IAEA ANNUAL REPORT 2018

IAEA
International Atomic Energy Agency
Atoms for Peace and Development

IAEA Annual Report 2018

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 2018.

GC(63)/5

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The Agency's Statute was approved on 23 October 1956 by the Conference on the Statute of the IAEA held at United Nations Headquarters, New York; it entered into force on 29 July 1957. The Headquarters of the Agency are located in Vienna. The IAEA's principal objective is "to accelerate and enlarge the contribution of atomic energy to peace, health and prosperity throughout the world".

[a] The name 'Eswatini' replaces the former name 'Swaziland' as of 29 June 2018.

[b] The name 'North Macedonia' replaces the former name 'The former Yugoslav Republic of Macedonia' as of 15 February 2019.

The Agency at a Glance

(as of 31 December 2018)

170 Member States.

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

62 years of international service.

2552 professional and support staff.

€365.9 million total Regular Budget for 2018[1]. Extrabudgetary expenditures in 2018 totalled **€84.9 million**.

€85.7 million target in 2018 for voluntary contributions to the Agency's Technical Cooperation Fund, supporting projects involving **3640** expert and lecturer assignments, **6739** meeting participants and other project personnel, **3282** participants in **196** regional and interregional training courses and **1816** fellows and scientific visitors.

146 countries and territories receiving support through the Agency's technical cooperation programme, including **35** least developed countries.

1016 active technical cooperation projects at the end of 2018.

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.

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

121 active CRPs involving **1626** approved research, technical and doctoral contracts and research agreements. In addition, **71** Research Coordination Meetings were held.

33 active IAEA Collaborating Centres. In 2018, **4** institutions were newly designated as IAEA Collaborating Centres and **2** centres were redesignated as IAEA Collaborating Centres for a period of 4 years.

16 national donors to the voluntary Nuclear Security Fund.

182 States in which safeguards agreements were being implemented[2,3] of which **134** States had additional protocols in force, with **2195** safeguards inspections performed in 2018. Safeguards expenditures in 2018 amounted to **€138.64** million in the operational portion of the Regular Budget and **€18.9** million in extrabudgetary resources.

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

600 000 visitors a month to iaea.org, representing a 20% increase since 2017. The Agency's social media audience reached **430 000** followers at the end of 2018, an 8% increase during the year. The Agency launched a multilingual version of its web site in 2018 and now has an on-line presence in Arabic, Chinese, French, Russian and Spanish, in addition to English.

4.2 million records in the Agency's International Nuclear Information System (INIS) database, with over **568 000** full texts not readily available through commercial channels and **3.2 million** page views in 2018.

1.2 million documents, technical reports, standards, conference proceedings, journals and books in the IAEA Library and over **8 000** visitors to the Library in 2018.

141 publications, including newsletters, issued in 2018 (in print and electronic formats).

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1 At the United Nations average rate of exchange of US $1.181 to €1.00. The total Regular Budget was €373.3 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.

In the area of nuclear technologies, in the course of 2018 the Board considered the *Nuclear Technology Review 2018*.

In the area of safety and security, the Board discussed the *Nuclear Safety Review 2018* and the *Nuclear Security Report 2018*.

As regards verification, the Board considered the *Safeguards Implementation Report for 2017*. It approved two safeguards agreements and three additional protocols. 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 Treaty on the Non Proliferation of Nuclear Weapons (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 2017* and approved financing for the Agency's technical cooperation programme for 2019.

The Board approved the recommendations contained in the *Proposal by the Chair of the Board of Governors on The Agency's Budget Update for 2019*.

Composition of the Board of Governors (2018–2019)

Chair:

HE Ms. Leena AL HADID
Ambassador
Governor from Jordan

Vice-Chairs:

HE Mr. Armen PAPIKYAN
Ambassador
Governor from Armenia

HE Mr. Ghislain D'HOOP
Ambassador
Governor from Belgium

Argentina
Armenia
Australia
Azerbaijan
Belgium
Brazil
Canada
Chile
China
Ecuador
Egypt
France
Germany
India
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Jordan
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Morocco
Netherlands
Niger
Pakistan
Portugal
Russian Federation
Serbia
South Africa
Sudan
Sweden
Thailand
United Kingdom of Great Britain and Northern Ireland
United States of America
Uruguay
Venezuela, Bolivarian Republic of

The General Conference

The General Conference comprises all Member States of the Agency and meets once a year. At the end of 2018, the Agency's membership was 170.

The Conference adopted resolutions on the Agency's financial statements for 2017 and budget for 2019; on nuclear and radiation safety; on nuclear security; on strengthening the Agency's technical cooperation activities; on strengthening the Agency's activities related to nuclear science, technology and applications, comprising non-power nuclear applications, nuclear power applications and nuclear knowledge management; on strengthening the effectiveness and improving the efficiency of Agency safeguards; on the implementation of the NPT Safeguards Agreement between the Agency and the Democratic People's Republic of Korea; and on the application of Agency safeguards in the Middle East. The Conference also adopted decisions on the progress made towards the entry into force of the amendment to Article XIV.A of the Statute of the Agency, approved in 1999; and on the report on the promotion of the efficiency and effectiveness of the Agency's decision making process.

Notes

- The *IAEA Annual Report 2018* aims to summarize only the significant activities of the Agency during the year in question. The main part of the report, starting on page 29, generally follows the programme structure as given in *The Agency's Programme and Budget 2018–2019* (GC(61)/4). The objectives included in the main part of the report are taken from that document and are to be interpreted consistently with the Agency's Statute and decisions of the Policy-Making Organs.
- 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 10 June 2019, the Board of Governors approved the Annual Report for 2018 for transmission to the General Conference.

Abbreviations

AFRA	African Regional Co-operative Agreement for Research, Development and Training Related to Nuclear Science and Technology
AMRAS	Advisory Missions on Regulatory Infrastructure for Radiation Safety
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
ARTEMIS	Integrated Review Service for Radioactive Waste and Spent Fuel Management Decommissioning and Remediation
CLP4NET	Cyber Learning Platform for Network Education and Training
CNIP	Country Nuclear Infrastructure Profile
CNPP	Country Nuclear Power Profile
CNS	Convention on Nuclear Safety
CPF	Country Programme Framework
CPPNM	Convention on the Physical Protection of Nuclear Material
CRP	coordinated research project
CSA	comprehensive safeguards agreement
DSRS	disused sealed radioactive source
EduTA	Education and Training Appraisal
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
GNSSN	Global Nuclear Safety and Security Network
HEU	high enriched uranium
IACRNE	Inter-Agency Committee on Radiological and Nuclear Emergencies
ICTP	Abdus Salam International Centre for Theoretical Physics
INIR	Integrated Nuclear Infrastructure Review
INIR-RR	Integrated Nuclear Infrastructure Review for Research Reactors
INIS	International Nuclear Information System
INLEX	International Expert Group on Nuclear Liability
INPRO	International Project on Innovative Nuclear Reactors and Fuel Cycles
INSARR	Integrated Safety Assessment of Research Reactors
INSSP	Integrated Nuclear Security Support Plan
IPPAS	International Physical Protection Advisory Service
IRMIS	International Radiation Monitoring Information System

IRRS	Integrated Regulatory Review Service
ISCA	Independent Safety Culture Assessment
ITDB	Incident and Trafficking Database (IAEA)
IWP	Integrated Work Plan
JCPOA	Joint Comprehensive Plan of Action
LEU	low enriched uranium
MESSAGE	Model for Energy Supply Strategy Alternatives and their General Environmental Impacts
NES	nuclear energy system
NPCs	National Participation Costs
NPT	Treaty on the Non-Proliferation of Nuclear Weapons
OA-ICC	Ocean Acidification International Coordination Centre
OECD	Organisation for Economic Co-operation and Development
OECD/NEA	OECD Nuclear Energy Agency
OMARR	Operation and Maintenance Assessment for Research Reactors
ORPAS	Occupational Radiation Protection Appraisal Service
OSART	Operational Safety Review Team
PACT	Programme of Action for Cancer Therapy (IAEA)
RAIS	Regulatory Authority Information System
RANET	Response and Assistance Network (IAEA)
RASIMS	Radiation Safety Information Management System
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
SIT	sterile insect technique
SMR	small and medium sized or modular reactor
SQP	small quantities protocol
TCF	Technical Cooperation Fund
TSR	Technical Safety Review
UNDAF	United Nations Development Assistance Framework
UNEP	United Nations Environment Programme
USIE	Unified System for Information Exchange in Incidents and Emergencies
VETLAB Network	Veterinary Diagnostic Laboratory Network
WAMP	Water Management Program
WHO	World Health Organization

Overview

For over six decades, the Agency has pursued 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." Under the motto 'Atoms for Peace and Development', it continues to make tangible contributions in meeting emerging global challenges in order to improve health, prosperity, peace and security around the world. Within the framework of its Statute, the Agency has maintained the flexibility to address the evolving needs of Member States and to help them achieve their national development goals.

This chapter provides an overview of some of the programmatic activities that 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

At the end of 2018, the world's 450 operational nuclear power reactors had a record global generating capacity of 396.4 gigawatts (electrical) (GW(e)). During the year, 9 reactors were connected to the grid and 7 were permanently shut down. Construction started on 5 reactors, with a total of 55 reactors under construction around the world.

The Agency's 2018 projections for global installed nuclear power capacity show an increase of 30% by 2030 (from 392 GW(e) at the end of 2017) in the high case scenario, but the low case scenario projects a 10% dip in capacity by 2030. In the longer term, capacity in the low case scenario is projected to decline for around a decade before rebounding to 2030 levels by 2050. In the high case, installed capacity is projected to reach 748 GW(e) by 2050.

Major conferences

In May, the Agency organized the Third International Conference on Human Resource Development for Nuclear Power Programmes: Meeting Challenges to Ensure the Future Nuclear Workforce Capability. The conference was held in Gyeongju, Republic of Korea, with over 500 participants from 62 Member States and 6 international organizations. Participants discussed the current situation of human resource development and the future of the nuclear labour market. The conference also highlighted practical solutions for use at the organizational, national and international levels to develop and maintain the human resources needed to support safe and sustainable nuclear power programmes.

The Agency's International Symposium on Uranium Raw Material for the Nuclear Fuel Cycle: Exploration, Mining, Production, Supply and Demand, Economics and Environmental Issues (URAM-2018), held in Vienna in June, was attended by 234 participants from 50 countries and 4 international organizations. Participants analysed uranium supply and demand scenarios and discussed new developments in uranium geology, exploration, mining, milling and processing, as well as the environmental requirements for uranium operations and site decommissioning.

The 27th IAEA Fusion Energy Conference (FEC 2018) took place in Gandhinagar, India, in October. Over 700 experts from 39 Member States and 4 international organizations shared research results, discussed progress made in national and international fusion programmes, and identified global advances in fusion theory, experiments, technology, engineering, safety and socioeconomics.

Climate change and sustainable development

At the 24th session of the Conference of the Parties to the United Nations Framework Convention on Climate Change (COP24), held in Katowice, Poland, in December, the Agency organized a joint side event with several organizations of the United Nations system on Sustainable Development Goal (SDG) 7, on affordable and clean energy. It also organized a side event focused on capacity building to support decision makers in planning the transition to a low carbon energy future, and participated in two other events to highlight both the role of nuclear science and technology in climate change mitigation and sustainable development and the Agency's energy planning support for Member States.

At the Ninth International Forum on Energy for Sustainable Development, held in Kyiv, in November, the Agency, in cooperation with the United Nations Economic Commission for Europe and the World Nuclear Association, organized three sessions on 'Nuclear Energy for Sustainable Development: Role in the Decarbonized Energy Mix'.

Energy assessment services

During 2018, the Agency provided technical support to Member States conducting energy planning studies and assessing the potential role of nuclear power in their future energy mix. This included energy planning tools — now in use by about 150 Member States and 21 international organizations — and related multilingual training materials and e-learning packages, as well as expert missions and energy assessment training and fellowships.

Two INPRO (International Project on Innovative Nuclear Reactors and Fuel Cycles) Dialogue Forums were held in 2018 to promote discussion of topics important for the long term sustainability of nuclear energy. The 15th INPRO Dialogue Forum, held in Vienna in July, provided 45 participants from 28 Member States and 3 international organizations with an opportunity to share information, perspectives and knowledge on issues important to national, regional and global nuclear supply chains. At the 16th INPRO Dialogue Forum, held in Vienna in December, 46 participants from 32 Member States and 2 international organizations discussed opportunities and challenges for non-electric applications of nuclear energy, including barriers to commercialization and potential solutions.

Support to operating nuclear power plants

In response to increased Member State interest, the Agency organized a Technical Meeting on the Justification of Commercial Industrial Instrumentation and Control Equipment for Nuclear Power Plant Applications, held in June in Toronto, Canada, and a Technical Meeting on Instrumentation and Control Aspects of Human Factors Engineering: Design

and Analysis, held in September in Madrid. The meetings enabled participants to share best practices and discuss instrumentation and control related challenges and issues, as well as strategies to overcome them. The Agency issued two publications on this topic in 2018: *Approaches for Overall Instrumentation and Control Architectures of Nuclear Power Plants* (IAEA Nuclear Energy Series No. NP-T-2.11) and *Dependability Assessment of Software for Safety Instrumentation and Control Systems at Nuclear Power Plants* (IAEA Nuclear Energy Series No. NP-T-3.27).

The Agency hosted the first meeting of the new Technical Working Group on Nuclear Power Plant Operations in September. At the meeting, 30 senior government officials and industry executives identified priority areas where Agency assistance could help relevant stakeholders improve the economic sustainability of nuclear power reactors in operation around the world.

Launching nuclear power programmes

The Agency continued to support Member States interested in, considering or embarking on a new nuclear power programme. In 2018, it conducted Integrated Nuclear Infrastructure Review (INIR) Phase 1 missions to the Niger, the Philippines and the Sudan, and an INIR Phase 2 mission to Saudi Arabia. The first INIR Phase 3 mission was conducted in June, to the United Arab Emirates. At the end of 2018, a total of 27 INIR missions had been conducted to 20 Member States. The Agency also conducted six expert missions to Ghana, Poland and Turkey, to support key organizations in the development of management systems for a nuclear power programme. It held workshops for Egypt, Kazakhstan and Kenya on using the Agency's Nuclear Power Human Resources modelling tool to assist them in understanding the human resource requirements and planning the workforce for new nuclear power programmes. The Agency continued to provide integrated support through Integrated Work Plans and to monitor progress using Country Nuclear Infrastructure Profiles. It also conducted around 40 interregional, regional and national capacity building activities dedicated to infrastructure development.

Capacity building, knowledge management and nuclear information

The Agency organized five Nuclear Energy Management Schools and two Nuclear Knowledge Management Schools in 2018. By the end of the year, over 1500 participants from around 80 Member States had benefited from these programmes. The Agency's Cyber Learning Platform for Network Education and Training (CLP4NET) hosted more than 640 on-line courses in 2018.

"The Agency's Cyber Learning Platform for Network Education and Training (CLP4NET) hosted more than 640 on-line courses in 2018."

The membership of the Agency's International Nuclear Information System (INIS) comprises 131 Member States and 24 international organizations. The IAEA Library continued to coordinate research support and document delivery among the 58 members of the International Nuclear Library Network.

Assurance of supply

The project to establish the IAEA Low Enriched Uranium Bank in Kazakhstan continued to make progress in 2018. The transit agreement with China entered into force on 15 February 2018. Two transport contracts were signed: one with the authorized organization from the Russian Federation and one with the authorized organization from Kazakhstan.

Concerning acquisition of low enriched uranium (LEU), the Agency signed supply contracts with two suppliers and aims to have the LEU delivered to the IAEA LEU Storage Facility before the end of 2019.

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

"In 2018, the Agency organized more than 30 meetings aimed at increasing fuel cycle sustainability.… attended by more than 900 participants from over 50 Member States"

In 2018, the Agency organized more than 30 meetings aimed at increasing fuel cycle sustainability, including 5 technical meetings, 2 technical working group meetings, 6 research coordination meetings and 18 consultancy meetings. The meetings were attended by more than 900 participants from over 50 Member States and focused on various aspects of uranium exploration and production; environmental remediation of uranium mining sites; fuel development, design, manufacture and performance assessment; and spent fuel management. In December, the Agency and the OECD Nuclear Energy Agency jointly published *Uranium 2018: Resources, Production and Demand*, also known as the 'Red Book'.

Technology development and innovation

The Agency launched two coordinated research projects (CRPs) on advanced water cooled reactors (WCRs). The CRP entitled 'Methodology for Assessing Pipe Failure Rates in Advanced Water Cooled Reactors' will draw on five decades of operating experience data from current WCRs to develop a new methodology for predicting pipe failure rates in advanced WCRs. In the CRP entitled 'Probabilistic Safety Assessment Benchmark for Multi-Unit/Multi-Reactor Sites', probabilistic safety assessment (PSA) practitioners from 20 Member States using WCR technologies will develop their current or planned PSA methods and identify technological solutions to reduce risks specific to multi-unit sites.

In October, the Agency held a technical meeting on nuclear–renewable hybrid energy systems, which can significantly reduce greenhouse gas emissions compared with conventional fossil fuel based systems. At the meeting, held at the Agency's Headquarters in Vienna, 24 experts from 15 Member States operating nuclear power plants or expanding or embarking on a nuclear power programme and from the European Commission discussed innovative concepts and research on the coordinated use of nuclear and renewable energy sources.

At the first meeting of the Technical Working Group on Small and Medium Sized or Modular Reactors, held in Vienna in April, 25 representatives of 14 Member States and 2 international organizations identified areas of common interest for future collaboration. These include the development of generic user requirements and criteria; collaboration on research, technology development and establishment of codes and standards; and the development of design engineering, testing, manufacturing, supply chain and construction technology to enable large scale deployment. In response to Member State requests, the Agency published a new edition of the supplement to its Advanced Reactors Information System database, entitled *Advances in Small Modular Reactor Technology Developments*, as well as *Deployment Indicators for Small Modular Reactors* (IAEA-TECDOC-1854).

The Agency issued two publications on the development and deployment of innovative liquid metal cooled fast neutron systems: *Experimental Facilities in Support of Liquid Metal Cooled Fast Neutron Systems* (IAEA Nuclear Energy Series No. NP-T-1.15), which provides an overview of and detailed information on more than 150 experimental facilities in 14 Member States and the European Union, and the proceedings of the International Conference on Fast Reactors and Related Fuel Cycles: Next Generation Nuclear Systems for Sustainable Development (FR17), held in Yekaterinburg, Russian Federation, in 2017.

The Agency organized three technical meetings on non-electric applications of nuclear power. At the Technical Meeting on the Deployment of Non-Electric Applications Using Nuclear Energy for Climate Change Mitigation, 18 participants from 16 Member States discussed the future role of non-electric applications of nuclear energy in efforts to combat climate change, in particular the use of waste heat from nuclear power plants in the heating and transport sectors. The Technical Meeting to Assess the Prospects of Coupling Non-Electric Applications to High Temperature Nuclear Reactors brought together 12 participants from 11 Member States, who exchanged information on near term

commercial technologies available for hydrogen production and addressed associated socioeconomic and environmental considerations. At the Technical Meeting on Efficient Energy and Water Management in Nuclear Power Plants: Strategies, Policies and Innovative Approaches, 14 experts from 10 Member States and an international organization shared operating experience related to strategies and policies aimed at improving water and energy management in nuclear power plants, and discussed possible ways to reuse waste heat for water production.

Research reactors

The Agency provided support to Member States in the planning, construction, operation, maintenance and use of research reactors through training, expert missions, peer review missions, outreach activities and networks, as well as through guidance provided in its publications. It launched the Integrated Nuclear Infrastructure Review for Research Reactors peer review service, carrying out the first two missions: to Nigeria in February, and to Viet Nam in December. In 2018, the Agency continued to support Nigeria's project to convert its miniature neutron source reactor to LEU fuel and to return the used high enriched uranium fuel to China; the three year project was completed in December.

Radioactive waste management, decommissioning and environmental remediation

At the request of Member States, the Agency completed six Integrated Review Service for Radioactive Waste and Spent Fuel Management, Decommissioning and Remediation (ARTEMIS) missions — to Brazil, Bulgaria, France, Italy, Luxembourg and Spain.

In January, the Agency reported on the outcomes of a three year project undertaken in cooperation with the European Commission and the OECD Nuclear Energy Agency in *Status and Trends in Spent Fuel and Radioactive Waste Management* (IAEA Nuclear Energy Series No. NW-T-1.14). The publication provides an overview of the topic as well as information on current inventories, expected future waste arisings and strategies for their long term management.

The Agency took part in a variety of field activities throughout the year, including providing support for the multi-year project to decommission the FOTON research reactor in Tashkent, which was completed in 2018, and conducting the fourth international peer review of the Mid-and-Long-Term Roadmap towards the Decommissioning of TEPCO's Fukushima Daiichi Nuclear Power Station Units 1–4.

Nuclear fusion

In September, the Agency issued *Integrated Approach to Safety Classification of Mechanical Components for Fusion Applications* (IAEA-TECDOC-1851), the first international reference document to comprehensively address the subject. The publication highlights the differences between the approaches currently used in fission and fusion reactors to identify and classify structures, systems and components important to safety, and offers guidance for fusion specific applications.

The Agency also initiated two CRPs in the area of nuclear fusion. The first, entitled 'Development of Compact Steady-State Fusion Neutron Sources', is aimed at establishing the suitability of steady-state compact fusion neutron sources for dedicated applications in fusion, fission and other sectors, and targeted products and services. The second, entitled 'Network of Small and Medium Size Magnetic Confinement Fusion Devices for Fusion Research', seeks to enlarge the network of magnetic confinement fusion devices used to perform experiments to study relevant plasma physics and support technology development, modelling analysis and the development of simulation and software tools.

Nuclear data

In April, the Agency launched a crowdsourcing initiative by challenging atomic data specialists around the world to submit innovative ways to visualize, analyse and explore simulations of different materials suitable for building fusion reactors. In particular, participants were invited to analyse simulations of the damage that can be caused to the reactor wall by the high-energy neutrons released by the fusion reaction. Of the 142 submissions from 37 Member States, the simulation method submitted by the Max Planck Institute for Nuclear Physics, which used molecular dynamics, was selected as the winner.

Accelerator technology and its applications

In September, the Agency published *Accelerator Simulation and Theoretical Modelling of Radiation Effects in Structural Materials* (IAEA Nuclear Energy Series No. NF-T-2.2), summarizing the findings and conclusions of a CRP of the same name aimed at supporting Member States in the development of advanced radiation resistant structural materials for use in innovative nuclear systems. In October, it hosted the first research coordination meeting of the new CRP entitled 'Ion Beam Irradiation for High Level Nuclear Waste Form Development (INWARD)'. Fifteen participants from eight Member States compared the accelerated damage caused by ion beam irradiation with the damage caused by radioactive decay in high level nuclear waste forms.

Nuclear instrumentation

In June, the Agency organized an expert mission to Tashkent to perform radiation monitoring measurements using mobile gamma spectrometers mounted on backpacks for the release of the FOTON Radiation and Technological Complex site after decommissioning. In October, it provided support for a national training exercise on monitoring radiological events using unmanned aerial vehicles held at four different sites in Brazil.

At a Technical Meeting on Current Trends and Developments in Nuclear Instrumentation, held in Vienna in December, 11 experts from 11 Member States reviewed and discussed state of the art portable nuclear instrumentation for in situ environmental monitoring, including analytical methodologies.

NUCLEAR SCIENCES AND APPLICATIONS

Major conferences

The Agency hosted the FAO/IAEA International Symposium on Plant Mutation Breeding and Biotechnology in Vienna in August. The symposium highlighted the latest developments, trends and challenges in plant mutation breeding and biotechnology, and gave participants an opportunity to exchange information and share experiences. It was attended by 350 delegates from 84 Member States and 4 international organizations.

In November, the Agency held the first IAEA Ministerial Conference on Nuclear Science and Technology: Addressing Current and Emerging Development Challenges. The conference was co-chaired by Costa Rica and Japan and attended by 1100 participants, including policy makers, scientists, technical experts and 54 ministers. The meeting culminated in the adoption of a Ministerial Declaration recognizing the important role of science, technology and innovation in achieving sustainable development and protecting the environment, as well as commitments among Member States for further cooperation in nuclear science and technology toward achievement of the 2030 Agenda for Sustainable Development.

The International Symposium on the Double Burden of Malnutrition for Effective Interventions, held in Vienna in December, was organized by the Agency, the World Health Organization (WHO) and the United Nations Children's Fund (UNICEF) to help tackle the double burden of malnutrition — the coexistence a range of conditions, from food insecurity and undernutrition to obesity and related non-communicable diseases. Member State experts in agriculture, nutrition, public health and the environment shared their experiences to better understand what causes the phenomenon and how to successfully prevent or mitigate it.

Renovation of the Nuclear Applications Laboratories (ReNuAL)

The Renovation of the Nuclear Applications Laboratories (ReNuAL/ReNuAL+) project made significant progress in 2018. In November, the Flexible Modular Laboratory was inaugurated during the Ministerial Conference on Nuclear Science and Technology. According to the current construction schedule, the Flexible Modular Laboratory will be completed in 2020.

Three more Member States — Brazil, Morocco and Portugal — made contributions to the laboratories' modernization during the year; by the end of 2018, 35 Member States had made financial or in-kind contributions totalling more than €34 million.

A record number of visitors — more than 100 delegations with over 1000 participants — toured the Seibersdorf laboratories during the year.

Food and Agriculture

Area-wide integrated pest management in the Niayes region of Senegal

Using the sterile insect technique as part of an integrated insect pest management approach, the Agency, in collaboration with the Food and Agriculture Organization of the United Nations, achieved the complete suppression of tsetse flies in the Niayes region of Senegal. By the end of the year, the intervention had resulted in a drastic reduction in trypanosomosis disease transmission, a significant increase in milk yields and imports of more productive cattle with a higher return on investment.

Sterile insect technique for control of mosquitoes

Significant progress was made in developing the sterile insect technique package to control disease transmitting mosquitoes (e.g. *Aedes aegypti* and *Aedes albopictus*), the vectors for dengue, chikungunya, Zika and yellow fever. Developments in mass rearing, genetic sexing strains and sex separation allowed the Agency to begin transferring the technology through a pilot project in Mexico.

Small-scale drip irrigation technology to assist farmers in Africa

The Agency scaled up the climate-smart soil and water management initiative piloted in the Sudan in 2016. The initiative, which uses small-scale drip irrigation technology guided by nuclear and related techniques, was introduced in impoverished rural areas of Mauritania and Zimbabwe in 2018. In Mauritania, more than 400 women and their families grew food for their own consumption and for selling to other areas, securing additional income for education and health. In Zimbabwe, improved crop production allowed women to generate additional income for their families.

"The Agency scaled up the climate-smart soil and water management initiative piloted in the Sudan in 2016."

Diagnosis and control of disease outbreaks

Through the Veterinary Diagnostic Laboratory (VETLAB) Network, the Agency provided Member State laboratories with training; technology packages; and equipment, reagents, emergency toolkits and personal protective equipment to strengthen their capabilities for effectively responding to outbreaks of animal diseases. During the year, it delivered validated serological and molecular techniques for disease detection and differentiation directly to Member States to fight outbreaks of zoonotic and transboundary animal diseases, including African swine fever in China, Hungary and Poland; peste des petits ruminants in Bulgaria; and avian influenza in the Democratic Republic of the Congo, Ghana, Lesotho, Mozambique, Myanmar and Namibia.

Integrated screening techniques for climate-smart agriculture

The Agency continued to develop integrated screening techniques based on molecular markers to speed up the development of improved plant varieties. Molecular marker technologies can accelerate crop improvement through faster screening for desirable plant traits, including tolerance to drought and/or high temperatures. During 2018, traditional mutation breeding technologies continued to produce new climate-smart varieties in Member States. Tafra-1, a new groundnut variety with 11% increased yield and terminal drought tolerance, was developed with Agency support and released in the Sudan. In Zambia, two varieties of cowpea — Lunkhwakwa and Lukusuzi — were released, both with improved yield and tolerance to drought, among other traits.

"In Zambia, two varieties of cowpea — Lunkhwakwa and Lukusuzi — were released, both with improved yield and tolerance to drought, among other traits."

New analytical technologies for supporting food authenticity and food traceability systems

In 2018, the Agency successfully concluded the CRP entitled 'Accessible Technologies for the Verification of Origin of Dairy Products as an Example Control System to Enhance Global Trade and Food Safety'. This five year project, with 17 participants from 15 Member States, successfully demonstrated the feasibility of using stable isotope and trace element analysis, combined with other nuclear and related techniques, to establish the geographical origin and authenticity of liquid milk and powdered milk.

Human Health

Estimating medical physics staffing levels for radiology and nuclear medicine departments

Unlike in radiation oncology, the role of the medical physicist in medical imaging is still underestimated, even though the vast majority of the population's exposure to ionizing radiation is due to medical imaging, and radiation injuries have been reported in computed tomography and interventional radiology. To help medical imaging departments determine the number of medical physicists needed to support established services, the Agency published *Medical Physics Staffing Needs in Diagnostic Imaging and Radionuclide Therapy: An Activity Based Approach* (IAEA Human Health Reports No. 15). The publication, endorsed by the International Organization for Medical Physics, describes an algorithm developed to estimate staffing levels. Information on the publication was disseminated at the Annual Meeting of the American Association of Physicists in Medicine in July and at the European Congress of Medical Physics in August. Since its publication in February, the report has remained one of the ten most downloaded publications on the Agency's web site.

Information technology to enhance management of cervical cancer

Every year, over one million gynaecological cancer cases and half a million related deaths are registered worldwide. The highly specialized oncology workforce needed for safe, effective management of these cancers is not readily available in all Member States. The Agency's African Radiation Oncology Network (AFRONET) provides access to training, up-to-date published literature, expert opinion and peer review of clinical cases in Africa to support better diagnosis and treatment of gynaecological malignancies through case presentations and discussions. In July, the Agency launched a new AFRONET e-learning module entitled 'Radionuclide Imaging in the Management of Gynaecological Cancers'. The new module presents 12 clinical cases involving the use of fluorine-18 fluorodeoxyglucose positron emission tomography–computed tomography (^{18}F-FDG PET–CT) to treat diverse gynaecological tumours in different clinical stages (e.g. evaluation of recurring disease, restaging after adjuvant therapy, monitoring the efficacy of treatments, radiotherapy planning). It also covers the emerging application of radioguided sentinel lymph node biopsy in patients with vulvar and cervical cancer.

Capacity building in hybrid imaging technologies

The Agency continued to support Member States in the use of nuclear techniques to address non-communicable diseases such as cancer and cardiovascular diseases, as well as infectious diseases such as tuberculosis and malaria. In 2018, it successfully concluded four CRPs on the appropriate use of medical imaging in the management of breast cancer, paediatric lymphoma and lung cancer, and on the role of different imaging modalities in the evaluation of patients with spinal infection after surgical interventions and the identification of patients with multidrug resistant tuberculosis. The results of the projects were used to establish standardized evaluation criteria for these clinical conditions and for clinical application of hybrid imaging for both non-communicable and communicable diseases. Participants in the workshops and training courses on hybrid imaging were awarded with continuing medical education credits from the European Union of Medical Specialists.

In February, the Agency launched a new three year project on the use of PET–CT in the evaluation of locally advanced breast cancer, a leading cause of cancer related morbidity and mortality in many Member States.

In 2018, the Agency released two e-learning modules, each with around 450 visitors, and broadcast two live webinars with around 100 participants each.

Water Resources Management

Mainstreaming of IWAVE methodology

The Agency began mainstreaming the IAEA Water Availability Enhancement (IWAVE) methodology in 2018. Its use is now standard in evaluations of technical cooperation projects on enhancing hydrological understanding to increase water availability and sustainability. The IWAVE methodology, developed and tested in Costa Rica, Oman and the Philippines through the Peaceful Uses Initiative, helps ensure the feasibility of isotope hydrology projects and their effective contribution to SDG 6, on clean water and sanitation. In 2018, IWAVE workshops were conducted through regional cooperation projects in Bolivia, Colombia, Kenya, Mexico, the Niger and Paraguay, focusing on the central question of whether national hydrological understanding was adequate to realize SDG 6.

Environment

High precision atmospheric greenhouse gas monitoring

"[The Agency] prepared three new isotopic standards for carbon, … enabling laboratories worldwide to report consistent isotopic data on greenhouse gases"

Knowledge of the small changes in the isotopic composition of greenhouse gases such as carbon dioxide is indispensable for calculating sources and sinks. The Agency provides certified reference materials to the global atmospheric science community and supports intergovernmental and national organizations to ensure the quality and comparability of high precision greenhouse gas measurements. In 2018, it prepared three new isotopic standards for carbon, to supplement a standard released in 2016, enabling laboratories worldwide to report consistent isotopic data on greenhouse gases, a necessary input for global climate models.

Understanding contaminants in the environment and in seafood

The Agency conducts research and builds scientific and technical capacity in Member States to help improve understanding of the behaviour of contaminants such as heavy metals, persistent organic pollutants and radionuclides in the environment and in seafood. In 2018, it validated a method for analysing brominated flame retardants — emerging contaminants that have adverse effects on the environment and humans — and developed a new double-tracer radioisotope technique to assess the bioaccumulation of caesium in commercially relevant fish. The Agency also helped build environmental monitoring capacity in Member States, to address impacts of climate change such as ocean acidification, ocean warming and deoxygenation, eutrophication and nutrient release, harmful algal bloom, and sea level rise.

Analysis of mercury in the marine environment

In 2018, the Agency began working closely with the United Nations Environment Programme (UNEP) and the Global Environment Facility to support implementation of the Minamata Convention on Mercury, a treaty to protect human health and the environment from anthropogenic releases of mercury and mercury compounds. The Agency participated in the second Conference of the Parties to the Minamata Convention on Mercury and associated side events, held in Geneva in November, where it presented its work on capacity building through the establishment of laboratories for analysis of mercury and its compounds, and training of laboratory personnel. The Agency also presented three new analytical methods validated in 2018 that enable Member States to better monitor mercury in, and help eliminate its release to, the marine environment.

Radioisotope Production and Radiation Technology

Major outcomes of a technical workshop on supply of the medical isotope actinium-225

Recognizing the growing focus on targeted alpha therapy using actinium-225 (Ac-225), the Agency organized a two day technical workshop on the supply of Ac-225 in October, with more than 70 participants from national laboratories, research institutes and private companies in 17 Member States. Participants highlighted the growing worldwide demand for Ac-225 for targeted alpha therapy and discussed the advantages and disadvantages of three main production routes to meet this projected demand: 'milking' of stockpiled uranium-233, spallation of thorium-232 with high energy proton accelerators, and production of Ac-225 from radium-226 with either proton cyclotrons or electron linear accelerators. They also

presented Ac-225 supply projections, shared recent research results and exchanged ideas on addressing the challenges of establishing a reliable supply of Ac-225.

Technical Meeting on Strategies for Preservation and Consolidation of Cultural Heritage Artefacts through Radiation Processing

The Agency, in cooperation with the Ruđer Bošković Institute, held a Technical Meeting on Strategies for Preservation and Consolidation of Cultural Heritage Artefacts through Radiation Processing in Zagreb in June. More than 30 experts from 20 countries discussed recent advances in radiation technology for cultural heritage preservation and shared their experiences in using these technologies in cooperation with stakeholders such as conservators and restorers for the preservation of cultural heritage.

Training and certification of professionals in the use of radiotracers and sealed sources for industrial applications

The demand from Member States for training and certification of professionals in the use of radiotracers and sealed sources continued to increase. To meet the growing need for capacity building in this area, the Agency organized four training and certification courses in 2018. Two regional training courses were held in Seibersdorf, in March, under the African Regional Co-operative Agreement for Research, Development and Training Related to Nuclear Science and Technology (AFRA), and in November, as part of a project under the Co-operation Agreement for the Promotion of Nuclear Science and Technology in Latin America and the Caribbean (ARCAL) for the Latin America and the Caribbean region. Two regional training courses were held at the National Institute for Nuclear Science and Technology, in Saclay, France, under AFRA, in June, and for the European region, in October. In total, 40 radiotracer specialists from 25 Member States were trained and certified according to International Society for Tracer and Radiation Applications standards in 2018.

NUCLEAR SAFETY AND SECURITY

Nuclear Safety

Priorities for nuclear safety

The Agency's identified priorities for nuclear, radiation, transport and waste safety, and emergency preparedness and response include strengthening regulatory frameworks, ageing management and long term operation of nuclear installations; leadership and management for safety; safety culture; training in emergency response arrangements; radiation protection; the safe management of disused sources; and activities related to decommissioning of nuclear installations, radioactive discharges to the environment and environmental remediation.

Safety standards

In November, the Commission on Safety Standards endorsed for submission to the Board of Governors the draft Safety Requirements publication *Site Evaluation for Nuclear Installations* (IAEA Safety Standards Series No. SSR-1). Its forthcoming publication will complete the Agency's set of Safety Requirements publications.

The Agency made the safety standards and nuclear security guidance publications issued in 2018 available on the Nuclear Safety and Security Online User Interface platform.

The platform was also used to develop a strategic plan for the revision of Safety Guides on the safety of nuclear fuel cycle facilities.

Peer review and advisory services

Member State requests for peer review and advisory services continued to increase in 2018. During the year, the Agency conducted 58 safety related peer review and advisory service missions to 50 Member States, including the 100th Integrated Regulatory Review Service (IRRS) mission and the 200th Operational Safety Review Team (OSART) mission. The Agency carried out nine IRRS missions, including two follow-up missions; two Emergency Preparedness Review (EPREV) missions; two Site and External Events Design (SEED) review missions; eight OSART missions, including a pre-OSART mission and two follow-up missions; two Independent Safety Culture Assessment (ISCA) missions; five Occupational Radiation Protection Appraisal Service (ORPAS) missions, including one follow-up mission; 13 Advisory Missions on Regulatory Infrastructure for Radiation Safety (AMRAS), including three follow-up missions; six Safety Aspects of Long Term Operation (SALTO) missions, including four pre-SALTO missions; three Integrated Safety Assessment of Research Reactors (INSARR) missions, including one follow-up mission; one Education and Training Appraisal (EduTA) mission; one Peer Review of Operational Safety Performance Experience (PROSPER) mission; and six Integrated Review Service for Radioactive Waste and Spent Fuel Management, Decommissioning and Remediation (ARTEMIS) missions, including the first combined IRRS–ARTEMIS mission. The Agency also carried out three Technical Safety Review (TSR) services: a Periodic Safety Review (TSR-PSR), a Design Safety Review (TSR-DS) and a Safety Requirements Review (TSR-SR).

Strengthening technical and scientific expertise

The Agency organized the fourth International Conference on Challenges Faced by Technical and Scientific Support Organizations in Enhancing Nuclear Safety and Security: Ensuring Effective and Sustainable Expertise, held in Brussels in October. More than 250 participants from 61 Member States and 5 international organizations discussed initiatives to develop and strengthen scientific and technical capabilities to support regulatory decision making for enhanced nuclear and radiation safety and security.

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

A technical meeting to share experience on implementing safety improvements at existing nuclear power plants was held in Vienna in June, attended by 35 participants from 21 Member States and 3 international organizations. The information shared on national practices will contribute to the development of an IAEA Technical Document.

The Agency finalized a study on the applicability of the safety requirements on nuclear power plant design established in *Safety of Nuclear Power Plants: Design* (IAEA Safety Standards Series No. SSR-2/1 (Rev. 1)) to small and medium sized or modular reactors intended for near term deployment. The Small Modular Reactor Regulators' Forum established three working groups: on licensing; on design and safety analysis; and on manufacturing, commissioning and operations.

Incident and emergency preparedness and response

The Agency held an International Symposium on Communicating Nuclear and Radiological Emergencies to the Public in Vienna in October, attracting almost 400 participants from 74 countries and 13 international organizations. The participants

emphasized the importance of implementing the Agency's safety standards and making use of its training materials, exercises and tools.

Radioactive waste management, environmental assessments and decommissioning of nuclear facilities

During the year, the Agency published *Guidance on the Management of Disused Radioactive Sources*, supplementary to the *Code of Conduct on the Safety and Security of Radioactive Sources*. The guidance addresses safety and security in an integrated manner, taking into account the Agency's safety standards and nuclear security guidance. The Agency also published the *Strategic Master Plan: Environmental Remediation of Uranium Legacy Sites in Central Asia*.

Two Safety Guides were issued to support Member States in their efforts to protect the environment from harmful effects of ionizing radiation: *Regulatory Control of Radioactive Discharges to the Environment* (IAEA Safety Standards Series No. GSG-9) and *Prospective Radiological Environmental Impact Assessment for Facilities and Activities* (IAEA Safety Standards Series No. GSG-10). Both publications were jointly sponsored by the Agency and UNEP.

Radiation protection

Three Safety Guides published in 2018 provide recommendations and guidance on meeting the requirements for the safe use of radiation established in the International Basic Safety Standards (IAEA Safety Standards Series No. GSR Part 3): *Radiation Protection and Safety in Medical Uses of Ionizing Radiation* (IAEA Safety Standards Series No. SSG-46), jointly sponsored by the International Labour Office, Pan American Health Organization and WHO; *Occupational Radiation Protection* (IAEA Safety Standards Series No. GSG-7), jointly sponsored by the International Labour Office; and *Radiation Protection of the Public and the Environment* (IAEA Safety Standards Series No. GSG-8), jointly sponsored by UNEP.

