving the Quality of the Technical Cooperation Programme

The Agency provided support to Member States throughout 2016 to further improve the quality of project designs developed for the 2018–2019 technical cooperation cycle. It organized around 30 workshops, training events and programme briefings for more than



FIG. 3. Participants in a workshop on the logical framework approach, April 2016.

600 individual technical cooperation stakeholders, including project counterparts, National Liaison Officers, Programme Management Officers and Technical Officers. These events were held both in-house and in Member States, and were tailored to the specific needs of the audience. Participants were provided with instructions and support on using the logical framework approach (LFA) to design new projects (Fig. 3), as well as on using monitoring and evaluation tools for ongoing projects.

The Agency revised and updated all relevant guidance documents relating to quality assurance of the technical cooperation programme, including the TC Programme Quality Criteria and the TC Programme Planning and Design Glossary. These documents, together with a new checklist, will help project teams to meet the quality requirements for the project document, to apply the LFA and to plan project work. The revised documents were made available to Member States and the Secretariat on the Programme Cycle Management Framework (PCMF) Reference Desk.

In November, the Agency conducted the first assessment of the quality of draft project designs prepared for the 2018–2019 technical cooperation cycle. Constructive feedback on the project documents with regard to their compliance with the TC Programme Quality Criteria and the Guidelines for the Planning and Design of the IAEA 2018–2019 Technical Cooperation Programme was provided to Member States.

Monitoring and Evaluating Technical Cooperation Projects

A pilot version of an electronic monitoring and reporting system for technical cooperation projects incorporating Project Progress Assessment Reports (PPARs) and project achievement reports was released in December, to be used for the 2016 reporting of all active technical cooperation projects. This new system will enable quicker and more relevant reporting for Member States, and will significantly facilitate the aggregation and interpretation of PPAR data for informed decision making.

Partnerships and Cooperation with the United Nations System and Other International Organizations

In the Latin America and the Caribbean region, the Agency partnered with the United Nations Convention to Combat Desertification (UNCCD) on soil erosion to highlight how isotopic techniques can provide evidence for use in combating desertification and adapting to climate change. The Agency took part in the 15th session of the Committee for the

Review of the Implementation of the Convention (CRIC 15) of UNCCD in Nairobi, Kenya, in November.

Also in 2016, the Agency, together with the United Nations Industrial Development Organization (UNIDO), hosted a meeting of the European Regional Directors of United Nations agencies for the first time. The meeting contributed to strengthened collaboration with the United Nations Development Programme (UNDP), the Food and Agriculture Organization of the United Nations, the United Nations Economic Commission for Europe (UNECE), the World Health Organization (WHO) and others.

Regional Agreements and Programming

Agency collaboration with regional agreement groups and other Member State groups supports stronger regional technical cooperation programmes that are focused on priorities identified at the regional level.

The African Regional Co-operative Agreement for Research, Development and Training Related to Nuclear Science and Technology (AFRA) continued to be the principal framework for promoting technical cooperation among developing countries in Africa and for enhancing regional cooperation among its 41 Governments Parties.

In July, Egypt hosted the 27th AFRA Technical Working Group Meeting in Sharm El Sheikh. The meeting participants reviewed and adopted concrete measures and actions to further enhance the implementation of AFRA regional projects and the management of its cooperative activities.

During the 60th regular session of the Agency's General Conference, the Agency held a Panel Discussion on the Deliverables and Effectiveness of the Technical Cooperation Programme in Africa. The panellists discussed the progress and results achieved with the assistance of the technical cooperation programme in Africa over the past decade. They focused particularly on capacity building and the programme's contributions to human health, water resource management, industrial applications and human resource development.

The 26th Meeting of Representatives of AFRA also took place during the 60th General Conference. Participants adopted the AFRA Annual Report 2015, the updated AFRA guidelines and indicators for the sustainability of nuclear institutions and the Charter of the Regional African Network of National Nuclear Institutions (RENANNI). The meeting also adopted the Regional Strategy to enhance the sustainability of nuclear medicine in Africa, 2016–2030.

In 2016, the total contribution of AFRA Governments Parties to the AFRA Fund was €841 376, of which €741 376 was allocated to technical cooperation projects, demonstrating the Parties' continued commitment to the technical cooperation programme. The remaining €100 000 was transferred to the Renovation of the Nuclear Applications Laboratories (ReNuAL) project, in support of the construction of the new laboratories at Seibersdorf.

In November, the Agency issued the first IAEA Brief, *Enhancing Patient Care in Africa through Safe Medical Imaging* (IAEA Brief 2016/1), highlighting the importance of having well qualified medical physicists in Africa to handle high-technology medical imaging.

In the Asia and the Pacific region, the Board of Representatives of the Co-operative Agreement for Arab States in Asia for Research, Development and Training related to Nuclear Science and Technology (ARASIA) identified and endorsed modalities and criteria for designating ARASIA regional resource centres.

In 2016, the national representatives of the Regional Co-operative Agreement for Research, Development and Training Related to Nuclear Science and Technology (RCA) for the Asia and the Pacific region endorsed an amended text of the Agreement, which is expected to enter into force in June 2017.

National Liaison Officers and national representatives from the Asia and the Pacific region met in Vienna in February to discuss challenges, opportunities and the way forward for the regional programme. The Regional Programme Framework for 2018–2028, a working document, was developed and endorsed during the February meeting and will guide the programming of non-RCA regional projects in the Asia and the Pacific region over the next ten years.

The Agency facilitated the establishment of regional networks for transport safety for the region of Asia and the Pacific through a regional project that aims at strengthening an effective compliance assurance regime for the transport of radioactive material. It also supported tailored regional projects in the field of emergency preparedness and response for various country groupings in the region.

Targeted human capacity building in the Asia and the Pacific region in 2016 contributed to a more cost effective and better coordinated capacity building process. Sri Lanka, for example, hosted two activities, on non-destructive testing and animal production; the Philippines accommodated a group fellowship activity on isotope hydrology; and an activity on plant mutation took place in Indonesia. In addition, new IAEA Curricula for Nuclear Medicine Professionals (ICNMP) were developed to support continued medical education for nuclear medicine professionals, enabling them to perform their duties competently, professionally and safely.

Work began in 2016 on updating the Europe Regional Profile, which is the main reference document and planning tool for regional technical cooperation projects. The new profile reflects the main priority thematic areas — human health; radioactive waste management and environment restoration; nuclear power; and nuclear and radiation safety — and identifies linkages with the SDGs.

In the Latin America and the Caribbean region, the Regional Co-operation Agreement for the Promotion of Nuclear Science and Technology in Latin America and the Caribbean (ARCAL) continued to contribute to sustainable development in the region, encouraging cooperation among countries and promoting the peaceful uses of nuclear science and technology to address the priorities and needs of the region. In 2016, ARCAL and the Agency worked together to strengthen the monitoring and evaluation process for technical cooperation projects. A guide was finalized to provide a methodology to enhance the implementation of regional projects and their connection to the ARCAL Regional Strategic Profile for Latin America and the Caribbean. The implementation of this methodology will provide input for future regional projects, improving the management of the Agency's regional technical cooperation programme and increasing the impact of nuclear technology in the Latin America and the Caribbean region.

During the 60th regular session of the Agency's General Conference, a meeting between the four Regional and Cooperative Agreements — AFRA, ARASIA, ARCAL and RCA — took place under the chairmanship of ARCAL. The meeting participants agreed to develop a plan of action to operationalize collaboration modalities between the Agreements, as defined in a concept paper establishing a Quadripartite Forum. The Agency supports these efforts, to facilitate the sharing of information, best practices and experience, and to explore common areas of inter-Agreement collaboration.

“[The Agency] participated in several high level international events on cancer, highlighting its role in the global fight against the disease.”

Programme of Action for Cancer Therapy (PACT)

The Agency continued to support low and middle income countries throughout 2016 to integrate radiation medicine in comprehensive national cancer control strategies in a sustainable manner. It participated in several high level international events on cancer, highlighting its role in the global fight against the disease.

In addition, the Agency facilitated the formulation of the Istanbul Declaration issued at the Special Session on First Ladies' Leadership on Cancer Control held in the margins of the

13th Organization of Islamic Cooperation (OIC) Summit in Turkey. The Declaration affirms the First Ladies' commitment to promote cancer awareness and advocacy programmes, and to advocate for the prioritization of cancer prevention and control in health agendas at both national and international level through a multi-sectoral approach.

The Agency conducted integrated missions of PACT (imPACT) reviews to eight Member States (Belarus, Belize, Honduras, Kenya, Kazakhstan, Liberia, Paraguay and Sierra Leone), providing recommendations on strengthening national cancer control services. Specifically, these recommendations support evidence based decision making and help Member States to prioritize interventions and investments for comprehensive cancer control programmes.

In Myanmar and El Salvador, the Agency, together with the International Agency for Research on Cancer and WHO, convened national workshops to prioritize and cost cancer control interventions.

The Agency continued to seek support from Member States, intergovernmental and non-governmental organizations, as well as the private sector for the Agency's cancer control activities. Extrabudgetary contributions of €1 591 281 were received from Agency Member States and partners.

Outreach and Communication

Outreach to Member States, current and potential partners, donors and the international development community continues to be an important focus for the Agency. Exhibitions focusing on technical cooperation activities were organized at the European Development Days, the Asian Development Bank's international Food Security Forum and the sixth Tokyo International Conference on African Development (TICAD VI), among others. At the 60th regular session of the Agency's General Conference, six side events showcased outputs of technical cooperation projects such as the pilot initiative to introduce nuclear science and technology in secondary schools in the Asia and the Pacific region, developed through a project entitled 'Supporting Sustainability and Networking of National Nuclear Institutions in Asia and the Pacific Region'.

