Overview

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.

The COVID-19 pandemic that shook the world in 2020 had a significant impact on the Agency. The Agency remained proactive, quickly adapting to the challenging new circumstances to continue carrying out its functions. Under the leadership of Director General Rafael Mariano Grossi, Agency staff demonstrated their professionalism, resilience and dedication, and achieved some remarkable outcomes, despite the constraints of lockdowns and disrupted international transport. The Agency continued to implement safeguards throughout the world to verify States' commitments to use nuclear material only for peaceful purposes. It successfully delivered on the largest technical cooperation project in Agency's history, in terms of both the number of beneficiary countries and the disbursement of resources, to help countries confront COVID-19. The Agency was also able to continue to deliver its programmatic activities with minimal disruption, while giving full attention to the health and well-being of staff.

The Agency and the COVID-19 Pandemic

The Agency scaled up the information technology (IT) infrastructure, adopted human resources guidelines on working arrangements and implemented relevant health and safety measures at Headquarters. Almost all staff and personnel were equipped to work from home. The Agency quickly and effectively adapted to remote working conditions and continued to deliver on its mandate. At the core of all the decisions was the health and well-being of Agency staff, primarily based on the evolving guidance from the Host Government. Business continuity arrangements were adjusted, and operations remained as close to normal as possible under the new constraints.

The Agency suspended all non-essential travel and physical meetings but continued with programmatic deliveries, using a virtual format where this was feasible and would not affect quality.

Necessary arrangements for remote simultaneous interpretation and adequate Internet connectivity were made to facilitate the meetings of the Agency's Policy-Making Organs. These meetings were organized in a combination of virtual, physical and hybrid settings, with scrupulous adherence to the governing rules and procedures and the relevant health related guidance. The meetings of the Programme and Budget Committee in May and the Board of Governors in June were successfully conducted in a virtual setting. The 64th regular session of the General Conference was held in a hybrid setting. The meeting of the Board of Governors in early September was conducted in a physical setting, and those of the Board and the Technical Assistance and Cooperation Committee in November were conducted entirely virtually.

The Agency's 1563rd Board of Governors meeting, held virtually with interpretation in the Board's six working languages at the Agency's Headquarters in Vienna.

Support to Member State efforts to address the pandemic

127
countries and territories requested and received assistance

285
national laboratories/ institutions received COVID-19 support packages and technical guidance

1950
RT–PCR and diagnostic kits and related items ordered for countries

500+
counterpart laboratories received updated SOPs, reagent information and validation data, delivered via VETLAB

In response to the growing number of requests for assistance in the rapid detection of COVID-19, the Agency procured and delivered to Member States diagnostic kits that use nuclear derived techniques (real-time reverse transcription–polymerase chain reaction, or real-time RT–PCR) through a dedicated technical cooperation project. Fifteen Member States and a private company supported the Agency's efforts with generous extrabudgetary funding of €26.3 million in total.

Under this technical cooperation project — the largest in the Agency's history — every effort was made to ensure timely procurement and delivery. The Agency coordinated with suppliers and freight forwarders on production and shipment, and worked closely with Member States to facilitate customs clearance and local deliveries. As a result, a total of 1950 orders for equipment for COVID-19 detection (238 sets of real-time RT–PCR equipment), biosafety cabinets, reagents and other supplies were delivered to 127 countries and territories.

To ensure that the equipment and materials procured to address Member State requests were in alignment with the overall United Nations response, the Agency coordinated with United Nations system organizations through the United Nations Crisis Management Team on COVID-19 and the supply chain task force as well as consortia led by the World Health Organization (WHO). The Agency concluded supply and logistics services agreements with WHO and the World Food Programme and participated in joint procurement of personal protective equipment led by the United Nations Children's Fund (UNICEF). The Agency also worked closely with the Food and Agriculture Organization of the United Nations (FAO) and WHO to provide a coordinated response to requests from its Member States.

Complementing these procurement activities, the Agency conducted a series of webinars and one-on-one advisory sessions to strengthen Member States' COVID-19 testing laboratories. The topics covered laboratory requirements for the effective use of real-time RT–PCR, including biosafety and biosecurity frameworks; best practices for sample collection and preparation; and interpretation of results and quality assurance and quality control. Additional guidance and webinars were provided to help health care providers in nuclear medicine and radiology facilities adjust their standard operating procedures to minimize the risk of COVID-19 infection among patients, staff and the public. This was particularly important for radiology practices used in COVID-19 diagnosis.

In addition, more than 500 animal production and health counterpart laboratories received updated standard operating procedures (SOPs), reagent information and validation data from the Agency through the Veterinary Diagnostic Laboratory (VETLAB) Network platform. Nine instructional videos were produced on the use of personal protective equipment; the collection, transport and storage of samples; and the use of real-time RT–PCR specifically for the detection of COVID-19.

During the year, 197 articles were published in the press on the role of the Agency and nuclear techniques, and an article on the Agency's web site explaining how real-time RT–PCR works became the most read iaea.org article of all time, reaching an audience of 570 000.

16 RT–PCR webinars were held with over **2000** participants, and almost **2000** subsequent viewings of the recordings to date

11 webinars on SOPs were held for health care providers in nuclear medicine, radiology and radiation oncology facilities, with over **6000** participants, and more than **7900** subsequent viewings of the recordings

Loading of a shipment of COVID-19 detection equipment to a Member State.

Safeguards implementation during the pandemic

To maintain effective safeguards implementation, the Agency applied a series of mitigating measures, drawing on business continuity and disaster recovery plans already in place or in development. These measures enabled the Agency to conduct all of its most time-critical in-field verification activities and almost all of the safeguards activities normally carried out at the Agency's Headquarters and regional offices.

Agency inspectors and technical staff made extraordinary efforts to fulfil their official duties, for example isolating for up to 14 days in their destination State, driving long distances and crossing various national borders — instead of flying — to conduct verification activities, embarking on missions without having a confirmed date or means to return to Vienna and having the length of missions extended significantly.

The Agency adjusted the operational conduct of safeguards activities at Headquarters and in the field, including rescheduling a number of activities. The Agency's regional offices were instrumental in ensuring that the Agency's safeguards activities continued. States played a very important role in supporting the Agency's work, including by ensuring continued access to nuclear facilities for Agency inspectors as well as staff movement across borders and transfers through airports. In response to the unavailability of many commercial flights, the Agency, for the first time, chartered flights to ensure that inspections would not stop, as the Director General said, "for a single minute". Despite all the challenges presented by the pandemic, the Agency was able to draw soundly based safeguards conclusions for all States for 2020.

An Agency inspector boarding a chartered aircraft.

Operation, safety and security of nuclear and radiation facilities and activities during the pandemic

The Agency's information systems remained fully operational. A COVID-19 Nuclear Power Plant Operating Experience Network was developed and piloted to assess measures undertaken by all 32 countries with operating nuclear power plants and to discuss the impact on training activities and human resources policies in nuclear power plants.

The Agency conducted a survey in April on the impact of COVID-19 on the safety and regulatory oversight of radiation sources; the conclusions, based on responses from 93 regulatory bodies, were shared with Member States. An Agency survey of major reactor based medical radioisotope producers indicated that most research reactors that produce radioisotopes continued to operate — as the production facilities had been defined as essential by the relevant governments — but that hospitals could face shortages due to bottlenecks in transport and distribution. The Agency set up a network for research reactor operators to share information on the status of research reactors and the remedial measures being implemented.

The Agency's Incident and Emergency Centre continued to ensure that the communication channels for notification of and information exchange on nuclear and radiological emergencies remained fully operational on a 24/7 basis, including during the lockdowns.

The development of safety standards and security guidance continued, and a gap analysis was performed to assess the need to enhance standards or guidance to meet additional requirements of pandemic situations. On the basis of this analysis, the Agency proposed enhancements to address pandemic situations in a few draft Safety Guides, to be presented to the appropriate committees for final approval. Although many Agency peer review and advisory services were deferred, some were conducted as scheduled.

The Integrated Safety Assessment of Research Reactors team concluded an eight day mission to assess the safety of the 10 MW LVR-15 research reactor in the Czech Republic. (Photograph courtesy of V. Vrbik, Research Centre Řež.)

NUCLEAR TECHNOLOGY

Nuclear Power, Fuel Cycle and Nuclear Technology

Status and trends

At the end of 2020, the world's total nuclear power capacity was 392.6 gigawatts (electrical) (GW(e)), generated by 442 operational nuclear power reactors in 32 countries. During the year, some 5.5 GW(e) of new nuclear capacity was connected to the grid, from five new pressurized water reactors, while 5.2 GW(e) of nuclear capacity was retired, with the permanent shutdown of six nuclear power reactors. Supplying 2553.2 terawatt-hours of greenhouse gas emission-free electricity, nuclear power accounted for about 10% of total global electricity generation and nearly a third of the world's low carbon electricity production. At the end of the year, 52 reactors were under construction around the world, including four where construction started in 2020.

The Agency's 2020 nuclear power projections remained largely in line with those of the previous year. In the high case, global nuclear electricity generating capacity was projected to increase by 82% to 715 GW(e) by 2050, corresponding to 11% of global electricity generation, versus around 10% in 2019. The low case projected a decrease of 7% to 363 GW(e), representing a 6% share of global electricity generation.