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

In 2018, the Agency conducted 428 capacity building activities in nuclear, radiation, transport and waste safety, and emergency preparedness and response. This included the Agency's 100th six month Postgraduate Educational Course in Radiation Protection and the Safety of Radiation Sources, which took place in Malaysia, with 35 participants from 18 Member States. More than 1800 students have now completed the course.

Two new Capacity Building Centres for Emergency Preparedness and Response were designated: one in China, operated by the China Institute for Radiation Protection and the General Hospital of Nuclear Industry, and one in the Russian Federation, operated by the Rosatom Technical Academy and the Rosatom Emergency Centre, St. Petersburg. The centres will provide national and international training courses, workshops and exercises on medical management of radiation exposures and dose assessment.

Strengthening global and regional networks and forums

The Agency coordinated over 100 national, regional and international activities under the auspices of the Global Nuclear Safety and Security Network (GNSSN) in 2018. This included support for the third meeting of the Steering Committee for the European and Central Asian Safety (EuCAS) Network, held in Prague in August, at which a new Working Group on Education and Training was established.

The Agency hosted the 27th Asian Nuclear Safety Network (ANSN) Steering Committee meeting in Vienna in May. The third ANSN plenary meeting, held in Vienna in September,

"The Agency coordinated over 100 national, regional and international activities under the auspices of the Global Nuclear Safety and Security Network (GNSSN) in 2018."

endorsed the new Terms of Reference for ANSN organizations, as well as a new ANSN vision and the establishment of new topical groups.

The Ibero-American Forum of Radiological and Nuclear Regulatory Agencies (FORO) approved three new projects at its annual plenary meeting, held in Brasilia in July: periodic verification and maintenance of reusable packaging for the transport of radioactive material not subject to design approval; licensing criteria and inspection requirements for centralized radiopharmacies; and regulatory practices in the licensing of nuclear reactor operators.

The CANDU Senior Regulators Group shared regulatory experience and information on safety enhancement programmes, events and associated corrective actions within the CANDU community during its annual meeting, held in Vienna in December.

Safety conventions

The Agency hosted and provided secretariat support to the Sixth Review Meeting of Contracting Parties to the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management, held in Vienna and attended by more than 850 delegates from 69 Contracting Parties and 4 observers. The Contracting Parties approved several recommendations, and also decided to hold an Extraordinary Meeting prior to the Organizational Meeting of the Seventh Review Meeting.

The Organizational Meeting for the Eighth Review Meeting of the Contracting Parties to the Convention on Nuclear Safety, held in October in Vienna, inter alia, established country groups and elected the Eighth Review Meeting president, vice presidents and country group officers.

The Agency's Radiation Safety and Nuclear Security Regulator

The Agency's Radiation Safety and Nuclear Security Regulator authorized the decommissioning of the Safeguards Analytical Laboratory; inspected and renewed the operation authorization of the Nuclear Material Laboratory; approved the Master Security Plan for the site of the Agency's laboratories in Seibersdorf; and authorized activities relating to the ReNuAL project, including the installation and acceptance testing of a linear accelerator for the Dosimetry Laboratory. Two Technical Agreements on the safety and on the security of the Agency's laboratories in Seibersdorf were concluded with the relevant Ministries of the Republic of Austria. They entered into force in February 2018 and December 2017, respectively.

Civil liability for nuclear damage

The International Expert Group on Nuclear Liability (INLEX) is an expert group that provides advice on issues related to nuclear liability as requested by the Director General or the Director of the Office of Legal Affairs. The 18th regular meeting of INLEX took place in Vienna in May. The Group, inter alia, discussed liability issues related to disposal facilities for radioactive waste. It was reaffirmed that the nuclear liability conventions would continue to apply during the period when institutional controls remained active, but that they could not be applied following the cessation of institutional controls over the site and in the absence of an operator, and therefore the State that had agreed to the closure of the installation would be expected to assume responsibility in case of any nuclear incident. The Group also discussed liability issues concerning the exclusion of radioisotopes that have reached the final stage of fabrication from the definition of 'radioactive products or waste' in the nuclear liability conventions and therefore from the scope of such conventions. In this respect, INLEX concluded that materials which have not reached the final stage of fabrication so as to be usable for any industrial, commercial, agricultural, medical, scientific or educational purpose, and the facilities where such materials are transformed into their

final form, are covered by the nuclear liability conventions. Based on this conclusion, INLEX specifically noted that molybdenum-99 contained in generators sent to hospitals and medical clinics falls outside the scope of the nuclear liability conventions.

INLEX continued to discuss the issue of the application of the nuclear liability conventions to transportable nuclear power plants and reiterated its conclusions that such a plant in a fixed position (i.e. in the case of a floating reactor, anchored to the seabed or the shore and attached to the shore by power lines) would fall under the definition of a 'nuclear installation' and therefore be covered by the nuclear liability regime. INLEX also noted that the transport of a factory-fuelled reactor would also be covered by the nuclear lability conventions, just as any other transport of nuclear material. Specific issues relating to transportable nuclear power plants will be addressed by INLEX at its next meeting in 2019.

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

Nuclear Security

Priorities for nuclear security

The Agency's identified priorities in the area of nuclear security include preparations for the third International Conference on Nuclear Security, to be held in 2020, and the promotion of universal adherence to the Amendment to the Convention on the Physical Protection of Nuclear Material (A/CPPNM).

International Conference on the Security of Radioactive Material: The Way Forward for Prevention and Detection

In December, the Agency organized the International Conference on the Security of Radioactive Material: The Way Forward for Prevention and Detection. The conference, which drew more than 550 experts from over 100 Member States, was the first Agency conference to bring together experts in facility protection and experts in the security of radioactive material out of regulatory control. Participants shared lessons learned and good practices, inter alia, in implementing the *Nuclear Security Recommendations on Radioactive Material and Associated Facilities* (IAEA Nuclear Security Series No. 14) and the *Nuclear Security Recommendations on Nuclear and Other Radioactive Material out of Regulatory Control* (IAEA Nuclear Security Series No. 15).

Amendment to the CPPNM

The Agency organized the fourth Technical Meeting of the Representatives of States Parties to the Convention on the Physical Protection of Nuclear Material (CPPNM) and the CPPNM Amendment, in Vienna in December, with the participation of more than 60 States Parties. The representatives discussed, inter alia, the role of designated Points of Contacts, as well as the exchange of information on laws and regulations giving effect to the CPPNM and A/CPPNM. In December, the Secretariat also facilitated an informal meeting of States Parties to the A/CPPNM, where preparations began for a conference of the States Parties to review the implementation of the CPPNM as amended, planned for 2021. Around 50 States Parties participated. Three regional workshops were also organized to promote universal adherence to the A/CPPNM.

IAEA Nuclear Security Series

The Nuclear Security Guidance Committee completed its second three-year term and started a third term in June. Five new IAEA Nuclear Security Series publications were issued in 2018: *Physical Protection of Nuclear Material and Nuclear Facilities (Implementation of INFCIRC/225/Revision 5)* (IAEA Nuclear Security Series No. 27-G); *Developing Regulations and Associated Administrative Measures for Nuclear Security* (IAEA Nuclear Security Series No. 29-G); *Sustaining a Nuclear Security Regime* (IAEA Nuclear Security Series No. 30-G); *Building Capacity for Nuclear Security* (IAEA Nuclear Security Series No. 31-G); and *Computer Security of Instrumentation and Control Systems at Nuclear Facilities* (IAEA Nuclear Security Series No. 33-T). By the end of 2018, a total of 32 publications had been issued in the series, a further 10 had been approved for publication and 14 more were at various stages of development.

Capacity building

"the Agency conducted 105 security related training activities — 42 at the national level and 63 at the international or regional level — providing training to more than 2200 participants from 139 States."

In 2018, the Agency conducted 105 security related training activities — 42 at the national level and 63 at the international or regional level — providing training to more than 2200 participants from 139 States. It also prioritized the development and implementation of Integrated Nuclear Security Support Plans (INSSPs) to assist Member States, upon request, in enhancing their nuclear security regimes. Three Member States approved their INSSPs in 2018, bringing the total number of approved INSSPs to 81. The Agency also provided assistance to five States hosting major public events aimed at strengthening implementation of nuclear security measures before and during the events. A workshop on nuclear security systems and measures for major public events held in Washington, D.C., in June was attended by an additional seven States planning to host major public events in the near future.

Peer review and advisory services

The Agency conducted four International Physical Protection Advisory Service (IPPAS) missions — to Ecuador, France, Japan and Switzerland. It also established a set of guidelines for International Nuclear Security Advisory Service (INSServ) missions.

NUCLEAR VERIFICATION[1,2]

Implementation of safeguards in 2018

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.

[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 Treaty on the Non-Proliferation of Nuclear Weapons is based on the number of instruments of ratification, accession or succession that have been deposited.

In 2018, safeguards were applied for 182 States[3,4] with safeguards agreements in force with the Agency. Of the 129 States that had both a comprehensive safeguards agreement (CSA) and an additional protocol (AP) in force[5] the Agency drew the broader conclusion that *all* nuclear material remained in peaceful activities for 70 States[6]; for the remaining 59 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 45 States with a CSA but 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 2018, integrated safeguards were implemented for 67 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 2018, 11 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

The Agency continued to implement the *Plan of Action to Promote the Conclusion of Safeguards Agreements and Additional Protocols*[9], which was updated in September 2018. During 2018, a CSA with a small quantities protocol (SQP) and an AP entered into force for Liberia. In addition, the Board of Governors approved a CSA with an SQP for the State of Palestine[10]. An AP entered into force for Serbia. An AP was signed for Algeria and the

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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 AP being provisionally applied, pending its entry into force.

6 And Taiwan, China.

7 Albania, Andorra, Armenia, Australia, Austria, Bangladesh, Belgium, Botswana, 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, Kazakhstan, Republic of Korea, Kuwait, Latvia, Libya, Lithuania, Luxembourg, Madagascar, Mali, Malta, Mauritius, Monaco, Montenegro, Netherlands, New Zealand, North Macedonia (the name 'North Macedonia' replaces the former name 'The former Yugoslav Republic of Macedonia' as of 15 February 2019), Norway, Palau, Peru, Philippines, Poland, Portugal, Romania, Seychelles, Singapore, Slovakia, Slovenia, South Africa, Spain, Sweden, Switzerland, Tajikistan, Ukraine, United Republic of Tanzania, Uruguay, Uzbekistan and Viet Nam.

8 And Taiwan, China.

9 Available at: *https://www.iaea.org/sites/default/files/18/09/sg-plan-of-action-2017-2018.pdf*

10 The designation employed does not imply the expression of any opinion whatsoever concerning the legal status of any country or territory or of its authorities, or concerning the delimitation of its frontiers.

Board of Governors approved an AP for Sri Lanka. A voluntary offer agreement and an AP thereto were signed for the United Kingdom. An SQP was rescinded for Malaysia and SQPs were amended for Paraguay, Tonga and the United States of America[11], in keeping with the Board of Governors' decision of 20 September 2005 regarding such protocols. By the end of 2018, safeguards agreements were in force with 183 States and APs were in force with 134 States. An AP continued to be provisionally applied pending its entry into force for the Islamic Republic of Iran. By the end of 2018, 64 States had accepted the revised SQP text (which was in force for 58 of these States) and 8 States had rescinded their SQPs.

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

Throughout 2018, the Agency continued to verify and monitor the nuclear-related commitments of the Islamic Republic of Iran (Iran) under the Joint Comprehensive Plan of Action (JCPOA). During the year, the Director General submitted four 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/2018/7, GOV/2018/24, GOV/2018/33 and GOV/2018/47).

Syrian Arab Republic (Syria)

In August 2018, the Director General submitted a report to the Board of Governors entitled *Implementation of the NPT Safeguards Agreement in the Syrian Arab Republic* (GOV/2018/35) covering relevant developments since the previous report in August 2017 (GOV/2017/37). 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.[12] In 2018, 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 diversion of declared nuclear material from peaceful activities. For 2018, the Agency concluded for Syria that declared nuclear material remained in peaceful activities.

Democratic People's Republic of Korea (DPRK)

In August 2018, 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/2018/34–GC(62)/12), which provided an update of developments since the Director General's report of August 2017 (GOV/2017/36-GC(61)/21). The Director General provided a further update in his introductory statement to the Board of Governors on 22 November 2018.

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[11] The United States of America has amended its small quantities protocol to the safeguards agreement reproduced in INFCIRC/366 between the United States of America and the Agency pursuant to Additional Protocol I of the Treaty of Tlatelolco, covering the United States of America's Protocol I territories.

[12] 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.

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.

In 2018, no verification activities were implemented in the field but the Agency continued to monitor developments in the DPRK's nuclear programme and to evaluate all safeguards relevant information available to it, including open source information and satellite imagery.

The Executive Group and the DPRK Team, created in August 2017,[13] have intensified their efforts. The DPRK Team has increased monitoring of the DPRK's nuclear programme through more frequent collection of satellite imagery and has enhanced its readiness to promptly undertake any activities it may be requested to conduct in the DPRK. Actions to enhance readiness have included: formulation and updating of verification approaches and procedures; identification of potential inspectors for initial activities in the DPRK and provision of specialized training for them; and ensuring the availability of appropriate verification technologies and equipment to support the initial activities. All of these efforts related to the Agency's enhanced readiness have been conducted within available resources, including extrabudgetary contributions from a number of Member States. Once a political agreement has been reached among the countries concerned, the Agency is ready to return to the DPRK in a timely manner, if requested to do so by the DPRK and subject to approval by the Board of Governors.

In 2018, the Agency continued to monitor the Yongbyon site. The Agency observed indications that were consistent with the operation of the Yongbyon Experimental Nuclear Power Plant (5MW(e)) reactor until mid-August 2018. From mid-August through November 2018 there were indications of intermittent reactor operation, and in December 2018 there were no indications of reactor operation. Starting in the first quarter of 2018, activities were observed near the Kuryong River, which may have been related to changes to the cooling system for the light water reactor (LWR) under construction and/or the 5MW(e) reactor. Between late April and early May 2018, there were indications of the operation of the steam plant that serves the Radiochemical Laboratory. The duration of the steam plant's operation was not sufficient to have supported the reprocessing of a complete core from the 5MW(e) reactor. 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. At the LWR, the Agency observed activities consistent with the fabrication of reactor components and the possible transfer of these components into the reactor building.

The Agency has evaluated all safeguards relevant information, including satellite imagery and open source information, about a group of buildings within a security perimeter in the vicinity of Pyongyang. The size of the main building and the characteristics of the associated infrastructure are not inconsistent with a centrifuge enrichment facility. The timeline of construction is not inconsistent with the reported uranium enrichment programme of the DPRK.[14]

The Agency has not had access to the Yongbyon site or to other locations in the DPRK. Without such access, the Agency cannot confirm either the operational status or configuration/design features of the facilities or locations, or the nature and purpose of the activities conducted therein.

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[13] GOV/2017/36-GC(61)/21, para. 12.

[14] GOV/2011/53-GC(55)/24, para. 30. In addition, GOV/2011/53-GC(55)/24, para. 50, noted reports on the provision of centrifuge enrichment technology to the DPRK and indications that the DPRK could produce UF_6 prior to 2001.

The continuation and further development of the DPRK's nuclear programme during 2018, including activities in relation to the Yongbyon Experimental Nuclear Power Plant (5 MW(e)) reactor, the use of the building which houses the reported centrifuge enrichment facility and the construction at the LWR, are clear violations of relevant United Nations Security Council resolutions, including resolution 2375 (2017), and are deeply regrettable.

Enhancing safeguards

In July 2018, the Director General submitted a report to the Board of Governors entitled *Implementation of State level Safeguards Approaches for States under Integrated Safeguards — Experience Gained and Lessons Learned* (GOV/2018/20). This report contains the Secretariat's analysis of experience gained and lessons learned in the updating and implementation of State-level safeguards approaches (SLAs) for States under integrated safeguards, as described in GOV/2013/38 and GOV/2014/41 and Corr.1.

During 2018, the Agency developed SLAs for five States with a CSA. This brings the total number of States with a CSA for which an SLA has been developed to 130. These 130 States hold 97% of all nuclear material (by significant quantity) under safeguards in States with a CSA and include 67 States with a CSA and an AP in force for which the broader conclusion has been drawn; 35 States with a CSA and an AP in force for which the broader conclusion has yet to be drawn; and 28 States with a CSA but no AP in force. For those States where SLAs are not implemented, in-field safeguards activities are based on the Safeguards Criteria, and new techniques and technologies are implemented, as applicable, to strengthen effectiveness and improve efficiency.

Cooperation with State and regional authorities

To assist States in building capacity for implementing their safeguards obligations, the Agency conducted 13 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. In total, more than 250 participants from some 50 countries were trained on safeguards related topics. The Agency also participated in three other training activities organized by Member States on a bilateral basis. In 2018, the Agency, upon request, conducted an IAEA State System of Accounting for and Control of Nuclear Material Advisory Service (ISSAS) mission to Mexico and participated in two INIR missions to the Niger and Saudi Arabia, both of which included, inter alia, the provision of 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 2018, the Agency ensured that the instrumentation and monitoring equipment installed in nuclear facilities around the world, which is vital to effective safeguards implementation, continued to function as required. It continued to implement the next generation surveillance system, replacing outdated surveillance units. By the end of 2018, a total of 881 next generation surveillance system cameras had been installed.

Safeguards analytical services

In 2018, the Agency collected 487 nuclear material samples that were analysed by the Agency's Nuclear Material Laboratory. It also collected 481 environmental samples during the year, which were analysed by the Network of Analytical Laboratories, including at the Agency's Environmental Sample Laboratory and the Nuclear Material Laboratory.

Developing the safeguards workforce

In 2018, the Agency conducted 165 safeguards training courses to provide safeguards inspectors and analysts with the necessary technical and behavioural competencies. These included two sessions of the Introductory Course on Agency Safeguards, held at the Agency's Headquarters for 30 newly recruited inspectors, and several courses held at nuclear facilities to enhance practical competencies for safeguards implementation in the field.

"In 2018, the Agency conducted 165 safeguards training courses"

Information technology: MOSAIC

The Agency completed the planned modernization of safeguards information technology on schedule in May and within scope and budget. The modernization completed under the Modernization of Safeguards Information Technology (MOSAIC) project has enhanced existing tools and software applications, introduced new IT tools and software applications, and strengthened information security.

Safeguards Symposium

In November, the Agency hosted the Symposium on International Safeguards: Building Future Safeguards Capabilities at its Headquarters in Vienna. The symposium focused on identifying innovative technologies that might be exploited for safeguards purposes; strengthening existing partnerships and creating new ones; and improving the day to day work of safeguards implementation. More than 800 people participated in the symposium, heralding from 90 Member States. Thanks to substantial support from several Member State Support Programmes, organizations and exhibitors, 90 individuals received travel support to attend the event, resulting in improved geographic diversity among the participants.

Preparing for the future

The Agency published the *Research and Development Plan — Enhancing Capabilities for Nuclear Verification* (STR-385) and the *Development and Implementation Support Programme for Nuclear Verification 2018–2019* (STR-386) in early 2018. The biennial meeting of the Member State Support Programme coordinators took place in February, at which the Secretariat informed Member States about its needs regarding improvements to the Agency's technical capabilities. The Development and Implementation Support Programme for Nuclear Verification comprises 285 support programme tasks in 25 projects. At the end of 2018, 20 Member States[15] and the European Commission had formal support programmes with the Agency.

MANAGEMENT OF TECHNICAL COOPERATION FOR DEVELOPMENT

The technical cooperation programme in 2018

The technical cooperation programme is the Agency's major vehicle for transferring technology and building capacities in the peaceful use of nuclear science and technology in Member States. In 2018, health and nutrition accounted for the highest proportion of actuals (disbursements) delivered through the technical cooperation programme, at 27.7%. This was followed by safety and security at 20.9%, and by food and agriculture at 20.3%.

[15] 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.

By the end of the year, financial implementation of the Technical Cooperation Fund stood at 85.7%. Regarding non-financial implementation, the programme supported, inter alia, 3640 expert and lecture assignments, 196 regional and interregional training courses, and 1816 fellowships and scientific visits.

Technical cooperation and the global development context

In 2018, the Agency attended the Multi-stakeholder Forum on Science, Technology and Innovation for the Sustainable Development Goals and the 2018 United Nations High-level Political Forum on Sustainable Development — the main platforms for follow-up and review of Agenda 2030 and the SDGs. During the High-level Political Forum on Sustainable Development, the Agency highlighted the contributions of nuclear science and technology to a variety of SDGs under review.

Throughout the year, the Agency took part in the United Nations Interagency Task Team on Science, Technology and Innovation for the SDGs, one of the pillars of the Technology Facilitation Mechanism to support implementation of SDG 17, on partnerships for the goals. It also contributed to the dialogue on implementation of the Addis Ababa Action Agenda through the United Nations Inter-Agency Task Force on Financing for Development. The 2018 Task Force report was the first to highlight the role nuclear and isotopic techniques play in increasing agricultural productivity and resilience.

In April, the Agency took part in the International Conference on Public–Private Partnerships for the Implementation of the 2030 Agenda for Sustainable Development, co-organized by the World Association for Sustainable Development and the Joint Inspection Unit of the United Nations system in Geneva. It used the opportunity to discuss lessons learned and best practices on public–private partnerships with other members of the United Nations system, and to give visibility to the Agency's support for science, technology and innovation in several thematic areas.

The Agency took part in the Global South-South Development Expo in New York in November to showcase how nuclear science and technology can promote development by leveraging the knowledge and capacities of the Global South.

Twenty-four Country Programme Frameworks and seven United Nations Development Assistance Frameworks (UNDAFs) were co-signed in 2018, bringing the total number of valid Country Programme Frameworks to 100 and the total number of valid UNDAFs to 56.

Overview of regional activities

Africa

Through its technical cooperation programme, the Agency provided assistance to 45 Member States in Africa in 2018, 26 of which are classified as least developed countries. Approximately 70% of this assistance was in the areas of food and agriculture, health and nutrition, and radiation safety — the main priority areas described in the AFRA Regional Strategic Cooperative Framework for 2019–2023 and the Regional Programme Framework for Africa. The Agency supported Member States in the attainment of the SDGs and contributed to the African Union's Agenda 2063 as well as the African Development Bank's 'High 5s' priorities — especially in the areas of energy, food and agriculture, industrialization and improving the quality of life. In 2018, the Agency and the African Union Commission concluded Practical Arrangements for the safe, secure and peaceful use of nuclear technologies for sustainable development in Africa.

In 2018, activities in Africa focused on building Member State capacities to manage national food resources and to control transboundary animal diseases, contaminants and other pollutants that might affect food safety. Nuclear techniques applied to plant breeding

helped to increase yields and to develop new varieties resistant to disease and to a more complex climate.

The Niayes area of Senegal was declared tsetse-free by the Government of Senegal on 8 December 2018. A mobile freezer was provided to Burkina Faso to facilitate the safe transport of blood from Ouagadougou abattoir to the insect mass-rearing centre in Bobo-Dioulasso. The supply of sterile males from the Bobo-Dioulasso insectary contributed to tsetse fly eradication in the Niayes area.

In Botswana, the laboratory network for early and rapid diagnosis of transboundary animal and zoonotic diseases was strengthened, leading to an improved turnaround time that enables earlier response. In 2018, the capacities of the satellite laboratory in Jwaneng, 200 km west of Gaborone, were expanded to include virological and bacteriological diagnoses, and the satellite veterinary laboratory in Maun, 1000 km north of Gaborone, became fully operational, focusing mainly on foot-and-mouth disease. In Namibia, foundation seeds for seven newly certified varieties of cowpea and four varieties of sorghum, developed through mutation breeding, were made available to farmers for planting in the 2018–2019 season.

A regional project strengthened Member State capacities to monitor marine pollution and to assess risks, contributing to marine resource conservation and management. In Morocco, environmental isotopes were used to improve the management and sustainable exploitation of groundwater in the Gharb plain and the Sebou Basin, a major agricultural region. In Zimbabwe, improved soil and water management enabled farmers to grow vegetables, in addition to the crops usually grown.

In January, Uganda inaugurated a new radiotherapy machine at the Uganda Cancer Institute, resuming essential treatment services for cancer patients following the breakdown of the country's previous equipment in 2016. The Agency supported the purchase of the new radiotherapy machine on a cost-sharing basis, as well as the decommissioning of the old machine and training of key staff required to run the centre. In the United Republic of Tanzania, Agency assistance supported the startup of radiotherapy treatment at the Bugando Medical Centre. The centre is expected to serve a population of some 13 million, easing the pressure on the country's other radiotherapy facility at Ocean Road Cancer Institute in Dar Es Salaam.

In 2018, six least developed countries — Ethiopia, Mali, Senegal, Uganda, the United Republic of Tanzania and Zambia — established or improved their first radioactive waste processing and storage facilities through regional technical cooperation projects.

Human resource capacity building activities in Africa are increasingly focused on long term training leading to professional qualification. In 2018, the Agency held two regional Postgraduate Educational Courses in Radiation Protection and the Safety of Radiation Sources, providing training in radiation safety for 40 young professionals, and two radiation safety 'train the trainers' events, for 50 participants, on the roles, duties and competencies of a radiation protection officer in medical and industrial facilities. Ten candidates completed a two year master's programme in nuclear science and technology at Alexandria University, Egypt, and the University of Ghana; and ten fellowships were awarded in the new PhD sandwich programme launched in 2018, allowing the candidates to carry out their PhD research work at a foreign university. The Agency also provided training in cancer therapy to radiation oncologists, medical physicists, radiation therapy technologists and radiopharmacists through national and regional projects.

"the Agency held two regional Postgraduate Educational Courses in Radiation Protection and the Safety of Radiation Sources, providing training in radiation safety for 40 young professionals"

Asia and the Pacific

In the Asia and the Pacific region, the key thematic areas of focus in 2018 were food and agriculture, nuclear safety and radiation protection, and human health and nutrition.

Eleven Agency fellows were trained at the International Centre for Synchrotron Light for Experimental Science and Applications in the Middle East in Jordan in 2018. The Centre

enables scientists from the region to cooperate on advanced research projects in areas such as biology, archaeology, medicine and material sciences. In 2018, the Agency strengthened South–South and triangular cooperation between Cambodia, the Lao People's Democratic Republic and Viet Nam, with the establishment of a framework for cooperation as well as the signature of Memorandums of Understanding in the areas of industrial applications, medicine, health and safety. Three sterile insect technique programmes were successfully implemented in Israel, Jordan and the territories under the jurisdiction of the Palestinian Authority, fully developing into a major integrated pest management strategy in Israel and Jordan. Integrated pest management strategies are being applied in the territories under the jurisdiction of the Palestinian Authority.

Radiation safety is a priority area for the Asia and the Pacific region. The Agency provided comprehensive and targeted assistance throughout 2018 through training activities, the provision of tools and equipment, and the revision and promulgation of national nuclear laws. Thirty-eight personnel (junior regulatory body staff, radiation protection officers and operator staff) were trained at the 15th Postgraduate Educational Course in Radiation Protection and the Safety of Radiation Sources. An intercomparison exercise organized by the Agency and hosted by the Australian Radiation Protection and Nuclear Safety Agency allowed laboratories in the region to assess their dosimetry capabilities, while training in November provided by the Korea Institute of Radiological and Medical Sciences, with cost sharing from the Republic of Korea provided through the Regional Co-operative Agreement for Research, Development and Training Related to Nuclear Science and Technology (RCA) Regional Office for the Asia and the Pacific region, improved the skills of 18 laboratory technicians in carrying out internal dose assessments. The Philippine Nuclear Research Institute provided training through an Agency technical cooperation project in the establishment of national registries of radiation sources to representatives from nine countries and territories that are about to establish regulatory bodies.

The Agency continued to support efforts to introduce nuclear science and technology to students in secondary schools in the Asia and the Pacific region through national and regional training courses. A new project launched in 2018 builds on the achievements of an earlier project that reached over 24 700 secondary school students in pilot countries in 2017. The new project has already reached more than 160 000 students through regional training courses and national workshops.

Europe

In 2018, the Agency provided technical assistance to 33 Member States in Europe and Central Asia focused mainly on nuclear and radiation safety, and human health.

In April, National Liaison Officers for the region endorsed the revised Regional Profile for 2018–2021, which establishes the priority thematic areas in the Europe and Central Asia region.

Two expert missions to Turkey enhanced the Turkish Atomic Energy Authority's capabilities in PSA for risk informed decision making by training nine people. Poland, an embarking nuclear power country, hosted an Agency expert mission that conducted national workshops on the Advanced Licensing Exercise Project, a capability development activity that supports the achievement of regulatory readiness. Twenty people received training through these events. A second national workshop focused on communication with the public in a nuclear or radiological emergency. Thirty-two participants from 12 Member States attended a regional workshop in Armenia that provided a forum to share experiences concerning technical challenges with the design, implementation and licensing of modern instrumentation and control systems for nuclear power plants.

Uzbekistan received assistance to enhance its environmental radiation monitoring network and to improve the laboratories of its national hydrometeorological service. With the new equipment and training for four staff provided in 2018, it is now able to determine

activity concentrations of low level alpha-emitting radionuclides, in addition to gross alpha-beta measurements. Uzbekistan's improved environmental monitoring network can now support environmental impact assessments, verify environmental safety and prepare for the implementation of environmental remediation programmes.

Latin America and the Caribbean

In the Latin America and the Caribbean region, the Agency's assistance was focused primarily on human health and nutrition, followed by safety, food and agriculture, and water and the environment. The regional programme also focused on improving the quality and sustainability of national nuclear institutions. In 2018, the first national Agency technical cooperation programmes were initiated for three new Member States: Antigua and Barbuda, Barbados and Guyana.

In health, activities focused on building capacity in radiation medicine, and the second edition of the master's programme on advanced radiotherapy was launched. Public brachytherapy services for the treatment of gynaecological tumours were re-established in Guatemala, and the first molecular radiobiology and oncology laboratory opened in the Bolivarian Republic of Venezuela with Agency support.

In safety, the regional programme focused on strengthening national regulatory infrastructure and providing assistance to ensure safety for end users of radiation sources. Assistance was provided to professional bodies in the region to finalize the Guide on the Prescription of Diagnostic Imaging for prescribing physicians to support the optimization and quality of radiodiagnostics. The first Emergency Preparedness and Response School for Caribbean Member States was successfully delivered, and the first Regional School of Nuclear and Radiological Leadership for Safety for young professionals was held in Mexico, training more than 30 future leaders in the region. In addition, a new managerial tool was developed to support strategic planning to prioritize safety assistance through national and regional programmes. Costa Rica inaugurated the first biodosimetry laboratory in Central America.

The implementation of non-destructive testing methods to evaluate the integrity and properties of civil infrastructure, material or components was a key objective for the region in 2018. Capacity building actions and equipment were procured to strengthen the identified four subregional reference centres for the inspection of civil structures which were established in Argentina, Chile, Mexico and Peru. They will have the capacity to provide immediate response in the case of national and regional emergencies and disasters.

The capacities of the Caribbean Observing Network for Ocean Acidification, which will monitor ocean acidification and its impact on harmful algal blooms, were strengthened. Agency activities helped build capacity in monitoring laboratories through four regional training events in the region.

In the field of agriculture and food safety, efforts focused on the development of new mutant varieties of tomato (tolerant of high temperature and drought), quinoa (resistant to local disease) and rice (resistant to herbicides).

In 2018, the Agency successfully supported the first pilot sterile mosquito release in Mexico — the first trial in the Latin America and the Caribbean region. The first release of sterile fruit flies took place in Ecuador, an initial step in the implementation of sterile insect technique technology in the country. At the regional level, the development of capabilities for the area-wide application of the sterile insect technique continued, contributing to opening up markets for the export of fruit and vegetables.

The delivery of low enriched fuel for the RP-10 research reactor in Peru was finalized. This reactor plays a key role in the production of radioisotopes in the country, as well as in research activities and the training of professionals and technicians.

Programme of Action for Cancer Therapy (PACT)

Throughout 2018, the Agency, in collaboration with key partners and donors, continued to help low and middle income Member States to improve the effectiveness of their radiation medicine services as part of a comprehensive cancer control framework. Activities focused on strengthening national cancer control capacities and mobilizing resources for the Agency's cancer control-related activities.

The Agency established a new partnership with Childhood Cancer International and enhanced relationships with existing partners from Member States and international financing institutions. It participated in key global health events such as the World Health Assembly in Geneva; the World Health Summit in Berlin; the Stop Cervical, Breast and Prostate Cancers in Africa Conference in Maseru, Lesotho; the Commonwealth East, Central and Southern Africa Health Ministers Conference in Harare; and the World Cancer Leaders' Summit and the World Cancer Congress, both in Kuala Lumpur.

"Seven Member States … received imPACT ('integrated missions of PACT') Review missions"

Seven Member States — Afghanistan, Guyana, Indonesia, Mauritius, Mexico, North Macedonia[16] and Ukraine — received imPACT ('integrated missions of PACT') Review missions, which looked at national cancer control capacities and needs, and provided governments with recommendations on how best to prioritize their cancer control activities and investments.

In close cooperation with WHO, expert advisory assistance was also provided to Lesotho, Malawi, Mozambique, Namibia, Nicaragua and Viet Nam to support the development of national cancer control plans. The Agency also provided expertise to examine Albania's progress in cancer control capacities.

The Agency held an expert meeting in Vienna in November to strengthen the current methodology for conducting imPACT Reviews. A workshop to support seven African Member States in the integrated planning and implementation of sustainable radiotherapy services took place at the Agency's Headquarters in December.

Legislative assistance

In 2018, the Agency continued to provide legislative assistance to its Member States through the technical cooperation programme. Country specific bilateral legislative assistance was provided to 17 Member States through written comments and advice on drafting national nuclear legislation, and one regional and five national workshops on nuclear law were organized during the year.

The Agency also organized the eighth session of the Nuclear Law Institute in Baden, Austria, in October. Sixty-one participants from Member States attended the training. The Nuclear Law Institute 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, with a particular focus on legislative drafting.

Technical cooperation programme management: Quality assurance activities, reporting and monitoring

Efforts continued throughout 2018 to develop and improve processes and tools to increase the quality of current and future technical cooperation programme cycles.

The electronic Project Progress Assessment Reports, introduced in 2017, led to higher submission rates in 2018. The new process enables quicker, more relevant reporting by Member States, contributing to more effective project implementation, monitoring and results evaluation. In addition, the Agency conducted field monitoring missions to Albania,

[16] The name 'North Macedonia' replaces the former name 'The former Yugoslav Republic of Macedonia' as of 15 February 2019.

Costa Rica, Israel, South Africa and the United Republic of Tanzania, to strengthen the programme's results oriented approach.

The Agency issued guidelines for the planning and design of the 2020–2021 technical cooperation programme cycle, and revised and updated project design templates and guidance, based on experience from past programme cycles and in response to recommendations from internal and external audits and evaluations. The Agency provided support to Member States and staff through a series of training events, workshops and briefing sessions covering every phase of the programme cycle, with the aim of increasing project efficiency, effectiveness and results orientation throughout the planning, implementation and review cycle. Close to 900 stakeholders used the recently updated e-learning course on designing technical cooperation projects using the logical framework approach in 2018.

Financial resources

The technical cooperation programme is funded by contributions to the Technical Cooperation Fund, as well as through extrabudgetary contributions, government cost sharing and contributions in kind. Overall, new resources reached a total of some €100.1 million in 2018, with approximately €82.6 million for the Technical Cooperation Fund (including assessed programme costs, National Participation Costs and miscellaneous income), €17.2 million in extrabudgetary resources, and about €0.3 million representing in kind contributions.

The rate of attainment for the Technical Cooperation Fund stood at 91.4% on payments and 92.6% on pledges at the end of 2018, while payment of National Participation Costs totalled €3.6 million.

Actuals

In 2018, approximately €94.7 million was disbursed to 146 countries or territories, of which 35 were least developed countries, reflecting the Agency's ongoing effort to address the development needs of those States.

MANAGEMENT ISSUES

Gender equality and gender mainstreaming

The Agency continued its efforts focused on promoting gender equality within the Secretariat, as well as gender mainstreaming in the Agency's programmes and activities. The Agency mainstreams gender in all relevant programmes and organizational practices, including efforts to enhance the participation of women as training participants, fellows, scientific visitors, project counterparts, researchers, experts and panellists. For the first time, the proportion of women in the professional and higher categories went over 30% as of the end of 2018, while that of women in senior management positions (D level or higher) was 29%.

Managing for results

The Agency's results based management approach to programme planning, monitoring and reporting was further strengthened in 2018. In the draft Programme and Budget for 2020–2021, specific focus was placed on better defining clear, outcome oriented results and indicators, while also mainstreaming cross-cutting issues. Related guidance was developed, and targeted training was provided. An accountability framework was issued to ensure that

the Secretariat delivers on its functions by fostering an environment of achieving concrete results through effective synergy and alignment of its activities and processes.

Partnerships and resource mobilization

The Secretariat continued to implement the Strategic Guidelines on Partnerships and Resource Mobilization using a one-house approach. It took steps to systematize its approval procedures and processes, enhance coordination and monitoring, and improve information sharing. The Secretariat continued existing collaboration arrangements and developed new partnerships, particularly with Member State institutions to promote technology transfer; and it leveraged mechanisms such as the United Nations Global Marketplace to reach out to a wider range of non-traditional partners.

Information and IT security

The Agency continued to strengthen its information and IT security in 2018, focusing on reducing the risk posed by phishing and unsupported legacy applications. The Agency also strengthened its efforts to further protect sensitive information.

Multilingual web site

The Agency launched web sites in Arabic, Chinese, French, Russian and Spanish in June. These sites contain over 450 static pages explaining the Agency's work in different areas, as well as over 250 news items. Each month, some five news articles or videos were made available in Arabic, Chinese, French, Russian and Spanish; different topics were selected for each site, based on their relevance and interest to the respective language community.

IAEA SCIENTIFIC FORUM

The IAEA Scientific Forum 2018, held during the 62nd General Conference in September, examined the role that nuclear science and technology play in addressing the challenges of climate change and how they can help more Member States. High level speakers, including Princess Sumaya bint El Hassan of Jordan, science ministers and experts, joined the Director General to present the role of nuclear techniques in mitigating, monitoring and adapting to climate change. Panellists noted public acceptance of nuclear power and capacity building in nuclear techniques as the main challenges. Further deployment of these nuclear techniques would benefit efforts to address challenges associated with climate change in the areas of food security and water scarcity, and help to reduce greenhouse gas emissions in a sustainable manner.

Nuclear Technology

Nuclear Power

Objective

To support Member States with existing nuclear power plants to enhance performance and ensure safe, secure, efficient and reliable long term operation, including development of human resource capability, leadership and management systems. To assist Member States embarking on new nuclear power programmes in planning and building their national nuclear infrastructures, including development of human resource capability, leadership and management systems. To provide methods and tools to support modelling, analyses and assessments of future NESs for sustainable development of nuclear energy, and collaborative frameworks and support for technology development and deployment of advanced nuclear reactors and non-electric applications.

Launching Nuclear Power Programmes

The Agency continued to support Member States considering or embarking on a new nuclear power programme by providing assistance through national workshops, expert missions, regional and interregional training activities, and review services. In 2018, 28 Member States were actively considering, planning or embarking on a nuclear power programme, four of which were constructing their first nuclear power plant (Table 1).

TABLE 1. Number of Member States considering or embarking on a nuclear power programme, according to their official statements (as of 31 December 2018)

First nuclear power plant started construction/under construction	4
First nuclear power plant ordered, but construction not yet started	1
Decided to introduce nuclear power and started preparing the appropriate infrastructure	4
Active preparation for a possible nuclear power programme with no final decision	8
Considering nuclear power programme	11

The Integrated Nuclear Infrastructure Review (INIR) continued to be one of the main Agency review services for countries embarking on a nuclear power programme, assisting them in evaluating the status of their nuclear power infrastructure development and in identifying gaps. In 2018, the Agency conducted INIR Phase 1 missions to the Niger, the Philippines and the Sudan, and an INIR Phase 2 mission to Saudi Arabia. The first INIR Phase 3 mission was conducted to the United Arab Emirates. A total of 27 INIR and INIR follow-up missions have been deployed to 20 Member States since the launch of this service in 2009 (Table 2).

TABLE 2. INIR missions conducted to Member States as of 31 December 2018

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

The Agency, through its technical cooperation programme, continued to support Member States in understanding nuclear infrastructure issues using the Milestones approach. The key areas of focus in 2018 were leadership and management systems, workforce planning and human resource development, stakeholder involvement and public communication, radioactive waste management, resource requirements, and financial risks associated with nuclear power infrastructure development. Through interregional, regional and national workshops, training courses and fellowships, the Agency provided practical training in various infrastructure issues to over 400 participants, including members of nuclear power development projects, regulatory bodies and technical support organizations.