The Agency held the annual Seminar on Technical Cooperation for Diplomats in Vienna in October, attended by 40 participants. The seminar is designed to provide Permanent Missions with a comprehensive overview of the technical cooperation programme.

Throughout the year, the Agency posted targeted outreach material of relevance to specific United Nations international days — including World Cancer Day, World Day to Combat Desertification and Drought, and World Health Day — using social media and the web to promote relevant technical cooperation activities.

The technical cooperation web site was updated with 72 web articles, 6 photo essays and 18 videos during 2016, and now has some 8500 visitors a month. In 2016, the site received over 102 000 visits. With the Agency's move to a new web content system, content on the technical cooperation web site was assimilated into many more pages of the Agency's main web site, enhancing programme visibility.

More than 770 tweets were sent out from the @IAEATC Twitter account, which now has over 3000 followers. The LinkedIn TC Alumni Group now has over 1600 members.

Legislative Assistance

In 2016, the Agency continued to provide legislative assistance to its Member States through the technical cooperation programme. Country specific bilateral legislative assistance was provided to 19 Member States by way of written comments and advice on drafting national nuclear legislation. The Agency also reviewed the legal frameworks of newcomer countries as part of Integrated Nuclear Infrastructure Review missions. Short

"Country specific bilateral legislative assistance was provided to 19 Member States by way of written comments and advice on drafting national nuclear legislation."

term scientific visits to Agency Headquarters were organized for a number of individuals, allowing fellows to gain further practical experience in nuclear law.

The Agency organized the sixth session of the Nuclear Law Institute in Baden, Austria, from 10 to 21 October 2016. The comprehensive two week course, which uses teaching methods based on interaction and practice, is designed to meet the increasing demand by Member States for legislative assistance and to enable participants to acquire a solid understanding of all aspects of nuclear law, as well as to draft, amend or review their national nuclear legislation. Fifty-eight participants from Member States attended the training.

Two subregional workshops on nuclear law were conducted for Member States of the Asia and the Pacific region in Singapore (13–17 June) and in Amman, Jordan (12–15 December). Seventy participants from 27 Member States attended these workshops. National workshops on nuclear law were also organized in Cambodia, Namibia, Nepal, Palau and Panama. The workshops addressed all aspects of nuclear law and created a forum for an exchange of views on topics relating to the international legal instruments.

Treaty Event

The Agency's sixth Treaty Event took place during the 60th regular session of the General Conference. The event provided Member States with a further opportunity to deposit their instruments of ratification, acceptance or approval of, or accession to, the treaties deposited with the Director General, notably those related to nuclear safety, security and civil liability for nuclear damage. The special focus of this year's Treaty Event was again the 2005 Amendment to the Convention on the Physical Protection of Nuclear Material. Representatives from several Member States were also briefed on the conventions adopted under Agency auspices.

Annex

Table A1.	Regular Budget allocation and utilization of resources in 2016 by Programme and Major Programme (in euros)
Table A2.	Extrabudgetary regular programme fund resource utilization in 2016 by Programme and Major Programme (in euros)
Table A3(a).	Disbursements (actuals) of the Technical Cooperation Fund by technical field and region in 2016
Table A3(b).	Graphical representation of the Technical Cooperation Fund disbursement information in Table A3(a)
Table A4.	Amount of nuclear material under Agency safeguards at the end of 2016 by type of agreement
Table A5.	Number of facilities and material balance areas outside facilities under Agency safeguards during 2016
Table A6.	Conclusion of safeguards agreements, additional protocols and small quantities protocols (as of 31 December 2016)
Table A7.	Participation in multilateral treaties for which the Director General is the 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 2016)
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)
Table A9.	Nuclear power reactors in operation and under construction in the world (as of 31 December 2016)
Table A10.	Member State participation in selected Agency activities
Table A11.	Integrated Nuclear Infrastructure Review (INIR) missions in 2016
Table A12.	Knowledge Management Assist Visit (KMAV) missions in 2016
Table A13.	Education and Training Appraisal (EduTA) missions in 2016
Table A14.	Emergency Preparedness Review (EPREV) missions in 2016
Table A15.	Integrated missions of the Agency's Programme of Action for Cancer Therapy (imPACT) in 2016
Table A16.	International Physical Protection Advisory Service (IPPAS) missions in 2016
Table A17.	Integrated Safety Assessment of Research Reactors (INSARR) missions in 2016
Table A18.	Safety expert missions for research reactors based on the INSARR methodology in 2016
Table A19.	Integrated Regulatory Review Service (IRRS) missions in 2016
Table A20.	Operational Safety Review Team (OSART) missions in 2016
Table A21.	Safety Aspects of Long Term Operation (SALTO) missions in 2016
Table A22.	Site and External Events Design (SEED) missions in 2016
Table A23.	Technical Safety Reviews (TSRs) in 2016
Table A24.	Advisory missions in 2016
Table A25.	Occupational Radiation Protection Appraisal Service (ORPAS) missions in 2016
Table A26.	IAEA-designated International Centres based on Research Reactor
Table A27.	Coordinated research projects initiated in 2016
Table A28.	Coordinated research projects completed in 2016
Table A29.	Publications issued in 2016
Table A30.	Technical cooperation training courses held in 2016
Table A31.	Relevant Agency web sites
Table A32(a).	Number and types of facilities under Agency safeguards by State during 2016
Table A32(b).	Facilities under Agency safeguards or containing safeguarded nuclear material during 2016

Note: Tables A27–A32 are available on the attached CD-ROM.

Table A1. Regular Budget allocation and utilization of resources in 2016 by Programme and Major Programme (in euros)

Major Programme (MP)/Programme	Original budget US \$1/€1	Adjusted budget US \$1/€0.903	Expenditure	Resource utilization	Unobligated balances
	a	b	c	d = c/b	e = b - c
MP1 — Nuclear Power, Fuel Cycle and Nuclear Science					
Overall management, coordination and common activities	3 202 953	3 154 150	3 133 881	99.4%	20 269
Nuclear Power	8 537 033	8 402 334	8 293 146	98.7%	109 188
Nuclear Fuel Cycle and Materials Technologies	6 815 074	6 713 899	6 300 138	93.8%	413 761
Capacity Building and Nuclear Knowledge for Sustainable Energy Development	10 233 234	10 093 501	9 656 162	95.7%	437 339
Nuclear Science	10 121 270	10 015 140	9 639 283	96.2%	375 857
Total Major Programme 1	38 909 564	38 379 024	37 022 610	96.5%	1 356 414
MP2 — Nuclear Techniques for Development and Environmental Protection					
Overall management, coordination and common activities	7 785 318	7 727 917	7 738 552	100.1%	(10 635)
Food and Agriculture	11 433 333	11 310 005	11 291 151	99.8%	18 854
Human Health	8 276 608	8 176 958	8 118 221	99.3%	58 737
Water Resources	3 466 371	3 428 407	3 422 642	99.8%	5 765
Environment	6 275 597	6 200 703	6 232 962	100.5%	(32 259)
Radioisotope Production and Radiation Technology	2 250 108	2 226 852	2 008 045	90.2%	218 807
Total Major Programme 2	39 487 335	39 070 842	38 811 573	99.3%	259 269
MP3 — Nuclear Safety and Security					
Overall management, coordination and common activities	3 988 447	3 927 526	3 691 233	94.0%	236 293
Incident and Emergency Preparedness and Response	4 250 797	4 194 055	4 103 582	97.8%	90 473
Safety of Nuclear Installations	10 261 763	10 084 677	9 957 361	98.7%	127 316
Radiation and Transport Safety	7 168 211	7 048 076	7 078 119	100.4%	(30 043)
Management of Radioactive Waste	3 668 294	3 608 775	3 349 314	92.8%	259 461
Nuclear Security	5 384 357	5 288 729	5 084 949	96.1%	203 780
Total Major Programme 3	34 721 869	34 151 838	33 264 558	97.4%	887 280
MP4 — Nuclear Verification					
Overall management, coordination and common activities	13 919 282	13 757 229	13 298 352	96.7%	458 877
Safeguards Implementation	113 183 014	111 568 504	110 918 802	99.4%	649 702
Other Verification Activities	451 642	442 320	471 278	106.5%	(28 958)
Development	7 473 122	7 325 404	8 275 648	113.0%	(950 244)
Total Major Programme 4	135 027 060	133 093 457	132 964 080	99.9%	129 377
MP5 — Policy, Management and Administration Services					
Policy, Management and Administration Services	78 611 528	77 872 617	74 862 397	96.1%	3 010 220
Total Major Programme 5	78 611 528	77 872 617	74 862 397	96.1%	3 010 220
MP6 — Management of Technical Cooperation for Development					
Management of Technical Cooperation for Development	24 536 684	24 183 701	23 368 093	96.6%	815 608
Total Major Programme 6	24 536 684	24 183 701	23 368 093	96.6%	815 608
Total Operational Regular Budget	351 294 040	346 751 479	340 293 311	98.1%	6 458 168
Major Capital Investment Funding Requirements					
MP1 — Nuclear Power, Fuel Cycle and Nuclear Science	—	—	—	—	—
MP2 — Nuclear Techniques for Development and Environmental Protection	2 489 920	2 489 920	—	—	2 489 920
MP3 — Nuclear Safety and Security	301 200	301 200	156 736	52.0%	144 464
MP4 — Nuclear Verification	1 204 800	1 204 800	1 093 829	90.8%	110 971
MP5 — Policy, Management and Administration Services	4 036 080	4 036 080	2 126 853	52.7%	1 909 227
MP6 — Management of Technical Cooperation for Development	—	—	—	—	—
Total Capital Regular Budget	8 032 000	8 032 000	3 377 418	42.0%	4 654 582
Total Agency Programmes	359 326 040	354 783 479	343 670 729	96.9%	11 112 750
Reimbursable work for others	2 673 748	2 673 748	3 013 013	112.7%	(339 265)
Total Regular Budget	361 999 788	357 457 227	346 683 742	97.0%	10 773 485

Column a: General Conference resolution GC (59)/RES/5 of September 2015 original budget at US \$1/€1.