In October, the Agency organized the International Conference on the Management of Naturally Occurring Radioactive Material (NORM) in Industry, held virtually. Participants highlighted the need for clear national policies, based on well defined inventories and sound cost estimation methodologies, to enable the establishment and implementation of NORM waste management strategies.

Climate change and sustainable development

At several events throughout the year, including the Clean Energy Transitions Summit organized by the International Energy Agency (IEA), the Director General emphasized the importance of nuclear power in providing stability to electrical grids, particularly those with high shares of variable renewable sources. The Director General noted that nuclear power plants can operate flexibly in line with electricity demand and limit the impact of seasonal fluctuations in renewable output. Nuclear power can also bolster energy security owing to the diversified supply of nuclear fuels and the capability to store nuclear fuel on site for several years of operation. The Director General also talked about the contribution of nuclear power to the future production of low carbon hydrogen, for use in energy storage, transportation, industry and other applications.

Energy assessment services

The Agency continued to assist Member States in building and strengthening their capacities for energy system analysis and energy planning, through distance support and e-learning. The Agency launched the updated Energy Scenarios Simulation Tool (ESST), which covers all energy products and can be used for rapid analysis of a country's overall energy system or its specific parts, such as power generation.

The Agency's International Project on Innovative Nuclear Reactors and Fuel Cycles (INPRO) updated its Nuclear Energy System Assessment Economics Support Tool (NEST), which now includes new types of nuclear power plant, updated and refined algorithms, several new economics functions, an improved interface and a complete user manual.

Support to operating nuclear power plants

The Agency launched the Nuclear Supply Chain Toolkit to support Member States in coordinating among owner/operators of nuclear facilities and their suppliers, regulators and technical support organizations. The webinar entitled 'Covid-19 and Its Impact on the Nuclear Power Supply Chain' highlighted the innovative solutions nuclear power plant operators introduced during the pandemic to overcome physical distancing and mobility restrictions, including remote quality and safety related assessments of systems, structures and components.

The Agency's new webinar series entitled 'Training and Qualification for Nuclear Facility Personnel' was launched to support Member States in meeting the challenge of ensuring the safety, reliability and performance of nuclear facilities, operating or newly built, by attaining and maintaining the competence and qualification of personnel.

Launching nuclear power programmes

In a milestone year for nuclear power, when two countries — Belarus and the United Arab Emirates — commissioned their first nuclear power plants, the Agency continued its assistance to newcomer countries. It conducted an Integrated Nuclear Infrastructure Review (INIR) Phase 3 mission to Belarus and delivered the final INIR report to the Government, with recommendations and suggestions aimed at assisting the country in making further progress ahead of commissioning the country's first reactor. The Agency also delivered the final report of the INIR Phase 2 mission to Egypt, conducted in late 2019, with recommendations and suggestions to help Egypt move its programme forward.

The Agency conducted virtual courses on topics ranging from establishing a national position on nuclear power, to financing and risk allocation, to contract specifications and reactor technology assessment. In addition, the Agency organized three webinars on the roles and responsibilities of the government and key organizations in developing a new nuclear power programme.

Capacity building, knowledge management and nuclear information

The Agency conducted five virtual Knowledge Management Assist Visit (KMAV) missions, to Chile, Hungary, Romania, Uzbekistan and Viet Nam, reviewing their knowledge management programmes and providing recommendations for enhancements.

The Agency launched a series of webinars on nuclear knowledge management to support professionals worldwide in maintaining and preserving the technical expertise and skills required for nuclear power programmes and other nuclear technologies.

Over the year, 123 374 new records were added to the International Nuclear Information System (INIS), a 49% increase compared with 2019. This includes 18 537 full text documents. The INIS repository was accessed by over 1.7 million users, who viewed 4 million pages and performed 2.5 million unique searches. This was the highest number of visits in the 50 year history of INIS and represented a 13% increase from the previous year.

Stakeholder involvement

The Agency conducted four webinars from the series entitled 'Stakeholder Involvement Related to Nuclear Power'. These webinars help strengthen the capacity of Member States to develop, implement, manage and adapt effective stakeholder involvement programmes for nuclear power.

Assurance of supply

The IAEA Low Enriched Uranium Bank in Kazakhstan, which became operational in 2019, continued safe operations at the Ulba Metallurgical Plant. A transport contract was signed with the China Nuclear Energy Industry Corporation (CNEIC), providing a second possible route (in addition to the route through the Russian Federation) for the transport of low enriched uranium (LEU) and/or equipment necessary for the operations of the IAEA LEU Bank.

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

As part of its 'E-learning on Spent Fuel and Radioactive Waste Management, Decommissioning and Environmental Remediation' collection, the Agency released a course on spent fuel storage. The course describes different choices for deploying storage facilities under the different spent fuel management strategies.

The Agency and the Nuclear Energy Agency of the Organisation for Economic Co-operation and Development jointly published Uranium 2020: Resources, Production and Demand, also known as the 'Red Book', which presents the most recent review of uranium market fundamentals and offers a statistical profile of the global uranium industry.

Reactor technology development and innovation

An Agency webinar series entitled 'Nuclear Technology Breakthroughs for the 21st Century' was launched to share information on how current and future sustainable nuclear energy systems can help countries to meet both growing energy demand and climate change goals. The webinars take into consideration advances in other energy technologies as well as developments in society at large.

The Agency published the 2020 edition of Advances in Small Modular Reactor Technology Developments, a supplement to its Advanced Reactors Information System (ARIS) database. It provides the latest data and information on small modular reactors around the world, including detailed descriptions of 72 reactors under development or construction in 18 countries. The booklet for the first time contains annexes on waste management and disposal as well as a section on microreactors.

Research reactors

The Agency designated the Institute for Nuclear Research Pitesti (RATEN ICN) in Romania and re-designated the French Alternative Energies and Atomic Energy Commission (CEA) as IAEA-designated International Centres based on Research Reactors (ICERRs). The ICERR programme enables researchers from various countries to have hands-on training and the opportunity to conduct experiments and work at state of the art facilities in other countries. There are now six ICERRs in six Member States.

Radioactive waste management

Despite restrictions in place owing to the global pandemic, the Agency assisted in successfully bringing high activity disused sealed radioactive sources, previously used in cancer treatment, to safer and more secure storage facilities in several countries, including Colombia.

Together with the Abdus Salam International Centre for Theoretical Physics (ICTP), the Agency organized the first Joint ICTP–IAEA International School on Radioactive Waste Cementation, held virtually. The event featured vibrant debates on a variety of topics,

including cement chemistry, as well as the latest theoretical and experimental advances and technological approaches to waste cementation.

Decommissioning and environmental remediation

The Agency's crowdsourcing challenge on decommissioning and environmental remediation, aimed at promoting innovative technologies and highlighting the attractive career opportunities available to young people in this field, received 26 submissions from 12 countries. The proposals showed significant potential for practical use in decommissioning and remediation operations. The five entries judged the best ranged from characterization toolkits and instruments for in-field measurements and collecting 3D radiation data to robots and artificial intelligence.

Nuclear fusion

The Agency launched a new Fusion Device Information System (FusDIS), the first interactive database offering information on more than 100 public and private experimental fusion research devices currently in operation, under construction, closed or being planned.

The Agency continued supporting international and regional schools on nuclear fusion, such as the international summer school on 'Plasma Physics and Controlled Fusion', organized by Peter the Great St. Petersburg Polytechnic University in the Russian Federation, and the Graduate University for Advanced Studies (SOKENDAI) in Japan, and the sixth ASEAN School on Plasma and Nuclear Fusion and the SOKENDAI Winter School, held in Thailand. The participants learned about the fundamentals of plasma physics and were trained to set up experiments, interpret results and present findings to peers.