"The Agency added new 'Legal Framework' and 'Industrial Involvement' modules to its on-line e-learning course based on the Milestones approach for nuclear newcomers"

The Agency held its annual Technical Meeting on Topical Issues in the Development of Nuclear Power Infrastructure in Vienna from 30 January to 2 February. At the meeting, 64 participants from 28 Member States and an international organization discussed challenges and exchanged experiences on a range of issues, including stakeholder involvement, the structure of owner/operator organizations, and infrastructure development for small and medium sized or modular reactors (SMRs). At a Technical Meeting on the Responsibilities and Capabilities of Owners and Operating Organizations in New Nuclear Power Programmes held in Vienna in July, 16 participants from 6 countries considering or embarking on a nuclear power programme and 7 countries operating nuclear power plants discussed the draft revision of *Initiating Nuclear Power Programmes: Responsibilities and Capabilities of Owners and Operators* (IAEA Nuclear Energy Series No. NG-T-3.1). The revised publication will further elaborate new issues and strategies for establishing an owner/operator organization and developing its competence.

The Technical Meeting on Funding for Waste Management and Decommissioning, also held in Vienna in July, focused on prospective capital and operating expenditures associated with the back end of the nuclear fuel cycle, other operational waste and the waste emerging from decommissioning of nuclear power plants and other nuclear facilities. The meeting was attended by 32 participants from 23 Member States — both embarking countries and countries with operating nuclear power plants — and 2 international organizations, who discussed methodologies for estimating the cost of such projects and ways to fund them.

In 2018, the Agency conducted six expert missions — to Ghana, Poland and Turkey — to support key organizations in the development of management systems for a nuclear power programme. It also held workshops for Egypt, Kazakhstan and Kenya on modelling human resource requirements and on workforce planning for new nuclear power programmes using its Nuclear Power Human Resources modelling tool.

The Agency continued to update its Country Nuclear Infrastructure Profiles (CNIPs) database, used to monitor the status of nuclear power infrastructure in Member States, and its Integrated Work Plan (IWP) tool, used for integrating Agency support for embarking countries actively developing a nuclear power programme. In 2018, the Agency held meetings with 12 Member States embarking on a nuclear power programme to develop or update their respective IWPs and CNIPs.

The Agency added new 'Legal Framework' and 'Industrial Involvement' modules to its on-line e-learning course based on the Milestones approach for nuclear newcomers. A total of 18 Milestone modules are now available on the Agency's web site.

Operating Nuclear Power Plants and Expanding Nuclear Power Programmes

At the end of 2018, over 65% of the world's operating nuclear power reactors had been in operation for longer than 30 years (Fig. 1). While nuclear reactors are typically licensed for 30–40 years, their operating lifespans are being extended significantly through appropriate life management programmes, including special safety reviews and assessments of their essential structures, systems and components. To provide support to its Member States in this area, the Agency published *Economic Assessment of the Long Term Operation of Nuclear Power Plants: Approaches and Experience* (IAEA Nuclear Energy Series No. NP-T-3.25), describing various approaches to techno-economic assessment of the long term operation of a nuclear power plant in its specific market environment. More specific guidance was issued in *Buried and Underground Piping and Tank Ageing Management for Nuclear Power Plants* (IAEA Nuclear Energy Series No. NP-T-3.20), one in a series of publications on assessment and management of ageing of major components of nuclear power plants.

At the first meeting of the Agency's new Technical Working Group on Nuclear Power Plant Operations in September, 30 senior government officials and industry executives identified priority areas where Agency assistance could help relevant stakeholders improve the economic sustainability of operating nuclear power reactors worldwide. To support Member States in considering future flexible operation of their nuclear power plants, the Agency issued *Non-baseload Operation in Nuclear Power Plants: Load Following and Frequency Control Modes of Flexible Operation* (IAEA Nuclear Energy Series No. NP-T-3.23), providing guidance based on current knowledge and operational experience.

The Agency published *Maintenance Optimization Programme for Nuclear Power Plants* (IAEA Nuclear Energy Series No. NP-T-3.8), sharing proven maintenance optimization methods and techniques essential for the overall performance and competitiveness of nuclear power plants. It also issued *Technical Support to Nuclear Power Plants and Programmes* (IAEA Nuclear Energy Series No. NP-T-3.28), addressing relevant aspects of requesting and obtaining effective technical support and using it appropriately in decision making on nuclear power programmes, projects and plants. Another new Agency publication, *Improvement of Effectiveness of In-Service Inspection in Nuclear Power Plants* (IAEA-TECDOC-1853), investigates the role of effective in-service inspection in maintaining or improving safety and the relationship of improvement and cost. The Agency also published *Dissimilar Metal Weld Inspection, Monitoring and Repair Approaches* (IAEA-TECDOC-1852), outlining good practices, lessons learned, guidance and practical case studies for inspection organizations, operating staff and local suppliers who provide inspection services to utilities.

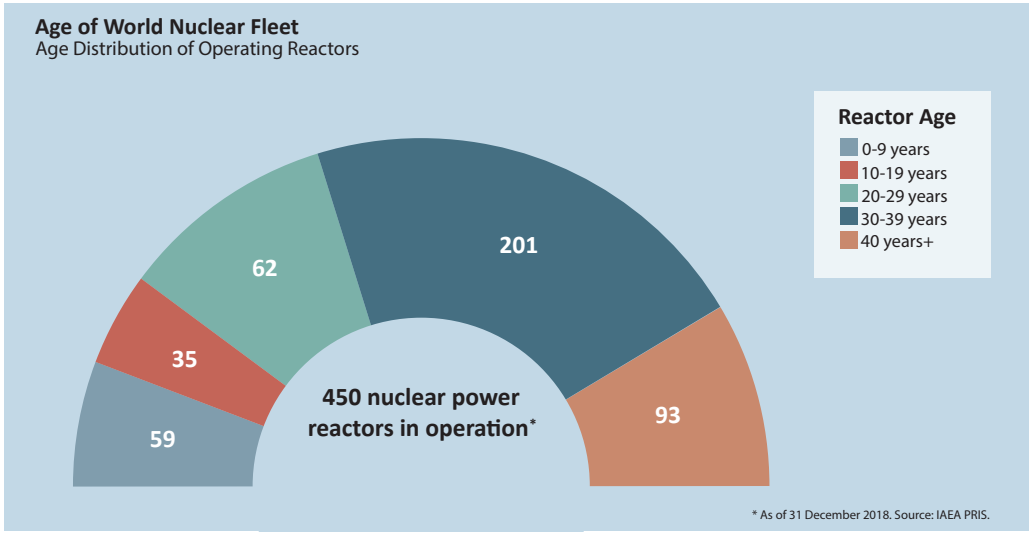

FIG. 1. Age distribution of operating nuclear power reactors as of 31 December 2018.

At the Technical Meeting on Integrated Risk Management: Risk Informed Processes and Programmes during the Lifetime of a Nuclear Power Plant, held in Beijing in July, and the Technical Meeting on Economic Considerations of Asset Management for Nuclear Power Plant Operation and Maintenance, held in Vienna in October, 37 participants from 14 Member States discussed how to extend traditional risk assessments to optimize plant performance. The Agency also held technical meetings related to the optimization of thermal performance, reload core design and core management, and the design modification process at operating nuclear power plants.

Nuclear power plant instrumentation and control remains both an area of rapid technological development, closely linked to facility modernization through digitalization, and an area particularly sensitive to obsolescence and supply chain challenges. In June, the Agency organized a Technical Meeting on Justification of Commercial Industrial Instrumentation and Control Equipment for Nuclear Power Plant Applications, in Toronto, Canada, where 74 participants from 17 Member States shared associated best practices and strategies to improve understanding of the topic. In September, it held a Technical Meeting on Instrumentation and Control Aspects of Human Factors Engineering: Design and Analysis, in Madrid, attended by 56 participants from 23 Member States. The meeting enabled the sharing of best practices and strategies used in the application of human factors engineering principles in the design of human–system interfaces, such as alarms, displays and controls in the plant. The Agency issued two publications related to this topic in 2018: *Approaches for Overall Instrumentation and Control Architectures of Nuclear Power Plants* (IAEA Nuclear Energy Series No. NP-T-2.11) and *Dependability Assessment of Software for Safety Instrumentation and Control Systems at Nuclear Power Plants* (IAEA Nuclear Energy Series No. NP-T-3.27).

To assist Member States in understanding and implementing the commissioning process for a new nuclear power plant or for upgrades or refurbishments of operating nuclear power plants, the Agency issued *Commissioning Guidelines for Nuclear Power Plants* (IAEA Nuclear Energy Series No. NP-T-2.10). The publication describes the commissioning process specific to nuclear power plants, the relevant management system requirements, typical organizational models and critical human resource issues. In August, the Agency held a Technical Meeting on Challenges and Opportunities in the Construction Management of Advanced Nuclear Power Plants in Shanghai, China. The meeting's 47 participants from 19 Member States discussed challenges and opportunities in advanced nuclear power plant construction, changes in industry structure and markets, and strategies and solutions to avoid cost overrun and schedule delay.

"In 2018, the Agency issued the 20th edition of the Country Nuclear Power Profiles (CNPP)"

In 2018, the Agency issued the 20th edition of the *Country Nuclear Power Profiles* (CNPP), a major, publicly available resource on the status and development of nuclear power programmes around the world. The 2018 edition, also available in a mobile version, outlines activities and summaries of 37 countries with developing or established nuclear power programmes.

Human Resource Development, Management and Stakeholder Involvement Support

The Agency's Third International Conference on Human Resource Development for Nuclear Power Programmes: Meeting Challenges to Ensure the Future Nuclear Workforce Capability was held in May in Gyeongju, Republic of Korea. The conference drew more than 500 experts in the areas of capacity building, human resource development, workforce planning, education and training, knowledge management and knowledge networks for nuclear power programmes. Sixty-two Member States and six international organizations were represented. Within the conference, an international student competition provided an opportunity for young students from five Member States to demonstrate innovative ways to educate local communities on the benefits of nuclear science and technology.

The International Conference on Quality, Leadership and Management in the Nuclear Industry–15th FORATOM–IAEA Management Systems Workshop was held in Ottawa in July. More than 350 nuclear industry professionals took part in the conference, which offered focused sessions for owner/operators, regulators and suppliers, and covered a variety of topics including project and quality management, leadership, and organizational and safety culture.

A Technical Meeting on Quality Assurance and Quality Control Activities as Part of a Nuclear Power Plant Management System: Lessons Learned and Good Practices, organized in Vienna in November, provided a forum for discussion of challenges in implementing requirements regarding quality management, quality assurance and quality control activities at nuclear facilities, including oversight of the supply chain. At the meeting, 60 specialists from 26 Member States exchanged their experiences in this area and considered practical solutions to overcome these challenges throughout the life cycle of a facility.

Stakeholder involvement continued to be an important area for countries at all stages of nuclear power development and operation. In 2018, the Agency conducted several expert missions on this topic tailored to the unique needs of individual Member States. It held a new interregional training course on the principles of stakeholder involvement in Vienna in September, with 19 participants from 17 Member States. The course will now be held annually. Also in September, the Agency held a Technical Meeting on Stakeholder Involvement across the Nuclear Power Plant Life Cycle, where 42 participants from 26 Member States and an international organization discussed common challenges as well as trends in and new ways of thinking about stakeholder involvement and public communication.

Nuclear Technology Development

Advanced water cooled reactors

Participants in the coordinated research project (CRP) entitled 'Methodology for Assessing Pipe Failure Rates in Advanced Water Cooled Reactors', from ten organizations in eight Member States, developed a research plan for advanced water cooled reactors and an overview of the existing methodologies for pipe reliability analysis in the current fleet. The CRP entitled 'Probabilistic Safety Assessment (PSA) Benchmark for Multi-Unit/Multi-Reactor Sites' brings together PSA practitioners from 20 Member States with multi-unit water cooled reactor sites to further develop and test their methodologies for extending existing single-unit PSA analyses and results to a realistic multi-unit site, considering potential scenarios leading to coincidental or consequential damage to multiple cores and spent fuel pools. At the project's first research coordination meeting, in June, an overall CRP task plan and the work plan for the first year of CRP implementation were developed.

At a Technical Meeting on Hydrogen Management in Severe Accidents, held in Vienna in September, 29 participants from 21 Member States and an international organization discussed hydrogen behaviour during severe accidents and validation and verification of codes, and identified further research and development needs. In October, the Agency conducted a pioneering Technical Meeting on Nuclear–Renewable Hybrid Energy Systems for Decarbonized Energy Production and Cogeneration, where 24 experts from 15 Member States exchanged knowledge on these technology designs and related innovations.

At the Training Workshop on the Development of Severe Accident Management Guidelines Using the IAEA's SAMG-D Toolkit, held in Vienna from 29 October to 1 November, 27 participants from 20 Member States shared knowledge about developing guidance on the mitigatory actions to be taken during severe accidents in nuclear power plants. This was the fourth such training workshop conducted by the Agency.

The Agency also conducted three national training courses, for Jordan, Saudi Arabia and Sri Lanka, and three interregional training courses on reactor technology assessment to support Member States that are considering or embarking on a new nuclear power

programme. An Excel based toolkit was provided to the Member States to train them in using the Agency's methodology for reactor technology assessment.

The First Joint ICTP–IAEA Course on Scientific Novelties in Phenomenology of Severe Accidents in Water Cooled Reactors was held in Trieste, Italy, in October. Attended by 25 young professionals and engineers from 16 Member States, the course covered a range of topics relevant to the progression of severe accidents in water cooled reactors, including an overview of the associated scientific issues and of technologies designed to cope with such events.

"the Agency conducted two interregional training courses on severe accidents in water cooled reactors and, using Agency basic principle simulators, three training courses on the physics and technology of advanced water cooled reactors."

In 2018, the Agency conducted two interregional training courses on severe accidents in water cooled reactors and, using Agency basic principle simulators, three training courses on the physics and technology of advanced water cooled reactors. To support these efforts, the Agency published *Developing a Systematic Education and Training Approach Using Personal Computer Based Simulators for Nuclear Power Programmes* (IAEA-TECDOC-1836), providing an overview of the current status of PC based basic principle simulators and their application in education and training.

Small and medium sized or modular reactors (SMRs)

In response to Member State interest in SMRs, the Agency published *Deployment Indicators for Small Modular Reactors* (IAEA-TECDOC-1854), presenting a methodology that can be used by Member States to evaluate indicators for the possible deployment of SMRs in a national energy portfolio. It also made available the 2018 edition of *Advances in Small Modular Reactor Technology Developments*, a supplement to its Advanced Reactors Information System database. The new edition contains design descriptions for 56 SMRs, provided by 14 Member States.

The first meeting of the new Technical Working Group on Small and Medium Sized or Modular Reactors took place in Vienna in April. Twenty-five representatives of 14 Member States and 2 international organizations identified topical areas of common interest for future collaboration, including development of generic user requirements and criteria; research, technology development and establishment of codes and standards; and design engineering, testing, manufacturing, supply chain and construction.

Fast reactors

The Agency issued two publications on topics related to fast reactors in 2018. The proceedings of the International Conference on Fast Reactors and Related Fuel Cycles: Next Generation Nuclear Systems for Sustainable Development (FR17), held in Yekaterinburg, Russian Federation in 2017, provides a summary of the different technical, plenary and young generation event sessions as well as the speeches delivered during the conference. *Experimental Facilities in Support of Liquid Metal Cooled Fast Neutron Systems* (IAEA Nuclear Energy Series No. NP-T-1.15) provides detailed information on experimental facilities currently in the design phase, under construction or in operation. The publication is a supplement to the Agency's corresponding on-line Catalogue of Facilities in Support of Liquid Metal Cooled Fast Neutron Systems.

The 2018 Joint ICTP–IAEA Workshop on Physics and Technology of Innovative Nuclear Energy Systems (Fig. 2) was attended by 36 young scientists, researchers, engineers and students from 20 Member States. The workshop, held in Trieste, Italy, in August, provided an opportunity to review state of the art reactor design concepts and nuclear fuel cycle options, including design and technological features of various innovative reactor types.

In 2018, the Agency launched two CRPs aimed at improving Member States' analytical capabilities for numerical simulation of sodium cooled fast reactors. The CRP entitled 'Neutronics Benchmark of CEFR Start-Up Tests' will focus on validation of the reactor neutronics simulation codes against recent experimental data measured during physical

FIG. 2. Participants in the Joint ICTP–IAEA Workshop on Physics and Technology of Innovative Nuclear Energy Systems discuss various design concepts and nuclear fuel cycle options.

start-up of the China Experimental Fast Reactor (CEFR). In the CRP entitled 'Benchmark Analysis of FFTF Loss of Flow Without Scram Test', state of the art simulation tools will be used to model multi-physics phenomena. Under the CRP, 25 participants from 13 countries will validate the tools against observations from tests at the Fast Flux Test Facility (FFTF) in the United States of America aimed at demonstrating the reactor's capability to survive severe unprotected loss of flow accidents.

High temperature reactors

As part of its initiative to preserve the knowledge of high temperature reactors developed in Member States, the Agency organized a Technical Meeting on Knowledge Preservation for Gas Cooled Reactor Technology and Experimental Facilities in Vienna in December. The meeting was attended by 17 participants from 11 Member States, who identified the knowledge of gas cooled reactors and high temperature gas reactors that needs to be preserved, such as reports, records, software codes and information on experimental facilities.

The Agency published a peer reviewed article on the use of heat from high temperature nuclear reactors as an option for energy neutral mineral processing, through the simultaneous extraction of unconventional uranium during primary ore processing. The article, published in the journal *Sustainability* in January, was produced by experts from 16 Member States participating in an ongoing CRP entitled 'Uranium/Thorium Fuelled High Temperature Gas Cooled Reactor Applications for Energy Neutral and Sustainable Comprehensive Extraction and Mineral Product Development Processes'.

In response to growing Member State interest in molten salt reactor technology, the Agency organized a Technical Meeting on the Status of the IAEA Nuclear Graphite Knowledge Base, held in Vienna in December. At the meeting, 11 molten salt reactor designers and graphite manufacturers from 8 Member States reviewed and updated data in the IAEA Nuclear Graphite Knowledge Base and identified new users of the database and further needs of Member States.

Non-electric Applications of Nuclear Power

In the area of non-electric applications of nuclear power, the Agency published *Examining the Technoeconomics of Nuclear Hydrogen Production and Benchmark Analysis of the IAEA HEEP Software* (IAEA-TECDOC-1859), documenting the results of a CRP completed in 2016. It also launched a new CRP entitled 'Assessing Technical and Economic Aspects of Nuclear Hydrogen Production for Near-term Deployment' with the participation of nine Member States.

A Technical Meeting on the Deployment of Non-Electric Applications Using Nuclear Energy for Climate Change Mitigation was held in Vienna in April. The meeting, with 18 participants from 16 Member States, focused on the future role of nuclear energy for non-electric applications, especially in the heating and transport sectors. At a Technical Meeting to Assess the Prospects of Coupling Non-Electric Applications to High Temperature Nuclear Reactors, held in Vienna in November, 12 participants from 11 Member States discussed the role of nuclear hydrogen production in the future hydrogen economy. In June, the Agency organized a Technical Meeting on Efficient Energy and Water Management in Nuclear Power Plants: Strategies, Policies and Innovative Approaches, where 14 participants from 10 Member States and an international organization reviewed the application of cogeneration — electricity generation and process heat production — for non-electric applications.

During the year, the Agency released an updated version of its Water Management Program (WAMP) software, used for the estimation of water needs in nuclear power plants.

Enhancing Global Nuclear Energy Sustainability through Innovation

The 15th INPRO (International Project on Innovative Nuclear Reactors and Fuel Cycles) Dialogue Forum on Sustainable Supply Chains for Advanced Nuclear Power Systems was held in Vienna in July. Forty-five participants from 28 Member States and 3 international organizations shared information, perspectives and knowledge on issues important to the national, regional and global nuclear supply chains. The 16th INPRO Dialogue Forum on Opportunities and Issues in Non-Electric Applications of Nuclear Energy, held in Vienna in December with 46 participants from 32 Member States and 2 international organizations, focused on technology and institutional aspects of the deployment of non-electric applications of nuclear energy, such as market, resources, effects of regulation and public acceptance issues.

The Agency issued *Enhancing Benefits of Nuclear Energy Technology Innovation through Cooperation among Countries: Final Report of the INPRO Collaborative Project SYNERGIES* (IAEA Nuclear Energy Series No. NF-T-4.9). The publication includes 28 case studies conducted by Member States to identify and evaluate mutually beneficial patterns of cooperation in the nuclear fuel cycle and associated driving forces and impediments.

It also published *Experience in Modelling Nuclear Energy Systems with MESSAGE: Country Case Studies* (IAEA-TECDOC-1837), documenting the experience gained in modelling national and global nuclear energy systems using the Agency's Model for Energy Supply Strategy Alternatives and their General Environmental Impacts (MESSAGE) code through various case studies performed by participating Member States. The feedback from the case studies demonstrated the analytical capabilities of the MESSAGE model and identified possible enhancements for the MESSAGE code and for nuclear energy system modelling.

Nuclear Fuel Cycle and Waste Management

Objective

To raise awareness and promote the implementation of a safe and sustainable fuel cycle and life cycle management for nuclear energy programmes and nuclear applications users, and contingency planning for post-incident situation. To support Member States in strengthening their own capabilities and trained human resources, or having access to the best available knowledge, technologies, services.

Uranium Resources and Processing

The Agency issued *Geological Classification of Uranium Deposits and Description of Selected Examples* (IAEA-TECDOC-1842), which provides a new classification scheme with improved definitions of uranium deposits and encompasses the recent advances in understanding of uranium geology and deposit genesis. It also published *World Distribution of Uranium Deposits (UDEPO) 2016 Edition* (IAEA-TECDOC-1843), presenting information on worldwide uranium deposits, including, for the first time, preliminary statistical and tabular analysis of the data. The information from these publications was released as an on-line interactive and integrated digital map entitled *World Distribution of Uranium Deposits, Second Edition*. The map (Fig. 1) provides information by types of deposit and features enhanced functionality with layers and query capability.

"[The Agency] published World Distribution of Uranium Deposits (UDEPO) 2016 Edition … *including, for the first time, preliminary statistical and tabular analysis of the data."*

FIG. 1. The second edition of the World Distribution of Uranium Deposits (UDEPO) map.

FIG. 2. Workshop participants at a trial mine of the Gattar uranium deposit, Egypt.

In May, the Agency organized a Regional Training Course on Achieving and Maintaining Good Operational and Environmental Performance of Uranium Projects in the African Region, held in Hurghada, Egypt. At the workshop, 31 participants from 13 Member States, including early to mid-career scientists, engineers, technicians and regulators as well as senior professionals, concluded that considering environmental, radiation protection, social and industrial safety issues is important at all stages of uranium projects (Fig. 2).

In June, the Agency issued *Uranium Resources as Co- and By-products of Polymetallic, Base, Rare Earth and Precious Metal Ore Deposits* (IAEA-TECDOC-1849) to raise awareness of the potential presence of uranium in ore deposits that are not commonly thought of as containing uranium, and thus to highlight potential additional sources of uranium.

The Agency's Interregional Workshop on Case Study of In-situ Leach Project: From Exploration to Closure, held in Beijing in August, enabled 55 participants from 9 Member States to exchange technical knowledge on in situ leaching of uranium, with an emphasis on China's experience. In October, the Agency organized an Interregional Workshop on Aspects of Effective Safety Practices and Implementation of a Conventional Safety Programme in Uranium Mines and Mills, in Adelaide, Australia. At the workshop, 17 participants from 15 Member States exchanged information on good practice in industrial mine safety programmes, an essential complement to radiation protection at uranium mines and mills.

The Agency issued *Unconformity-related Uranium Deposits* (IAEA-TECDOC 1857) in November, describing existing and emerging technologies for effective integration of geological, geophysical and geochemical data to recognize a deposit's 'footprint'. Improved understanding of the characteristics of such deposits is expected to help refine exploration and evaluation strategies.

The 27th edition of the joint IAEA–OECD Nuclear Energy Agency publication *Uranium 2018: Resources, Production and Demand*, also known as the 'Red Book', was published in December. It provides the most recent review of world uranium market fundamentals and presents a statistical profile of the world uranium industry, including data from 41 uranium producing and consuming countries. One of the main findings of the publication is that the world's supply of uranium is more than adequate to meet projected demand for the

foreseeable future, provided investment is secured to ensure that identified resources can be brought into production in a timely manner. Also in December, the Agency published *Quantitative and Spatial Evaluations of Undiscovered Uranium Resources* (IAEA-TECDOC-1861), providing an overview of aspects of the uranium production cycle, including an evaluation of the global uranium supply and demand situation.

Nuclear Power Reactor Fuel

Forty experts from 12 Member States attended the Technical Meeting on Light Water Reactor Fuel Enrichment beyond the 5% Limit: Perspectives and Challenges, held in Moscow in August. Participants exchanged views on national perspectives, R&D progress and results, and related licensing issues for the use of fuel enrichment above the 5% limit in light water reactors.

The Agency issued *Accelerator Simulation and Theoretical Modelling of Radiation Effects in Structural Materials* (IAEA Nuclear Energy Series No. NF-T-2.2), summarizing the findings and conclusions of the coordinated research project (CRP) entitled 'Accelerator Simulation and Theoretical Modelling of Radiation Effects (SMoRE)'. The four year project supported Member States in the development of advanced radiation resistant structural materials for use in innovative nuclear systems.

During the Technical Meeting on Nuclear Fuel Cycle Facilities: Information System and Ageing Issues, held in Vienna in October, ten experts from ten Member States presented and discussed country reports on nuclear fuel cycle facilities and their general trends and projections.

Management of Spent Fuel from Nuclear Power Reactors

A Technical Meeting on the Management of Spent Fuel at Shutdown Reactor Sites, Including Those to Be Shut Down Prematurely was held in Vienna in June, attended by nine experts from eight Member States and an international organization. At the meeting, operators discussed different plans for managing spent fuel at shutdown nuclear power plants and the issues associated with spent fuel management over the long term. The information obtained during the meeting will be consolidated and published as an IAEA Technical Document and used to update global inventories of spent fuel at shutdown reactor sites.

In July, 29 experts from 19 Member States participated in the Technical Meeting on Integrated Approaches to the Back End of the Fuel Cycle, where they discussed and analysed how decisions made in one part of the nuclear fuel cycle may affect its back end. The meeting participants also identified processes and best practices for a holistic approach to the fuel cycle, with an emphasis on all potential impacts on spent fuel (re)processing, recycling, storage, transport and disposal.

Radioactive Waste Management

Member State demand for the Agency's peer review and advisory services continued to increase. At the request of Member States, the Agency completed five Integrated Review Service for Radioactive Waste and Spent Fuel Management, Decommissioning and Remediation (ARTEMIS) missions, to Brazil, Bulgaria, France, Italy and Luxembourg, and a combined ARTEMIS and Integrated Regulatory Review Service (IRRS) mission to Spain. It received a further seven Member State requests for ARTEMIS reviews, to be conducted in the next few years.

The Agency organized a meeting in Vienna in November, where 14 experts shared lessons from recent ARTEMIS missions, which will be included in the ARTEMIS guidelines, as appropriate.

The Agency held a Technical Meeting on the Current Status of the Predisposal Management of Institutional Radioactive Waste at its Headquarters in Vienna in July. More than 30 participants from 25 Member States reviewed trends in the processing and storage of institutional radioactive waste, and areas that require special consideration and further development. These reviews will be published in a technical report that will also include case studies, in order to provide updated information on institutional radioactive waste processing and storage technologies and facilities. In March, the Agency organized a Technical Meeting on Methodologies and Approaches to Address Challenges in Managing Radioactive Waste from Past Activities, to gather the experiences of Member States in managing legacy waste inventories, including information on the barriers to implementing successful management of such inventories, strategies to facilitate cleanup activities and actions that need to be taken now in order to avoid waste streams becoming legacy waste in the future. The meeting, held in Vienna, was attended by 26 participants from 14 Member States.

The Agency finalized the structure of its Nuclear Communicator's Toolbox, which provides a range of resources to assist in the communication of nuclear matters to the public and the media. It also held a Technical Meeting on Learning from the Experiences of Local Communities on Stakeholder Involvement in Radioactive Waste Management Programmes, with 95 participants from 25 Member States and an international organization. The participants shared experiences and lessons learned on topics related to local stakeholder involvement in radioactive waste management and provided input for a new publication on this topic.

The Agency launched two new CRPs in the field of radioactive waste management in 2018. The CRP entitled 'Management of Wastes Containing Long-lived Alpha Emitters: Characterization, Processing and Storage' is aimed at increasing the understanding of the inventory, diversity and methods of handling wastes containing long lived alpha emitters. The CRP entitled 'Developing a Framework for the Effective Implementation of a Borehole Disposal System' focuses on the development of a standardized set of technical specifications, procedures, guidance and training material to address all aspects of a disposal programme and to make this disposal solution more readily implementable by Member States.

"the Agency completed the development of its on-line course on disused sealed radioactive sources (DSRSs) and published it on [CLP4NET]."

In 2018, the Agency completed the development of its on-line course on disused sealed radioactive sources (DSRSs) and published it on the Cyber Learning Platform for Network Education and Training (CLP4NET). To enhance the use of e-learning modules, the Agency made a number of e-learning modules available off-line, and developed and translated into other languages training courses based on e learning modules.

The Agency, in cooperation with the European Commission and the Nuclear Energy Agency of the Organisation for Economic Co-operation and Development, held the Annual Meeting on the Status and Trends Project on Spent Fuel and Radioactive Waste, in Luxembourg in July. At the meeting, 30 participants from 14 Member States reviewed the second project report, which provides an updated overview of the global arisings of spent fuel and radioactive waste and provisions for their long term management. The first project report, entitled *Status and Trends in Spent Fuel and Radioactive Waste Management* (IAEA Nuclear Energy Series No. NW-T-1.14), was published in January.

The Agency also published *Options for Management of Spent Fuel and Radioactive Waste for Countries Developing New Nuclear Power Programmes* (IAEA Nuclear Energy Series No. NW-T-1.24 (Rev. 1)), an update of guidance originally published in 2013. The revised publication provides a summary of key issues related to the development of a sound radioactive waste and spent nuclear fuel management system.

Management of Disused Sealed Radioactive Sources

At the request of Member States, the Agency completed a project to remove 27 Category 1 and 2 DSRSs from Bolivia, Ecuador, Paraguay, Peru and Uruguay. The five month project was completed in March with the transport of the sources to Germany and the United States of America for recycling. Another three Category 1 and 2 DSRSs were removed from Lebanon and sent back to Canada. The Agency also supported the training of about 80 experts from more than 45 Member States in conditioning, and safe and secure management of Category 3 to 5 DSRSs. Missions to condition DSRSs were conducted to Chile, Ghana, Indonesia, Jordan, Malaysia, Malta, Sri Lanka and Viet Nam.

Over 80 Member State delegates attended the Agency's side event entitled 'Innovative Solutions for the Effective Management of Disused Sealed Radioactive Sources' held in Vienna in September, during the 62nd regular session of the General Conference. The event highlighted different technologies for the management of DSRSs and how they are used in different national settings and conditions. It also featured a hands-on demonstration of safe handling of DSRSs (Fig. 3).

FIG. 3. Agency experts demonstrate safe handling of DSRSs (with mock objects) at the 62nd regular session of the General Conference.

Decommissioning and Environmental Remediation

Decommissioning

The second phase of the Agency's international collaborative project on Data Analysis and Collection for Costing of Research Reactor Decommissioning (DACCORD) made significant progress, including the development of methodologies and associated software to analyse uncertainties in cost estimates. At an Agency technical meeting held in Vienna in October, 29 participants from 26 Member States contributed to the development of the final report of the project, including determination of the detailed decommissioning costing cases to be addressed, costing implications of different strategies for facility characterization, and approaches to addressing uncertainty and risk in decommissioning cost estimates.

The Agency's on-site support in the decommissioning of the FOTON research reactor in Tashkent resulted in the release of the site from regulatory control in September, followed by the conventional demolition of buildings and structures on the site.

In November, the Agency conducted the fourth international peer review of Japan's Mid-and-Long-Term Roadmap towards the Decommissioning of TEPCO's Fukushima Daiichi Nuclear Power Station Units 1-4 and delivered a preliminary summary report on the progress made. The report acknowledges Japan's significant progress towards a stable situation since the accident in March 2011, which will enable Japan to focus more resources on detailed planning and implementation of decommissioning activities on the whole site.

The Agency published *Lessons Learned from the Deferred Dismantling of Nuclear Facilities* (IAEA Nuclear Energy Series No. NW-T-2.11), providing a consolidated review of experience and practical guidance on planning, managing and implementing the safe enclosure of shutdown nuclear facilities. It also launched an initiative to produce a report outlining training and human resources needs for decommissioning of nuclear facilities.

The Agency's International Decommissioning Network (IDN) continued to promote collaboration and information sharing, including through the development of the wiki based resource on decommissioning technologies and case studies from ongoing decommissioning projects. More than 100 case studies from decommissioning projects were uploaded to the IDN wiki in 2018, bringing the total number to 280. Together with descriptions of about 130 technological processes used in decommissioning, this information is shared with decommissioning experts all over the world as members of IDN.

Environmental remediation

The Agency organized the ninth annual Plenary Meeting of the Network on Environmental Management and Remediation (ENVIRONET) in Vienna, from 30 October to 1 November. The meeting's 50 participants from 24 Member States reviewed the status of the different projects conducted under the auspices of ENVIRONET, discussed possible improvements and suggested future activities. By sharing outcomes of several projects through ENVIRONET, the Agency helped Member States to develop their remediation programme strategies, such as for the remediation of uranium mining legacy sites in Bulgaria.

"the Agency organized a Practical Training Course on Planning and Implementation of Nuclear Facility Decommissioning and Remediation of Radioactively Contaminated Sites…. [presenting] aspects that can constrain or delay project implementation"

In April, the Agency organized a Practical Training Course on Planning and Implementation of Nuclear Facility Decommissioning and Remediation of Radioactively Contaminated Sites, held at Argonne National Laboratory in the United States of America and attended by 20 experts from 17 Member States. The course presented aspects of decommissioning and remediation that can constrain or delay project implementation as well as potential mechanisms that can assist in overcoming them. The course will serve as the basis for the development of an Agency School of Environmental Remediation.

The Agency supported the first European NORM Association workshop and organized a Technical Meeting on Naturally Occurring Radioactive Material, held concurrently in Katowice, Poland, in November. Among the objectives of these events were the development of project guidance on inventory of naturally occurring radioactive material (NORM) waste at the national level, formulation of NORM policy and strategy, and cost estimates of NORM waste management approaches.

Capacity Building and Nuclear Knowledge for Sustainable Energy Development

Objective

To support Member States in strengthening their capacities to elaborate robust energy strategies, plans and programmes, and to improve the understanding of nuclear technology's contribution in achieving the SDGs. To support Member States in strengthening their capacities to establish, manage and utilize their nuclear knowledge base by disseminating knowledge management methodologies, guidance and tools. To acquire, preserve and provide information in the area of nuclear science and technology to facilitate sustainable information sharing among Member States.

Energy Modelling, Databanks and Capacity Building

In 2018, the Agency conducted 34 capacity building events, providing training in energy planning to over 300 professionals from over 60 Member States in Africa, Eastern Europe and Latin America and the Caribbean. The Agency updated and enhanced its energy planning tools — now in use by 150 Member States and 21 international organizations — as well as the related multilingual training materials, including e-learning packages.

At the United Nations Global SDG 7 Conference, held in Bangkok in February, the Agency hosted an exhibition to present its energy planning activities, including its tools for developing comprehensive supply and demand analysis and assessing energy policies for the achievement of the Sustainable Development Goals (SDGs). At the United Nations High-level Political Forum on Sustainable Development, held in New York in July, the Agency supported the training session on SDG 7, addressing affordable and clean energy, and presented key elements of its capacity building framework for energy planning.

The Agency updated its annual publication *Energy, Electricity and Nuclear Power Estimates for the Period up to 2050* (Reference Data Series No. 1), which incorporates recent market and policy developments and provides detailed descriptions of the current situation and projections for the future.

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Energy–Economy–Environment (3E) Analysis

At the 24th session of the Conference of the Parties to the United Nations Framework Convention on Climate Change (COP24), held in Katowice, Poland, in December, the Agency served as the focal point for the United Nations exhibit showcasing low carbon energy pathways supporting the SDGs and nationally determined contributions. It also led the joint United Nations side event on SDG 7 (Fig. 1), focused on clean and affordable energy and solutions for cities, particularly megacities. The event covered supply options such as small and medium sized or modular reactors, and demand requirements such as efficiency, electro-mobility, modernized industrial zones and e-commerce. The Agency's side event at

FIG. 1. The Agency led the joint United Nations side event entitled 'Clean and Affordable Energy for Sustainable Urbanization and Development' at COP24 in December.

the SDG Pavilion highlighted the role of capacity building in informing decision makers on the transition to a low carbon future. To increase outreach, the Agency participated in side events organized within the international initiatives 'Nuclear for Climate' and 'Nuclear Innovation: Clean Energy Future' to stress the role of nuclear science and technology in combatting climate change and contributing to sustainable development, and to present the Agency's support for Member States in energy planning.

Ahead of COP24, the Agency produced a report entitled *Climate Change and Nuclear Power 2018* and a new brochure entitled *Financing Nuclear Power in Evolving Electricity Markets*. The new materials augment the Agency's ongoing support to Member States in the implementation of the Paris Agreement on climate change.

At the Ninth International Forum on Energy for Sustainable Development, held in Kyiv in November, the Agency cooperated with the United Nations Economic Commission for Europe to organize the session on nuclear energy for sustainable development. One of the conclusions of the Forum was that all energy sources — including renewables, nuclear energy and high efficiency fossil fuel with carbon capture and storage — must be considered, along with new business models and significant improvements in energy efficiency and productivity, to ensure that the energy needed for sustainable development is available and affordable.

In November, the Agency brought together 23 experts from 14 Member States and 4 United Nations agencies and non-governmental organizations at a technical meeting to showcase and exchange experience on the Agency's climate, land, energy and water framework for developing integrated energy and sustainable development strategies.

Throughout 2018, the Agency continued several initiatives to address Member States' needs in terms of approaches to cost estimation and the assessment of economic effects of nuclear power projects. In April, the Agency convened a Technical Meeting on Nuclear Power Cost Estimation and Analysis Methodologies, with 45 experts from 20 Member States, as part of a series of meetings within the nuclear cost basis project initiated in 2017. In June, training was provided to 20 experts from the Philippines on the newly developed Extended Input Output Model for Nuclear Power Plant Impact Assessment (EMPOWER) modelling tool for estimating economy-wide, sectoral and employment effects of national nuclear power programmes.

Nuclear Knowledge Management

In 2018, five Nuclear Energy Management (NEM) Schools, held in Italy, Japan, the Russian Federation and South Africa, attracted 128 participants. This included the first Russia–IAEA Nuclear Energy Management School for Managers in Nuclear Organizations, which focused on supporting middle level managers and decision makers in the nuclear sector in enhancing managerial and technical competencies essential for establishing or expanding national nuclear energy programmes. Two Nuclear Knowledge Management (NKM) Schools were also held, attended by 71 participants from 30 Member States. To date, a total of 887 NEM School participants and 698 NKM School participants from around 80 Member States have benefited from these programmes.

The Agency's Cyber Learning Platform for Network Education and Training (CLP4NET) hosted more than 640 on-line courses in 2018, including the courses for prequalification for the NEM and NKM Schools.

The Agency carried out Knowledge Management Assist Visits (KMAVs) to the Emirates Nuclear Energy Corporation in the United Arab Emirates in February, to the National Nuclear Energy Agency of Indonesia in June, and to the Nuclear Energy Commission of Mongolia and the National University of Mongolia in December. The objective of the visits was to review the nuclear knowledge management programmes of these institutions and to provide expert advice on how to improve them.

Through its Education Capability Assessment and Planning framework, the Agency provided support to Nigeria in efforts to establish sustainable nuclear education and training programmes. It also implemented initial KMAVs to the National Polytechnic University of Armenia and the Harbin Engineering University in China to assess the feasibility of implementing master's programmes in nuclear technology management at these universities within the Agency's International Nuclear Management Academy framework.

"INIS reached 4.2 million records, including almost 570 000 full texts that are not available through commercial channels."

Collection and Dissemination of Nuclear Information

At the end of 2018, the membership of the International Nuclear Information System (INIS) comprised 131 Member States and 24 international organizations. INIS reached 4.2 million records, including almost 570 000 full texts that are not available through commercial channels. The Agency added 108 196 bibliographic records and over 19 000 full texts to the INIS repository, which had over 3.2 million page views during the year. The INIS Multilingual Thesaurus continued to serve the international community in eight languages.

The 39th Consultative Meeting of INIS Liaison Officers, held in Vienna in October, was attended by 66 participants from 61 Member States and 2 international organizations. The event featured an INIS forum entitled 'The Changing World of Information', where invited speakers discussed topics such as the role of information systems and services in achieving the SDGs.

The IAEA Library continued to ensure that information resources and services remained current, cost effective and easily accessible. In 2018, the number of electronic journals available through the Library increased to over 58 300, more than 8000 people visited the Library, over 1900 items were checked out and over 1800 interlibrary loans were enabled. The Agency created over 1100 personalized Library user profiles, in response to continued requests for tailored packaging of nuclear information products and services. It also offered 15 training sessions on general aspects of the Library, attended by 220 participants.

Nuclear Science

Objective

To support Member States in strengthening capabilities in the development and application of nuclear science as a tool for their technological and economic development. To assist Member States in enhancing sustainable operation, including effective utilization of research reactors, in implementing new research reactor projects and nuclear capacity building programmes, based on access to research reactors.

