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Strengthening the Agency's Activities related to Nuclear Science, Technology and Applications

Report by the Director General

Summary

In response to General Conference resolutions GC(62)/RES/9 and GC(61)/RES/11, this document contains progress reports on:

- Part A: Non-power nuclear applications:
  - General (Annex 1)
  - Support to the African Union's Pan African Tsetse and Trypanosomosis Eradication Campaign (AU-PATTEC) (Annex 2)
  - Use of Isotope Hydrology for Water Resources Management (Annex 3)
  - Renovation of the Agency's Nuclear Applications Laboratories at Seibersdorf (Annex 4)

- Part B: Nuclear power applications:
  - General (Annex 5);
  - Communication and Agency Cooperation with Other Organizations (Annex 5);
  - Operating Nuclear Power Plants (Annex 5);
  - Agency Activities in the Development of Innovative Nuclear Technology (Annex 6);
  - Approaches to Supporting Nuclear Power Infrastructure Development (Annex 7); and
  - Small and Medium Sized or Modular Reactors — Development and Deployment (Annex 8).

Further information on the Agency's activities related to nuclear science, technology and applications can be found in the *Nuclear Technology Review 2019* (document GC(63)/INF/2); the *IAEA Annual*

Report 2018 (GC(63)/5), in particular the section on nuclear technology; and the *Technical Cooperation Report for 2018* (GC(63)/INF/4).

Recommended Action

- It is recommended that the Board take note of Annexes 1–8 of this report and authorize the Director General to submit the report to the General Conference at its 63rd regular session.

General

A. Background

1. In resolution GC(62)/RES/9, the General Conference requested the Director General, in conformity with the Statute, to continue to pursue, in consultation with Member States, the Agency's activities in the areas of nuclear science, technology and applications, with special emphasis on supporting the development of nuclear applications in Member States with a view to strengthening infrastructures and fostering science, technology and engineering for meeting sustainable growth and development needs of Member States in a safe manner.

2. The General Conference recommended that the Director General report on the progress made in the areas of nuclear science, technology and applications to the Board of Governors and to the General Conference at its 63rd regular session. This report has been prepared in response to that recommendation.

B. Progress since the 62nd Regular Session of the General Conference

3. The Agency continued to collaborate with designated Member State institutions to implement the Agency's programmatic activities and promote the practical use of nuclear techniques. These Collaborating Centres focus on research and development and assist Member States with the implementation of the 2030 Agenda for Sustainable Development. The Agency currently has 33 Collaborating Centres, of which 4 were newly designated and 2 re-designated in 2018 as Collaborating Centres for a period of four years. The Agency continues to rely on substantive support from its Collaborating Centres to fully implement its programme and to disseminate knowledge in line with the 2030 Agenda for Sustainable Development.

4. In response to Member States' request to organize a Ministerial Conference in 2018 on nuclear science, technology and applications for peaceful uses, and their delivery to Member States through the Agency's technical cooperation programme, while highlighting their future contribution to sustainable development, the first IAEA Ministerial Conference on Nuclear Science and Technology: Addressing Current and Emerging Development Challenges was held in November 2018. The conference was attended by 1100 participants, including policy makers, scientists, technical experts and 54 ministers. The conference culminated in the adoption of a Ministerial Declaration that will pave the way for further cooperation in nuclear science and technology in Member States supporting the attainment of the Sustainable Development Goals.

5. The Agency continued to strengthen its cooperation with the World Meteorological Organization (WMO) and its Global Atmosphere Watch programme on atmospheric greenhouse gas monitoring. The Agency participated in the WMO Global Atmospheric Watch Regional Workshop held in Jakarta from 7 to 8 August 2019, to discuss atmospheric monitoring activities. Furthermore, the Agency, through its Ocean Acidification International Coordination Centre, continued to support cooperation and collaboration between Member States to address climate change. The Agency also participated in the

Blue Oceans Conference held in Monrovia from 18 to 21 March 2019, and the 4th Global Ocean Acidification Observing Network (GOA-ON) International Workshop in Hangzhou, China, from 14 to 17 April 2019.

6. Progress was made in strengthening the partnership between the Agency and the United Nations Environment Programme (UNEP). A new relationship has been established in the framework of the UNEP led Minamata Convention on Mercury and a roadmap has been developed to outline the Agency's involvement in the quality assurance as well as capacity building activities necessary to implement the Convention.

7. The Agency continued to develop and disseminate IT tools in various areas of nuclear applications. The Agency developed an e-learning course on neutron imaging whilst a '*Regional Workshop on Training in Neutron Imaging'* was held in December 2018 with participation of experts from ten Member States; furthermore, the e-learning course on neutron activation analysis was reviewed, revised and expanded in May 2019. The course has been completed by 206 users from 57 Member States. Two new e-learning courses entitled 'Strategic Planning for National Nuclear Institutions' and 'Introduction to In-situ Techniques for Radiological Characterization of Sites' were released on the Agency's Cyber Learning Platform for Network Education and Training in April 2019.

8. The Agency continued to strengthen its relationship with the World Health Organization (WHO) through cooperation in various areas and joint initiatives. The International Symposium on Understanding the Double Burden of Malnutrition for Effective Interventions, held from 10 to 13 December 2018 in Vienna and attended by 463 participants from 89 Member States, was jointly hosted by the Agency, the WHO and the United Nations Children's Fund. The output documents prepared in close consultation with the WHO, identifies opportunities for future collaboration. The Agency supported the update of the WHO Guidelines on Good Manufacturing Practices for Radiopharmaceutical Products and reviewed the monograph for radiopharmaceuticals of The International Pharmacopeia. The United Nations Interagency Task Force on the Prevention and Control of Non-communicable Diseases coordinates the activities of several United Nations organizations and other intergovernmental organizations, overseen by the WHO, to support governments to meet high-level commitments to respond to non-communicable disease epidemics worldwide. The Agency has actively participated in the elaboration of the United Nations Interagency Task Force 2019–2021 strategy, including participation through various working groups and global joint programmes. The collaboration with WHO extends also into other areas such as the control of insect vectors of human diseases.

9. A treatment planning system has been purchased for the high dose rate brachytherapy system installed in the IAEA's Dosimetry Laboratory in Seibersdorf. The system will be used to support training and the development of a new dosimetry audit methodology through a CRP. A new range of mammography beam qualities was also introduced in the laboratories in 2018 which is now available for calibration of dosimetry standards from Member States for subsequent dissemination to clinical medical physicists, to support their efforts to optimize breast imaging systems. The Agency continues to participate in the Joint Global Programme on Cervical Cancer Prevention and Control. The Agency is also part of the WHO's cervical cancer elimination initiative, the strategic document for which will be presented to the World Health Assembly in 2020.

10. Recognizing the demand from Member States for continued training and support in radiation medicine, the Agency published an IAEA Human Health Reports publication entitled '*Introduction of Image Guided Radiotherapy into Clinical Practice*'. Furthermore, the Agency is conducting a CRP entitled 'Randomized Phase III Clinical Trial of Stereotactic Body Radiation Therapy versus Transarterial Chemoembolization in Hepatocellular Carcinoma' and a study on the implementation of image-guided brachytherapy for cervical cancer. The Agency has also made available two e-learning modules on the Human Health Campus to support professionals in keeping abreast of emerging applications, such as the appropriate use of radionuclide imaging in the management of gynaecological cancers, and the use of peptide receptor radionuclide therapy for neuroendocrine tumours.

11. The Veterinary Diagnostic Laboratory Network (VETLAB), comprising laboratories in 45 African and 19 Asian countries and expanding in 2019 to Europe and Latin America and the Caribbean, has increased its capacity to rapidly respond to infectious disease threats. The network is also facilitating the rapid sharing of the most up-to-date laboratory technologies and procedures for animal and zoonotic diseases. In 2018, VETLAB technical meetings were held in Vienna gathering 160 experts from all VETLAB participating countries plus laboratory heads to share experiences on monitoring and containing highly contagious viruses responsible for emerging zoonotic diseases, such as avian influenza, African swine fever and Ebola. In addition, VETLAB enabled the training of 97 laboratory staff of African and Asian laboratories in four training courses. Important improvements were achieved on the application of advanced technologies in the diagnostic portfolios of partner laboratories such as the use of multiple pathogen detection and the use of sequencing to confirm diseases and better characterize the pathogens. Nearly 600 samples from 58 laboratories in 42 Member States have been sequenced, many of them already published in the US National Center for Biotechnology Information's GenBank database.

12. The Agency continued to support more than 60 national and regional projects in Member States aimed at the production of medical radioisotopes and radiopharmaceuticals through the technical cooperation programme. Recognizing the growing focus on targeted alpha therapy using actinium-225 (Ac-225), the Agency organized a workshop on supply of Ac-225 in October 2018, attended by more than 70 participants from national laboratories, research institutes and private companies in 17 Member States, to discuss the production and availability of Ac-225, a promising alpha emitter for therapy. A new Database on Cyclotrons for Radionuclide Production was also launched on the Agency's website in 2018. Furthermore, a Technical Meeting on the Production and Quality Control of Short-Lived Radiopharmaceuticals for Positron Emission Tomography was held in Romania in December 2018 attended by 15 Member States. The Agency published *Gallium-68 Cyclotron Production* (IAEA-TECDOC-1863) in 2019 and is currently developing two publications on the production of alternate radioisotopes using medical cyclotrons and on preclinical testing of radiopharmaceuticals.

13. The Agency continued to provide support to Member States through the technical cooperation programme to strengthen quality assurance in radiopharmaceutical development. A Technical Meeting on Strengthening Quality Assurance/Quality Control Protocols in Radiation Facilities through Dosimetry Intercomparison was held in October 2018 with participants from 19 Member States. Furthermore, the Agency also published *Quality Control in the Production of Radiopharmaceuticals* (IAEA-TECDOC-1856) in 2018.

14. The Agency, upon request from interested Member States, when technically and economically feasible, continued providing technical assistance to emerging national and regional efforts to establish non-highly enriched uranium (HEU) based molybdenum-99 (Mo-99) production capabilities. In this regard, the Technical Meeting on Global Capabilities for the Production and Manufacture of Non-High Enriched Uranium Mo-99 Targets was held in Vienna in October 2018. A cooperation meeting with Argentina was held in November 2018 to discuss management of uranium-bearing wastes from Mo-99 production in the context of HEU minimization.

15. The Agency continued to support Member States in exploring the use of accelerators for various radiation technology applications through the technical cooperation programme. The Agency is developing new databases on irradiation facilities, pertaining to both gamma and electron beam installations. The Joint ICTP–IAEA Advanced School on Ion Beam Driven Materials Engineering: Accelerators for a New Technology Era, held 1–5 October 2018, in Trieste, Italy, and attended by 25 participants from 15 Member States, aimed to engage the next generation of researchers in this field. The Agency also organized two Technical Meetings in Vienna in October and December 2018 to discuss the status of the techniques employed at ion beam accelerators to irradiate and analyse materials relevant to future fusion reactors, and the various applications that rely on the production and subsequent acceleration of radioactive ion beams. Furthermore, cross-cutting outreach materials were published showcasing various application areas of ion beams and neutrons for material modification and analysis. The Agency also facilitated Member States' access to perform experiments at state-of-the-art facilities, such as the beam facility of the Ruđer Bošković Institute in Croatia and Elettra synchrotron light facility in Italy.

16. The Agency also undertook the initial shielding calculations necessary for facility design of a neutron science facility in Seibersdorf, to enable the Agency's Nuclear Science and Instrumentation Laboratory to support Member States in capacity building through education and hands-on training, facilitation of applied research, and provision of specialized services. Equipment have also been secured through contributions from two Member States.

17. The Agency continues to support Member States through the technical cooperation programme in the installation of gamma irradiators, electron beam accelerators and installations to produce medical and industrial radioisotopes and radiopharmaceuticals. The first meetings of two new CRPs entitled 'Imaging Technologies for Process Investigation and Component Testing' and 'Enhancing the Beneficial Effects of Radiation Processing in Nanotechnology' were held in Vienna in February and March 2019, respectively. The Agency also published *Radiation Treatment of Wastewater for Reuse with Particular Focus on Wastewaters Containing Organic Pollutants* (IAEA-TECDOC-1855) in 2018. Furthermore, a side event entitled 'Non-Destructive Testing (NDT): Methods and Techniques for Civil Structures in Pre- and Post-Management of Natural Disasters' was held during the 62nd regular session of the General Conference in 2018. A Technical Meeting on Basic Radiation Chemistry for Polymer Modification was held in Poland, in September 2018, with participation from 18 Member States.

18. The Agency continued to develop appropriate instruments and to make available, to requesting Member States, services for the rapid and economic mapping of radioactivity on the Earth's surface. In this regard, a training workshop organized through the ALMERA network took place in May 2019, in Hungary, on in-situ gamma spectrometry to train Member States on the detection of environmental contamination. Two expert missions were conducted to Brazil and Uzbekistan over the reporting period, one for training on radiation monitoring measurements and the other to support a national training exercise for monitoring radiological events using unmanned aerial vehicles.

19. Furthermore, in December 2018, the Agency organized a Technical Meeting on Current Trends and Developments in Nuclear Instrumentation in Vienna, which was attended by experts from 11 Member States. A coding tool was developed to facilitate the interpretation of geographic information system linked radiological measurements and the production of maps.

20. The Agency strengthened its activities in the area of fusion science and technology by signing Practical Arrangements with ITER, in June 2019, in the area of nuclear fusion with emphasis on: promotion and outreach; capacity building through the newly established ITER academy as well as relevant Agency training events; sharing of nuclear safety and radiation protection related experience by the ITER facility; and considerations for the development of nuclear fusion safety requirements and standards relevant to the establishment of the necessary nuclear infrastructure for future nuclear fusion energy facilities. Furthermore, to continue the activities on the demonstration fusion power plant (DEMO), the Agency organized a DEMO Programme Workshop in the Republic of Korea, attended by 64 experts from 12 Members States, to assess the present status and prospects for progress in the use of magnet technology for magnetic confinement fusion, control of DEMO plasmas, remote maintenance and plant logistics. In addition, the 27th IAEA Fusion Energy Conference (FEC 2018), which is the reference conference in the field and the largest organized by the Agency, took place in Ahmedabad, India, from 22 to 27 October 2018. The Conference was attended by 718 experts from 39 Member States and 4 international organizations.

21. Also, the Agency launched the Global Network for the Atomic and Molecular Physics of Plasmas, a consortium of research groups working in the area of fundamental atomic and molecular physics relevant to plasma processes. In 2018, the Agency issued *Integrated Approach to Safety Classification of Mechanical Components for Fusion Applications* (IAEA-TECDOC-1851) which serves as the first international reference document in this technical area.

22. The Agency's Isotope Browser for smartphones reached 85 000 downloads during the reporting period. A Medical Isotope Production Browser has been developed which will enable users to determine the best production route based on their input — the website will be operational in October 2019. A crowdsourcing challenge on the computational simulation of damage in a fusion reactor was successfully launched and completed.

23. The Agency has commenced a 'Doctoral CRP on Advanced Radiotherapy Techniques', which seeks to increase capacity in Member States to develop sustainable educational and research programmes. The Agency continued to promote education and training of professionals in radiation medicine through web-based tools and projects such as the African Radiation Oncology Network, the successful African virtual tumour board, the development of e-contouring teaching, and a CRP entitled 'E-Learning for Teaching and Assessing Competency in Radiotherapy Contouring for Multidisciplinary Teams in Low- and Middle-Income Countries'.