Column b: Original budget revalued at the United Nations operational average rate of exchange of €0.903 to US \$1 in 2016.

Table A2. Extrabudgetary regular programme fund resource utilization in 2016 by Programme and Major Programme (in euros)

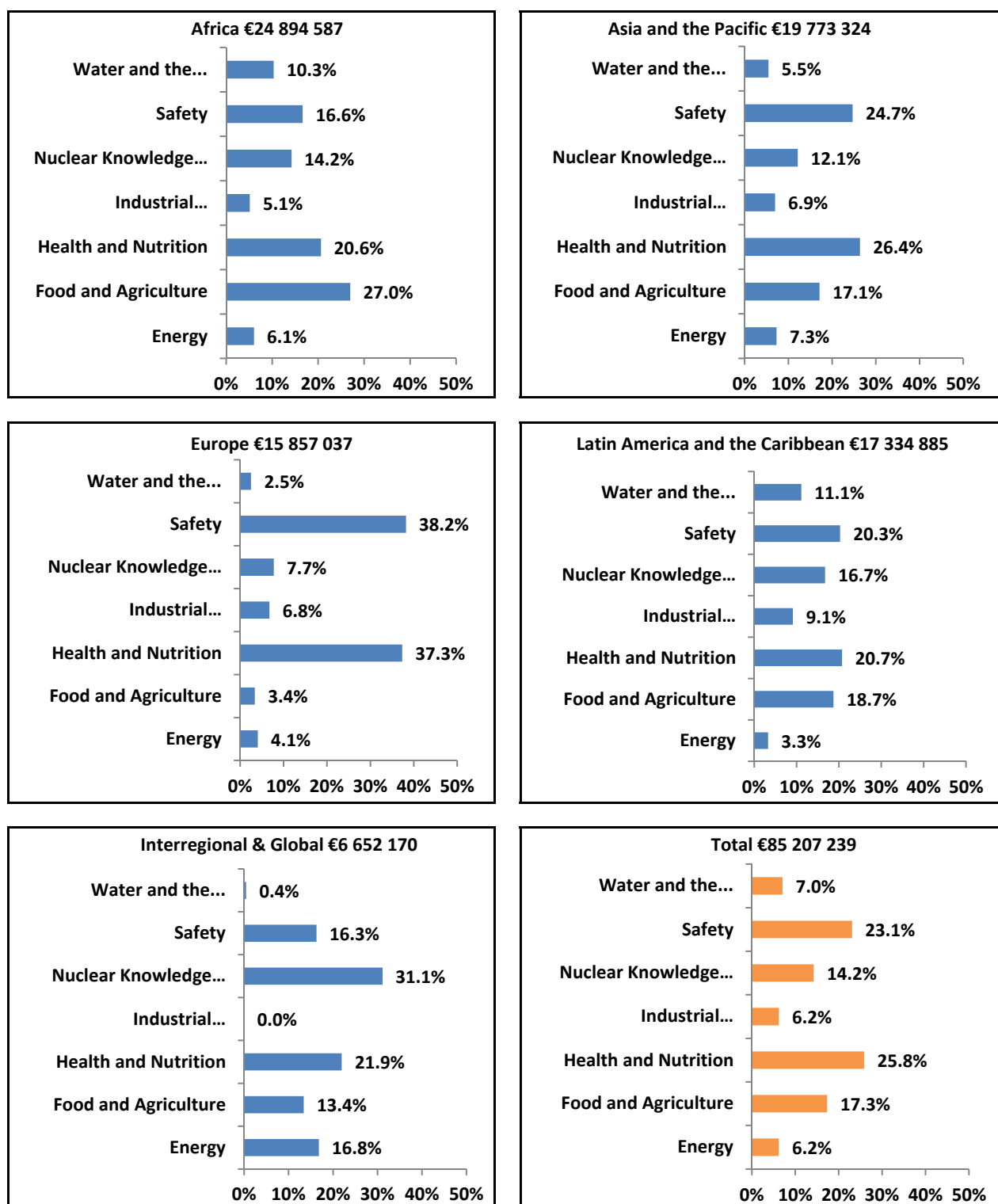
Major Programme (MP)/Programme	2016 expenditure
MP1 — Nuclear Power, Fuel Cycle and Nuclear Science	
Overall management, coordination and common activities	61 207
Nuclear Power	3 199 729
Nuclear Fuel Cycle and Materials Technologies	4 531 352
Capacity Building and Nuclear Knowledge for Sustainable Energy Development	669 595
Nuclear Science	1 397 277
Total Major Programme 1	9 859 160
MP2 — Nuclear Techniques for Development and Environmental Protection	
Overall management, coordination and common activities	4 105 228
Food and Agriculture	3 681 364
Human Health	591 452
Water Resources	9 089
Environment	2 018 585
Radioisotope Production and Radiation Technology	—
Total Major Programme 2	10 405 718
MP3 — Nuclear Safety and Security	
Overall management, coordination and common activities	4 841 387
Incident and Emergency Preparedness and Response	352 039
Safety of Nuclear Installations	5 449 433
Radiation and Transport Safety	2 215 027
Management of Radioactive Waste	1 096 981
Nuclear Security	31 536 668
Total Major Programme 3	45 491 535
MP4 — Nuclear Verification	
Overall management, coordination and common activities	1 284 153
Safeguards Implementation	15 713 020
Other Verification Activities	—
Development	12 417 562
Total Major Programme 4	29 414 735
MP5 — Policy, Management and Administration Services	
Policy, Management and Administration Services	1 112 457
Total Major Programme 5	1 112 457
MP6 — Management of Technical Cooperation for Development	
Management of Technical Cooperation for Development	91 685
Total Major Programme 6	91 685
Total extrabudgetary programme funds	96 375 290

Table A3(a). Disbursements (actuals) of the Technical Cooperation Fund by technical field and region in 2016

Summary of all regions (in euros)							
Technical field	Africa	Asia and the Pacific	Europe	Latin America and the Caribbean	Global/interregional	PACT ^a	Total
Energy	1 508 657	1 438 115	645 324	568 541	1 117 775		5 278 412
Food and Agriculture	6 714 778	3 386 397	536 653	3 246 657	891 005		14 775 490
Health and Nutrition	5 133 015	5 216 606	5 920 488	3 596 599	1 459 023	695 237	22 020 967
Industrial Applications/ Radiation Technology	1 281 454	1 372 692	1 071 689	1 583 368			5 309 203
Nuclear Knowledge Development and Management	3 540 060	2 398 542	1 227 151	2 898 518	2 071 928		12 136 199
Safety	4 143 475	4 883 059	6 058 775	3 513 783	1 082 958		19 682 049
Water and the Environment	2 573 148	1 077 913	396 957	1 927 420	29 482		6 004 920
Total	24 894 587	19 773 324	15 857 037	17 334 885	6 652 170	695 237	85 207 239

^a PACT: Programme of Action for Cancer Therapy.

Table A3(b). Graphical representation of the Technical Cooperation Fund disbursement information in Table A3(a)



Note: See Table A3(a) for the full titles of the technical fields.

Table A4. Amount of nuclear material under Agency safeguards at the end of 2016 by type of agreement

Nuclear material	Comprehensive safeguards agreement ^a	INFCIRC/66-type agreement	Voluntary offer agreement	Quantity in significant quantities (SQs)
Plutonium ^b contained in irradiated fuel and in fuel elements in reactor cores	134 615	2 381	19 218	156 214
Separated plutonium outside reactor cores	1 412	5	10 656	12 073
High enriched uranium (equal to or greater than 20% U-235)	179	2	0	181
Low enriched uranium (less than 20% U-235)	18 998	248	1 609	20 855
Source material ^c (natural and depleted uranium and thorium)	10 619	650	3 463	14 732
U-233	18	0	0	18
Total SQs of nuclear material	165 841	3 286	34 946	204 073

Amount of heavy water under Agency safeguards at the end of 2016 by type of agreement

Non-nuclear material ^d	Comprehensive safeguards agreement	INFCIRC/66-type agreement	Voluntary offer agreement	Quantity in tonnes
Heavy water (tonnes)		432.0		432.7^e

^a Includes nuclear material under Agency safeguards in Taiwan, China; excludes nuclear material in the Democratic People's Republic of Korea.

^b The quantity includes an estimated amount (10 000 SQs) of plutonium in fuel elements loaded into reactor cores and plutonium in other irradiated fuel, which has not yet been reported to the Agency under agreed reporting procedures.

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

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

^e Includes 0.7 tonnes of heavy water under Agency safeguards in Taiwan, China.

Table A5. Number of facilities and material balance areas outside facilities under Agency safeguards during 2016

Type	Comprehensive safeguards agreement ^a	INFCIRC/66-type agreement	Voluntary offer agreement	Total
Power reactors	236	12	1	249
Research reactors and critical assemblies	148	3	1	152
Conversion plants	18	0	0	18
Fuel fabrication plants	41	2	1	44
Reprocessing plants	9	0	1	10
Enrichment plants	16	0	3	19
Separate storage facilities	130	2	4	136
Other facilities	81	0	0	81
Facility subtotals	679	19	11	709
Material balance areas containing locations outside facilities ^b	580	1	0	581
Total	1259	20	11	1290

^a Includes facilities in Taiwan, China; excludes facilities in the Democratic People's Republic of Korea.