Nuclear Data

Nuclear physics experts can now coordinate their efforts to develop better nuclear reaction data tables through the Agency's new International Nuclear Data Evaluation Network (INDEN). Launched in 2018, INDEN is expected to stimulate advances in neutron cross-section evaluation of nuclides that are particularly relevant to nuclear technologies. Within INDEN, experts can collaborate on innovative measurements and model simulations to come to the best possible nuclear reaction data tables for light nuclides such as carbon and nitrogen, structural materials such as chromium and nickel, and important actinides such as the plutonium isotopes.

The Agency's Nuclear Data Services portal continued to host key nuclear data libraries for both power and non-power applications. Additions in 2018 included the JENDL Photonuclear Data File 2016 (JENDL/PD-2016) and the JENDL Activation Cross Section File for Nuclear Decommissioning 2017 (JENDL/AD-2017), both released by Japan.

The Agency organized a crowdsourcing challenge aimed at analysing computer simulated damage to a fusion reactor wall exposed to high temperatures and bombardment by highly energetic neutrons and other particles. The challenge was won by a team of scientists from the Max Planck Institute for Plasma Physics and the Max Planck Computing and Data Facility in Garching, Germany, whose molecular dynamics approach simulated this the most efficiently (Fig. 1).

Research Reactors

Utilization and applications of research reactors

The Agency carried out proficiency testing involving 41 neutron activation analysis laboratories in 29 Member States through an interlaboratory comparison that provided evidence of the validity of their measurement results. In October, it organized a Training Workshop on E-learning Tools for Neutron Activation Analysis, with 28 participants from 22 Member States, as well as an expert mission to evaluate the current status of the neutron activation analysis facility at the Jordan Research and Training Reactor.

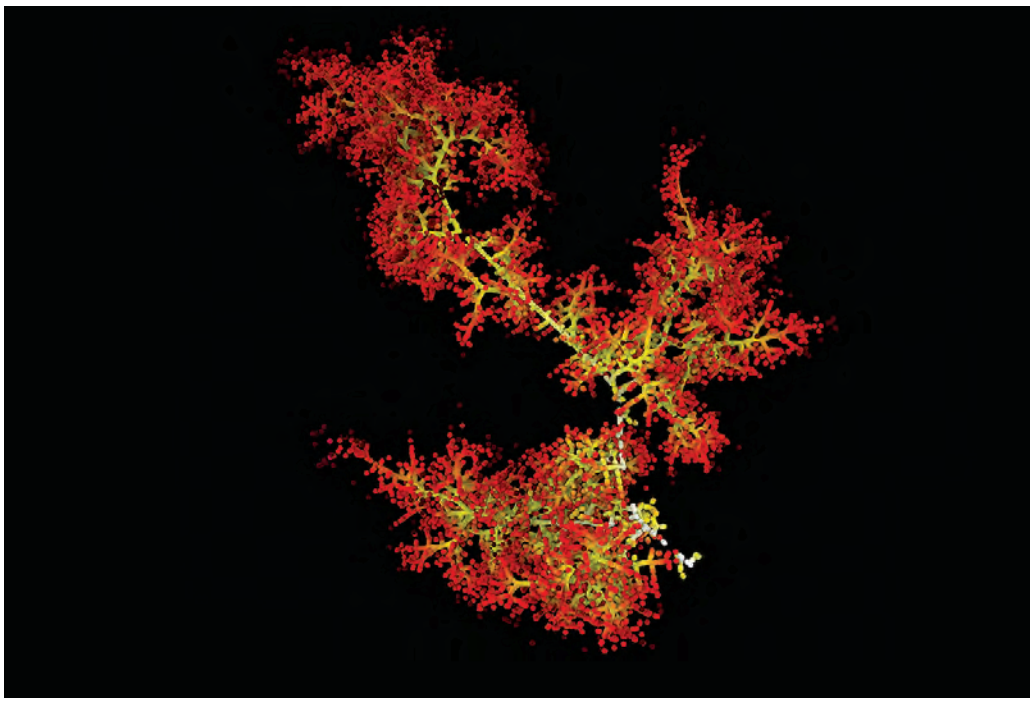

FIG. 1. Representation of a molecular dynamics simulation of damage to a fusion reactor wall from the Max Planck Institute for Plasma Physics, Germany. (Photograph reproduced courtesy of Max Planck Institute for Plasma Physics, Germany.)

The Agency initiated a round robin test of contrast and resolution in 2-D and 3-D neutron imaging, in cooperation with the Paul Scherrer Institute. Five participants from five Member States had completed measurements by the end of the year. This effort marks the first steps toward international standards in the area of digital neutron radiography and tomography.

In October, the Technical Meeting on the Safety and Utilization of Subcritical Assemblies, held in Vienna, brought together 17 experts from 14 Member States to discuss issues related to the safe management and effective use of such facilities, including associated challenges, experiences and good practices. Participants also exchanged experiences in the application of the Agency's safety requirements for research reactors to subcritical assemblies.

A Training Workshop on Expansion of the Research Reactor Stakeholder Base through Strategic and Business Plans focused on methodologies for developing strategies and action plans to re-evaluate stakeholder needs and define new research reactor applications to expand their use. The workshop, held in Vienna in November, provided training to 25 participants from 18 Member States. Also in November, in cooperation with the Asia–Oceania Neutron Scattering Association (AONSA) and the Australian Nuclear Science and Technology Organisation (ANSTO), the Agency organized the AONSA 2018 Neutron School, in Sydney, Australia. The school provided young scientists with an introduction to neutron scattering techniques through hands-on experiments and data analysis conducted using instruments at the ANSTO.

The Agency issued two publications presenting the results of completed coordinated research projects (CRPs) on neutron activation analysis: *Advances in Neutron Activation Analysis of Large Objects with Emphasis on Archaeological Examples* (IAEA-TECDOC-1838) and *Development of an Integrated Approach to Routine Automation of Neutron Activation Analysis* (IAEA-TECDOC-1839).

New research reactor projects, infrastructure development and capacity building

"The first two INIR-RR missions were conducted in 2018"

The Agency's new Integrated Nuclear Infrastructure Review for Research Reactors (INIR-RR) peer review service assists Member States in the development of infrastructure for nuclear research reactors. The first two INIR-RR missions were conducted in 2018 — to Nigeria in February, and to Viet Nam in December. The final INIR RR mission report was delivered to Nigeria in December.

The Agency organized two workshops on its Milestones approach for a new research reactor project and on preparing for an INIR-RR mission. The first workshop, held in Zambia in September, was attended by about 20 representatives of governmental, public and private organizations; the second workshop, held in Thailand in November, provided information for around 50 representatives of various stakeholder organizations. A Training Workshop on the IAEA's Research Reactor Milestones Approach and on the Establishment of the Infrastructure for a New Research Reactor was held in October in Vienna, with 20 participants from 13 Member States, representing reactor operators, regulators, designers and vendors. The workshop focused on sharing experiences, challenges and lessons learned in the development and implementation of new research reactor projects. Thailand also hosted an expert mission on site evaluation for a new research reactor.

During the year, the Agency consolidated and expanded its instruments and tools: the Internet Reactor Laboratory, a distance training tool mainly for academic education (broadcasting sessions continued in 2018 for the Africa, Europe, and Latin America and the Caribbean regions); the Research Reactor Regional Schools (RRRSs), for basic training; the Eastern European Research Reactor Initiative (EERRI) for advanced hands-on training, mainly for young professionals; and the IAEA-designated International Centre based on Research Reactor (ICERR) scheme for specific, advanced training for young and senior professionals. In June, a Technical Meeting on the Role of Research Reactors in Human Capacity Building in Support of Nuclear Technology enabled 30 participants from 22 Member States to share their experiences using hands-on training at research reactors as a tool for the development and preservation of practical nuclear competencies.

The Agency provided support for the 14th Eastern European Research Reactor Initiative fellowship training course, which took place in Vienna and Prague from 24 September to 2 November. The course provided ten participants from six Member States with the necessary background to carry out activities related to the planning, commissioning, safe operation, maintenance and effective utilization of research reactors.

A new Agency publication issued in 2018, *Feasibility Study Preparation for New Research Reactor Programmes* (IAEA Nuclear Energy Series No. NG-T-3.18), describes considerations concerning the justification for a new research reactor, associated key nuclear infrastructure issues, cost–benefit analysis and risk management that should be addressed prior to authorization of a new research reactor project.

Research reactor fuel cycle

The Agency continued to provide support for the project to convert Nigeria's only operating research reactor, a miniature neutron source reactor (MNSR), from high enriched uranium (HEU) fuel to low enriched uranium (LEU) fuel and to return the HEU fuel to China. The project was successfully completed in December (Fig. 2). During the year, the Agency held two technical meetings on related topics. The ninth annual Technical Meeting on the Conversion of Miniature Neutron Source Reactors from High Enriched Uranium to Low Enriched Uranium Fuel, in Abuja, provided an opportunity for 21 participants from 6 countries to share lessons learned and discuss technical challenges related to MNSR conversion and HEU repatriation projects. At the 12th Technical Meeting on Lessons Learned from High Enriched Uranium Take-back Programmes, held in Beijing, 81 participants from

FIG. 2. Workers loading the HEU fuel into a container for transportation from Nigeria to China in December.

19 Member States shared information about the technical, legal, logistical, administrative and other challenges they had encountered in preparing and performing shipment operations, in order to facilitate planning for future shipments and to help avoid potential delays.

Technical experts and policy makers exchanged information about recent developments and prospects for further HEU minimization efforts at the third International Symposium on HEU Minimization. The symposium, organized by the Agency in cooperation with the Norwegian Ministry of Foreign Affairs and the Norwegian Radiation Protection Authority, was held in Oslo in June.

In November, the Agency supported the International Meeting on Reduced Enrichment for Research and Test Reactors, organized by the United States Department of Energy's National Nuclear Security Administration under its material management and minimization conversion programme. Held in Edinburgh, the meeting was attended by 148 participants from 22 Member States. Participants shared information on and experience with LEU fuels, conversion analysis studies and licensing of converted research reactors.

In October, 25 current and prospective producers of molybdenum-99 (Mo-99) from 11 Member States took part in a Technical Meeting on Global Capabilities for the Production and Manufacture of Non-High Enriched Uranium Mo-99 Targets. The participants shared experiences and discussed developments in the manufacture of non-HEU isotope production targets.

In November, the Agency held a Training Workshop on Research Reactor Spent Fuel Management in Vienna, where 38 owners, operators, designers and regulators of research reactors from 24 Member States exchanged information, experiences and knowledge relevant to spent fuel management.

Research reactor operation and maintenance

In March, the Agency conducted an Operation and Maintenance Assessment for Research Reactors (OMARR) mission to Uzbekistan's WWR-SM research reactor, aimed at improving operational and maintenance practices at the facility. Another OMARR mission was conducted in November to the TRIGA research reactor of the Bangladesh Atomic Energy Commission (BAEC). The mission team provided recommendations and suggestions to support BAEC in its preparation of an action plan to ensure efficient and

reliable operation of its research reactor for the next 15–20 years. In May, the Agency conducted a pre-OMARR mission to the TRICO-II research reactor in the Democratic Republic of the Congo, identifying areas requiring thorough review during the main mission.

The Agency organized two training workshops in the area of research reactors during the year. The Training Workshop on Online Monitoring, Non-Destructive Examination and In-Service Inspection of Research Reactors, held in Vienna in June and attended by 23 participants from 21 Member States, was aimed at improving practical competences in this field. The Workshop on Decommissioning Planning for Research Reactors, held in Vienna in August with 37 participants from 32 Member States, focused on the need to create a decommissioning plan while developing a reactor design and to update the plan during the reactor's operation.

In October, a Technical Meeting on Good Practices for the Operation and Maintenance of Research Reactors, with 30 participants from 26 Member States, provided a forum for the exchange of information, experiences and practical knowledge aimed at enhancing the performance, safety and reliability of such facilities.

The Agency organized a training course on the operation and maintenance of research reactors for the Latin America and the Caribbean region, held in Santiago in October. The 12 participants from 6 Member States also evaluated the Agency's relevant training materials to identify possible adjustments or improvements for future training courses on the same topic.

In November, an expert mission to Bangladesh carried out non-destructive examination and in-service inspection of the BAEC TRIGA research reactor. The Agency provided an underwater camera for visual inspection of reactor components located in the reactor pool.

Accelerator Applications

Accelerator Simulation and Theoretical Modelling of Radiation Effects in Structural Materials (IAEA Nuclear Energy Series No. NF-T-2.2), a new Agency publication issued in 2018, summarizes the key results of a CRP on the development of advanced radiation resistant structural materials for use in innovative nuclear systems. Nineteen leading nuclear research and development organizations from 15 Member States took part in the multi-year project.

In June, the Agency launched a new CRP entitled 'Facilitating Experiments with Ion Beam Accelerators'. The five year project will provide access to ion beam facilities for researchers from developing Member States without accelerators for analytical and irradiation purposes, as well as for hands-on training courses.

In October, a Technical Meeting on Advanced Methodologies for the Analysis of Materials in Energy Applications Using Ion Beam Accelerators, in Vienna, brought together 23 experts from 15 Member States. Participants discussed the current status of the techniques employed at ion beam accelerators to irradiate and analyse materials relevant to fast spectrum power reactors as well as future fusion reactors.

At a Technical Meeting on Novel Multidisciplinary Applications with Unstable Ion Beams and Complementary Techniques, organized in Vienna in December, 22 experts from 12 Member States discussed recent advances in unstable beam production and acceleration technologies, as well as various applications of radioactive ion beams, from materials research to radioisotope production.

Together with the Abdus Salam International Centre for Theoretical Physics (ICTP), the Agency organized a Joint ICTP–IAEA Advanced School on Ion Beam Driven Materials Engineering: Accelerators for a New Technology Era in Trieste, Italy, in October. The school highlighted the latest technological developments for engineering new material properties with ion beams, focusing in particular on quantum technologies. Twenty-five PhD students and early career researchers from 15 Member States took part.

In October, at the first Research Coordination Meeting of a CRP entitled 'Ion Beam Irradiation for High Level Nuclear Waste Form Development (INWARD)', 15 experts from 8 Member States discussed the use of ion beams to produce accelerated damage of waste forms in order to analyse and predict the behaviour of high level nuclear waste under different storage conditions. The results will be used to define the source terms for waste forms in evolving repository designs, thus enhancing the design and reducing uncertainty and costs.

The Agency's Accelerator Knowledge Portal was updated to include five different types of research infrastructure: electrostatic accelerators, synchrotron light sources, spallation neutron sources, neutron scattering instruments and X ray free electron lasers. In 2018, the portal was visited by 3135 users from 111 Member States.

The Agency published an article entitled 'IAEA fosters nuclear analytical techniques for forensic science' in the journal *Forensic Chemistry*. The paper focuses on the use of ion and neutron beam techniques for elemental and molecular analysis and on the Agency's role in coordinating the development of different techniques in the area of forensics. This article also served as an introduction to eight individual Member State publications on the same topic.

In October, the Agency organized a Technical Meeting on Guidelines for the Establishment and Optimization of Cold Neutron Sources in Research Reactor and Accelerator Facilities, aimed at producing a report on operating experience and the outlook for the development of cold neutron moderators, including design details and safety considerations. The meeting, held in Vienna, was attended by 26 participants from 13 Member States.

The Agency completed a comprehensive feasibility study for the establishment of a compact ion beam accelerator at its laboratories in Seibersdorf. The study was based on an extensive survey involving over 60 institutions and organizations in 40 Member States, aimed at identifying the need for access to accelerator technologies and applications, including for education and training.

The Agency published a brochure entitled *Discover the World with Nuclear Physics* showing various applications of ion beams and neutrons for material modification and analysis. The brochure features case studies — ranging from the methods used to analyse water on Mars and optimize fuel cells to those used to monitor air pollution — demonstrating the usefulness of these techniques for scientific purposes and for everyday life.

Nuclear Instrumentation

Over the year, the Agency's Nuclear Science and Instrumentation Laboratory organized or contributed to a series of training workshops and courses held at the Agency's facilities in Seibersdorf. About 100 participants from more than 30 Member States benefited from hands-on exercises using diverse instrumentation and detectors. Topics covered ranged from the use of radiotracers or radioisotope sealed source methodologies for industrial applications to radiological mapping with portable detection systems and nuclear analytical techniques employed for elemental analysis of various samples.

"[The Agency's Nuclear Science and Instrumentation Laboratory] organized and hosted group fellowship training on analytical techniques and applications based on X ray fluorescence, providing training for five fellows"

The laboratory also organized and hosted group fellowship training on analytical techniques and applications based on X ray fluorescence, providing training for five fellows from Brazil, Nigeria and Sri Lanka. It also commissioned a full-field X ray fluorescence spectrometer, used for non-destructive study of the spatial distribution of elements. The new equipment will be made available for training of fellows and young researchers.

In December, the Agency organized a Technical Meeting on Current Trends and Developments in Nuclear Instrumentation, where 11 experts from 11 Member States reviewed state of the art portable nuclear instrumentation for in situ environmental monitoring and discussed challenges for its effective utilization and maintenance.

In June, the Agency conducted an expert mission using backpack gamma spectrometers to measure radiation levels at the site of the Radiation and Technological Complex in

FIG. 3. Testing of the equipment installed at the ion beam accelerator facility at the Bangladesh Atomic Energy Commission.

Tashkent prior to the site's release from regulatory control. In October, the Agency provided support for a national training exercise on monitoring radiological events using an unmanned aerial vehicle system for rapid environmental mapping at four sites in Brazil.

The Agency, on request, provided targeted scientific and technical support to small accelerator facilities in Bangladesh (Fig. 3), Lebanon and Thailand. This included setting up dedicated beamlines and instrumentation, assisting in maintenance, installing upgrades, troubleshooting of default equipment and training personnel.

The Agency coordinated two proficiency test campaigns for interested analytical laboratories to help Member States improve the quality of their analytical results. Forty-three laboratories from 33 Member States tested samples of urban dust loaded on air filters, and 41 laboratories from 29 Member States tested samples of marine sediment and animal tissue.

The Agency also developed a tool based on R Markdown — a plain text format used to create dynamic documents — to facilitate the interpretation of geographic information systems for radiological measurements and the production of maps. The software was distributed to 19 interested national organizations from 16 Member States.

Nuclear Fusion

The 27th IAEA Fusion Energy Conference (FEC 2018) was held in Gandhinagar, India, in October. Over 700 experts from 39 Member States and 4 international organizations took part in discussions on key physics and technology issues, and on innovative concepts relevant to the use of nuclear fusion as a source of energy (Fig. 4).

The Agency issued a publication entitled *Integrated Approach to Safety Classification of Mechanical Components for Fusion Applications* (IAEA-TECDOC-1851), the first international reference document to comprehensively address this subject. The publication highlights the current state of the art assessment of safety classification of components for fusion applications.

The Agency's Eighth Technical Meeting on the Physics and Technology of Inertial Fusion Energy Targets and Chambers took place in Tashkent in March. Fifteen experts from 9 Member States took part, discussing technical solutions relevant to the design and

FIG. 4. The 27th IAEA FEC, a major event in the field of fusion, drew more than 700 participants and featured over 100 plenary talks and some 700 posters.

development of some key components of future inertial fusion reactors, including related safety considerations.

The Fifth IAEA Demonstration Fusion Power Plant Programme Workshop (DEMO) Programme Workshop, held in Daejeon, Republic of Korea, in May, assessed the present status of and prospects for progress in the use of magnet technology for magnetic confinement fusion, control of DEMO plasmas, and remote maintenance and plant logistics. The event included presentations on integrated assessment of liquid metals as plasma facing components on the first wall and divertor, on the status and progress of the Korean fusion demonstration reactor, and on the status and scientific objectives of the JT60-SA research tokamak in Japan. It was attended by 64 experts from 12 Member States and an international organization.

The First IAEA Workshop on Fusion Enterprises took place in June in Santa Fe, United States of America. During the workshop, 38 participants from 4 Member States analysed recent scientific and technical developments in this field, as well as the role of the private sector in the commercialization of future fusion energy systems.

During the 62nd regular session of the General Conference in September, the Agency organized a side event entitled 'Fusion Energy for Peace and Sustainable Development'. More than 100 delegates attended the event, which featured the film *Let There Be Light*, a documentary about the quest for fusion energy.

The Joint ICTP–IAEA College on Plasma Physics took place from 29 October to 9 November in Trieste, Italy. The college's 78 participants from 26 Member States focused on the study of collective phenomena of macroscopic systems in diverse settings such as classical and quantum domains, laboratories, space and cosmological systems.

Support for the ICTP

The Agency continued to support the ICTP in 2018, conducting 12 joint events attended by about 240 participants. Through the Sandwich Training Educational Programme, the Agency supported 25 PhD students. Agency support for the ICTP enables scientists from developing Member States to enhance knowledge and exchange information in the fields of theoretical physics and applied sciences.

Food and Agriculture

Objective

To contribute to the sustainable intensification of agricultural production and the improvement of global food security through capacity building and technology transfer to Member States. To increase the resilience of livelihoods to threats and crises that impact agriculture, including climate change, biothreats, food safety risks, and nuclear or radiological emergencies. 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.

Area-Wide Integrated Pest Management in the Niayes Region of Senegal

In 2018, the Agency, through the Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture, provided instrumental support to the Government led effort to suppress the tsetse population in the Niayes region of Senegal. As part of a long term tsetse eradication campaign, the Agency supplied technical support for and strategic advice on executing the overall tsetse control programme, involving the use of area-wide integrated pest management including the sterile insect technique (SIT) (Fig. 1). It also maintained

FIG. 1. Release of sterile tsetse flies in Senegal's Niayes region as part of a tsetse fly suppression and eradication campaign.

a colony of the target species at its laboratories in Seibersdorf, sending a shipment of 4000 sterile male pupae to Senegal for release each week. The weekly shipments of male pupae were produced in Slovakia and irradiated at the Agency's laboratories before transport. During the year, the Agency also provided technical backstopping to scientists in Burkina Faso to assist with the production of the sterile males to be used in Senegal.

The campaign resulted in the suppression of the tsetse population throughout the Niayes region and a dramatic decline in the frequency of the deadly African animal trypanosomosis disease transmitted by it. With the suppression of the tsetse fly, farmers who had been rearing only local cattle breeds — with natural tolerance to trypanosomosis but low milk and meat production and inferior reproductive rates — began importing more productive cattle, leading to increased incomes and a higher return on investment. This in turn brought a tenfold increase in imports of cattle and a 50–60% decrease in the overall cost of imported cattle.

Sterile Insect Technique for Control of Mosquitoes

In 2018, the Agency made important R&D advances on the SIT package to control disease-transmitting mosquitoes such as *Aedes aegypti* and *A. albopictus*, the vectors for dengue, chikungunya, Zika and yellow fever. Key developments during the year included a new automated mosquito larval counter for consistent and standardized rearing of mosquito in immature stages, and cost effective mosquito larval diets and a new mass rearing cage to reduce rearing costs. These developments allowed the Agency to initiate technology transfer to Member States through pilot projects to supress vector populations. In this context, by helping to design pilot trials and providing equipment for insect rearing, the Agency supported the use of area-wide integrated pest management in field suppression trials of SIT at a small scale in China, Greece and Italy (*A. albopictus*) and in Mexico (*A. aegypti*), and in field validation of a drone device to release sterile male *Aedes* mosquitoes in Brazil. This crucial upstream R&D, carried out at the Insect Pest Control Laboratory in Seibersdorf, was conducted collaboratively with national research institutes. Capacity building and the development of technology packages for transfer to Member States are central to these R&D activities. In 2018, mass rearing equipment was shipped to eight Member States; traps and other laboratory equipment were provided to 14 Member States; and expert missions were conducted to 12 Member States.

"Key developments during the year included a new automated mosquito larval counter for consistent and standardized rearing of mosquito in immature stages"

Many of the research outputs for *Aedes* species may also be useful for controlling *Anopheles* species, vectors for malaria. In 2018, R&D continued on *A. arabiensis*, focused on the development of a genetic sexing strain.

Small-Scale Drip Irrigation to Assist Farmers in Africa

As part of an initiative to expand the use of climate-smart soil and water management practices in Africa, the Agency introduced small-scale drip irrigation technology, guided by nuclear and related techniques, into impoverished rural areas of Mauritania and Zimbabwe in 2018. Through its Soil and Water Management and Crop Nutrition Laboratory in Seibersdorf, the Agency used stable isotope nitrogen-15 and neutron probes for measuring the moisture content of soil to determine the most effective use of fertilizer and water for enhanced subsistence agriculture in these arid areas. It then trained local experts and farmers in the use of the technology and in installing small-scale drip irrigation systems suited to local needs (Fig. 2). During the year, the initiative produced socioeconomic impacts for family farmers, particularly women, helping them not only to grow food in arid areas, but also to plant new types of vegetables, increase yields, improve the nutrition and health of their families and communities, and generate additional income. In Zimbabwe, increased

FIG. 2. Smallholder farmers in Mauritania, including women, have begun using small-scale drip irrigation to grow vegetables on arid land.

crop production allowed children to return to school and women to generate income from the sale of their produce. In Mauritania, more than 400 women and their families produced food for their own consumption and for selling, securing additional income for education and health. During the year, local authorities began scaling up the use of this technology by setting up more drip irrigation systems.

Diagnosis and Control of Disease Outbreaks

Food security and the livelihoods of livestock farmers in several Member States continued to be at risk from the continuous threats posed by animal infectious diseases, whose spread is exacerbated by climate change and the transboundary movement of animals and people. In 2018, the Agency, through its Veterinary Diagnostic Laboratory (VETLAB) Network, supported efforts to control outbreaks of African swine fever in Asia and Eastern Europe and peste des petits ruminants in Europe, the Middle East and Asia. Drawing on R&D carried out at the Animal Production and Health Laboratory in Seibersdorf, and continuous capacity building and transfer of technology, the VETLAB Network was able to share timely information among its technical networks regarding outbreaks of animal diseases, thus helping to control and contain them. It also provided technical support to strengthen the capabilities of Member State laboratories for the early detection, characterization, monitoring and control of animal diseases such as African swine fever in China, Hungary and Poland; peste des petits ruminants in Bulgaria; and Avian influenza in the Democratic Republic of the Congo (Fig. 3), Ghana, Lesotho, Mozambique, Myanmar and Namibia. The Agency conducted an interlaboratory test with the participation of 27 laboratories from 25 Member States worldwide aimed at verifying their proficiency and competence in diagnosing peste des petits ruminants through laboratory testing.

FIG. 3. In the Democratic Republic of the Congo, staff of the Central Veterinary Laboratory perform laboratory analysis for the characterization of Avian influenza during the 2018 outbreak.

Integrated Screening Techniques for Climate-Smart Agriculture

The Agency improved and tested integrated screening techniques in mutation breeding to support the development of climate-smart crop varieties adapted for climate change. In 2018, it developed and released two improved mutant varieties with tolerance to drought: the groundnut variety Tafra-1 in the Sudan, and the cowpea variety CBC5 in Zimbabwe.

During the year, the Agency's work on climate proofing of food crops, carried out through its Plant Breeding and Genetics Laboratory in Seibersdorf, yielded significant advances in heat and drought tolerance of rice and sorghum. For rice, pre-field screening protocols were developed for heat-tolerant mutants, and physiological screening protocols for tolerance to terminal drought stress were developed and used to confirm the improved performance of advanced mutant rice lines that showed better grain filling under drought stress imposed under greenhouse conditions. In sorghum, early maturity — an important secondary trait that facilitates drought avoidance — was explored in detail and an associated genomic region was identified; the genomic region will be explored further for the development of molecular marker(s). In this regard, the Agency put in place, for the first time, molecular marker and doubled haploid technologies that accelerate the pace of crop improvements to maintain resilience in the face of climate change and began sharing these technologies with Member States. As a result, one new CRP project was launched and another was designed in 2018. Both projects will focus on improving crop resistance to increasing frequencies and intensities of pests and diseases triggered by climate change.

"The Agency improved and tested integrated screening techniques in mutation breeding to support the development of climate-smart crop varieties adapted for climate change."

New Analytical Technologies for Supporting Food Authenticity and Food Traceability Systems

In 2018, the Agency concluded a five year CRP entitled 'Accessible Technologies for the Verification of Origin of Dairy Products as an Example Control System to Enhance Global Trade and Food Safety' that led to the development of innovative analytical methods for food authenticity and food traceability systems. The CRP successfully demonstrated the feasibility of using stable isotope and trace element (SITE) analysis combined with other nuclear and related techniques to establish the geographical origin and authenticity of both liquid and powdered milk. Achieving this important outcome involved the publication of 19 standard operating procedures and numerous scientific articles, including a standard operating procedure on the elemental analysis of milk powders using laser ablation inductively coupled plasma mass spectrometry in geographic sourcing. The dissemination effort helped those Member States involved in the CRP to become increasingly aware of the importance of SITE analysis and its wider applications in food authenticity and traceability based on production methods and geographical origin, as well as its potential to reduce barriers to trade and enhance consumer confidence. As a result, 13 Member States began increasing investments in their SITE capabilities in 2018. Furthermore, within the framework of the CRP, pilot studies were carried out in Slovenia and Singapore: Slovenia created and put in place the 'Selected Quality — Slovenia' protective mark for Slovenian milk and dairy products, using SITE as a 'fingerprinting' method for food authenticity and traceability, while Singapore, which imports all the milk products it consumes, used SITE profiling to verify the provenance of those imports.

Human Health

Objective

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

Estimating Required Medical Physics Staffing Levels for Radiology and Nuclear Medicine Departments

The vast majority of the population's exposure to ionizing radiation is due to medical imaging, yet the role of the medical physicist in this area is still largely underestimated. The widespread, and rapidly expanding, use of radiopharmaceuticals for therapeutic purposes requires clinical medical physicists competent to oversee equipment specification, maintenance and routine quality control, and to carry out specialized dosimetry calculations, all of which are key to quality management, dose optimization and clinical dosimetry. To help medical imaging departments determine the number of medical physicists needed to support established services, in 2018 the Agency published *Medical Physics Staffing Needs in Diagnostic Imaging and Radionuclide Therapy: An Activity Based Approach* (IAEA Human Health Reports No. 15). The publication, endorsed by the International Organization for Medical Physics, describes activity based staffing levels developed based on the roles and responsibilities of the medical physicist as described in international guidelines such as IAEA Safety Standards Series No. GSR Part 3 and in IAEA Human Health Series No. 25. These roles and responsibilities are divided into the following six major categories: equipment dependent; patient dependent; radiation protection related; service related; training related; or academic teaching and research related.

The publication also includes an accompanying spreadsheet developed to facilitate calculations of staffing needs in line with the guidance set out in the main text. The algorithm can be used to estimate staffing levels required for different sized institutions, including scenarios where comprehensive services are provided across multiple sites. The significance of and need for such guidance is evident from the interest of end users in Member States — the report has remained one of the ten most downloaded publications on the Agency's web site since its publication in February.

"The publication… includes an accompanying spreadsheet developed to facilitate calculations of staffing needs in line with the guidance set out in the main text."

Information Technology to Enhance Management of Cervical Cancer

Every year, over one million gynaecological cancer cases and half a million related deaths are registered worldwide. The highly specialized oncology workforce needed for safe, effective management of these cancers is not readily available in all Member States. To

FIG. 1. A PET–CT image of a 57 year old female patient with ovarian cancer showing high abnormal uptake in different areas corresponding to peritoneal carcinomatosis. (Image reproduced courtesy of the University of Lyon, France.)

help address this need, particularly in isolated regions in Africa, the Agency founded the African Radiation Oncology Network (AFRONET) in 2012. AFRONET provides access to training, up-to-date published literature, expert opinion and peer review of clinical cases in Africa, to support better diagnosis and treatment of gynaecological malignancies through case presentations and discussions. In 2018, this virtual platform was expanded to include other regions and languages and further site specific specialization, including a dedicated space for cervical and childhood cancers.

In July, the Agency launched a new e-learning module that presents 12 clinical cases involving the use of ^{18}F-FDG PET–CT (fluorine-18 fluorodeoxyglucose positron emission tomography–computed tomography) to manage diverse gynaecological tumours in different clinical stages (e.g. evaluation of recurring disease, restaging after adjuvant therapy, monitoring the efficacy of treatments, radiotherapy planning) (Fig. 1). It also covers the emerging application of radioguided sentinel lymph node biopsy in patients with vulvar and cervical cancer.

At the 12th Congress of the World Federation of Nuclear Medicine and Biology in April, technical experts from the Agency gave a presentation entitled ‘International Guidelines on Sentinel Lymphoscintigraphy in Gynaecological Cancers’.

Increasing Human Capacity through Research, Education and Workshops

The Agency continued to support Member States in the use of nuclear techniques to address non-communicable diseases such as cancer and cardiovascular diseases, as well as infectious diseases such as tuberculosis and malaria. The use of hybrid imaging technologies plays a crucial role in the early diagnosis and management of patients suffering from these diseases. The Agency assists Member States in improving their technical capabilities through coordinated research projects and e-learning activities, including the development of e-learning modules.

In the area of cancer management, the Agency emphasized the clinical applications of standard and novel radiopharmaceuticals for medical imaging. In 2018, it successfully concluded four coordinated research projects on the appropriate use of medical imaging in the management of breast cancer, paediatric lymphoma and lung cancer, and on the role of different imaging modalities in the evaluation of patients with spinal infection after surgical interventions and the identification of patients with multidrug resistant tuberculosis. The results of the projects were used to establish standardized evaluation criteria for these clinical conditions and for clinical application of hybrid imaging in both non-communicable and communicable diseases. In addition, participants in the workshops and training courses on hybrid imaging were awarded continuing medical education credits from the European Union of Medical Specialists, which assists them in maintaining their professional accreditation in their home countries.

During the year, the Agency released e-learning modules entitled 'Peptide Receptors Radionuclide Therapy' and 'Radionuclide Imaging in the Management of Gynaecological Cancer'. The modules support interactive learning and provide immediate feedback for each task accomplished as well as enhanced interaction for learners.

The Agency also provided training for nine nuclear medicine specialists and an electronic engineer from the Centre for Nuclear Medicine of the Clinical Centre of Serbia. Equipment provided to the Centre by the Agency in 2018 has contributed to faster, more accurate patient diagnosis, particularly for thyroid disease. The Centre hosted the IAEA–EANM European School of Multimodality Imaging & Therapy (ESMIT) Autumn School in September, enabling nuclear medicine professionals in the region to share experiences and knowledge.

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.

Enhancing Groundwater Resources Availability

The Agency began mainstreaming the IAEA Water Availability Enhancement Project (IWAVE) methodology in 2018. Its use is now standard in evaluations of technical cooperation projects aimed at enhancing hydrological understanding in order to increase water availability and sustainability. The IWAVE methodology helps ensure the feasibility of isotope hydrology projects and their effective contribution to achieving Sustainable Development Goal (SDG) 6 on clean water and sanitation.

In 2018, comprehensive groundwater recharge assessments from environmental isotope mapping were completed by three counterparts, with Agency assistance, for five aquifers in Argentina, Brazil and Colombia. Isotopic data collected from the aquifers were used to establish a regional hydrogeochemical and isotope (oxygen-18, deuterium and tritium) database for precipitation, surface water and groundwater, to be maintained by counterpart institutes. The groundwater isotopic data are being integrated into new hydrological maps, highlighting the recharge areas where replenishment is taking place and the need for groundwater protection zones in areas with higher vulnerability to pollution.

Water Resource Assessment

Mining operations pose a water resources challenge. Mining activities use extensive water resources in processing ores, and important water quality issues may arise because of groundwater and surface water entering mine sites and encountering primary and secondary minerals. The potential role of isotope hydrology tools in addressing the environmental impact of these activities was the topic of a technical meeting held in Vienna in June. Experts from 11 Member States reviewed recent developments in the use of geochemical and isotope tools for water source identification and characterization, mine water management, contaminant (acid mine drainage) assessment, mine area restoration and management of abandoned mines, as well as the use of various tracers. Participants highlighted the need to better assess and expand the use of geochemical and isotope tools in characterizing sources, processes, pathways and environmental factors to enhance hydrogeological models in mining areas.

In 2018, the Agency completed a coordinated research project that focused on improving understanding of the hydrology of large river basins using geochemical and isotope

FIG. 1. Sampling in the St. Lawrence River as part of an isotope monitoring programme in Canada. (Photograph courtesy of J.-F. Hélie.)

parameters to constrain and model water, nutrient and sediment dynamics in large river basins (Fig. 1). Large rivers are a significant source of fresh water for drinking, agricultural and industrial supplies, fisheries, transportation and energy production. Human impacts on large watersheds — including intensive agriculture, discharge of wastewater, impoundments, irrigation and damming — have profound effects on river water balance, biogeochemistry and sediment transport. The four year coordinated research project, involving participants from 17 Member States, contributed to strengthening the Agency's Global Network of Isotopes in Rivers (GNIR) programme by improving understanding of the relationship between hydrological and biogeochemical processes in large river basins, thus contributing to achieving SDG target 6.6 on restoring water related ecosystems, including mountains, forests, wetland, rivers, aquifers and lakes.

The Ping River is a major artery that provides water and livelihoods to the northern and central regions of Thailand. Severe drought during the dry season and flooding in the rainy season cause severe water challenges in this region. In 2018, the Agency, through the technical cooperation programme, helped complete the construction of a river bank filtration system that improves understanding of the interaction between surface water and groundwater needed to measure the impact of drought on water availability for agriculture and domestic uses. The feasibility of this system was established using hydrochemical and isotope tools to generate essential hydrological information.

"the Agency…helped complete the construction of a river bank filtration system that improves understanding of the interaction between surface water and groundwater"

A regional project completed in 2018, carried out under the African Regional Co-operative Agreement for Research, Development and Training Related to Nuclear Science and Technology, built capacity and developed human resources in 17 Member States in the use of isotope hydrology techniques in water management. Teaching modules on isotope hydrology tools and methods were updated to provide basic knowledge for integrating isotope hydrology tools as part of water resources assessment. These modules will be incorporated into university curricula in the participating Member States, including at the three regional designated centres in Egypt, Morocco and Tunisia.

Analytical Capacity and Services

Increasing concentrations of dissolved nitrate and other nutrients in rivers, lakes, groundwater and estuaries can cause negative effects on water and ecosystems, such as eutrophication and hypoxic zones in coastal oceans, often leading to undrinkable water. At the Technical Meeting on Advanced Analytical Methods for Tritium and Stable Isotopes of Carbon and Nitrogen, participants from eight Member States reviewed advances in sample preparation and analysis using low cost laser isotope analysers. Isotope tools may significantly improve analytical accessibility and facilitate widespread use of nitrate isotopes for coordinated research projects and technical cooperation projects. The use of nitrogen and oxygen isotope fingerprinting of nitrate is critical to allow isotope hydrologists to identify and distinguish sources of nitrate in aquatic systems and to quantify natural remediation processes like denitrification. The experts recommended ways to expand the use of nitrate isotopes for pollution studies and recommended an international intercomparison exercise of nitrate isotopes to ensure the reliability of laboratories in preparation and analytical methods.

Environment

Objective

To support Member States in identifying environmental problems caused by radioactive and non-radioactive pollutants and climate change, using nuclear, isotopic and related techniques, and to propose mitigation and adaptation strategies and tools. To enhance the capability 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.

Analysis of Mercury in the Marine Environment

In 2018, the Agency, in close collaboration with the United Nations Environment Programme (UNEP) and the Global Environment Facility, intensified its efforts to support implementation of the Minamata Convention on Mercury, a treaty to protect human health and the environment from anthropogenic releases of mercury and mercury compounds. During the year, the Agency, through its technical cooperation programme and in cooperation with UNEP's Regional Seas Programme, provided expertise and assistance to 20 Member States in Africa — Algeria, Benin, Cameroon, Congo, Côte d'Ivoire, Djibouti, Egypt, Gabon, Ghana, Kenya, Madagascar, Mauritania, Mauritius, Morocco, Namibia, Nigeria, Senegal, South Africa, Tunisia and the United Republic of Tanzania — through training courses, proficiency tests and other modalities, including training in mercury analysis at the Monaco laboratories. In 2018, the Agency also procured mercury analysers for installation in eight African Member States. Such capacity building activities enable laboratories to monitor this toxic element in the environment, a prerequisite for policy makers to implement actions to reduce and/or eliminate the release of anthropogenic mercury in these States.

The Agency continued to assist Member States in enhancing their capabilities to detect mercury and methylmercury in fish and other seafood and in marine sediment, and to study transfer processes up the food chain. In 2018, it developed and validated three analytical procedures for determining mercury and its species in seafood samples. It also produced a new certified reference material for trace elements and methylmercury in fish samples. The new material can be used by Member State laboratories as part of their quality control procedures to validate analytical procedures and to establish traceability against internationally agreed standards.

"In 2018, [the Agency] developed and validated three analytical procedures for determining mercury and its species in seafood samples."

