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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(59)/RES/12 and GC(60)/RES/12, this document contains progress reports on support to the African Union's Pan African Tsetse and Trypanosomosis Eradication Campaign (AU-PATTEC) (Annex 1); the Renovation of the Nuclear Applications Laboratories (ReNuAL) (Annex 2); use of isotope hydrology for water resources management (Annex 3); nuclear energy activities (Annex 4); Agency activities in the development of innovative nuclear technology (Annex 5); approaches to supporting nuclear power infrastructure development (Annex 6); and the development and deployment of small and medium sized reactors, including small modular reactors (Annex 7).
- Further information on the Agency's activities related to nuclear science, technology and applications can be found in the *Nuclear Technology Review 2017* (document GC(61)/INF/4); the *IAEA Annual Report 2016* (GC(61)/3), in particular the section on nuclear technology; and the *Technical Cooperation Report for 2016* (GC(61)/INF/7).

Recommended Action

- It is recommended that the Board take note of Annexes 1–7 to this report and authorize the Director General to submit the report to the General Conference at its 61st regular session.

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

A. Background

1. In resolution GC(60)/RES/12/A.3, the General Conference recognized that tsetse flies and the trypanosomosis problem which they cause are increasing and constitute one of the greatest constraints on the African continent's socio-economic development, affecting the health of humans and, in particular, of livestock. This undermines sustainable rural development and leads to increased poverty and food insecurity.

2. The General Conference requested the Agency and other partners to strengthen capacity building in Member States in support of informed decision-making regarding the choice of tsetse and trypanosomosis control 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 operational SIT field projects. It also requested strengthened support for research and development and technology transfer to African Member States to complement their efforts in creating and expanding tsetse-free zones.

B. Progress since the 60th Regular Session of the General Conference

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

3. The Agency was represented at the 15th meeting of National Coordinators for the African Union's Pan African Tsetse and Trypanosomosis Eradication Campaign (AU-PATTEC) and at the fifth meeting of the AU-PATTEC Steering Committee, both of which were held in Addis Ababa, Ethiopia, in November 2016. A presentation was given to update AU-PATTEC members on the current status of activities of the Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture and the Agency's Department of Technical Cooperation in support of tsetse and trypanosomosis control. The Agency continued to recognize that the tsetse and trypanosomosis problem constitutes one of the greatest constraints for socio-economic development of the African continent, and that will continue close collaboration with AU-PATTEC in its goal to eliminate tsetse flies and trypanosomosis through the creation of sustainable tsetse and trypanosomosis free areas.

4. The Agency continued its collaboration with the Food and Agriculture Organization of the United Nations (FAO) in support of the AU-PATTEC initiative by developing further the national atlases of tsetse and trypanosomosis in Ethiopia and Zimbabwe and by contributing to the concept of a progressive control pathway for African animal trypanosomosis.

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

5. The Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture and the Agency's Department of Technical Cooperation have 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 major constraint to both livestock and agricultural crop production in sub-Saharan Africa. The support comes through the provision of technical advice, procurement of equipment and materials, training courses and workshops, fellowships and scientific visits and research conducted at the IAEA's Nuclear Applications Laboratories in Seibersdorf. In addition experts participate in a number of coordinated research projects (CRPs) that address gaps in scientific knowledge.

6. The Agency's support strengthened capacity in Member States, enabling them to obtain and analyse baseline data that can contribute to 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 60th regular session of the General Conference support in this area has been provided to Burkina Faso, Ethiopia, Kenya, Mozambique, Senegal, South Africa, Swaziland, Uganda, the United Republic of Tanzania and Zimbabwe.

7. The Agency continues to provide technical support to West African countries to help them harmonize their efforts in controlling tsetse and trypanosomosis. A workshop on strengthening national planning in the formulation and implementation of tsetse and trypanosomiasis intervention programmes in Member States of the Economic Community of West African States was held in Bobo-Dioulasso, Burkina Faso, from 24 to 28 April 2017. Participants from nine Member States attended the workshop.

8. Since September 2016, the Agency has supported 11 fellowships and scientific visits. The fellowships provided individual training at specialized institutions for a total duration of more than 800 days. A number of these fellowships and scientific visits included periods spent at the Insect Pest Control Laboratory (IPCL) in Seibersdorf, Austria.

9. The third FAO/IAEA International Conference on Area-Wide Management of Insect Pests organized by the Joint FAO/IAEA Division was held in Vienna, Austria, in May 2017 and was attended by 360 participants. Many of the participants were from tsetse affected countries and several of them shared their experience at the conference.

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 the application of the SIT against major tsetse fly species.

11. A method for identifying natural barriers of tsetse populations that has been developed using genetic distance between tsetse populations and remotely sensed environmental data is currently being applied to identify isolated populations of *Glossina swynnertoni* in the border region between Kenya and the United Republic of Tanzania that can be later targeted for elimination.

12. The development of molecular tools to identify tsetse fly species has continued during the past year. The complete mitochondrial DNA has been sequenced for six tsetse species.

13. Fifteen countries continued to participate in applied research on the inhibition of trypanosome transmission through symbiotic microbes under the CRP entitled 'Enhancing Vector Refractoriness to

Trypanosome Infection'. The final Research Coordination Meeting for this CRP will be held in the United Republic of Tanzania in November 2017.

14. Advances in knowledge and applicable technologies arising from these research activities are widely disseminated through publications in peer-reviewed scientific journals as well as through conference presentations and training courses. The Joint FAO/IAEA Division issues a number of significant publications in the field of tsetse and trypanosomosis both in journals and through published guidelines, manuals and standard operating procedures (SOPs). During the reporting period, an SOP for long distance shipments of tsetse sterile male pupae was published, summarizing the main findings and recommendations from the research work conducted in the previous year.

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

B.3.1. Senegal (SEN/5/037)

15. 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 an SIT component. The target area has been divided into three operational blocks that are being treated sequentially. Monitoring has continued in Block 1, where sterile male releases stopped at the end of 2014, and no wild tsetse flies have been trapped since mid-2012. This additional twelve-month period of no wild trap catches increases the confidence that the wild fly population in Block 1 has been eradicated. In Block 2, releases of sterile males have continued and no wild flies have been trapped since February 2017. In Block 3, releases of sterile males that had been initiated in mid-2016 were suspended in early 2017, to enable higher release rates in Block 2. Releases in Block 3 will be resumed once the project receives more sterile male flies from the mass rearing centres in Burkina Faso and Slovakia.

B.3.2. Ethiopia (ETH/5/019)

16. The Agency has continued supporting the Ethiopian Government to integrate the SIT into its programme to eliminate *Glossina fuscipes fuscipes* from the Deme River Basin in the Southern Rift Valley. The information management has significantly improved due to the development and use of a system of databases. The colonies of *G. pallidipes* and *G. f. fuscipes* in the insectary of Kality have substantially improved their performance, multiplying by more than three times their size and pupal production.

17. In the field, the entomological surveys have been reinforced after the production of a predictive distribution model that has identified all suitable habitats for the wild population. The maintenance of the target barrier in the Deme gorge and the suppression in the identified hotspots, together with increased releases of sterile males, have led to extremely low densities of the wild population.

18. The unmanned aerial system prototype that has been developed for aerial releases of sterile males could not be put into operation because the relevant authorities have not yet granted the necessary authorization. It is anticipated that this system will eventually contribute to the cost reduction of the SIT component of the project.

B.3.3. Burkina Faso (RAF/5/077 and BKF/5/018)

19. The Agency has provided technical support, capacity and equipment for the Insectary of Bobo-Dioulasso in Burkina Faso. This insectary, inaugurated in February 2017, is the largest insectary in West Africa and is expected to produce sterile insects for several field projects in the region. Several tsetse species have been established with the support of the Agency and the Joint FAO/IAEA Division, and the colonies are currently being upgraded.

20. In collaboration with the Agency and the International Centre of Research and Development for Livestock in Subhumid Zones (CIRDES) based in Bobo-Dioulasso, Burkina Faso continues to support the Government of Senegal in its efforts to eradicate a tsetse fly population in the Niayes region through the weekly supply of sterile male tsetse flies.

B.3.4. Uganda (UGA/5/036)

21. The mandatory licences to import and operate an unmanned aerial system to release sterile tsetse flies in the Ssese Islands (Kalangala District) have been obtained. The Agency will provide the equipment and training required to validate this technology at the field level in September 2017.

22. Ground spraying activities have been conducted in the Ssese Islands using the equipment supplied by the Agency. Three Ugandan counterparts have been trained, through Agency fellowships, in Senegal on the SIT component of a tsetse elimination programme.

B.3.5. Zimbabwe (ZIM/5/019)

23. The Agency continues to support feasibility studies for the eradication of tsetse flies from the Matusadona National Park in Zimbabwe. This support has included training at the Slovak Academy of Sciences, Bratislava, and at the IPCL in Seibersdorf. Mating compatibility tests have been conducted in the field insectary of Makuti. Equipment and further support were provided jointly by the Agency and FAO to continue the development of the national atlas on tsetse and trypanosomosis for managing and planning tsetse control activities using the SIT where feasible.

C. Conclusion

24. African trypanosomosis affecting livestock continues to pose a significant constraint to development in much of sub-Saharan Africa, especially in the rural areas where poverty and lack of infrastructure are most acute. Where technically feasible, the SIT can be a significant tool for alleviating this constraint as a component of area-wide integrated pest control interventions. It provides an environmentally friendly option of eradicating the tsetse fly vector populations, removing the risk not only of animal trypanosomosis but also of human trypanosomosis (sleeping sickness) where it occurs. The benefits achieved, such as the improved ability to rear livestock for milk, meat and animal traction to grow crops, will substantially improve the livelihoods of rural populations. The Agency continues to assist in building capacity in this area within Member States in sub-Saharan Africa.

25. The major constraints to successful and more widespread application of the SIT in suitable areas are the lack of mass rearing infrastructure in Africa and the appropriate management structures for mass rearing and area-wide pest control operations. During the past year, progress has been made to address these constraints with the inauguration of the Insectary of Bobo-Dioulasso and the reinforcement of management capacities through a range of activities.

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 (NA) 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 officially began on 1 January 2014. In resolution GC(60)/RES/12.A.6, the General Conference requested the Director General to report on progress made in implementing the resolution at its 61st regular session.

2. 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 Plus (ReNuAL+). That report gives details on the progress made in the implementation of ReNuAL, the scoping and costing of ReNuAL+ and resource mobilization.

B. Progress since the 60th Regular Session of the General Conference

B.1. Implementation Progress

3. Building construction has made steady progress since it commenced in July 2016 and remains on schedule and on budget, with ReNuAL and ReNuAL+ elements now being implemented. The frame and envelope of the new Insect Pest Control Laboratory (IPCL) are complete, and furnishing of the interior of the building is under way. Transition planning to prepare for the move from the current IPCL to the new IPCL began in early 2017.

4. Construction of the frame and envelope of all three planned laboratories of the new Flexible Modular Laboratory (FML) began in July 2017 and is planned for completion in the first quarter of 2018. Interior furnishing will be carried out concurrently beginning in October 2017. Full completion of the FML remains subject to the availability of further extrabudgetary resources that are required no later than September 2017 for the interior furnishing of the third laboratory. Installation of the new site infrastructure to support the operations of the IPCL and FML is proceeding simultaneously with building construction.

5. Construction of the new bunker for the Dosimetry Laboratory (DOL) to house a medical linear accelerator (linac) began in August 2017. The linac is planned to be delivered in March 2018 for installation and commissioning.

6. Four of the NA laboratories are planned to remain in the existing laboratory building and will receive targeted refurbishment to provide them with additional capabilities and to consolidate and modernize their space. The plan for the refurbishment programme will be completed by the end of

2017. Initial implementation of this programme can begin in 2018, but its larger components can only commence when space in the existing building is vacated by the laboratories that will move to the FML. This vacated space is necessary for the refurbishment programme to be implemented with minimal disruption to the operations of the laboratories remaining in the existing building.

B.2. ReNuAL+ Planning

7. Detailed planning for ReNuAL+ was carried out in the second half of 2016, with the resulting scope and cost estimates described in document GOV/INF/2017/1. The scope of ReNuAL+ consists of elements of ReNuAL that cannot be accommodated within ReNuAL's €31 million budget, as well as of the further upgrades required to complete the modernization of the NA laboratories. The target budget for ReNuAL+ is €26 million.

8. The elements of ReNuAL moved to ReNuAL+ have been prioritized for resource mobilization and implementation, and the implementation of some of these elements is now under way. These elements are: completion of the final part of the interior of the IPCL; construction of the third planned laboratory of the FML, the Animal Production and Health Laboratory (APHL); construction of the DOL bunker; and the remaining equipment needs that were part of ReNuAL's original scope.

B.3. Financial Status and Resource Mobilization

B.3.1. Financial Status

9. Full funding of the ReNuAL project's €31 million budget was achieved in September 2016.

10. More than €6 million in further extrabudgetary funds has been pledged or provided since fundraising for ReNuAL+ began in July 2016. These funds are sufficient to fund the completion of the IPCL, construction of the DOL bunker and construction of the frame and envelope of the APHL. Ten Member States, the Food and Agriculture Organization of the United Nations (FAO), one of the Agency's Collaborating Centres and two private individuals have provided these contributions. In the draft Programme and Budget for 2018–2019 €2 million has been proposed for ReNuAL+ in the MCIF for each year.

11. Overall, approximately €27 million in extrabudgetary funds has been raised for ReNuAL and ReNuAL+ to date, with financial contributions received from 29 Member States and other donors such as those mentioned above.

12. Currently, an additional €4.7 million in extrabudgetary funds is required no later than September 2017 to enable furnishing of the interior of the APHL to proceed on schedule with the other two FML laboratories. If these funds are not received in a timely manner, the construction contract for the FML will have to be restructured and the interior furnishing of the APHL extracted to be implemented later as a separate contract. This will delay completion of the FML and increase costs.