Nuclear data

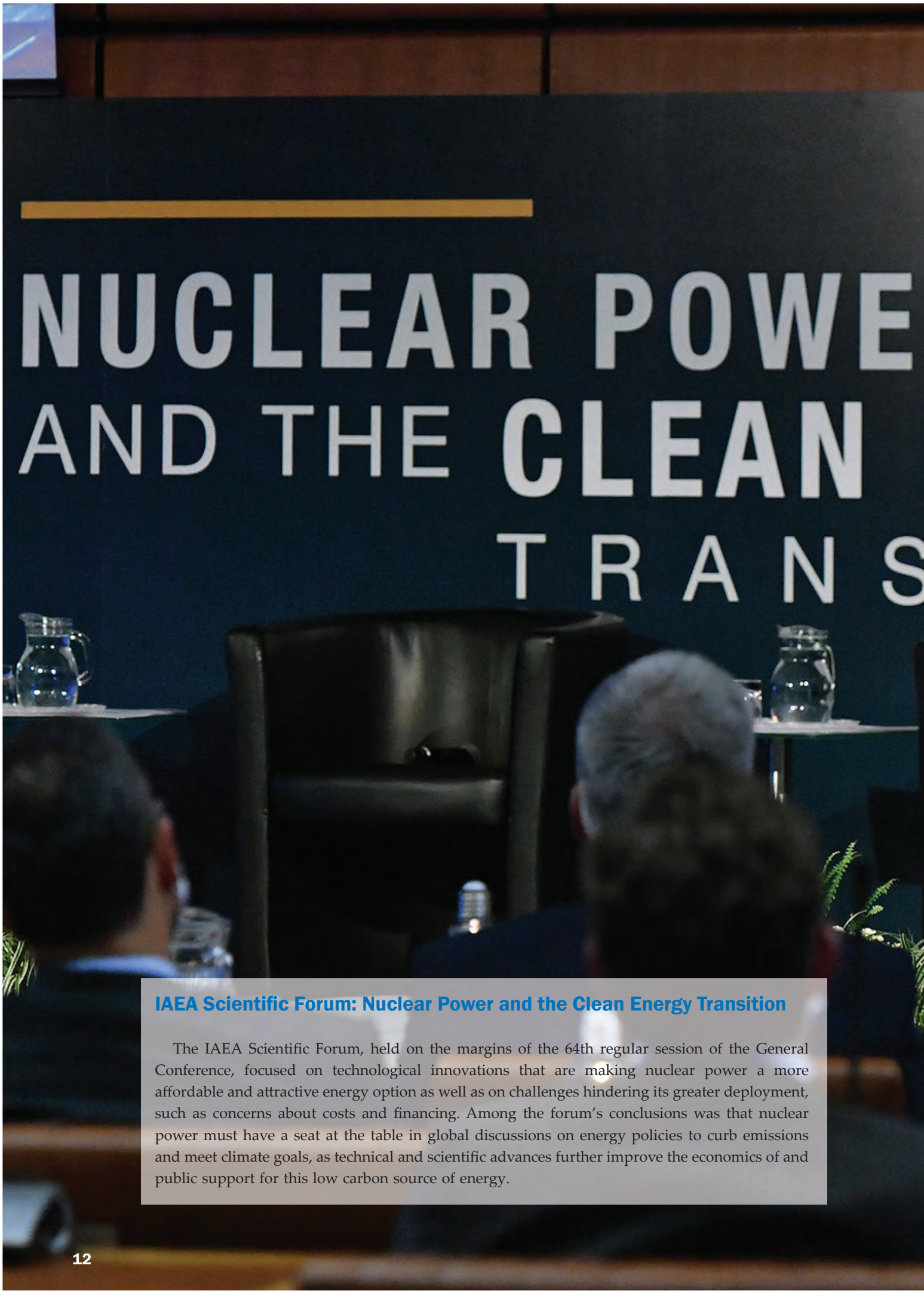
The Agency launched a coordinated research project (CRP) entitled 'Updating Fission Yield Data for Applications' to improve existing fission yield evaluations for uranium-235, plutonium-239 and californium-252. This CRP will enable the compilation of all new experimental data, including uncertainty quantification, so that the fission yield data can be reliably applied in reactor and other nuclear analysis, leading to more accurate predictions of nuclear inventories and fuel depletion profiles.

Accelerator technology and its applications

Member States' access to expert services in accelerator and beam line design and technique development will increase as a result of the designation of Elettra Sincrotrone Trieste in Italy as an IAEA Collaborating Centre for light source and beam line technology. Through this designation, the Agency will also provide assistance to Member States planning to build or improve their own synchrotron facilities by training scientists and technologists in key areas.

Nuclear instrumentation

The Agency facilitated remote access to resources on nuclear instrumentation and information exchange through further development and consolidation of the Nuclear Science and Instrumentation Portal, including the creation of virtual 'sibling' laboratory rooms that allow virtual tours of the experimental facilities. This enables researchers from around the world to access relevant e-learning materials, technical documents and reports relating to nuclear instrumentation and applications based on the use of X rays, neutrons and ion beams. It also offers downloads of various software tools for experimental data acquisition, analysis and interpretation.



IAEA Scientific Forum: Nuclear Power and the Clean Energy Transition

The IAEA Scientific Forum, held on the margins of the 64th regular session of the General Conference, focused on technological innovations that are making nuclear power a more affordable and attractive energy option as well as on challenges hindering its greater deployment, such as concerns about costs and financing. Among the forum's conclusions was that nuclear power must have a seat at the table in global discussions on energy policies to curb emissions and meet climate goals, as technical and scientific advances further improve the economics of and public support for this low carbon source of energy.

Director General Grossi delivers his remarks at the opening session of the 2020 Scientific Forum on Nuclear Power and the Clean Energy transition.

NUCLEAR SCIENCES AND APPLICATIONS

The International Conference on Molecular Imaging and Clinical PET–CT in the Era of Theranostics (IPET 2020)

In November, the International Conference on Molecular Imaging and PET–CT in the Era of Theranostics (IPET-2020) provided a platform for live presentations on important clinical aspects and the appropriate use of medical imaging in the management of patients with cancer. Special sessions were dedicated to COVID-19, education, ethics and leadership, and a keynote lecture focused on the global burden of cancer. The conference, which had the cooperation of ten professional organizations and was held virtually, was attended by over 3000 participants from 126 Member States, with many more accessing the recorded lectures on-line. Participants were awarded 15 continuing medical education credits; such credits are a requirement for maintaining medical licences in many Member States.

Analytical Laboratories for the Measurement of Environmental Radioactivity (ALMERA) network: Twenty five year anniversary

The annual coordination meeting of the Analytical Laboratories for the Measurement of Environmental Radioactivity (ALMERA) network, held as a virtual event in 2020, marked the network's 25th anniversary. Future activities stemming from the meeting will focus on strengthened collaboration for emergency preparedness and response, increased interest in specialized proficiency tests and reference materials, and targeted training. Established in 1995, the ALMERA network brings together 190 expert laboratories across 89 Member States, providing Member States with reliable environmental radioactivity data for routine monitoring and in the case of nuclear or radiological emergencies.

Food and Agriculture

New technique to distinguish between artificial and naturally occurring soil erosion

In 2020, the Agency developed a technique to distinguish and apportion naturally occurring and anthropogenic soil erosion in upland agroecosystems using caesium-137 resampling. The technique involves repeated soil sampling at set time intervals to determine the rate of erosion using caesium-137 fallout radionuclides. The approach, which has been demonstrated in field studies carried out in China, Italy, Morocco and Spain, allows evaluation of the effectiveness of soil conservation measures. This information is important for identifying appropriate soil conservation and management practices to minimize soil erosion and its negative impact.

Enhancing agricultural water management

In 2020, the Agency developed the cosmic ray neutron sensor (CRNS) technology to bridge the soil moisture measurement gap between large scale satellite imaging and point scale ground sensors for managing agricultural water productivity. By combining CRNS technology with satellite imagery, high resolution soil moisture maps for agricultural water management can be produced. The technology, which was developed at the IAEA Seibersdorf laboratories, was tested in both temperate and semi-arid environments and can be used to support agricultural decision making, not only for agricultural water management purposes but also for hydrology and drought and flood prediction. It may even be useful in efforts to prevent the spread of the desert locust in the future.

Impacts of phosphorus fertilizers on agriculture and the environment

Phosphorus fertilizers are known to increase crop productivity; however, when applied in excess, they pollute the soil and groundwater. To assess phosphorus pollution in freshwater ecosystems and the environment, the Agency — through technical support from a CRP and applied research and development — modified a technique developed at the IAEA Seibersdorf laboratories in 2018 involving the stable isotopes of oxygen in phosphate (δ^{18}Op) to address specific practical issues when applied in different environments.

Development of a DNA chip for camel improvement

As an adaptation to climate change, pastoralists in Africa who have historically depended on cattle are shifting to camel husbandry, because camels can better tolerate severe drought and the prolonged dry periods brought on by climate change. At the same time, there is a growing market for camel milk and other products that provide a source of income to nomadic herders in Asia and Africa. Today, thanks to advances in nuclear and related genomic technologies, it is possible to estimate the breeding potential of an animal on the day of its birth simply by looking at its deoxyribonucleic acid (DNA). Genome maps produced using a nuclear technique known as radiation hybrid mapping can pinpoint the location of specific features in an animal's chromosomes, so-called DNA markers. During 2020, the Agency, in collaboration with partners, developed a multi-species camelid DNA chip for selection and breeding of more productive camels. This novel multi-species chip can be used for genetic evaluation and improvement of several members of the Camelidae family including the dromedary, Bactrian camel, alpaca and llama.

Human Health

New on-line data entry platform and calculator for body composition

One of the main stable isotope techniques used in nutrition assessments is the deuterium dilution technique for body composition assessment. The final outputs of the assessment rely on information from several sources. The difficulty of keeping track of many variables from different sources at different time points and of preparing the data for statistical analysis is often underestimated and may be a bottleneck in projects. In 2020, the Agency developed an on-line data entry platform and body composition calculator to improve the quality of data, support data management, and facilitate good record keeping and standardized calculations. The platform, which was built using the Agency's International Research Integration System (IRIS), also makes it possible to add and provide safe storage for project specific data, making it a one stop location for data management and entry.