Support to the African Union's Pan African Tsetse and Trypanosomosis Eradication Campaign (AU-PATTEC)

A. Background

1. In resolution GC(62)/RES/9.A.3, the General Conference recognized that tsetse flies and the trypanosomosis problem which they cause constitute one of the greatest constraints on the African continent's socio-economic development, affecting the health of humans and of livestock, limiting sustainable rural development and thus causing increased poverty and food insecurity.

2. The General Conference requested the Agency and other partners to strengthen capacity building in Member States for informed decision-making regarding the choice of tsetse and trypanosomosis strategies and the cost-effective integration of sterile insect technique (SIT) operations into area-wide integrated pest management campaigns. The General Conference also requested the Secretariat, in cooperation with Member States and other partners, to maintain funding through the Regular Budget and the Technical Cooperation Fund for consistent assistance to selected operational SIT field projects and to strengthen its support for research and development and technology transfer to African Member States in order to complement their efforts to create and subsequently expand tsetse-free zones.

3. The General Conference requested the Director General to report on the progress made in the implementation of GC(62)/RES/9.A.3 resolution to the Board of Governors and to the General Conference at its 63rd regular session.

B. Progress since the 62nd Regular Session of the General Conference

B.1. Strengthening Collaboration with AU-PATTEC and Other Partners

4. The Agency was represented at the 17th meeting of coordinators/focal points for AU-PATTEC and at the seventh meeting of the AU-PATTEC Steering Committee, which were held in Addis Ababa in November 2018. A presentation was given to update AU-PATTEC members on the status of the activities of the Joint FAO/IAEA Programme of Nuclear Techniques in Food and Agriculture and the Agency's assistance provided under the technical cooperation programme in support of tsetse and trypanosomosis control. The Agency will continue its close collaboration with AU-PATTEC on its goal to eliminate tsetse flies and trypanosomosis through the creation of sustainable tsetse and trypanosomosis free areas.

5. In the framework of the Practical Agreements signed with the African Union Commission in February 2018 to expand the areas of cooperation, a task force meeting took place in February 2019 in Kigali. The aim was to develop an action plan and identify concrete initiatives for implementation in support of the African Union's Agenda 2063 and the Sustainable Development Goals.

6. The Agency continued to support AU-PATTEC through the technical cooperation programme providing expert services for the development of a bankable project to mobilize resources to accelerate the implementation of PATTEC activities.

B.2. Capacity Building through Applied Research and Technical Cooperation

7. The Agency continued to respond to Member States' requests for support in incorporating SIT into area-wide integrated pest management (AW-IPM) to eliminate or control tsetse-transmitted trypanosomosis. The disease has been recognized as a major constraint to both livestock and agricultural crop production in sub-Saharan Africa. The support included the provision of technical advice, procurement of equipment and materials, training courses and workshops, fellowships and scientific visits, as well as research conducted at the Insect Pest Control Laboratory in Seibersdorf. In addition, experts from affected Member States participated in the first meeting of the coordinated research project (CRP) entitled 'Improvement of Colony Management in Insect Mass-rearing for Sterile Insect Technique Applications', which includes a research group on tsetse flies.

8. The Agency's support strengthened capacity in Member States, enabling them to obtain and analyse baseline data to support informed decision-making regarding the choice and feasibility of available tsetse and trypanosomosis suppression or eradication strategies, including the cost-effective integration of SIT operations into AW-IPM campaigns. Since the 62nd regular session of the General Conference, support in this area has been provided to Burkina Faso, Chad, Ethiopia, Mali, Senegal, South Africa, Uganda, the United Republic of Tanzania, Zambia and Zimbabwe.

9. Since September 2018, the Agency has supported eight fellowships and scientific visits, for training, as well as research and development, in different aspects of SIT, and its applications to manage tsetse population. The fellowships provided individual training at specialized institutions for a total duration of more than 600 days. The Insect Pest Control Laboratory (IPCL) at Seibersdorf has hosted two PhD students who worked under the supervision of senior Agency scientists on research topics pertaining to the tsetse microbiome and the release of chilled tsetse flies. Furthermore, three regional and international training courses were organized through the technical cooperation programme with the participation of 37 trainees from tsetse-affected countries.

10. Research activities at the IPCL have continued to focus on the development and validation of technologies that can substantially contribute to the cost reduction and simplification of SIT application against major tsetse fly species. A pupae sex sorter based on image analysis of pupae under near infrared light has been developed since the last session of the General Conference. This sorter will significantly simplify the procedures and reduce the cost of mass rearing in the insectaries, among other benefits.

11. Capacity building on the use of molecular tools to identify tsetse fly and trypanosome species has continued during the reporting period. Standard operating procedures have been published and a regional training course on this specific topic was organized in Burkina Faso. Furthermore, the Agency continues to equip molecular laboratories in Burkina Faso, Chad, Ethiopia, Mali, the United Republic of Tanzania, Zambia and Zimbabwe.

12. Advances in knowledge and applicable technologies arising from the above-mentioned research activities are widely disseminated through publications in peer-reviewed scientific journals, as well as through conference presentations and training courses. Several publications related to tsetse flies and trypanosomosis, including guidelines, manuals and standard operating procedures were published. During the reporting period, 13 scientific papers related to tsetse flies and trypanosomosis were published in peer reviewed journals. In addition, the final research results of the CRP on 'Enhancing

Vector Refractoriness to Trypanosome Infection' were published, in 2018, in a special issue of the *BMC Microbiology* journal comprising 23 scientific papers.

B.3. Support for the Planning and Implementation of SIT Activities

13. Under technical cooperation project SEN/5/037, the Agency has continued to provide technical support to the Government of Senegal in its programme to eradicate the tsetse fly *Glossina palpalis gambiensis* from the highly productive agricultural region of Niayes, to the north-east of Dakar, using an AW-IPM approach with a SIT component. The tsetse suppression campaign has yielded excellent results as demonstrated by the fact that, over the past two years, the Government of Senegal has imported ten times more productive cattle into the area, as compared to the same period before the project started.

14. In Ethiopia, under technical cooperation project ETH/5/021, two high endurance remotely piloted aircraft systems for the release of sterile flies in the Deme valley have been delivered to the National Institute for Control and Eradication of Tsetse and Trypanosomosis. On-site training in the maintenance and operation of these systems has been organized. Mass rearing equipment for the insectary in Kality is being procured by the Agency.

15. Under technical cooperation projects RAF/5/080 and BKF/5/020, the Agency has continued to provide technical support, capacity building and equipment for the Insectary of Bobo-Dioulasso (IBD) in Burkina Faso. This insectary, inaugurated in February 2017, is the largest insectary in West Africa. The size of the colony of *G. palpalis gambiensis* is increasing and has reached 1 400 000 reproductive females. Pilot releases of sterile males are planned for the end of 2019 in the Mounhoun river region. The IBD continues to support the Government of Senegal in its efforts to eradicate a tsetse fly population in the Niayes region through the twice-weekly supply of sterile male tsetse flies.

16. Under technical cooperation project CHD/5/007, entomological baseline data have been collected in the Mandoul area, one of the few remaining active foci of sleeping sickness in Chad. The population of the vector tsetse fly *G. fuscipes fuscipes* has been suppressed and a predicted distribution model has been produced, indicating that the population pocket is isolated from that of other foci. A field insectary has been built and equipped in Moundou and studies on vector competence of sterile males fed with trypanocidal drugs have been conducted in collaboration with the joint unit of the Institute of Research for Development and the International Cooperation Centre of Agricultural Research for Development in Montpellier, France.

Use of Isotope Hydrology for Water Resources Management

A. Background

1. At its 61st regular session in September 2017, the General Conference, through resolution GC(61)/RES/11.A.3, requested the Director General, ,subject to the availability of resources, to continue to further strengthen the efforts directed towards the fuller utilization of isotope and nuclear techniques for water resources development and management in the interested countries; to continue to help Member States obtain easy access to isotopic analysis by upgrading selected laboratories; to expand activities related to the IAEA Water Availably Enhancement (IWAVE) Project and to groundwater management; to strengthen activities which contribute to the understanding of climate and its impact on the water cycle; and to continue to develop human resources in isotope hydrology. It further requested the Director General to report on achievements in implementing resolution GC (61)/RES/11. A. 3 to the Board of Governors and to the General Conference at its 63rd regular session.

B. Progress since the 61st Regular Session of the General Conference

B.1. Strengthening Isotope Hydrology Activities and the IWAVE Approach

2. Access to clean fresh water is a key factor for human wellbeing as recognized in Sustainable Development Goal (SDG) 6. Comprehensive water resources assessment and management, as reflected in SDG 6.5, requires multidisciplinary approaches supported by scientific data on the occurrence, distribution and flow of water resources. Reliable water resources assessments, particularly for groundwater, are lacking in many Member States, limiting their capacity to address major challenges in achieving water security under changing conditions. Continued support to Member States is needed to promote the application and routine use of isotope hydrology tools as part of national water strategies. Isotope methods provide important hydrological information required to address major knowledge gaps in the understanding of global and regional water cycles.

3. Groundwater in aquifers comprises over 96% of Earth’s available fresh water, and its exploitation has rapidly increased in keeping with global population growth. Groundwater is a primary source of fresh water for almost half the world's population; however, around 90% of groundwater extraction is used for agricultural and irrigation purposes. In many parts of the world, groundwater levels are declining owing to intensive agricultural withdrawals that far exceed natural replenishment rates, particularly in arid and semi-arid areas where ancient non-renewable groundwater is increasingly being exploited. Despite the importance of aquifers, many national water authorities still have insufficient information regarding the extent, capacity and quality of their groundwater reserves. The capacities of national scientific and technical authorities need to be strengthened so that they can implement

science-based policies to substantiate and implement appropriate groundwater and surface water management and remediation policies and practices.

4. Groundwater radioisotopic age dating provides essential scientific information to guide the sustainable exploitation of aquifers, and permits quantifiable estimates of aquifer replenishment rates, which in turn inform better estimates of pumping rates and the amount of water that can be utilized without overexploitation and serious water level declines. Newly emerging noble gas radioisotope dating techniques using, for example, argon-39, krypton-81 and helium-3/tritium, covering decades to million-year ages are increasingly demanded to better assess the history and replenishment rates of ancient groundwater supplies that are being exploited in Member States. The Agency has focused on new noble gas and radioisotope research, field training, and analytical services aimed at implementing the deployment of noble gases for groundwater age dating to map resource availability and vulnerability.

5. The IWAVE Project uses a systematic hydrological assessment approach designed to help Member States better identify deficiencies hindering their realization of SDG 6. An IWAVE stakeholder review assessment outlines the scientific and hydrological gaps and information needed to improve water resources availability. IWAVE assessments help identify the technical capacities and field efforts needed to obtain knowledge to understand water availability, with a focus on the applicability and efficacy of nuclear methods. The Agency began mainstreaming the IWAVE methodology in 2016 through regional TC projects and, as of 2018, in the design phase of new technical cooperation projects, which helps to ensure the viability of isotope hydrology project outcomes in achieving SDG 6 on clean water and sanitation.

6. IWAVE assessments were applied in regional cooperation projects in Latin America and Africa in the 2016–2018 period through the technical cooperation programme. A regional technical cooperation water management project in the Sahel incorporated IWAVE assessments built on the lessons learned from the previous project. In 2018, the Agency completed a comprehensive IWAVE groundwater assessment in Latin America for five aquifers in Argentina, Brazil and Colombia. Isotopic data were used to establish regional hydrogeochemical and isotope frameworks for precipitation, surface water and groundwater. The isotopic data are being integrated into new hydrological maps, highlighting areas where replenishment is occurring and vulnerability to over extraction or pollution is high. IWAVE workshops were conducted through the technical cooperation programme in Bolivia, Colombia, Kenya, Mexico, the Niger and Paraguay, focusing on how to effectively employ nuclear methods in hydrology to realize SDG 6.

7. In May 2019, the Agency hosted the International Symposium on Isotope Hydrology: Advancing the Understanding of Water Cycle Processes, which was attended by over 260 professionals from 74 Member States. The delegates reviewed state-of-the-art isotope applications in hydrology and helped to identify research, analytical and training requirements to support the wider use of isotope hydrology for sustainable development. As groundwater is the largest reservoir of fresh water on earth, global groundwater depletion poses a significant threat to water security. In this context, the Agency focuses on research, training, protocol development and analytical services aimed at expanding the use of groundwater age dating with isotopes to map water resources availability, sustainability and vulnerability to pollution.

8. The Agency worked closely with Japan to understand the distribution and environmental dynamics of radionuclides released in the accident at the Fukushima Daiichi nuclear power plant in 2011. This cooperation has taken place through Practical Arrangements between Fukushima Prefecture and the Agency through the Fukushima Prefecture Initiative Project on the Study of Simple and Rapid Analysis Methods for Radionuclides, which seeks to strengthen the Prefecture’s analytical capacity to measure the radioactive isotope tritium in water samples. The Agency provided comprehensive training on the principles and operation of the tritium analyses, and the Prefecture’s scientists are now able to

process water samples for tritium analysis. An intercomparison exercise ensured quality of the data and the analysis protocols. The experience gained helped build public confidence in mitigation actions and brought new insights into management of radionuclide accidents.

9. A previous technical meeting held to explore how conventional and advanced isotopic tools could be used to assess the environmental impact of fracking on groundwater and surface water quality resulted in experts publishing a scientific paper in 2018, demonstrating how isotope methods could be effectively employed to evaluate contamination by fluids and gas leakage during fracking operations.

10. The Agency held a Technical Meeting on Nitrogen and Isotopes in Atmospheric Waters in September 2017 to examine the current knowledge and gaps pertaining to nitrogenous compounds in the atmosphere, practices for monitoring them, and their impact on freshwater resources and aquatic systems in comparison to other terrestrial nitrogen sources of pollution such as fertilizers, human waste and industrial discharges. During the meeting, experts from 11 Member States explored how isotopes could be used to understand natural atmospheric nitrogen deposition and to develop more effective policies aimed at preventing the degradation of surface water and groundwater sources.

11. Mining uses extensive water resources in processing ore, and water quality issues often arise because of groundwater and surface water entering mine pits and the discharge of acid and metals. The role of isotope hydrology in addressing environmental impacts of mining was the topic of the Technical Meeting on Development of Guidelines for the Integrated Use of Hydrological, Geophysical and Isotope Tools in Mining Operations held in June 2018. Experts from 11 Member States reviewed developments in the use of geochemical and isotope tools for mine water source identification and characterization, mine water management, contaminant assessment, mine restoration and management of abandoned mines, as well as the use of tracers. Participants highlighted the need to expand the use of geochemical and isotope tools in characterizing sources, processes, pathways and environmental factors to enhance hydrogeological models in mining areas.

12. The Agency held a Technical Meeting on Advanced Analytical Methods for Stable Isotopes of Oxygen and Nitrogen in Water and Nitrogenous Compounds in 2018 to review recent developments in isotopic analytical methods commonly used for different applications in environmental sciences, such as nitrogen pollution in surface waters and groundwaters. Experts from seven Member States explored new and rapid methods for isotope analysis that can be used to facilitate access to a more routine and low-cost analysis of nitrogen isotopes for Member States that currently do not have the capability to carry out nutrient isotope analysis. The experts recommended ways to expand the use of nitrate isotopes for pollution studies and recommended an international intercomparison exercise of nitrate isotopes to ensure the readiness of laboratories.