B.3.2. Resource Mobilization Strategy

13. The Secretariat has continued to pursue a project-specific resource mobilization strategy that seeks resources from Member States and non-traditional donors. In support of this strategy, new and targeted resource mobilization products have been developed for the individual elements of ReNuAL+, including a new ReNuAL+ donor package that provides comprehensive information on the project and its funding requirements. When suggested or required by specific potential donors, these products have been tailored to respond to the donors' particular interests or requirements.

14. Also in support of resource mobilization, the ReNuAL web pages were fully redesigned in the second quarter of 2017 with new content provided on ReNuAL+. The pages are continuingly updated

with new information. Furthermore, the Secretariat continues to publish periodic news briefs that report on the status of the project and promote awareness of its requirements. Laboratory tours continue to play an essential role in fundraising efforts, with 65 tours conducted since the 60th regular session of the General Conference.

B.3.3. Resource Mobilization Efforts with Member States

15. The Secretariat has continued to engage in bilateral discussions with a wide number of Member States to support fundraising. The goal of these activities is to maximize both the amount of funds raised as well as 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.

16. Members of the group have been significant bilateral contributors to the project, and the group remains an important vehicle for maintaining and increasing awareness of ReNuAL among Member States and for generating Member State support for the project. A Friends of ReNuAL tour of the construction site took place in March 2017, and meetings of the group were held in September 2016, May 2017 and July 2017 to call for additional contributions and support.

17. In order to keep Member States appraised of the status of the project and to request further financial support, the Secretariat issued, in February 2017, document GOV/INF/2017/1, which provides a detailed update on the status of ReNuAL and ReNuAL+ and current funding requirements. The Secretariat conducted an informal technical briefing in February 2017 to present the document to Member States.

B.3.4. Resource Mobilization Efforts with Non-traditional donors

18. The Secretariat has continued its efforts to attract support from non-traditional donors, with the primary focus remaining on equipment manufacturers to help meet the equipment needs of the laboratories. Since the 60th regular session of the General Conference, the Secretariat engaged with nine companies to discuss potential partnerships, with these discussions normally initiated by the manufacturers. Partnership discussions and negotiations tend to be complex and time-consuming given the differing requirements and priorities of the Agency and manufacturers. However, considerable progress has been made in developing modalities for cost-free loans of equipment that are consistent with the Agency's regulations, rules, policies and guidelines, with several partnership agreements either concluded or in process.

19. A key achievement has been the finalization of a partnership agreement with a manufacturer to provide the DOL with a linac, which has an estimated market value of €2.8 million, as a cost-free loan of equipment for up to ten years. In terms of estimated market value, this represents the largest partnership of its kind to date for the Agency. Such efforts will continue in order to obtain the required equipment for the NA laboratories at the lowest possible cost. In parallel, the Secretariat will continue to refine and streamline the process for establishing such partnerships.

20. In addition to equipment manufacturers, the Secretariat has also engaged with multiple foundations to seek contributions for elements of ReNuAL+. To date, no foundation has expressed interest in providing funding for an infrastructure project of this kind.

C. Next Steps

21. As building construction progresses toward completion, greater focus will be placed on the procurement of equipment still required to furnish the new laboratories, and transition planning will intensify to prepare for the move of laboratories into the new buildings. The portion of the IPCL to be completed under ReNuAL is scheduled to be done by December 2017, with the final portion to be built under ReNuAL+ planned for completion by the end of the first quarter of 2018. Transition into the new building is planned to take a minimum of six months.

22. The first two laboratories of the FML will be constructed under ReNuAL and are planned for completion in mid-2018. The APHL can be completed as part of ReNuAL+ by the end of 2018, provided the remaining required extrabudgetary funds are received in a timely manner. This will allow the transition of all laboratories into the FML to be completed by the third quarter of 2019. The DOL bunker is scheduled for completion at the end of the first quarter of 2018, with operations beginning in the third quarter of 2018.

23. Once the necessary funds have been raised to complete construction of the APHL, resource mobilization efforts will shift to focus on the remaining equipment needs as well as those related to the targeted refurbishment programme.

Use of Isotope Hydrology for Water Resources Management

A. Background

1. At its 59th regular session in September 2015, the General Conference, through resolution GC(59)/RES/12.A.3, requested the Director General to continue to further strengthen the efforts directed towards fuller utilization of isotope and nuclear techniques for water resource development and management in interested countries by helping Member States obtain easy access to isotopic analysis, including for noble gases, through the upgrading of selected laboratories; to expand activities related to the IAEA Water Availably Enhancement (IWAVE) Project and the management of groundwater resources; to strengthen activities which enhance understanding of the climate and of 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(59)/RES/12.A.3 to the Board of Governors and to the General Conference at its 61st regular session.

B. Progress since the 59th Regular Session of the General Conference

B.1. Strengthening of Isotope Hydrology Activities and the IWAVE Project

2. Groundwater is the 'reservoir' for 98% of the earth's available fresh water, representing about sixty times more fresh water than can be found in lakes and streams. Groundwater accounts for some 33% of total global water withdrawals and over half of all irrigation water used to grow the world's food. Despite its dominance as the primary source of fresh water, national water authorities usually have an incomplete understanding of the quantity and quality of groundwater. The capacities of scientific and technical authorities need to be strengthened so that they can understand these resources properly and substantiate and implement sound national water management policies and practices.

3. Groundwater dating provides essential knowledge for the sustainable exploitation of an aquifer, as it reveals the rate at which the aquifer recharges and gives an indication of the volume of water that can be removed without causing adverse effects as a result of falling water tables and/or disruption to ecosystems. New isotope analysis techniques, such as those using the isotopes of noble gases (helium, neon, argon, krypton and xenon), are at the forefront of efforts to promote understanding and technical capabilities in developing Member States, which are necessary for them to sustainably manage their water resources. The Agency has focused on research, training, protocol development and analytical services aimed at expanding the use of groundwater age dating with isotopes to map water resources.

4. In 2016, the pilot phase of the IAEA Water Availability Enhancement (IWAVE) Project, funded through the Peaceful Uses Initiative, was completed in Costa Rica, Oman and the Philippines. The three Member States, with assistance from the Agency and through national institutions with a water mandate, developed a comprehensive approach to identify gaps in their national hydrological

information systems, as well as in their capacities for sustainable water resources management. The project provided training in approaches to data sharing, and fostered dialogue and collaboration that led to new data collection and an improved understanding of resource availability. The Agency worked with experts in Costa Rica to develop a national 'Agenda for Water' outlining the country's goals. In Oman, it helped with the development of a scientifically sound assessment of groundwater in the agriculturally important Samail catchment. In the Philippines, capacity was strengthened in the National Water Resources Board and the Philippine Nuclear Research Institute to assess groundwater resources and their vulnerability to pollution in two of the country's nine water stressed regions.

5. The IWAVE methodology as tested in the pilot phase, and lessons learned therein, have been integrated into technical cooperation projects. A regional technical cooperation project RLA/7/018 "Improving Knowledge of Groundwater Resources to Contribute to their Protection, Integrated Management and Governance (ARCAL CXXXV)" was designed and is being implemented since 2014 with the objective of introducing the IWAVE methodology in some Member States in Latin America. The project succeeded in addressing water issues at the national scale and resulted in several additions and recommendations which will be included and further developed in the next phase of the project, starting in 2018. Similarly, one further regional technical cooperation project with similar objectives has been designed for the Africa region and proposed under the 2018-2019 TC Programme cycle.

6. The regional technical cooperation project RAF/7/011 'Integrated and Sustainable Management of Shared Aquifer Systems and Basins of the Sahel Region 'was completed in 2016. Based on new hydrological information acquired using hydrochemical and isotope tracers, project participants concluded that most of the shallow aquifers contained good quality, recently recharged, partly untapped groundwater, however the analysis indicated that some aquifers were locally affected by various sources of pollution. This information will contribute to better use and protection of the aquifers.

7. A regional technical cooperation project RAF/8/042 "Adding the Groundwater Dimension in the Nile Basin" was completed in 2016. The project assisted the nine riparian Member States- Burundi, Democratic Republic of the Congo, Egypt, Ethiopia, Kenya, Rwanda, Sudan, United Republic of Tanzania and Uganda- in building capacity for incorporating and assessing groundwater bodies in the management of the Nile Basin water resources. The Agency, in collaboration with Colorado State University (United States of America), developed a new model called IAEA Water Balance Model with Isotopes (IWBMIso) that was used within the framework of the project for improved estimation of catchment scale water balance using isotope data. The model has been made available on the Agency's website.

8. As a follow-up to the Technical Meeting held in 2014 on surface water and groundwater contamination following the accident at the Fukushima Daiichi nuclear power plant (NPP), the Agency, in cooperation with Japan's Ministry of Economy, Trade and Industry (METI), organized an experts' meeting in Tokyo, Japan, in February 2016. The experts attending this meeting reviewed the Tokyo Electric Power Company's (TEPCO's) achievements and future plans for understanding and managing groundwater inflow, and made recommendations for improvements to the models used for simulating groundwater flow. These recommendations were also disseminated to nearly 20 participants from various Japanese academic and research institutions through a seminar organized by METI immediately after the conclusion of the experts' meeting.

9. In addition, the Agency collaborated with METI and TEPCO in 2016 to conduct a study of groundwater at the Fukushima Daiichi NPP site using isotope hydrology, in particular the tritium-helium dating method to estimate the age of groundwater. Results indicated separate

groundwater flow systems in various geological layers, providing independent criteria for improved management of groundwater inflow into the reactor buildings.

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

10. A number of training courses were held to build Member State capacity in isotope hydrology. An interregional training course was held in Vienna, Austria, in 2016 with 16 participants from 14 Member States. The course focused on the advanced uses of multiple stable isotopes and radionuclides, and on an isotope-enabled water balance model for estimating water availability at basin and sub-basin scales. Furthermore, participants from 13 Member States also attended a one-week training course, held in Vienna, Austria, in October 2016, which covered low level tritium analyses for hydrological studies using a system developed by the Agency.

11. The number of Member State laboratories equipped through the technical cooperation programme to use isotope measurement techniques based on laser spectroscopy increased in 2016. Three laboratories in Bangladesh, Peru and the Philippines were equipped with lower cost and easy-to-use tritium enrichment units developed by the Agency. A total of 65 laboratories in 54 Member States now have the operational laser spectroscopy instruments that are required to measure stable oxygen and hydrogen isotopes.

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

13. The Agency upgraded its Isotope Hydrology Laboratory with the installation of a new mass spectrometer during the reporting period, in 2015, expanding its capacity to provide analytical services to Member States for groundwater age dating using noble gas isotopes. The new equipment doubles the number of samples that can be analysed for technical cooperation and research projects.

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

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

15. The Agency completed a CRP entitled ‘Environmental Isotope and Age Dating Methods to Assess Water Quality in Rivers Affected by Shallow Groundwater Discharges’ in 2016. Project participants used isotopic methods to assess how groundwater discharges affect the quality of river water, particularly given the impact of climate change on rainfall patterns and groundwater recharge. The results of individual studies were published in peer reviewed journals in 2016 and will be used as reference material for future technical cooperation projects.

Nuclear Energy Activities

A. General

1. This Annex highlights a number of activities undertaken by the Agency as requested by the General Conference in resolution GC(60)/RES/12, specifically in Section A.1 on non-power nuclear applications and in Section B on nuclear power applications.

2. To assist Member States in establishing regional training and education centres for the specialized training of nuclear and radiological experts, the Agency has continued to support the regional networks of research reactors and their regionally managed training programmes. In the field of disused sealed radioactive sources, the Agency has maintained its support for the development of local capabilities in Africa and South-East Asia, including in the use of mobile hot cell units for the conditioning of spent high activity radioactive sources.[1]

3. The Agency continued to engage stakeholders to sensitise and address the challenges in regards to the long term availability of research reactor fuels. Specifically, assistance was provided through the relevant national technical cooperation (TC) project to Indonesia to explore the possibility of converting the TRIGA research reactor in Bandung to use plate-type fuel. The Agency cooperated in the organization of the 37th annual International Meeting on Reduced Enrichment for Research and Test Reactors, which was hosted by the United States Department of Energy's National Nuclear Security Administration (NNSA) and organized by Argonne National Laboratory in October 2016 in Antwerp, Belgium.[2]

4. The Agency continued providing support to interested Member States for the development of national capacities in the operation of nuclear power plants (NPPs) and in embarking on new nuclear power programmes. For example, a capacity building digital hub, accessible to all Member States, was introduced. This new resource features communities of practice, links to online versions of relevant Agency publications and documents, and e-learning facilities to support human resource development (HRD) and the implementation of training and management system requirements. The Agency also continued to support Member States interested in, or embarking on, new or expanded nuclear power programmes in establishing the appropriate legal/legislative and regulatory framework, strengthening coordination among national institutions, drafting and reviewing HRD plans, and developing radioactive waste management policies and strategies. Through focused interregional, regional and national workshops, training courses and fellowships, the Agency provided substantive guidance on various infrastructure issues to organizations involved in nuclear power development, including regulatory bodies and technical support organizations. More than 45 events (including Technical Meetings, roadmap discussions, self-evaluation support missions and expert missions/workshops) took place in 2016–2017, focusing on the enhancement of Member States' awareness and understanding of the Agency's Milestones approach for the development of a national infrastructure for nuclear power, as well as on specific key infrastructure issues, such as establishing a national position on nuclear power programmes, management, HRD, funding and financing, and radioactive waste management. In addition, Member States' capacities for energy planning were strengthened to assist with the submission and maintenance of their nationally determined contributions under the Paris Climate

[1] This relates to operative paragraph 19 of resolution GC(60)/RES/12.A.1.

[2] This relates to operative paragraph 20 of resolution GC(60)/RES/12.A.1.