Biological dosimetry

The Agency installed a number of pieces of biodosimetry research equipment this year, including the Metafer imaging platform, an important tool for biodosimetry that enables the reconstruction of a particular radiation dose received by patients after planned or accidental exposure. Other similar biodosimetry methods and infrastructure available at the IAEA Seibersdorf laboratories can be used to support applications in molecular research, medical cytogenetics, forensics, and viral diagnostics and quantification, including for severe acute respiratory syndrome coronavirus 2, the virus that causes COVID-19.

Enhancing capacity building in small field dosimetry for advanced radiotherapy technologies

The Agency has provided training in dosimetry to medical physicists from around the world since 2017, when it published the first international code of practice dedicated to dosimetry for small static fields. Agency training courses on dosimetry used in advanced radiotherapy technologies and techniques have been held for several years in all regions. The course materials have been assembled and expanded into a self-paced e-learning course entitled 'IAEA TRS483 Code of Practice on Dosimetry of Small Static Fields Used in External Beam Radiotherapy'. Released on the Agency's Cyber Learning Platform for Network Education and Training (CLP4Net) in 2020, the course enables clinical radiotherapy medical physicists to undergo continuous professional development on demand and to contribute to ensuring that patients receive accurate doses from complex radiotherapy techniques.

SPECT/CT Atlas of Quality Control and Image Artefacts

The technology involved in performing scans in the nuclear medicine department hospital is a complex fusion of nuclear medicine and radiological imaging techniques that have evolved over 50 years into sophisticated hybrid systems known as SPECT–CT, or single photon emission computed tomography–computed tomography. The new Agency publication SPECT/CT Atlas of Quality Control and Image Artefacts (IAEA Human Health Series No. 36) presents an overview of potential pitfalls as well as the quality control procedures and standards required in SPECT–CT.

Water Resources

Assessment of mining impacts on water resources utilization and pollution

Mining activities can pollute underground aquifers and surface water bodies. To help safeguard water resources, a new CRP will focus on the development and application of stable isotope and radioisotope techniques for efficient water resources management in diverse mining operations. Two thematically related technical cooperation projects completed in 2020 in Argentina and Chile used isotope hydrology methods to guide water quality remediation efforts to help eliminate pollution of water resources from active and abandoned mines.

Application of machine learning tools for global isotope hydrology networks

Machine learning tools were applied to the Global Network of Isotopes in Precipitation (GNIP) — the Agency's isotope hydrology database established 60 years ago — to detect climate driven processes and hydrological changes. New high resolution isotope prediction maps were generated that will enable scientists to predict the stable isotope (oxygen-18 and hydrogen-2) and radioisotope (hydrogen-3) content of rainfall around the world. This information will help policy makers protect vulnerable aquifers and can be used to validate global climate change prediction models. Application of the machine learning tools revealed that large scale cyclical hydroclimatic processes such as the North Atlantic and Pacific Decadal Oscillations are moderators of global climate change impacts.

Environment

Evidence of positive effects from strict global contaminant releases restriction

The Agency released an assessment report on century-scale global pollution trends derived from data on select coastal environments. The report, entitled 'Global Pollution Trends: Coastal Ecosystem Assessment for the Past Century', highlights legacy and emerging coastal contaminants and concludes that the amount of strictly regulated contaminants — such as polychlorinated biphenyls (PCBs), a subclass of persistent organic pollutants — has been decreasing globally over the past 50 years. This trend demonstrates that strict policies can have a positive environmental impact.

A ten year time series of marine microplastic abundance in the coastal waters off Ecuador

In 2020, scientists from the Agency and Ecuador completed a first ever, decade long study of the abundance of marine microplastic particles at select sites in the coastal waters off Ecuador. Results confirm that the abundance of marine microplastic particles in these waters has risen consistently over the past few years. Unless action is taken to change this trajectory, by 2050 the quantity of marine microplastic particles is projected to increase more than tenfold from 2008 values.

Emergency response to Mauritius oil spill to assess effects on coral reef ecosystems

In July 2020, a cargo ship ran aground on a coral reef in Mauritius and began leaking oil into nearby coastal waters, potentially endangering corals, fish and other marine life. The Agency, upon the request of the Government, provided an emergency response to help address potential environmental consequences of the oil spill. After technical consultations, it advised Mauritius to develop and implement a comprehensive long term monitoring programme for the impacted coastal waters, sediment, biota and air. With the procurement of dedicated laboratory equipment and training of local staff, the Agency helped the national laboratories to increase their capacity to monitor the effects of the oil spill in the marine environment and associated volatile organic compounds in the air and to assess their potential toxicological impacts.

Radioisotope Production and Radiation Technologies

Recycling of polymer waste for structural and non-structural materials by using ionizing radiation

The CRP entitled 'Recycling of Polymer Waste for Structural and Non-Structural Materials by using Ionizing Radiation', launched in 2020, will build on outcomes of a consultancy meeting held during the year involving recognized international experts in the field of plastic waste recycling using radiation technologies. The CRP targets reduction of plastic waste volumes using radiation technologies and is part of the Agency's ongoing, integrated response aimed at assisting Member States in using nuclear techniques to address plastic pollution challenges.

Production of cyclotron based gallium-68 radioisotope and related radiopharmaceuticals

Gallium-68 has become one of the most important medical radioisotopes for disease diagnosis, and a new CRP entitled 'Production of Cyclotron-Based Gallium-68 Radioisotope and Related Radiopharmaceuticals' was launched to focus on a new route of gallium-68 production that will allow more Member States to produce it locally. The CRP aims to formulate guidelines and promote networks to enable cyclotron based production of gallium-68 and the preparation of gallium-68 radiopharmaceuticals for preclinical and human use.

Zoonotic Disease Integrated Action (ZODIAC)

The Zoonotic Disease Integrated Action (ZODIAC) project was launched in 2020, drawing on the Agency's experience supporting Member States in using nuclear and nuclear derived techniques to enhance global response preparedness to combat zoonotic diseases such as COVID-19, Ebola, avian influenza and Zika. The project, through its interconnected pillars, will increase Member States' capacity for early detection and monitoring of pathogens in the animal–human interface. It will support countries in creating appropriate ZODIAC relevant infrastructure by providing equipment, training and necessary research and development tools. The project will maintain a network of participating laboratories for storing and exchanging relevant scientific and technical information. ZODIAC also envisages providing increased access to reliable data for Member States to improve understanding of the impact of zoonotic diseases on human health and to support science based decision making using radiation imaging technologies or radiomics. At the General Conference, Member States adopted a resolution on ZODIAC, and in November the Board of Governors approved an off-cycle interregional technical cooperation project aimed at building the infrastructure and human capacity needed to implement ZODIAC activities. The Agency will continue to seek opportunities for establishing partnerships with national and international organizations as well as non-traditional partners to create synergies with other initiatives.

Inauguration of The Yukiya Amano Laboratories Building and Launch of ReNuAL 2

Director General Grossi and Austrian Federal Minister for European and International Affairs Alexander Schallenberg officially opened The Yukiya Amano Laboratories building on 5 June 2020, marking the completion of all new facilities launched to date under the Renovation of the Nuclear Applications Laboratories (ReNuAL) initiative. The new facility now serves as the home to the Animal Production and Health Laboratory, the Food and Environmental Protection Laboratory and the Soil and Water Management and Crop Nutrition Laboratory. Providing more laboratory space and significant improvements to scientific and research capabilities, the new building has strengthened the capacity of the three laboratories to support Member States in responding to existing and emerging challenges, including COVID-19. The opening of The Yukiya Amano Laboratories building followed the launch in 2019 of two other major facilities constructed under this initiative — a new Insect Pest Control Laboratory building and a new linear accelerator facility for the Dosimetry Laboratory.

The Director General launched the final phase of laboratory modernization in September. ReNuAL 2 will include construction of a new building for three laboratories, refurbishment of the Dosimetry Laboratory and replacement of ageing greenhouses. The modern facilities will strengthen the laboratories' support for Member States on climate-smart agriculture, environmental resource management and food security.

Austrian Foreign Minister Schallenberg and Director General Grossi formally open The Yukiya Amano Laboratories building.

NUCLEAR SAFETY AND SECURITY

Nuclear Safety

Safety standards and their application

The Agency issued one General Safety Guide and nine Specific Safety Guides after endorsement by the Commission on Safety Standards. It conducted 15 safety related peer review and advisory service missions to support 15 Member States in their application of Agency safety standards. Although Member State requests for these services remained high, the majority of reviews requiring site visits were postponed until 2021, owing to the COVID-19 pandemic travel restrictions.

International Conference on Radiation Safety: Improving Radiation Protection in Practice

In November, the Agency organized the International Conference on Radiation Safety: Improving Radiation Protection in Practice, held as a virtual event in cooperation with seven international organizations. The conference underscored the need to apply the principles of justification and optimization to the use of radiation, underlining that ethical principles such as prudence, reasonableness and tolerability must also be taken into account in decision making.

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

The Agency held a technical meeting of the International Generic Ageing Lessons Learned (IGALL) Steering Committee as well as nine workshops and eight IGALL meetings to support operators, regulators and other organizations in ageing management and long term operation of nuclear power plants.