B.2. Expanding Access to Isotope Techniques and Capacity Building

13. Generic and specialized training courses, technical workshops and development of e-learning materials were offered to build Member State capacity and expertise in isotope hydrology. Three interregional training courses were held in 2017–2018 with 41 participants from 39 Member States. The training focused on the use of stable isotopes and radioisotopes, including an isotope-enabled water balance model for estimating water fluxes at the basin and sub-basin scales. A regional project completed in 2018, carried out under the African Regional Co-operative Agreement for Research, Development and Training Related to Nuclear Science and Technology, built capacity and developed human resources in 17 Member States in the use of isotope hydrology techniques in water management. Teaching modules on isotope hydrology tools and methods were updated to provide basic knowledge for integrating isotope hydrology tools as part of water resources assessment. These modules will be incorporated into university curricula in the participating Member States, including at the three regional designated centres in Egypt, Morocco and Tunisia.

14. To develop capacity for conducting independent isotopic hydrology analyses, during the reporting period, the Agency conducted two training courses on analysis of low levels of environmental tritium and four training courses on stable isotope analyses by laser absorption spectroscopy. In total, 51 water experts and technicians from 43 Member States benefited from the hands-on analytical training courses.

15. Eight isotope hydrology laboratories were equipped with or upgraded their laser spectrometry analysers in 2018–2019 through the Agency's technical cooperation programme. Since the laser technology for stable isotope analyses became available ten years ago, a total of 70 laboratories in 57 Member States have benefitted from the Agency's support to acquire laser spectroscopy instruments used to measure stable oxygen and hydrogen isotopes in their hydrological samples.

16. The Agency through the technical cooperation programme provided six tritium enrichment units (TEUs) developed by the Agency to six Member States during the reporting period. The Agency continues to develop new low cost, easy-to-operate TEUs based on permeable electrolytic membrane technologies, with deployment of new units expected at the end of the 2019–2020 biennium. The TEUs are being used to conduct more precise assessments of groundwater replenishment rates and conduct groundwater vulnerability mapping.

17. As Member States increase their capacity in tritium analysis for groundwater and surface water age dating, accurate and precise measurements remain a challenge for many laboratories. In 2018, the Agency conducted a worldwide Tritium Intercomparison (TRIC) test to assess the proficiency of radioisotope laboratories in hydrology. Over 90 laboratories from 50 Member States participated in the TRIC test. All laboratories received performance reports to identify and remediate performance deficiencies.

18. The Agency published the results of the Water Isotope Interlaboratory Comparison in 2018, involving analysis of stable isotopes of hydrogen and oxygen in test samples. A record number of 235 laboratories worldwide participated in the test. The results showed that approximately 75% of the laboratories produced reliable isotope data suitable for use in water resource investigations; however, around 25% underperformed owing to systemic errors, mistakes and poorly performing instrumentation. Several strategies to improve and correct analytical problems were recommended, such as the use of new data evaluation strategies and screening runs for contamination, as well as the inclusion of additional control standards.

19. The Agency published a new Tritium Information Management System (TRIMS) software platform in 2018 to support laboratories. The software is available online and is cost-free to tritium laboratories in Member States. TRIMS helps laboratories to manage and monitor the precision and accuracy of low level tritium measurements for groundwater age dating purposes. Three training courses for TRIMS software adoption and implementation were held from 2017 to 2019, where 35 laboratory technicians and analysts were trained, representing 31 Member States.

20. The Agency upgraded its Isotope Hydrology Laboratory with the installation of a new noble gas isotope ratio mass spectrometer and gas extraction system in 2018, expanding its capacity to provide analytical services to Member States for groundwater age dating using noble gas isotopes. The new equipment will help to meet the increasing demand for noble gas age dating for technical cooperation and coordinated research projects.

21. Increasing concentrations of nutrients in rivers, lakes, groundwater and estuaries cause negative effects on water and ecosystems, such as eutrophication and hypoxic zones in coastal oceans, often leading to undrinkable water. The use of nitrogen and oxygen isotope fingerprinting of nitrate is critical to allow isotope hydrologists to identify and distinguish sources of nitrate in aquatic systems and to quantify natural remediation processes like denitrification. The Agency completed laboratory trials with a new laser-based system and sample preparation procedure for analysing the stable isotopes nitrogen-15

and oxygen-18 in nutrient contaminants such as nitrates, a common pollutant in surface water and groundwater. The new system provides Member States with a lower cost analytical option for evaluating nitrate pollution of water sources and is being used to train counterparts.

B.3. Improving Understanding of the Water Cycle and Climate Change

22. The Agency significantly strengthened the operation of the IAEA/World Meteorological Organization Global Network of Isotopes in Precipitation (GNIP) in the reporting cycle by establishing 40 additional isotope monitoring sites, in collaboration with national institutions. The Agency supported the establishment of national precipitation isotopic observation networks, and sites in three new Member States were added. The Agency developed and tested new isotopic rain samplers that are being distributed to partners in Member States. The GNIP network has approximately 400 active stations in 91 Member States, and the database has over 130 000 monthly stable isotope or tritium data entries and time series spanning up to 60 years. These important isotope data sets and accompanying maps are used by scientists for an increasingly diverse range of purposes, including climate modelling, regional and global hydrological studies, ecohydrology and food authenticity.

23. In 2018, the Agency completed a coordinated research project that focused on improving the understanding of the hydrology of large river basins using geochemical and isotope parameters to constrain and model water, nutrient and sediment dynamics in large river basins. Large rivers are an important source of fresh water for drinking, agricultural and industrial supplies, fisheries, transportation and energy production. Human impacts on large watersheds, including intensive agriculture, discharge of wastewater, impoundments, irrigation and damming have profound effects on river water balance, biogeochemistry and sediment transport. A four-year coordinated research project, involving participants from 17 Member States, contributed to strengthening the Agency's Global Network of Isotopes in Rivers programme by improving understanding of the relationship between hydrological and biogeochemical processes in large river basins, thus contributing to achieving SDG 6.6 on restoring water related ecosystems, including mountains, forests, wetland, rivers, aquifers and lakes.

24. Climate change adaptation is informed by scientific knowledge and technology; through its water resources management activities, the Agency seeks to advance both. The Agency completed a coordinated research project entitled 'Stable Isotopes in Precipitation and Paleoclimatic Archives in Tropical Areas to Improve Regional Hydrological and Climatic Impact Models'. Participants from 13 Member States used isotope technology to collect precipitation isotope data, either daily or on an event basis. The data were then compared with isotope data obtained from various palaeoclimate archives, and the results were used to improve predictive regional and global climate and water balance models.

Renovation of the Agency's Nuclear Applications Laboratories at Seibersdorf

A. Background

1. During the 56th regular session of the General Conference in September 2012, the Director General called for an initiative to modernize and renovate the eight laboratories of the Department of Nuclear Sciences and Applications in Seibersdorf to enable them to meet the growing and evolving needs of Member States. The General Conference supported the initiative of the Director General in resolution GC(56)/RES/12.A.5., and the Renovation of the Nuclear Applications Laboratories (ReNuAL) project was officially launched on 1 January 2014. The strategy for the project was issued in May 2014 in document GOV/INF/2014/11 and Corr.1.

2. ReNuAL Plus (ReNuAL+) was delineated in an addendum to the strategy that was issued in September 2014 (document GOV/INF/2014/11/Add.1) to provide for improvements required by the laboratories that could not be accommodated within scope of the ReNuAL project. In February 2017, the Secretariat issued document GOV/INF/2017/1, *Renovation of the Nuclear Applications Laboratories (ReNuAL) Project*, which updated Member States on the status of ReNuAL and ReNuAL+ and provided details on the implementation of ReNuAL, the scoping and costing of ReNuAL+, and efforts on resource mobilization.

3. The ReNuAL and ReNuAL+ projects are delivering new laboratory buildings to house four of the eight nuclear applications laboratories in Seibersdorf and have provided a new linear accelerator facility for the Dosimetry Laboratory. The four remaining laboratories will benefit from expanded space and enhancements to core infrastructure in the existing buildings once other laboratories currently sharing those facilities move into their new space. The successful conclusion of these projects will enable the nuclear applications laboratories to respond to growing and evolving Member State needs and assist their efforts to achieve the Sustainable Development Goals through the peaceful application of nuclear science and technology in the areas of food and agriculture, human health, the environment, and the development and use of nuclear scientific instrumentation.

4. The General Conference, in resolution GC(62)/RES/9.A.6, requested the Director General to report on the progress made in the implementation of this resolution to the General Conference at its 63rd regular session.

B. Progress since the 62nd Regular Session of the General Conference

B.1. Implementation Status

5. The construction of laboratory buildings has made steady progress since it commenced in July 2016, with the ReNuAL elements fully completed and the ReNuAL+ elements well under way. Major construction for the new Flexible Modular Laboratory (FML) building was completed in November 2018, and the building was inaugurated during the IAEA Ministerial Conference on Nuclear Science and Technology: Addressing Current and Emerging Development Challenges, held

28-30 November 2018. The fit-out of the FML is ongoing and will continue into the first quarter of 2020.

6. The new energy centre is operational. A cogeneration feature will be incorporated into the energy centre by early 2020 reducing energy consumption and emissions. Considering the sensitivity of insect colonies to new environments, an orderly move into the new Insect Pest Control Laboratory (IPCL) commenced following the availability of heating and cooling from the new energy centre and in accordance with a detailed transition plan and is expected to be completed in early 2020.

7. Construction and fit-out of the new bunker and control room for the Dosimetry Laboratory to house a medical linear accelerator was completed in the first quarter of 2019. An event to mark the entry into operation of the new linear accelerator facility took place on 6 June 2019.

B.2. Financial Status and Resource Mobilization

B.2.1. Financial Status

8. In 2019, the total target for funding of ReNuAL and ReNuAL+ was adjusted from €57 million to €57.8 million to align the planned to actual and projected expenditure. This reflected an adjustment of ReNuAL project funding from €31 million to €31.6 million, and an adjustment of the ReNuAL+ target budget from €26 million to €26.2 million. Full funding of the ReNuAL project's adjusted €31.6 million budget was achieved in September 2016. It comprises €0.6 million from the Operational Regular Budget, €10.3 million from the Major Capital Investment Fund (MCIF) and €20.7 million of extrabudgetary funding, excluding funding related to enabling activities.

9. Over €36 million in extrabudgetary funds has been raised for ReNuAL and ReNuAL+ to date, with financial and in-kind contributions received from 38 Member States and additional financial and in-kind support received from non-traditional donors. Once all new pledged contributions are received and upon approval of the 2020–2021 MCIF budget request for ReNuAL+, the remaining extrabudgetary resource requirement to achieve full funding of the combined ReNuAL/ReNuAL+ project budget of €57.8 million would be €2.6 million.

B.2.2. Funding Priorities

10. The funding projected to complete all new facilities currently undergoing fit-out has been mobilized. The next objective will be to obtain the remaining €2.6 million in extrabudgetary funds required to complete the final element of the ReNuAL+ project: the targeted enhancement, including necessary upgrades to core infrastructure, of the facility to be used by the four laboratories (Terrestrial Environment Laboratory, the Plant Breeding and Genetics Laboratory, the Nuclear Science and Instrumentation Laboratory, and the Dosimetry Laboratory) that will remain in the existing buildings.

B.2.3. Resource Mobilization Strategy

11. The Secretariat has continued to pursue an element-specific resource mobilization strategy that seeks resources from Member States and non-traditional donors based on existing funding requirements. In support of this strategy, new and targeted resource mobilization products have been developed for individual elements of ReNuAL+, including donor packages, that provide comprehensive information on the remaining elements of the project and their funding requirements.

12. Laboratory tours continue to play an essential role in fundraising efforts; the nuclear applications laboratories hosted more than 100 delegations with over 1000 participants, nearly double the figures from the previous year. The Secretariat continues to publish periodic news briefs and produce videos

that report on the status of the project and promote awareness of its requirements. Special events organized by the Secretariat, including the November 2018 inauguration of the FML, the June 2019 linear accelerator opening event, and side events at the General Conference and Ministerial Conference, provide valuable additional support to resource mobilization efforts. A donor wall displaying a 'national brick' for each Member State contributor to the project was unveiled on the opening day of the 61st regular session of the General Conference. Since then, representatives of all first-time Member State contributors are invited to symbolically place their national brick in the donor wall during special events. Five additional Member States have announced first-time pledges to the project since the 62nd regular session of the General Conference. The ReNuAL/ReNuAL+ web pages are regularly updated with new information.

B.2.4. Resource Mobilization Efforts with Member States

13. The Secretariat has continued to engage in bilateral discussions with a wide number of Member States to support fundraising, resulting in 38 Member States contributing towards the ReNuAL and ReNuAL+ projects to date. The goal of these activities is to maximize both the amount of funds raised and the number of contributing Member States. In this context, the Friends of ReNuAL, an informal group open to all Member States and co-chaired by Germany and South Africa, has continued to play an important role.

14. Members of the Friends group, which last met in February 2019, have been significant bilateral contributors to the project, and the group remains an important vehicle for maintaining and increasing awareness of ReNuAL/ReNuAL+ among Member States and for generating Member State support for the project.

B.2.5. Resource Mobilization Efforts with Non-Traditional Donors

15. The Secretariat has continued its efforts to attract support from non-traditional donors, with the primary focus on equipment manufacturers to help meet the equipment needs of the laboratories. Notable successes to date include a partnership agreement which enabled the use of the Dosimetry Laboratory's new linear accelerator and a memorandum of cooperation for a donation through the Peaceful Uses Initiative of a liquid chromatograph for use in activities to support Member States in research on food safety and training.

16. Since the 62nd regular session of the General Conference, the Secretariat has continued to pursue possibilities with the private sector to expand on the potential for partnership opportunities. Given large remaining equipment requirements and based on the successful partnerships already achieved, the Secretariat began an initiative to generate interest in private sector partnerships by listing equipment needs under the ReNuAL/ReNuAL+ initiative on the United Nations Global Marketplace (UNGM). The equipment needs were posted twice over the past one and a half years, with the second posting having closed in April 2019. Together, the two UNGM listings have generated four offers for partnerships, currently in various stages of internal processing, and one additional expression of interest in an equipment loan, pending clarification of details. Such efforts are aimed at obtaining the required equipment for the nuclear applications laboratories with the least amount of resources expended by the Secretariat.

17. Efforts are also ongoing to engage with relevant foundations on possible support for the ReNuAL/ReNuAL+ initiative as well as related research activities.

C. Next Steps

18. With all the new facilities on track to become operational by the 2nd quarter of 2020, the targeted enhancement of laboratories that will remain in the existing buildings will be the focus. This "enhancement" element of the ReNuAL+ project can only begin when three of the laboratories relocate to the new buildings. The upgrades to core building and laboratory infrastructure are planned to be implemented in a phased approach. The Secretariat is currently developing a strategy to optimize the effective use of funding available in the frame of the ReNuAL+ project for the targeted enhancement of the core infrastructure in the four remaining laboratories. This includes assessing existing building and laboratory infrastructure to identify required upgrades, determining the scope of lab enhancement that would address the needs of Member States, and setting priorities.

19. Resource mobilization efforts will focus on raising by early 2020 the €2.6 million in extrabudgetary funds still needed to reach the overall ReNuAL/ ReNuAL+ target budget and implement the enhancement element of the project, and on further expanding partnerships to meet critical equipment needs. In parallel, the Secretariat will explore extrabudgetary avenues to fund required lab enhancements and equipment beyond the ReNuAL+ project budget.