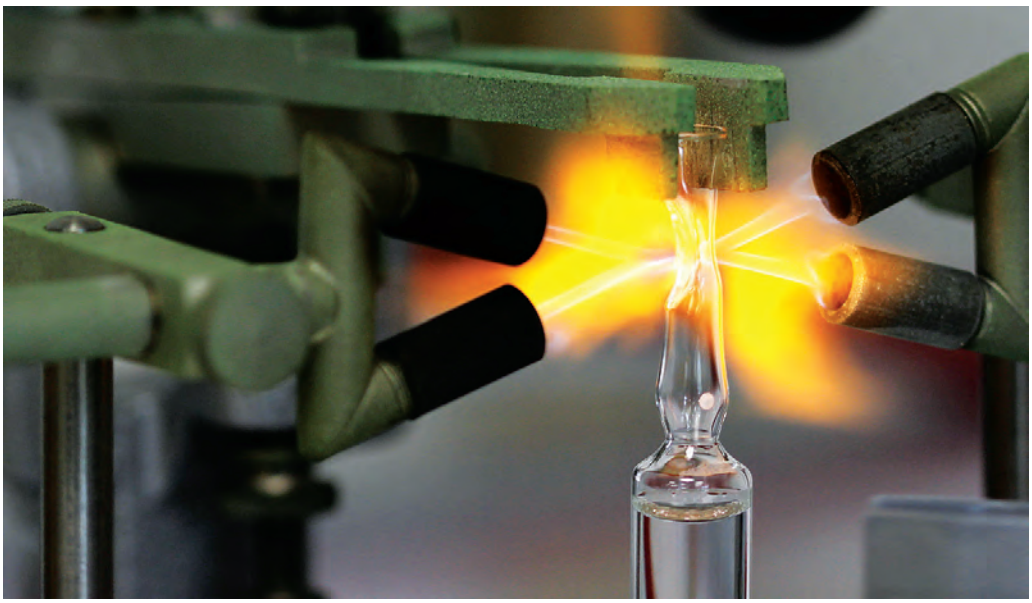

FIG. 1. Sealing of the Agency's carbonate reference material, a standard necessary for high precision carbon dioxide stable isotope calibration and monitoring.

High Precision Atmospheric Greenhouse Gas Monitoring

"the Agency developed three new isotopic standards for carbon (carbonate reference material) to supplement a standard released in 2016"

Knowledge of the small changes in the isotopic composition of greenhouse gases such as carbon dioxide is indispensable for calculating sources and sinks. The Agency provides certified reference materials to the global atmospheric science community and support to intergovernmental and national organizations to ensure the quality and comparability of high precision greenhouse gas measurements. During the year, the Agency developed three new isotopic standards for carbon (carbonate reference material) to supplement a standard released in 2016 (Fig. 1). The new standards enable laboratories worldwide to report consistent isotopic data on greenhouse gases, a necessary input to global climate models.

The Agency is currently the main provider of such standards worldwide. In 2018, the Agency standards were adopted by the World Meteorological Organization as the basis for all stable isotope data reporting at the organization's last meeting of experts on carbon dioxide and other greenhouse gas measuring techniques.

Understanding Contaminants in the Environment and in Seafood

Member States continued to face a variety of challenges in their marine environment with the potential for wide-ranging impacts on people's health and livelihoods. Some of these challenges are made more difficult by the effects of climate change, including extreme weather events and rising sea levels, and scarce resources. Using nuclear and isotopic techniques, the Agency conducted research and helped build scientific and technical capacity in Member States to improve understanding of the behaviour of contaminants in coastal and marine ecosystems and their biota. In 2018, to better understand the movement of heavy metals such as lead into marine organisms, Agency scientists used nuclear and isotopic techniques under controlled laboratory conditions to precisely quantify the movement and fate of contaminants and their impact on a range of aquatic biota such as fish and oysters. This research has allowed Member States to better assess environmental risk, particularly on issues related to seafood safety.

FIG. 2. Scientists from the Marshall Islands receive training in sampling techniques at the Agency's Environment Laboratories in Monaco to independently monitor environmental radioactivity.

The Agency continued to build capacity in Member States to improve understanding of radionuclide contamination. In 2018, it trained two scientists from the Marshall Islands in gamma spectrometry, enabling them to independently monitor the radioactivity of environmental and food samples (Fig. 2). It also trained two scientists, from Cuba and the Philippines, in the use of the radioligand receptor binding assay, a nuclear tool used to quickly and precisely determine the presence of biotoxins produced by harmful algal blooms. By improving understanding of other contaminants affecting small island developing States, such as heavy metals and persistent organic pollutants, the Agency is contributing to the robustness of seafood safety programmes in these Member States.

Ocean acidification is another environmental challenge facing many Member States, in particular small island developing States that are economically and culturally dependent on the ocean and therefore particularly vulnerable to threats from ocean warming and acidification. As part of its capacity building initiatives, the Agency, through the Ocean Acidification International Coordination Centre (OA-ICC), hosted a Technical Meeting on the Management, Analysis and Quality Control of Ocean Acidification Observation Data in Monaco in October, with participation from 15 scientists representing 15 countries from different regions around the world. During this meeting, participants learned how to apply theories on quality assurance and quality control techniques to their own data sets.

Radioisotope Production and Radiation Technology

Objective

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

Radioisotopes and Radiopharmaceuticals

In 2018, the Agency implemented several activities aimed at supporting Member States in the production of important medical radioisotopes such as molybdenum-99 and emerging medical radioisotopes such as the alpha emitter actinium-225 (Ac-225). Ac-225 has had remarkable results in clinical trials performed worldwide for the treatment of advanced prostate cancer using the radiopharmaceutical Ac-225-PSMA (prostate-specific membrane antigen). Recognizing the growing interest in targeted alpha therapy using Ac-225, the Agency held a two day workshop on the supply of actinium-225, co-hosted by the Joint Research Centre, in Karlsruhe, Germany. Participants discussed the need for diverse production methods to ensure that the supply of Ac-225 meets the ever-increasing demand. The meeting, held in Vienna in October, was attended by 70 participants from 17 Member States.

Results of clinical trials conducted to date (Fig. 1), and data on the worldwide demand for Ac-225 for targeted alpha therapy, were presented by several participants from the medical and radiopharmaceutical community. Three main production routes for meeting this projected demand were discussed: 'milking' of stockpiled uranium-233, spallation of thorium-232 with high energy proton accelerators, and production of Ac-225 from radium-226 with either proton cyclotrons or electron linear accelerators. The advantages

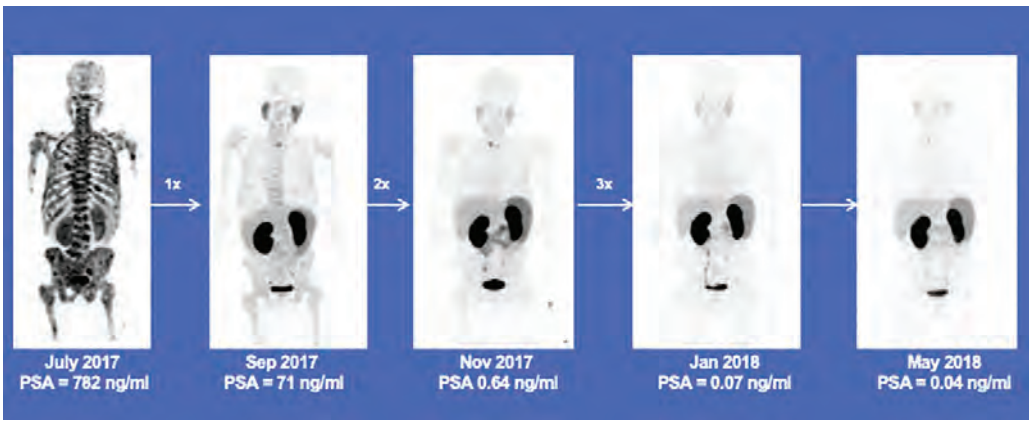

FIG. 1. Results presented by a participant at the Technical Meeting on Supply of Ac-225 showing the successful use of Ac-225-PSMA to treat prostate cancer.

FIG. 2. View of Saint Martin's chapel in Stari Brod, Croatia, after conservation and restoration using radiation technology. (Photograph from the archive of the Croatian Restoration Institute (CRI), Croatia; reproduced with permission.)

and disadvantages of each of the production methods were presented, along with Ac-225 supply projections. The meeting provided the participants a unique opportunity to exchange ideas and discuss results and the challenges in establishing a reliable supply of the promising therapeutic radioisotope Ac-225. It also allowed for the strengthening of existing collaborations and the creation of new ones.

Industrial Applications of Radiation Technology

The application of ionizing radiation for the inactivation of microorganisms is a powerful technique for disinfecting paper, textiles and wood based cultural heritage artefacts. In June, the Agency held a Technical Meeting on Strategies for Preservation and Consolidation of Cultural Heritage Artefacts through Radiation Processing at the Ruđer Bošković Institute in Croatia. The meeting brought together 30 experts in the use of this technique from 20 Member States (Fig. 2). The participants shared their experiences regarding the recent advances in radiation technology for cultural heritage preservation with stakeholders such as conservators and restorers. The meeting participants proposed the development of harmonized guidance, expected to benefit future activities in the field directly by ensuring safe cultural heritage irradiation practices in the future.

The demand from Member States for training and certification of professionals in the use of radiotracers and sealed sources continues to increase. To meet the growing need for development in this area, the Agency organized four training and certification courses in 2018. Technical backstopping was provided by the Agency, and certification was provided by the International Society for Tracer and Radiation Applications (ISTRA). In total, 40 radiotracer specialists from 25 Member States were trained and certified according to ISTRA standards.

Nuclear Safety and Security

Incident and Emergency Preparedness and Response

Objective

To maintain and further enhance efficient Agency, national and international EPR capabilities and arrangements for effective response to nuclear or radiological incidents and emergencies independent of the triggering events. To improve exchange of information on nuclear or radiological incidents and emergencies among Member States, international stakeholders and the public and media in the preparedness stage and during the response to nuclear or radiological incidents and emergencies, independent of the triggering events.

Strengthening Emergency Preparedness Arrangements

"The Agency also provided…32 advisory services on EPR."

The Agency assisted Member States in strengthening their emergency preparedness and response (EPR) arrangements and capabilities through its peer review services and EPR training events and workshops. In 2018, the Agency conducted two Emergency Preparedness Review (EPREV) missions — one to Belarus and one to Cuba. The updated *Emergency Preparedness Review* (EPREV) *Guidelines* (IAEA Services Series No. 36), including the new performance indicators, were issued in October. The Agency also provided, upon Member State request, 32 advisory services on EPR.

The Agency held 51 workshops and training events to assist Member States in implementing the requirements established in *Preparedness and Response for a Nuclear or Radiological Emergency* (IAEA Safety Standards Series No. GSR Part 7) and associated guidance, including 32 events at the interregional or regional level and 19 at the national level. In October, a webinar held jointly by the Agency and the Food and Agriculture Organization of the United Nations, with some 200 participants, raised awareness about GSR Part 7 requirements related to food safety in a nuclear or radiological emergency. The Agency, in cooperation with the European Commission, held a workshop in Luxembourg in December during which participants discussed the EPR requirements in GSR Part 7 and in relevant European Union legislation, along with national experiences of their implementation.

The Agency conducted three Schools of Radiation Emergency Management to address requests from Member States for comprehensive training on all relevant EPR topics. A total of 82 participants from 46 Member States attended the schools, held in Austria in October (Fig. 1), and in Morocco and the United States of America in November.

The Agency published a Safety Guide entitled *Arrangements for the Termination of a Nuclear or Radiological Emergency* (IAEA Safety Standards Series No. GSG-11), jointly sponsored by ten international organizations. It also issued a new Emergency Preparedness and Response Series publication entitled *Medical Management of Persons Internally Contaminated with Radionuclides in a Nuclear or Radiological Emergency: A Manual for Medical Personnel* (EPR-Internal Contamination (2018)), jointly sponsored by the International Federation of

FIG. 1. The School of Radiation Emergency Management, held in Tulln, Austria, in October, included training on emergency scenarios through virtual reality. (Photograph reproduced courtesy of A. Geosev/BMI.)

Red Cross and Red Crescent Societies, the Pan American Health Organization and the World Health Organization. An Agency report entitled *The Radiological Accident in Chilca* was also published.

In cooperation with 18 participating organizations from 14 Member States, the Agency launched a coordinated research project entitled 'Development of Approaches, Methodologies and Criteria for Determining the Technical Basis for Emergency Planning Zone for Small Modular Reactor Deployment'. During the first research coordination meeting, held in Vienna in May, the participating organizations agreed on the structure of the project and discussed the scope and approach of the research to be conducted.

Response Arrangements with Member States

The Agency organized 14 Convention Exercises (ConvEx) with Member States and international organizations during the year. The exercises, carried out under 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), tested emergency communication channels, assistance mechanisms and the Agency's assessment and prognosis process. They also tested Member State capabilities for requesting and preparing to receive assistance, exchange emergency information on appropriate protective actions and communicate with the public during a nuclear or radiological emergency. The ConvEx 2018 schedule was expanded to include new exercises to test specific aspects of an emergency response, such as coordination of public communication among relevant international organizations.

The Agency participated in 35 national emergency exercises, providing support during the events and in their evaluation. This included a major national emergency exercise held in Japan in August, in which the Agency observed and provided feedback on an exercise involving simultaneous events at two nuclear power plants with overlapping emergency planning zones. All exercises included communications using the Unified System for Information Exchange in Incidents and Emergencies (USIE) Exercise web site. The Agency

also tested connections for videoconferencing with emergency contact points in several Member States.

The updated publication *IAEA Response and Assistance Network* (EPR-RANET 2018) was published in July. The manual contains guidance on actions to be performed by States providing and requesting international assistance.

The Ninth Meeting of the Representatives of Competent Authorities Identified under the Early Notification Convention and the Assistance Convention took place in Vienna in June. The 135 participants from 84 Member States and 2 international organizations discussed topics such as implementation of the Early Notification and Assistance Conventions and the Agency's safety requirements dealing with notification, reporting and information exchange, the provision of international assistance (in particular, in education and training on EPR), and communication with the public, as well as training and exercises. The Agency encouraged Member States to establish contact points for emergency communication if they had not yet done so.

The Agency launched an updated version of the USIE web site to enable users to revise information about an event by entering short messages in free text fields, instead of completing new reporting forms. The updated version also allows the transfer and storage of encrypted confidential information. The Agency further enhanced USIE's security by incorporating two factor authentication of user accounts.

A new version of the Emergency Preparedness and Response Information Management System (EPRIMS) was launched, with improved usability and information sharing features. During the year, the Agency held eight webinars on using EPRIMS.

The Agency enhanced the International Radiation Monitoring Information System (IRMIS) by incorporating a new validation tool that improves compatibility with the International Radiological Information Exchange (IRIX) data standard. A new feature was added to IRMIS to enable users to upload and share radioisotope-specific air concentrations and ground depositions.

An International Symposium on Communicating Nuclear and Radiological Emergencies to the Public was held in Vienna in October. The conference included a Young Innovative Communicators Competition open to students and early career professionals.

In view of the importance of communicating with the public during an emergency, the Agency procured a tool that simulates social media use during an emergency to be used in its emergency exercise programme. The tool will be used to test preparedness to cope with this aspect of an emergency and to develop scenarios for exercises with Member States.

"the Agency procured a tool that simulates social media use during an emergency to be used in its emergency exercise programme."

Response to Events

The Agency was informed by the competent authorities, or became aware through earthquake alerts or media reports, of 313 events involving or suspected to involve ionizing radiation (Fig. 2). It took response actions in 60 of these events. It made five offers of good offices, including for events involving lost radioactive sources and those triggered by earthquakes. In response to a request for assistance from the Government of South Africa, an Agency Assistance Mission involving Response and Assistance Network (RANET) capabilities provided medical advice in response to the overexposure of a patient.

Inter-Agency Coordination

The first ConvEx-2f exercise was held in November with representatives of 6 of the 18 international organizations that are members of the Inter-Agency Committee on Radiological and Nuclear Emergencies. The exercise evaluated the coordination of communication with the public among relevant international organizations.

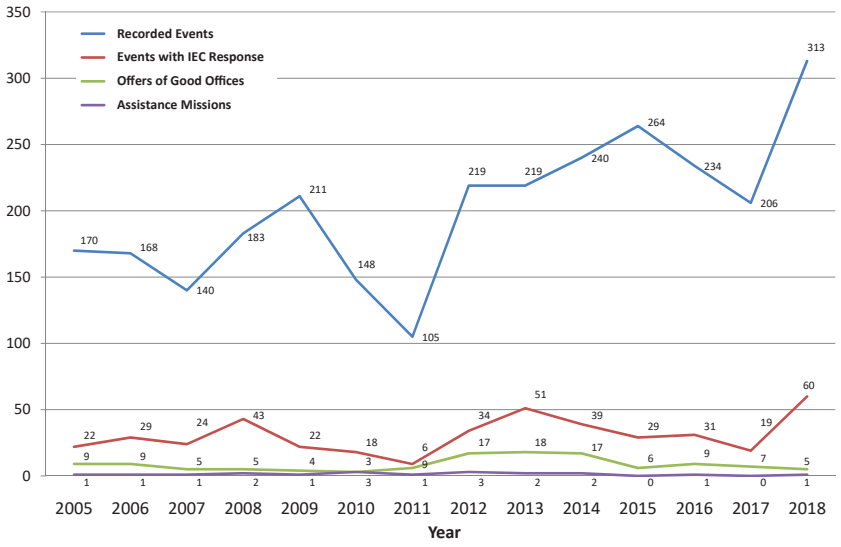

FIG. 2. Number of radiation events the Agency became aware of, and Agency responses, since 2005.

In-house Preparedness and Response

The Agency organized a comprehensive programme of training classes and exercises to enhance the skills and knowledge of Agency staff members serving as qualified responders in the Incident and Emergency System. The programme offered 186 hours of training during the year, including 74 classes for 206 Agency staff responders. The Agency held four full response exercises, including a ConvEx-2c exercise, hosted by Ireland in November, based on a scenario of a transnational radiological emergency triggered by a nuclear security event (Fig. 3). In 2018, 700 external visitors learned about the Incident and Emergency Centre during presentations and tours of its operational area.

FIG. 3. Agency staff participate in a ConvEx-2c exercise hosted by Ireland in November to test arrangements for response to a simulated radiological emergency triggered by a nuclear security event.

Safety of Nuclear Installations

Objective

To support Member States in improving the safety of nuclear installations during site evaluation, design, construction and operation through the development of safety standards and providing for their application. To support Member States in establishing and strengthening the safety infrastructure including through safety reviews and advisory services. To assist adherence to, and facilitate implementation of, the CNS and the Code of Conduct on the Safety of Research Reactors. To support Member States in capacity building through education and training, encouraging the exchange of information and operating experience, as well as international cooperation including the coordination of research and development activities.

Regulatory Infrastructure for Safety

The Agency published two Safety Guides on regulatory infrastructure for safety in 2018: *Organization, Management and Staffing of the Regulatory Body for Safety* (IAEA Safety Standards Series No. GSG-12) and *Functions and Processes of the Regulatory Body for Safety* (IAEA Safety Standards Series No. GSG-13).

Throughout the year, it assisted Member States with operating nuclear power plants in strengthening their national regulatory infrastructure for nuclear and radiation safety through the Integrated Regulatory Review Service (IRRS). The Agency conducted an IRRS mission to Spain and two follow-up IRRS missions — to Hungary and to the Netherlands. In November, the Agency held a workshop in Luxembourg where participants exchanged information, experiences and lessons learned from IRRS missions conducted since 2014. They also discussed developments and expectations for the IRRS programme and explored longer term improvements in the planning and implementation of IRRS missions. The Agency also organized a regional workshop, in Luxembourg in November, where participants discussed specific aspects related to IRRS missions conducted to Member States that are part of the European Union (Fig. 1).

The Agency conducted 49 expert missions, workshops and training activities that provided guidance and information on establishing an effective safety infrastructure in line with the recommendations set out in *Establishing the Safety Infrastructure for a Nuclear Power Programme* (IAEA Safety Standards Series No. SSG-16). It also conducted two Hands-on Regulatory Inspector Training Workshops for Member States embarking on a nuclear power programme. The workshops were held at the Zwentendorf nuclear power plant in Austria in May (Fig. 2), with 13 participants from 12 Member States, and in October, with 17 participants from 15 Member States.

The Small Modular Reactor Regulators' Forum established three working groups — on licensing; design and safety analysis; and manufacturing, commissioning and operations. The Agency facilitated two Forum meetings in Vienna, in March and October. The Forum

"The Agency conducted 49 expert missions, workshops and training activities that provided guidance and information on establishing an effective safety infrastructure…"

FIG. 1. Participants in the Regional Workshop on Lessons Learned from Integrated Regulatory Review Service (IRRS) Missions Conducted in the European Union, held in Luxembourg in November.

published a report summarizing the work carried out over the past three years. The report focuses on defence in depth, the graded approach and emergency planning zones applied to small modular reactors and is available on the Agency's web site.

Convention on Nuclear Safety

The Agency held a meeting in Vienna in late January and early February at which the Officers of the Seventh Review Meeting of the Contracting Parties to the Convention on Nuclear Safety provided feedback on their experience in reporting on the principles of the Vienna Declaration on Nuclear Safety. The group of Officers prepared a report that was considered at the Organizational Meeting for the Eighth Review Meeting, which was held in Vienna in October. At the meeting, the Convention on Nuclear Safety Contracting Parties also established Country Groups and elected the President, Vice-Presidents and the Country Group Officers of the Eighth Review Meeting.

Design Safety and Safety Assessment

The Agency supported Member States in sharing information and experience through the Technical Meeting to Share Experience on Implementing Safety Improvements at Existing Nuclear Power Plants; the Technical Meeting on Current Approaches in Member States to the Analysis of Design Extension Conditions for New Nuclear Power Plants; and the Technical Meeting on the Development of a Methodology for Aggregation of Various Risk Contributors for Nuclear Facilities. Three Agency workshops held in 2018 addressed the application of the new safety requirements for nuclear power plant design; severe accident analysis; and the development of severe accident management guidelines.

The Agency conducted three Technical Safety Review (TSR) services: one on periodic safety review, in the Czech Republic; one on design safety, in Bangladesh; and one on safety requirements, in Saudi Arabia. It also streamlined the TSR services guidelines by providing a common approach across the services' technical areas.

The Agency finalized a study on how the safety requirements established in *Safety of Nuclear Power Plants: Design* (IAEA Safety Standards Series No. SSR-2/1 (Rev. 1)) are to be

FIG. 2. Participants in the Hands-on Regulatory Inspector Training Workshop for Member States embarking on a nuclear power programme at the Zwentendorf nuclear power plant.

applied to small and medium sized or modular reactors intended for near term deployment. It also completed a case study on multi-unit probabilistic safety assessment (MUPSA) that provided feedback on the applicability of the MUPSA methodology previously developed. The lessons from the case study, reflecting the experience from the practical use of the methodology, were used to improve the application of the MUPSA methodology.

Safety and Protection against External Hazards

The Agency conducted two Site and External Events Design (SEED) review missions in November — to the Islamic Republic of Iran and to Kenya. Also in the framework of the SEED service, it conducted five expert missions — to Armenia, Bolivia, Jordan, the Sudan and Turkey — and held nine capacity building workshops — in Egypt, Kazakhstan, Malaysia, Pakistan, the Philippines, Romania, Sri Lanka, Tunisia and Turkey.

The Agency held a Technical Meeting on the Design and Reassessment of Nuclear Installations for Protection against External Hazards where it shared information on the progress of activities for protection of nuclear installations against extreme external events. The meeting's 58 participants from 37 Member States discussed plans for future activities in this area.

The Agency organized two workshops in cooperation with the Government of France in 2018. In May, it conducted the Second Workshop on Best Practices in Physics-Based Fault Rupture Models for Seismic Hazard Assessment of Nuclear Installations: Issues and Challenges towards Full Seismic Risk Analysis, attended by 126 professionals from 29 Member States. In December, it held a Workshop on Testing and Updating Probabilistic Seismic Hazard Analysis on the Basis of Observations, with 81 participants from 20 Member States.

The Agency issued three publications on protection against external hazards during the year: *Safety Aspects of Nuclear Power Plants in Human Induced External Events: Assessment of Structures* (Safety Reports Series No. 87); *Consideration of External Hazards in Probabilistic Safety Assessment for Single Unit and Multi-unit Nuclear Power Plants* (Safety Reports Series No. 92); and *Best Practices in Physics Based Fault Rupture Models for Seismic Hazard Assessment of Nuclear Installations* (IAEA-TECDOC-1833).

Operational Safety of Nuclear Power Plants

In June, the Agency issued a new Safety Guide entitled *Operating Experience Feedback for Nuclear Installations* (IAEA Safety Standards Series No. SSG-50), which supersedes IAEA Safety Standards Series No. NS-G-2.11. The publication provides recommendations for establishing, implementing, assessing and continuously improving an operating experience programme for nuclear installations and regulatory bodies.

In November, the Agency issued *Ageing Management and Development of a Programme for Long Term Operation of Nuclear Power Plants* (IAEA Safety Standards Series No. SSG-48), which supersedes IAEA Safety Standards Series No. NS-G-2.12. This new Safety Guide provides recommendations to operating organizations and regulatory bodies for implementing and improving ageing management and for developing a programme for safe long term operation of nuclear power plants.

The Agency conducted six OSART missions — one each to the Islamic Republic of Iran, the Russian Federation (Corporate OSART), Spain (Fig. 3) and the United Kingdom, as well as two to Finland, one of which was held at a nuclear power plant in the pre-operational phase prior to initial fuel load. It also conducted two follow-up OSART missions — to Canada and Slovenia. The Agency compiled an OSART missions highlight report summarizing the most significant findings of missions and follow-up visits undertaken from 2013 to 2015. The report describes the main trends and good practices identified, and provides an assessment of overall OSART mission outcomes.

The Memorandum of Understanding between the Agency and the World Association of Nuclear Operators (WANO) was extended, to further enhance cooperation and to optimize the use of OSART missions and WANO follow-up peer review visits to nuclear power plants.

The Agency supported the efforts of operating organizations to enhance their safety culture capabilities. In April, it conducted a workshop on Safety Culture Assessment Support at Kola nuclear power plant in the Russian Federation. In September, two workshops on the Safety Culture Continuous Improvement Process (SCCIP) Implementation Support Programme were conducted at Rosenergoatom in Moscow and at Kalinin nuclear power plant in Udomlya. It also carried out an SCCIP follow-up support mission to Laguna Verde nuclear power plant in Veracruz, Mexico, in August; a mission to Accra focusing on human factors, leadership for safety and safety culture in October; a safety culture self-assessment mission to Fennovoima in Helsinki in November; and an expert mission to Chashma nuclear power plant in Islamabad focusing on safety culture and safety culture self-assessment methodologies for senior management of nuclear power plants in December. The Agency also carried out two Independent Safety Culture Assessment peer review missions — to Norway in February and to South Africa in August.

"with the [OECD/NEA], the Agency issued Nuclear Power Plant Operating Experience, covering the period 2012–2014."

The Agency held two national workshops on regulatory oversight of safety culture — in Ljubljana in January and in Islamabad in November. It also held one regional workshop on self-assessment of safety culture for nuclear regulatory bodies in Hanoi in October.

The Agency supported Member States in the area of leadership for safety through a workshop on leadership and safety culture for senior managers, held in Vienna in September; a workshop on a systemic approach to safety, held in Vienna in October; and instructor training on safety leadership for member countries of the Asian Nuclear Safety Network (ANSN), held in Fukui prefecture, Japan, in April. The Agency also held national workshops in this area in Ghana, the Islamic Republic of Iran and Poland. It evaluated and enhanced the pilot International School of Nuclear and Radiological Leadership for Safety. Two Schools were held in November — one in India and one in Mexico.

In cooperation with the Nuclear Energy Agency of the Organisation for Economic Co-operation and Development (OECD/NEA), the Agency issued *Nuclear Power Plant Operating Experience*, covering the period 2012–2014. The publication highlights lessons based on a review of event reports received from participating Member States through

FIG. 3. Members of the OSART team conducting the 200th OSART review, in Almaraz, Spain.

the International Reporting System for Operating Experience (IRS). The Agency, with the OECD/NEA, began expanding the IRS database to incorporate the construction experience database (ConEX).

The Agency supported Member States in their efforts to continuously improve operational safety performance through learning from operating experience, holding two technical meetings in Vienna, one in September in cooperation with WANO Moscow Centre, and one in October in cooperation with the OECD/NEA. It also organized seven workshops to enhance Member State capacities to prevent events through root cause investigations, effective corrective action programmes and the use of operating experience — one each in Argentina, Austria, Belarus, the Czech Republic and Slovenia, and two in the Russian Federation. An expert mission to Ukraine supported efforts to enhance operating experience programmes at Ukrainian nuclear power plants.

The Agency conducted four Pre-SALTO missions, to Argentina, Brazil, Bulgaria and Ukraine; two SALTO missions, to Armenia and Sweden; and two expert missions, to Pakistan and South Africa. All of the missions reviewed ageing management and plant preparations for long term operation. The Agency conducted 12 workshops on ageing management and long term operation, in Argentina, Armenia, Bulgaria, China, the Islamic Republic of Iran, Mexico (two), Pakistan, Romania, South Africa, Spain and the United Kingdom. It prepared a SALTO mission highlight report summarizing the most significant findings of missions conducted from July 2015 to June 2018. The report describes main trends and good practices, and provides an overall assessment of SALTO mission results. The Agency held eight working group meetings, a steering committee meeting and a workshop in the framework of the International Generic Ageing Lessons Learned programme to share lessons learned regarding ageing management and long term operation.

Safety of Research Reactor and Fuel Cycle Facilities

The Agency conducted two Integrated Safety Assessment of Research Reactors (INSARR) missions, to the Democratic Republic of the Congo and to Ghana, and a follow-up INSARR mission to Jordan. The Agency also conducted safety expert missions to research reactors

in Egypt, Jordan and Uzbekistan, and supported new research reactor projects in the Plurinational State of Bolivia, Nigeria, Saudi Arabia, Thailand and Viet Nam.

The Agency published the *Guidelines for Self-assessment of Research Reactor Safety* (IAEA Services Series No. 35) to assist research reactor operating organizations in preparing for future INSARR missions.

In July, it held a regional meeting on the application of the Code of Conduct on the Safety of Research Reactors for the Africa region in Rabat. The meeting's 15 participants from ten Member States exchanged information on the safety status of their research reactors and on their experience in applying the provisions of the Code.

In December, the Agency issued *Regulatory Inspection of Research Reactors — Training Material* (Training Course Series (CD-ROM) No. 66). The information included is intended to assist Member States in establishing and implementing regulatory inspection programmes for research reactors and in improving the competencies of regulatory staff in charge of regulatory inspection of research reactors.

The Agency supported Member States in sharing information and experience through a Technical Meeting on Criticality Safety in Nuclear Fuel Cycle Facilities, held in Vienna in April, and a Technical Meeting on the Use of a Graded Approach in the Application of the Safety Requirements for Nuclear Fuel Cycle Facilities, held in Vienna in July. In September, the Agency hosted the biannual Technical Meeting for the National Coordinators of the Joint IAEA–OECD/NEA Fuel Incident Notification and Analysis System (FINAS) at its Headquarters in Vienna.

Radiation and Transport Safety

Objective

To support Member States in improving radiation safety of people and the environment through the development of safety standards and providing for their application. To support Member States in establishing the appropriate safety infrastructure through support and implementation of the Code of Conduct on the Safety and Security of Radioactive Sources, and through safety reviews and advisory services. To support Member States in capacity building through education and training, and in encouraging the exchange of information and experience.

Radiation Safety and Monitoring

The Agency conducted four Occupational Radiation Protection Appraisal Service (ORPAS) missions — to Bosnia and Herzegovina, the Dominican Republic, Indonesia and Panama (Fig. 1) — and one follow-up mission to the United Republic of Tanzania. The missions encouraged national regulatory authorities, technical support organizations and end users to use a graded approach for control, monitoring and recording of occupational exposure.

The Agency held regional training courses on justification of medical radiation exposure and the use of referral guidelines in Warsaw in September, with 25 participants from 15 Member States, and on the appropriate and safe use of imaging in Tbilisi in June, with

FIG. 1. An ORPAS team visiting a plant for the production of sterile screw worm flies during the ORPAS mission to Panama.

19 participants from 12 Member States. It also conducted a workshop on responsibilities for radiation protection in medicine in Vienna in April with 45 participants from 28 Member States. The Agency, together with the Abdus Salam International Centre for Theoretical Physics, organized a course on quality assurance and dose management in hybrid imaging, held in Trieste, Italy, in September, with 69 participants from 48 Member States. The Agency developed an e-learning course on radiation protection in medicine for radiation technologists that focuses on C-arm fluoroscopy to increase awareness of dose reduction techniques.

"In 2018, [the Agency] organized nine webinars on radiation protection of patients, with around 1500 participants from 100 Member States."

The Agency assisted Member States in sharing information and experience through a Technical Meeting on Experiences with the Implementation of the Bonn Call for Action, held in Vienna in March, with 34 participants from 21 Member States and 9 international organizations, and a Technical Meeting on Preventing Unintended and Accidental Exposures in Nuclear Medicine, held in Vienna in May, with 45 participants from 33 Member States and 11 international organizations.

The Agency continued to use webinars to reach medical professionals and other experts around the world. In 2018, it organized nine webinars on radiation protection of patients, with around 1500 participants from 100 Member States. In cooperation with the Conference of Radiation Control Program Directors (CRCPD), the European Radon Association and the World Health Organization (WHO), the Agency held six webinars on radon related topics for 750 participants from 58 Member States. In November, in cooperation with CRCPD, it held a webinar on naturally occurring radioactive material (NORM) with around 120 attendees from 63 Member States. The webinar was the first in a series to address worker protection in industrial activities involving NORM.

The Agency, in cooperation with the Food and Agriculture Organization of the United Nations, the United Nations Scientific Committee on the Effects of Atomic Radiation and WHO, completed a literature review of measurements of natural radionuclides in food published during the period 1998–2017. The data will be used to assess the range of radiation doses associated with different 'cluster diets', as defined by WHO in its Global Environmental Monitoring System (GEMS)/Food consumption database.

Regulatory Infrastructure

The Agency conducted six Integrated Regulatory Review Service (IRRS) missions to Member States without operating nuclear power plants — Australia, Austria, Chile, Georgia, Luxembourg and Moldova. It conducted ten Advisory Missions on Regulatory Infrastructure for Radiation Safety (AMRAS) — to Angola, Benin, Burkina Faso, Chad, El Salvador, Eswatini[1], Kuwait, Liberia, Mozambique and Rwanda. It also conducted three follow-up AMRAS missions — to Paraguay, Uganda and Uruguay. The AMRAS missions provided advice and, where appropriate, support to States in their efforts to establish or improve national regulatory infrastructure for radiation safety.

The Agency conducted an Education and Training Appraisal (EduTA) mission to Tajikistan and five advisory missions on education and training in radiation, transport and waste safety — to Brazil, Chile, Kyrgyzstan, Mexico and Panama. It provided specialized training in radiation, transport and waste safety through five Postgraduate Educational Courses in Radiation Protection and the Safety of Radiation Sources, in English, French and Spanish, held at the Agency affiliated regional training centres in Africa, Asia, Europe, and Latin America and the Caribbean.

In response to increasing Member State demand for guidance on strengthening regulatory requirements for education, training, qualification and competence of radiation protection officers and qualified experts, the Agency held three regional workshops: one

[1] The name 'Eswatini' replaces the former name 'Swaziland' as of 29 June 2018.

for Europe, held in Sliema, Malta, in October; one for the Asia and the Pacific region, held in Amman in November; and one for Latin America and the Caribbean, held in Panama City in December. It also held six 'train the trainers' workshops for radiation protection officers: in Montevideo in March; in Hanoi in May; in Tirana and in Dushanbe in June; and two in Rabat in November (one in French and one in English).

The Agency held a Regional Meeting on the Management of Radioactivity in Scrap Metal for Recycling and in Semi-finished Products in Abuja in June to assist African Member States in establishing national programmes for managing radioactive sources that could be found in scrap metal.

Agency support for Member States in establishing and strengthening their national regulatory infrastructure for radiation safety included five workshops focused on the establishment of a management system for the regulatory body, authorization and inspection of facilities, and regulatory control of cyclotrons and other new technologies. The workshops were attended by a total of around 100 participants from 25 Member States. The Agency also conducted seven expert missions to Member States to train regulatory staff in using and customizing the Regulatory Authority Information System (RAIS) 3.4 web system. Five RAIS servers were provided to Member States to assist regulatory bodies in managing safety related records.

The Agency held three Open-ended Meetings of Legal and Technical Experts on the 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 and Guidance on the Management of Disused Radioactive Sources. The first meeting, organized for the Europe region, was held in Bucharest in May and attended by 23 participants from 18 Member States; the second, for the Africa region, took place in Kampala in September and was attended by 32 participants from 28 Member States; and the third, for the Latin America and the Caribbean region, was held in Montevideo in October and attended by 19 participants from 12 Member States. The Agency also held an Interregional Open-ended Meeting of Legal and Technical Experts on Implementation of the Code of Conduct and its supplementary Guidance for Small Island Developing States in the Caribbean and Pacific Areas. At the meeting, held in Vienna in August, 34 experts from 17 Member States shared experiences on the application of the Code of Conduct and its supplementary Guidance.

At the Open-ended Meeting of Legal and Technical Experts on Implementation of the Guidance on the Import and Export of Radioactive Sources, held in Vienna in June, participants exchanged information and identified ways to promote the safe and secure management of radioactive sources during import and export worldwide. The meeting, attended by 155 experts from 86 Member States, concluded that there is currently no need to revise the Guidance, and that efforts should be focused on the full and systematic implementation of its existing provisions.

To support efforts by Member States to strengthen national regulatory frameworks and the safe and secure management of disused sealed radioactive sources, the Agency implemented a number of regional and international projects, including several meetings and workshops on cradle-to-grave control of radioactive sources, with an emphasis on the management of radioactive sources after the end of their useful life. This included the Regional Workshop: School on Drafting Regulations — Radiation Safety Stream attended by 21 experts from 14 European Member States, held in Vienna in August.

Transport Safety

The Agency published *Regulations for the Safe Transport of Radioactive Material: 2018 Edition* (IAEA Safety Standards Series No. SSR-6 (Rev. 1)). It also completed and piloted the e-learning training course on *Regulations for the Safe Transport of Radioactive Material: 2012 Edition* (IAEA Safety Standards Series No. SSR-6).

"[The Agency] also completed and piloted the e-learning training course on Regulations for the Safe Transport of Radioactive Material: 2012 Edition"

Radiation Safety Information Management System

The Agency continued operating the Radiation Safety Information Management System (RASIMS) tool to assist Member States that receive technical support from the Agency in evaluating their application of the Agency's radiation safety standards. The Agency held two consultancy meetings in 2018, during which national coordinators from all regions tested and evaluated a new version of the tool that was under development. In October, 18 RASIMS national coordinators learned how to use the new version during an interregional workshop held in Vienna.

Radioactive Waste Management and Environmental Safety

Objective

To support Member States in improving the safety of radioactive waste and spent fuel management, including geologic repositories for HLW, decommissioning, remediation and environmental releases, through the development of safety standards and providing for their application. To support Member States in improving the safety of radioactive waste and spent fuel management, including geologic repositories for HLW, decommissioning, remediation and environmental releases through peer reviews and advisory services. To support Member States in capacity building through education and training, and encouraging the exchange of information and experience.

Radioactive Waste and Spent Fuel Management

The Agency conducted five Integrated Review Service for Radioactive Waste and Spent Fuel Management, Decommissioning and Remediation (ARTEMIS) missions — to Brazil, Bulgaria, France, Italy and Luxembourg— as well as the first combined Integrated Regulatory Review Service (IRRS)–ARTEMIS mission — to Spain.

The Agency continued to implement the International Project on Demonstration of the Operational and Long-Term Safety of Geological Disposal Facilities for Radioactive Waste (GEOSAF Part III). A Technical Meeting of the Working Groups for GEOSAF Part III took place in Vienna in April, with 18 participants from 11 Member States. The Second Plenary Meeting for GEOSAF III took place in Vienna in June, involving 25 participants from 15 Member States. These activities focused on decision making following monitoring of geological disposal facilities and on the interaction between regulators and operators during the licensing of such facilities.

Assessment and Management of Environmental Releases

The Agency held the third Technical Meeting of the second phase of the Modelling and Data for Radiological Impact Assessments (MODARIA II) programme in Vienna in October, attended by approximately 150 participants from 47 Member States. The programme builds experience in the assessment of radiation doses from radionuclides released to or present in the environment.

Decommissioning and Remediation Safety

In June, the Agency held the first Technical Meeting on the International Project on Decommissioning of Small Facilities. The three year project, with 41 participants from

33 Member States, will support the development of national infrastructure for planning and decommissioning of small medical, industrial and research facilities, and the application of relevant safety standards.

Thirty-six participants from 27 Member States took part in the Agency's launch of the Regulatory Forum for Safety of Uranium Production and NORM (REGSUN) in June. REGSUN promotes the development of regulatory capacity to ensure safe and sustainable management of naturally occurring radioactive material residues and residues from uranium production, inter alia, by the application of a graded approach to regulation. REGSUN will also provide strategic direction for future Agency work.

In September, the Agency held the first Technical Meeting on the International Project on Completion of Decommissioning. The project, with 40 participants from 29 Member States, will provide a systematic overview of practical experience worldwide in defining decommissioning end states, in demonstrating compliance with end state criteria, and in defining and implementing any needed measures and controls after the end of decommissioning. Information gathered in this project will be used in the revision of the Safety Guide *Release of Sites from Regulatory Control on Termination of Practices* (IAEA Safety Standards Series No. WS-G-5.1).