Change Agreement. New approaches and tools were developed, including e-learning packages and distance training facilities that can be used prior to face-to-face training. New assessment methodologies and tools were developed to compare the economics of energy technologies (including nuclear power) and assess lifetime extension of existing NPPs. Furthermore, a Technical Meeting on the Macroeconomic Benefits of Nuclear Power Programmes was held from 21 to 25 November 2016 in Vienna, Austria, with 15 participants from 10 Member States. Participants discussed methods and models for assessing the macroeconomic impact of nuclear energy. Also, a coordinated research project (CRP) entitled 'Assessing the National and Regional Economic and Social Effects of Nuclear Programmes' is in progress. Within the framework of this project, participants from 15 Member States have presented case studies at the country level and shared their experiences with the application of models for quantitative macroeconomic analysis of nuclear projects. A Training Course on Understanding the Physics and Technology of Pressurized Water Reactors Using Educational Basic Principle Simulators was held from 24 to 28 October 2016 in Ocoyoacac, Mexico, with 46 participants from one Member State. A Workshop on the Physics and Technology of Innovative Nuclear Energy Systems for Sustainable Development, organized jointly by the International Centre for Theoretical Physics (ICTP) and the Agency, was held in Trieste, Italy, from 29 August to 2 September 2016. Another joint event was the Training Course on the Application of Computational Fluid Dynamics Codes to Nuclear Power Plant Design and Safety Analysis, organized by Shanghai Jiao Tong University (SJTU) and the Agency, which was hosted by SJTU in Shanghai, China, from 29 August to 2 September 2016 and attended by 60 participants from three Member States. Finally, the Agency conducted a National Workshop on Nuclear Reactor Technology Assessment under the relevant TC project in Nairobi, Kenya, from 19 to 21 June 2016.[3]

5. Member States are receiving support to enable them to adopt a holistic approach towards HRD spanning the complete 'life cycle' of a nuclear worker, from the selection and recruitment of staff, initial training and development, ongoing career opportunities, staff motivation and retention issues, leadership and management development and transition, through to retirement. Such an approach is appropriate for both embarking countries and Member States with ongoing nuclear power programmes that face challenges in nuclear workforce demographics associated with lifetime extensions and the progress into decommissioning. The 'feeder' organizations that provide the necessary education and training to new generations also form part of the nuclear worker life cycle. In this connection, the wide variety of representatives from nuclear facilities, nuclear utilities, nuclear regulatory bodies and academia from 19 Member States who attended the 12th meeting of the Technical Working Group on Managing Human Resources in the Field of Nuclear Energy (TWG-MHR) held in Vienna, Austria, from 13 to 17 June 2016, offered valuable insights into many aspects of using a holistic approach for the management of human resources. In response to the recommendations from the TWG-MHR meeting, a number of capacity building initiatives have been launched, including the creation of an HRD self-assessment and assistance service, the development of an accreditation methodology for a systematic approach to nuclear training, the identification of new ways of learning to support nuclear education and training programmes, the development of guidance on fitness for duty of a nuclear workforce, and a CRP on organizational culture. Technical Meetings under all these initiatives are taking place throughout 2017, and associated publications are under development. The Secretariat is also developing an HRD digital hub to improve communication and access to Agency information. With respect to waste management, strong and active support continues to be provided through over 70 TC projects that are currently being implemented, and a further 30 projects in this area are at the design stage.[4]

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[3] This relates to operative paragraphs 2 and 4 of resolution GC(60)/RES/12.B.1.

[4] This relates to operative paragraph 3 of resolution GC(60)/RES/12.B.1.

6. There are currently over 45 national, regional and interregional TC projects supporting countries that are considering or planning the introduction of nuclear power. In order to better coordinate the assistance it provides to newcomer countries, the Agency implemented coordination mechanisms such as Country Nuclear Infrastructure Profiles (CNIPs) and Integrated Work Plans (IWPs). Each CNIP maintained by the Agency reflects the results of Integrated Nuclear Infrastructure Review (INIR) missions and other Agency review services, and shows the status of individual countries that have hosted such missions. Each IWP, on the other hand, is a mutually agreed working document describing the Agency's planned nuclear infrastructure support activities in the Member State for a fixed period. Taking into account the recommendations from the INIR missions, complemented by the results of other Agency review services and TC projects, the CNIPs and IWPs of several countries have been updated in consultation with the Member States concerned. This process has permitted all Agency Departments involved in infrastructure development projects to integrate their efforts to develop jointly an appropriate package of services and advice commensurate with a Member State's status of progress and available Agency resources. In addition, the Agency's INIR missions continue to be in high demand among embarking Member States. These missions provide governments and nuclear programme stakeholders with an overall, integrated view of their status with respect to all 19 infrastructure issues outlined in the Milestones approach to the introduction of a nuclear power programme. As part of INIR missions, Agency experts from the Departments of Nuclear Energy, Nuclear Safety and Security, and Safeguards as well as from the Office of Legal Affairs, together with international experts, review progress in infrastructure development achieved by the host country and make recommendations and suggestions on how further progress can be made. INIR recommendations enable Member States to determine which infrastructure areas require further development to meet programme needs and schedule requirements. Since the first INIR mission in 2009, 22 INIR missions (18 full missions and 4 follow-up missions) have been conducted in 16 Member States at their specific request. Subsequent to the 60th regular session of the General Conference in September 2016, INIR Phase 1 missions were conducted in Ghana, Kazakhstan and Malaysia. Self-evaluation support and pre-INIR missions were conducted in Algeria, the Sudan and Tunisia. In accordance with requests from Member States, INIR missions are planned for Poland, Tunisia and the United Arab Emirates before the end of 2017.

7. The Agency continued to pursue activities in the areas of innovative nuclear technologies with a view to strengthening infrastructure, safety and security, and fostering science, technology, engineering and capacity building through the utilization of existing and planned experimental facilities and materials testing reactors, as well as through the development and validation of advanced modelling and simulation tools. In this connection it is worth mentioning the newly developed Catalogue of Facilities in Support of Liquid Metal Cooled Fast Neutron Systems (LMFNS Catalogue), a living database that presents detailed information on more than 150 experimental facilities under design, construction or operation in 14 Member States. It contains detailed data and information on 79 facilities that can support the development of sodium cooled fast reactors (SFRs), as well as on 72 facilities that can support the development of lead and lead–bismuth eutectic cooled fast reactors (LFRs). Multiple-choice filtering options by main research fields, by reactor type (SFR, LFR and dual SFR/LFR application) and by country are available. A new IAEA Nuclear Energy Series publication entitled *Experimental Facilities in Support of Liquid Metal Cooled Fast Neutron Systems: A Compendium,* to be published in 2017, will present an overview of, as well as detailed information on, the experimental facilities covered by the LMFNS Catalogue. Both the database and the associated publication aim to facilitate cooperation between organizations with an active programme on fast neutron systems, and are expected to enhance the utilization of such facilities within the associated experimental programmes and to motivate young engineers and researchers to work in the field of advanced reactors. An IAEA Technical Document (TECDOC) on the results of the CRP entitled 'Benchmark Analyses of an EBR-II Shutdown Heat Removal Tests' was published in 2017, in connection with the International Conference on Fast Reactors and Related Fuel Cycles: Next

Generation Nuclear Systems for Sustainable Development which was held in Yekaterinburg, Russian Federation, from 26 to 29 June 2017. The fourth Research Coordination Meeting (RCM) of the CRP entitled 'HTGR Reactor Physics, Thermal-Hydraulics and Depletion Uncertainty Analysis' took place in Vienna, Austria from 22 to 25 May 2017. Phase I of the CRP is currently being finalized. Within the framework of this CRP, 18 participants from 7 Member States have reviewed high fidelity methods and a unique approach to quantify uncertainties in high temperature gas cooled reactor (HTGR) design and safety analyses through the comparison of results from well-defined benchmark problems. The CRP entitled 'Application of Computational Fluid Dynamics (CFD) Codes for Nuclear Power Plant Design' is ongoing and involves 11 participants from 11 Member States. This CRP will result in the publication of one IAEA Nuclear Energy Series report and two TECDOCs summarizing current and planned applications of CFD computer codes around the world, and documenting in detail two benchmarks for the validation of such codes. Under this CRP a training course on the fundamentals of CFD computer codes and their use in NPP design and safety demonstration was developed and organized in Shanghai, China, from 29 August to 2 September 2016, with over 60 participants attending. A second Training Workshop on the Development of Severe Accident Management Guidelines Using the Agency's Severe Accident Management Guideline Development (SAMG-D) Toolkit was held in Vienna, Austria, from 15 to 16 December 2016 and attracted 47 participants from 25 Member States and three international organizations: the Institute of Nuclear Power Operations, the Nuclear Energy Agency of the Organisation for Economic Co-operation and Development (OECD/NEA), and the WANO Moscow Centre . The workshop provided unique and up-to-date information on the development of severe accident management guidelines (SAMGs) and their application and use in many countries. The update and maintenance of the SAMG-D Toolkit, initially released in July 2015, has been completed and the new version is to be released during the third quarter of 2017.

8. The Institute for Transuranium Elements of the European Commission's Joint Research Centre organized, in cooperation with the Agency, the 53rd Annual Meeting on Hot Laboratories and Remote Handling at its headquarters in Karlsruhe, Germany, from 2 to 6 October 2016. Approximately 60 participants attended the meeting and presented a comprehensive overview of hot lab activities in their countries. The 2016 Nuclear Materials Conference (NuMat2016) was organized by the French Alternative Energies and Atomic Energy Commission, in association with the *Journal of Nuclear Materials* and in cooperation with the Agency, in Montpellier, France, from 7 to 10 November 2016. Approximately 360 participants attended the conference. NuMat serves as an umbrella for international meetings on nuclear materials science related to fission and fusion reactors and the overall nuclear fuel cycle.[5]

9. The Agency continued and strengthened efforts, together with other relevant international organizations and initiatives, to assist Member States in developing robust and harmonized regulatory approaches in support of the licensing of innovative nuclear systems. Within the framework of the Agency's collaboration with the Generation IV International Forum (GIF), a series of joint Agency-GIF workshops on the safety of SFRs have been held since 2010. The sixth IAEA–GIF Technical Meeting/Workshop on the Safety of Sodium Cooled Fast Reactors took place in Vienna, Austria, from 14 to 15 November 2016 and was attended by 20 participants from 9 Member States who discussed the results of the Agency's review of the GIF report on Safety Design Criteria and Safety Design Guidelines for SFRs. A CRP entitled 'Modular High Temperature Gas Cooled Reactor Safety Design' with 15 participants from 9 Member States and two representatives from GIF is ongoing. The applicability of the Agency's current safety design criteria for large water-cooled

[5] This relates to operative paragraph 7 of resolution GC(60)/RES/12.B.1 and operative paragraph 19 of resolution GC(60)/RES/12.B.4.

reactors as well as the development of new specific design criteria for High Temperature Gas-cooled Reactors (HTGRs) are being explored as part of this CRP. Possible cooperation with the Generation IV International Forum to develop the criteria further for Very High Temperature Reactor applications is also being discussed.

10. Two meetings of the International Scientific Programme Committee for the 2017 International Conference on Fast Reactors and Related Fuel Cycles: Next Generation Nuclear Systems for Sustainable Development (FR17) were organized in Vienna, Austria, in November 2016 and April 2017 to review the more than 550 abstracts submitted and to draw up the conference's scientific programme. The conferences in this series are organized every four years, and they constitute the most important forum on fast reactors and related fuel cycle technology. The 2017 conference was the third in the series — following on from the two previous international conferences held in Kyoto, Japan, in 2009 and Paris, France, in 2013 — and it took place from 26 to 29 June 2017 in Yekaterinburg, Russian Federation, close to the BN-600 reactor at the Beloyarsk NPP, an SFR which has been in operation since 1980, and its successor, the BN-800 reactor, which was recently put into operation. The conference, which was hosted by the Government of the Russian Federation through the State Atomic Energy Corporation "Rosatom", was attended by 610 experts from 29 Member States and three international organizations. In addition, the Department of Nuclear Safety and Security and the Department of Nuclear Energy jointly organized the International Conference on Topical Issues in Nuclear Installation Safety: Safety Demonstration of Advanced Water Cooled Nuclear Power Plants, which was held in Vienna, Austria, from 6 to 9 June 2017 with approximately 300 participants from 48 Member States and 5 international organizations. The purpose of the conference was to foster the exchange of information on the latest approaches, advances and challenges in the demonstration of the safety of NPPs that are planned to be licensed and constructed in the near future, in particular those with advanced water cooled reactors and small and medium sized or modular reactors.[6]

11. A Technical Meeting on the Status of Molten Salt Reactor Technology was held in Vienna, Austria, from 31 October to 3 November 2016 with 35 participants from 17 Member States. It was the first comprehensive international meeting on molten salt reactors to be organized by the Agency and served as an opportunity for Member States to share information on the status, prospects and challenges of this advanced reactor technology, laying the foundations for enhanced international cooperation in this area. A TECDOC on the status of molten salt reactor technology is under development.[7]

12. Efforts to reduce the number of finalized but unpublished documents have been twofold. The Agency has worked to find pragmatic solutions to quality issues such as figure/formats and has provided more in-depth editing and rewriting services where needed. To address the issue of speed of publication, additional support mechanisms have been introduced, including increased resources, where feasible, during busy times as well as a programme of updates to introduce workflow support and provide more transparency during the final stage of the process of producing a publication.[8]

13. In March 2016, the Agency launched a new web page for Member States to review upcoming documents that are being prepared for publication as part of the IAEA Nuclear Energy Series. This information is shared at the earliest stage of the process and allows Member States (via their Permanent Missions) to contact an identified focal point (Publications Officer) to express interest in reviewing the document before it is published. In addition, numerous Technical Meetings are held at

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[6] This relates to operative paragraph 9 of resolution GC(60)/RES/12.B.1.

[7] This relates to operative paragraph 10 of resolution GC(60)/RES/12.B.1.