General, Communication and Agency Cooperation with Other Organizations, and Operating Nuclear Power Plants

A. Background

1. The General Conference, at its 62nd regular session, noted that the Agency's objectives as outlined in Article II of the Statute include "to accelerate and enlarge the contribution of atomic energy to peace, health and prosperity throughout the world" and that its statutory functions include "to encourage and assist research on, and practical application of, atomic energy for peaceful uses", "to foster the exchange of scientific and technical information" and "to encourage the exchange and training of scientists and experts in the field of peaceful uses of atomic energy", including the production of electric power, with due consideration for the needs of developing countries.

2. The General Conference recalled that launching new, as well as maintaining and expanding existing nuclear power programmes, requires the development, implementation and continuous improvement of appropriate infrastructure to ensure the safe, secure, efficient and sustainable use of nuclear power, and implementation of the highest standards of nuclear safety, taking into account relevant Agency standards and guidance and relevant international instruments, as well as a strong and long-term commitment of national authorities to creating and maintaining this infrastructure. It also recalled the growing interest in a number of Member States in next generation reactor designs and that the development of innovative fast reactors, closed fuel cycles and alternative fuel cycles (e.g. thorium, recycled uranium and plutonium) may be regarded as steps towards future sustainable and safe nuclear power that can extend the lifetime of nuclear fuel resources and be an effective solution for the management of radioactive waste and spent fuel.

3. The General Conference noted the important role that the Agency plays in assisting Member States in the establishment, preservation and enhancement of nuclear knowledge and in implementing effective knowledge management programmes at all levels and confirmed the important role of nuclear knowledge management programmes in strengthening nuclear education, training and networking capabilities. It also drew attention to the long-term benefits of implementing effective and targeted capacity building activities to support national plans to implement new or expanding nuclear power programmes, especially in developing countries.

4. The General Conference also noted the increasing number of requests from Member States for advice on the exploration of uranium resources and on mining and milling for safe, secure and effective uranium production while minimizing the environmental impact. It also noted the importance of identifying undiscovered uranium resources or secondary uranium resources, and underlined the necessity to support uranium mine remediation as part of a sustainable nuclear programme.

5. The General Conference emphasized the need to ensure effective management of spent fuel, which, for some Member States, includes reprocessing and recycling, as well as of radioactive waste, including its transport, decommissioning and remediation, in a safe, secure and sustainable manner, and

confirmed the important role of science and technology in continuously addressing these challenges, particularly through innovations.

6. The General Conference also recognized that the growing number of shutdown reactors is increasing the need to develop adequate methods and techniques for decommissioning, environmental remediation and managing large volumes of radioactive waste, including contaminated water, resulting from the decommissioning of facilities, legacy practices and radiological or nuclear accidents, and to share lessons learned in that regard.

7. The General Conference recognized the role that safe, secure, reliably operated and well-utilized research reactors can play in national, regional and international nuclear science and technology programmes, including support of research and development (R&D) in the fields of neutron science, fuel and material testing, and education and training. It also commended the Secretariat for the continued support provided for the implementation and promotion of the IAEA-designated International Centre based on Research Reactor (ICERR) scheme and acknowledged the establishment of the ICERR-Net cooperation network.

8. The General Conference welcomed the Secretariat's contributions to international discussions addressing global climate change, such as at the Conferences of the Parties to the United Nations Framework Convention on Climate Change (COP), took note of the participation of the Agency in the Intergovernmental Panel on Climate Change (IPCC), and commended the proactive approach of the Secretariat to identifying relevant areas of activities among the 17 Sustainable Development Goals adopted by the United Nations in 2015.

9. The General Conference emphasized the essential role the Agency plays as an international forum for the exchange of information and experience on nuclear power plant (NPP) operation and for the continuous improvement of this exchange among interested Member States. It also noted the growing importance of long term operation of existing NPPs and underlined the need to share relevant lessons learned from long term operations, including safety aspects, for the benefit of new programmes that may have NPPs capable of operating beyond 60 years.

10. The General Conference also emphasized the importance of adequate human resources for ensuring, inter alia, the safe and secure operation and the effective regulation of a nuclear power programme, and noted the increasing need, worldwide, for trained and qualified personnel to implement nuclear energy-related activities during construction, commissioning and operation. These activities include long term operation, performance improvements, effective management of radioactive waste and spent fuel, and decommissioning, with a focus on the optimization of training programmes for operating organizations.

11. The General Conference requested the Director General to report to the Board of Governors, as appropriate, and to the General Conference at its 63rd regular session on developments relevant to resolutions GC(62)/RES/9.B. This Annex highlights a number of activities undertaken by the Agency as requested in the resolution GC(62)/RES/9.B and not covered in Annexes 6 and 7.

B. Progress Made Since the 62nd Regular Session of the General Conference

B.1. General

B.1.1. Introduction

12. To assist Member States in fostering international cooperation and in disseminating well-balanced information on nuclear energy, the International Nuclear Information System (INIS) repository offers access to 4.2 million records, with direct links to over 1.7 million full text documents. Over 100 000 records are added each year, and there were 3.2 million page views by 1.1 million unique visitors in 2018. The Agency continued to maintain relevant databases, such as the Power Reactor Information System and country nuclear power profiles, and to issue related periodic publications, including the latest edition of *Country Nuclear Power Profiles* in September 2018 and *Nuclear Power Reactors in the World* (Reference Data Series No. 2) in May 2019.

13. The Agency continued to support approximately 30 interested Member States in building their national nuclear power infrastructure when embarking on new nuclear power programmes through the organization of relevant Technical Meetings, workshops and conferences, notably the annual Technical Meeting on Topical Issues in the Development of Nuclear Power Infrastructure, held in January-February 2019, with the attendance of 82 experts from 39 Member States and 2 international organizations. Moreover, Agency support is provided through Integrated Nuclear Infrastructure Review (INIR) missions to review the status of nuclear power infrastructure development in Member States. Based on INIR mission results, Member State-specific Integrated Work Plans (IWPs) and Country Nuclear Infrastructure Profiles (CNIPs) are developed or updated by cross-Departmental core teams in conjunction with the relevant Member State. The Agency has also developed and published an interactive e-learning series to support Member States in planning and implementing their nuclear infrastructure development plans for new nuclear power programmes. The e-learning modules explain the Milestones approach and various aspects and challenges related to nuclear power infrastructure development. A total of 18 modules have been published on the Agency's website, and further modules are planned to be developed and published to complete the e-learning series. The latest two new modules added to the series are entitled 'Legal Framework' and 'Industrial Involvement'. In December 2018, the Agency also released an e-learning module on boiling water reactor technology, aimed at advancing capacity building in newcomer countries.

14. The Agency continued to support Member States in the area of nuclear knowledge management by conducting Knowledge Management Assist Visit (KMAV) missions, to Mongolia (Nuclear Research Center, University of Mongolia, Ulaanbaatar) in December 2018, with 35 participants from 18 organizations; to Brazil (Electronuclear, Angra), with 38 participants from 3 organizations; to Pakistan (Pakistan Atomic Energy Commission, Islamabad) in April 2019, with 53 participants from 12 organizations; and to Egypt Nuclear Power Programme Department of the Egyptian Government in June 2019 in Cairo, with 30 participants from 5 organizations. The Technical Meeting to Share Experience on Knowledge Management Assist Visit (KMAV) Missions for Nuclear Organizations was held in March 2019 at the Agency's Headquarters in Vienna, with 31 participants from 19 Member States. The Annual Meeting of the International Nuclear Management Academy (INMA) took place in Vienna in November 2018, with 26 participants from 13 Member States. In addition, a consultancy meeting of the INMA Advisory Board took place in Vienna in June 2019, with 8 participants from 6 Member States. INMA endorsement mission reports were completed for the University of Tokyo, Japan, North-West University, South Africa, the University of the Witwatersrand, South Africa and Texas A&M University, United States of America. An Education Capability Assessment Planning

mission was conducted in Nigeria in December 2018, with 25 participants from 16 national educational institutions and representatives of the Nigeria Atomic Energy Commission. A Human Resources Knowledge Development mission took place in Japan in March 2019, with nine participants from six Member States. The Agency also organized a Technical Meeting on Design Knowledge Base Preservation: Issues and Challenges for Nuclear Waste Management Organizations in May 2019, attended by 17 participants from 10 Member States and 2 international organizations.

15. The Agency also strengthened its efforts in the area of distance learning by further promoting the use of the Agency-wide learning management system, the Cyber Learning Platform for Network Education and Training (CLP4NET). More than 640 e-learning modules are available on CLP4NET, covering a broad range of topics, and efforts are being made to continue to improve the learning experience offered by the platform. The Agency's International Decommissioning Network (IDN) provides a Wiki-based resource for the sharing of information on all aspects of decommissioning, including information on technology and case studies. In addition, a new practice has been introduced in INIS of collecting and offering to Member States access to various papers and presentations from Agency meetings. The Agency encourages Member States to make use of this system either by consulting the available documents or by submitting their own documents for long-term preservation.

16. The Agency has continued support to Member States, in particular developing countries, in sending participants to Nuclear Energy Management (NEM) Schools. A joint Agency–Russian Federation NEM School was held in St Petersburg, Russian Federation, in September 2018, with 23 participants from 10 Member States. A second of these Schools was held in Sochi, Russian Federation in April 2019, with 39 participants from 17 Member States. A joint Agency–International Centre for Theoretical Physics (ICTP) NEM School was held in Trieste, Italy in October 2018 and was attended by 35 participants from 3 Member States. An NEM School was held for the Africa region in South Africa in November 2018, attended by 23 participants from 13 Member States, and an Agency Nuclear Knowledge Management School was held in Costa Rica in December 2018, with 22 participants from 9 Member States. The Korea-IAEA NKM School was held in Daejon, Republic of Korea in June 2019 with 22 participants from 13 Member States.

17. To assist Member States in planning and assessing the economic, socio-economic and environmental impact of their energy programmes, developing their national infrastructures for nuclear power and defining their long-term strategies for sustainable nuclear energy, the Agency published, jointly with the Nuclear Energy Agency of the Organisation for Economic Co-operation and Development (OECD/NEA), the report *Measuring Employment Generated by the Nuclear Power Sector* in 2018. The Agency also organized a Technical Meeting on Measuring the Macroeconomic Impacts of a Nuclear Power Plant Programme in June 2019 at the Agency's Headquarters in Vienna, which was attended by 24 participants from 14 Member States and 3 international organizations. A Technical Meeting on the IAEA's Climate, Land, Energy and Water Framework, with 23 participants from 14 Member States, 3 international organizations and the KTH Royal Institute of Technology in Stockholm, was also held in November 2018 at the IAEA's Headquarters.

18. To assist Member States in managing suspect and counterfeit items in the nuclear industry, the Agency issued the Nuclear Energy Series publication *Managing Counterfeit and Fraudulent Items in the Nuclear Industry* (IAEA Nuclear Energy Series NP-T-3.26) in January 2019 and is organizing a pilot training course on nuclear supply chain management and procurement, from 30 September to 4 October 2019, which will address suspect and counterfeit items.

19. The mechanism for Member States' review of Nuclear Energy Series (NES) publications was launched by the Agency in September 2018 and has since been further consolidated. It enables interested Member States to contribute to the review of draft publications and broader involvement of Member States. The information is made available via the Department of Nuclear Energy's official web page.

Moreover, Technical Working Groups (TWGs) have been engaged as review committees of the Agency's publications in a more systematic way. The NES structure was revised to better reflect the topical areas on which the Agency provides guidance or methodologies to Member States. The revised structure was discussed and supported by members of the Standing Advisory Group on Nuclear Energy at its annual meeting, held in May 2019. The new structure will be enforced before the end of the year and will allow for the clear identification of those publications that are most current and those that have been superseded, in order to enhance accessibility and usability of NES publications.

20. In order to fulfil its role improving the understanding of the potential contribution of nuclear power in addressing Sustainable Development Goals (SDGs) and climate change, the Agency is organizing, in cooperation with the OECD/NEA, the International Conference on Climate Change and the Role of Nuclear Power in October 2019 at the Agency's Headquarters in Vienna. Preparatory activities for the International Conference have included two Scientific Programme Committee meetings held in October 2018 and May 2019. Several Member States and international organizations have already confirmed their participation and contribution to the Conference.

21. Through the organization of capacity building workshops for nuclear power programme senior management within the framework of the Peaceful Uses Initiative project 'Supporting the Development of Management Systems and Nuclear Safety Culture in Countries Introducing Nuclear Power Programmes', the Agency continued to assist Member States embarking on new or expanding nuclear power programmes in the development of management systems in order to enhance understanding and execution of leadership and responsibility for management systems to ensure safety, security, effectiveness and sustainability of nuclear power programmes; and in establishing an adequate organizational culture in key organizations involved in nuclear power programmes. In addition, the Agency has further expanded its support for the development of management systems in Member States introducing new nuclear power programmes through expert missions and guidance in the areas of leadership and management systems. The Agency conducted two Independent Safety Culture Assessment missions, in South Africa in August 2018 and in Thailand in March 2019; one follow-up mission was conducted, in the Netherlands in April 2019.

22. The Agency continued to assist Member States in enhancing public awareness and understanding of peaceful uses of nuclear energy through the organization of the annual Technical Meeting on Stakeholder Involvement across the Nuclear Power Plant Life Cycle, held in June 2019, with the participation of 49 experts from 29 Member States and 1 international organization, group scientific visits and a training course on stakeholder involvement within the framework of the technical cooperation (TC) interregional project. The Agency also implemented country-specific workshops on stakeholder involvement, upon request, to five Member States — Belarus, the Islamic Republic of Iran, Jordan, Morocco and Poland — during this period. Stakeholder involvement, including public information/communication, is one of the key issues of the Milestones approach and is addressed at each stage of nuclear power programme development. The Agency conducted the first webinar entitled 'Understanding Stakeholder Involvement as a Strategic Tool for a Nuclear Power Programme' in June 2019, with 93 participants. Five additional webinars will take place in the coming months on specific stakeholder involvement topics. The Agency also continued its work on updating the Nuclear Communicators' Toolbox, with the goal of launching the updated version by the end of 2019. The Agency also held a Technical Meeting on Learning from the Experiences of Local Communities on Stakeholder Involvement in Radioactive Waste Management Programmes at the Agency's Headquarters in Vienna in November 2018, with 89 participants from 22 Member States; considerations from this work are being developed as part of an IAEA publication.

23. The Agency continued its efforts to enhance Member States' understanding of funding requirements for nuclear power infrastructure development and potential approaches to financing nuclear power programmes through the publication of a guidance document on managing financial risks

associated with nuclear new builds and through the development of a document on resource requirements for infrastructure development. Additionally, the Agency organized a Technical Meeting on Funding for Waste Management and Decommissioning in July 2018, with the attendance of 34 participants from 21 Member States, as well as an interregional training course on funding and economic aspects of nuclear power programmes, hosted by France in October 2018, with the attendance of 19 participants from 19 Member States. National workshops under the respective IWPs to support individual Member States in reviewing financing options for a nuclear power programme have also been provided. The Agency also continued the development of a report on costing methods and funding schemes for radioactive waste disposal programmes and a TECDOC on financing nuclear investments, both expected to be published by the end of the year.

24. To analyse the technical and economic cost drivers for economic sustainability of nuclear power and to determine the value of nuclear power in the energy mix considering environmental conditions, the Agency organized a regional workshop on techno-economic feasibility studies in the uranium production cycle, which was held in Namibia in November 2018 and attended by 29 participants from 16 Member States. This workshop aimed to strengthen sustainable uranium production cycle activities in Africa through improved techno-economic feasibility studies and assessments. In addition, a Technical Meeting on Uranium Production Feasibility Studies: Processing, Economic, Social and Environmental Aspects was held in Vienna in January 2019, at which the 18 participants from 15 Member States discussed the content of a forthcoming TECDOC that will focus on uranium production feasibility studies, including exploration, mining, processing, economic, social and environmental aspects. The Agency is also developing a TECDOC on the topic of cost estimation methodologies for spent fuel management, to define the specifications for developing a calculation tool which will be revised during a Technical Meeting to be held on the topic in November 2019. In March 2019, the Agency also conducted a Technical Meeting on Costing Approaches for Nuclear Technology Developers attended by 65 participants from 30 Member States and one international organization.