"Thirty-six participants from 27 Member States took part in the Agency's launch of the Regulatory Forum for Safety of Uranium Production and NORM (REGSUN) in June."

The Agency published the *Strategic Master Plan for Environmental Remediation of Uranium Legacy Sites in Central Asia* in English in May and in Russian in September. The plan was presented at a side event entitled 'Uranium Legacy Sites — The Environmental Remediation Programme in Central Asia' hosted by the European Union in the framework of the Sixth Review Meeting of the Contracting Parties to the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management, and at side events at the 62nd regular session of the Agency's General Conference and the 73rd session of the United Nations General Assembly in September. International support for the Central Asian countries in remediating their uranium production legacy sites is coordinated by the Coordination Group for Uranium Legacy Sites (CGULS), which comprises the Agency, the Commonwealth of Independent States, the European Commission and the European Bank for Reconstruction and Development.

Joint Convention

The Sixth Review Meeting of the Contracting Parties to the Joint Convention, held in Vienna from 21 May to 1 June, was attended by more than 850 delegates from 69 Contracting Parties (Fig. 1). The meeting was also attended by 4 observers (Lebanon and the Philippines as Signatory States of the Joint Convention, the Islamic Republic of Iran and the Nuclear Energy Agency of the Organisation for Economic Co-operation and Development). The Contracting Parties reviewed national reports in country groups and identified good progress in many areas of safety of spent fuel and radioactive waste management. At the plenary, the Contracting Parties adopted a number of proposals to improve the effectiveness of the peer review process, addressing the submission and the content of the national reports and the submission of proposals to be considered at review meetings.

The Contracting Parties also decided by consensus to hold an Extraordinary Meeting prior to the Organizational Meeting for the Seventh Review Meeting of the Contracting Parties, with a view to discussing possible ways to improve procedural mechanisms of the Joint Convention. The summary report was published on the Agency's web site.

The Agency held a Regional Workshop to Promote the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management for Member States from the Asia and the Pacific region in Jakarta in October.

In 2018, Mexico, Paraguay, Serbia and Thailand became Contracting Parties to the Joint Convention, bringing the total number of Contracting Parties to 80.

FIG. 1. Opening of the plenary session of the Sixth Review Meeting of the Contracting Parties to the Joint Convention, held at the Agency's Headquarters in Vienna.

Nuclear Security

Objective

To contribute to global efforts to achieve effective nuclear security, by establishing comprehensive nuclear security guidance and promoting 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 in strengthening the international cooperation and coordination of assistance in a manner 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.

International Conference on the Security of Radioactive Material

The Agency organized the International Conference on the Security of Radioactive Material: The Way Forward for Prevention and Detection, held in Vienna in December (Fig. 1). The conference, attended by some 550 participants from over 100 Member States and co-chaired by Italy and Senegal, featured six main panel sessions and 28 specialized technical sessions. Topics addressed included international cooperation, communication, sustainability of national nuclear security regimes, State experiences in prevention and detection, the roles and initiatives of international organizations, securing nuclear material during its full life cycle, and the detection of radioactive material involved in criminal and unauthorized acts.

International Conference on Nuclear Security

The Agency organized two programme committee meetings, chaired by Bulgaria and Egypt, to develop the announcement, themes and high level and technical discussion topics for the third International Conference on Nuclear Security: Sustaining and Strengthening Efforts, to be held in February 2020.

The Convention on the Physical Protection of Nuclear Material (CPPNM) and Its Amendment

The Agency continued to promote universal adherence to the Amendment to the CPPNM (A/CPPNM), including through three regional workshops held for Southeast Asia, for French-speaking Africa and for Russian-speaking States.

The fourth Technical Meeting of the Representatives of States Parties to the Convention on the Physical Protection of Nuclear Material (CPPNM) and the CPPNM Amendment was

FIG. 1. Participants in the International Conference on the Security of Radioactive Material held in Vienna in December.

held in December in Vienna and attended by around 60 participants. The representatives discussed, inter alia, the information on laws and regulations giving effect to the CPPNM and A/CPPNM, as well as the role of designated Points of Contact. Immediately following this meeting, the Secretariat also facilitated an informal meeting of the Parties to the A/CPPNM, which initiated preparations for the 2021 Conference of the Parties to the A/CPPNM to review the implementation of the amended Convention and its adequacy, as foreseen in Article 16.1 of the amended Convention. Around 50 Parties to the A/CPPNM attended the meeting.

Nuclear Security Guidance

The Agency continued to develop comprehensive guidance on nuclear security. The Nuclear Security Guidance Committee, comprising representatives of 57 Member States, met twice during 2018. The June meeting marked the beginning of the committee's third three-year term. Five new publications were issued in 2018. At the end of the year, the IAEA Nuclear Security Series comprised 32 publications, with a further 10 approved for publication and 14 more under development. The road map for the IAEA Nuclear Security Series publications was updated to identify further priorities for development of guidance during the third term.

Needs Assessment

The Agency continued to develop and implement Integrated Nuclear Security Support Plans (INSSPs) to assist States, upon request, in systematically and comprehensively enhancing their national nuclear security regimes. Three Member States approved their INSSPs in 2018, bringing the total number of approved INSSPs to 81.

FIG. 2. Participants in an Agency training course on transport security of nuclear material at Kerntechnische Hilfsdienst GmbH in Karlsruhe, Germany.

Capacity Building for Nuclear Security

The Agency conducted 105 security related training activities in 2018 — 42 at the national level and 63 at the international or regional level — with more than 2200 participants from 139 States (Fig. 2). In addition, 879 trainees from 123 States completed 3760 e-learning modules. In addition, a Technical Meeting on Security of Nuclear and other Radioactive Material in Transport was held in July, where transport security regulators, international organizations, operators and other experts shared information and discussed challenges faced by Member States.

The Agency continued to respond to State requests for assistance with the development of national Nuclear Security Training and Support Centres, both on a bilateral basis and through the International Network for Nuclear Security Training and Support Centres. The International Nuclear Security Education Network grew in 2018 with the addition of five institutions. The network, which assists States in establishing and enhancing educational programmes in nuclear security, now comprises 177 institutions in 63 Member States.

Risk Reduction

The Agency continued to support efforts by States to protect radioactive material during and after use. In 2018, 27 Category 1 and 2 disused sealed sources were removed from five countries in Latin America. Physical protection upgrades were also initiated to facilities using high activity radioactive sources in Egypt, Libya and Pakistan, and upgrades to such facilities were completed in Malaysia.

Coordinated Research Projects

The Agency completed the coordinated research project entitled 'Development of Nuclear Security Assessment Methodologies for Regulated Facilities', involving 34 participants from 16 Member States and 1 organization. The three year project developed and validated

a methodological framework for nuclear security assessment, and identified the data needed for such an assessment as well as the ways to collect and use such data to assess security effectiveness at a range of facilities and activities. The Agency also initiated a coordinated research project entitled 'Applying Nuclear Forensic Science to Respond to a Nuclear Security Event'. This project will seek to promote consistent and scientifically defensible implementation of nuclear forensic examination, in line with national laws and international legal instruments, and in particular to link nuclear science with investigative requirements.

Advisory Services

The Agency conducted International Physical Protection Advisory Service (IPPAS) missions to Ecuador, France, Japan and Switzerland, bringing the total number of IPPAS missions conducted to 85. The Agency also established new guidelines for INSServ missions.

Major Public Events

The Agency provided assistance in implementing nuclear security systems and measures for major public events to seven States — Argentina, Belarus, Indonesia, the Niger, Panama, Uganda and the United Republic of Tanzania. This included four coordination meetings and ten training events. As part of these activities, the Agency lent 391 radiation detection instruments and, upon request, provided three major public event analysis reports.

"the Agency lent 391 radiation detection instruments and, upon request, provided three major public event analysis reports."

Incident and Trafficking Database

In 2018, Benin and the Congo joined the Incident and Trafficking Database (ITDB) programme. States reported 253 national incidents to the ITDB during the year; 243 involved radioactive sources and radioactively contaminated material and 14 involved nuclear material. Seven reported incidents involved acts of trafficking or malicious use. The Triennial Technical Meeting of States' Points of Contact for the Incident and Trafficking Database was held in Vienna in May.

Nuclear Security Fund

In 2018, the Agency accepted financial pledges to the Nuclear Security Fund amounting to €22.2 million. These pledges included financial contributions from 16 Member States and non-traditional donors.

Nuclear Verification

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, and, in accordance with the Agency's Statute, assist with other verification tasks, including in connection with nuclear disarmament or arms control agreements, as requested by States and approved by the Board of Governors.

Implementation of Safeguards in 2018

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

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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 Treaty on the Non-Proliferation of Nuclear Weapons is based on the number of instruments of ratification, accession or succession that have been deposited.

In 2018, safeguards were applied for 182 States[3,4] with safeguards agreements in force with the Agency. Of the 129 States that had both a CSA and an AP in force[5] the Agency drew the broader conclusion that *all* nuclear material remained in peaceful activities for 70 States[6]; for the remaining 59 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 45 States with a CSA but 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 2018, integrated safeguards were implemented for 67 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 2018, 11 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

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 of safeguards agreements and APs as of 31 December 2018 is shown in Table A6 in the

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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 AP being provisionally applied, pending its entry into force.

6 And Taiwan, China.

7 Albania, Andorra, Armenia, Australia, Austria, Bangladesh, Belgium, Botswana, 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, Kazakhstan, Republic of Korea, Kuwait, Latvia, Libya, Lithuania, Luxembourg, Madagascar, Mali, Malta, Mauritius, Monaco, Montenegro, Netherlands, New Zealand, North Macedonia (the name 'North Macedonia' replaces the former name 'The former Yugoslav Republic of Macedonia' as of 15 February 2019), Norway, Palau, Peru, Philippines, Poland, Portugal, Romania, Seychelles, Singapore, Slovakia, Slovenia, South Africa, Spain, Sweden, Switzerland, Tajikistan, Ukraine, United Republic of Tanzania, Uruguay, Uzbekistan and Viet Nam.

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.

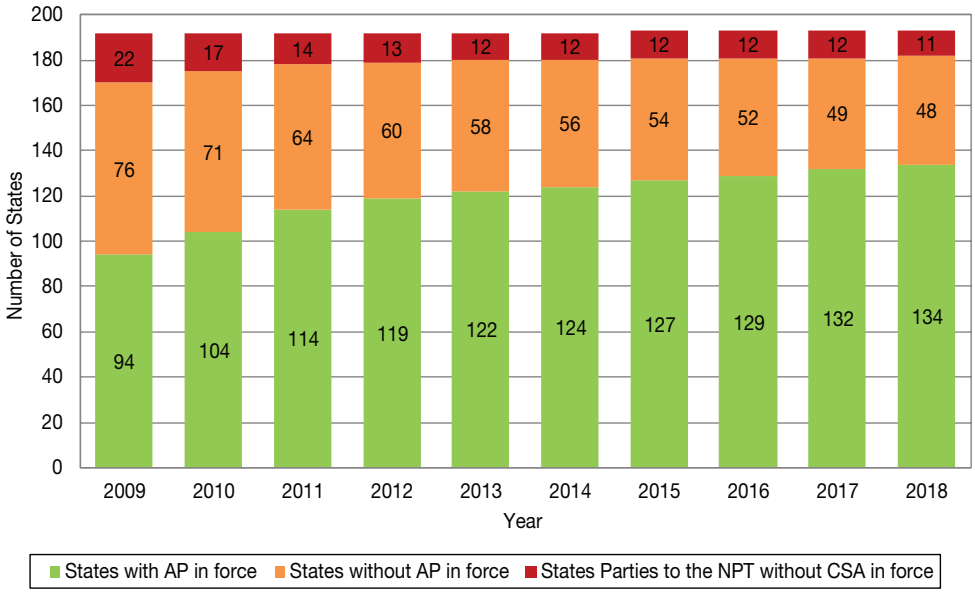

FIG. 1. Number of APs for States with safeguards agreements in force, 2009–2018 (the Democratic People's Republic of Korea is not included).

Annex to this report. During 2018, a CSA with an SQP and an AP entered into force for Liberia. In addition, the Board of Governors approved a CSA with an SQP for the State of Palestine[10]. An AP entered into force for Serbia. An AP was signed for Algeria, and the Board of Governors approved an AP for Sri Lanka. A voluntary offer agreement and an AP thereto were signed for the United Kingdom. By the end of 2018, safeguards agreements were in force with 183 States and APs were in force with 134 States. An AP continued to be provisionally applied pending its entry into force for the Islamic Republic of Iran.

The Agency continued to implement the *Plan of Action to Promote the Conclusion of Safeguards Agreements and Additional Protocols*[11], which was updated in September 2018. The Agency organized an outreach workshop for diplomats from Permanent Missions and Embassies located in Berlin, Brussels, Geneva and London (Vienna, 11–12 June), a national workshop for Nepal (Kathmandu, 10–12 December) and country visits to Sao Tome and Principe (18–19 June) and Cabo Verde (21–22 June). During these outreach activities, the Agency encouraged States to conclude a CSA and an AP, and to amend their SQPs. In addition, the Agency held consultations with representatives of a number of Member and non-Member States in Geneva, Jakarta, Lisbon, 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 2018, an SQP was rescinded for Malaysia and SQPs were amended for Paraguay, Tonga and the United States of America[12]. By the end of 2018, 64 States had accepted the revised SQP text (which was in force for 58 of these States) and 8 States had rescinded their SQPs.

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[10] The designation employed does not imply the expression of any opinion whatsoever concerning the legal status of any country or territory or of its authorities, or concerning the delimitation of its frontiers.

[11] Available at: *https://www.iaea.org/sites/default/files/18/09/sg-plan-of-action-2017-2018.pdf*

[12] The United States of America has amended its small quantities protocol to the safeguards agreement reproduced in INFCIRC/366 between the United States of America and the Agency pursuant to Additional Protocol I of the Treaty of Tlatelolco, covering the United States of America's Protocol I territories.

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

Throughout 2018, the Agency continued to verify and monitor the nuclear-related commitments of the Islamic Republic of Iran (Iran) under the Joint Comprehensive Plan of Action (JCPOA). During the year, the Director General submitted four 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/2018/7, GOV/2018/24, GOV/2018/33 and GOV/2018/47).

Syrian Arab Republic (Syria)

In August 2018, the Director General submitted a report to the Board of Governors entitled *Implementation of the NPT Safeguards Agreement in the Syrian Arab Republic* (GOV/2018/35) covering relevant developments since the previous report in August 2017 (GOV/2017/37). 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.[13] In 2018, 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 diversion of declared nuclear material from peaceful activities. For 2018, the Agency concluded for Syria that declared nuclear material remained in peaceful activities.

Democratic People's Republic of Korea (DPRK)

In August 2018, 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/2018/34–GC(62)/12), which provided an update of developments since the Director General's report of August 2017 (GOV/2017/36 GC(61)/21). The Director General provided a further update in his introductory statement to the Board of Governors on 22 November 2018.

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.

In 2018, no verification activities were implemented in the field but the Agency continued to monitor developments in the DPRK's nuclear programme and to evaluate all safeguards relevant information available to it, including open source information and satellite imagery.

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[13] 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 Executive Group and the DPRK Team, created in August 2017,[14] have intensified their efforts. The DPRK Team has increased monitoring of the DPRK's nuclear programme through more frequent collection of satellite imagery and has enhanced its readiness to promptly undertake any activities it may be requested to conduct in the DPRK. Actions to enhance readiness have included: formulation and updating of verification approaches and procedures; identification of potential inspectors for initial activities in the DPRK and provision of specialized training for them; and ensuring the availability of appropriate verification technologies and equipment to support the initial activities. All of these efforts related to the Agency's enhanced readiness have been conducted within available resources, including extrabudgetary contributions from a number of Member States. Once a political agreement has been reached among the countries concerned, the Agency is ready to return to the DPRK in a timely manner, if requested to do so by the DPRK and subject to approval by the Board of Governors.

In 2018, the Agency continued to monitor the Yongbyon site. The Agency observed indications that were consistent with the operation of the Yongbyon Experimental Nuclear Power Plant (5MW(e)) reactor until mid-August 2018. From mid-August through November 2018 there were indications of intermittent reactor operation, and in December 2018 there were no indications of reactor operation. Starting in the first quarter of 2018, activities were observed near the Kuryong River, which may have been related to changes to the cooling system for the light water reactor (LWR) under construction and/or the 5MW(e) reactor. Between late April and early May 2018, there were indications of the operation of the steam plant that serves the Radiochemical Laboratory. The duration of the steam plant's operation was not sufficient to have supported the reprocessing of a complete core from the 5MW(e) reactor. 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. At the LWR, the Agency observed activities consistent with the fabrication of reactor components and the possible transfer of these components into the reactor building.

The Agency has evaluated all safeguards relevant information, including satellite imagery and open source information, about a group of buildings within a security perimeter in the vicinity of Pyongyang. The size of the main building and the characteristics of the associated infrastructure are not inconsistent with a centrifuge enrichment facility. The timeline of construction is not inconsistent with the reported uranium enrichment programme of the DPRK.[15]

The Agency has not had access to the Yongbyon site or to other locations in the DPRK. Without such access, the Agency cannot confirm either the operational status or configuration/design features of the facilities or locations, or the nature and purpose of the activities conducted therein.

The continuation and further development of the DPRK's nuclear programme during 2018, including activities in relation to the Yongbyon Experimental Nuclear Power Plant (5 MW(e)) reactor, the use of the building which houses the reported centrifuge enrichment facility and the construction at the LWR, are clear violations of relevant United Nations Security Council resolutions, including resolution 2375 (2017), and are deeply regrettable.

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[14] GOV/2017/36-GC(61)/21, para. 12.

[15] GOV/2011/53-GC(55)/24, para. 30. In addition, GOV/2011/53-GC(55)/24, para. 50, noted reports on the provision of centrifuge enrichment technology to the DPRK and indications that the DPRK could produce UF_6 prior to 2001.

Enhancing Safeguards

Evolving safeguards implementation

In July 2018, the Director General submitted a report to the Board of Governors entitled *Implementation of State-level Safeguards Approaches for States under Integrated Safeguards — Experience Gained and Lessons Learned* (GOV/2018/20). This report contains the Secretariat's analysis of experience gained and lessons learned in the updating and implementation of State-level safeguards approaches (SLAs) for States under integrated safeguards, as described in GOV/2013/38 and GOV/2014/41 and Corr.1.

During 2018, the Agency developed SLAs for five States with a CSA. This brings the total number of States with a CSA for which an SLA has been developed to 130. These 130 States hold 97% of all nuclear material (by significant quantity) under safeguards in States with a CSA and include 67 States with a CSA and an AP in force for which the broader conclusion has been drawn; 35 States with a CSA and an AP in force for which the broader conclusion has yet to be drawn; and 28 States with a CSA but no AP in force. For those States where SLAs are not implemented, in-field safeguards activities are based on the Safeguards Criteria, and new techniques and technologies are implemented, as applicable, to strengthen effectiveness and improve efficiency.

Cooperation with State and regional authorities

To assist States in building capacity for implementing their safeguards obligations, the Agency conducted 13 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. In total, more than 250 participants from some 50 countries were trained on safeguards related topics. The Agency also participated in three other training activities organized by Member States on a bilateral basis. All of these activities were supported financially or in kind through Member State Support Programmes.

In April, the Agency published *International Safeguards in the Design of Facilities for Long Term Spent Fuel Management* (IAEA Nuclear Energy Series No. NF-T-3.1) to provide guidance on the early consideration of safeguards measures in the design and construction of a nuclear facility. The Agency, upon request, conducted an IAEA State System of Accounting for and Control of Nuclear Material Advisory Service (ISSAS) mission to Mexico. It also participated in two Integrated Nuclear Infrastructure Review (INIR) missions, to the Niger and Saudi Arabia, both of which included, inter alia, the provision of 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

"By the end of the year, the Agency had installed a total of 171 unattended monitoring systems in 24 States."

Throughout 2018, the Agency ensured that the instrumentation and monitoring equipment installed in nuclear facilities around the world, which is vital to effective safeguards implementation, continued to function as required. During the year, 1097 portable and resident non-destructive assay systems comprising 2366 separate pieces of equipment were prepared and assembled for safeguards use. By the end of the year, the Agency had installed a total of 171 unattended monitoring systems in 24 States. It also had 1563 cameras operating at 277 facilities in 37 States[16]. By the end of 2018, remote data transmission infrastructure ensured the collection of 1102 unattended safeguards data streams from 137 facilities in 29 States. Of these, 414 data streams were produced by surveillance systems, 128 by unattended monitoring systems and 560 by electronic seals.

[16] And Taiwan, China.

The Agency continued to implement the next generation surveillance system, replacing outdated surveillance units. By the end of 2018, a total of 881 next generation surveillance system cameras had been installed in 29 States[17]. In 2018, a passive gamma emission tomography (PGET) unit deployed at a nuclear power plant was successfully operated from the Agency's Headquarters, demonstrating the feasibility of remote operation of the system. The PGET system is able to detect missing or replaced rods in spent fuel assemblies, thus providing the Agency with an unprecedented capability of verifying irradiated items.

In 2018, the Agency continued cooperative efforts with Member States, the Brazilian–Argentine Agency for Accounting and Control of Nuclear Materials (ABACC) and the European Commission. These focused on procurement, acceptance testing, installation and maintenance of safeguards equipment designated for joint use, and staff training.

The Agency continued to undertake activities aimed at identifying and evaluating emerging instrumentation technologies that could support safeguards implementation. These activities were performed in close cooperation with Member State Support Programmes. In 2018, the next generation Cherenkov viewing device was tested in the field. One of the field tests was conducted in conjunction with the deployment of three robotized unmanned surface systems. This enabled the Agency to validate the feasibility of automating the verification of spent fuel stored under water.

Safeguards analytical services

The Agency's Network of Analytical Laboratories consists of the Agency's Safeguards Analytical Laboratory and 22 other qualified laboratories in Australia, Brazil, China, France, Hungary, Japan, the Republic of Korea, the Russian Federation, the United Kingdom, the United States of America and of the European Commission. Additional laboratories for sample analysis and reference material provision were in the process of qualification in Argentina, Belgium, Canada, Germany, the Netherlands and the United Kingdom.

In 2018, the Agency collected 487 nuclear material samples that were analysed by the Agency's Nuclear Material Laboratory. The Agency also collected 481 environmental samples, which resulted in analysis of 1020 subsamples; a total of 192 of these subsamples were analysed at the Agency's Environmental Sample Laboratory (Fig. 2) and the Nuclear Material Laboratory, with the remainder analysed by other laboratories in the Network of Analytical Laboratories.

"The Agency also collected 481 environmental samples, which resulted in analysis of 1020 subsamples"

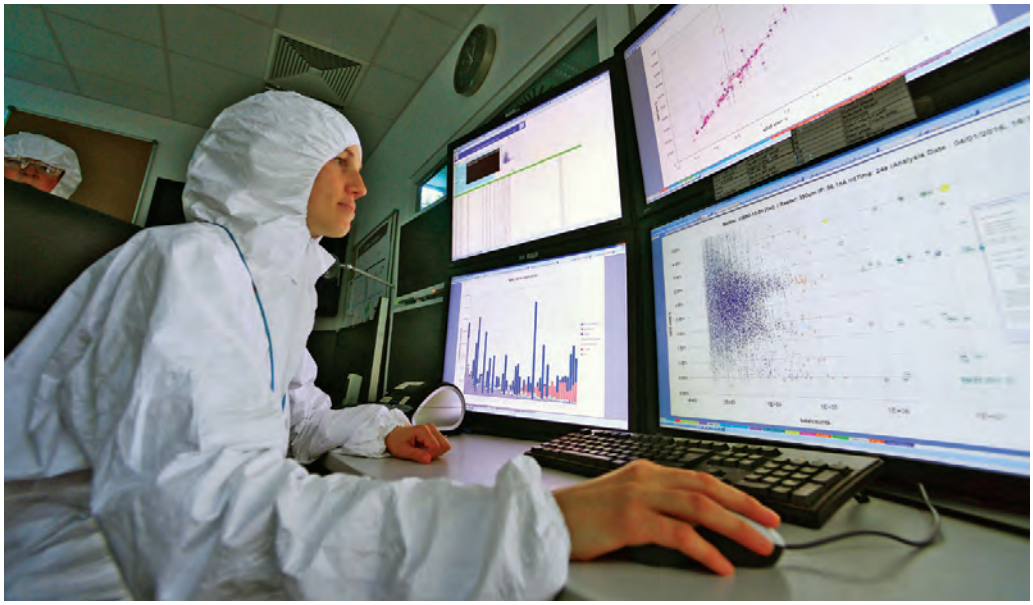


FIG. 2. Analysing results at the Agency's Environmental Sample Laboratory, Seibersdorf, Austria.

[17] And Taiwan, China.

FIG. 3. Agency safeguards inspectors in training at the E. Andronikashvili Institute of Physics in Tbilisi.

Support

Developing the safeguards workforce

In 2018, the Agency conducted two Introductory Courses on Agency Safeguards, for a total of 30 newly recruited inspectors. During the year, it conducted 165 safeguards training courses to provide safeguards inspectors and analysts with the necessary technical and behavioural competencies. The 2018 Safeguards Traineeship Programme was successfully completed by six trainees from Cameroon, Jordan, Kenya, Thailand, Turkey and Viet Nam. To enhance practical competencies for safeguards implementation in the field, a number of courses were held at nuclear facilities (Fig. 3) to train safeguards staff in a realistic, effective, consistent and integrated manner. These training courses provide participants with the understanding and skills necessary to prepare, conduct and report on inspections, and conduct design information verification activities and complementary accesses. Other courses were held at the Agency's Headquarters with the aim of developing skills for processing safeguards relevant data, for example, by developing analytical skills relevant to the effective use of collaborative analysis tools. New training courses were also developed in 2018, including a refresher training course on the legal basis for safeguards and a training course on accelerators and associated proliferation risks. The Agency continued to engage with Member State Support Programmes in the development of tools for training and in the conduct of courses at nuclear facilities.

Significant Safeguards Projects

Information technology: MOSAIC

The Agency completed the planned modernization of safeguards information technology (IT) on schedule on 15 May 2018, within scope and budget. The modernization, completed under the Modernization of Safeguards Information Technology (MOSAIC) project, has enhanced existing tools and software applications in the safeguards IT system, introduced new IT tools and software applications relevant to safeguards implementation, and strengthened information security. Through the completion of the modernization activities, the Department of Safeguards has established an IT system that, inter alia,

FIG. 4. Demonstration of virtual reality technologies at the thirteenth Symposium on International Safeguards, held at the Agency's Headquarters in Vienna in November.

provides for effective and efficient collection, processing and evaluation of safeguards relevant information; increased facilitation of the conduct of diversion and acquisition path analysis; greater assistance to inspectors in conducting safeguards activities in the field and at Agency Headquarters; better underpinning of the Agency's safeguards techniques and technologies; and the continued drawing of soundly based safeguards conclusions. Building on the experience gained during the MOSAIC project, the Agency has incorporated best practices into the provision and maintenance of safeguards IT.

Safeguards Symposium

In November, the Agency hosted the Symposium on International Safeguards: Building Future Safeguards Capabilities at its Headquarters in Vienna. The symposium focused on identifying innovative technologies that might be exploited for safeguards purposes; strengthening existing partnerships and creating new ones; and improving the day to day work of safeguards implementation (Fig. 4). More than 800 people from 90 Member States participated in the symposium. Thanks to substantial support from several Member State Support Programmes, organizations and exhibitors, 90 individuals received travel support to attend the event, resulting in improved geographic diversity among the participants.

Preparing for the Future

The Agency published the *Research and Development Plan — Enhancing Capabilities for Nuclear Verification* (STR-385) and the *Development and Implementation Support Programme for Nuclear Verification 2018–2019* (STR-386) in early 2018. The biennial meeting of the Member State Support Programme coordinators took place in February, at which the Secretariat informed Member States about its needs regarding improvements to the Agency's technical capabilities. The Development and Implementation Support Programme for Nuclear Verification comprises 285 support programme tasks in 25 projects. At the end of 2018, 20 Member States[18] and the European Commission had formal support programmes with the Agency.

[18] 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

Management of Technical Cooperation for Development

Objective

To develop and implement a needs based, responsive technical cooperation programme in an effective and efficient manner to strengthen the technical capacities of Member States in the peaceful application and safe use of nuclear technologies for sustainable development.

The Technical Cooperation Programme

The technical cooperation programme is the Agency's major vehicle for transferring nuclear technology and building capacity in nuclear applications in Member States. The programme supports Member States in achieving their development priorities, including relevant nationally identified targets under the Sustainable Development Goals (SDGs). It also facilitates regional and interregional cooperation among Member States and partners.

The technical cooperation activities of the Agency were highlighted at the IAEA Ministerial Conference on Nuclear Science and Technology: Addressing Current and Emerging Development Challenges, held in Vienna in November. Many technical cooperation counterparts and experts participated as speakers and panellists, and an African Regional Co-operative Agreement for Research, Development and Training Related to Nuclear Science and Technology (AFRA) side event examined the challenges facing low and middle income countries wishing to provide sustainable radiotherapy services. Panellists from the field of radiotherapy and cancer control planning led the discussion, providing guidance and lessons learned on topics ranging from establishing a radiotherapy centre to the steps needed to expand radiotherapy in a sustainable manner. The technical cooperation programme was also presented at an exhibition on the margins of the conference.

"[An AFRA] side event examined the challenges facing low and middle income countries wishing to provide sustainable radiotherapy services."

Country Programme Frameworks and Revised Supplementary Agreements

The Country Programme Framework (CPF) provides a frame of reference for technical cooperation between a Member State and the Agency, helping Member States to define mutually agreed development needs and priorities that can be supported through the programme. In 2018, the Agency co-signed 24 CPFs, for Antigua and Barbuda, Armenia, Bahrain, Bangladesh, the Plurinational State of Bolivia, Botswana, Brunei Darussalam, Bulgaria, Cyprus, the Democratic Republic of the Congo, Ethiopia, Jamaica, Kyrgyzstan, Lesotho, Malta, Morocco, Nicaragua, Nigeria, Peru, Slovenia, Tajikistan, Turkey, the United Republic of Tanzania and the Bolivarian Republic of Venezuela. In total, there were 100 valid CPFs by the end of 2018.

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. Two Member States, Liberia and Turkmenistan, signed RSAs in 2018, increasing the total number of valid RSAs at the end of 2018 to 136.

United Nations Development Assistance Frameworks

The Agency co-signed seven new United Nations Development Assistance Framework (UNDAFs) in 2018 — for Burkina Faso, Ghana, Lesotho, Malawi, Mauritania, Rwanda and Seychelles — bringing the total of valid UNDAFs co-signed by the Agency to 56. UNDAFs offer an avenue for the Agency to raise awareness about its technical cooperation work among national development coordination and planning bodies, as well as the United Nations and other partners.

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

"the Agency drew attention to the benefits of nuclear science and technology in fields as diverse as agriculture, health, industry, energy, water management and environmental monitoring."

In 2018, the Agency attended the Multi-stakeholder Forum on Science, Technology and Innovation for the SDGs and the 2018 United Nations High-level Political Forum on Sustainable Development in New York. The Agency highlighted the contributions of nuclear science and technology to a variety of SDGs under review, such as water resource management, air pollution monitoring, and sustainable land and water management practices.

During the thematic review on advancing science, technology and innovation to achieve the SDGs, the Agency drew attention to the benefits of nuclear science and technology in fields as diverse as agriculture, health, industry, energy, water management and environmental monitoring.

The Agency continued to support the World Nuclear University Summer Institute, which took place in Busan and Gyeongju, Republic of Korea, from 26 June to 3 August 2018, through selecting 13 fellows to attend the programme and to learn from the world's foremost leaders and experts in nuclear science, engineering and business.

Partnership Agreements and Practical Arrangements

The long-standing partnership between the Agency and the European Commission continued through the implementation of the 2016 Delegation Agreement, under the Instrument for Nuclear Safety Cooperation, throughout 2018. A number of activities were carried out, including a regional training course on conditioning of spent low activity gamma-emitting and neutron sources in Dakar in July. Fourteen participants from five countries were trained. The objective of the course was to operationalize the first radioactive waste facility for Senegal.

Strengthening South–South and triangular cooperation

In February, the Agency and the Ministry of Research, Technology and Higher Education of Indonesia signed Practical Arrangements to strengthen and enhance South–South cooperation. The Practical Arrangements facilitate training and capacity building assistance, the provision of experts and lecturers, and the use of laboratory and analytical facilities to support other developing countries, including least developed countries and small island developing States.

In April, the Agency signed a Memorandum of Understanding with the Ministry of Science, Technology and Higher Education and the Ministry of Health of Portugal to promote South–South and triangular cooperation among Portuguese-speaking countries, aiming to enhance collaboration in health, nuclear medicine and radiation oncology. Portugal agreed to support 50 fellowships and scientific visits implemented through the technical cooperation programme on a cost-free basis during the period 2019–2023, particularly, but not exclusively, for Portuguese-speaking Member States.

Practical Arrangements were signed between the Agency and Enresa (the Spanish National Company for Radioactive Waste) in May. The Practical Arrangements govern cooperation between the two organizations in the field of radioactive waste management and decommissioning. Enresa will make qualified experts available for Agency activities and will host capacity building activities.

The Agency signed Practical Arrangements with a consortium of 11 Japanese universities and institutions in November, to support human resource development in nuclear medicine around the world. The Practical Arrangements will boost training opportunities for medical professionals in Agency Member States in the use of imaging techniques to diagnose and manage non-communicable diseases, with a special emphasis on degenerative brain disorders such as dementia, Alzheimer's disease and Parkinson's disease.

The Agency facilitated the signature of three Memoranda of Understanding between Mexico and Costa Rica, Mexico and Peru, and Costa Rica and Peru as part of its efforts to strengthen the networking and sustainability of national nuclear institutes in the region.

Africa

African Member States face a shortage of qualified workers in nuclear science and technology, and often rely on training provided abroad. With the support of the Agency, a first of its kind meeting in June gathered Vice-Chancellors of African universities and representatives of regional bodies involved in education and training. The meeting focused on the means to address human resource development needs in Africa. It was hosted by Kenya's National Commission for Science, Technology and Innovation.

Asia and the Pacific

The Agency strengthened its partnership with the Asian Development Bank with the signature of a Cooperation Framework Agreement in October to formalize closer cooperation on country and regional programming as well as analytical work, training and capacity building activities. The agreement will contribute to sustainable socioeconomic development in Asia in the fields of agriculture and food safety, climate change and disaster risk management, the environment, health and water.

As a first step in this cooperation, the Agency attended the Asian Development Bank's 2018 Asia Water Forum, raising awareness among key stakeholders in the region of the role of nuclear technology in addressing the challenges of the water–agriculture–energy nexus.

Under the Practical Arrangements signed between the Agency and the China Atomic Energy Authority, China hosted the master's and doctoral degree studies of 16 students in the area of nuclear science and technology at Harbin Engineering University.

Europe

In Europe and Central Asia, the Agency prioritized efforts to build sustainable partnerships with diverse stakeholders in 2018. Partners such as the Czech Republic's State Office for Nuclear Safety provided expertise and training to enhance nuclear safety in the Europe region.

In November, the Agency participated in the Global Environment Facility Biennial International Waters Conference to establish partnerships with relevant stakeholders and water projects in Europe to help ensure that future Agency support for the evaluation of groundwater resources and groundwater–surface water interactions, in the context of adapting to climate change, complements existing water management activities in the region and enhances evidence based decision making in support of SDG 6.

The Russian Federation hosted four training courses on infrastructure for nuclear power programmes and related safety assessments, two Nuclear Energy Management Schools and eight scientific visits in 2018.

Latin America and the Caribbean

Practical Arrangements between the University of the West Indies at Mona and the Agency were signed in May. The new Practical Arrangements underpin collaboration between the two organizations in the training of professionals in radiology, nuclear medicine, radiotherapy, medical radiation physics, the use of stable isotopes in nutrition and radiation safety.

In August, the Agency and the Caribbean Community Climate Change Centre signed Practical Arrangements to cooperate in the use of nuclear science and technology to combat climate change. The Practical Arrangements contribute to the promotion of the Agency's technical cooperation activities in Caribbean countries that are new Agency Member States and they provide for cooperation among the Caribbean Ministries of Environment, Health and Agriculture; regional organizations; the Caribbean Regional Fisheries Mechanism and the Caribbean Public Health Agency (CARPHA). Under the framework of the arrangements, the Agency and the Caribbean Community Climate Change Centre organized a workshop on the 'Contribution of Nuclear Science and Technology to Building Climate Resilience in the Caribbean' in Vienna in August.

The Agency and the Caribbean Agricultural Health and Food Safety Agency signed Practical Arrangements in November. The Practical Arrangements provide a framework for cooperation in the areas of sustainable agriculture and food safety.

Programme of Action for Cancer Therapy (PACT)

The Agency signed Practical Arrangements with Childhood Cancer International for collaboration in paediatric radiation oncology activities in low and middle income countries.

A series of events were co-organized with the Islamic Development Bank and the Organisation of Islamic Cooperation, including a meeting with Austria based financial institutions in Vienna, to discuss how Member States can access funds and ways to finance large scale cancer control infrastructure projects. In July, the Islamic Development Bank, the Asian Development Bank and the Agency discussed 'Cooperation in Support of Asian Countries' Efforts to Tackle Cancer' at a high level seminar during the forum on Innovations and Actions against Non-Communicable Diseases (NCDs) held in Manila.

In July, the Agency participated in a high level regional seminar on cancer awareness and advocacy in Burkina Faso, hosted and attended by the African First Ladies and organized by the Organisation of Islamic Cooperation. The Agency also worked with the Commonwealth Secretariat to organize a high level panel on 'Partnering to Tackle Cervical Cancer' at the 67th East, Central and Southern Africa Health Community Health Ministers Conference.

The Russian Federation supported the implementation of five regional training courses. Ninety-eight health professionals from 15 Member States (Armenia, Azerbaijan, Belarus, Bulgaria, Estonia, Hungary, Kazakhstan, Kyrgyzstan, Latvia, Lithuania, Montenegro, Republic of Moldova, Serbia, Turkmenistan and Uzbekistan) were trained in high accuracy

radiotherapy, including brachytherapy, quality assurance for radiotherapy and treatment planning systems, as well as in protection, safety and accident prevention in radiotherapy.

The Agency facilitated on the job training of two radiation oncologists and two radiotherapy technicians from the United Republic of Tanzania at leading cancer care facilities in Israel. The training was delivered as part of an ongoing technical cooperation project to strengthen and expand the national cancer control programme.

In 2018, outreach to potential donors and partners began for a large initiative to expand nuclear medicine and radiotherapy services for cancers specific to women, for cancer related training in Africa and for childhood cancers. Collaboration on resource mobilization and awareness raising activities, supporting national strategies and programmes, and building health workforce capacities for comprehensive cancer control in low and middle income countries was explored with potential partners.

Regional Cooperative Agreements and Regional Programming

Africa

The third AFRA Regional Strategic Cooperative Framework (RCF), for the period 2019–2023, was finalized at an AFRA task force meeting in Mauritius in 2018. The framework supports identification and prioritization of opportunities for regional cooperation in the sustainable promotion of peaceful applications of nuclear science and technology in Africa, and facilitates partnership building. Priority areas for the new RCF include human health, food and agriculture, and radiation safety. The AFRA RCF emphasized the need for further improving the delivery and quality of the technical cooperation programme in the region. The quality of individual and group training was a major consideration in order to better address the significant need for qualified human resources in Africa through, for example, pre-training e-learning courses, systematic examination at the end of the training courses and longer training activities. The task force also established mechanisms for South–South collaboration and triangular cooperation in other areas, including energy development, industrial applications and water resources.

The 29th AFRA Technical Working Group Meeting was held in Ghana in July. Participants adopted recommendations to further enhance regional cooperation in Africa, including through the establishment of new AFRA regional designated centres.

In September, the Agency hosted the 29th Meeting of AFRA Representatives on the margins of the 62nd regular session of the Agency's General Conference. The meeting participants endorsed the 2017 AFRA Annual Report, the third AFRA RCF for 2019–2023 and the proposed AFRA Regional Project Note for 2020–2021.

Asia and the Pacific

The preparation of the regional programme for the Asia and the Pacific region focused on established priorities, including enhancing radiation safety infrastructure, and considered mechanisms to enhance cooperation through mentor–mentee relationships, enhancing partnerships and advancing expertise already existing in the region.

The Regional Co-operative Agreement for Research, Development and Training Related to Nuclear Science and Technology (RCA) established a plan of action for the development of the 2020–2021 RCA programme. Eight project proposals were submitted for the 2020–2021 technical cooperation cycle. The RCA continued to explore opportunities to strengthen partnerships, to secure extrabudgetary funding in support of the RCA programme and to promote technical cooperation among developing countries through South–North and South–South cooperation. The RCA Guidance and Operating Rules were revised to enhance the effectiveness and efficiency of RCA activities.