^b Includes 56 material balance areas in States with amended small quantities protocols.

Table A6. Conclusion of safeguards agreements, additional protocols and small quantities protocols (as of 31 December 2016)

State ^a	Small quantities protocols ^b	Safeguards agreements ^c	INFCIRC	Additional protocols
Afghanistan	Amended: 28 Jan. 2016	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	Amended: 24 April 2013	In force: 18 Oct. 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	Amended: 5 March 2012	In force: 9 Sept. 1996	528	In force: 15 Nov. 2013
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	Rescinded: 15 July 2015	In force: 29 April 1999	580	In force: 29 Nov. 2000
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, Plurinational State of ²	X	In force: 6 Feb. 1995	465	
Bosnia and Herzegovina		In force: 4 April 2013	851	In force: 3 July 2013
Botswana		In force: 24 Aug. 2006	694	In force: 24 Aug. 2006
Brazil ⁶		In force: 4 March 1994	435	
Brunei Darussalam	X	In force: 4 Nov. 1987	365	
Bulgaria ⁷		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

State ^a	Small quantities protocols ^b	Safeguards agreements ^c	INFCIRC	Additional protocols
Burundi	In force: 27 Sept. 2007	In force: 27 Sept. 2007	719	In force: 27 Sept. 2007
<i>Cabo Verde</i>	<i>Amended: 27 March 2006</i>	<i>Signed: 28 June 2005</i>		<i>Signed: 28 June 2005</i>
Cambodia	Amended: 16 July 2014	In force: 17 Dec. 1999	586	In force: 24 April 2015
Cameroon	X	In force: 17 Dec. 2004	641	In force: 29 Sept. 2016
Canada		In force: 21 Feb. 1972	164	In force: 8 Sept. 2000
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 ⁸		In force: 5 April 1995	476	In force: 3 Nov. 2003
China		In force: 18 Sept. 1989	369*	In force: 28 March 2002
Colombia ⁸		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	In force: 28 Oct. 2011	In force: 28 Oct. 2011	831	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	In force: 5 May 2016
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 ⁹		Accession: 1 May 2008	193	Accession: 1 May 2008
Czech Republic ¹⁰		Accession: 1 Oct. 2009	193	Accession: 1 Oct. 2009
Democratic Republic of the Congo		In force: 9 Nov. 1972	183	In force: 9 April 2003
Denmark ¹¹		In force: 1 March 1972 In force: 21 Feb. 1977	176 193	In force: 22 March 2013 In force: 30 April 2004
Djibouti	In force: 26 May 2015	In force: 26 May 2015	884	In force: 26 May 2015
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
Democratic People's Republic of Korea		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
<i>Equatorial Guinea</i>	<i>Approved: 13 June 1986</i>	<i>Approved: 13 June 1986</i>		

State ^a	Small quantities protocols ^b	Safeguards agreements ^c	INFCIRC	Additional protocols
<i>Eritrea</i>				
Estonia ¹²		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 ¹³		Accession: 1 Oct. 1995	193	In force: 30 April 2004
France	X	In force: 12 Sept. 1981 In force: 26 Oct. 2007 ¹⁴	290* 718	In force: 30 April 2004
Gabon	Amended: 30 Oct. 2013	In force: 25 March 2010	792	In force: 25 March 2010
Gambia	Amended: 17 Oct. 2011	In force: 8 Aug. 1978	277	In force: 18 Oct. 2011
Georgia		In force: 3 June 2003	617	In force: 3 June 2003
Germany ¹⁵		In force: 21 Feb. 1977	193	In force: 30 April 2004
Ghana	Rescinded: 24 Feb. 2012	In force: 17 Feb. 1975	226	In force: 11 June 2004
Greece ¹⁶		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
<i>Guinea</i>	<i>Signed: 13 Dec. 2011</i>	<i>Signed: 13 Dec. 2011</i>		<i>Signed: 13 Dec. 2011</i>
<i>Guinea-Bissau</i>	<i>Signed: 21 June 2013</i>	<i>Signed: 21 June 2013</i>		<i>Signed: 21 June 2013</i>
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 ¹⁷		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
India¹⁸		In force: 30 Sept. 1971 In force: 17 Nov. 1977 In force: 27 Sept. 1988 In force: 11 Oct. 1989 In force: 1 March 1994 In force: 11 May 2009	211 260 360 374 433 754	In force: 25 July 2014
Indonesia		In force: 14 July 1980	283	In force: 29 Sept. 1999
Iran, Islamic Republic of ¹⁹		In force: 15 May 1974	214	Signed: 18 Dec. 2003
Iraq		In force: 29 Feb. 1972	172	In force: 10 Oct. 2012

State ^a	Small quantities protocols ^b	Safeguards agreements ^c	INFCIRC	Additional protocols
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	Rescinded: 24 Apr. 2015	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: 9 Nov. 2004
Korea, Republic of		In force: 14 Nov. 1975	236	In force: 19 Feb. 2004
Kuwait	Amended: 26 July 2013	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 People's Democratic Republic	X	In force: 5 April 2001	599	Signed: 5 Nov. 2014
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		Approved: 8 June 2016		Approved: 8 June 2016
Libya		In force: 8 July 1980	282	In force: 11 Aug. 2006
Liechtenstein		In force: 4 Oct. 1979	275	In force: 25 Nov. 2015
Lithuania ²¹		Accession: 1 Jan. 2008	193	Accession: 1 Jan. 2008
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	Amended: 20 March 2013	In force: 10 Dec. 2009	788	In force: 10 Dec. 2009

State ^a	Small quantities protocols ^b	Safeguards agreements ^c	INFCIRC	Additional protocols
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
<i>Micronesia, Federated States of</i>	<i>Signed: 1 June 2015</i>	<i>Signed: 1 June 2015</i>		
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	Signed: 17 Sept. 2013
Namibia	X	In force: 15 April 1998	551	In force: 20 Feb. 2012
Nauru	X	In force: 13 April 1984	317	
Nepal	X	In force: 22 June 1972	186	
Netherlands	X	In force: 5 June 1975 ¹⁴ In force: 21 Feb. 1977	229 193	In force: 30 April 2004
New Zealand ²⁴	Amended: 24 Feb. 2014	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	Rescinded: 14 Aug. 2012	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 In force: 17 June 1968 In force: 17 Oct. 1969 In force: 18 March 1976 In force: 2 March 1977 In force: 10 Sept. 1991 In force: 24 Feb. 1993 In force: 22 Feb. 2007 In force: 15 April 2011	34 116 135 239 248 393 418 705 816	
Palau	Amended: 15 March 2006	In force: 13 May 2005	650	In force: 13 May 2005
<i>Palestine</i>				
Panama ⁸	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

State ^a	Small quantities protocols ^b	Safeguards agreements ^c	INFCIRC	Additional protocols
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 Sept. 2011	In force: 17 May 2006	690	In force: 1 June 2012
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
Saint Kitts and Nevis ⁵	Amended: 19 Aug. 2016	In force: 7 May 1996	514	In force: 19 May 2014
Saint Lucia ⁵	X	In force: 2 Feb. 1990	379	
St Vincent and 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	
<i>São Tomé and Príncipe</i>				
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	
<i>Somalia</i>				
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	

State ^a	Small quantities protocols ^b	Safeguards agreements ^c	INFCIRC	Additional protocols
Suriname ²	X	In force: 2 Feb. 1979	269	
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	Rescinded: 6 Nov. 2015	In force: 14 Dec. 2004	639	In force: 14 Dec. 2004
Thailand		In force: 16 May 1974	241	Signed: 22 Sept. 2005
The former Yugoslav Republic of Macedonia	Amended: 9 July 2009	In force: 16 April 2002	610	In force: 11 May 2007
<i>Timor-Leste</i>	<i>Signed: 6 Oct. 2009</i>	<i>Signed: 6 Oct. 2009</i>		<i>Signed: 6 Oct. 2009</i>
Togo	Amended: 8 Oct. 2015	In force: 18 July 2012	840	In force: 18 July 2012
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 ³² In force: 14 Aug. 1978 Signed: 6 Jan. 1993 ¹⁴	175 263*	In force: 30 April 2004
United Republic 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 In force: 6 April 1989 ¹⁴	288* 366	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	In force: 21 May 2013	In force: 21 May 2013	852	In force: 21 May 2013
Venezuela, Bolivarian Republic of ²		In force: 11 March 1982	300	
Viet Nam		In force: 23 Feb. 1990	376	In force: 17 Sept. 2012

State ^a	Small quantities protocols ^b	Safeguards agreements ^c	INFCIRC	Additional protocols
Yemen	X	In force: 14 Aug. 2002	614	
Zambia	X	In force: 22 Sept. 1994	456	Signed: 13 May 2009
Zimbabwe	Amended: 31 Aug. 2011	In force: 26 June 1995	483	

Key

Bold States not party to the Treaty of the Non-Proliferation of Nuclear Weapons (NPT) whose safeguards agreements are of INFCIRC/66-type.

Italics States Parties to the NPT that have not yet brought into force comprehensive safeguards agreements (CSAs) pursuant to Article III of the NPT.

* Voluntary offer safeguards agreement with NPT nuclear-weapon States.

X 'X' in the 'small quantities protocols' column indicates that the State has an operative small quantities protocol (SQP). 'Amended' indicates that the operative SQP is based on the revised SQP standardized text.

NB: This table 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 upon the entry into force of a CSA. Unless otherwise indicated, the safeguards agreements referred to are CSAs concluded pursuant to the NPT.

^a An entry in this column does not imply the expression of any opinion whatsoever on the part of the Agency concerning the legal status of any country or territory or of its authorities, or concerning the delimitation of its frontiers.