[8] This relates to operative paragraph 11 of resolution GC(60)/RES/12.B.1.

which Member State representatives have the opportunity to contribute to the drafting of various types of documents.[9]

14. The 26th edition of the 'Red Book', a recognized world reference on uranium jointly prepared by the OECD/NEA and the IAEA, was published in November 2016 and provides analyses and information from 49 uranium producing and consuming countries. Regarding uranium production, a Training Workshop on the Evaluation of Undiscovered Uranium Resources was organized in Buenos Aires, Argentina, from 24 to 28 October 2016 with 28 local Argentinian and 18 international experts, illustrating the high level of Member State interest in assessing potential uranium resources for their own countries. A Training Workshop on Uranium Geochemistry in the Asia-Pacific Region was held in Bangkok, Thailand, from 16 to19 May 2017 and attended by 36 participants from 19 Member States interested in sustainable uranium mining. The second RCM of the CRP entitled 'Geochemical and Mineralogical Characterization of Uranium and Thorium Deposits' was organized in Kingston, Canada, from 30 May to 2 June 2017. It was attended by eight participants from eight Member States who presented the activities they had carried out since the beginning of the CRP and their plans for the second part of the project. The first consultancy meeting to prepare for the International Symposium on Uranium Raw Material for Nuclear Fuel Cycle: Exploration, Mining, Production, Supply and Demand, Economics and Environmental Issues (URAM-2018) was held in Vienna, Austria, from 8 to 11 May 2017 and attended by eight experts from seven Member States and one international organization (the United Nations Economic Commission for Europe (UNECE)).[10]

15. The second RCM of the CRP entitled 'Analysis of Options and Experimental Examination of Fuels for Water Cooled Reactors with Increased Accident Tolerance' took place in Vienna, Austria, from 20 to 22 June 2017. It was attended by 18 participants from 13 Member States and one international organization who reviewed the research activities carried out since the first RCM and discussed the plans for the second half of the CRP, the main objectives of which are to provide information to Member States in support of decision-making on the choices available to improve the safety of NPPs under severe accident conditions; to provide data, analyses and advanced techniques for understanding and predicting the behaviour of the fuel components and the integral performance of accident tolerant fuel designs under normal and transient conditions; and to demonstrate improvements to fuel performance under severe accident conditions.[11]

16. In order to move forward with the establishment of the IAEA Low Enriched Uranium Bank, a transit agreement between the IAEA and China was signed in Beijing on 5 April 2017 for the transport of low enriched uranium (LEU). Furthermore, the Agency held a workshop in Vienna, Austria, from 3 to 5 October 2016 with 39 participants from 18 Member States to present those factors that may be relevant to LEU acquisition. The outcomes of the workshop have been considered in the revision of the Procurement Plan for the acquisition of LEU for the IAEA LEU Bank.[12]

17. The Agency continues to strengthen its efforts related to nuclear power, the nuclear fuel cycle and radioactive waste management in Member States. A number of meetings have been jointly organized by the Department of Nuclear Energy and the Department of Nuclear Safety and Security, such as the International Conference on the Safety of Radioactive Waste Management, held in Vienna, Austria, from 21 to 25 November 2016, with 276 participants from 63 Member States and 4 international organizations. A Workshop on the Integrated Review Service for Radioactive Waste

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[9] This relates to operative paragraph 12 of resolution GC(60)/RES/12.B.1.

[10] This relates to operative paragraphs 13 and 14 of resolution GC(60)/RES/12.B.1.

[11] This relates to operative paragraph 15 of resolution GC(60)/RES/12.B.1.

[12] This relates to operative paragraphs 16 and 17 of resolution GC(60)/RES/12.B.1.

and Spent Fuel Management, Decommissioning and Remediation (ARTEMIS) was held in Vienna, Austria, from 10 to 13 April 2017 with over 96 participants from 49 Member States. A new TECDOC entitled *Processing of Irradiated Graphite to Meet Acceptance Criteria for Waste Disposal* (IAEA-TECDOC-1790) was published in 2016. The Agency cooperated with other organizations in the following meetings: the fifth International Conference on Geological Repositories in December 2016 in Paris, France, hosted by the OECD/NEA, in close cooperation with France's National Radioactive Waste Management Agency; the eighth workshop of the European ALARA Network for Naturally Occurring Radioactive Materials in December 2016 in Stockholm, Sweden, hosted by the Swedish Radiation Safety Authority; a Workshop on Current and Emerging Methods for Optimising Safety and Efficiency in Nuclear Decommissioning from 7 to 10 February 2017 in Sarpsborg and Halden, Norway, hosted by the Institute for Energy Technology and the OECD/NEA's Halden Reactor Project; a Workshop on Strengthening the Security of Radioactive Sources in Central Asia from 24 to 25 May 2017 in Astana, Kazakhstan, hosted by the Nuclear Threat Initiative (USA) and the Center for Energy and Security Studies (Russian Federation), in partnership with the Agency and the Government of Kazakhstan; the eighth annual Nuclear Decommissioning and Waste Management Conference Europe organized by Nuclear Energy Insider (UK) from 24 to 25 May 2017 in Manchester, United Kingdom[13]; the 2017 Waste Management Conference in March 2017 in Phoenix, Arizona, USA, organized by WM Symposia; the International Conference on Risk Perception, Communication and Ethics of Exposures to Ionizing Radiation: Social and Ethical Aspects of Decision-making in Radiological Risk Situations in Vienna, Austria, from 25 to 28 June 2017, in cooperation with the Belgian Nuclear Research Centre; and a workshop of the European Commission-supported project 'Metrology for Decommissioning Nuclear Facilities' in October 2016. In addition, the Agency participated in the following international activities: a Workshop on Low-Level Radioactive Waste Management and Disposition, with the US National Academy of Sciences in Washington DC, United States of America, from 24 to 25 October 2016; a meeting of the scientific advisory board for the DISTINCTIVE project[14] in York, United Kingdom, from 5 to 6 April 2017; a joint ICTP–Agency Workshop on Radiation Effects in Nuclear Waste Forms and Their Consequences for Storage and Disposal, held in Trieste, Italy, from 12 to 16 September 2016 with 34 participants from 17 Member States; the work of the scientific advisory board of the Austrian radioactive waste management organization (Nuclear Engineering Seibersdorf); the meeting of the OECD/NEA Working Party on Decommissioning and Dismantling hosted by Italy's Nuclear Plant Management Company (SOGIN) in Rome, Italy, from 25 to 27 October 2016; the meeting of the OECD/NEA Radioactive Waste Management Committee in Paris, France, from 30 to 31 March 2017; a meeting of the European Nuclear Safety Regulators Group's Working Group on Waste Management and Decommissioning in Córdoba, Spain, on 8 March 2017; and the second meeting of the OECD/NEA Expert Group on Waste Inventorying and Reporting Methodology in Paris, France, on 22 February 2017.[15]

18. The Agency continued to encourage international cooperation in the safe management of spent fuel and radioactive waste. A fourth CRP on the subject of 'Spent Fuel Performance Assessment and Research' (SPAR-IV) was initiated in 2016 with 11 participating institutions from 9 Member States. The main objective of the SPAR-IV project is to develop a technical knowledge base on the long term behaviour of power reactor spent fuel and storage system materials through the evaluation of operating

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[13] See: http://www.nuclearenergyinsider.com/decom/.

[14] The DISTINCTIVE ('Decommissioning, Immobilisation and Storage Solutions for Nuclear Waste Inventories') consortium links a set of 32 world-leading research projects within the broad area of nuclear waste management, decommissioning and disposal. The consortium is a collaboration of ten universities and three key industry partners from across the United Kingdom.

[15] This relates to operative paragraph 19 of resolution GC(60)/RES/12.B.1.

experience and research. The first RCM of this CRP was held in Vienna, Austria, from 15 to 19 August 2016. Most of the discussions focused on hydride reorientation (zirconium clad fuels), new studies of thermal analysis modelling of spent fuel, and storage casks.[16]

19. Close cooperation continues with the OECD/NEA and the European Commission on the preparation of the tripartite report *Status and Trends in Spent Fuel and Radioactive Waste Management*, and the final draft of the report is now being reviewed within the Secretariat. This report is closely linked to the Net Enabled Waste Management Database (NEWMDB), which has received authorized submissions from 46 Member States covering over 90% of existing operational NPPs. As part of efforts to improve Agency safety standards as well as to strengthen cooperation with other international organizations in this area, a Technical Meeting of NEWMDB Country Coordinators will be held in September 2017 with 25 participants from 20 Member States.[17]

20. Progress was made on the preparation of a report entitled *Processing and Storage of Activated Materials from Reactor Cores and Structures* through the work done at a Technical Meeting held in Vienna, Austria, from 10 to 14 July 2017 with 24 participants from 16 Member States. With respect to e-learning on topics related to radioactive waste management and/or disposal; the Agency published 15 new lectures (under 7 existing e-learning modules) covering disused sealed radioactive sources (DSRSs), geological disposal and environmental remediation. In the area of decommissioning, a further 16 lectures under 8 existing modules were upgraded to include narration. In order for these lectures to be more accessible to Member States, 12 lectures on the fundamentals of radioactive waste disposal and on principles, policies and strategies in this area were translated into Russian, and 8 lectures in the area of DSRSs were translated into French and Spanish. The preparation of e-learning material on spent fuel management is in its final phase, and similar work is under way to develop new material on predisposal radioactive waste management and to update the existing lecture on environmental remediation.[18]

21. The Agency continued the preparation of Safety and Technical Reports and on the management of large amounts of waste generated after a nuclear or radiological accident, and on the implementation of post-accident decommissioning and environmental remediation projects. Progress on the report entitled *Lessons Learned in Predisposal Management of Radioactive Waste in the Aftermath of Nuclear Accidents* was achieved thanks to a meeting of experts in July 2017 to finalize the draft manuscript. Work towards completion of a new publication entitled *Contracting in Decommissioning and Environmental Remediation* continued through internal review of the draft report which addressed the comments raised by various Member States. A draft document entitled *Guidance for Developing Cost Estimates for Environmental Remediation Projects* was finalized.[19]

22. The Agency continued to promote information sharing in order to achieve better integration of approaches to the back end of the fuel cycle that have an impact on retrievability, transportation and recycling of spent nuclear fuel. For example, the CRP entitled 'Options and Technologies for Managing the Back End of the Research Reactor Nuclear Fuel Cycle' is progressing, and the second RCM was held from 29 August to 2 September 2016 in Kjeller, Norway, with 17 participants from 13 Member States. The third and last RCM is planned to take place in December 2017, and the development of an Agency publication on the topic of this project has been initiated. The second RCM under the CRP entitled 'Benchmarks of Computational Tools against Experimental Data on Fuel

[16] This relates to operative paragraphs 18 and 20 of resolution GC(60)/RES/12.B.1.

[17] This relates to operative paragraphs 21, 25 and 28 of resolution GC(60)/RES/12.B.1.

[18] This relates to operative paragraph 22 of resolution GC(60)/RES/12.B.1.

[19] This relates to operative paragraph 23 of resolution GC(60)/RES/12.B.1.

Burnup and Material Activation for Utilization, Operation and Safety Analysis of Research Reactors' was held from 18 to 22 July 2016 in Vienna, Austria, with 13 participants from 11 Member States.[20]

23. The Agency formulated milestone and guidance documents on decommissioning and action plans to support decommissioning. Two new publications on these topics were issued in 2016: *Managing the Unexpected in Decommissioning* (IAEA Nuclear Energy Series No. NW-T-2.8) and *Advancing Implementation of Decommissioning and Environmental Remediation Programmes* (IAEA Nuclear Energy Series No. NW-T-1.10). A Technical Meeting to prepare a new publication based on the Constraints to Implementing Decommissioning and Environmental Remediation (CIDER) Project was held in July 2016, with 35 participants from 35 Member States, resulting in finalization of the draft text, which is entitled *Lessons Learned from Deferred Dismantling of Nuclear Facilities*. A further new publication with the provisional title *Contracting and Partnering in Decommissioning and Environmental Remediation* is being developed. A final draft of the report entitled *Addressing Uncertainties in Cost Estimates for Decommissioning Nuclear Facilities* was prepared for publication. Furthermore, the Agency supported an international cooperation framework for the implementation of decommissioning with a view to promoting the safe, secure, efficient and sustainable execution of decommissioning-related activities by further strengthening the following networks that are active in this field: the International Decommissioning Network (IDN), the Network on Environmental Management and Remediation (ENVIRONET), the Underground Research Facilities Network for Geological Disposal (URF Network), the International Network of Laboratories for Nuclear Waste Characterization (LABONET), the International Predisposal Network (IPN), and the International Low Level Waste Disposal Network (DISPONET). The Agency's efforts to enhance the implementation of decommissioning activities were discussed at various meetings of the above-mentioned networks: a Technical Meeting of the IDN held in November–December 2016, with 33 participants from 19 Member States; a Technical Meeting of ENVIRONET held in November-December 2016, with 39 participants from 25 Member States; a Technical Meeting of the URF Network held in October 2016, with 20 participants 17 Member States; a Technical Meeting of LABONET held in November 2016, with 28 participants from 20 Member States; a joint IPN-DISPONET Technical Meeting on the Management of Radioactive Waste Streams That Present Specific Challenges held in November–December 2016, with 20 participants from 19 Member States; and a Technical Meeting of DISPONET held in July 2016, with 20 participants from 19 Member States.[21]

24. The Agency continued to promote the Integrated Review Service for Radioactive Waste and Spent Fuel Management, Decommissioning and Remediation (ARTEMIS), explaining its benefits as a means of encouraging Member States to request such peer reviews where appropriate. Specifically, the Agency continued with the development of ARTEMIS guidelines and procedures, taking into account the Member States' various needs as well as the Agency's experience with other peer review services, while at the same time accepting Member States' requests for such missions. The objective is to deliver an effective and supportive review service, as a joint and coordinated effort of two Departments (Nuclear Energy and Nuclear Safety and Security). Specific activities include a workshop on the ARTEMIS service held in Vienna, Austria, from 10 to 13 April 2017, with 96 participants from 49 Member States, and the planning of ARTEMIS review missions to the following Member States: Italy in July 2017 (with the mission to focus on decommissioning); Australia in 2017/2018 (siting of a near surface repository); and, within the framework of the European Union's Radioactive Waste and Spent Fuel Management Directive (Council Directive 2011/70/Euratom), Poland in October 2017, France in January 2018, Spain in October 2018, and Denmark in 2020–2021.

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[20] This relates to operative paragraphs 24 and 43 of resolution GC(60)/RES/12.B.1.

[21] This relates to operative paragraph 26 of resolution GC(60)/RES/12.B.1.