The Co-operative Agreement for Arab States in Asia for Research, Development and Training related to Nuclear Science and Technology (ARASIA) continued to promote technical cooperation and South–South cooperation among its States Parties. The first two ARASIA regional resource centres — the Kuwait Cancer Control Center and the American University of Beirut Medical Center — were designated in November to facilitate cooperation among ARASIA States Parties. Seven new project proposals were submitted to the Agency under the ARASIA technical cooperation programme for the 2020–2021 cycle, building on previous achievements, exploring new areas that address transboundary and common problems within ARASIA States Parties, and focusing on building self-reliance and establishing networks.

Europe

The Agency focused on maintaining its strong interactions with Member States and relevant regional and international partners in 2018. Strategic meetings were convened to consider topics such as the new CPF template, activities in priority thematic areas where the Agency can make a valuable contribution, and the finalization of the Europe Regional Profile. In January, 23 new regional projects were launched in the new 2018–2019 technical cooperation cycle.

While Europe does not have a formal regional cooperative agreement, Member States adopted a revised Europe Regional Profile for 2018–2021 in April, which provided direction for the planning of the regional programme for 2020–2021. Consultations were held with Member States to enhance project designs to support Member State development objectives. In 2018, Member States also agreed to update the Strategic Framework for the Technical Cooperation Programme in the Europe region.

Within Europe and Central Asia, several Member States are embarking or considering embarking on a nuclear power programme. Throughout 2018, the Agency supported Member States at all stages of their decision making process and throughout the subsequent steps to design, construct and commission a nuclear power plant, in accordance with established Agency guidelines and standards. For Member States operating nuclear power plants or expanding their nuclear power capacity, the Agency supported effective long term safe operation as well as assurance of uranium production and supply. For example, 32 participants from 12 Member States attended a regional workshop on the application and licensing of digital instrumentation and control systems for nuclear power plants in November in Yerevan, Armenia. The workshop was organized under the framework of a regional technical cooperation project that aims to strengthen nuclear power plant lifetime management for long term operation.

In 2018, the Agency provided support to strengthen radiation and nuclear safety in Europe and Central Asia, including remediation of former uranium sites, infrastructure development, safety and long term operation of nuclear power plants. In addition, the Agency's activities focused on strengthening regulatory frameworks in the region. A workshop in July brought together representatives from 25 countries to discuss regulatory frameworks for the decommissioning of small medical, industrial and research facilities that use radioactive materials and radioactive sources, and identified the status of decommissioning regulations.

Several Member States in Europe are highly interested in the preservation of cultural heritage. Two representatives of Heritage Malta's Diagnostic Science Laboratories and the national regulatory body undertook a group scientific visit to the University of Ferrara in Italy to learn about K-edge radiography for cultural heritage (Fig. 1). As a result, they are able to better characterize cultural artefacts in Malta using the K-edge technique. Improvements were made to shielding for radiography at the Diagnostic Science Laboratories of Heritage Malta.

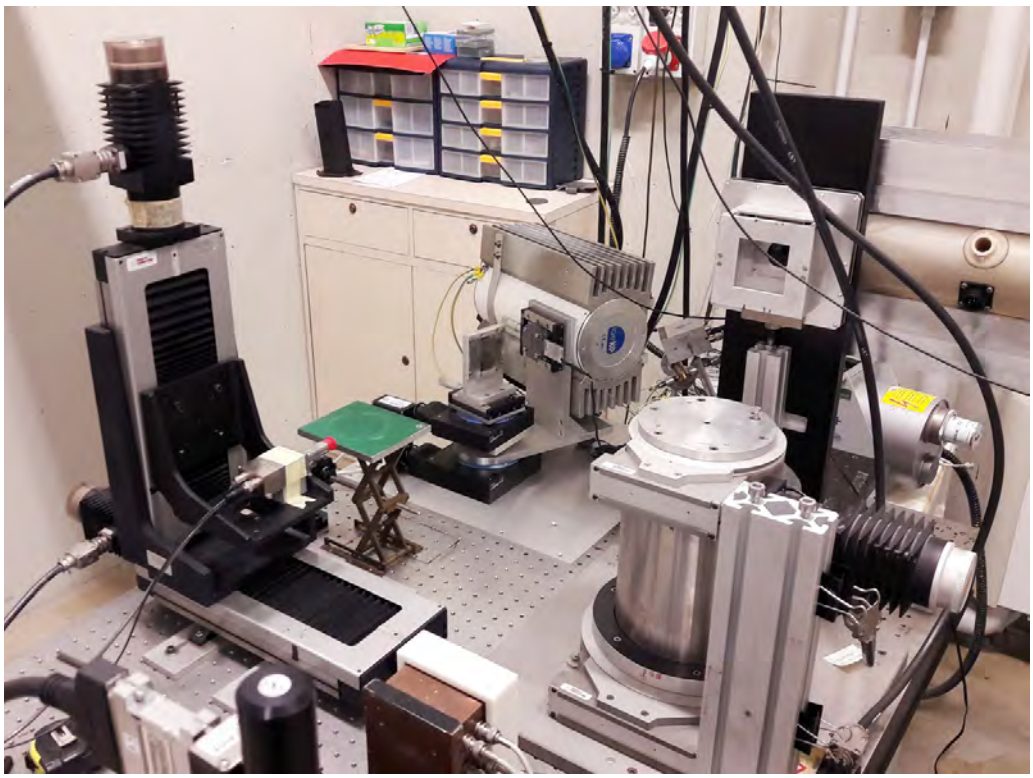


FIG. 1. Scientific visitors from Malta were trained on the application of a K-edge goniometer for cultural heritage. (Photograph reproduced courtesy of M. Grima/Heritage Malta.)

Latin America and the Caribbean

The 19th coordination meeting of the Regional Co-operation Agreement for the Promotion of Nuclear Science and Technology in Latin America and the Caribbean (ARCAL) Technical Coordination Board took place in Vienna in May to identify regional priorities, to select project proposals for the 2020–2021 technical cooperation cycle and to analyse the progress made by the ARCAL regional programme. The participants also agreed on new communication and partnership strategies, as well as a new monitoring and evaluation plan.

In September, the 19th Meeting of the ARCAL Board of Representatives took place in Vienna during the Agency's 62nd regular session of the General Conference. Representatives of ARCAL States Parties considered the achievements of the previous year and reviewed the ten regional projects proposed for the next technical cooperation cycle (2020–2021). The representatives also approved an action plan for a communication strategy regarding ARCAL's 35th anniversary, due to be celebrated in 2019.

The Agency is facilitating the preparation of the 2020–2026 Regional Strategic Profile for technical cooperation in Member States in the Caribbean. A meeting of experts from the Caribbean in November advanced the preparation process, ensuring alignment of the document with regional priorities. The document will guide Agency activities in the region, providing a framework for collaboration with regional organizations and among Member States.

Programme of Action for Cancer Therapy

The Agency participated in the World Health Assembly; the World Health Summit; the Stop Cervical, Breast and Prostate Cancers in Africa Conference; the Commonwealth East, Central and Southern Africa (ECSA) Health Ministers Conference; the World Cancer

Leaders' Summit; and the World Cancer Congress, highlighting the Agency's efforts to support Member States in addressing cancer control priorities and needs. The Agency also attended meetings of the United Nations Interagency Task Force on the Prevention and Control of Non-communicable Diseases, which coordinates the activities of relevant United Nations and other intergovernmental organizations that support countries in meeting commitments in response to global epidemics of non-communicable diseases.

Seven Member States conducted imPACT Review missions — Afghanistan, Guyana, Indonesia, Mauritius, Mexico, North Macedonia[1] and Ukraine. Recommendations from imPACT Reviews provide support to evidence based decision making to strengthen national cancer control capacities and facilitate the identification of priority interventions and investments. imPACT Reviews form the basis for dedicated follow-up assistance, such as the development of national cancer control plans, in cooperation with partners.

With the World Health Organization, the Agency provided Lesotho, Malawi, Mozambique, Namibia, Nicaragua and Viet Nam with expert advisory support for the development of national cancer control plans. Albania also received an expert assessment of its advances in cancer control.

Managing the Agency's Technical Cooperation Programme

Member State priorities in 2018, as reflected in programme disbursements, were health and nutrition, safety and security, and food and agriculture (Fig. 2), with some variations in emphasis across regions. By the end of the year, 1016 projects were active. During the year, 182 projects were closed, of which one was cancelled in consultation with the relevant Member State, and an additional 508 projects were in the process of being closed. No Programme Reserve projects were requested.

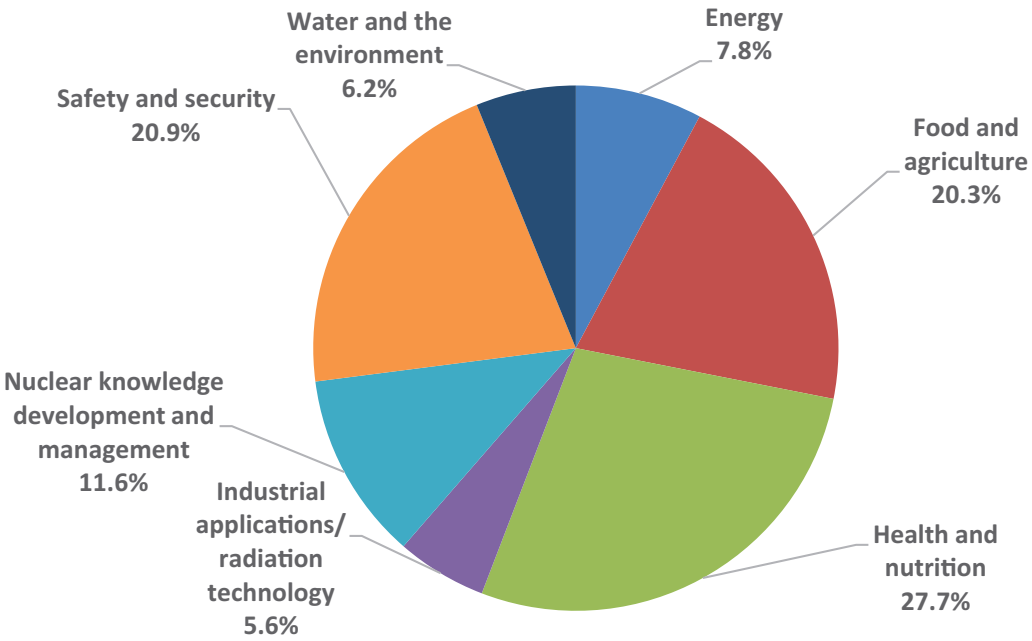


FIG. 2. Actuals by technical field for 2018. (Percentages do not add up to 100% owing to rounding.)

[1] The name 'North Macedonia' replaces the former name 'The former Yugoslav Republic of Macedonia' as of 15 February 2019.

Financial Highlights

Payments to the 2018 Technical Cooperation Fund (TCF) totalled €78.3 million (not including National Participation Costs (NPCs), assessed programme cost (APC) arrears and miscellaneous income), against the target of €85.7 million, with the rate of attainment on payments at the end of 2018 standing at 91.4% (Fig. 3). The use of these resources resulted in a TCF implementation rate of 85.7%.

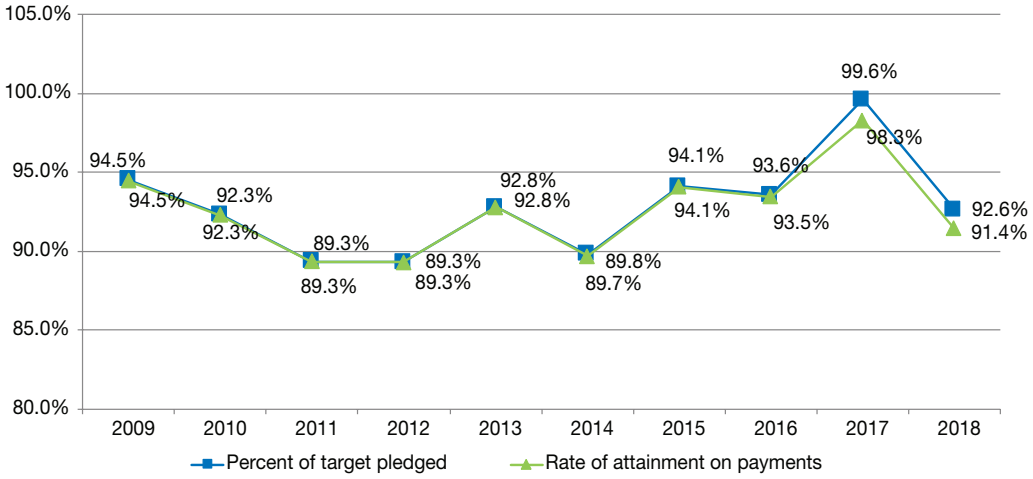


FIG. 3. Trends in the rate of attainment, 2009–2018.

Improving the Quality of the Technical Cooperation Programme

The Agency conducted training events and briefings for some 475 technical cooperation stakeholders at the Agency's Headquarters and in Member States in 2018. Activities included training in the use of the logical framework approach, country and regional project design workshops, training in monitoring and evaluation with a focus on completion of Project Progress Assessment Reports, presentations on the technical cooperation quality criteria, and general information about the technical cooperation programme in the form of orientation workshops. The updated on-line logical framework approach training module has been used by close to 900 technical cooperation stakeholders since its launch.

The Guidelines for the Planning and Design of the IAEA 2020–2021 Technical Cooperation Programme were issued in January. Project design templates and guidance were also reviewed and updated, based on the experience of previous technical cooperation cycles and to address recommendations from internal and external audits and evaluations.

Monitoring and Evaluating Technical Cooperation Projects

A detailed analysis of electronic Project Progress Assessment Reports (e-PPARs) for 2017 submitted through the new electronic technical cooperation reports platform was conducted in 2018. Since its introduction in 2017, the electronic platform has led to significant improvements in the submission and completion rates, volume and quality of submissions.

Outreach and Communication

Outreach to Member States, current and potential partners, donors and the international development community is an essential activity for the Agency. The technical cooperation programme was presented at the IAEA Ministerial Conference on Nuclear Science and Technology: Addressing Current and Emerging Development Challenges, the International Symposium on Understanding the Double Burden of Malnutrition for Effective Interventions and the International Symposium on Communicating Nuclear and Radiological Emergencies to the Public.

An exhibition focusing on the Agency's activities in human health was organized at the 63rd CARPHA Annual Health Research Conference, held in Saint Kitts and Nevis in June. The Agency also participated at the World Health Summit and spoke at the 'Managing the Next Decade in Cancer' panel discussion, among other cancer related events. It was also present at the Global South–South Development Expo in New York and participated in 'The RoK-UNOSSC Facility: Innovation in Practice, Challenges and Solutions' side event.

At the 62nd regular session of the Agency's General Conference, three side events showcased Agency support to Member State efforts to address cancer, the Intercontinental Nuclear Institute and women from Africa working in the nuclear field.

More than 60 diplomats from 43 Permanent Missions attended the annual Seminar on Technical Cooperation for Diplomats in Vienna, and 19 diplomats from 18 Permanent Missions attended the first Seminar on Technical Cooperation for Diplomats in Geneva in October. The seminars provided participants with a comprehensive overview of the technical cooperation programme.

In 2018, 155 news items on technical cooperation were posted on-line, including 7 photo essays and 15 videos. During the year, more than 770 tweets were sent out from the @IAEATC Twitter account, which now has over 4500 followers. The LinkedIn TC Alumni Group now has over 1700 members.

Legislative Assistance

In 2018, the Agency continued to provide legislative assistance to its Member States through the technical cooperation programme. Country specific bilateral legislative assistance was provided to 17 Member States through written comments and advice on drafting national nuclear legislation. The Agency also reviewed the legal framework of a number of newcomer countries as part of the Integrated Nuclear Infrastructure Review missions. Short 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 eighth session of the Nuclear Law Institute (NLI) in Baden, Austria, in October. 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. Sixty-one participants from 52 Member States attended the training.

One regional workshop on nuclear law was conducted for Member States of Latin America and the Caribbean in Santiago in June. The workshop addressed all aspects of nuclear law and created a forum for an exchange of views on topics relating to the international legal instruments. The event was attended by 33 participants from 18 Member States of the region. National workshops on different aspects of nuclear law were also organized in the Plurinational State of Bolivia, the Lao People's Democratic Republic, Lesotho, the Philippines and the Sudan.

Treaty Event

The Agency's eighth Treaty Event took place during the 62nd regular session of the General Conference, providing 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. Representatives of several Member States were also briefed on the conventions adopted under Agency auspices. This year's Treaty Event focused in particular on the Convention on Nuclear Safety and the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management

Annex

Note: Tables A33–A38 are available on the attached CD-ROM.

Table A1. Regular Budget allocation and utilization of resources in 2018 by Programme and Major Programme (in euros)

Major Programme (MP)/Programme	Original budget US $1/€1	Adjusted budget US $1/€0.847	Expenditure	Resource utilization	Balances
	a*	b**	c	d = c/b	e = b - c
MP1 — Nuclear Power, Fuel Cycle and Nuclear Science					
Overall management, coordination and common activities	3 134 965	3 057 889	3 036 037	99.3%	21 852
Nuclear Power	8 698 141	8 482 035	8 200 272	96.7%	281 763
Nuclear Fuel Cycle and Materials Technologies	7 352 806	7 179 032	6 935 879	96.6%	243 153
Capacity Building and Nuclear Knowledge for Sustainable Energy Development	10 326 191	10 105 671	9 174 724	90.8%	930 947
Nuclear Science	10 331 978	10 165 141	9 886 591	97.3%	278 549
Total Major Programme 1	**39 844 081**	**38 989 768**	**37 233 503**	**95.5%**	**1 756 265**
MP2 — Nuclear Techniques for Development and Environmental Protection					
Overall management, coordination and common activities	7 842 153	7 749 123	7 837 894	101.1%	(88 771)
Food and Agriculture	11 653 361	11 463 665	11 484 082	100.2%	(20 417)
Human Health	8 560 287	8 395 413	8 354 430	99.5%	40 983
Water Resources	3 599 384	3 541 674	3 565 688	100.7%	(24 014)
Environment	6 431 279	6 316 669	6 281 919	99.4%	34 750
Radioisotope Production and Radiation Technology	2 393 070	2 353 538	2 247 633	95.5%	105 905
Total Major Programme 2	**40 479 534**	**39 820 082**	**39 771 646**	**99.9%**	**48 436**
MP3 — Nuclear Safety and Security					
Overall management, coordination and common activities	3 914 342	3 815 892	3 803 451	99.7%	12 441
Incident and Emergency Preparedness and Response	4 331 663	4 237 606	4 213 183	99.4%	24 423
Safety of Nuclear Installations	10 369 996	10 088 230	10 027 739	99.4%	60 491
Radiation and Transport Safety	7 408 980	7 219 346	7 313 537	101.3%	(94 191)
Radioactive Waste Management and Environmental Safety	3 744 708	3 655 548	3 567 237	97.6%	88 311
Nuclear Security	5 842 977	5 673 081	5 229 455	92.2%	443 626
Total Major Programme 3	**35 612 666**	**34 689 703**	**34 154 602**	**98.5%**	**535 101**
MP4 — Nuclear Verification					
Overall management, coordination and common activities	14 301 527	14 067 595	13 306 670	94.6%	760 925
Safeguards Implementation	121 082 207	118 256 917	119 097 574	100.7%	(840 657)
Other Verification Activities	1 739 630	1 677 411	1 649 363	98.3%	28 048
Development	4 837 563	4 699 156	4 587 708	97.6%	111 448
Total Major Programme 4	**141 960 927**	**138 701 079**	**138 641 315**	**100.0%**	**59 764**
MP5 — Policy, Management and Administration Services					
Policy, Management and Administration Services	79 048 022	77 893 066	76 964 397	98.8%	928 669
Total Major Programme 5	**79 048 022**	**77 893 066**	**76 964 397**	**98.8%**	**928 669**
MP6 — Management of Technical Cooperation for Development					
Management of Technical Cooperation for Development	25 534 194	24 975 289	24 679 939	98.8%	295 350
Total Major Programme 6	**25 534 194**	**24 975 289**	**24 679 939**	**98.8%**	**295 350**
Total Operational Regular Budget	**362 479 424**	**355 068 987**	**351 445 402**	**99.0%**	**3 623 585**
Major Capital Investment Funding Requirements* **					
MP1 — Nuclear Power, Fuel Cycle and Nuclear Science	–	–	–	–	–
MP2 — Nuclear Techniques for Development and Environmental Protection	2 011 381	2 011 381	1 401 197	69.7%	610 184
MP3 — Nuclear Safety and Security	270 144	270 144	92 820	34.4%	177 324
MP4 — Nuclear Verification	2 016 000	2 016 000	1 008 000	50.0%	1 008 000
MP5 — Policy, Management and Administration Services	3 761 856	3 761 856	2 207 117	58.7%	1 554 739
MP6 — Management of Technical Cooperation for Development	–	–	–	–	–
Total Capital Regular Budget	**8 059 381**	**8 059 381**	**4 709 134**	**58.4%**	**3 350 247**
Total Agency Programmes	**370 538 805**	**363 128 368**	**356 154 536**	**98.1%**	**6 973 832**
Reimbursable Work for Others	2 782 851	2 782 851	3 107 795	111.7%	(324 944)
Total Regular Budget	**373 321 656**	**365 911 219**	**359 262 331**	**98.2%**	**6 648 888**

* General Conference resolution GC(61)/RES/4 of September 2017 original budget at US $1/€1.

** Original budget revalued at the United Nations operational average rate of exchange of €0.847 to US $1 in 2018.

*** Additional information about the Major Capital Investment Fund can be found in note 39d of *The Agency's Financial Statements for 2018.*

Table A2. Extrabudgetary regular programme fund resource utilization in 2018 by Programme and Major Programme (in euros)

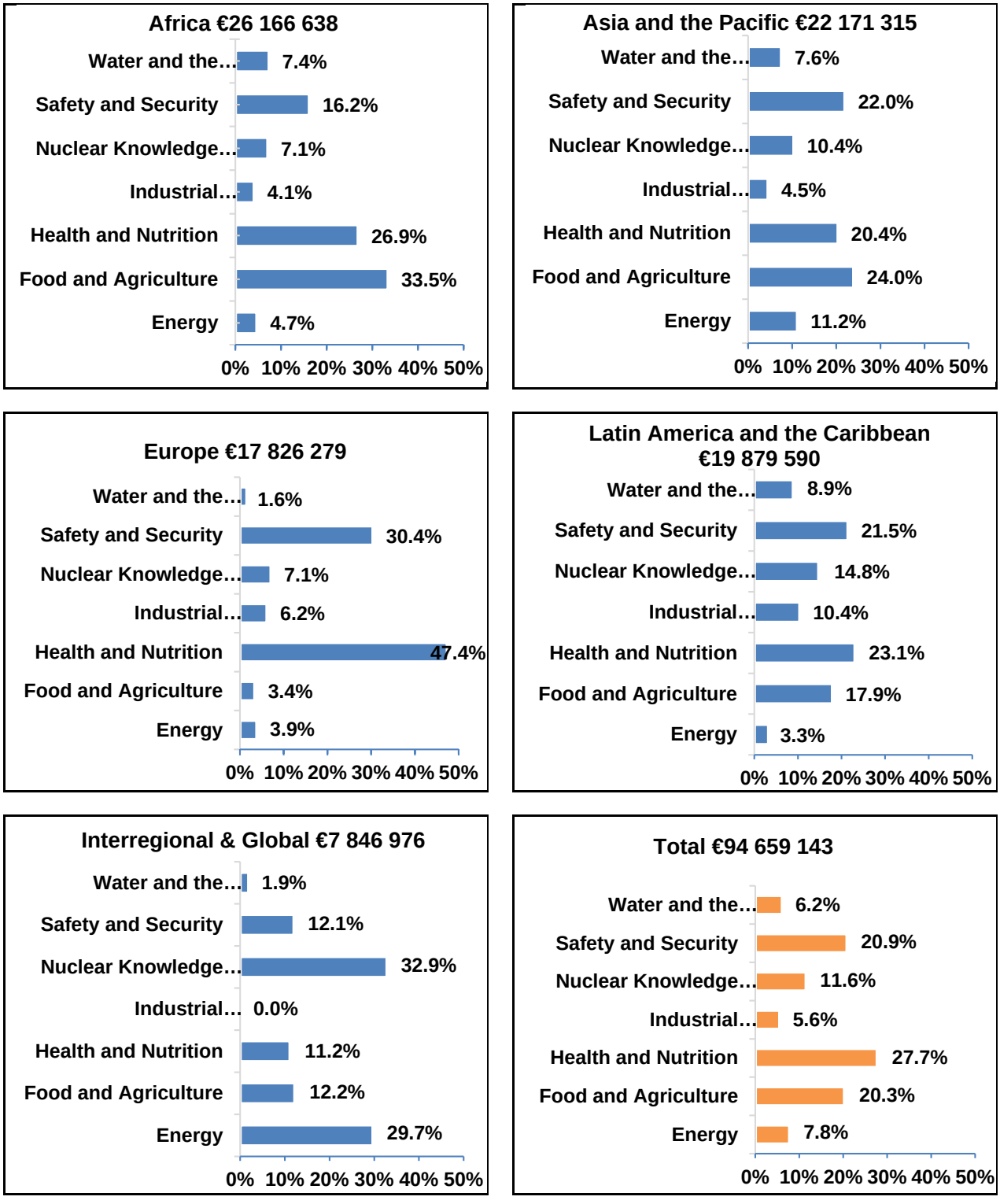
Major Programme (MP)/Programme	2018 net expenditure
MP1 — Nuclear Power, Fuel Cycle and Nuclear Science	
Overall management, coordination and common activities	95 844
Nuclear Power	3 321 130
Nuclear Fuel Cycle and Materials Technologies	3 525 439
Capacity Building and Nuclear Knowledge for Sustainable Energy Development	704 847
Nuclear Science	5 008 511
Total Major Programme 1	**12 655 771**
MP2 — Nuclear Techniques for Development and Environmental Protection	
Overall management, coordination and common activities	11 633 229
Food and Agriculture	3 020 594
Human Health	547 187
Water Resources	572 483
Environment	1 282 746
Radioisotope Production and Radiation Technology	106 169
Total Major Programme 2	**17 162 408**
MP3 — Nuclear Safety and Security	
Overall management, coordination and common activities	4 057 275
Incident and Emergency Preparedness and Response	1 154 769
Safety of Nuclear Installations	4 507 092
Radiation and Transport Safety	2 923 713
Radioactive Waste Management and Environmental Safety	1 585 281
Nuclear Security	19 453 035
Total Major Programme 3	**33 681 165**
MP4 — Nuclear Verification	
Overall management, coordination and common activities	635 015
Safeguards Implementation	11 157 665
Other Verification Activities	5 790 660
Development	1 274 993
Total Major Programme 4	**18 858 333**
MP5 — Policy, Management and Administration Services	
Policy, Management and Administration Services	2 060 636
Total Major Programme 5	**2 060 636**
MP6 — Management of Technical Cooperation for Development	
Management of Technical Cooperation for Development	495 203
Total Major Programme 6	**495 203**
Total extrabudgetary programme funds	**84 913 516**

Table A3(a). Disbursements (actuals) of the Technical Cooperation Fund by technical field and region in 2018

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	1 235 980	2 481 752	689 567	653 021	2 332 444		**7 392 765**
Food and Agriculture	8 758 360	5 310 839	607 454	3 565 479	960 503		**19 202 634**
Health and Nutrition	7 039 917	4 525 008	8 450 797	4 593 611	876 845	768 345	**26 254 523**
Industrial Applications/ Radiation Technology	1 083 371	1 003 501	1 103 627	2 076 028			**5 266 527**
Nuclear Knowledge Development and Management	1 864 877	2 302 468	1 268 335	2 938 638	2 579 829		**10 954 148**
Safety and Security	4 244 757	4 870 094	5 422 422	4 274 091	946 744		**19 758 108**
Water and the Environment	1 939 375	1 677 653	284 077	1 778 722	150 611		**5 830 438**
Total	**26 166 638**	**22 171 315**	**17 826 279**	**19 879 590**	**7 846 976**	**768 345**	**94 659 143**

[a] PACT: Programme of Action for Cancer Therapy.

Table A3(b). Graphical representation of the 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 2018 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	140 888	2 726	20 139	163 753
Separated plutonium outside reactor cores	1 157	5	10 917	12 079
High enriched uranium (equal to or greater than 20% U-235)	159	1	0	160
Low enriched uranium (less than 20% U-235)	19 401	333	1 402	21 136
Source material[c] (natural and depleted uranium and thorium)	11 815	1 172	2 681	15 668
U-233	18	0	0	18
Total SQs of nuclear material	**173 438**	**4 237**	**35 139**	**212 814**

Amount of heavy water under Agency safeguards at the end of 2018 by type of agreement				
Non-nuclear material[d]	**Comprehensive safeguards agreement**	**INFCIRC/66-type agreement**	**Voluntary offer agreement**	**Quantity in tonnes**
Heavy water (tonnes)		**422.9**		**423.6[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 (9 000 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 2018

Type	Comprehensive safeguards agreement[a]	INFCIRC/66-type agreement[b]	Voluntary offer agreement	Total
Power reactors	240	16	1	**257**
Research reactors and critical assemblies	147	3	1	**151**
Conversion plants	18	0	0	**18**
Fuel fabrication plants	40	2	1	**43**
Reprocessing plants	10	0	1	**11**
Enrichment plants	16	0	3	**19**
Separate storage facilities	136	2	4	**142**
Other facilities	80	0	0	**80**
Facility subtotals	**687**	**23**	**11**	**721**
Material balance areas containing locations outside facilities[c]	592	1	0	**593**
Total	**1279**	**24**	**11**	**1314**

[a] Covering safeguards agreements pursuant to the Treaty on the Non-Proliferation of Nuclear Weapons and/or the Treaty of Tlatelolco and other comprehensive safeguards agreements; includes facilities in Taiwan, China.

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

[c] Includes 59 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 2018)

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 Jul. 2005
Albania[1]		In force: 25 Mar. 1988	359	In force: 3 Nov. 2010
Algeria		In force: 7 Jan. 1997	531	Signed: 16 Feb. 2018
Andorra	Amended: 24 Apr. 2013	In force: 18 Oct. 2010	808	In force: 19 Dec. 2011
Angola	In force: 28 Apr. 2010	In force: 28 Apr. 2010	800	In force: 28 Apr. 2010
Antigua and Barbuda[2]	Amended: 5 Mar. 2012	In force: 9 Sep. 1996	528	In force: 15 Nov. 2013
Argentina[3]		In force: 4 Mar. 1994	435	
Armenia		In force: 5 May 1994	455	In force: 28 Jun. 2004
Australia		In force: 10 Jul. 1974	217	In force: 12 Dec. 1997
Austria[4]		Accession: 31 Jul. 1996	193	In force: 30 Apr. 2004
Azerbaijan		In force: 29 Apr. 1999	580	In force: 29 Nov. 2000
Bahamas[2]	Amended: 25 Jul. 2007	In force: 12 Sep. 1997	544	
Bahrain	In force: 10 May 2009	In force: 10 May 2009	767	In force: 20 Jul. 2011
Bangladesh		In force: 11 Jun. 1982	301	In force: 30 Mar. 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 Apr. 2004
Belize[5]	X	In force: 21 Jan. 1997	532	
Benin	*Amended: 15 Apr. 2008*	*Signed: 7 Jun. 2005*		*Signed: 7 Jun. 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 Apr. 2013	851	In force: 3 Jul. 2013
Botswana		In force: 24 Aug. 2006	694	In force: 24 Aug. 2006
Brazil[6]		In force: 4 Mar. 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 Apr. 2003	618	In force: 17 Apr. 2003

State[a]	Small quantities protocols[b]	Safeguards agreements[c]	INFCIRC	Additional protocols
Burundi	In force: 27 Sep. 2007	In force: 27 Sep. 2007	719	In force: 27 Sep. 2007
Cabo Verde	*Amended: 27 Mar. 2006*	*Signed: 28 Jun. 2005*		*Signed: 28 Jun. 2005*
Cambodia	Amended: 16 Jul. 2014	In force: 17 Dec. 1999	586	In force: 24 Apr. 2015
Cameroon	X	In force: 17 Dec. 2004	641	In force: 29 Sep. 2016
Canada		In force: 21 Feb. 1972	164	In force: 8 Sep. 2000
Central African Republic	In force: 7 Sep. 2009	In force: 7 Sep. 2009	777	In force: 7 Sep. 2009
Chad	In force: 13 May 2010	In force: 13 May 2010	802	In force: 13 May 2010
Chile[8]		In force: 5 Apr. 1995	476	In force: 3 Nov. 2003
China		In force: 18 Sep. 1989	369*	In force: 28 Mar. 2002
Colombia[8]		In force: 22 Dec. 1982	306	In force: 5 Mar. 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 Jun. 2011
Côte d'Ivoire		In force: 8 Sep. 1983	309	In force: 5 May 2016
Croatia[9]		Accession: 1 Apr. 2017	193	Accession: 1 Apr. 2017
Cuba[2]		In force: 3 Jun. 2004	633	In force: 3 Jun. 2004
Cyprus[10]		Accession: 1 May 2008	193	Accession: 1 May 2008
Czech Republic[11]		Accession: 1 Oct. 2009	193	Accession: 1 Oct. 2009
Democratic Republic of the Congo		In force: 9 Nov. 1972	183	In force: 9 Apr. 2003
Denmark[12]		In force: 1 Mar. 1972 In force: 21 Feb. 1977	176 193	In force: 22 Mar. 2013 In force: 30 Apr. 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 Apr. 1992	403	
Ecuador[2]	Amended: 7 Apr. 2006	In force: 10 Mar. 1975	231	In force: 24 Oct. 2001
Egypt		In force: 30 Jun. 1982	302	
El Salvador[2]	Amended: 10 Jun. 2011	In force: 22 Apr. 1975	232	In force: 24 May 2004

State[a]	Small quantities protocols[b]	Safeguards agreements[c]	INFCIRC	Additional protocols
Equatorial Guinea	*Approved: 13 Jun. 1986*	*Approved: 13 Jun. 1986*		
Eritrea				
Estonia[13]		Accession: 1 Dec. 2005	193	Accession: 1 Dec. 2005
Eswatini[d]	Amended: 23 Jul. 2010	In force: 28 Jul. 1975	227	In force: 8 Sep. 2010
Ethiopia	X	In force: 2 Dec. 1977	261	
Fiji	X	In force: 22 Mar. 1973	192	In force: 14 Jul. 2006
Finland[14]		Accession: 1 Oct. 1995	193	In force: 30 Apr. 2004
France	X	In force: 12 Sep. 1981 In force: 26 Oct. 2007[15]	290* 718	In force: 30 Apr. 2004
Gabon	Amended: 30 Oct. 2013	In force: 25 Mar. 2010	792	In force: 25 Mar. 2010
Gambia	Amended: 17 Oct. 2011	In force: 8 Aug. 1978	277	In force: 18 Oct. 2011
Georgia		In force: 3 Jun. 2003	617	In force: 3 Jun. 2003
Germany[16]		In force: 21 Feb. 1977	193	In force: 30 Apr. 2004
Ghana		In force: 17 Feb. 1975	226	In force: 11 Jun. 2004
Greece[17]		Accession: 17 Dec. 1981	193	In force: 30 Apr. 2004
Grenada[2]	X	In force: 23 Jul. 1996	525	
Guatemala[2]	Amended: 26 Apr. 2011	In force: 1 Feb. 1982	299	In force: 28 May 2008
Guinea	*Signed: 13 Dec. 2011*	*Signed: 13 Dec. 2011*		*Signed: 13 Dec. 2011*
Guinea-Bissau	*Signed: 21 Jun. 2013*	*Signed: 21 Jun. 2013*		*Signed: 21 Jun. 2013*
Guyana[2]	X	In force: 23 May 1997	543	
Haiti[2]	X	In force: 9 Mar. 2006	681	In force: 9 Mar. 2006
Holy See	Amended: 11 Sep. 2006	In force: 1 Aug. 1972	187	In force: 24 Sep. 1998
Honduras[2]	Amended: 20 Sep. 2007	In force: 18 Apr. 1975	235	In force: 17 Nov. 2017
Hungary[18]		Accession: 1 Jul. 2007	193	Accession: 1 Jul. 2007
Iceland	Amended: 15 Mar. 2010	In force: 16 Oct. 1974	215	In force: 12 Sep. 2003
India[19]		In force: 30 Sep. 1971 In force: 17 Nov. 1977 In force: 27 Sep. 1988 In force: 11 Oct. 1989 In force: 1 Mar. 1994 In force: 11 May 2009	211 260 360 374 433 754	In force: 25 Jul. 2014
Indonesia		In force: 14 Jul. 1980	283	In force: 29 Sep. 1999

State[a]	Small quantities protocols[b]	Safeguards agreements[c]	INFCIRC	Additional protocols
Iran, Islamic Republic of [20]		In force: 15 May 1974	214	Signed: 18 Dec. 2003
Iraq		In force: 29 Feb. 1972	172	In force: 10 Oct. 2012
Ireland		In force: 21 Feb. 1977	193	In force: 30 Apr. 2004
Israel		In force: 4 Apr. 1975	249/Add.1	
Italy		In force: 21 Feb. 1977	193	In force: 30 Apr. 2004
Jamaica[2]		In force: 6 Nov. 1978	265	In force: 19 Mar. 2003
Japan		In force: 2 Dec. 1977	255	In force: 16 Dec. 1999
Jordan		In force: 21 Feb. 1978	258	In force: 28 Jul. 1998
Kazakhstan		In force: 11 Aug. 1995	504	In force: 9 May 2007
Kenya	In force: 18 Sep. 2009	In force: 18 Sep. 2009	778	In force: 18 Sep. 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 Jul. 2013	In force: 7 Mar. 2002	607	In force: 2 Jun. 2003
Kyrgyzstan	X	In force: 3 Feb. 2004	629	In force: 10 Nov. 2011
Lao People's Democratic Republic	X	In force: 5 Apr. 2001	599	Signed: 5 Nov. 2014
Latvia[21]		Accession: 1 Oct. 2008	193	Accession: 1 Oct. 2008
Lebanon	Amended: 5 Sep. 2007	In force: 5 Mar. 1973	191	
Lesotho	Amended: 8 Sep. 2009	In force: 12 Jun. 1973	199	In force: 26 Apr. 2010
Liberia	In force: 10 Dec. 2018	In force: 10 Dec. 2018	927	In force: 10 Dec. 2018
Libya		In force: 8 Jul. 1980	282	In force: 11 Aug. 2006
Liechtenstein		In force: 4 Oct. 1979	275	In force: 25 Nov. 2015
Lithuania[22]		Accession: 1 Jan. 2008	193	Accession: 1 Jan. 2008
Luxembourg		In force: 21 Feb. 1977	193	In force: 30 Apr. 2004
Madagascar	Amended: 29 May 2008	In force: 14 Jun. 1973	200	In force: 18 Sep. 2003
Malawi	Amended: 29 Feb. 2008	In force: 3 Aug. 1992	409	In force: 26 Jul. 2007
Malaysia		In force: 29 Feb. 1972	182	Signed: 22 Nov. 2005
Maldives	X	In force: 2 Oct. 1977	253	
Mali	Amended: 18 Apr. 2006	In force: 12 Sep. 2002	615	In force: 12 Sep. 2002

State[a]	Small quantities protocols[b]	Safeguards agreements[c]	INFCIRC	Additional protocols
Malta[23]		Accession: 1 Jul. 2007	193	Accession: 1 Jul. 2007
Marshall Islands		In force: 3 May 2005	653	In force: 3 May 2005
Mauritania	Amended: 20 Mar. 2013	In force: 10 Dec. 2009	788	In force: 10 Dec. 2009
Mauritius	Amended: 26 Sep. 2008	In force: 31 Jan. 1973	190	In force: 17 Dec. 2007
Mexico[24]		In force: 14 Sep. 1973	197	In force: 4 Mar. 2011
Micronesia, Federated States of	*Signed: 1 Jun. 2015*	*Signed: 1 Jun. 2015*		
Monaco	Amended: 27 Nov. 2008	In force: 13 Jun. 1996	524	In force: 30 Sep. 1999
Mongolia	X	In force: 5 Sep. 1972	188	In force: 12 May 2003
Montenegro	In force: 4 Mar. 2011	In force: 4 Mar. 2011	814	In force: 4 Mar. 2011
Morocco		In force: 18 Feb. 1975	228	In force: 21 Apr. 2011
Mozambique	In force: 1 Mar. 2011	In force: 1 Mar. 2011	813	In force: 1 Mar. 2011
Myanmar	X	In force: 20 Apr. 1995	477	Signed: 17 Sep. 2013
Namibia	X	In force: 15 Apr. 1998	551	In force: 20 Feb. 2012
Nauru	X	In force: 13 Apr. 1984	317	
Nepal	X	In force: 22 Jun. 1972	186	
Netherlands	X	In force: 5 Jun. 1975[15] In force: 21 Feb. 1977	229 193	In force: 30 Apr. 2004
New Zealand[25]	Amended: 24 Feb. 2014	In force: 29 Feb. 1972	185	In force: 24 Sep. 1998
Nicaragua[2]	Amended: 12 Jun. 2009	In force: 29 Dec. 1976	246	In force: 18 Feb. 2005
Niger		In force: 16 Feb. 2005	664	In force: 2 May 2007
Nigeria		In force: 29 Feb. 1988	358	In force: 4 Apr. 2007
North Macedonia[e]	Amended: 9 Jul. 2009	In force: 16 Apr. 2002	610	In force: 11 May 2007
Norway		In force: 1 Mar. 1972	177	In force: 16 May 2000
Oman	X	In force: 5 Sep. 2006	691	
Pakistan		In force: 5 Mar. 1962 In force: 17 Jun. 1968 In force: 17 Oct. 1969 In force: 18 Mar. 1976 In force: 2 Mar. 1977 In force: 10 Sep. 1991 In force: 24 Feb. 1993 In force: 22 Feb. 2007 In force: 15 Apr. 2011 In force: 3 May 2017	34 116 135 239 248 393 418 705 816 920	

State[a]	Small quantities protocols[b]	Safeguards agreements[c]	INFCIRC	Additional protocols
Palau	Amended: 15 Mar. 2006	In force: 13 May 2005	650	In force: 13 May 2005
Panama[8]	Amended: 4 Mar. 2011	In force: 23 Mar. 1984	316	In force: 11 Dec. 2001
Papua New Guinea	X	In force: 13 Oct. 1983	312	
Paraguay[2]	Amended: 17 Jul. 2018	In force: 20 Mar. 1979	279	In force: 15 Sep. 2004
Peru[2]		In force: 1 Aug. 1979	273	In force: 23 Jul. 2001
Philippines		In force: 16 Oct. 1974	216	In force: 26 Feb. 2010
Poland[26]		Accession: 1 Mar. 2007	193	Accession: 1 Mar. 2007
Portugal[27]		Accession: 1 Jul. 1986	193	In force: 30 Apr. 2004
Qatar	In force: 21 Jan. 2009	In force: 21 Jan. 2009	747	
Republic of Moldova	Amended: 1 Sep. 2011	In force: 17 May 2006	690	In force: 1 Jun. 2012
Romania[28]		Accession: 1 May 2010	193	Accession: 1 May 2010
Russian Federation		In force: 10 Jun. 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	
Saint 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 Sep. 1998	575	
São Tomé and Príncipe				
Saudi Arabia	X	In force: 13 Jan. 2009	746	
Senegal	Amended: 6 Jan. 2010	In force: 14 Jan. 1980	276	In force: 24 Jul. 2017
Serbia[29]		In force: 28 Dec. 1973	204	In force: 17 Sep. 2018
Seychelles	Amended: 31 Oct. 2006	In force: 19 Jul. 2004	635	In force: 13 Oct. 2004
Sierra Leone	X	In force: 4 Dec. 2009	787	
Singapore	Amended: 31 Mar. 2008	In force: 18 Oct. 1977	259	In force: 31 Mar. 2008
Slovakia[30]		Accession: 1 Dec. 2005	193	Accession: 1 Dec. 2005
Slovenia[31]		Accession: 1 Sep. 2006	193	Accession: 1 Sep. 2006
Solomon Islands	X	In force: 17 Jun. 1993	420	

State[a]	Small quantities protocols[b]	Safeguards agreements[c]	INFCIRC	Additional protocols
Somalia				
South Africa		In force: 16 Sep. 1991	394	In force: 13 Sep. 2002
Spain		Accession: 5 Apr. 1989	193	In force: 30 Apr. 2004
Sri Lanka		In force: 6 Aug. 1984	320	Approved: 12 Sep. 2018
State of Palestine[32]	*Approved: 7 Mar. 2018*	*Approved: 7 Mar. 2018*		
Sudan	X	In force: 7 Jan. 1977	245	
Suriname[2]	X	In force: 2 Feb. 1979	269	
Sweden[33]		Accession: 1 Jun. 1995	193	In force: 30 Apr. 2004
Switzerland		In force: 6 Sep. 1978	264	In force: 1 Feb. 2005
Syrian Arab Republic		In force: 18 May 1992	407	
Tajikistan		In force: 14 Dec. 2004	639	In force: 14 Dec. 2004
Thailand		In force: 16 May 1974	241	In force: 17 Nov. 2017
Timor-Leste	*Signed: 6 Oct. 2009*	*Signed: 6 Oct. 2009*		*Signed: 6 Oct. 2009*
Togo	Amended: 8 Oct. 2015	In force: 18 July 2012	840	In force: 18 July 2012
Tonga	Amended: 3 Apr. 2018	In force: 18 Nov. 1993	426	
Trinidad and Tobago[2]	X	In force: 4 Nov. 1992	414	
Tunisia		In force: 13 Mar. 1990	381	Signed: 24 May 2005
Turkey		In force: 1 Sep. 1981	295	In force: 17 Jul. 2001
Turkmenistan		In force: 3 Jan. 2006	673	In force: 3 Jan. 2006
Tuvalu	X	In force: 15 Mar. 1991	391	
Uganda	Amended: 24 Jun. 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		In force: 9 Oct. 2003	622	In force: 20 Dec. 2010
United Kingdom	Signed: 6 Jan. 1993	In force: 14 Dec. 1972[34] In force: 14 Aug. 1978 Signed: 6 Jan. 1993[15] Signed: 7 Jun. 2018*	175 263*	In force: 30 Apr. 2004 Signed: 7 Jun. 2018
United Republic of Tanzania	Amended: 10 Jun. 2009	In force: 7 Feb. 2005	643	In force: 7 Feb. 2005
United States of America	Amended: 3 Jul. 2018	In force: 9 Dec. 1980 In force: 6 Apr. 1989[15]	288* 366	In force: 6 Jan. 2009
Uruguay[2]		In force: 17 Sep. 1976	157	In force: 30 Apr. 2004

State[a]	Small quantities protocols[b]	Safeguards agreements[c]	INFCIRC	Additional protocols
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 Mar. 1982	300	
Viet Nam		In force: 23 Feb. 1990	376	In force: 17 Sep. 2012
Yemen	X	In force: 14 Aug. 2002	614	
Zambia	X	In force: 22 Sep. 1994	456	Signed: 13 May 2009
Zimbabwe	Amended: 31 Aug. 2011	In force: 26 Jun. 1995	483	

Key

Bold States not party to the Treaty on 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.