^b Provided that they meet certain eligibility criteria (including that the quantities of nuclear material do not exceed the limits set out in paragraph 37 of INFCIRC/153(Corrected)), countries have the option to conclude an SQP to their CSAs that holds in abeyance the implementation of most of the detailed provisions set out in Part II of the CSAs as long as eligibility criteria continue to apply. This column contains countries whose CSA with an SQP based on the original standard text has been approved by the Board of Governors and for which, as far as the Secretariat is aware, these eligibility criteria 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.

^c The Agency also applies safeguards for Taiwan, China, under two agreements, which entered into force on 13 October 1969 (INFCIRC/133) and 6 December 1971 (INFCIRC/158), 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 is pursuant 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 for Austria under the NPT bilateral safeguards agreement (INFCIRC/156), in force since 23 July 1972, was suspended on 31 July 1996, on which date the agreement of 5 April 1973 between the non-nuclear-weapon States of Euratom, Euratom and the Agency (INFCIRC/193), to which Austria had acceded, entered into force for Austria.

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

⁶ 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 requirement 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 requirement of Article III of the NPT.

⁷ The application of safeguards for Bulgaria under the NPT bilateral 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.

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

- ⁹ The application of safeguards for Cyprus under the NPT bilateral safeguards agreement (INFCIRC/189), in force since 26 January 1973, was suspended on 1 May 2008, on which date the agreement of 5 April 1973 between the non-nuclear-weapon States of Euratom, Euratom and the Agency (INFCIRC/193), to which Cyprus had acceded, entered into force for Cyprus.
- ¹⁰ The application of safeguards for the Czech Republic under the NPT bilateral 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.
- ¹¹ The application of safeguards for Denmark under the NPT bilateral safeguards agreement (INFCIRC/176), in force since 1 March 1972, was suspended on 21 February 1977, on which date the agreement of 5 April 1973 between the non-nuclear-weapon States of Euratom, Euratom and the Agency (INFCIRC/193) entered into force for Denmark. Since 21 February 1977, INFCIRC/193 also applies to the Faroe Islands. Upon Greenland's secession from Euratom as of 31 January 1985, INFCIRC/176 re-entered into force for Greenland. The Additional Protocol for Greenland entered into force on 22 March 2013 (INFCIRC/176/Add.1).
- ¹² The application of safeguards for Estonia under the NPT bilateral safeguards agreement (INFCIRC/547), in force since 24 November 1997, was suspended on 1 December 2005, on which date the agreement of 5 April 1973 between the non-nuclear-weapon States of Euratom, Euratom and the Agency (INFCIRC/193), to which Estonia had acceded, entered into force for Estonia.
- ¹³ The application of safeguards for Finland under the NPT bilateral safeguards agreement (INFCIRC/155), in force since 9 February 1972, was suspended on 1 October 1995, on which date the agreement of 5 April 1973 between the non-nuclear-weapon States of Euratom, Euratom and the Agency (INFCIRC/193), to which Finland had acceded, entered into force for Finland.
- ¹⁴ The safeguards agreement is pursuant to Additional Protocol I to the Treaty of Tlatelolco.
- ¹⁵ The NPT safeguards agreement of 7 March 1972 concluded with the German Democratic Republic (INFCIRC/181) is no longer in force with effect from 3 October 1990, on which date the German Democratic Republic acceded to the Federal Republic of Germany.
- ¹⁶ The application of safeguards for Greece under the NPT bilateral safeguards agreement (INFCIRC/166), in force since 1 March 1972, was suspended on 17 December 1981, on which date the agreement of 5 April 1973 between the non-nuclear-weapon States of Euratom, Euratom and the Agency (INFCIRC/193), to which Greece had acceded, entered into force for Greece.
- ¹⁷ The application of safeguards for Hungary under the NPT bilateral 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.
- ¹⁸ The application of safeguards for India under the safeguards agreement between the Agency, Canada and India (INFCIRC/211), in force since 30 September 1971, was suspended as of 20 March 2015. The application of safeguards for India under the following safeguards agreements between the Agency and India was suspended as of 30 June 2016: INFCIRC/260, in force since 17 November 1977; INFCIRC/360, in force since 27 September 1988; INFCIRC/374, in force since 11 October 1989; and INFCIRC/433, in force since 1 March 1994. Items subject to safeguards under the aforementioned safeguards agreements are subject to safeguards under the safeguards agreement between India and the Agency (INFCIRC/754), which entered into force on 11 May 2009.
- ¹⁹ Pending entry into force, the additional protocol is being applied provisionally for the Islamic Republic of Iran as of 16 January 2016.
- ²⁰ The application of safeguards for Latvia under the NPT bilateral 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 for Lithuania under the NPT bilateral 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 for Malta under the NPT bilateral 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 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. Amendments to the SQP entered into force only for New Zealand on 24 February 2014 (INFCIRC/185/Mod.1).
- ²⁵ The application of safeguards for Poland under the NPT bilateral 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 for Portugal under the NPT bilateral 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 for Romania under the NPT bilateral 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 for Serbia to the extent relevant to the territory of Serbia.
- ²⁹ The application of safeguards for Slovakia under the NPT bilateral 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 for Slovenia under the NPT bilateral 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 for Sweden under the NPT bilateral 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 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 the 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 2016)

	State/Organization	P&I	VC	CPNM	CPNM-AM	ENC	AC	JP	NS	RADW	PAVC	CSC	RSA	VI	XIV.A
*	Afghanistan			P		Sr	Sr						P	X	
*	Albania	P		P	P	P	P		P	P			P	X	X
*	Algeria			Pr	P	Pr	Pr		S				P	X	X
	Andorra			Pr											
*	Angola					P							P		
*	Antigua and Barbuda			P	P								P		
*	Argentina	P	P	Pr	P	Pr	Pr	S	P	P	P	P	P	X	X
*	Armenia		P	P	Pr	P	P		P	P			P		
*	Australia	P		P	P	Pr	Pr		P	P		S			X
*	Austria			Pr	P	P	Pr		Pr	P				X	X
*	Azerbaijan			Pr	Pr								P		
*	Bahamas			Pr											
*	Bahrain			Pr	P	Pr			P				P		
*	Bangladesh			P		P	P		P				P		
*	Barbados														
*	Belarus	Pr	P	Pr		Pr	Pr		P	P	P		P	X	X
*	Belgium	Pr		Pr	Pr	P	P	S	P	P					
*	Belize												P		
*	Benin	P											P		
	Bhutan														
*	Bolivia, Plurinational State of	P	P	P		Pr	Pr						P		
*	Bosnia and Herzegovina	Pr	P	P	P	P	P		P	P	P		P	X	X
*	Botswana			P	P	P	P			P			P		
*	Brazil	P	P	P		P	P		P	P			P	X	X
*	Brunei Darussalam														
*	Bulgaria	P	P	P	P	P	P	P	P	P			P	X	X

	State/Organization	P&I	VC	CPPNM	CPPNM-AM	ENC	AC	JP	NS	RADW	PAVC	CSC	RSA	VI	XIVA
*	Burkina Faso			P	P	P	P						P		
*	Burundi												P		
	Cabo Verde			P											
*	Cambodia			P		P			P				P		
*	Cameroon	P	P	P	P	P	P	P					P		
*	Canada	Pr		P	Pr	Pr	Pr		P	P		S		X	X
*	Central African Republic			P									P		
*	Chad												P		
*	Chile	Pr	Pr	P	P	P	P	P	P	P			P		
*	China	Pr		Pr	P	Pr	Pr		P	Pr			P		
*	Colombia	P	S	P	P	P	Pr						P	X	X
	Comoros			P											
*	Congo														
*	Costa Rica			P		P	P						P		
*	Côte d'Ivoire			P	P	S	S						P		
*	Croatia	P	P	P	P	P	P	P	P	P			P	X	X
*	Cuba	Pr	P	Pr	P	Pr	Pr		S				P		
*	Cyprus	P		Pr	P	P	P		P	P			P	X	X
*	Czech Republic	P	P	P	P	P	P	P	P	P	S	S	P	X	X
	Dem. People's Rep. of Korea					Sr	Sr								
*	Dem. Rep. of the Congo	P		P		S	S						P		
*	Denmark	Pr		Pr	Pr	P	Pr	Pr	Pr	Pr				X	X
*	Djibouti			P	P								P		
*	Dominica			P									P		
*	Dominican Republic			P	P	P							P		
*	Ecuador	P		P									P		X
*	Egypt	P	P			Pr	Pr	P	S				P		
*	El Salvador			Pr	P	Pr	Pr						P	X	

	State/Organization	P&I	VC	CPNM	CPNM-AM	ENC	AC	JP	NS	RADW	PAVC	CSC	RSA	VI	XIVA
	Equatorial Guinea			P											
*	Eritrea														
*	Estonia	P	P	P	P	P	P	P	P	P			P	X	X
*	Ethiopia												P	X	
*	Fiji			P	P								P		
*	Finland	P		Pr	P	P	Pr	P	P	P				X	X
*	France			Pr	P	Pr	Pr	Pr	P	P				X	X
*	Gabon			P	P	P	P			P			P		
	Gambia														
*	Georgia			P	P	P				P			P		
*	Germany	Pr		Pr	P	Pr	Pr	P	P	P				X	X
*	Ghana	P		P	P	P	P		P	P		P	P		
*	Greece	P		Pr	P	Pr	Pr	P	P	P			P	X	X
	Grenada			P											
*	Guatemala			Pr		P	P						P		
	Guinea			P											
	Guinea-Bissau														
*	Guyana			P											
*	Haiti			S									P		
*	Holy See	P				S	S							X	X
*	Honduras			P									P		
*	Hungary	Pr	P	P	P	P	P	P	P	P	S		P	X	X
*	Iceland	P		P	P	P	P		P	P			P	X	X
*	India	P		Pr	P	Pr	Pr		P			Pr			
*	Indonesia	Pr		Pr	P	Pr	Pr		P	P	S	S	P		
*	Iran, Islamic Republic of	P				Pr	Pr						P		X
*	Iraq	P		P		Pr	Pr						P		
*	Ireland	P		Pr	P	P	Pr		P	P			P	X	X