25. The annual publication *Energy, Electricity and Nuclear Power Estimates for the Period up to 2050* (Reference Data Series No. 1) (RDS-1) was substantially improved by including more information and creating separate sections addressing both global development and region-specific trends. Since 2017, the publication has adopted United Nations regional definitions. Based on recommendations from Member States, the figures were introduced alongside explanatory text that explicitly addresses new additions versus retirements of nuclear power plants.

26. To strengthen long-term research programmes designed to learn about severe accidents and related decommissioning activities, the Agency organized the second Research Coordination Meeting (RCM) of the coordinated research project (CRP) entitled ‘Management of Severely Damaged Spent Fuel and Corium’ in November 2018 in Fukushima, Japan. The meeting was attended by 7 CRP partners from 5 Member States, who gave updates on their research projects, agreed on the structure of the CRP’s final report and discussed whether there were any outstanding questions in relation to the Fukushima Daiichi NPP Unit 1 decommissioning work that could be answered. The Agency also completed the International Project on Managing the Decommissioning and Remediation of Damaged Nuclear Facilities. The project report is being finalized and is expected to be published in 2020. Interaction with Japan’s Ministry of the Environment continued on the review of the progress of the remediation of the off-site areas affected by the Fukushima Daiichi accident. An Agency meeting is planned to be held in Tokyo in July 2019 to summarize the report on the remediation progress.

27. In September 2018, the Agency held a Technical Meeting on Hydrogen Management in Severe Accidents in Vienna, with 29 participants from 21 Member States and 1 international organization. In October 2018, the 4th Training Workshop on the Development of Severe Accident Management Guidelines Using the IAEA’s SAMG-D Toolkit was held at the Agency’s Headquarters in Vienna and

attended by 27 participants from 20 Member States. The Agency is also planning to hold the first RCM to launch a new CRP entitled 'Advancing the State-of-Practice in Uncertainty and Sensitivity Methodologies for Severe Accident Analysis in Water Cooled Reactors' in October 2019. In June 2019, a TECDOC entitled *Status and Evaluation of Severe Accident Simulation Codes for Water Cooled Reactors* (IAEA-TECDOC-1872) was issued.

28. The Agency continued to cooperate with national and international industrial standardization organizations, such as the International Organization for Standardization (ISO) and the American Society of Mechanical Engineers to ensure that the development or revision of relevant standards take the perspectives of the Agency's Member States into consideration. The International Radioactive Waste Technical Committee (WATEC) also included representatives from the ISO, the European Technical Safety Organisations Network and the European Demolition Association.

B.1.2. Nuclear Fuel Cycle and Waste Management

29. To assist Member States interested in uranium production to develop and maintain sustainable activities through appropriate technology, infrastructure and stakeholder involvement, and to foster the development of skilled human resources, the Agency issued a TECDOC entitled *Unconformity-related Uranium Deposits* (IAEA-TECDOC-1857) in November 2018, which provides a description of existing and emerging technologies to effectively integrate geological, geophysical and geochemical data to recognize the footprint of uranium deposits and the key vectors of uranium mineralization. In December 2018, the biennial joint publication of the OECD/NEA and the Agency, *Uranium 2018: Resources, Production and Demand*, also known as the 'Red Book', was issued. It provides the most recent review of world uranium market fundamentals and presents a statistical profile of the world uranium industry, including data from 41 uranium-producing and uranium-consuming countries. Also, in December 2018, the Agency issued *Quantitative and Spatial Evaluations of Undiscovered Uranium Resources* (IAEA-TECDOC-1861), which provides an overview of uranium production cycle aspects, including evaluations of the global uranium supply/demand situation.

30. In October, the Agency organized an Interregional Workshop on Aspects of Effective Safety Practices and the Implementation of a Conventional Safety Programme in Uranium Mines and Mills in Adelaide, Australia. The workshop provided the 17 participants from 15 Member States with field experience and an opportunity to exchange information on good practice in industrial mine safety programmes, an essential complement to radiation protection at uranium mines and mills. A NES report on remediation of groundwater affected by operations in the scope of uranium mining sites has been approved for publication. The report considers a life cycle perspective to avoid the need for future extensive remediation works.

31. In pursuing activities to enhance Member State capabilities in modelling, predicting and improving the understanding of the behaviour of current and advanced nuclear fuel under accident conditions, the Agency held a Technical Meeting on Modelling of Fuel Behaviour in Design Basis Accidents and Design Extension Conditions in Shenzhen, China, in May 2019 attended by 31 experts from 14 Member States. The participants endorsed the proposal to initiate a CRP on Testing and Simulation of Advanced Technology Fuels (ATF-TS). In November 2018, the third RCM of the CRP entitled 'Analysis of Options and Experimental Examination of Fuels for Water Cooled Reactors with Increased Accident Tolerance (ACTOF)' was held. The meeting was attended by 17 CRP partners and 5 observers from 12 Member States, who presented their individual status reports on the work undertaken since the last RCM in the area of supporting options for the development of nuclear fuel with an improved tolerance of severe accident conditions. Participants also discussed and agreed on actions and a work plan, both individual and joint, for the finalization of a TECDOC compiling the results of the project, including topics such as round robin tests, benchmark calculations of iron-chromium-aluminium cladding and severe accident modelling. In September 2018, the Agency also

issued *Accelerator Simulation and Theoretical Modelling of Radiation Effects in Structural Materials* (IAEA Nuclear Energy Series No. NF-T-2.2), which summarizes the findings and conclusions of the related CRP aimed at supporting Member States in the development of advanced radiation-resistant structural materials for implementation in innovative nuclear systems.

32. To assist interested Member States in analysing the technical challenges that may hinder the sustainable operation of nuclear fuel cycle facilities, the Agency held a Technical Meeting on Nuclear Fuel Cycle Facilities in Vienna in October 2018, gathering 10 experts from 10 Member States, who presented and discussed country reports on nuclear fuel cycle facilities and their general trends and projections; information system management and ageing issues were also discussed during the meeting. The results of the research conducted since the first RCM were discussed by seven partners of the CRP entitled 'Ageing Management Programmes for Spent Fuel Dry Storage Systems', who gathered at an RCM held in Chicago, United States of America, from 29 April to 3 May 2019. The 17 participants provided an overview of their research results to date and set out the actions and a work plan, both individual and joint, for a final TECDOC containing the outcomes of the project.

33. To analyse the potential technical challenges that may affect the transportability of spent fuel after long term storage, the Agency issued *Behaviour of Spent Power Reactor Fuel During Storage* (IAEA-TECDOC-1862) in February 2019. The publication compiles the main results of successive CRPs on spent fuel performance and the behaviour of spent fuel assemblies in storage since the 1980s. In March 2019, the Agency issued a publication entitled *Storing Spent Fuel until Transport to Reprocessing or Disposal* (IAEA Nuclear Energy Series No. NF-T-3.3), which identifies issues and challenges relevant to the development and implementation of options, policies, strategies and programmes for ensuring the safe, secure and effective storage of spent fuel until transport for reprocessing or disposal. A Technical Meeting is planned to be held in September 2019 for the development of a TECDOC on transport of higher burnup uranium oxide and mixed oxide spent fuel.

34. Regarding the IAEA Low Enriched Uranium (LEU) Bank in Kazakhstan, the Agency signed two supply contracts to purchase LEU with Kazatomprom of Kazakhstan and Orano of France. The Agency also signed a transport contract under the Transit Agreement with the Authorized Organization from the Russian Federation and a transport contract under the Facility Operator Agreement with the appointed Kazakhstan railway company. The Agency expects that LEU will be delivered to the IAEA LEU Storage Facility before the end of 2019, and the IAEA LEU Bank will be established and become operational.

35. The Agency presented its work on the development of multilateral approaches to the nuclear fuel cycle at a meeting of the European Repository Development Organisation (ERDO) in Paris in December 2018. ERDO is a multinational working group whose members are nominated by the appropriate Government-level organizations and was established to study the feasibility of setting up a development organization that would implement one or more shared geological repositories in Europe. Also, in Paris in December 2018, the Agency participated in a workshop on 'Multinational Repository Financing: Challenges and Alternate Approaches' during a meeting of the Reliable Nuclear Fuel Services Working Group (RNFSWG) of the International Framework for Nuclear Energy Cooperation (IFNEC).

36. To assist Member States, including those embarking on nuclear power programmes, to develop and implement adequate disposal programmes, the Agency convened a Technical Meeting on Characterization Methods and Technologies to Meet Waste Acceptance Criteria in May 2019 at the Agency's Headquarters in Vienna, within the framework of the International Network of Laboratories for Nuclear Waste Characterization. The meeting was attended by 42 participants from 24 Member States. A Technical Meeting on the Practices and Challenges Associated with the Management of Bituminized Radioactive Waste was held in Vienna in March 2019, within the framework of the International Predisposal Network, and was attended by 23 participants from 10 Member States. Furthermore, a Technical Meeting on Disposal Options for Smaller Radioactive Waste Inventories was

organized in Vienna in May 2019, attended by 35 participants from 28 Member States, and the 2019 Symposium on the Scientific Basis of Nuclear Waste Management is planned to be held at the Agency's Headquarters in Vienna in October 2019. The Agency also presented its work in this area at the International Seminar on Innovations and Challenges in Radioactive Waste Management and Disposal, held in Mumbai, India in January 2019. An Agency publication on irradiated graphite processing approaches and a compendium on research, development and demonstration results carried out at underground research facilities are under preparation. The final report of the CRP 'Spent Fuel Performance Assessment and Research (SPAR-IV)' was drafted prior to the last RCM, which is planned to take place in October 2019.

37. To support Member States in the adoption of best practices for managing naturally occurring radioactive material (NORM) residue/wastes (including inventory determination, reuse, recycling, storage and disposal options) and to remediate NORM-contaminated sites, the Agency has been developing the Network on Environmental Management and Remediation (ENVIRONET) NORM project. The project aims to provide Member States with guidelines on policies and strategies for NORM management, calculation of NORM inventory and assessment of costs related to the management of NORM waste until its disposal. On this topic, the Agency organized a Technical Meeting on Naturally Occurring Radioactive Material in Katowice, Poland in November 2018, attended by 25 participants from 15 Member States, which took place in parallel with a European NORM Association workshop. The Technical Meeting focused on both the analysis of achievements of the ENVIRONET Working Group on NORM and the planning of further work. The Agency will also organize the first International Conference on the Management of NORM in Industry in 2020, with the aim of identifying good practices and harmonizing these practices across Member States.

38. To promote information sharing to better integrate approaches to the back end of the fuel cycle that impact retrievability, transport, storage and recycling of spent fuel, and to assist Member States, including those embarking on nuclear power programmes, to develop and implement adequate disposal programmes, the Agency organized the International Conference on the Management of Spent Fuel from Nuclear Power Reactors: Learning from the Past, Enabling the Future, in Vienna in June 2019, attended by over 250 participants and observers from approximately 45 Member States and 7 international organizations. The Agency also delivered a regional Training Workshop on the Roadmap for a Generic Deep Geological Disposal Programme in Gyeongju, Republic of Korea, in March 2019. A Technical Meeting on Design Knowledge Base Preservation: Issues and Challenges for Radioactive Waste Management Organizations, focusing on deep geological disposal projects, was organized in Vienna in May 2019, attended by 22 participants from 12 Member States and 1 international organization. In January 2019, the Agency launched a CRP entitled 'Developing a Framework for the Effective Implementation of a Borehole Disposal System' (T22002) and it is planning the first RCM of the CRP entitled 'Management of Wastes Containing Long-lived Alpha Emitters: Characterization, Processing and Storage' (T13017), to be held in Vienna in August 2019.

39. The Agency continued to work closely with the European Commission, OECD/NEA and other organizations to develop the second edition of *Status and Trends in Spent Fuel and Radioactive Waste Management* (IAEA Nuclear Energy Series No. NW-T-1.14). WATEC reviewed the document in its meeting in April 2019.

40. The Agency continued to develop guidance documents on decommissioning and action plans to support decommissioning. Among them, a collaborative project entitled 'Human Resource Development for Decommissioning of Nuclear Power Plants' was launched and the first Technical Meeting on this project will be held in July 2019. Another international collaborative project on the current global status of decommissioning projects and their future evolution was launched by the Agency in 2019, and the first Technical Meeting on this project is planned to be held in August 2019. The Agency also organized a Technical Meeting on the second phase of the Constraints to Implementing

Decommissioning and Environmental Remediation (CIDER) Project at the Agency's Headquarters in Vienna in March 2019, with 22 participants from 18 Member States. The purpose of the meeting was to assess the results and lessons learned from the activities carried out by the working groups on strategy development, on stakeholder engagement and on capacity building over the past years, and to formulate further suggestions. The Agency is also supporting an initiative known as 'SHARE', which was launched in 2019 under the auspices of the European Commission's Horizon 2020 Research and Innovation Framework Programme, in order to determine key research needs in the area of decommissioning over the next decade and beyond. Within the context of innovation, and given the growing importance of digital technologies in decommissioning, the Agency designated the Institute for Energy Technology (IFE) in Norway as a Collaborating Centre in June 2019. Regarding collaboration frameworks, the Annual Forum of the Agency's International Decommissioning Network (IDN) was hosted by the French Alternative Energies and Atomic Energy Commission in Marcoule, France, in October 2018 and attended by 43 participants from 20 Member States.

41. The Agency strengthened its activities in the remediation of legacy sites, of facilities undergoing decommissioning, of sites affected by nuclear accidents and of sites containing increased levels of radioactivity that are amenable to control. Examples of such activities include the 'LeTrench Project' (remediation of sites containing legacy waste in trenches), the Definition of Environmental Remediation End States (DERES) Project (determination of end states in remediation) and the IDN/ENVIRONET CIDER Project (to address and overcome constraints to implementation of both environmental remediation and decommissioning projects). A Technical Meeting on the Remediation of Legacy Trenches (known as 'Le Trench' project) was held in October 2018 at the Agency's Headquarters Vienna and attended by 20 participants from 14 Member States. This enabled knowledge and information sharing on the evaluation, management and remediation of sites with buried waste. The Agency also organized the annual forum of ENVIRONET in Vienna, from 30 October to 2 November 2018, which was attended by 50 participants from 26 Member States. ENVIRONET has appointed regional coordinators to facilitate the sharing of information in specific regions and address specific needs. This could lead to the establishment of regional training and educational hubs in the future. Preparation of different technical reports on a wide range of topics continued, including guidance documents on cost estimate of environmental remediation projects, use of mathematical models in environmental remediation works and use of engineered barriers in the scope of environmental remediation projects. The School of Decommissioning and Environmental Remediation concept has been further developed within a new TC interregional project framework.