The Agency published *Experiences in Implementing Safety Improvements at Existing Nuclear Power Plants* (IAEA-TECDOC-1894), which includes a variety of technical approaches that can be applied by Member States, and *Effective Management of Regulatory Experience for Safety* (IAEA-TECDOC-1899), providing a source of knowledge and learning for improving overall regulatory effectiveness for ensuring safety.

Safe deployment of advanced reactors

The Agency initiated the development of a Safety Report to provide a roadmap for the application of its safety standards as part of a technology neutral safety and regulatory framework to small modular reactors and published *Applicability of Design Safety Requirements to Small Modular Reactor Technologies Intended for Near Term Deployment* (IAEA-TECDOC-1936). The safety characteristics of small modular reactors, which are advanced reactors with passive safety features, differ from those of the current fleet of nuclear power plants; therefore, the application of safety standards may provide a challenge to some regulators. The report will assist them in the review and licensing process.

Assisting countries embarking on a new nuclear power programme

The Agency assisted Member States embarking on nuclear power programmes in developing a regulatory framework for siting and site evaluation by continuing to apply the Integrated Work Plan process to 17 Member States.

The Regulatory Cooperation Forum (RCF) launched the 2020–2024 RCF Strategic Plan to address common challenges in developing a regulatory framework for countries introducing or expanding their nuclear power programmes. The topics to be addressed

under the plan include independence of regulatory bodies, human resources, and drafting of regulations and guides.

Incident and emergency preparedness and response

The Agency, in the framework of the Emergency Preparedness and Response Standards Committee, identified priorities for developing additional guidance to support Member States in further aligning their national emergency preparedness and response (EPR) arrangements with IAEA Safety Standards Series No. GSR Part 7, *Preparedness and Response for a Nuclear or Radiological Emergency*. This prioritization will inform a work plan to develop additional guidance to enhance Member States' understanding of the implementation of GSR Part 7 requirements, thus strengthening their national EPR arrangements.

The Agency held the Tenth Meeting of the Representatives of Competent Authorities Identified under the Early Notification Convention and the Assistance Convention as a virtual event. The meeting adopted nine conclusions with 22 associated actions for the Secretariat and Member States to establish, maintain and strengthen national operational arrangements to implement the Convention on Early Notification of a Nuclear Accident and the Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency; utilize and refine tools to securely exchange information, request and deliver assistance, ensure effective public communication, share environmental radiation data in a nuclear or radiological emergency, and perform assessments and prognoses; and conduct and promote international and national exercises to test emergency preparedness and response.

Radioactive waste management, environmental assessments and decommissioning of nuclear facilities

On the basis of the lessons identified from the first Integrated Regulatory Review Service (IRRS) and Integrated Review Service for Radioactive Waste and Spent Fuel Management, Decommissioning and Remediation (ARTEMIS) combined mission, the Agency finalized guidelines to support efficient implementation of future IRRS–ARTEMIS combined missions. These combined missions continue to be requested by Member States.

The Agency held the Second Technical Meeting of the International Project on Decommissioning of Small Facilities (MIRDEC) and the Third Technical Meeting of the International Project on Completion of Decommissioning (COMDEC). The MIRDEC meeting resulted in further collection, review and exchange of experiences, knowledge and lessons on the decommissioning of small medical, industrial and research facilities. The COMDEC meeting furthered knowledge sharing and lessons regarding completion of decommissioning, which is concerned with actions taken to prepare sites for re-use and for termination of regulatory authorization.

The Agency published *Safety Culture Practices for the Regulatory Body* (IAEA-TECDOC-1895) and made available a harmonized safety culture model, jointly developed with the World Association of Nuclear Operators (WANO) and the Institute of Nuclear Power Operations (INPO) in the United States of America. The model is a comprehensive tool intended for all organizations that deal directly or indirectly with ionizing radiation, enabling them to set goals, implement changes and measure progress.

Radiation protection

The Agency held 18 webinars on radiation safety addressing patient protection, occupational radiation protection, radon, non-medical human imaging, food and drinking water, and consumer products, in collaboration with professional societies and international organizations. It also conducted a series of webinars bringing together leading experts to

share knowledge and expertise on strengthening radiation protection efforts and ensuring continuity of all services important for radiation protection.

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

The Agency conducted 205 capacity building activities, including over 100 EPR related webinars. These aimed at building capacity in Member States in nuclear, radiation, transport and waste safety, and in emergency preparedness and response.

At an Agency International School of Nuclear and Radiological Leadership for Safety held in Tokyo, participants gained an understanding of the role of leadership in strengthening nuclear safety in practice. The Agency extended the Practical Arrangements between the IAEA and the Ibero-American Forum of Radiological and Nuclear Regulatory Agencies (FORO) on Cooperation in the Areas of Nuclear and Radiation Safety, Emergency Preparedness and Response and Nuclear Security in July.

The Agency created a dedicated area on the CLP4NET e-learning platform to host materials from the virtual School for Drafting Regulations, including training materials and technical documentation, and launched Version 2 of Modules 1–4 of the e-learning course on the safe transport of radioactive material to reflect requirements established in IAEA Safety Standards Series No. SSR-6 (Rev. 1), *Regulations for the Safe Transport of Radioactive Material*. These developments will make the learning materials of the School accessible to a wider audience in the important area of drafting safety regulations in line with Agency safety standards.

Safety conventions

Owing to measures imposed in response to COVID-19, the Organizational Meeting for the Seventh Review Meeting of the Contracting Parties to the Joint Convention was initially postponed and then held virtually later in the year. The Fourth Extraordinary Meeting and Seventh Review Meeting of the Contracting Parties to the Joint Convention were also postponed. The Eighth Review Meeting of the Contracting Parties to the Convention on Nuclear Safety was postponed.

The Agency's Radiation Safety and Nuclear Security Regulator

The authorizations of the Agency's internal service providers for individual monitoring and calibration services and the operation authorization of the Dosimetry Laboratory were renewed. Authorizations were also issued for the operation of the Insect Pest Control Laboratory in the new building in Seibersdorf and for the processing of plutonium-containing material for transfer from the Nuclear Material Laboratory to the Oak Ridge National Laboratory in the United States of America. In addition, the safety case for The Yukiya Amano Laboratories in Seibersdorf was reviewed and assessed, and a regulatory guide on cross-Divisional activities was prepared.

Civil liability for nuclear damage

The International Expert Group on Nuclear Liability (INLEX), which provides advice to the Director General and the Director of the Office of Legal Affairs on issues relating to civil liability for nuclear damage, held its 20th regular meeting in June 2020 virtually. Participants heard about new developments and activities by the Secretariat in the field of civil liability for nuclear damage and discussed future outreach activities.

With the assistance of INLEX members, the Secretariat undertook several outreach activities to provide an overview of the international nuclear liability regime and its

implementation in national laws, such as a workshop for newcomer countries and a virtual seminar for Pakistan. In addition, the Director General sent letters in June to selected Member States, in particular those which already operate nuclear power plants, or are considering or working towards introducing nuclear power, encouraging them to adhere to relevant nuclear liability treaties.

In October, following a request made by Canada on behalf of the Contracting Parties to the Convention on Supplementary Compensation for Nuclear Damage (CSC), the Secretariat agreed to convene future meetings of the Contracting Parties and Signatories to the CSC on a regular basis.

Nuclear Security

International Conference on Nuclear Security: Sustaining and Strengthening Efforts

In February, the Agency organized the International Conference on Nuclear Security: Sustaining and Strengthening Efforts (ICONS 2020) in Vienna (Fig. 1). The conference brought together more than 1900 participants, including a record number of 53 ministers, to formulate and exchange views on experiences and achievements for nuclear security, including cybersecurity. Member States adopted a Ministerial Declaration reaffirming their support for nuclear security, and 109 national statements were delivered.

FIG. 1. The Director General delivers his remarks at the closing session of the International Conference on Nuclear Security ICONS 2020: Sustaining and Strengthening Efforts, held in February.

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

In line with Article 16.1 of the Convention on the Physical Protection of Nuclear Material (CPPNM), as amended in 2005, the Secretariat continued to facilitate preparations for the Conference of the Parties to the Amendment to the CPPNM. A meeting of the Preparatory Committee for the Conference took place virtually in December. The Agency continued encouraging universal adherence to and effective implementation of the CPPNM and its Amendment and provided assistance upon request. A further three States became party to the CPPNM and its Amendment in 2020.

Assistance to Member States

During 2020, the Agency supported the consolidation of nine high activity disused sealed radioactive sources. The Agency completed physical protection upgrades in two Member States at two research reactors, a nuclear power plant and 13 hospitals. It also provided assistance in drafting nuclear security regulations to 18 Member States. The Agency provided one Member State with handheld detection equipment and another with a mobile radiation portal monitor. Additionally, the Agency established a pool of radiation detection equipment available for loan with the Malaysian Atomic Energy Licensing Board and supplied detection equipment to Lebanon following the Beirut port explosion in August. The Agency conducted 42 training events, most of them virtually; continued to deliver its e-learning activities; and held a new computer security incident response course.