	State/Organization	P&I	VC	CPPNM	CPPNM-AM	ENC	AC	JP	NS	RADW	PAVC	CSC	RSA	VI	XIVA
*	Israel		Sr	Pr	Pr	Pr	Pr		S				P	X	
*	Italy	Pr		Pr	P	Pr	Pr	P	P	P	S	S		X	X
*	Jamaica	P		P	P								P		
*	Japan	P		P	P	P	Pr		P	Pr		Pr		X	X
*	Jordan	Pr	P	Pr	P	P	P		P	P	Pr		P		
*	Kazakhstan	P	P	P	P	P	P		P	P	P		P		
*	Kenya			P	P								P		X
	Kiribati														
*	Korea, Republic of	Pr		Pr	P	P	Pr		P	P			P	X	X
*	Kuwait	P		Pr	P	P	P		P				P		
*	Kyrgyzstan			P	P					P			P		
*	Lao People's Dem. Rep.			Pr		P	P						P		
*	Latvia	P	P	P	P	P	P	P	P	P	P		P	X	X
*	Lebanon		P	P		P	P		P	S	S	S	P		
*	Lesotho			P	P	P	P			P			P		
*	Liberia														
*	Libya			P	P	P	P		P				P	X	
*	Liechtenstein			P	P	P	P							X	X
*	Lithuania	P	P	P	P	P	P	P	P	P	S	S	P	X	X
*	Luxembourg	Pr		Pr	P	P	P		P	P				X	X
*	Madagascar			P									P		
*	Malawi			P									P		
*	Malaysia					Pr	Pr						P		
	Maldives														
*	Mali			P	P	P	P		P				P		
*	Malta			P	P				P	P			P	X	X
*	Marshall Islands			P	P								P		
*	Mauritania			P	P	P	P			P			P		

	State/Organization	P&I	VC	CPPNM	CPPNM-AM	ENC	AC	JP	NS	RADW	PAVC	CSC	RSA	VI	XIVA
*	Mauritius	P	P			Pr	Pr			P		S	P		
*	Mexico	Pr	P	P	P	P	P		P				P	X	X
	Micronesia, Federated States of														
*	Monaco			P		Pr	Pr		S					X	X
*	Mongolia	P		P		P	P						P		
*	Montenegro	P	P	P	P	P	P		P	P	P	P	P		
*	Morocco	Pr	S	P	P	P	P	S	S	P	P	P	P	X	
*	Mozambique	P		Pr		P	P						P		
*	Myanmar					Pr							P	X	X
*	Namibia			P									P		
	Nauru			P	P										
*	Nepal												P		
*	Netherlands	Pr		Pr	Pr	Pr	Pr	Pr	Pr	Pr				X	X
*	New Zealand	P		Pr	Pr	P	Pr								
*	Nicaragua	P		P	P	Pr	Pr		S				P		
*	Niger	P	P	P	P	S	S				P		P		
*	Nigeria	P	P	P	P	P	P		P	P			P		
	Niue			P											
*	Norway	P		Pr	P	P	Pr	P	P	P				X	X
*	Oman	Pr		Pr		Pr	Pr		P	P			P		
*	Pakistan	Pr		Pr	Pr	Pr	Pr		P				P	X	X
*	Palau	P		P									P		
*	Panama			P		P	P						P	X	
*	Papua New Guinea														
*	Paraguay			P	P	P	P		P				P		
*	Peru		P	Pr	P	Pr	Pr		P	P	S	S	P	X	X
*	Philippines	P	P	P		P	P	S	S	S	S	S	P		
*	Poland	P	P	P	P	P	P	P	P	P	P		P	X	X

	State/Organization	P&I	VC	CPPNM	CPPNM-AM	ENC	AC	JP	NS	RADW	PAVC	CSC	RSA	VI	XIVA
*	Portugal	Pr		Pr	P	P	P	S	P	P			P	X	X
*	Qatar			Pr	P	P	P						P		
*	Republic of Moldova	Pr	P	P	P	P	P		P	Pr			P	X	X
*	Romania	Pr	P	P	P	Pr	Pr	P	P	P	P	P	P	X	X
*	Russian Federation	Pr	P	P	P	Pr	Pr		P	P					
*	Rwanda			P									P		
	Saint Kitts and Nevis			P											
	Saint Lucia			Pr	P										
	St Vincent and the Grenadines		P			P	P	P							
	Samoa														
*	San Marino			P	P										
	São Tomé and Príncipe														
*	Saudi Arabia		P	Pr	P	Pr	Pr		P	P	Pr		P		
*	Senegal	P	P	P		P	P		P	P		S	P		
*	Serbia	P	P	P	P	P	P						P		
*	Seychelles			P	P								P		X
*	Sierra Leone					S	S						P		
*	Singapore	Pr		Pr	Pr	P	P		P				P		
*	Slovakia	P	P	P	P	P	P	P	P	P			P	X	X
*	Slovenia	P		P	P	P	P	P	P	P			P	X	X
	Solomon Islands														
	Somalia														
*	South Africa	Pr		P		Pr	Pr		P	P			P	X	X
*	Spain	P	S	Pr	P	Pr	Pr	S	P	P			P	X	X
*	Sri Lanka					Pr	Pr		P				P		
*	Sudan			P		S	S		S				P		
	Suriname														
*	Swaziland			P	P										

	State/Organization	P&I	VC	CPPNM	CPPNM-AM	ENC	AC	JP	NS	RADW	PAVC	CSC	RSA	VI	XIVA
*	Sweden	P		Pr	P	P	Pr	P	P	P				X	X
*	Switzerland	Pr		Pr	P	P	P	S	P	P				X	X
*	Syrian Arab Republic	P				S	S		S				P		X
*	Tajikistan	P		P	P	P	P			P			P		
*	Thailand	Pr				Pr	Pr						P		
*	The former Yugoslav Republic of Macedonia		P	P	P	P	P		P	P			P		
	Timor Leste														
*	Togo			P									P		
	Tonga			P											
*	Trinidad and Tobago		P	P											
*	Tunisia	P		P	P	P	P		P				P	X	X
*	Turkey	Pr		Pr	Pr	Pr	Pr	P	P				P	X	X
*	Turkmenistan			P	P										
	Tuvalu														
*	Uganda			P									P		
*	Ukraine	Pr	P	P	P	Pr	Pr	P	Pr	P	S	S	P	X	X
*	United Arab Emirates			P	P	Pr	Pr	P	P	P	Pr	Pr	P		
*	United Kingdom	P	S	Pr	Pr	Pr	Pr	S	Pr	P				X	X
*	United Republic of Tanzania			P		P	P						P		
*	United States of America			P	Pr	Pr	Pr		P	P		Pr			
*	Uruguay		P	P	P	P	P	P	P	P			P	X	
*	Uzbekistan			P	P					P			P		
*	Vanuatu												P		
*	Venezuela, Bolivarian Republic of					Pr							P		
*	Viet Nam	P		Pr	P	Pr	Pr		P	P			P		
*	Yemen			P											
*	Zambia			P									P		
*	Zimbabwe					S	S						P		

State/Organization	P&I	VC	CPPNM	CPPNM-AM	ENC	AC	JP	NS	RADW	PAVC	CSC	RSA	VI	XIV.A
Euratom			Pr	Pr	Pr	Pr		Pr	Pr					
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
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
CSC	Convention on Supplementary Compensation for Nuclear Damage
RSA	Revised Supplementary Agreement Concerning the Provision of Technical Assistance by the IAEA
VI	Acceptance of Amendment to Article VI of the IAEA Statute, as informed by the depositary Government
XIV.A	Acceptance of Amendment to Article XIV.A of the IAEA Statute, as informed by the depositary Government
*	Agency Member State
P	Party
S	Signatory
r	Existing reservation/declaration
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 2016, the status of the Agreement remained unchanged with 84 Parties.

Convention on Early Notification of a Nuclear Accident (reproduced in INFCIRC/335). Entered into force on 27 October 1986. In 2016, 1 State became a Party to the Convention. By the end of the year, there were 120 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 2016, 1 State became a Party to the Convention. By the end of the year there were 113 Parties

Convention on Nuclear Safety (reproduced in INFCIRC/449). Entered into force on 24 October 1996. In 2016, the status of the Convention remained unchanged. By the end of the year, there were 78 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 2016, 3 States became Parties to the Convention. By the end of the year, there were 73 Parties.

Convention on the Physical Protection of Nuclear Material (reproduced in INFCIRC/274/Rev.1). Entered into force on 8 February 1987. In 2016, 1 State became a Party to the Convention. By the end of the year, there were 154 Parties.

Amendment to the Convention on the Physical Protection of Nuclear Material. Entered into force on 8 May 2016. In 2016, 15 States adhered to the Amendment. By the end of the year, there were 106 Parties.

Vienna Convention on Civil Liability for Nuclear Damage (reproduced in INFCIRC/500). Entered into force on 12 November 1977. In 2016, the status of the Convention remained unchanged with 40 Parties.

Optional Protocol Concerning the Compulsory Settlement of Disputes (reproduced in INFCIRC/500/Add.3). Entered into force on 13 May 1999. In 2016, the status of the Protocol remained unchanged with 2 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 2016, the status of the Protocol remained unchanged with 28 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 2016, 1 State became a Party to the Protocol. By the end of the year, there were 13 Parties.