Finally, the Agency is ensuring continuous mobilization of available in-house experience and expertise, as well as continuous cooperation with experts from the Member States.[22]

25. The Agency continued to provide assistance to Member States, including those embarking on nuclear power programmes, with the development and implementation of adequate disposal programmes. A suite of documents is currently being developed that will give an updated overview of best practices in this area. These include the *Roadmap for the Development of a Geological Disposal Programme*, a report entitled *Site Investigation Technologies and Techniques for Radioactive Waste Disposal Facilities*, the *Compendium of Results of Research, Development and Demonstration Activities Carried out at Underground Research Facilities for Geological Disposal*, a report entitled *Communication and Stakeholder Involvement in Radioactive Waste Disposal*, and a report entitled *Costing Methods and Funding Schemes for Radioactive Waste Disposal Programmes.* Consultancy and/or Technical Meetings were held, or are planned, to further capture international best practices and to bring all of these documents to the publication stage. Furthermore, a Technical Meeting on the Compendium of Results of Research, Development and Demonstration Activities Carried out at Underground Research Facilities for Geological Disposal will be held in Gyeongju, Republic of Korea, in September 2017, with 30 participants from 30 Member States. This meeting will contribute to the preparation of an almanac covering 50 years of global research, development and demonstration activities conducted at underground research facilities. Also, a Technical Meeting was held in May 2017, with 30 participants from 30 Member States to advance the work on the planned new publication entitled *Site Investigation Technologies and Techniques for Radioactive Waste Disposal Facilities*.[23]

26. Preparations for the fourth International Ministerial Conference on Nuclear Power in the 21st Century, which will take place in Abu Dhabi, United Arab Emirates, from 30 October to 1 November 2017, have continued throughout the reporting period. The conference programme has been agreed and participants for the various round table sessions identified. A website for the conference has also been developed, and over 400 participants are expected.[24]

27. The 14th workshop on management systems organized jointly by the Agency and the European Atomic Forum was held in Vienna, Austria, in December 2016. The workshop had the theme "Leadership and Management: From Standards to Practices" and sought to raise awareness and increase understanding of management systems and of how these can integrate all the vital objectives of nuclear facilities and activities. Over 110 participants from 28 Member States attended the workshop, which provided an international forum for the exchange of information on the status of various management system and quality management standards, as well as the sharing of experience, practical examples and case studies related to leadership/organizational culture, implementation of the risk based/informed approach as part of an integrated management system, and practices in various countries. Moreover, a Technical Meeting on Management and Leadership of Nuclear Projects from New Build to Decommissioning will be held in Vienna, Austria, from 7 to 10 August 2017. Also, in support of all aspects of decommissioning, radioactive waste management, environmental remediation and the management of DSRSs, a Technical Meeting on Experiences in the Management of Disused Ionizing Smoke Detectors was held in Vienna, Austria, in May 2017 with 12 participants from 8 Member States. A number of successful operations were conducted in 2016 to remove DSRSs from user premises and to relocate them to proper storage conditions. The repatriation of one French-origin Category 1 teletherapy DSRS from Lebanon took place in August 2016. Similarly, one Category 1

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[22] This relates to operative paragraph 27 of resolution GC(60)/RES/12.B.1.

[23] This relates to operative paragraph 29 of resolution GC(60)/RES/12.B.1.

[24] This relates to operative paragraph 30 of resolution GC(60)/RES/12.B.1.

disused source was removed from a teletherapy head in Uganda and transferred to safe and secure storage allowing for refurbishment of the bunker with a new teletherapy device and the resumption of cancer treatment services in Uganda. The Agency initiated removal projects of Category 1 and 2 disused sources in several Member States, including Albania, Burkina Faso, Lebanon and the former Yugoslav Republic of Macedonia, with removals scheduled for completion in 2017.[25]

28. The Agency continued to enhance Member States' understanding of potential approaches to the financing of nuclear power programmes, including radioactive waste management, in a changing international financial landscape. A Technical Meeting has been scheduled for the fourth quarter of 2017 to discuss resource requirements for nuclear power infrastructure development as well as a new IAEA Nuclear Energy Series publication that is being prepared on this topic. Workshops on financing nuclear power programmes, decommissioning and radioactive waste management funds were held in a number of Member States upon request. A Regional Meeting on the Economics of Nuclear Power, Funding of Nuclear Power Programmes and Risk Allocation in Nuclear Power Projects was held in Nairobi, Kenya from 10-13 April 2017, and attended by 44 participants from 22 African Member States. The CRP entitled 'Financing Nuclear Investments' coordinates efforts by Member States, supported by in-house activities, to seek innovative ways of financing nuclear energy projects in the fast changing world of the global financing industry. Participants, drawn from Australia, Bulgaria, China, Croatia, Indonesia, Jordan, Kenya, Pakistan, South Africa, Uruguay and Viet Nam, presented their finalized projects at the third and final RCM of the CRP held in November 2016. A Technical Meeting on Financial Modelling in December 2016 was attended by 19 participants, who were taught/educated to become 'knowledgeable customers' with a good understanding of financial models for new build NPPs so that they can oversee the quality of the work carried out by financial advisors, as well as understand the ways in which a model can and should be used as part of the decision-making process in nuclear power projects.[26]

29. The Agency continued to analyse the technical and economic cost drivers for the economic sustainability of NPP operation, especially in the area of life extension, in order to determine the value of nuclear power in the energy mix considering environmental conditions. A final draft of an IAEA Nuclear Energy Series report entitled *Economic Assessment of Long Term Operation of Nuclear Power Plants: Approaches and Experience* has been developed following extensive review by internal and external experts. An accompanying analytical tool called FinLTO ('Analytical Tool for Financial Analysis of Long Term Operation of Existing Nuclear Power Plants') has also been developed. A training workshop on the FinLTO tool is planned to be held in August 2017. A total of 23 participants from 18 Member States participated in a Technical Meeting to consider the financial impacts of safety reassessments and heavy component upgrades at operating NPPs which may have implications for economic sustainability in the context of long term operation. Also, the Technical Meeting on the Role and Sustainability of Nuclear Power in the National Energy Mix including the Long Term Operation of Nuclear Power Plants was held in Amsterdam, Netherlands, in June 2016. Technical, financial and policy experts from the 28 Member States and 5 international organizations discussed the future role of nuclear power in the energy mix and how it can continue to contribute towards clean, secure and affordable electricity generation. It was emphasized that nuclear power will be an important part of electricity and energy policies for meeting climate change, energy security, growth and prosperity goals. However, facing challenges, particularly from electricity market structures and financial risks,

[25] This relates to operative paragraph 31 of resolution GC(60)/RES/12.B.1.

[26] This relates to operative paragraph 33 of resolution GC(60)/RES/12.B.1.

nuclear technologies will need to be even more innovative and progressive in order to coexist with other clean energy sources. [27]

30. The Agency will publish the report entitled *International Status and Prospects for Nuclear Power* on a four-year basis, starting in 2017. The 2017 report will also serve as an input document for the International Ministerial Conference on Nuclear Power in the 21st Century to be held in Abu Dhabi, United Arab Emirates. Also, the annual publication *Energy, Electricity and Nuclear Power Estimates for the Period up to 2050* (Reference Data Series No. 1), which provides information on trends in nuclear power development around the world, is being redesigned and improved in order to help it reach a wider audience. The next edition of the publication will be in a new format.[28]

31. The Agency has completed the CRP entitled 'Qualification, Condition Monitoring and Management of Ageing of Low Voltage Cables in Nuclear Power Plants', the purpose of which was to carry out a benchmark analysis of condition monitoring techniques for aged low voltage cables in NPPs in order to provide information and guidelines on how to monitor the performance of insulation and jacket materials of existing cables and establish a programme of cable degradation monitoring for the current fleet of NPPs as well as for next generation reactors. This CRP involved 11 chief scientific investigators and 21 observers representing 17 Member States. The technical report will be published in the fourth quarter of 2017. Furthermore, a CRP entitled 'Management of Wastes Containing Long-lived Alpha Emitters: Characterization, Processing and Storage' was launched in 2017. The Agency continued to support nuclear information sharing through the International Nuclear Information System and the International Nuclear Library Network in order to improve cooperation in scientific research and development (R&D).[29]

32. The Secretariat fostered regional and international efforts to ensure wide access to existing multipurpose research reactors which support improved research reactor utilization and facilitate safe, effective and sustainable operation of these facilities. For example, following the designation of the French Alternative Energies and Atomic Energy Commission (CEA) as the first IAEA-designated International Centre based on Research Reactor (ICERR), which took place in 2015, the Research Institute of Atomic Reactors (Dimitrovgrad, Russian Federation) was designated as the second ICERR during the 60th regular session of the General Conference in September 2016. The Nuclear School "Experiments on Reactor Physics and Neutron Applications for the Asia-Pacific Region", organized by Dalat Nuclear Research Institute (DRNI) (Viet Nam) and the Thailand Institute of Nuclear Technology in cooperation with the Agency, took place in Bangkok, Thailand, from 21-28 March 2017. The 12th edition of the Eastern European Research Reactor Initiative's (EERRI's) six-week fellowship training course on research reactors, organized in cooperation with the Agency, was hosted in Austria and the Czech Republic (with lectures contributed by Slovenian experts) from 19 September to 28 October 2016. The EERRI course was attended by seven fellows, all of whom successfully completed it. Also, the Agency's Internet Reactor Laboratory (IRL) project entered into full implementation in September 2016 with six live transmissions in Latin America (with the RA-6 reactor of Argentina's National Atomic Energy Commission serving as the host facility and recipient universities in Colombia, Cuba and Ecuador) and five live transmissions in Europe and Africa (with the ISIS research reactor of France's CEA as the host facility and recipient universities in Belarus, Lithuania, Tunisia and the United Republic of Tanzania). The IRL project is funded mainly by the United States Department of State through the Peaceful Uses Initiative. In 2016, two research reactor organizations, the Australian Nuclear Science and Technology Organisation and the Reactor

[27] This relates to operative paragraph 34 of resolution GC(60)/RES/12.B.1.

[28] This relates to operative paragraphs 36 and 37 of resolution GC(60)/RES/12.B.1.

[29] This relates to operative paragraph 39 of resolution GC(60)/RES/12.B.1.

Institute Delft (Netherlands), were designated as Collaborating Centres in the areas, respectively, of multi-analytical techniques for materials research, environmental studies and industrial applications; and neutron-activation and neutron-beam based methodologies of research reactors.[30]

33. Assistance to Member States considering their first research reactor continued through the provision of support for the development of systematic, comprehensive and appropriately graded infrastructure, as well as through the publication of guidelines on the applications of research reactors that can help Member State organizations to make informed decisions that ensure the strategic viability and enduring sustainability of such projects. For example, in order to provide Member States with practical information and knowledge relating to the application of the Agency's 'Milestones approach for research reactors' — based on *Specific Considerations and Milestones for a Research Reactor Project* (IAEA Nuclear Energy Series No. NP-T-5.1) — a workshop on this topic was organized by the Agency in October 2016 with 20 participants from 17 Member States. Meetings to develop a guidance document entitled *Preparation of the Feasibility Study for a New Research Reactor Project* took place in May 2016 and in March 2017. This guidance document is expected to be issued as part of the IAEA Nuclear Energy Series by 2018. A training workshop organized in Vienna, Austria, in December 2016 aimed to assist research reactor managers and key stakeholders with the development and review of research reactor strategic plans. The workshop was attended by 37 participants from 30 Member States. As many as 26 strategic plans were submitted prior to the workshop and, with the support of international experts, comments and recommendations were provided during the workshop that were based on the guidelines contained in *Strategic Planning for Research Reactors* (IAEA Nuclear Energy Series No. NG-T-3.16). On a related topic, one expert mission was conducted at the invitation of the Jordan Atomic Energy Commission to assist in the assessment and planning for efficient utilization of the Jordan Research and Training Reactor (JRTR). The JRTR achieved first criticality in April 2016 and completed hot commissioning tests in December 2016. The Technical Meeting on Specific Applications of Research Reactors: Production and Use of Radiotracers was held in Vienna, Austria, in June 2016 and brought together research reactor organizations, users and other stakeholders involved in radiotracer production and usage. The meeting was attended by 23 participants from 22 Member States who reported on their experiences, good practices, lessons learned and challenges related to radiotracer production and the applications of radiotracers, including opportunities to increase stakeholders' interest and the visibility of radiotracer techniques. A Technical Meeting on the Role of Research Reactors in Providing Support for Nuclear Power Programmes was organized in Vienna, Austria, June 2016, attracting 29 participants from 24 Member States. The participants concluded that research reactors could play an important role in supporting new and ongoing nuclear power programmes. The following areas in which research reactors could make key contributions were identified: R&D; human resource development; public awareness and confidence building; and development of other elements of the national infrastructure for nuclear power. In 2016, the Agency supported development of a new e-learning tool on neutron activation analysis (NAA), which is intended to serve as a comprehensive source of training materials, including case studies and quiz capabilities, and is eventually expected to contain as many as 45 modules with more than 2000 slides that can be used for lectures or self-learning. In order to review and test this new NAA e-learning tool, the Agency organized a dedicated workshop in Vienna, Austria, in October 2016 that was attended by 28 participants from 25 Member States. The feedback

[30] This relates to operative paragraph 17 of resolution GC(60)/RES/12.A.1, operative paragraphs 40, 41, 45 and 46 of resolution GC(60)/RES/12.B.1, and operative paragraph 17 of resolution GC(60)/RES/12.B.4.

and comments collected at the workshop will further improve the quality of the tool before its final release for public use in the fourth quarter of 2017.[31]