NUCLEAR VERIFICATION[1,2]

Implementing safeguards and other verification activities in 2020 was much more of a challenge as a result of the global COVID-19 pandemic. Nevertheless, with considerable extra effort and adaptation to the new circumstances, the Agency conducted almost the same level of verification activities as in the previous year. The Agency carried out over 2 850 verification activities (2 953 in 2019) and spent more than 12 700 days in the field conducting those activities (13 140 in 2019). This ensured that the Agency was able to draw soundly based conclusions for all States in which safeguards were implemented by the Agency for 2020.

Implementation of safeguards in 2020

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.

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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 2020, safeguards were applied for 183 States[3,4] with safeguards agreements in force with the Agency. Of the 131 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 72 States[6] (for 66 of which[7] integrated safeguards were implemented during the whole of 2020); 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 44 States with a CSA but with no AP in force, the Agency concluded only that *declared* nuclear material remained in peaceful activities.

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 States, the Agency concluded that nuclear material in the selected facilities to which safeguards had been applied remained in peaceful activities or had been withdrawn from safeguards as provided for in the agreements. The Agency also implemented safeguards for three States not party to the NPT pursuant to item-specific safeguards agreements based on INFCIRC/66/Rev.2. For these States, the Agency concluded that nuclear material, facilities or other items to which safeguards had been applied remained in peaceful activities.

As of 31 December 2020, 10 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, and the amendment or rescission of small quantities protocols (SQPs). The status of safeguards agreements and APs as of 31 December 2020 is shown in Table A6 in the Annex to this report. During 2020, a CSA with an SQP and an AP was approved by the Board of Governors for Eritrea. A voluntary offer agreement and an AP entered into force for the United Kingdom. An SQP was amended for Haiti. In 2020, the Director General sent letters to 31 States with SQPs based on the original standard text calling upon them to amend or rescind their SQPs. At the end of 2020, 94 States had operative SQPs in force, of which 63 SQPs were based on the revised standard text. Eight 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 2020, 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, four quarterly reports and four reports providing updates on developments in between the issuance of the quarterly reports were submitted 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).*

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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 And Taiwan, China.

Islamic Republic of Iran

During 2020, the Agency interacted with Iran to clarify information relating to the correctness and completeness of Iran's declarations under its Safeguards Agreement and AP. The Agency submitted three reports to the Board of Governors entitled *NPT Safeguards Agreement with the Islamic Republic of Iran*.

Director General Grossi in Tehran

Following Iran's denial of access, under the AP, for the Agency to two undeclared locations in Iran, in June 2020 the Board of Governors adopted a resolution in which it called on Iran to fully cooperate with the Agency and satisfy the Agency's requests without any further delay, including by providing prompt access to the locations specified by the Agency. In August 2020, Director General Grossi had discussions in Tehran with President Rouhani, Foreign Minister Zarif and Head of the Atomic Energy Organization of Iran (AEOI) and Vice-President Salehi. The objectives of the Director General's visit were to establish a direct channel of communication with high level Iranian officials and to make concrete progress in addressing the Agency's outstanding questions related to safeguards, in particular to resolve the issue of access.

On 26 August 2020, Director General Grossi and Head of the AEOI and Vice-President Salehi issued a joint statement in which Iran and the Agency agreed to further reinforce their cooperation and enhance mutual trust to facilitate the full implementation of Iran's Safeguards Agreement and AP and reached an agreement on the resolution of the safeguards implementation issues specified by the Agency.

Following the issuance of the joint statement, the Agency conducted both complementary accesses, under the AP, at the two locations specified by the Agency, where Agency inspectors took environmental samples as planned. At the end of the year, these samples were being analysed by laboratories that are part of the Agency's Network of Analytical Laboratories, including the Agency's own analytical laboratories in Seibersdorf, Austria.

The Director General speaks to the press following his return from Tehran.

Syrian Arab Republic (Syria)

In September 2020, the Director General submitted a report to the Board of Governors entitled *Implementation of the NPT Safeguards Agreement in the Syrian Arab Republic*. The Director General urged Syria to cooperate fully with the Agency in connection with all unresolved issues and expressed his willingness to engage with Syria to take concrete steps towards a mutually acceptable solution to this matter. Syria has yet to respond to these calls.

Democratic People's Republic of Korea (DPRK)

In September 2020, the Director General submitted a report to the Board of Governors and the General Conference entitled *Application of Safeguards in the Democratic People's Republic of Korea*. In 2020, 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. The Agency has not had access to the Yongbyon site or to other locations in the DPRK. The Secretariat intensified efforts to enhance the Agency's readiness to play its essential role in verifying the DPRK's nuclear programme once a political agreement has been reached among the countries concerned. The continuation of the DPRK's nuclear programme is a clear violation of relevant United Nations Security Council resolutions and is deeply regrettable.

Enhancing safeguards

During 2020, the Agency developed State-level safeguards approaches (SLAs) for two States with a CSA and an AP in force. This brings the total number of States with a CSA for which an SLA has been developed to 133. These 133 States hold 97% of all nuclear material (by significant quantity) under Agency safeguards in States with a CSA and include 70 States with a CSA and an AP in force and a broader conclusion; 36 States with a CSA and an AP in force and without a broader conclusion; and 27 States with a CSA but no AP in force. The Agency developed an SLA for a State with a voluntary offer agreement and an AP in force. There are now two States with a voluntary offer agreement and an AP in force for which an SLA has been developed.

Cooperation with State and regional authorities

Due to the COVID-19 pandemic, in 2020 the Agency had to postpone many of its international, regional and national training courses aimed at assisting States in building capacity for implementing their safeguards obligations. To address the training needs of States, the Agency developed new safeguards e-learning courses, including a course entitled 'Basics of Safeguards', as well as several modules on nuclear material accounting. To further help States strengthen the effectiveness of their State or regional authority responsible for safeguards implementation (SRA) and of their respective State system of accounting for and control of nuclear material (SSAC), the Agency launched the IAEA Comprehensive Capacity-Building Initiative for SSACs and SRAs (COMPASS) to provide assistance and services tailored to the needs of the State concerned.

Safeguards equipment and tools

Despite the pandemic in 2020, the Agency ensured that instrumentation and monitoring equipment used by inspectors during inspections or installed in nuclear facilities around the world and services related to the provision thereof, continued to function as required.

At the end of the year, 1611 unattended safeguards data streams[8] were collected remotely from 142 facilities in 31 States[9] around the world. The Agency also had 1530 cameras operating or ready to use at 260 facilities in 37 States[10]. The transition to the next generation surveillance system, to replace earlier generation cameras that have reached the end of their life cycle, neared completion.

Safeguards analytical services

In 2020, the Agency collected 489 nuclear material samples, 460 environmental samples and 9 heavy water samples that were analysed by the Agency's laboratories in Seibersdorf and by the Network of Analytical Laboratories.

Developing the safeguards workforce

In 2020, the Agency conducted 39 distinct safeguards training courses, helping to provide safeguards inspectors, analysts and supporting staff with the necessary core and functional competencies. Owing to the COVID-19 pandemic, redevelopment and redesign of training courses enabled the delivery of some hybrid and on-line courses to safeguards staff.

Preparing for the future

As part of its strategic foresight and planning activities for nuclear safeguards aimed at taking advantage of technological advances, the Agency held a workshop in January to identify new opportunities, explore challenges, and deepen its understanding of emerging technologies. The workshop generated ideas related to the use of artificial intelligence, novel approaches to verifying spent nuclear fuel and visualization techniques for analysis.

MANAGEMENT OF TECHNICAL COOPERATION FOR DEVELOPMENT

The technical cooperation programme in 2020

The technical cooperation programme is the major vehicle through which the Agency transfers nuclear technology to Member States and builds their capacities in the peaceful use of nuclear science and technology. In 2020, the Agency provided support and assistance to Member States through almost 2000 national, regional and interregional technical cooperation projects. Nuclear knowledge development and management accounted for the highest proportion of actuals (disbursements) delivered through the programme, at 33.1%. This was followed by health and nutrition at 23.5%, and by food and agriculture at 18.8%. By the end of the year, financial implementation of the Technical Cooperation Fund stood at 80.4%, thanks to the joint efforts of Member States and the Secretariat, and despite the challenges posed by the COVID-19 pandemic in delivering certain capacity building activities.

Twelve Country Programme Frameworks (CPFs) — for Chad, Chile, Croatia, Georgia, Indonesia, the Lao People's Democratic Republic, Mauritania, Mauritius, Panama, the Republic of Moldova, Sudan and Togo — were signed in 2020. By the end of the year, the total number of valid CPFs was 113.

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8 A data stream is a flow of information coming from a data collection module.

9 And Taiwan, China.

10 And Taiwan, China.

Continuation of technical cooperation programme delivery in challenging circumstances

At the outset of the COVID-19 pandemic, the Secretariat moved immediately to ensure business continuity and the safety of fellows and scientific visitors. In close consultation with Member States, 102 fellows and scientific visitors were repatriated, while around 120 chose to shelter in place.