Convention on Supplementary Compensation for Nuclear Damage (reproduced in INFCIRC/567). Entered into force on 17 April 2015. In 2016, 2 States became Parties to the Convention. By the end of the year, there were 9 Parties.

Revised Supplementary Agreement Concerning the Provision of Technical Assistance by the IAEA (RSA). In 2016, 7 States concluded an RSA. By the end of the year, there were 132 States party to an RSA Agreement.

Fifth 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.23). Entered into force on 31 August 2011 with effect from 12 June 2012. In 2016, the status remained unchanged with 17 Parties.

African Regional Co-operative Agreement for Research, Development and Training Related to Nuclear Science and Technology (AFRA) (Fifth Extension) (reproduced in INFCIRC/377/Add.20). Entered into force on 4 April 2015. In 2016, 11 States became Parties to the Agreement. By the end of the year, there were 27 Parties.

Agreement to Extend the Co-operation Agreement for the Promotion of Nuclear Science and Technology in Latin America and the Caribbean (ARCAL) (reproduced in INFCIRC/582/Add.4). Entered into force on 5 September 2015. In 2016, 2 States became Parties to the Agreement. By the end of the year, there were 19 Parties.

Co-operative Agreement for Arab States in Asia for Research, Development and Training Related to Nuclear Science and Technology (ARASIA) (Second Extension) (reproduced in INFCIRC/613/Add.3). Entered into force on 29 July 2014. In 2016, 1 State became a Party to the Agreement. By the end of the year, there were 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 2016, the status of the Agreement 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 2016, the status of the Agreement remained unchanged with 6 Parties.

Table A9. Nuclear power reactors in operation and under construction in the world (as of 31 December 2016)^a

Country	Reactors in operation		Reactors under construction		Nuclear electricity supplied in 2016		Total operating experience through 2016	
	No. of units	Total MW(e)	No. of units	Total MW(e)	TW-h	% of total	Years	Months
Argentina	3	1 632	1	25	7.7	5.6	79	2
Armenia	1	375			2.2	31.4	42	8
Belarus			2	2 218				
Belgium	7	5 913			41.4	51.7	282	7
Brazil	2	1 884	1	1 245	15.0	2.9	51	3
Bulgaria	2	1 926			15.1	35.0	161	3
Canada	19	13 554			95.7	15.6	712	6
China	36	31 384	21	21 622	197.8	3.6	243	2
Czech Republic	6	3 930			22.7	29.4	152	10
Finland	4	2 764	1	1 600	22.3	33.7	151	4
France	58	63 130	1	1 630	386.5	72.3	2 106	4
Germany	8	10 799			80.1	13.1	824	7
Hungary	4	1 889			15.2	51.3	126	2
India	22	6 240	5	2 990	35.0	3.4	460	11
Iran, Islamic Republic of	1	915			5.9	2.1	5	4
Japan	42	39 752	2	2 653	17.5	2.2	1 781	5
Korea, Republic of	25	23 077	3	4 020	154.3	30.3	498	11
Mexico	2	1 552			10.3	6.2	49	11
Netherlands	1	482			3.7	3.4	72	0
Pakistan	4	1 005	3	2 343	5.4	4.4	67	11
Romania	2	1 300			10.4	17.1	29	11
Russian Federation	35	26 111	7	5 520	184.1	17.1	1 226	9
Slovakia	4	1 814	2	880	13.7	54.1	160	7
Slovenia	1	688			5.4	35.2	35	3
South Africa	2	1 860			15.2	6.6	64	3
Spain	7	7 121			56.1	21.4	322	1
Sweden	10	9 740			60.6	40.0	442	6
Switzerland	5	3 333			20.3	34.4	209	11
Ukraine	15	13 107	2	2 070	76.1	52.3	473	6
United Arab Emirates			4	5 380				
United Kingdom	15	8 918			65.1	20.4	1 574	7
United States of America	99	99 869	4	4 468	804.9	19.7	4 210	9
Total^{b, c}	448	391 116	61	61 264	2 476.2		16 982	5

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

^b The total figures include the following data from Taiwan, China: 6 units, 5052 MW(e) in operation; 2 units, 2600 MW(e) under construction; 30.5 TW-h of nuclear electricity generation, representing 13.7% of the total electricity generated.

^c The total operating experience also includes shutdown plants in Italy (80 years, 8 months), Kazakhstan (25 years, 10 months), Lithuania (43 years, 6 months) and Taiwan, China (212 years, 1 month).

Table A10. Member State participation in selected Agency activities

Member State	No. of research contracts and agreements	No. of Collaborating Centres	Services provided to Member States					
			ALMERA ^a	Dosimetry audits for radiotherapy	Plant irradiation services	QUANUM ^b	QUAADRIL ^c	QUATRO ^d
Afghanistan								
Albania	1			4				
Algeria	7							
Angola	1							
Antigua and Barbuda								
Argentina	46		1					
Armenia	3			2				
Australia	44	1	3					
Austria	22		2		2			
Azerbaijan	2							
Bahamas								
Bahrain				3				
Bangladesh	24			1				
Barbados								
Belarus	5		1	20				
Belgium	24		2					
Belize								
Benin	1							
Bolivia, Plurinational State of								
Bosnia and Herzegovina	1		3	12				
Botswana				2				
Brazil	49	2	4					
Brunei Darussalam								
Bulgaria	10		2		1			
Burkina Faso	6	1			2			
Burundi					1			
Cambodia	1			1	2			

Member State	No. of research contracts and agreements	No. of Collaborating Centres	Services provided to Member States					
			ALMERA ^a	Dosimetry audits for radiotherapy	Plant irradiation services	QUANUM ^b	QUADRIL ^c	QUATRO ^d
Cameroon	7			2	1			
Canada	38		3					
Central African Republic								
Chad								
Chile	19		1	8				
China	87		3	22				
Colombia	7			3				
Congo								
Costa Rica	6	1	1	7	1			
Côte d'Ivoire	2				1			
Croatia	12		2	5				
Cuba	16		3	11		1		
Cyprus			1					
Czech Republic	13		1		2			
Dem. Rep. of the Congo	1				1			
Denmark	4		1					
Djibouti	1							
Dominica								
Dominican Republic								
Ecuador	2		1	10				
Egypt	21		1	5				
El Salvador				5	1			
Eritrea					1			
Estonia	7		1	12				
Ethiopia	6		1	2				
Fiji								
Finland	10		1					
France	50	2	5					

Member State	No. of research contracts and agreements	No. of Collaborating Centres	Services provided to Member States					
			ALMERA ^a	Dosimetry audits for radiotherapy	Plant irradiation services	QUANUM ^b	QUADRIL ^c	QUATRO ^d
Gabon								
Georgia	4			6				
Germany	56		3		8			
Ghana	16			2				
Greece	18		5					
Guatemala	6			4	1			
Guyana								
Haiti								
Holy See								
Honduras					1			
Hungary	16	2	2	24	1			
Iceland			1					
India	75	1	3	20	1			
Indonesia	22	1	1	13		1		
Iran, Islamic Republic of	12		1					
Iraq	1		1	7	1			
Ireland			1					
Israel	4		1			3		
Italy	54	2	8		1			
Jamaica	4		1					
Japan	55	2	1					
Jordan	9		1					
Kazakhstan	4		1	26				
Kenya	17		1	11				
Korea, Republic of	43	2	2					
Kuwait	5		1					
Kyrgyzstan								
Lao People's Dem. Rep.	1							

Member State	No. of research contracts and agreements	No. of Collaborating Centres	Services provided to Member States					
			ALMERA ^a	Dosimetry audits for radiotherapy	Plant irradiation services	QUANUM ^b	QUADRIL ^c	QUATRO ^d
Latvia	1		1	5				
Lebanon	2		1	17				
Lesotho								
Liberia								
Libya					1			
Liechtenstein								
Lithuania	5		3	10				
Luxembourg			1					
Madagascar	5		1					
Malawi								
Malaysia	24	1	1	19		1		
Mali	1							
Malta				2				
Marshall Islands								
Mauritania					1			
Mauritius	4							
Mexico	22	1	3	33		1		
Monaco								
Mongolia	3		1	1	1			
Montenegro	2		1					
Morocco	19	1	1	17				1
Mozambique	1				1			
Myanmar	2		1	5		1		
Namibia	1			1	1			
Nepal	1			8	1			
Netherlands	15	1	3		1			
New Zealand	7		1					
Nicaragua				2				

Member State	No. of research contracts and agreements	No. of Collaborating Centres	Services provided to Member States					
			ALMERA ^a	Dosimetry audits for radiotherapy	Plant irradiation services	QUANUM ^b	QUAADRIL ^c	QUATRO ^d
Niger					1			
Nigeria	5			2	1			
Norway	6		2					
Oman				3	1			
Pakistan	42		1					
Palau								
Panama	1		1	7				
Papua New Guinea				1				
Paraguay				2				
Peru	11		1	13				
Philippines	16	1	1	9		2		
Poland	33	1	3					
Portugal	9		1	3				
Qatar			1					
Republic of Moldova				3				
Romania	10		3	20	1			
Russian Federation	52		3	51				
Rwanda								
San Marino								
Saudi Arabia	4	1	1	9				
Senegal	8							
Serbia	8		3	16				
Seychelles								
Sierra Leone					1			
Singapore	9		1					
Slovakia	5		3					
Slovenia	10		1					
South Africa	35		3	34				

Member State	No. of research contracts and agreements	No. of Collaborating Centres	Services provided to Member States					
			ALMERA ^a	Dosimetry audits for radiotherapy	Plant irradiation services	QUANUM ^b	QUAADRIL ^c	QUATRO ^d
Spain	35	1	2		2			
Sri Lanka	9		1	15	3			
Sudan	2				1			
Swaziland								
Sweden	12		2					
Switzerland	8	1	3					
Syrian Arab Republic	6		1	6				
Tajikistan	1		1					
Thailand	24		2	26		1		
The former Yugoslav Republic of Macedonia	5		1	3				
Togo								
Trinidad and Tobago				5				
Tunisia	10		1	6				
Turkey	12		2	33				
Turkmenistan								
Uganda	7							
Ukraine	25		1	37				
United Arab Emirates	1		2	2				
United Kingdom	55		4		1			
United Republic of Tanzania	4			2	3			
United States of America	132	1	6					
Uruguay	13		1	9				
Uzbekistan	2				1			
Vanuatu								
Venezuela, Bolivarian Republic of	2		2	30				
Viet Nam	20			6				
Yemen								

Member State	No. of research contracts and agreements	No. of Collaborating Centres	Services provided to Member States					
			ALMERA ^a	Dosimetry audits for radiotherapy	Plant irradiation services	QUANUM ^b	QUAADRIL ^c	QUATRO ^d
Zambia	4	1						
Zimbabwe	2			2				

^a ALMERA: Analytical Laboratories for the Measurement of Environmental Radioactivity.