42. To further promote the Integrated Review Service for Radioactive Waste and Spent Fuel Management, Decommissioning and Remediation (ARTEMIS) peer review service, the Agency convened a workshop in Vienna in March 2019, attended by 70 participants, from 40 Member States. With support from the European Commission, the Agency had also previously convened a meeting to receive and consider feedback from the international experts involved in the first ARTEMIS reviews, which took place in Vienna in November 2018, with 14 participants from 10 Member States and 1 international organization. The Agency conducted a training course for international experts undertaking forthcoming ARTEMIS missions in Vienna in January 2019, with 11 participants from 10 Member States. At the request of the Member States, the Agency completed ARTEMIS peer review missions in Luxembourg, in September 2018; in Spain, in October 2018; in Brazil, in November 2018; and in Estonia, in March 2019.

43. The Agency continued cooperation with the European Commission in order to update the Spent Fuel and Waste Information Tool (SWIFT). A Technical Meeting for this purpose is planned to be held in July 2019.

44. The Agency further strengthened its activities in support of the effective management of disused sealed radioactive sources (DSRSs) by providing support to field operations and capacity building in

the areas of characterization, dismantling and packaging for storage or transport; by developing Qualified Technical Centres for DSRS management; and by fostering cooperative efforts to further strengthen the supporting information on the borehole disposal of DSRSs, with a view to enhancing the safety and security of DSRSs in the long term. The Agency continued to support projects on the borehole disposal of DSRSs in Malaysia and in Ghana (funded by Global Affairs Canada and managed by the Division of Nuclear Security). This support included the design, development, shipping and associated training/operation of a Mobile Tool Kit Facility (MTKF), which consists of a standard sea-shipping container that has been equipped as a fully operable workshop to assess and condition lower category DSRSs (Categories 3 to 5) for storage or preparation for borehole disposal. The MTKF was shipped to Malaysia for upcoming borehole operations. The Agency made progress in the development of three publications on the borehole disposal of DSRSs, including the convening of a Technical Meeting in Vienna in December 2018, involving 29 participants from 20 Member States. The Agency progressed in the development of a document to support Member States in taking well-informed decisions about the management of their DSRS inventories. This included the development of an Agency report and trial missions in Jordan in May 2019 and Indonesia in June 2019. One Category 1 disused teletherapy source was removed from North Macedonia and shipped to an authorized recipient outside the country in February 2019, and two Category 1 DSRSs are to be removed from Albania and shipped to an authorized recipient outside the country in July 2019. Multiple statements of work were completed for high activity source removals in Cambodia, Croatia, Cyprus, Nicaragua, Nepal, Slovenia and Tunisia, to be implemented by the end of 2019. Training for Agency personnel in the operation of the model 435 Type B(U) package to be used for Category 1 and 2 source recoveries from Member States was conducted in May 2019. In addition, the Agency organized training courses in Morocco in October 2018 and April 2019 to build capacity for conditioning Category 3–5 DSRSs; the courses were attended by 23 participants from 21 Member States. Training on orphan sources was provided for the national counterparts in Guyana, in March 2019, and Jamaica, in December 2018. A Regional Training Course on Conducting Orphan Source Searches was also held in Kenya in January-February 2019, with 18 participants from 9 Member States. The Agency also organized a regional workshop in Zambia in March 2019 to build capacity for the implementation of the Code of Conduct on the Safety and Security of Radioactive Sources and the Guidance on the Management of Disused Radioactive Sources; the workshop was attended by 35 participants from 30 Member States. The Agency also conducted several expert missions to assist Member States in managing DSRSs, including in Viet Nam in September 2018, Costa Rica in November 2018, Jordan in November–December 2018, Malta in December 2018, Iceland in January 2019, Haiti in February 2019, Bahrain in February 2019 and Sudan in March 2019. Furthermore, in December 2018, the Agency organized a meeting to finalize the Terms of Reference and assessment process for establishing Qualified Technical Centres for managing DSRSs.

B.1.3. Research Reactors

45. The Agency continued to support the functioning and expansion of the ICERR scheme by facilitating networking among designated ICERRs and promoting access to their facilities through different Agency mechanisms. The second ICERR network (ICERRNet) meeting was organized by the Agency in March 2019 alongside the European Research Reactor Conference; participants endorsed the Agency's proposal to develop a Peaceful Uses Initiative project to support networking among ICERRs and to promote information sharing in Member States on ICERR capabilities.

46. To assist Member States in studying new research reactor programmes, the Agency organized a training workshop on the Milestones approach and on the establishment of the infrastructure for a new research reactor programme at its Headquarters in Vienna in October 2018; the workshop was attended by 24 participants from 15 Member States. National workshops on the same topics were conducted in Zambia in September 2018 and in Thailand in November 2018. The Agency also held a training workshop on the expansion of research reactor stakeholder base through strategic and business plans in

Vienna in November 2018, with experts and 25 participants representing 18 Members States, of which 8 represented planned facilities; they shared relevant methodologies, implementation strategies and good practices in research reactor utilization at successfully operating facilities. A Workshop on the Application and Utilization Planning of the Low Power Research Reactor (LPRR) was held in Riyadh in January 2019 to share experience and provide guidance. Additionally, a Technical Meeting on the Establishment and Optimization of Cold Neutron Sources in Research Reactors and Accelerator Facilities was organized by the Agency in October 2018, attended by 26 participants from 13 Member States, to produce an Agency report on guidance on this subject for Member States, in particular to embarking countries. The publication *Feasibility Study Preparation for New Research Reactor Programmes* (IAEA Nuclear Energy Series No. NG-T-3.18) was issued in 2018, as well as the publications *Advances in Neutron Activation Analysis of Large Objects with Emphasis on Archaeological Examples* (IAEA-TECDOC-1838) and *Development of an Integrated Approach to Routine Automation of Neutron Activation Analysis* (IAEA-TECDOC-1839). Progress has also been made in the development of an NES publication on project management in research reactor construction.

47. The Agency continued to provide guidance on all aspects of the research reactor life cycle, including the development of ageing management programmes at both new and older research reactors, to ensure continuous improvements in safety and reliability, sustainable long term operation, the sustainability of fuel supply, and the exploration of efficient and effective disposition options for spent fuel and waste management and the development of knowledgeable customer capabilities in Member States with research reactor decommissioning activities. In October 2018, a Technical Meeting on Good Practices for the Operation and Maintenance of Research Reactors was held in Vienna, with 34 participants from 32 Member States. In the same month, a Regional Training Course on Operation and Maintenance of Research Reactors was conducted for the Latin America and the Caribbean region; the course was based on the Agency's training material on reactor theory, research reactors and operation and safety of research reactors.

48. In November, an expert mission on non-destructive examination and in-service inspection, supported by the use of the Agency's underwater camera for research reactors, and an Operation and Maintenance Assessment of Research Reactors (OMARR) peer review mission were conducted at the TRIGA research reactor in Bangladesh. Recommendations and suggestions were provided to support the Bangladesh Atomic Energy Commission in preparing an action plan to ensure the efficient and reliable operation of the TRIGA reactor for the next 15–20 years. In January 2019, a pre-OMARR mission was conducted to the TRIGA-2000 research reactor in Bandung, Indonesia, and the scope and methodology for conducting the main OMARR mission were finalized. A follow-up OMARR mission to the WWR-SM research reactor in Uzbekistan is planned for August 2019 and will focus on the long term operation of the reactor. In May 2019, a Technical Meeting on Risk Informed In-Service Inspection and Decision Making for Research Reactors was held at the Agency's Headquarters in Vienna, in order to provide an overview of the practices of in-service inspection, probabilistic assessments, and risk informed in-service inspection and decision making in Member States, with 22 participants from 18 Member States. The scope and methodology of a proposed CRP on risk informed in-service inspection and decision making for research reactors were finalized. A number of relevant meetings are planned to be held at the Agency's Headquarters by the end of the year, including: a Training Workshop on Integrated Management Systems and Good Practices for Research Reactors, in June 2019, and a Technical Meeting on Upgrades to Digital Instrumentation and Control Systems for Research Reactors, in July 2019. The Agency also continued to implement the second phase of the Data Analysis and Collection for Costing of Research Reactor Decommissioning project, which brings together a community of experts working on research reactor decommissioning planning and costing.

49. The project for decommissioning the IIN-3M FOTON research reactor in Tashkent was completed; the site was released from regulatory control in September 2018 and follow-up clean-up

activities were finished in December 2018. The Agency made progress in the development of several relevant publications, including on options and technologies for managing the back end of the research reactor nuclear fuel cycle, benchmarks of computational tools against experimental data on fuel burnup and material activation for utilization, operation and safety analysis of research reactors; on post irradiation examination methods and processes for research reactor fuel; and on uranium–molybdenum (U-Mo) dispersion fuel for research reactors.

50. To further strengthen its efforts to support capacity building based on the use of research reactors, in June 2018 the Agency organized a Technical Meeting on The Role of Research Reactors in Human Capacity Building in Support of Nuclear Technology, held in Vienna and attended by 30 participants from 22 Member States. In October 2018, the 14th Eastern European Research Reactor Initiative fellowship training course was held in cooperation with Vienna University of Technology, Austria, the Czech Technical University in Prague, Czech Republic, the Jožef Stefan Institute, Slovenia, and Budapest University of Technology and Economics, Hungary. The course was attended by 10 participants from 6 Member States. The implementation of the Internet Reactor Laboratory (IRL) project continued: six half-day sessions were broadcast from the RA-6 research reactor in Argentina to students in Colombia, Cuba and Ecuador, and two sessions from the ISIS research reactor in France to students in Belarus, Lithuania and Tunisia. Equipment and software were delivered in order to set up the IRL at the MA-R1 research reactor of Morocco's National Centre for Nuclear Energy, Sciences and Technology, and at the AGN-201K research reactor of the Kyung Hee University, Republic of Korea. In November 2018, a Research Reactor School was conducted in Indonesia and Malaysia in cooperation with the Agency, for 13 participants from 9 Member States from the Asia Pacific region.

51. The Agency continued to support, upon the request of Member States, international programmes designed to minimize the civilian use of high enriched uranium (HEU). The conversion of Nigeria Research Reactor-1 (NIRR-1) miniature neutron source reactor in Nigeria from HEU to LEU fuel was successfully completed; NIRR-1 achieved first criticality with LEU fuel supplied by China in November 2018, and the irradiated HEU fuel was transferred to China in December. The experience gained from the project was discussed at the Technical Meeting on the Conversion of Miniature Neutron Source Reactors from High Enriched Uranium to Low Enriched Uranium Fuel in Abuja, attended by 20 participants from 6 Member States. In November 2018, the United States Department of Energy's National Nuclear Security Administration organized the International Meeting on Reduced Enrichment for Research and Test Reactors in Edinburgh, Scotland, in cooperation with the Agency, which was attended by 148 participants from 22 Member States. In October, the Agency held a Technical Meeting on Global Capabilities for the Production and Manufacture of Non-High Enriched Uranium Mo-99 Targets, with 25 participants from 11 Member States. In December, the Agency participated in the seventh Workshop on Signatures of Man-Made Isotope Production, organized in Sydney, Australia.

B.2. Communication and Agency Cooperation with Other Organizations

52. During the reporting period, the Agency continued to cooperate with international initiatives participating in the activities of the revitalized UN-Energy mechanisms, including contributing to the vision, operational modalities and governance of UN-Energy; sharing information on the Agency's role in energy planning; and registering the International Conference on Climate Change and the Role of Nuclear Power in the UN-Energy event calendar.

53. In its efforts to provide comprehensive information on the potential of nuclear energy as a low carbon energy source and its potential to contribute to mitigating climate change, the Agency published the non-serial report entitled *Climate Change and Nuclear Power 2018* and other scientific brochures, and developed videos on the role of nuclear power in combating climate change.

54. The Agency attended COP24 in Katowice, Poland, in December 2018 and conducted activities to gain visibility in helping its Member States strengthen their energy planning capacity for combating climate change. These activities included organizing two side events, participating in two other side events as panellists, holding meetings with other international organizations, such as the United Nations Department of Economic and Social Affairs (UNDESA), the United Nations Framework Convention on Climate Change (UNFCCC) and the IPCC, on issues related to cooperation, and disseminating Agency publications on the role of nuclear energy. The Agency also attended the Global Conference on Synergies between the 2030 Agenda and Paris Agreement, organized by UNDESA and UNFCCC and held in Copenhagen in April 2019; participated in the United Nations Expert Group Meeting organized by UNDESA and the International Labour Organization in Geneva, Switzerland, in April 2019; and attended the 49th Session of the IPCC in Kyoto, Japan, in May 2019.

55. The Agency continued to facilitate cooperation between Member States by exchanging information on relevant experiences and good practices with respect to nuclear power programmes through synergies with other international organizations. For example, the Agency organized, jointly with OECD/NEA, the United Kingdom's National Nuclear Laboratory, the Electric Power Research Institute and the Korea Hydro & Nuclear Power Company, the Global Forum on Innovation for the Future of Nuclear Energy in Gyeongju, Republic of Korea, in June 2019. The event brought together over 370 participants from 16 Member States and 100 companies and organizations and explored opportunities and identified tangible actions to accelerate the deployment of technical, cultural, leadership, management and business process innovations to improve the sustainability of operating nuclear power reactors worldwide. The Agency also continued to strengthen its engagement with the World Association of Nuclear Operators (WANO). The Agency continued to participate in OECD/NEA initiatives, such as the Task Group on Optimising Management of Low-level Radioactive Materials and Waste from Decommissioning and the Decommissioning Cost Estimation Group. Additionally, the Agency continued to support a number of collaborative research and innovation projects on decommissioning and remediation that are being implemented as part of the European Commission's Horizon 2020 Research and Innovation Framework Programme, including the 'TERRITORIES' project, the 'INSIDER' project and the 'SHARE' project, in order to develop a road map for future decommissioning research needs.

56. The Agency continued to support IFNEC in the organization of the IFNEC Global Ministerial Conference: Bringing the World SMRs and Advanced Nuclear Technology, to be held in Washington DC, United States of America, in November 2019. In addition to having a presence in the IFNEC's Steering Group, the Agency cooperates with IFNEC via its two Working Groups — the Infrastructure Development Group and the RNFSWG. Representatives from IFNEC participate at the Technical Meeting on Topical Issues in the Development of Nuclear Power Infrastructure, held annually in Vienna, most recently in January–February 2019. The Agency also participated in the meeting of the IFNEC Working Group, held in Beijing in June 2019.

B.3. Operating Nuclear Power Plants

57. The Agency has supported Member States' work across a broad range of technical areas related to engineering support for existing nuclear power reactors, and to new reactor construction in countries that already have nuclear power programmes. The Agency held several Technical Meetings in these areas during the reporting period. Specifically, a Technical Meeting on Challenges and Opportunities in the Construction Management of Advanced Nuclear Power Plants brought 40 participants from 18 Member States together in Shanghai, China, in August 2018. The Agency also hosted its inaugural meeting of the Technical Working Group on Nuclear Power Plant Operations in Vienna in September 2018. The event gathered 30 executive-level experts, 20 members and 10 observers from 20 Member States and 6 international organizations to discuss common challenges and opportunities and make

appropriate, high-level recommendations for the Agency's consideration. In October 2018, 22 experts from 11 Member States came together in Gyeongju, Republic of Korea to discuss improving plant thermal efficiency at a Technical Meeting on Thermal Performance Monitoring and Optimization in Nuclear Power Plants. In December 2018, the Agency hosted a Technical Meeting on Reload Design and Core Management in Operating Nuclear Power Plants: Experiences and Lessons Learned, attended by 20 experts from 14 Member States. The Agency held the biannual Technical Meeting for the National Coordinators of the Joint IAEA–OECD/NEA Fuel Incident Notification and Analysis System (FINAS) in Vienna in September 2018 to facilitate the exchange of operating experience, attended by 27 Coordinators from 18 Member States. In May 2019, the Agency held a Technical Meeting on Expanding and Improving Country Nuclear Power Profiles in Vienna, attended by 14 participants from 13 Member States and 1 international organization. The Agency also conducted three Operational Safety Review Team (OSART) missions, in China in January 2019, the Islamic Republic of Iran in September 2018 and the Russian Federation in November 2018, and one OSART mission at an NPP in the pre-operational phase prior to initial fuel load, in France in June 2019. Seven OSART follow-up missions were conducted, in Canada in September 2018, China in January 2019, France in May 2019, Romania in March 2019, the Russian Federation in May 2019, Slovenia in October 2018 and the United States of America in April 2019. During the reporting period, the following relevant publications were issued: *Maintenance Optimization Programme for Nuclear Power Plants* (Nuclear Energy Series No. NP-T-3.8), *Technical Support to Nuclear Power Plants and Programmes* (IAEA Nuclear Energy Series No. NP-T-3.28), *Industrial Safety Guidelines for Nuclear Facilities* (IAEA Nuclear Energy Series No. NP-T-3.3), *Dissimilar Metal Weld Inspection, Monitoring and Repair Approaches* (IAEA-TECDOC-1852) and *Improvement of Effectiveness of In–Service Inspection in Nuclear Power Plants* (IAEA-TECDOC-1853).