Given the challenges and restrictions related to the pandemic, the Agency worked closely with counterparts to reprioritize activities and reschedule planned events. Fellowship placements for long term training continued throughout the year, in close consultation with Member States on feasibility and acceptance. Where appropriate, face to face events were replaced with remote training, meetings and expert services, and the quality of these events was assessed jointly by Member States and the Secretariat. Procurements planned for the 2020–2021 technical cooperation cycle were carefully reviewed, and some procurements planned for implementation in 2021 were initiated in 2020. In the Programme of Action for Cancer Therapy (PACT), a new hybrid modality was introduced to carry out imPACT (integrated missions of PACT) Review missions partially virtually

Overview of regional activities

Africa

The technical cooperation programme provided assistance to 45 Member States in Africa in 2020, of which 26 are classified as least developed countries. Approximately 70% of this assistance was delivered in food and agriculture, health and nutrition, radiation and nuclear safety, and human resource development. Throughout 2020, the Agency continued to work closely with the African Union Commission, and held several webinars with the African Commission on Nuclear Energy on topics related to the development of nuclear power in Africa and women in nuclear science in Africa.

Under a regional project for PhD sandwich programmes, 13 candidates from 13 Member States (including ten least developed countries) pursued Agency fellowship training to carry out their PhD research work at foreign universities. To enhance expertise in isotope hydrology, a regional water resources management project for the Sahel region also awarded 15 PhD sandwich fellowships. Most students were able to complete their first period at foreign universities despite the COVID-19 restrictions.

Most African Member States received assistance to strengthen their capabilities for safe and secure testing for COVID-19, supporting national efforts to control the pandemic. States Parties to the African Regional Co operative Agreement for Research, Development and Training Related to Nuclear Science and Technology (AFRA) conducted a mid-term review of the AFRA Regional Strategic Cooperative Framework for 2019–2023 in 2020, taking into consideration emerging priority areas.

Asia and the Pacific

In 2020, the technical cooperation programme in Asia and the Pacific provided technical assistance to 37 Member States and territories, including eight least developed countries and five small island developing States. Assistance focused on food and agriculture, human health and nutrition, radiation and nuclear safety infrastructure, and water and the environment.

In collaboration with the WHO Regional Office for the Western Pacific, a series of webinars was organized for COVID-19 testing laboratories. Arrangements were initiated to replicate the series through the WHO Regional Offices for South-East Asia and the Eastern Mediterranean in Arabic.

Two new publications highlighting technical cooperation achievements in the region were launched. *Journeys to Success: A collection of success stories from IAEA technical cooperation in Asia and the Pacific* showcases projects that have brought about positive change; while *Social and Economic Impact Assessment of Mutation Breeding in Crops of the RCA Programme in Asia and the Pacific*, a first-of-its-kind socioeconomic impact assessment conducted by the Regional Co-operative Agreement for Research, Development and Training Related to Nuclear Science and Technology (RCA) for Asia and the Pacific with support from the Agency, examines quantifiable achievements made through the crop mutation breeding programme under the RCA (Fig. 2). Five new resource centres of the Co-operative Agreement for Arab States in Asia for Research, Development and Training related to Nuclear Science and Technology (ARASIA) for secondary standards dosimetry have been identified, expanding the existing resource centres for human health.

FIG. 2. The Regional Co-operative Agreement (RCA) for Asia and the Pacific has conducted a socioeconomic assessment of achievements made under the RCA crop mutation breeding programme.

Europe

The technical cooperation programme provided assistance to 33 Member States in Europe and Central Asia, focusing predominantly on nuclear and radiation safety and human health. Efforts continued to strengthen radiation medicine within the region, particularly in Central Asia, where significant investments are planned in cancer management.

Support for Member States embarking or considering embarking on a nuclear power programme was strengthened, including in effective and safe long term operation, radioactive waste management and environmental remediation. The Agency enhanced capabilities for

the application of isotope tracer technology in groundwater and coastal management, and for the identification of sources of air pollution and aerosols. Environmental monitoring and impact assessment capabilities for public and environmental protection were supported by the generation of fit-for-purpose, comparable and optimized radiological monitoring data according to international standards.

Latin America and the Caribbean

In 2020, the Agency provided technical assistance to 31 Member States in the Latin America and the Caribbean region, focusing on human health, safety, food and agriculture, and water and the environment.

The Regional Co-operation Agreement for the Promotion of Nuclear Science and Technology in Latin America and the Caribbean (ARCAL) continues to be the main mechanism to promote South–South cooperation in the region. ARCAL's new Regional Strategic Profile, 'Agenda ARCAL 2030', was launched during the ARCAL meeting on the margins of the 64th regular session of the Agency's General Conference. The document will guide the development and implementation of regional projects for the coming decade.

At the end of the year, Hurricanes Eta and Iota hit Central America, with devastating consequences for human lives and basic infrastructure. Through the technical cooperation programme, the Agency procured mobile X ray systems for Guatemala, Honduras and Nicaragua to restore medical diagnostic facilities and enable the provision of urgently needed services for affected populations in remote areas. Support for the implementation of non destructive testing to assess damage to civil infrastructure was included as part of the assistance package.

Programme of Action for Cancer Therapy (PACT)

Through PACT, the Agency focused on reviewing national capacities for cancer control, supporting national cancer control planning and mobilizing additional resources and partnerships.

ImPACT Review missions, conducted jointly by the Agency, WHO and the International Agency for Research on Cancer, assess a country's cancer control capacities and needs, and identify priority interventions to effectively respond to its cancer burden. In 2020, ImPACT Reviews were conducted for the Central African Republic, Mali and Senegal, using a hybrid physical–virtual format. Reviews were also initiated in the Democratic Republic of the Congo, Iraq and Nepal. Virtual consultations were held with more than 10 Member States to take stock of their progress in the implementation of cancer control efforts and imPACT Review recommendations.

The Agency established collaboration with the Joint United Nations Programme on HIV/AIDS (UNAIDS) to scale up cervical cancer services; further expanded its partnership with the Islamic Development Bank (IsDB) to address women's cancers; and signed a partnership with the Global Access to Cancer Care Foundation in November to train cancer care professionals in low and middle income countries. Collaboration with WHO and the International Agency for Research on Cancer was further strengthened, and the critical role of the Agency in global cancer control was highlighted at key global events, including the World Health Assembly and WHO Regional Committee meetings, as well as at the second PACT partner meeting.

Technical cooperation and the global development context

The work of the Agency's technical cooperation programme was dominated by the response to the COVID-19 pandemic, programmatically and in terms of advocacy and outreach with external partners. Building on past achievements, the Agency continued to

position nuclear science and technology as an important driver in the implementation of the 2030 Agenda for Sustainable Development.

At the beginning of the year, a special session on nuclear technology applications for the Sustainable Development Goals (SDGs) was included in the programme of a workshop of the United Nations Inter-agency Task Team on Science, Technology and Innovation for the SDGs. This event provided an overview of how nuclear science and technology can support national efforts to achieve the SDGs and offered concrete examples of solutions where nuclear techniques can improve human and animal health, accelerate prosperity and protect the planet.

Following on from this, in June the Agency presented at a special preparatory session of the High-level Political Forum on Sustainable Development on science, technology and innovation in the response to the pandemic. The Agency signalled its commitment to SDG 17, on partnerships for the goals, and the Technology Facilitation Mechanism — one of the main commitments under the goal — by becoming a key partner in the new 2030 Connect platform, launched in July to share information about technology for achieving the SDGs with a broad community of decision makers, academia and representatives of the private sector and civil society. The Agency's emergency response technology was showcased among the solutions to address the COVID-19 pandemic.

Addressing the plastic pollution problem has been the focus of several technical cooperation projects. Countries in Latin America and the Caribbean have been at the forefront of enhancing their capabilities in marine environmental monitoring, with a focus on nano- and microplastics. In the Asia and the Pacific region, a financial feasibility model was developed through a regional project which can be applied for establishing a irradiator based pilot plant for plastic recycling.

Legislative assistance

Country specific bilateral legislative assistance was provided to 12 Member States through written comments and advice on drafting national nuclear legislation, and one regional workshop on harmonizing national nuclear law with international and European law was held. Four virtual activities on nuclear law were held as an on-line alternative to some training activities. In addition, a new series of interactive webinars on nuclear law was launched. Given the success of this series and in response to expressed interest from industry, law firms, non-governmental organizations, civil society and academia, a supplementary webinar — Nuclear Law in Practice: The IAEA Perspective — was held for the general public. The 2020 session of the annual interregional Nuclear Law Institute (NLI) training event was postponed until 2021.

Technical cooperation programme management

Quality assurance activities, reporting and monitoring

In 2020, the Agency made significant progress in developing processes and tools to increase programme quality in line with the principles of results based management, including an update of the TC Programme Quality Criteria, and the development of impact assessment approaches, on-line tutorials and training materials on risk management. Given global travel restrictions, training material on results based management and project design for the 2022–2023 technical cooperation cycle was made available in electronic format on the Programme Cycle Management Framework IT platform.

Increased efforts were made to develop appropriate methods and metrics to demonstrate the impact of the Agency programme and to improve evidence based reporting on the results delivered. In addition, the electronic technical cooperation reports platform was further developed to increase the current overall Project Progress Assessment Report

(PPAR) submission rate of 71%. The submission and finalization of electronic versions of PPARs (e-PPARs) and Project Achievement Reports as a basis for systematic collection of experiences and success stories was strongly encouraged.