34. The Agency continued to provide guidance on all aspects of the research reactor life cycle, including the development of ageing management programmes to ensure continuous improvements in safety and reliability, the sustainability of fuel supply, the exploration of disposition options for spent fuel and waste management. The Research Reactor Ageing Database was developed on a new platform with more advanced and secure software, and the contents of the legacy database were migrated to it, along with the new information. The database was launched in March 2017. The final RCM of the CRP entitled 'Establishment of a Material Properties Database for Irradiated Core Structural Components for Continued Safe Operation and Lifetime Extension of Ageing Research Reactors' took place from 10 to13 April 2017 in Vienna, Austria, and was attended by 15 participants from 11 Member States. Development of the material properties database covered by this project is ongoing. In January 2016, the first RCM of the CRP entitled 'Condition Monitoring and Incipient Failure Detection of Rotating Equipment at Research Reactors' was held in Vienna, Austria, and was attended by 17 participants from 12 Member States. In April 2016, an expert mission was undertaken under the relevant TC project to advise on the design of instrumentation and control systems for Indonesia's Bandung research reactor. Another expert mission undertaken in April 2016 provided advice on the ageing management programme for the Pakistan Research Reactor 1. In July 2016, an expert mission was conducted under the relevant TC project to the Maria research reactor in Poland in order to support the procurement of equipment for upgrading the reactor coolant temperature monitoring system. In the context of the Agency's Operation and Maintenance Assessment for Research Reactors (OMARR) peer review service, a preliminary (Pre-OMARR) mission to the WWR-SM reactor in Uzbekistantook place from 21-23 June, 2017. In November 2016, a Training Workshop on Integrated Management Systems for Research Reactors was organized by the Agency in Vienna, Austria, with 31 participants from 29 Member States. Finally, a Technical Meeting on the Data Analysis and Collection for Costing of Research Reactor Decommissioning (DACCORD) Project was held in September 2016, with 16 participants from 16 Member States. A final draft of the DACCORD project report has been submitted for publication.[32]

35. The preparation of publications and the provision of relevant support related to the development of LEU fuels for research reactors continued in 2016. In September 2016, in cooperation with Poland, the United States Department of Energy's NNSA, the Russian Federation and the Agency, the last remaining 61 kg of Russian-origin high enriched uranium (HEU) materials from the Maria research reactor located in Świerk-Otwock, Poland, were repatriated to the Russian Federation. This removal made Poland free of HEU. The Agency continued to support Ghana in its efforts to convert and transfer the HEU core of its miniature neutron source reactor (MNSR), which is expected to occur in by the end of August 2017. In July 2016, the Agency and the China Institute of Atomic Energy held an international meeting in Beijing, China, for high level delegates from all Member States operating an MNSR to witness, at the Zero Power Test Facility, the achievement of first criticality by the LEU core for the Ghana Research Reactor-1. In December 2016, representatives of each country operating an MNSR, as well as stakeholders supporting the HEU conversion and removal activities, participated in the annual Technical Meeting on the Conversion of Miniature Neutron Source Reactors from High Enriched Uranium to Low Enriched Uranium Fuel, held in Accra, Ghana. In June 2016, the United States Department of Energy's NNSA, through the Savannah River National Laboratory, hosted the Tenth Technical Meeting on Lessons Learned from the Russian Research Reactor Fuel Return

[31] This relates to operative paragraph 18 of resolution GC(60)/RES/12.A.1 and operative paragraph 42 of resolution GC(60)/RES/12.B.1.

[32] This relates to operative paragraphs 43 and 44 of resolution GC(60)/RES/12.B.1.

Programme, which took place in Charleston, South Carolina, USA, and was attended by 78 participants from 17 countries representing facility operators, regulatory bodies, decision-makers and other stakeholders involved in ensuring financial and coordination support for the implementation of HEU minimization efforts. The meeting included updates on HEU minimization projects for HEU originating from China, the Russian Federation and the United States of America. In July 2016, a new CRP entitled 'Accelerator Driven System (ADS) Applications and Use of Low Enriched Uranium in ADSs' was initiated and the first RCM held in Vienna, Austria, with 24 participants from 15 Member States. Efforts to support medical isotope production without the use of HEU continued. The Agency participated in the 2016 Topical Meeting on Molybdenum-99 Technology Development, the sixth Workshop on Signatures of Man-Made Isotope Production, and in the work of the OECD/NEA's High-level Group on the Security of Supply of Medical Radioisotopes throughout the year to support these efforts.[33]

36. The Agency continued to facilitate the exchange of information on R&D addressing safety issues highlighted by the Fukushima Daiichi accident, as well as the strengthening of long term research programmes to learn about severe accidents and related decommissioning activities. The Agency organizes training courses and workshops to emphasize the importance of safety, security and safeguards in new nuclear power programmes — for example, the Interregional Training Course on the Implementation of National Requirements for Nuclear Power Programmes held in Abu Dhabi, United Arab Emirates, in January 2017 — and it is also organizing similar training events in the field of environmental protection. The framework for safety, security, safeguards and environmental protection and their interfaces are major topics covered by INIR missions. A Technical Meeting on Phenomenology and Technologies Relevant to In-Vessel Melt Retention and Ex-Vessel Corium Cooling was hosted by the Government of China through the Shanghai Nuclear Engineering Research and Design Institute (SNERDI) in Shanghai, China, from 17 to 21 October 2016. In total, 52 participants from 18 Member States as well as 11 observers from the host country participated in the meeting. Thirty-three presentations were given and discussed in detail during the meeting, which provided the participants with a good opportunity to exchange information on their R&D activities in the areas of in-vessel melt retention (IVMR) and ex-vessel corium cooling (EVCC). The meeting enhanced communication between utilities, vendors, research institutes, universities, regulatory bodies and technical support organizations. The presentations and discussions at the meeting brought the participants up to date with the current status of phenomenology and technologies in the areas of IVRM and EVCC, and possible activities for international cooperation were proposed. A Workshop on Advances in Understanding the Progression of Severe Accidents in Boiling Water Reactors was held in Vienna, Austria, from 17 to 21 July 2017. The workshop provided a forum for the exchange of information on forensic investigation and analyses of the damaged reactor units at the Fukushima Daiichi NPP in order to advance understanding of the progression of the Fukushima Daiichi accident. Participants also shared information on experimental research activities and their results with a view to achieving a better understanding of accident progression in boiling water reactors in general and reducing uncertainties with regard to severe accident phenomenology. Finally, the cooperation between the institutions participating in the Underground Research Facilities Network for Geological Disposal was strengthened as a result of a Technical Meeting held in Vienna, Austria, in June 2017, which was attended by 40 participants from 40 Member States.[34]

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[33] This relates to operative paragraphs 14 and 15 of resolution GC(60)/RES/12.A.1 and operative paragraph 47 of resolution GC(60)/RES/12.B.1.

[34] This relates to operative paragraph 48 of resolution GC(60)/RES/12.B.1.

B. Communication and Cooperation with Other Organizations

37. Publications issued by the Agency in advance of the 22nd session of the Conference of the Parties to the United Nations Framework Convention on Climate Change (COP22) held in November 2016 included the 2016 edition of the booklet *Climate Change and Nuclear Power*, a non-serial publication entitled *Nuclear Power and Sustainable Development*, and a new brochure dealing with climate change entitled *Nuclear Power and the Paris Agreement*. Publications issued in 2017 include the synthesis report from a CRP dealing with an integrated framework for the assessment of climate, land, energy and water (CLEW) strategies, and a report on the results of the CRP entitled 'Techno-economic Evaluation of Options for Adapting Nuclear and Other Energy Infrastructure to Long Term Climate Change and Extreme Weather'. Also, in collaboration with the United Nations Department of Economic and Social Affairs and the United Nations Development Programme, the Agency conducted pilot projects in Nicaragua and Uganda to provide training on the integrated assessment of resource systems using the CLEW framework. . The Agency participated in the biannual 2017 Vienna Energy Forum, which was held from 9 to 12 May 2017 and had the theme "Sustainable energy for the implementation of the SDGs and the Paris Agreement" The Agency also participated in the Vienna Energy Club (VEC), a collaborative gathering of ten Vienna-based international organizations that deal with energy: the Energy Community, the IAEA, IIASA, the International Peace Institute, the OPEC Fund for International Development, the Organization of the Petroleum Exporting Countries (OPEC), the Organization for Security and Co-operation in Europe, the Renewable Energy and Energy Efficiency Partnership, the SE4ALL initiative and UNIDO.. With regard to newcomer countries, stakeholder involvement, the provision of information and communicating with the public are major considerations that should be taken into account when following the Agency's Milestones approach. A Technical Meeting on Developing Public Communication, Consultation and Participation in Nuclear Power Programmes was held in Vienna, Austria, from 20 to 23 September 2016 and a Technical Meeting on Stakeholder Involvement and Public Information was held in Vienna, Austria, from 13 to 16 June 2017 and included a simulated Town Hall Public Meeting. These Technical Meetings provided an overview of the dimensions and challenges involving stakeholders, providing information and communicating with the public on nuclear power, and gathered information from Member States about current issues and challenges they are facing as well as their specific needs for future Agency guidance and activities. A country-specific expert mission on stakeholder involvement was also held in Turkey from 25 to 28 April 2017. Finally, through the International Nuclear Library Network, the Agency facilitated the collaboration of Member State information centres to enhance scientific research aimed at supporting the achievement of the SDGs.[35]

38. The Agency was represented together with other United Nations system agencies at COP22, which was held in Marrakesh, Morocco, from 6 to 18 November 2016, with the Agency participating in joint United Nations system side events dealing with the role of nuclear and isotopic techniques in climate action and the role of innovation in meeting the Paris Climate Agreement target to keep the increase in average global temperatures below 2°C compared to pre-industrial levels.

39. In order to enhance scientific collaboration on global climate change, the Agency participated with other United Nations organisations at the 44th Session of the Intergovernmental Panel on Climate Change (IPCC-44), which was held in Bangkok, Thailand, from 17 to 20 October 2016 to follow up on the IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels which is being prepared as part of the Sixth Assessment Report (AR6) cycle. The Agency closely

[35] This relates to operative paragraph 1 of resolution GC(60)/RES/12.B.2.

following on the progress on other key AR6 products, including the Special Report on climate change, oceans and cryosphere and the Special Report on climate change, desertification, land degradation, sustainable land management, food security, and greenhouse gas fluxes in terrestrial ecosystems, by participating at IPCC-45 (Guadalajara, Jalisco, Mexico, 28–31 March 2017).[36]

40. The IAEA continued to collaborate with the OECD/NEA at various levels, ranging from IAEA participation in high level meetings of the Steering Committee for Nuclear Energy and OECD/NEA participation in the 60th regular session of the Agency's General Conference and meetings of the Board of Governors; through international endeavours such as the OECD/NEA-hosted International Framework for Nuclear Energy Cooperation, the IAEA's Standing Advisory Group on Nuclear Energy, and the Generation IV International Forum and its interactions with the IAEA's International Project on Innovative Nuclear Reactors and Fuel Cycles (INPRO); down to very specific activities at the technical working level.[37]

C. Operation of Existing Nuclear Power Plants

41. The Agency continued to support interested Member States in their efforts to meet demands for trained and qualified personnel. For example, 30 participants from 21 Member States and the World Nuclear University attended a Technical Meeting in October 2016 on the development of human resource development (HRD) modelling tools in support of nuclear power infrastructure. The meeting focused on Member States' and organizations' approaches to HRD and workforce planning, the use of modelling tools, the challenges in developing a national workforce plan, international opportunities and lessons learned using the Agency's Nuclear Power Human Resources modelling tool. In response to growing interest in HRD-related topics, a Technical Meeting on Evaluating the Effectiveness of Training and Return on Investment was held in April 2016 at the Ringhals NPP in Sweden. A total of 22 participants from 13 Member States attended and discussed plant performance improvement, human performance and the improvement of training programmes.[38]

42. The 14th workshop on management systems organized jointly by the Agency and the European Atomic Forum was held in Vienna, Austria, in December 2016. The workshop had the theme "Leadership and Management: From Standards to Practices" and sought to raise awareness and increase understanding of management systems and of how these can integrate all the vital objectives of nuclear facilities and activities. Over 110 participants from 28 Member States attended the workshop, which provided an international forum for the exchange of information on the status of various management systems and quality management standards, as well as the sharing of experience, practical examples and case studies related to leadership/organizational culture, implementation of the risk based/informed approach as part of an integrated management system, and practices in various countries. The Agency organized the sixth Nuclear Operating Organization Cooperation Forum as a side event during the 60th regular session of the General Conference in September 2016. During the forum, which attracted over a hundred participants, industry executives from China, Finland, France, the Russian Federation and the USA discussed the economic sustainability of nuclear power generation in the next decade. This regular General Conference side event provides a platform for senior leaders from operating organizations and supporting institutions to hold discussions and

[36] This relates to operative paragraph 3 of resolution GC(60)/RES/12.B.2.

[37] This relates to operative paragraph 5 of resolution GC(60)/RES/12.B.2.

[38] This relates to operative paragraphs 1 and 2 of resolution GC(60)/RES/12.B.3.

exchange ideas on the current and future challenges of nuclear electricity generation. A Technical Meeting on Developing Public Communication, Consultation and Participation in Nuclear Power Programmes was held in September 2016. A total of 44 participants from 27 Member States and 3 international organizations attended this meeting and exchanged lessons learned and good practices related to public communication and stakeholder involvement. Public communication continues to be a high priority for Member States, and the revision of the Nuclear Communicator's Toolbox portal on the Agency's website will be of great assistance to them in this respect. A Technical Meeting on the Optimization of Non-Destructive Examination and In-Service Inspection to Improve Nuclear Power Plant Performance was held in Espoo, Finland, in April 2017. A total of 25 participants from 10 Member States attended this meeting to exchange good practices and lessons learned in relation to in-service inspection (ISI) programmes and their requirements, the principles of non-destructive examination and ISI methodologies, as well as the status of risk-informed inspections in Member States. The discussions at the meeting were taken into account in the draft version of a new technical publication being developed by the Agency on how to achieve an effective ISI programme.[39]

43. A total of 75 participants from 13 Member States participated in a Technical Meeting on Plant Life Management during the Transition from Operation to Decommissioning of Nuclear Power Plants held in Kyungju, Republic of Korea, in September 2016. This meeting aimed to enable participants to understand and discuss the critical factors which should be considered in planning and implementing decisions on the decommissioning of NPPs. It was highlighted at the meeting that, in view of significant cultural and organizational changes, the availability of relevant data and records as well as good communication and involvement of all stakeholders were essential in taking such decisions. A biennial meeting of the Technical Working Group on Life Management of Nuclear Power Plants (TWG-LMNPP) was organized in February 2017. A total of 31 members (18 TWG members and 15 observers) from 19 Member States and one international organization discussed various current and emerging issues that would need the focus of the Agency.. The TWG-LMNPP comprises experts from Member States who provide advice to the Agency on all aspects of life management of NPPs with the aim of ensuring safe, economical and reliable long term operation. The TWG-LMNPP actively promotes Member States' collaboration in coordinated research programmes and the implementation of the results of research work. Progress was made with the preparations for the fourth International Conference on Nuclear Power Plant Life Management, which will be held in Lyon, France, in October 2017. The purpose of the conference is to provide a forum for information exchange on national and international practices as well as regulatory approaches related to plant life management for long term operation, considering any impacts from the Fukushima Daiichi nuclear accident on the sustainability, safety and efficiency of NPPs. Approximately 400 participants from invited countries and organizations will attend the conference, which is being hosted by the Government of France in cooperation with Électricité de France and the Nuclear Generation II and III Association. Also, the fourth RCM of the CRP entitled 'Prediction of Axial and Radial Creep in Pressure Tubes' was held in Vienna, Austria, from 5 to 9 September 2016; the meeting focused on reviewing the work completed by the participants with regard to microstructure characterization and the development of predictive models.[40]

44. The Agency organized a meeting of the Technical Working Group on Managing Human Resources in the Field of Nuclear Energy (TWG-MHR) in June 2016. The mix of representatives from nuclear facilities, nuclear utilities, nuclear regulatory bodies and academia from 19 Member States offered a broad perspective on the many aspects of managing human resources. The reliable supply and long-term retention of personnel to ensure a competent workforce are together one of the biggest

[39] This relates to operative paragraph 3 of resolution GC(60)/RES/12.B.3.