58. In supporting interested Member States in the management of ageing and plant life management, the Agency organized a Technical Meeting on Economic Considerations of Asset Management for Nuclear Power Plant Operation and Maintenance in Vienna in October 2018, attended by 13 participants from 11 Member States and 1 international organization. In October–November 2018, a Technical Meeting on Design Modification Process during the Lifetime of a Nuclear Power Plant: Challenges and Good Practices was held in Vienna and attended by 25 participants from 17 Member States and 1 international organization. The Agency also organized the annual meeting of the Technical Working Group on Life Management of Nuclear Power Plants in February 2019. The Agency conducted three Safety Aspects of Long Term Operation (SALTO) missions, in Armenia in November 2018, Mexico in March 2019 and Sweden in June 2019, and two pre-SALTO missions that reviewed existing plant programmes and long term operation plans at an early stage of their preparation, in Argentina in October 2018 and Spain in January 2019. Two SALTO follow-up missions were conducted, in Belgium in June 2019 and China in May 2019. The following relevant publications were issued during the reporting period: a Safety Guide entitled *Ageing Management and Development of a Programme for Long Term Operation of Nuclear Power Plants* (IAEA Safety Standards Series No. SSG-48), *Economic Assessment of Long Term Operation of Nuclear Power Plants: Approaches and Experience* (IAEA Nuclear Energy Series No. NP-T-3.25) and *Buried and Underground Piping and Tank Ageing Management for Nuclear Power Plants* (IAEA Nuclear Energy Series No. NP-T-3.20).

59. To disseminate best practices and experience related to the whole life cycle of facilities and activities, including the need to maintain an appropriate organizational structure while nuclear power plants are in permanent shutdown or in transition to decommissioning, the Agency issued *Lessons Learned from the Deferred Dismantling of Nuclear Facilities* (IAEA Nuclear Energy Series No. NW-T-2.11) in September 2018 and *Decommissioning after a Nuclear Accident: Approaches, Techniques and Implementation Considerations* (IAEA Nuclear Energy Series NW-T-2.10) in June 2019. In addition, draft publications on management of transition of nuclear power plants from operation to decommissioning; remediation of groundwater at uranium mining and processing sites;

decommissioning of particle accelerators; and systematic approach to training are in the advanced stages of preparation. The Agency also made available the first version of the Nuclear Leadership Development Web-based Toolkit via the Nuclear Energy Capacity Building Hub, which is accessible to registered users.

60. To provide further support to interested Member States in the justification of commercial industrial instrumentation and control (I&C) equipment for nuclear power plant applications and I&C aspects of human factors engineering, as well as to discuss the challenges and issues that need to be resolved in this area, the Agency brought together 53 experts from 23 Member States at a Technical Meeting on Instrumentation and Control Aspects of Human Factors Engineering: Design and Analysis in Madrid in September 2018. The Technical Working Group on Nuclear Power Plant Instrumentation and Control met in Vienna in May 2019. Two publications on this topic were issued during the reporting period: *Approaches for Overall Instrumentation and Control Architectures of Nuclear Power Plants* (IAEA Nuclear Energy Series No.NP-T-2.11) and *Dependability Assessment of Software for Safety Instrumentation and Control Systems at Nuclear Power Plants* (IAEA Nuclear Energy Series No. NP-T-3.27).

61. To further enhance the support for grid and NPP interfaces, grid reliability, and cooling water usage, an international training course on grid interfaces was held, with 22 participants from 12 Member States at Argonne National Laboratory, Chicago, United States of America in June 2019, for Member States with new nuclear power programmes.

62. To promote best practices and lessons learned with respect to procurement and supply chain issues, a pilot version of the Nuclear Supply Chain Management Web-based Toolkit, focusing particularly on quality and new technical challenges and solutions, will be launched in August 2019. Besides, to support experience sharing on quality control and quality surveillance activities related to nuclear construction, component manufacturing and modifications, a NES publication on management of nuclear power plant projects and a TECDOC on quality assurance/quality control activities in nuclear power plants are in advanced stages of preparation.

63. To support Member States with nuclear power programmes to develop a knowledgeable workforce, the Agency has initiated the revision of two NES publications, namely, *Managing Human Resources in the Field of Nuclear Energy* and *Workforce Planning for New Nuclear Power Programmes*. The Agency also developed a new TECDOC on a methodology to evaluate the effectiveness of training in nuclear facilities, which was approved for publication in June 2019. The proceedings of the Third International Conference on Human Resource Development for Nuclear Power Programmes: Meeting Challenges to Ensure the Future Nuclear Workforce Capability, which took place in 2018, were also published.

Agency Activities in the Development of Innovative Nuclear Technology

A. Background

1. The General Conference, at its 62nd regular session, noted the progress achieved in a number of Member States in the development of innovative nuclear energy system technologies and the high technical and economic potential of international collaboration in the development of such technologies. It also highlighted the need for an effective and efficient transition from the research and development (R&D) and innovation stage to proven technology stage.

2. The General Conference also recognized that a number of Member States are planning to license, construct and operate prototypes or demonstrations of fast neutron systems, high temperature reactors, thermonuclear experimental reactors and other innovative reactors and integrated systems within the next decades, and encouraged the Secretariat to foster this process through the provision of international fora for the exchange of information, thus supporting interested Member States to develop innovative technology with enhanced safety, proliferation resistance and economic performance. It also noted the increased interest in technology developments in the area of molten salt and molten-salt cooled advanced reactors.

3. The General Conference requested the Director General to report to the Board of Governors, as appropriate, and to the General Conference at its 63rd regular session on developments relevant to resolution GC(62)/RES/9.B.4.

B. Progress Made Since the 62nd Regular Session of the General Conference

4. To assist interested Member States in building long term national nuclear energy strategies and in long term sustainable nuclear energy deployment decision-making, the Agency organized, in October 2018, in Vienna, a Technical Meeting on the INPRO Collaborative Project "Comparative Evaluation of Nuclear Energy System Options" (CENESO), attended by 14 experts from 13 Member States. Also, in April 2019, a Technical Meeting on INPRO Service for Member States: Scenario Analysis and Decision Support for Development of Nuclear Energy Systems with Enhanced Sustainability was held in Vienna, attended by 23 experts from 20 Member States.

5. In January 2019, the Agency held an online conference at the request of Kenya on "Trial application of the KIND[1]/CENESO[2] toolkit for comparison of NES[3] options". This online

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[1] Key Indicators for Innovative Nuclear Energy Systems

[2] Comparative Evaluation of Nuclear System Options

[3] Nuclear energy system

conference was attended by a team from the Kenya Nuclear Electricity Board and support was provided to help the participants carry out their national case study. As a result, the Kenyan case study was drafted and submitted for inclusion in the IAEA Technical Document (TECDOC) planned for the CENESO project.

6. To complete a full technical editing review of the final report of the INPRO collaborative project "Roadmaps for a Transition to Globally Sustainable Nuclear Energy Systems" (ROADMAPS), the Agency organized a meeting on ROADMAPS in May 2019.

7. To promote collaboration among interested Member States in developing innovative, globally sustainable nuclear energy systems, in October 2018, the Agency conducted a Technical Meeting on Nuclear–Renewable Hybrid Energy Systems for Decarbonized Energy Production and Cogeneration in Vienna, with 24 participants from 17 Member States and two international organizations.

8. In December 2018, the Agency held a meeting in Vienna to further progress in the preparation of a TECDOC related to INPRO study on cooperative approaches to the back end of the nuclear fuel cycle: drivers and institutional, economic and legal impediments.

9. To further examine the role that technological and institutional innovations can play in improving nuclear power infrastructure, the Agency organized, in December 2018, in Vienna, the 16th INPRO Dialogue Forum on Opportunities and Issues in Non-Electric Applications of Nuclear Energy, attended by 43 experts from 32 Member States.

10. The Agency continued sharing NPP basic principle simulators with Member States to support training and education on nuclear technologies. The Agency also held a meeting of experts from Tsinghua University, China, on high temperature gas cooled reactor basic educational training simulator requirements and development in May 2019 in Vienna following China's offer to develop and donate the first basic education simulator of a modular high temperature gas cooled reactor to the Agency.

11. The Agency continued the process of updating the INPRO Manuals and, in June 2019, held a meeting on revision of the INPRO Manual on Proliferation Resistance, in Vienna, attended by 8 experts from 4 Member States. The Agency also made progress in the preparation of a publication on INPRO case study for the deployment of a factory fuelled small modular reactor; a meeting for this purpose was held, in September 2018, in Vienna, attended by 20 experts from 8 Member States

12. The Agency will hold an informal technical briefing on its work on transportable nuclear power plants (TNPPs) at the end of August 2019.

13. In March 2019, the Agency, in cooperation with the Generation IV International Forum (GIF) conducted a Joint IAEA–GIF Technical Meeting/Workshop on the Safety of Liquid Metal Cooled Fast Reactors in Vienna, attended by 25 participants from 11 Member States and three international organizations, and 14 participants from the Agency. The 13th GIF–INPRO/IAEA Interface Meeting was held in May 2019, in Vienna, with the purpose to share information on innovation programmes and coordinate between GIF and the Agency.

14. The Agency has continued to provide opportunities to Member States to exchange knowledge and experience in the area of innovative, globally sustainable nuclear energy systems. The first Joint ICTP-IAEA Course on Scientific Novelties in Phenomenology of Severe Accidents in Water Cooled Reactors (WCRs) was held in October 2018, in Trieste, Italy, and attended by 25 participants from 16 Member States, while the 2nd Joint ICTP–IAEA Course on the same topic was held in June 2019, with 28 participants from 14 Member States. A Regional Training Workshop on Phenomenology and Numerical Simulations of Severe Accidents in Advanced WCRs was held in December 2018 in the School of Advanced Nuclear Energy System Studies of the Global Centre for Nuclear Energy Partnership, New Delhi, with 25 participants from 4 Member States. A National Workshop on Nuclear

Power Technology and Nuclear Power Education and Training was conducted in December 2018, in Colombo with 61 participants from 23 organizations. A Regional Training Course on Pressurized Water Reactor Technology Using PC Basic Principle and GlassTop Nuclear Power Plant Simulators was held at the University of Sharjah, United Arab Emirates, with 16 participants from 6 Member States. A National Training Workshop on Modelling Physics and Technology of Hydrogen Management in Severe Accidents was conducted in April 2019, at the State Power Investment Corporation, Beijing, and was attended by 49 participants. A Regional Training Workshop on Physics and Technology of Advanced WCRs with Computer-Based Educational Simulators was held in April 2019 at China Nuclear Power Operation Technology Corporation, Wuhan, China, and was attended by nine participants from six Member States. A Regional Training Course on Science and Technology of Water Cooled Reactors and Introduction of Supercritical Water Cooled Reactor Concepts was held in September 2019 at Hanyang University, Seoul. The Agency also issued three Training Course Series publications: *PCTRAN Generic Pressurized Water Reactor Simulator Exercise Handbook* (Training Course Series No. 68, 2019) in support of training courses on advanced WCRs and hands-on learning; *Passive Safety Systems in Water Cooled Reactors: An Overview and Demonstration with Basic Principle Simulators* (Training Course Series No. 69, 2019) in support of training courses on passive safety systems; and *Introduction to Water Cooled Reactor Theory with the Micro-Physics Simulator Lite Edition* (Training Course Series No. 70, 2019) in support of training courses on WCR fundamentals.

15. To further explore, share and disseminate information on new reactor and fuel cycle technologies with improved utilization of natural resources and enhanced proliferation resistance, the Agency issued, in November 2018, *Experimental Facilities in Support of Liquid Metal Cooled Fast Neutron Systems* (IAEA Nuclear Energy Series No. NP-T-1.15) that is complemented by the online Catalogue of Facilities in Support of Liquid Metal Cooled Fast Neutron Systems available in NUCLEUS. In August 2019, the Agency plans to update this catalogue based on the contributions proposed by 13 experts from 10 Member States. Also, in March 2019, a publication entitled *Reliability of Advanced High Power, Extended Burnup Pressurized Heavy Water Reactor Fuels* (IAEA TECDOC No. 1865) was issued, which presents a comprehensive summary of the technical work carried out during the related Agency CRP. In December 2018, the Agency published the proceedings of the International Conference on Fast Reactors and Related Fuel Cycles: Next Generation Nuclear Systems for Sustainable Development (FR17), which was held in the Russian Federation in June 2017.

16. The Agency continued to explore activities in the area of innovative nuclear technologies, such as alternative fuel cycles (e.g. thorium, recycled uranium and plutonium) and Generation IV nuclear energy systems. In November 2018, 33 experts representing 29 organization from 17 Member States participated in the first RCM of the new CRP entitled ‘Benchmark Analysis of FFTF Loss of Flow Without Scram Test’. In December 2018, the Agency conducted, in Vienna, the Technical Meeting on the Status of the IAEA Nuclear Graphite Knowledge Base attended by 11 participants from 7 Member States. In the same month, the Agency conducted, in Vienna, the Technical Meeting on Knowledge Preservation for Gas Cooled Reactor Technology and Experimental Facilities attended by 17 participants from 11 Member States. In January 2019, the fourth RCM on Understanding and Prediction of Thermal Hydraulics Phenomena Relevant to Supercritical Water Cooled Reactors was held in Vienna leading to the finalization of a TECDOC. In April 2019, the Agency also organized the third RCM on Radioactive Release from the Prototype Fast Breeder Reactor under Severe Accident Conditions where 14 participants from 6 Member States presented the final results of numerical simulations and drafted the first version of an Agency publication. In the same month, the Agency issued *Status of Research and Technology Development for Supercritical Water Cooled Reactors* (IAEA-TECDOC-1869). In June 2019, two relevant CRPs were launched: a CRP entitled ‘Probabilistic Safety Assessment (PSA) Benchmark for Multi-Unit, Multi-Reactor Sites’, with the first RCM attended by 20 participants from 15 Member States; and a CRP entitled ‘Methodology for Assessing Pipe Failure Rates in Advanced Water Cooled Reactors (WCRs)’, with the first RCM attended by 12 participants from 8 Member States.

In March 2019, the Agency issued *Nuclear Fuel Cycle Simulation System: Improvements and Applications* (IAEA TECDOC No. 1864), a scenario-based computer simulation tool that can model various nuclear fuel cycle options in various types of nuclear reactors.