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 €128.6 million in 2020, with approximately €84.5 million for the Technical Cooperation Fund (including assessed programme costs arrears, National Participation Costs and miscellaneous income), €44.1 million in extrabudgetary resources and about €0.1 million representing in-kind contributions. The rate of attainment for the Technical Cooperation Fund stood at 91.1% on payments and 92.6% on pledges at the end of 2020. Payment of National Participation Costs totalled € 3.7 million.

Actuals

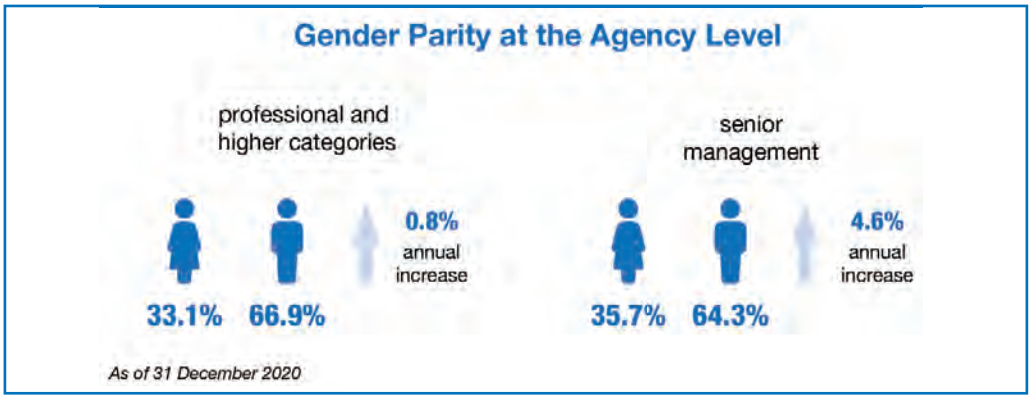
In 2020, approximately €92.1 million was disbursed to 146 countries or territories, of which 35 were least developed countries.

MANAGEMENT ISSUES

Gender parity

Further to the goal set by the Director General, the Agency is striving to achieve gender parity in all levels of the Professional and higher categories by 2025. In May, the Agency adopted within human resources policies new special measures that, among other things, focus on outreach activities to attract more women to apply for vacancies, and establish accountability and monitoring mechanisms for the implementation of these measures, including training for managers.

As a result, and in the context of the Agency policy of preserving the highest standards of efficiency, technical competence and integrity, 57.6% of all job offers in the Professional and higher categories were extended to and accepted by women. At the end of 2020, the proportion of women in the Professional and higher categories was 33.1% and that of women in senior management positions (D level or higher) was 35.7%. These figures represent an increase of 0.8% and 4.6%, respectively, compared with the adjusted figures[11] from December 2019.



[11] The figures for 2019 have been retroactively updated to align with the criteria established in the Special Measures for the Achievement of Gender Parity issued in 2020. They now include temporary assistance, extrabudgetary and non-competitive positions.

Towards More Women in the Nuclear Field: The IAEA Marie Skłodowska-Curie Fellowship Programme

In March, the Director General launched the IAEA Marie Skłodowska-Curie Fellowship Programme (MSCFP), which aims to inspire and encourage women to pursue a career in nuclear science and technology, nuclear safety and security, or non-proliferation, by providing scholarships for master's programmes and an opportunity to pursue internships relating to their field of study, facilitated by the Agency.

The MSCFP has received broad support from Member States and non-governmental organizations, with a number of them making financial and in-kind contributions.

The first 100 recipients of scholarships under the MSCFP were selected in November. They come from 71 countries and study a wide range of nuclear related subjects.

Lesego Mvembeli from South Africa, studying applied radiation science and technology at North West University in South Africa

"I am a girl from a village in Mafikeng, and I have always dreamed of becoming a scientist. I decided to study applied radiation science out of interest; I wanted to find out more about it. When I learned more about nuclear energy, I thought it was the most fascinating subject and I decided to pursue a master's degree in it. The IAEA MSCFP helps me do that, both to finance my studies and complete my research.

"In the future, I see myself as an influential scientist who will work all over the world and especially in countries that are yet to have technological developments, helping them have better and easier lives."

"As a physics graduate, I have a special interest in medical physics. This field is not only about nuclear radiation, but also about human well-being. I have seen very closely the hard stages that a person with cancer must go through and I want, with all my heart, to help improve the quality of life for those people and contribute to an early diagnosis to increase their chance of overcoming the disease.

"In 10 years, I see myself as a mature professional, helping my country in strengthening medical physics at the research level in hospitals, universities or research centres."

Duque Geraldyne Ule from Colombia, studying medical physics at Universidade de Sao Paolo in Brazil

Nanako Kawano from Japan, studying nuclear engineering/nuclear communication/fusion at Tokyo Institute of Technology in Japan

"The Fukushima Daiichi accident in 2011 inspired me to choose nuclear engineering as my master's degree. I am extremely interested in technical but also social challenges faced by nuclear science and technology. My dream is to make our lives more comfortable with nuclear energy. I specialize in liquid divertors, since they are directly related to the safety and efficiency of operating the reactors continuously.

"I used to have a great fear of nuclear technology because of the Fukushima Daiichi accident. In the future I hope to work on improving nuclear power plants and to share the correct knowledge on nuclear science."

"The MSCFP scholarship will mitigate my stress in financially supporting my studies and will allow me to fully focus on my academic work and research. During my undergraduate physics studies, I came across the field of nuclear physics and I realized its importance in understanding the physical world. I was especially interested in the close links of experimental nuclear physics with applied nuclear science.

"In 10 years, I imagine myself as part of a diverse scientific community, conducting research in nuclear science and technology for a better world. I also hope to inspire young scientists and especially young women to work in nuclear research and contribute to the peaceful uses of nuclear science."

Stamatina Alexandropoulou from Greece, studying nuclear physics at the University of York, UK

Lindsay Leslie Bryda from the United States of America, studying nuclear security at the Middlebury Institute of International Studies, USA

"The IAEA MSCFP will remove much of the financial burden from my master's programme in non-proliferation and terrorism. As the world will increasingly feel the effects of climate change, more countries will likely embrace nuclear power. However, we need to ensure that robust measures are undertaken to keep this material out of terrorists' hands.

"I hope to play a role in building the international nuclear security regime and develop more stringent systems to track nuclear material in all phases."

Managing for results

In 2020, special attention was given to collecting and analysing data that would be useful for applying a results based approach to performance assessment during the COVID-19 pandemic. Necessary tools and capacity building activities on accountability for results were also developed to support operationalization of the Accountability Framework.

Partnerships and resource mobilization

The Agency mobilized more resources and expanded partnerships beyond its traditional donors to meet increasing demand from Member States. The Agency seized opportunities for new partnerships and built on existing ones with a view to increasing funding for technical cooperation activities and for new flagship initiatives solely funded by extrabudgetary contributions, such as the ZODIAC initiative, the MSCFP and ReNuAL 2.

Coordination and cooperation with other international organizations, governments and non-traditional partners were expanded. The Agency forged partnerships and topical collaborations with the IEA, UNAIDS, the United Nations Environment Programme, the United Nations Industrial Development Organization and WHO, among others, in areas ranging from clean energy transition to COVID-19 assistance. The Agency also established partnerships with numerous national and international professional associations and organizations, particularly in the area of training and capacity building.

The Agency also made use of the United Nations Global Marketplace for involving the private sector in providing key equipment to its laboratories. These laboratories are of interest to private companies and organizations because they are extensively used to support Member States in building capacity for peaceful applications of nuclear science and technology to meet their sustainable development goals.

An event was held to mark the 10th anniversary of the Peaceful Uses Initiative (PUI). By the end of 2020, PUI had helped to provide more than €174 million in funding and supported over 300 projects benefitting more than 150 Member States. At the event, PUI donors and recipients acknowledged the significant role of the PUI, including the announcement made by the United States of America to continue supporting the PUI for the next five years. The Director General invited all Member States in a position to do so to continue to support the initiative.

Information security and technology

In addition to addressing the operational needs of the Agency in the context of the COVID-19 pandemic, special focus continued to be given to the ongoing cyberthreats as a part of the Agency's regular IT operations. In this context, the Agency implemented a new security incident and event management system to prevent, detect and respond to threats. The Agency continued to focus on educating staff on their role in protecting the Agency's most sensitive information through phishing and other information security awareness efforts. It also made concerted efforts to upgrade systems and decommission legacy systems to reduce vulnerabilities.

The Agency moved IT servers and equipment supporting the work done at Seibersdorf from a room that was not fit-for-purpose into a new first class data centre in the Insect Pest Control Laboratory in Seibersdorf. This move supports a higher level of reliability as well as more data capacity needed by the scientists.

Multilingualism

In 2020, the Agency began offering regionally targeted (or 'localized') news on its web site to better serve its audience in Arabic, Chinese, French, Russian and Spanish, which by the end of the year accounted for 14% of overall web traffic. This, along with search engine optimization measures, has led to a 50% growth in readership.

The Agency launched an account on the Chinese social media network Weibo, while maintaining regular publishing of content on its Facebook accounts in Arabic, French, Russian and Spanish. The number of followers on social media in languages other than English grew by 33% during the year.