[40] This relates to operative paragraph 4 of resolution GC(60)/RES/12.B.3.

challenges for the nuclear community and for all phases of the nuclear facility life cycle. The TWG-MHR members are experts on the educational programmes, training procedures, worker productivity issues and staffing plans within their respective countries, and at this meeting they were accordingly able to make recommendations to the Agency regarding future directions and activities for the period 2018–2021.[41]

45. The Agency organized a Technical Meeting on Architectural Approaches in the Design of Nuclear Power Plant Instrumentation and Control Systems in Grenoble, France, in September 2016. A total of 70 participants from 22 Member States attended this meeting and shared experiences, discussed the role of architectural approaches to be considered in the design of digital instrumentation and control (I&C) systems, and reviewed the draft version of a new IAEA Nuclear Energy Series report on the same subject. An RCM was organized under the CRP entitled 'Application of Wireless Technologies in Nuclear Power Plant Instrumentation and Control Systems' in July 2016. Altogether 16 participants from 9 Member States — including chief scientific investigators (CSIs) and observers from research and technical support organizations, vendors and universities — attended the RCM and discussed and demonstrated techniques for advanced wireless communication in I&C systems at NPPs that can be used to transfer process and diagnostic information, offering an alternative to wired solutions. The objective of this meeting, which was the project's second RCM, was to bring together the CSIs participating in the project to review progress, outline plans for future investigations and further develop the draft project report on the basis of the results achieved during the first half of the CRP. A meeting of the Technical Working Group on Nuclear Power Plant Instrumentation and Control (TWG-NPPIC) was held in May 2017 with the participation of 42 experts from 20 Member States. TWG-NPPIC members provided advice and guidance on, and marshalled support in their respective countries for, the implementation of the Agency's programmatic activities in the areas of I&C during the period 2018–2021. The TWG-NPPIC focuses its work on activities related to I&C for power reactor plants. A Technical Meeting on Engineering and Design Aspects of Computer Security in Instrumentation and Control Systems for Nuclear Power Plants was held in Gloucester, UK, in May 2017. The purpose of this meeting was to serve as an international forum for sharing best practices and strategies used in the engineering and design of computer security measures for I&C systems at NPPs, as well as for discussing the challenges and issues that need to be resolved in this area. A total of 85 participants from 25 Member States attended the meeting.[42]

46. A Technical Meeting on Grid Stability and Off-Site Power Reliability was held in Zagreb, Croatia, in September 2016. A total of 50 participants from 22 Member States attended the meeting and shared operational experience and case studies related to grid stability. At the meeting a draft document on grid stability was discussed which will be used to supplement the existing publication *Electric Grid Reliability and Interface with Nuclear Power Plants* (IAEA Nuclear Energy Series No. NG-T-3.8). The plant level actions for ensuring grid reliability outlined in this document should be consistent with the guidance provided in the Safety Guide *Design of Electrical Power Systems for Nuclear Power Plants* (IAEA Safety Standards Series No. SSG-34). In addition, the scope of the document needs to be expanded so that it covers not only off-site power reliability, but also off-site power quality. Technical support was provided to embarking countries focusing on grid issues. For example, an expert mission was conducted in Egypt in March 2017 to provide the future owner/operator under the country's nuclear power project, as well as the load dispatching centre, grid operators, national experts and all related national agencies, with updated guidance and information on worldwide experiences related to power system performance requirements for NPPs, and on the connection and operation of electric grids. The mission helped to enhance the Egyptian counterparts'

[41] This relates to operative paragraph 5 of resolution GC(60)/RES/12.B.3.

[42] This relates to operative paragraph 6 of resolution GC(60)/RES/12.B.3.

understanding of various aspects involved in the integration of an NPP into an electric grid and the evaluation of power network stability, as well as of specific considerations that should be taken into account when connecting a future NPP (or NPPs) to Egypt's national power system.[43]

47. The Agency continued to identify and promote best practices and lessons learned with respect to procurement and supply chain issues and also to support experience sharing related to nuclear construction, component manufacturing, and modifications. A new report on procurement activities and on counterfeit, fraudulent and substandard items, intended for publication in the IAEA Nuclear Energy Series, provides an overview of nuclear procurement processes and issues of special concern as well as guidance on good practices for setting up and managing a high-quality procurement organization. Lessons learned for organizations considering new build nuclear projects are also included. A new publication entitled *Procurement Engineering and Supply Chain Guidelines in Support of Operation and Maintenance of Nuclear Facilities* and a related online Nuclear Contracting Toolkit were recently issued. The toolkit is intended to support all levels of procurement activity related to a major nuclear power project, and to help manage the expectations of stakeholders, customers and suppliers alike. It provides step-by-step guidance on how to develop a procurement strategy, propose and solicit bids and negotiate and manage contracts. It also includes templates and application guides for various types of contracts. The procurement and contracting process for new NPPs is a complex endeavour and is essential for the success of such projects. Efficient, fair and equitable contracts are, thus, a key element of safe, secure and sustainable nuclear power generation. A Technical Meeting on Procurement Activities and on Counterfeit, Fraudulent and Substandard Items was held in September 2016. A total of 28 participants from 19 Member States and one international organization attended this meeting and shared experiences and lessons learned in addressing counterfeit and fraudulent items associated with the construction and operation of nuclear facilities. The specific objectives of the meeting were to collect feedback from Member States on the draft text of a revised version of *Managing suspect and counterfeit items in the nuclear industry* (IAEA-TECDOC-1169) which is being developed by the Agency, to understand how legal and safety aspects related to procurement functions are managed within Member States, to discuss any advantages and disadvantages of the current arrangements, and to obtain feedback from Member States with respect to procurement functions. A Technical Meeting on Risk Management in Nuclear Power Plant Construction was organized in September 2016. A total of 37 participants from 19 Member States and two international organizations attended the meeting and presented various practices and methods to manage risks associated with NPP construction projects The Agency organized a Technical Meeting on Quality Control and Quality Assurance and on Their Relationship with Management Systems in May–June 2016. Sixty-five representatives of the nuclear industry, supply chain organizations, regulatory bodies and research institutions from 26 Member States and two international organizations discussed important areas of quality assurance and quality control in nuclear facilities and their relationship with management systems, including the needs of new or expanding nuclear power programmes, supply chains and operating facilities. A Technical Meeting on Managing Obsolescence, Spare Parts and Replacement in Operating Nuclear Power Plants was held at SNERDI in Shanghai, China, from 6 to 9 June 2017 with 20 participants from 13 Member States. The purpose of the meeting was to share experiences and lessons learned in addressing inventory control of spare parts and obsolescence management associated with the construction and operation of NPPs and to collect information from Member States for use in developing a draft IAEA Technical Document (TECDOC) on these topics.[44]

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[43] This relates to operative paragraph 7 of resolution GC(60)/RES/12.B.3.

[44] This relates to operative paragraph 8 of resolution GC(60)/RES/12.B.3.

Agency Activities in the Development of Innovative Nuclear Technology

1. In resolution GC(60)/RES/12, adopted on 30September 2016, the General Conference referred to the role of innovative technologies in addressing improved nuclear safety and sustainability. It also noted the progress achieved in a number of Member States in the development of technology for advanced and innovative nuclear energy systems and the high technical and economic potential of international collaboration in the development of such technology.

2. The Agency continued to support Member States with broad energy planning and long term nuclear energy planning, economic analysis and techno-economic assessments, as well as with Nuclear Energy System Assessments (NESAs). Various draft NESA reports were received from Ukraine in 2017. A consultancy under the International Project on Innovative Nuclear Reactors and Fuel Cycles (INPRO) with Ukraine on its NESA reports will be held in Vienna in August 2017. An INPRO team made a preparatory visit to Malaysia in May 2017 to discuss details of a potential NESA within the Malaysia project. Draft terms of reference were produced and are under consideration by Malaysia for further action. Cooperation continued under INPRO on limited scope NESAs for specific liquid metal fuelled reactor designs with China, India and the Russian Federation. INPRO received the first draft NESA report from the Russian Federation in October 2016. In June 2017, a 3rd joint consultancy of the three Member States was held to present and discuss revised drafts and plan next steps and future publications. Six experts from three Member States participated in the consultancy meeting. European regional training on "Nuclear Energy System Modelling and Assessment using the INPRO Methodology" will be held in October 2017 in Warsaw, Poland.In 2016, 25 training events on energy planning organized through national, regional and interregional technical cooperation projects. These events helped more than 600 energy planning professionals from 78 countries to enhance their expertise for conducting national energy planning studies.[45]

3. INPRO successfully completed the Synergistic Nuclear Energy Regional Group Interactions Evaluated for Sustainability (SYNERGIES) collaborative project and the Secretariat submitted the final report, entitled *Enhancing Benefits of Nuclear Energy Technology Innovation through Cooperation among Countries*, for publication. An INPRO side event was held during the 60th regular session of the General Conference, with 55 Member State participants. A consultancy meeting was held in May 2017 with 11 participants from 8 Member States at which a final report was drafted on the Key Indicators for Innovative Nuclear Energy Systems (KIND) collaborative project; the draft report is currently undergoing detailed technical reviews and editing with participating Member State experts. The Agency drafted an IAEA Technical Document (TECDOC) provisionally entitled *Experience in Modelling Nuclear Energy Systems with MESSAGE: Country Case Studies*. An INPRO Technical Meeting was held on the Roadmaps for a Transition to Globally Sustainable Nuclear Energy Systems (ROADMAPS) collaborative project in October 2016 with 17 participants from 13 Member States. Finally, a kick off consultancy meeting for a new INPRO collaborative project called Comparative Evaluation of Nuclear Energy System Options (CENESO) will be held in November 2017.[46]

4. The Model for Energy Supply Strategy Alternatives and their General Environmental Impacts (MESSAGE) and the INPRO methodology have been harmonized. The Agency published *Modelling*

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[45] This relates to operative paragraph 3 of resolution GC(60)/RES/12.B.4.

[46] This relates to operative paragraphs 4 and 6 of resolution GC(60)/RES/12.B.4.

Nuclear Energy Systems with MESSAGE: A User's Guide (IAEA Nuclear Energy Series No. NG-T-5.2) in 2016. Guidebooks and training programmes have been designed and are being implemented for integrated assessment. A TECDOC on experience with nuclear energy system modelling with MESSAGE is being developed to share the diverse experience from five country studies.

5. A Technical Meeting on the Socio-Economic Aspects of Nuclear Cogeneration was held in November 2016 in Vienna, with the participation of 16 participants from 11 Member States and the Nuclear Energy Agency of the Organisation for Economic Co-operation and Development (OECD/NEA). The purpose of the meeting was to exchange information on the common concerns and challenges related to nuclear cogeneration including design, coupling, operation and impact of such projects with respect to economic, social and environmental aspects; to facilitate the exchange of operating experiences generated from nuclear cogeneration demonstrated projects, mainly on desalination, district heating and hydrogen production applications; and to discuss prospects of future nuclear cogeneration using advanced nuclear reactor technologies, mainly small modular reactors. In December 2016, the third Research Coordination Meeting under the coordinated research project (CRP) entitled Application of Advanced Low Temperature Desalination Systems to Support Nuclear Power Plants and Non-Electric Applications was held in Vienna. The CRP was concluded with this meeting and the results are expected to be published in a TECDOC after being compiled and assessed.

6. A consultancy meeting, with the participation of six experts from five Member States, on efficient water management in water cooled reactors was held in Vienna in December 2016 to assess recent strategies for efficient water management in nuclear power plants, and to enhance information exchange among Member States on issues related to the assessment of the Palo Verde nuclear power plant project on water reclamation technology and strategies to efficiently operate nuclear power plants in regions suffering from water scarcity. A roadmap was created for the upgrade of the Agency's Water Management Program in Nuclear Power Plants (WAMP) tool as well as the update of IAEA Nuclear Energy Series No. NP-T-2.6 entitled *Efficient Water Management in Water Cooled Reactors* to add an Annex on the practical experience at the Palo Verde plant.

7. In July 2017, the Agency held a Technical Meeting to Examine the Role of Nuclear Hydrogen Production in the Context of the Hydrogen Economy in Vienna, with the participation of 12 experts from 10 Member States and from the OECD/NEA. Hydrogen is becoming an attractive source of clean, next-generation fuel that can help Member States meet their requirements under the Paris Agreement adopted at the 21st session of the Conference of the Parties to the United Nations Framework Convention on Climate Change (COP21). The objective was to collect up-to-date information on the status of technologies and the latest economic figures on hydrogen production in general and on nuclear hydrogen production in particular. A technical report detailing the identification of the status of progress on nuclear hydrogen production using currently available demonstration plants, challenges and prospects for large scale hydrogen production, and the status of promising technologies will be developed. In addition, feedback on the use of the IAEA tool HEEP and potential update will be made.