Approaches to Supporting Nuclear Power Infrastructure Development

A. Background

1. The General Conference, at its 62nd regular session, recognized that the development, implementation and maintenance of an appropriate infrastructure to support the successful introduction of nuclear power and its safe, secure and efficient use is an issue of great importance, especially for countries that are considering and planning for the introduction of nuclear power, as well as for countries expanding their nuclear power programme.

2. The General Conference also noted the importance of coordination of activities within the Agency for nuclear infrastructure development, through the Nuclear Power Support Group, the Infrastructure Coordination Group and the respective Core Teams established to support each specific Member State considering and planning the introduction of nuclear power, or the expansion of their existing nuclear power programme. It also recognized the continued value of the Agency's Integrated Nuclear Infrastructure Review (INIR) missions, which provide expert and peer-based evaluations, in helping requesting Member States to determine their nuclear infrastructure development status and needs.

3. The General Conference requested the Director General to report to the Board of Governors, as appropriate, and to the General Conference at its 63rd regular session on developments relevant to resolution GC(62)/RES/9.B.5.

B. Progress Made Since the 62nd Regular Session of the General Conference

4. The Agency continued its efforts in providing integrated assistance to Member States embarking on or expanding nuclear power programmes based on the Milestones approach described in *Milestones in the Development of a National Infrastructure for Nuclear Power* (IAEA Nuclear Energy Series No. NG-G-3.1 (Rev. 1), 2015) through strengthening of the inter-Departmental Nuclear Power Support Group providing policy and direction at Divisional level and the Infrastructure Coordination Group at Section level, as well as through the enhanced accountability of the Member State specific core teams including representatives from all relevant Departments (Nuclear Energy, Nuclear Safety and Security, Safeguards, Technical Cooperation) and the Office of Legal Affairs. The core teams participated in bilateral meetings with the respective Member States to develop or update their national Integrated Work Plans (IWPs) and Country Nuclear Infrastructure Profiles (CNIPs) in order to plan and tailor Agency assistance to the current needs of each Member State and to monitor the progress of national infrastructure development following INIR missions. Meetings to update the IWPs were held in Vienna, with Bangladesh, Belarus, Jordan, Kenya, the Niger, Nigeria, Poland, Saudi Arabia, the Sudan, Turkey and the United Arab Emirates.

5. The Agency continued to consolidate the application of the Milestones approach to support the development of nuclear infrastructure in Member States interested in or embarking on new nuclear power programmes. At the request of the Philippines, a pre-INIR mission was conducted in October 2018, followed by a Phase 1 INIR mission in December 2018. A mission was conducted in Egypt in March 2019 to support the development of Egypt's self-evaluation report (SER), followed by a pre-INIR mission in May 2019. A workshop on a planned INIR Phase 3 mission was also conducted in Belarus in June 2019. The growing recognition of IAEA Nuclear Energy Series No. NG-G-3.1 (Rev. 1), as a key document for nuclear power infrastructure development has further resulted in the examination of its applicability for the construction of small and medium sized or modular reactors (SMRs). The consideration of SMRs in such guidance document as well as in the evaluation methodology for the conduct of INIR missions will be further explored subject to the work done by the SMR Regulators' Forum and the expected near-term deployment of first-of-a-kind SMR design.

6. The Agency continued to learn lessons from the conduct of SER support missions, pre-INIR, INIR and INIR follow-up missions, which were also taken into consideration during the development of *Guidelines for Preparing and Conducting an Integrated Nuclear Infrastructure Review (INIR)* (IAEA Services Series No. 34). Similarly, lessons learned are incorporated into revisions of existing publications and the development of new publications related to nuclear infrastructure development. The Agency initiated, through the organization of two consultancy meetings in February and May 2019, in Vienna, the development of a TECDOC on ten years of INIR missions: lessons learned, challenges and solutions. A side event on the same topic, held during the 62nd regular session of the General Conference, provided an opportunity for the Secretariat and Member States to discuss their experience and share lessons learned. The event was attended by around 125 participants from Member State delegations and Agency staff.

7. The Agency continued to conduct INIR missions, where appropriate, in a combination of English and one of the United Nations official languages to facilitate the highest level of information exchange. Whereas SERs are expected to be submitted in English, supporting documents can be provided in other United Nations official languages. The main INIR mission report is published in English. Additionally, the Agency initiated the translation of IAEA Nuclear Energy Series No. NG-G-3.1 (Rev. 1) into Arabic, French and Russian. Through regular training of external experts and staff members from relevant Departments, the continued sustainability of the INIR service and the availability of a broad pool of experts is being ensured. The Agency continued to ensure that the use of external experts for INIR missions did not constitute a conflict of interest or provide a commercial advantage.

8. The Agency continued to promote cooperation between embarking countries and those with established nuclear power programmes. The comprehensive capacity building programme for countries embarking on nuclear power is supported by the participation of countries embarking, expanding and operating nuclear power plants. Through the organization of Technical Meetings, workshops and conferences, the Agency continued to encourage broad international participation, cooperation and exchange of knowledge and experience among representatives from embarking and operating Member States and from other organizations. In this regard, the Agency held, in Vienna, the Technical Meeting on Topical Issues in the Development of Nuclear Power Infrastructure with 82 participants from 39 Member States and two international organizations (January–February 2019), the Technical Meeting on Human Resource Development Analysis and the Use of the Nuclear Power Human Resource (NPHR) Modelling Tool for New Nuclear Power Programmes with 32 participants from 17 Member States (February 2019); the Technical Meeting on Stakeholder Involvement and Communication for New and Expanding Nuclear Power Programmes with 49 participants from 29 Member States and one international organization (June 2019); and the Technical Meeting on Case Studies: Experiences of Member States in Building a Regulatory Framework for the Oversight of New Nuclear Power Plants with 41 participants from 21 Member States (June 2019). Similarly, the membership of the Technical

Working Group on Nuclear Power Infrastructure, which convenes annually, includes participants/experts from Member States with established nuclear power programmes and from embarking countries. Experts to support IWP-related activities (for example national workshops, or expert missions) are, in most cases, recruited from experienced operating Member States.

9. Supported by external experts, the Agency undertakes continuous systematic reviews, most recently in April 2019, of the Nuclear Infrastructure Bibliography to identify areas not covered by existing Agency publications as well as publications in need of revision. An updated nuclear infrastructure bibliography was subsequently published on the Agency website and has proven to be a useful tool in supporting countries embarking on nuclear power programmes in building competence.

10. The Agency continued to support Member States in developing knowledgeable future owner/operators. A revision of the publication *Initiating Nuclear Power Programmes: Responsibilities and Capabilities of Owners and Operators* (IAEA Nuclear Energy Series No. NG-T-3.1) has been recently been made available, as draft working material, in the Nuclear Infrastructure Bibliography with the provisional title 'Responsibilities and Capabilities of Owner/Operators in the Development of a National Infrastructure for Nuclear Power'; the revised publication takes into consideration lessons learned and the concept of a knowledgeable customer. Moreover, the Agency continued to strengthen training and knowledge on the issue by organizing national workshops for future owner/operators within the framework of national technical cooperation projects, as well as an Interregional Training Course on Licensing and Construction Preparation and Oversight for New and Expanding Nuclear Power Programmes in the Republic of Korea in July 2019 and the Group Scientific Visit for Owner/Operators to the Russian Federation in May 2019, with nine participants from nine Member States, carried out within the framework of interregional technical cooperation project INT/2/018.

11. To the extent possible, and if permitted by the Member State concerned, the Agency continued facilitating the incorporation of bilateral assistance into the IWP. This coordination is a feature embodied in the revised Terms of Reference for the IWP and CNIP. Member States are encouraged to share information about activities related to infrastructure development performed in cooperation with other international organizations, donors and the vendor.

12. In November 2018, the Agency conducted a Training Course on Reactor Technology Assessment: Testing the IAEA's Reactor Assessment Methodology, in Vienna, with 11 participants from 9 Member States. The course had the objective of updating the reactor technology assessment methodology by incorporating feedback and lessons learned. The refinement and updates of the methodology were finalized in April 2019 with the contribution of nine experts from eight Member States.

13. The Agency continued its efforts to pursue a gradual comprehensive capacity building approach for newcomer countries and to streamline and reduce overlaps in the offer of training courses on infrastructure development implemented within the framework of technical cooperation project INT/2/018, as well as to increasingly encourage technology-neutral multi-donor courses. A meeting with Member States providing financial support and expertise for training courses was organized for this purpose during the 62nd regular session of the General Conference, during which a report proposing ways to streamline and improve existing and proposed training courses was presented.

Small and Medium Sized or Modular Reactors — Development and Deployment

A. Background

1. The General Conference, at its 61st regular session, noted that the Agency has a dedicated project to support small and medium sized or modular reactors (SMRs) and highlighted SMRs' potential as an option for enhancing energy availability and supply security both in expanding and embarking countries and to address economics, environmental protection, safety and security, reliability, enhanced proliferation resistance and waste management issues. It also noted that SMRs could play an important role in appropriate markets with cogeneration such as district heating, desalination and hydrogen production systems in future, and their potential for innovative energy systems.

2. The General Conference requested the Director General to report to the Board of Governors, as appropriate, and to the General Conference at its 63rd regular session on developments relevant to resolution GC(61)/RES/11.B.6.

B. Progress Made Since the 61st Regular Session of the General Conference

3. The 'Milestones Approach' described in IAEA Nuclear Energy Series No. NG-G-3.1 (Rev. 1) and the Integrated Nuclear Infrastructure Review (INIR) evaluation methodology described in *Evaluation of the Status of National Nuclear Infrastructure Development* (IAEA Nuclear Energy Series No. NG-T-3.2 (Rev. 1)) are technology neutral and were developed taking into account experience in nuclear power infrastructure development for large land based NPPs. Whereas the same infrastructure issues are relevant for SMRs, some of the requirements may be different when compared to those for large NPPs. In July 2017, the Agency reviewed the INIR evaluation methodology and concluded that, to a large extent, the methodology is applicable to the deployment of SMRs. The Agency has planned to further analyse, by the end of 2019 and with the contribution of representatives from Member States developing SMRs, the adaptations needed for different requirements. A revision of IAEA Nuclear Energy Series No. NG-G-3.1 (Rev. 1), foreseen to commence in 2020, will take the results of such analysis as well as those of work done by the Technical Working Group on Small and Medium Sized or Modular Reactors (TWG-SMR) and the SMR Regulators' Forum, into account.

4. To continue to promote effective international exchange of information on options of SMRs available internationally for deployment, the Agency conducted the first meeting of the TWG-SMR in April 2018, which was attended by 24 participants from 15 Member States and two international organizations. At the meeting, participants discussed recent advances in SMR technology, and identified subjects of common interest for future collaboration through information exchange and cooperative research. In addition, 14 Member States were officially appointed as members of the TWG-SMR; the second meeting is planned to be held in July 2019 with the participation of 20 Member States. In September 2018, the Agency conducted a Workshop on Design and Technology Status of Water Cooled

SMRs for Near Term Deployment in Vienna, with 16 participants from 13 Member States. In October 2018, a Workshop on Design and Technology Status of Innovative (Non Water Cooled) SMRs for Near Term Deployment was held in Vienna, with 26 participants from 19 Member States. In February 2019, the Agency organized a Regional Workshop on Non-Electric Nuclear Applications: Options, Technology Readiness and Available IAEA Toolkits in Prague, with 20 participants from 16 Member States. The 17th INPRO Dialogue Forum on Opportunities and Challenges in Small Modular Reactors is planned for July 2019, in Ulsan Metropolitan City, Republic of Korea. The Forum will offer a platform for technology holders, technology users and other stakeholders from all interested Member States to understand user needs and concerns compared to possibilities and limitations of the technology holders. The biennial booklet *Advances in Small Modular Reactor Technology Developments — A Supplement to the IAEA Advanced Reactors Information System (ARIS) 2018 Edition* was released in September 2018.

5. To foster international cooperation in studies of the social and economic impacts of SMR deployment in developing countries, the Agency conducted a Regional Workshop on Infrastructure, Economic and Financing Aspects of Small Modular Reactors in October 2018, in Vienna, with 18 participants from 16 Member States. Also, in June 2019, the Agency conducted in Pitești, Romania, a Regional Workshop on SMR Deployment Scenarios in Global Energy Portfolio with 18 participants from 13 Member States.

6. The Agency continued supporting competent organizations of the United Nations system in providing advice on the development and deployment of SMRs. In this regard, expert input and review was provided to the United Nations Economic Commission for Europe for the development of a report entitled *The Role of Nuclear Energy in Sustainable Development: Entry Pathways*.

7. The Agency continued working on defining indicators of safety performance, operability, maintainability and constructability so as to assist countries in assessing advanced SMR technologies and developing guidance for SMR technology implementation. In this regard, in September 2018, a publication entitled *Deployment Indicators for Small Modular Reactors — Methodology, Analysis of Key Factors and Case Studies* (IAEA-TECDOC-1854) was issued.

8. To continue providing guidance to Member States for safety, security, economics, licensing and regulatory reviews of SMRs of various designs, in 2018 the Agency launched a new CRP entitled ‘Development of Approaches, Methodologies and Criteria for Determining the Technical Basis for Emergency Planning Zone for Small Modular Reactor Deployment’; the first RCM was held in May 2018, in Vienna, with 24 participants from 14 Member States; the second Research Coordination Meeting was held in May 2019, in Beijing, with 21 participants from 13 Member States.

9. To foster collaboration among interested Member States with the objective of facilitating the licensing of SMRs, the Agency concluded in December 2018 the CRP entitled ‘Modular High Temperature Gas Reactor Safety Design’ focused on high temperature gas reactor (HTGR) technology specific safety design requirements, with contributions from ten organizations in nine Member States. The outcomes of the CRP will be captured in a publication under preparation.

10. To facilitate capacity building in embarking countries as regards SMR technology assessment, in October 2017 the Agency conducted, in Tunis, the Technical Meeting on Technology Assessment of Small Modular Reactors for Near Term Deployment with 23 participants from 13 Member States to discuss, in an integrated manner, the status of small modular reactor designs and technologies deployable in the near term, and approaches for their technology assessment. In June 2019, the Agency also conducted the Regional Workshop on Technology Assessment of SMRs in Vienna, with 21 participants from 11 Member States.

11. The Agency continued activities in both the development of key enabling technologies and the resolution of key infrastructure issues for innovative SMRs of various types. In 2017, the Agency implemented a new CRP with the specific objectives to conduct identification, reviews and assessments of design approaches of passive safety systems adopted in water cooled small modular reactors and their performance evaluation methods. In October 2017, the Agency conducted, in Vienna, the first RCM of the CRP entitled 'Design and Performance Assessment of Passive Engineered Safety Features in Advanced Small Modular Reactors' attended by seven participants from six Member States. In May 2018, the Agency conducted the second RCM of this CRP in Vienna, with 12 participants from 10 Member States.

12. The Agency's support to Indonesia on HTGR technology and deployment continued with two expert missions to review the design and documentation of the Reaktor Daya Eksperimental, a pebble bed high temperature reactor, in Serpong, Indonesia, in October 2017 and February 2019 with four experts and more than 30 participants. To assist Indonesia in preparing for licensing, an expert mission to support the regulator to establish a Phenomena Identification and Ranking Table to facilitate regulatory review and assessment of HTGRs was conducted in June 2019, with three experts and over 20 participants. The Agency also conducted a National Workshop on Technology, Regulations and Standards of HTGRs in October 2017 in Riyadh, attended by 20 local participants and supported by one external expert.