^b QUANUM: Quality Assurance in Nuclear Medicine.

^c QUAADRIL: Quality Assurance Audit for Diagnostic Radiology Improvement and Learning.

^d QUATRO: Quality Assurance Team for Radiation Oncology.

Table A11. Integrated Nuclear Infrastructure Review (INIR) missions in 2016

Type	Country
INIR follow-up	Bangladesh
INIR	Kazakhstan
INIR	Malaysia
INIR follow-up	Poland

Table A12. Knowledge Management Assist Visit (KMAV) missions in 2016

Type	Organization/nuclear power plant	Country
KMAV	Nuclear Power Production and Development Company (NPPD)	Islamic Republic of Iran
KMAV	Leningrad nuclear power plant	Russian Federation
KMAV	Shanghai Nuclear Engineering Research and Design Institute (SNERDI)	China

Table A13. Education and Training Appraisal (EduTA) missions in 2016

Type	Country
EduTA	Cuba
EduTA	Georgia
EduTA	Peru
EduTA preparatory	United Arab Emirates

Table A14. Emergency Preparedness Review (EPREV) missions in 2016

Type	Country
EPREV	Hungary
EPREV	Indonesia
EPREV preparatory mission	Indonesia

Table A15. Integrated missions of the Agency's Programme of Action for Cancer Therapy (imPACT) in 2016

Type	Country
imPACT	Belize
imPACT	Honduras
imPACT	Kazakhstan
imPACT	Paraguay
imPACT	Sierra Leone

Table A16. International Physical Protection Advisory Service (IPPAS) missions in 2016

Type	Country
IPPAS	Albania
IPPAS	Malaysia
IPPAS	Poland
IPPAS	Sweden
IPPAS	United Arab Emirates
IPPAS	United Kingdom

Table A17. Integrated Safety Assessment of Research Reactors (INSARR) missions in 2016

Type	Country
INSARR	Jordan
INSARR	Netherlands
INSARR	Portugal
INSARR follow-up	Malaysia

Table A18. Safety expert missions for research reactors based on the INSARR methodology in 2016

Type	Country
Safety mission	Indonesia, Jamaica, Malaysia, Peru and Poland

Table A19. Integrated Regulatory Review Service (IRRS) missions in 2016

Type	Country
IRRS	Belarus
IRRS	Estonia
IRRS	Italy
IRRS	Japan
IRRS	Kenya
IRRS	Lithuania
IRRS	South Africa
IRRS follow-up	Bulgaria
IRRS follow-up	China
IRRS follow-up	Sweden

Table A20. Operational Safety Review Team (OSART) missions in 2016

Type	Country
OSART	Canada
OSART	France
OSART	Romania
OSART follow-up	France
OSART follow-up	France
OSART follow-up	Hungary
OSART follow-up	Netherlands
OSART follow-up	Russian Federation

Table A21. Safety Aspects of Long Term Operation (SALTO) missions in 2016

Type	Country
SALTO	Argentina
SALTO	Armenia
SALTO	Bulgaria
SALTO	Sweden
SALTO follow-up	Belgium
SALTO follow-up	Czech Republic
SALTO follow-up	Sweden

Table A22. Site and External Events Design (SEED) missions in 2016

Type	Country
SEED	Japan
SEED	Jordan
SEED	Pakistan
SEED	Poland
SEED	Tunisia
SEED preparatory	Belarus
SEED preparatory	France
SEED preparatory	Iran, Islamic Republic of

Table A23. Technical Safety Reviews (TSRs) in 2016

Type	Location/Design	Country
Generic reactor safety	CAP1400	China
Generic reactor safety	ACP100	China
Probabilistic safety assessment	Dukovany	Czech Republic

Table A24. Advisory missions in 2016

Type	Country
Regulatory infrastructure for the control of radioactive sources	Antigua and Barbuda, Cambodia, Ecuador, El Salvador, Liberia, Madagascar, Morocco, Qatar and Sri Lanka
Operational Safety Performance Experience Review (PROSPER)	Russian Federation
Expert mission to provide recommendations for safe conversion of a research reactor to use low enriched uranium fuel	Ghana

Table A25. Occupational Radiation Protection Appraisal Service (ORPAS) missions in 2016

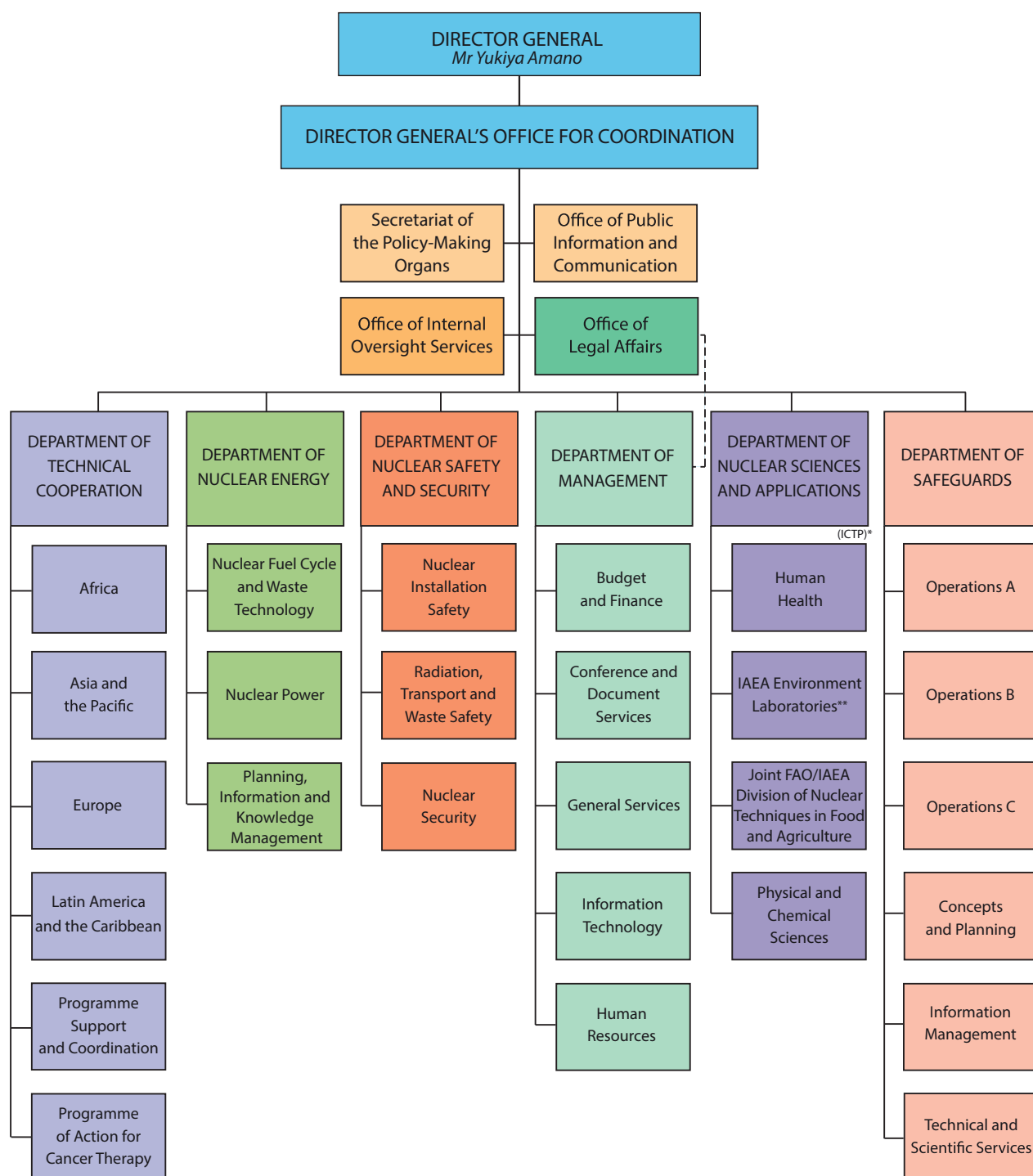
Type	Country
ORPAS	Costa Rica
ORPAS	Ghana
ORPAS follow-up	Uruguay
Pre-ORPAS	Malaysia
Pre-ORPAS	Morocco
Pre-ORPAS	Paraguay

Table A26. IAEA-designated International Centres based on Research Reactor

Country	Number
France	2
Russian Federation	1

ORGANIZATIONAL CHART

(as of 31 December 2016)



* The Abdus Salam International Centre for Theoretical Physics (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.”*

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