[d] The name 'Eswatini' replaces the former name 'Swaziland' as of 29 June 2018.

[e] The name 'North Macedonia' replaces the former name 'The former Yugoslav Republic of Macedonia' as of 15 February 2019.

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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 Croatia under the NPT bilateral safeguards agreement (INFCIRC/463), in force since 19 January 1995, was suspended on 1 April 2017, 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 Croatia had acceded, entered into force for Croatia.

[10] 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.

[11] 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.

[12] 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).

[13] 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.

[14] 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.

[15] The safeguards agreement is in connection with Additional Protocol I to the Treaty of Tlatelolco.

[16] The NPT safeguards agreement of 7 March 1972 concluded with the German Democratic Republic (INFCIRC/181) is no longer in force with effect from 3 October 1990, on which date the German Democratic Republic acceded to the Federal Republic of Germany.

[17] The application of safeguards 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.

[18] 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.

[19] 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.

[20] Pending entry into force, the Additional Protocol is being applied provisionally for the Islamic Republic of Iran as of 16 January 2016.

[21] 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.

[22] 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.

[23] 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.

[24] 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.

[25] 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).

[26] 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.

[27] 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.

[28] 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.

[29] 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.

[30] 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.

[31] 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.

[32] The designation employed does not imply the expression of any opinion whatsoever concerning the legal status of any country or territory or of its authorities, or concerning the delimitation of its frontiers.

[33] 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.

[34] 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 (status as of 31 December 2018)

	State/Organization[a]	P&I	ENC	AC	CNS	JC	CPPNM	A/CPPNM	VC	A-VC	CSC	JP
*	Afghanistan						X					
*	Albania	X	X	X	X	X	X	X				
*	Algeria		X	X			X	X				
	Andorra						X					
*	Angola		X									
*	Antigua and Barbuda						X	X				
*	Argentina	X	X	X	X	X	X	X	X	X	X	
*	Armenia		X	X	X	X	X	X	X			
*	Australia	X	X	X	X	X	X	X				
*	Austria		X	X	X	X	X	X				
*	Azerbaijan						X	X				
*	Bahamas						X					
*	Bahrain		X		X		X	X				
*	Bangladesh		X	X	X		X	X				
*	Barbados											
*	Belarus	X	X	X	X	X	X		X	X		
*	Belgium	X	X	X	X	X	X	X				
*	Belize											
*	Benin	X										
	Bhutan											
*	Bolivia, Plurinational State of	X	X	X			X	X	X			
*	Bosnia and Herzegovina	X	X	X	X	X	X	X	X	X		
*	Botswana		X	X		X	X	X				
*	Brazil	X	X	X	X	X	X		X			
*	Brunei Darussalam	X										
*	Bulgaria	X	X	X	X	X	X	X	X			X

	State/Organization[a]	P&I	ENC	AC	CNS	JC	CPPNM	A/CPPNM	VC	A-VC	CSC	JP
*	Burkina Faso		X	X			X	X				
*	Burundi											
	Cabo Verde						X					
*	Cambodia		X		X		X					
*	Cameroon	X	X	X			X	X	X			X
*	Canada	X	X	X	X	X	X	X			X	
*	Central African Republic						X					
*	Chad											
*	Chile	X	X	X	X	X	X	X	X			X
*	China	X	X	X	X	X	X	X				
*	Colombia	X	X	X			X	X				
	Comoros						X					
*	Congo	X										
*	Costa Rica		X	X			X	X				
*	Côte d'Ivoire						X	X				
*	Croatia	X	X	X	X	X	X	X	X			X
*	Cuba	X	X	X	X	X	X	X	X			
*	Cyprus	X	X	X	X	X	X	X				
*	Czech Republic	X	X	X	X	X	X	X	X			X
	Dem. People's Rep. of Korea											
*	Dem. Rep. of the Congo	X					X					
*	Denmark	X	X	X	X	X	X	X				X
*	Djibouti						X	X				
*	Dominica						X					
*	Dominican Republic		X				X	X				
*	Ecuador	X					X	X				
*	Egypt	X	X	X					X			X
*	El Salvador		X	X			X	X				

	State/Organization[a]	P&I	ENC	AC	CNS	JC	CPPNM	A/CPPNM	VC	A-VC	CSC	JP
	Equatorial Guinea						X					
*	Eritrea											
*	Estonia	X	X	X	X	X	X	X	X			X
*	Eswatini[b]						X	X				
*	Ethiopia											
*	Fiji						X	X				
*	Finland	X	X	X	X	X	X	X				X
*	France		X	X	X	X	X	X				X
*	Gabon		X	X		X	X	X				
	Gambia											
*	Georgia		X	X		X	X	X				
*	Germany	X	X	X	X	X	X	X				X
*	Ghana	X	X	X	X	X	X	X			X	
*	Greece	X	X	X	X	X	X	X				X
*	Grenada						X					
*	Guatemala		X	X			X					
	Guinea						X					
	Guinea-Bissau						X					
*	Guyana						X					
*	Haiti											
*	Holy See	X										
*	Honduras						X					
*	Hungary	X	X	X	X	X	X	X	X			X
*	Iceland	X	X	X	X	X	X	X				
*	India	X	X	X	X		X	X			X	
*	Indonesia	X	X	X	X	X	X	X				
*	Iran, Islamic Republic of	X	X	X								
*	Iraq	X	X	X			X					

	State/Organization[a]	P&I	ENC	AC	CNS	JC	CPPNM	A/CPPNM	VC	A-VC	CSC	JP
*	Ireland	X	X	X	X	X	X	X				
*	Israel		X	X			X	X				
*	Italy	X	X	X	X	X	X	X				X
*	Jamaica	X					X	X				
*	Japan	X	X	X	X	X	X	X			X	
*	Jordan	X	X	X	X	X	X	X	X	X		
*	Kazakhstan	X	X	X	X	X	X	X	X	X		
*	Kenya						X	X				
	Kiribati											
*	Korea, Republic of	X	X	X	X	X	X	X				
*	Kuwait	X	X	X	X		X	X				
*	Kyrgyzstan					X	X	X				
*	Lao People's Dem. Rep.		X	X			X					
*	Latvia	X	X	X	X	X	X	X	X	X		X
*	Lebanon		X	X	X		X		X			
*	Lesotho		X	X		X	X	X				
*	Liberia											
*	Libya		X	X	X		X	X				
*	Liechtenstein		X	X			X	X				
*	Lithuania	X	X	X	X	X	X	X	X			X
*	Luxembourg	X	X	X	X	X	X	X				
*	Madagascar		X	X	X	X	X	X				
*	Malawi						X					
*	Malaysia		X	X								
	Maldives											
*	Mali		X	X	X		X	X				
*	Malta				X	X	X	X				
*	Marshall Islands						X	X				

	State/Organization[a]	P&I	ENC	AC	CNS	JC	CPPNM	A/CPPNM	VC	A-VC	CSC	JP
*	Mauritania		X	X		X	X	X				
*	Mauritius	X	X	X		X			X			
*	Mexico	X	X	X	X	X	X	X	X			
	Micronesia, Federated States of											
*	Monaco		X	X			X	X				
*	Mongolia	X	X	X			X					
*	Montenegro	X	X	X	X	X	X	X	X	X	X	
*	Morocco	X	X	X		X	X	X		X	X	
*	Mozambique	X	X	X			X					
*	Myanmar		X		X		X	X				
*	Namibia						X	X				
	Nauru						X	X				
*	Nepal											
*	Netherlands	X	X	X	X	X	X	X				X
*	New Zealand	X	X	X			X	X				
*	Nicaragua	X	X	X			X	X				
*	Niger	X		X	X	X	X	X	X	X		
*	Nigeria	X	X	X	X	X	X	X	X			
	Niue						X					
*	North Macedonia[c]		X	X	X	X	X	X	X			
*	Norway	X	X	X	X	X	X	X				X
*	Oman	X	X	X	X	X	X					
*	Pakistan	X	X	X	X		X	X				
*	Palau	X					X					
	Palestine						X[d]	X[d]				
*	Panama		X	X			X	X				
*	Papua New Guinea											
*	Paraguay		X	X	X	X	X	X				

	State/Organization[a]	P&I	ENC	AC	CNS	JC	CPPNM	A/CPPNM	VC	A-VC	CSC	JP
*	Peru		X	X	X	X	X	X	X			
*	Philippines	X	X	X			X		X			
*	Poland	X	X	X	X	X	X	X	X	X		X
*	Portugal	X	X	X	X	X	X	X				
*	Qatar		X	X			X	X				
*	Republic of Moldova	X	X	X	X	X	X	X	X			
*	Romania	X	X	X	X	X	X	X	X	X	X	X
*	Russian Federation	X	X	X	X	X	X	X	X			
*	Rwanda						X					
	Saint Kitts and Nevis						X					
	Saint Lucia						X	X				
*	Saint Vincent and the Grenadines		X	X					X			X
	Samoa											
*	San Marino						X	X				
	São Tomé and Príncipe											
*	Saudi Arabia		X	X	X	X	X	X	X	X		
*	Senegal	X	X	X	X	X	X	X	X			
*	Serbia	X	X	X	X	X	X	X	X			
*	Seychelles						X	X				
*	Sierra Leone											
*	Singapore	X	X	X	X		X	X				
*	Slovakia	X	X	X	X	X	X	X	X			X
*	Slovenia	X	X	X	X	X	X	X				X
	Solomon Islands											
	Somalia											
*	South Africa	X	X	X	X	X	X					
	South Sudan											
*	Spain	X	X	X	X	X	X	X				

	State/Organization[a]	P&I	ENC	AC	CNS	JC	CPPNM	A/CPPNM	VC	A-VC	CSC	JP
*	Sri Lanka		X	X	X							
*	Sudan						X					
	Suriname											
*	Sweden	X	X	X	X	X	X	X				X
*	Switzerland	X	X	X	X	X	X	X				
*	Syrian Arab Republic	X	X	X	X							
*	Tajikistan	X	X	X		X	X	X				
*	Thailand	X	X	X	X	X	X	X				
	Timor Leste											
*	Togo						X					
	Tonga						X					
*	Trinidad and Tobago						X		X			
*	Tunisia	X	X	X	X		X	X				
*	Turkey	X	X	X	X		X	X				X
*	Turkmenistan						X	X				
	Tuvalu											
*	Uganda						X					
*	Ukraine	X	X	X	X	X	X	X	X			X
*	United Arab Emirates		X	X	X	X	X	X		X	X	X
*	United Kingdom	X	X	X	X	X	X	X				
*	United Republic of Tanzania		X	X			X					
*	United States of America		X	X	X	X	X	X			X	
*	Uruguay		X	X	X	X	X	X	X			X
*	Uzbekistan					X	X	X				
*	Vanuatu											
*	Venezuela, Bolivarian Republic of		X									
*	Viet Nam	X	X	X	X	X	X	X				
*	Yemen						X					

	State/Organization[a]	P&I	ENC	AC	CNS	JC	CPPNM	A/CPPNM	VC	A-VC	CSC	JP
*	Zambia						X					
*	Zimbabwe											
	Euratom		X	X	X	X	X	X				
	FAO		X	X								
	WHO		X	X								
	WMO		X	X								

P&I	Agreement on the Privileges and Immunities of the IAEA
ENC	Convention on Early Notification of a Nuclear Accident
AC	Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency
CNS	Convention on Nuclear Safety
JC	Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management
CPPNM	Convention on the Physical Protection of Nuclear Material
A/CPPNM	Amendment to the Convention on the Physical Protection of Nuclear Material
VC	Vienna Convention on Civil Liability for Nuclear Damage
A-VC	Protocol to Amend the Vienna Convention on Civil Liability for Nuclear Damage
CSC	Convention on Supplementary Compensation for Nuclear Damage
JP	Joint Protocol Relating to the Application of the Vienna Convention and the Paris Convention
*	Agency Member State
X	Party

[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] The name 'Eswatini' replaces the former name 'Swaziland' as of 29 June 2018.

[c] The name 'North Macedonia' replaces the former name 'The former Yugoslav Republic of Macedonia' as of 15 February 2019.

[d] Acceded as State of Palestine.

Table A8. Member States that have concluded a Revised Supplementary Agreement (status as of 31 December 2018)

Afghanistan
Albania
Algeria
Angola
Antigua and Barbuda
Argentina
Armenia
Azerbaijan
Bahrain
Bangladesh
Belarus
Belize
Benin
Bolivia, Plurinational State of
Bosnia and Herzegovina
Botswana
Brazil
Bulgaria
Burkina Faso
Burundi
Cambodia
Cameroon
Central African Republic
Chad
Chile
China
Colombia
Congo
Costa Rica
Côte d'Ivoire
Croatia
Cuba
Cyprus
Czech Republic
Democratic Republic of the Congo
Djibouti
Dominica
Dominican Republic
Ecuador
Egypt
El Salvador
Estonia
Eswatini[a]
Ethiopia
Fiji
Gabon
Georgia
Ghana
Greece
Guatemala
Haiti
Honduras
Hungary
Iceland
Indonesia
Iran, Islamic Republic of
Iraq
Ireland
Israel
Jamaica
Jordan
Kazakhstan
Kenya
Korea, Republic of
Kuwait
Kyrgyzstan
Lao People's Democratic Republic
Latvia
Lebanon
Lesotho
Liberia
Libya
Lithuania
Madagascar
Malawi
Malaysia
Mali
Malta
Marshall Islands
Mauritania
Mauritius
Mexico
Mongolia
Montenegro
Morocco
Mozambique
Myanmar
Namibia
Nepal
Nicaragua
Niger
Nigeria
North Macedonia[b]
Oman
Pakistan
Palau
Panama
Paraguay
Peru
Philippines
Poland
Portugal
Qatar
Republic of Moldova
Romania
Rwanda
Saudi Arabia
Senegal
Serbia
Seychelles
Sierra Leone
Singapore
Slovakia
Slovenia
South Africa
Spain
Sri Lanka
Sudan
Syrian Arab Republic
Tajikistan
Thailand
Togo
Tunisia
Turkey
Turkmenistan
Uganda
Ukraine
United Arab Emirates
United Republic of Tanzania
Uruguay
Uzbekistan
Vanuatu
Venezuela, Bolivarian Republic of
Viet Nam
Zambia
Zimbabwe

[a] The name 'Eswatini' replaces the former name 'Swaziland' as of 29 June 2018.

[b] The name 'North Macedonia' replaces the former name 'The former Yugoslav Republic of Macedonia' as of 15 February 2019.

Table A9. Acceptance of Amendment to Article VI of the Agency's Statute (status as of 31 December 2018)

Afghanistan
Albania
Algeria
Argentina
Austria
Belarus
Bosnia and Herzegovina
Brazil
Bulgaria
Canada
Colombia
Croatia
Cyprus
Czech Republic
Denmark
El Salvador
Estonia
Ethiopia
Finland
France
Germany
Greece
Holy See
Hungary
Iceland
Ireland
Israel
Italy
Japan
Korea, Republic of
Latvia
Libya
Liechtenstein
Lithuania
Luxembourg
Malta
Mexico
Monaco
Morocco
Myanmar
Netherlands
Norway
Pakistan
Panama
Peru
Poland
Portugal
Republic of Moldova
Romania
San Marino
Slovakia
Slovenia
South Africa
Spain
Sweden
Switzerland
Tunisia
Turkey
Ukraine
United Kingdom
Uruguay

Table A10. Acceptance of Amendment to Article XIV.A of the Agency's Statute (status as of 31 December 2018)

Albania
Algeria
Argentina
Australia
Austria
Belarus
Bosnia and Herzegovina
Brazil
Bulgaria
Canada
Colombia
Croatia
Cyprus
Czech Republic
Denmark
Ecuador
Estonia
Finland
France
Germany
Greece
Holy See
Hungary
Iceland
Iran, Islamic Republic of
Ireland
Italy
Japan
Kenya
Korea, Republic of
Latvia
Liechtenstein
Lithuania
Luxembourg
Malta
Mexico
Monaco
Myanmar
Netherlands
Norway
Pakistan
Peru
Poland
Portugal
Republic of Moldova
Romania
San Marino
Seychelles
Slovakia
Slovenia
South Africa
Spain
Sweden
Switzerland
Syrian Arab Republic
Tunisia
Turkey
Ukraine
United Kingdom

Table A11. 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 2018, there were 2 new Parties to the Agreement. By the end of the year, there were 86 Parties.

Convention on Early Notification of a Nuclear Accident (reproduced in INFCIRC/335). Entered into force on 27 October 1986. In 2018, there was 1 new Party to the Convention. By the end of the year, there were 122 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 2018, there were 2 new Parties to the Convention. By the end of the year, there were 117 Parties.

Convention on Nuclear Safety (reproduced in INFCIRC/449). Entered into force on 24 October 1996. In 2018, there were 2 new Parties to the Convention. By the end of the year, there were 85 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 2018, there were 4 new Parties to the Convention. By the end of the year, there were 80 Parties.

Convention on the Physical Protection of Nuclear Material (reproduced in INFCIRC/274/Rev.1). Entered into force on 8 February 1987. In 2018, there were 2 new Parties to the Convention. By the end of the year, there were 157 Parties.

Amendment to the Convention on the Physical Protection of Nuclear Material. Entered into force on 8 May 2016. In 2018, there were 3 new Parties to the Amendment. By the end of the year, there were 118 Parties.

Vienna Convention on Civil Liability for Nuclear Damage (reproduced in INFCIRC/500). Entered into force on 12 November 1977. In 2018, 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 2018, the status of the Protocol remained unchanged with 2 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 2018, the status of the Protocol remained unchanged with 13 Parties.

Convention on Supplementary Compensation for Nuclear Damage (reproduced in INFCIRC/567). Entered into force on 15 April 2015. In 2018, the status of the Convention remained unchanged with 10 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 2018, the status of the Protocol remained unchanged with 28 Parties.

Revised Supplementary Agreements Concerning the Provision of Technical Assistance by the IAEA (RSA). In 2018, 2 RSAs were concluded. By the end of the year, there were 136 States party to an RSA.

Regional Co-operative Agreement for Research, Development and Training Related to Nuclear Science and Technology, 2017 (2017 RCA) (reproduced in INFCIRC/919). Entered into force on 11 June 2017. In 2018, there were 2 new Parties to the Agreement. By the end of the year, there were 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 2018, there were 4 new Parties to the Agreement. By the end of the year, there were 41 Parties.

Co-operation Agreement for the Promotion of Nuclear Science and Technology in Latin America and the Caribbean (ARCAL) (First Extension) (reproduced in INFCIRC/582/Add.4). Entered into force on 5 September 2015. In 2018, the status of the Agreement remained unchanged with 21 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 2018, the status of the Agreement remained unchanged with 9 Parties.

Agreement on the Establishment of the ITER International Fusion Energy Organization for the Joint Implementation of the ITER Project (reproduced in INFCIRC/702). Entered into force on 24 October 2007. In 2018, 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 2018, the status of the Agreement remained unchanged with 6 Parties.

Table A12. Nuclear power reactors in operation and under construction in the world (as of 31 December 2018)[a]

Country	Reactors in operation		Reactors under construction		Nuclear electricity supplied in 2018		Total operating experience through 2018	
	No. of units	Total MW(e)	No. of units	Total MW(e)	TW·h	% of total	Years	Months
Argentina	3	1 633	1	25	6.5	4.7	85	2
Armenia	1	375			1.9	25.6	44	8
Bangladesh			2	2 160				
Belarus			2	2 220				
Belgium	7	5 918			27.3	39.0	296	7
Brazil	2	1 884	1	1 340	14.8	2.7	55	3
Bulgaria	2	1 966			15.4	34.7	165	3
Canada	19	13 554			94.4	14.9	750	6
China	46	42 858	11	10 982	277.1	4.2	322	11
Czech Republic	6	3 932			28.3	34.5	164	10
Finland	4	2 784	1	1 600	21.9	32.4	159	4
France	58	63 130	1	1 630	395.9	71.7	2 222	4
Germany	7	9 515			71.9	11.7	839	7
Hungary	4	1 902			14.9	50.6	134	2
India	22	6 255	7	4 824	35.4	3.1	504	11
Iran, Islamic Republic of	1	915			6.3	2.1	7	4
Japan	38	36 476	2	2 653	49.3	6.2	1 863	2
Korea, Republic of	24	22 444	5	6 700	127.1	23.7	547	5
Mexico	2	1 552			13.2	5.3	53	11
Netherlands	1	482			3.3	3.1	74	0
Pakistan	5	1 318	2	2 028	9.3	6.8	77	5
Romania	2	1 300			10.5	17.2	33	11
Russian Federation	36	27 252	6	4 573	191.3	17.9	1 298	6
Slovakia	4	1 814	2	880	13.8	55.0	168	7
Slovenia	1	688			5.5	35.9	37	3

Country	Reactors in operation		Reactors under construction		Nuclear electricity supplied in 2018		Total operating experience through 2018	
	No. of units	Total MW(e)	No. of units	Total MW(e)	TW·h	% of total	Years	Months
South Africa	2	1 860			10.6	4.7	68	3
Spain	7	7 121			53.4	20.4	336	1
Sweden	8	8 613			65.9	40.3	459	0
Switzerland	5	3 333			24.5	37.7	219	11
Turkey			1	1 114				
Ukraine	15	13 107	2	2 070	79.5	53.0	503	6
United Arab Emirates			4	5 380				
United Kingdom	15	8 923	1	1 630	59.1	17.7	1 604	7
United States of America	98	99 061	2	2 234	808.0	19.3	4 408	6
Total [b, c]	**450**	**396 413**	**55**	**56 643**	**2 563.0**		**17 880**	**11**

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

[b] The total figures include the following data from Taiwan, China: 5 units, 4448 MW(e) in operation; 2 units, 2600 MW(e) under construction; 26.7 TW·h of nuclear electricity generation, representing 11.4% 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) and Lithuania (43 years, 6 months), and shutdown and operational plants in Taiwan, China (224 years, 1 month).

Table A13. 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			7				
Algeria	4			5				
Angola	1			3				
Antigua and Barbuda								
Argentina	42	1	1			1		
Armenia	2			0				
Australia	35	1	3					
Austria	22		2		3			
Azerbaijan	1			2				
Bahamas								
Bahrain				6				
Bangladesh	23			11				
Barbados								
Belarus	4		1	19				
Belgium	21		2					
Belize								
Benin	1							
Bolivia, Plurinational State of				2				
Bosnia and Herzegovina	1		3	10				
Botswana	1							
Brazil	49	3	4					
Brunei Darussalam								
Bulgaria	7		2	2	1			
Burkina Faso	7	1			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]	QUAADRIL [c]	QUATRO [d]
Burundi					1			
Cambodia	1			3				
Cameroon	6				1			
Canada	32		3					
Central African Republic								
Chad								
Chile	19		1					
China	86		3	14				
Colombia	6			34		1		
Congo								
Costa Rica	2	1	1					
Côte d'Ivoire	1				1			
Croatia	13		2	10				
Cuba	13		3	8				
Cyprus			1	0				1
Czech Republic	8		1					
Dem. Rep. of the Congo	1							
Denmark	4		1					
Djibouti	1							
Dominica								
Dominican Republic								
Ecuador	2		1	1				
Egypt	24		1	11				
El Salvador				4				
Eritrea								
Estonia	7		1	2		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]	QUAADRIL [c]	QUATRO [d]
Eswatini[e]								
Ethiopia	7		1					
Fiji								
Finland	10		1					
France	50	2	5					
Gabon								
Georgia	2							
Germany	46		3		6			
Ghana	13			2	1			
Greece	14		5					
Grenada								
Guatemala	8							
Guyana								
Haiti								
Holy See								
Honduras								
Hungary	19	2	2	13	1			
Iceland			1					
India	69	1	3	76				
Indonesia	24	2	1	2				
Iran, Islamic Republic of	16		1					
Iraq	1		1	3	3			
Ireland			1					
Israel	8		2	25			1	
Italy	50	1	8					
Jamaica	6		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]	QUAADRIL [c]	QUATRO [d]
Japan	47	2	1					
Jordan	6		1	4				
Kazakhstan	1		1	28				
Kenya	14		1	10				
Korea, Republic of	37	2	2			1		
Kuwait	5		1					
Kyrgyzstan								
Lao People's Dem. Rep.	1			4				
Latvia			1	5				
Lebanon	3		1	13				1
Lesotho					1			
Liberia								
Libya								
Liechtenstein								
Lithuania	5		3	10				
Luxembourg			1					
Madagascar	4		1					
Malawi					1			
Malaysia	24	2	1	27				
Mali	2				1			
Malta				6				1
Marshall Islands								
Mauritania								
Mauritius	3							
Mexico	24	2	3	1				
Monaco								
Mongolia	3		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]	QUAADRIL [c]	QUATRO [d]
Montenegro	2		1					
Morocco	23	1	1	15		1		1
Mozambique								
Myanmar	3		1	2				
Namibia				1	1			
Nepal	1			2				
Netherlands	10	1	4		4			
New Zealand	4		1					
Nicaragua	1							
Niger								
Nigeria	6							
North Macedonia[f]	5		1	3				
Norway	6		2					
Oman					1			
Pakistan	41		1					
Palau								
Panama	1		1	2				
Papua New Guinea	1							
Paraguay								
Peru	10		1	15				
Philippines	14	1	1					
Poland	23	1	5		1			
Portugal	9		1					
Qatar			1		2			
Republic of Moldova	1			3				
Romania	12		3	47	2			
Russian Federation	44		3	59				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]	QUAADRIL [c]	QUATRO [d]
Rwanda								
Saint Vincent and the Grenadines								
San Marino								
Saudi Arabia	4	1	1	18				
Senegal	7			3	1			
Serbia	7		5	14				
Seychelles								
Sierra Leone					1			
Singapore	13		1					
Slovakia	5		3					
Slovenia	8		1	4				
South Africa	34		3	50				1
Spain	37	1	2					
Sri Lanka	12		1	13				
Sudan	6				2			
Sweden	8		2					
Switzerland	5	1	3					
Syrian Arab Republic	7		1					
Tajikistan	1		1	1				
Thailand	23		2	15		1	1	1
Togo								
Trinidad and Tobago				6				
Tunisia	7		1	25				
Turkey	14		2	40				
Turkmenistan								
Uganda	7			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]	QUAADRIL [c]	QUATRO [d]
Ukraine	22		1	46				
United Arab Emirates	1	1	2	5				1
United Kingdom	51		4		3			
United Republic of Tanzania	2			5	1			
United States of America	110	1	7					
Uruguay	14		1					
Uzbekistan	2				2			
Vanuatu								
Venezuela, Bolivarian Republic of	2		2	26				
Viet Nam	22	1						
Yemen								
Zambia	6		1					
Zimbabwe	1			3	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.

[e] The name 'Eswatini' replaces the former name 'Swaziland' as of 29 June 2018.

[f] The name 'North Macedonia' replaces the former name 'The former Yugoslav Republic of Macedonia' as of 15 February 2019.

Table A14. Advisory Missions on Regulatory Infrastructure for Radiation Safety (AMRAS) in 2018

Type	Country
AMRAS	Angola
AMRAS	Benin
AMRAS	Plurinational State of Bolivia
AMRAS	Burkina Faso
AMRAS	El Salvador
AMRAS	Eswatini[a]
AMRAS	Kuwait
AMRAS	Liberia
AMRAS	Mozambique
AMRAS	Rwanda
AMRAS follow-up	Paraguay
AMRAS follow-up	Uganda
AMRAS follow-up	Uruguay

[a] The name 'Eswatini' replaces the former name 'Swaziland' as of 29 June 2018.

Table A15. Integrated Review Service for Radioactive Waste and Spent Fuel Management, Decommissioning and Remediation (ARTEMIS) missions in 2018

Type	Country
ARTEMIS	Brazil
ARTEMIS	Bulgaria
ARTEMIS	France
ARTEMIS	Italy
ARTEMIS	Luxembourg
ARTEMIS	Spain

Table A16. Education and Training Appraisal (EduTA) missions in 2018

Type	Country
EduTA	Tajikistan

Table A17. Emergency Preparedness Review (EPREV) missions in 2018

Type	Country
EPREV	Belarus
EPREV	Cuba

Table A18. Integrated missions of the Agency's Programme of Action for Cancer Therapy (imPACT) in 2018

Type	Country
imPACT	Afghanistan
imPACT	Guyana
imPACT	Indonesia
imPACT	Mauritius
imPACT	Mexico
imPACT	North Macedonia[a]
imPACT	Ukraine

[a] The name 'North Macedonia' replaces the former name 'The former Yugoslav Republic of Macedonia' as of 15 February 2019.

Table A19. Integrated Nuclear Infrastructure Review (INIR) missions in 2018

Type	Country
INIR Phase 1	Niger
INIR Phase 1	Philippines
INIR Phase 1	Sudan
INIR Phase 2	Saudi Arabia
INIR Phase 3	United Arab Emirates

Table A20. Integrated Nuclear Infrastructure Review for Research Reactors (INIR-RR) missions in 2018

Type	Country
INIR-RR	Nigeria
INIR-RR	Viet Nam

Table A21. Integrated Safety Assessment of Research Reactors (INSARR) missions in 2018

Type	Country
INSARR	Democratic Republic of the Congo
INSARR	Ghana
INSARR follow-up	Jordan

Table A22. International Physical Protection Advisory Service (IPPAS) missions in 2018

Type	Country
IPPAS	Ecuador
IPPAS	Switzerland
IPPAS follow-up	France
IPPAS follow-up	Japan

Table A23. Integrated Regulatory Review Service (IRRS) missions in 2018

Type	Country
IRRS	Australia
IRRS	Austria
IRRS	Chile
IRRS	Georgia
IRRS	Luxembourg
IRRS	Republic of Moldova
IRRS	Spain
IRRS follow-up	Hungary
IRRS follow-up	Netherlands

Table A24. Independent Safety Culture Assessment (ISCA) missions in 2018

Type	Country
ISCA	Norway
ISCA	South Africa

Table A25. Knowledge Management Assist Visit (KMAV) missions in 2018

Type	Organization/nuclear power plant	Country
KMAV	National Nuclear Energy Agency	Indonesia
KMAV	Nuclear Energy Commission	Mongolia
KMAV	National University of Mongolia	Mongolia
KMAV	Emirates Nuclear Energy Corporation	United Arab Emirates

Table A26. Occupational Radiation Protection Appraisal Service (ORPAS) missions in 2018

Type	Country
ORPAS	Bosnia and Herzegovina
ORPAS	Dominican Republic
ORPAS	Indonesia
ORPAS	Panama
ORPAS follow-up	United Republic of Tanzania

Table A27. Operation and Maintenance Assessment for Research Reactors (OMARR) missions in 2018

Type	Country
OMARR	Bangladesh
OMARR	Uzbekistan

Table A28. Operational Safety Review Team (OSART) missions in 2018

Type	Country
OSART	Finland
OSART	Islamic Republic of Iran
OSART	Russian Federation
OSART	Spain
OSART	United Kingdom
OSART pre-operational	Finland
OSART follow-up	Canada
OSART follow-up	Slovenia

Table A29. Peer Review of Operational Safety Performance Experience (PROSPER) missions in 2018

Type	Country
PROSPER	Ukraine

Table A30. Safety Aspects of Long Term Operation (SALTO) missions in 2018

Type	Country
SALTO	Armenia
SALTO	Sweden
Pre-SALTO	Argentina
Pre-SALTO	Brazil
Pre-SALTO	Bulgaria
Pre-SALTO	Ukraine

Table A31. Site and External Events Design (SEED) missions in 2018

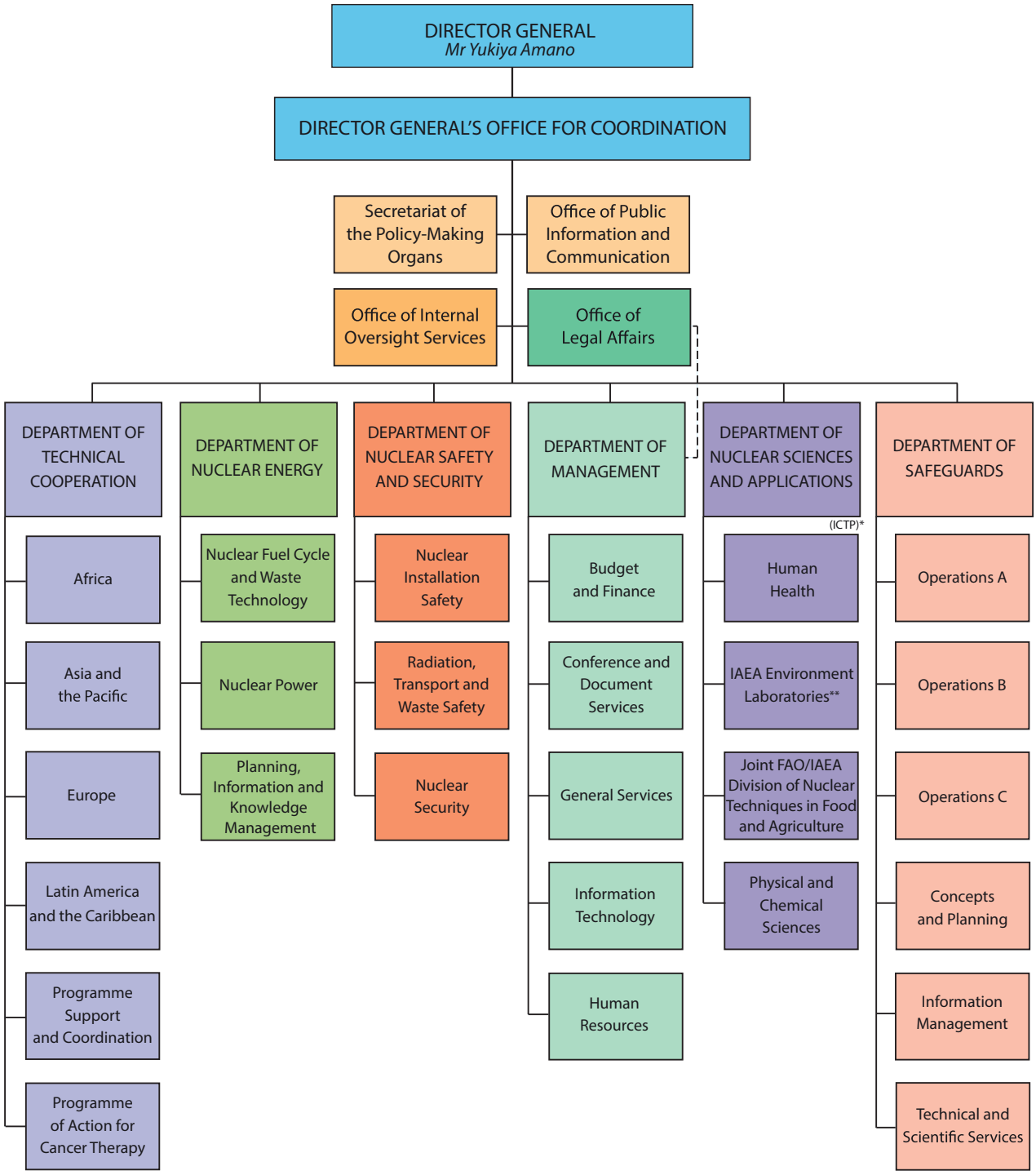
Type	Country
SEED	Islamic Republic of Iran
SEED	Kenya

Table A32. Technical Safety Reviews (TSRs) in 2018

Type	Country
Design Safety Review	Bangladesh
Periodic Safety Review	Czech Republic
Safety Requirements Review	Saudi Arabia

ORGANIZATIONAL CHART

(as of 31 December 2018)



* 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."

Article II of the IAEA Statute

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