8. In response to General Conference resolutions GC(57)/RES/12 and GC(58)/RES/13, *Opportunities for Cogeneration Using Nuclear Energy* (IAEA Nuclear Energy Series No. NP-T-4.1) was published in May 2017, and *Industrial Applications of Nuclear Energy* is expected to be published later in 2017. In addition, a generic guidance report on nuclear cogeneration options is being prepared by the Agency for publication in 2018. The final draft of the TECDOC reporting the results of the completed CRP on techno-economic aspects of hydrogen production using nuclear energy and Hydrogen Economic Evaluation Program (HEEP) benchmarking was prepared and submitted for internal approval and will be published in October 2017.

9. A TECDOC entitled *Severe Accident Mitigation through Improvements in Filtered Containment Vent Systems and Containment Cooling Strategies for Water Cooled Reactors* (IAEA-TECDOC-1812) was published in May 2017 as a proceedings of the Technical Meeting held in Vienna, from 31 August to 3 September 2015. Contributions from 26 Member States in this TECDOC address one of the most important lessons learned from the Fukushima Daiichi accident on reliable containment venting systems that can be crucial for effective accident management during severe accidents.

10. A Technical Meeting on Heat Transfer, Thermal-Hydraulics and System Design for Supercritical Water Cooled Reactors was held in August 2016 in the United Kingdom. In total, 24 participants from 9 Member States and 9 observers from the host organization participated in the meeting. Participants expressed a strong interest in understanding and improving prediction accuracy of thermal-hydraulic parameters to support the development of supercritical water reactor (SCWR) concepts. The Agency organized a Technical Meeting on Materials and Chemistry for Supercritical Water Cooled Reactors in October 2016 in the Czech Republic. In total, 19 nominated participants from 9 Member States and 2 international organizations participated in the meeting. At the meeting, the current status of R&D and remaining challenges were discussed in the area of materials and chemistry for SCWRs, and future collaborative activities were proposed and discussed. Also, the 3rd Research Coordination Meeting of the CRP entitled Understanding and Prediction of Thermal Hydraulics Phenomena Relevant to Supercritical Water Cooled Reactors was held in Madison, USA in June 2017. It was attended by ten chief scientific investigators from nine Member States (one through Skype) and three observers from the host organization. The participants exchanged information on the progress of their R&D activities, created a research plan for the following year, and updated the CRP and task plan. Participants submitted joint papers on their collaborative work in the CRP, and the ultimate output will be a TECDOC synthesizing the main results of the CRP.

11. Through the IAEA Library and relevant systems and networks, the Agency continued to provide platforms for information exchange and preservation of non-conventional publications on sustainable nuclear energy systems to empower Member State collaboration.[47]

12. A Technical Meeting on the INPRO Study on Cooperative Approaches to the Back End of the Nuclear Fuel Cycle: Drivers and Institutional, Economic and Legal Impediments was held in November 2016, with 19 participants from 15 Member States and the OECD/NEA. A related Consultancy meeting was held in May 2017, with 14 participants from 8 Member States. The structure and content of a publication on the study was developed and extended drafts of some chapters were prepared. A working plan for the study with a list of contributions and defined responsibilities was also agreed.[48]

13. The 13th INPRO Dialogue Forum on Legal and Institutional Issues in the Global Deployment of Small Modular Reactors was held in October of 2016, with 60 participants from 21 Member States, the International Framework for Nuclear Energy Cooperation, the OECD/NEA and the World Nuclear Association (WNA). The 14th INPRO Dialogue Forum on the Potential of Nuclear Energy to Support the Sustainable Development Goals, including Climate Change Mitigation was held in June 2017, with 57 participants from 22 Member States and the WNA.[49]

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[47] This relates to operative paragraph 5 of resolution GC(60)/RES/12.B.4.

[48] This relates to operative paragraphs 7 and 14 of resolution GC(60)/RES/12.B.4.

[49] This relates to operative paragraph 8 of resolution GC(60)/RES/12.B.4.

14. Based on the use of *Modelling Nuclear Energy Systems with MESSAGE: A User's Guide* (IAEA Nuclear Energy Series No. NG-T-5.2), country case studies were conducted by research teams from Argentina, China, Romania, the Russian Federation and Ukraine. A TECDOC is being developed to share this experience with teams from other countries. In January 2017, the Agency released the updated versions of the two toolkits on nuclear desalination and on nuclear hydrogen production. The toolkits enable stakeholders and users from Member States to access technical publications on these topics through the links in the toolkits; download Agency tools to perform economic analysis and conduct comparative assessments for nuclear cogeneration applications; and learn about the Agency activities on related topics. INPRO also provided a series of online conferences on the application of the ROADMAPS-ET software for national case studies in December 2016 and January 2017.[50]

15. In 2016, the Agency published *INPRO Methodology for Sustainability Assessment of Nuclear Energy Systems: Environmental Impact of Stressors* (IAEA Nuclear Energy Series No. NG-T-3.15). INPRO also completed all necessary internal and external review processes and submitted draft of *INPRO Methodology for Sustainability Assessment of Nuclear Energy Systems: Waste Management* in October 2016. INPRO completed the final drafts of *INPRO Methodology for Sustainability Assessment of Nuclear Energy Systems: Safety of Nuclear Reactors* and *INPRO Methodology for Sustainability Assessment of Nuclear Energy Systems: Safety of Fuel Cycle Facilities* in April and February 2017, following external coordination and these drafts have now been submitted for internal coordination with the Department of Nuclear Safety and Security. INPRO held a Technical Meeting for Member State review of the drafts of these two INPRO Methodology publications in November 2016 with the participation of 28 experts from 19 Member States. INPRO will hold a Technical Meeting for Member State review of the drafts of the INPRO Methodology publications in the areas of proliferation resistance and methodology overview in October 2017.[51]

16. Consultancy meetings on the INPRO Case Study for the Deployment of a Factory Fuelled Small Modular Reactor were held in November 2016, involving 15 experts from 6 Member States, and in April 2017, involving 18 experts from 7 Member States, at which a table of contents for the final report was agreed, further action plan and main contributors were identified, information from the external stakeholders was gathered and analysed, and some chapters of the report were drafted.[52]

17. The 11th GIF–INPRO/IAEA Interface Meeting took place from 20 to 21 February 2017. More than 15 participants representing 8 Member States and 3 international organizations (OECD/NEA, European Union and Generation IV International Forum (GIF)) provided an update on the current status of the six generation IV systems as well as several cross-cutting activities. Information was shared on the related Agency activities on technology development, safeguards, economic modelling, and education and training, and the cooperation matrix and joint activities were reviewed. In addition, INPRO participated in a meeting of the GIF Proliferation Resistance and Physical Protection Working Group, held in October 2016 in the Republic of Korea, and the Agency gave a presentation at the Sustainable Nuclear Energy Technology Platform (SNETP) meeting in Bratislava, Slovakia, in November 2016 (SNETP is the reactor development component of the European Sustainable Nuclear Industrial Initiative).

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[50] This relates to operative paragraph 10 of resolution GC(60)/RES/12.B.4.

[51] This relates to operative paragraph 12 of resolution GC(60)/RES/12.B.4.

[52] This relates to operative paragraphs 13 and 18 of resolution GC(60)/RES/12.B.4.

18. The Technical Working Group on Fast Reactors (TWG-FR), since its establishment in 1967, has been the foundation of the Agency's activities in the field of fast reactor research and technology development. For the past five decades this group has provided advice and supported the implementation of the Agency's programme. With a current membership of more than 25 countries, the TWG-FR plays a significant role in addressing major issues, finding coordinated solutions to overcome technological/research barriers, and effectively communicating and transferring knowledge amongst its members. A combined vision of all the members helps in overcoming challenges and increasing efficiency. The 50th meeting of the TWG-FR was held in May 2017 attended by 30 participants from 25 Member States.[53]

19. A joint workshop on innovative nuclear energy systems was held by the Agency and the International Centre for Theoretical Physics from 29 August to 2 September 2016 in Trieste, and was attended by 47 participants from 24 Member States[54].

20. A Technical Meeting on New Concepts in Innovative Water Cooled Reactor Technology was held in Vienna from 13 to 17 March 2017. The meeting provided a forum for information exchange between the 19 participants from 16 Member States, and to present and discuss how the future utilization of nuclear power worldwide will depend on improvements in the competitiveness of the technology while still meeting the rigorous safety requirements. The participants were from operators, universities, research institutes, technical support organizations and organizations responsible for national nuclear power programmes in newcomer countries. The topical sessions provided opportunities for participants from countries with established national nuclear power programmes and countries embarking on nuclear power programmes to share information on their experiences and identified needs and challenges for the future that the nuclear power industry should provide to be more competitive in the energy market. The Technical Meeting on the Status of Molten Salt Reactor Technology was held from 31 October to 3 November 2016. More than 35 participants from 17 Member States laid the foundations for enhanced international cooperation on molten salt reactor technology. A TECDOC on the status of molten salt reactor technology is under development. The second Research Coordination Meeting on Uranium/Thorium Fuelled High Temperature Gas Cooled Reactor Applications for Energy Neutral and Sustainable Comprehensive Extraction and Mineral Product Development Processes was held from 3 to 6 July 2017, at which 14 participants from 14 Member States investigated the use of thermal processes heated by high temperature gas cooled reactors to achieve the total extraction of all minerals, including the uranium and thorium to fuel the nuclear reactor (to be reviewed end of by 10 July 2017).[55]

21. A study on passive shutdown systems for fast reactors was started in October 2015 in order to promote the exchange of information on projects and programmes dealing with passive shutdown systems for fast reactors at the national and international level. An IAEA Nuclear Energy Series publication on Passive Shutdown Systems for Fast Neutron Reactors is being prepared to summarize the results of this activity. The meeting on preparing this publication was held in February 2017 and was attended by 20 participants from 15 Member States. A Fourth Research Coordination Meeting under the CRP entitled Sodium Properties and Safe Operation of Experimental Facilities in Support of the Development and Deployment of Sodium Cooled Fast Reactors (NAPRO) was held in June 2017. Nine organizations from nine Member States are participating in this CRP. The CRP is focused on the need for consistent and up to date sodium property data for use by Member States. In addition, some Member States have expressed their interest in an international effort focused on obtaining and sharing

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[53] This relates to operative paragraph 14 of resolution GC(60)/RES/12.B.4.

[54] This relates to operative paragraph 16 of resolution GC(60)/RES/12.B.4.

[55] This relates to operative paragraphs 18 and 19 of resolution GC(60)/RES/12.B.4.

design approaches and guidelines, best practices for operation, and safety of sodium experimental facilities including prevention and mitigation of sodium leaks, prevention and detection of sodium fires, assessment of sodium impact in the environment after accidental release, and hydrogen hazards in cleaning facilities. Two IAEA Nuclear Energy Series publications: NAPRO Handbook on Sodium Physical and Chemical Properties and NAPRO Handbook on Sodium Thermal-Hydraulic Correlations, are currently under preparation.[56]

[56] This relates to operative paragraph 19 of resolution GC(60)/RES/12.B.4.

Approaches to Supporting Nuclear Power Infrastructure Development

1. The Secretariat continues to encourage broad international participation in Technical Meetings, workshops and conferences on nuclear infrastructure development, and is appreciative of in-kind support provided by Member States through their cost-free participation.[57]

2. The Agency continues to coordinate and tailor its supporting activities (provision of national, regional or inter-regional workshops, expert missions, review missions, facilitation of scientific visits and fellowships) implemented through multiple technical cooperation projects aimed at building capacity in embarking countries. The Country Nuclear Infrastructure Profiles and Integrated Work Plans have been tailored to guide services provided to Member States, while taking into account the results and experience acquired through six years of Integrated Nuclear Infrastructure Review (INIR) missions as reflected in the study conducted by the Secretariat and published in *Integrated Nuclear Infrastructure Review (INIR) Missions: The First Six Years* (IAEA-TECDOC-1779).[58]

3. The TECDOC analyses the outcomes from the INIR missions and summarizes the challenges faced by countries hosting INIR missions and the approaches that they have developed to address these challenges. The lessons learned from INIR missions have also been taken into account in the preparation of *Evaluation of the Status of National Nuclear Infrastructure Development* (IAEA Nuclear Energy Series No. NG-T-3.2/Rev.1, 2016); the leaflet entitled *Introducing Nuclear Power: The Role of National Leadership* published in all 6 official languages in 2016; a revision to *Responsibilities and Capabilities of a Nuclear Energy Programme Implementing Organization* (IAEA Nuclear Energy Series No. NG-T-3.6) which is expected to be published in 2017; and a revision to *INIR: Integrated Nuclear Infrastructure Review Missions — Guidance on Preparing and Conducting INIR Missions (Rev. 1)* which will be published in the IAEA Service Series in 2017.[59]

4. The draft evaluation methodology for INIR Phase 3 missions was used in 2016 to simulate, with the support of the United Arab Emirates, a Phase 3 self-evaluation in 2016 and the Phase 3 evaluation methodology was finalized following this exercise. A guide to preparing the self-evaluation report, incorporating the results of other Agency review services (Integrated Regulatory Review Service, Emergency Preparedness Review, International Physical Protection Advisory Service, IAEA State System of Accounting for and Control of Nuclear Material Advisory Service, Pre-Operational Safety Review Team), was also developed. The methodology is expected to be provisionally applied in a Member State before the final publication is prepared and issued.[60]

5. The annual Technical Meeting on Topical Issues in the Development of Nuclear Power Infrastructure was held in February 2017 with approximately 80 participants from around 40 Member States, representing government ministries, organizations responsible for nuclear power programme planning in embarking countries, current and future owner/operator organizations, vendors, technical support organizations, universities and regulatory agencies. The annual meetings provide opportunities for participants from operating and embarking countries to share their experiences and lessons learned

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[57] This relates to operative paragraph 2 of resolution GC(60)/RES/12.B.5.

[58] This relates to operative paragraph 5 of resolution GC(60)/RES/12.B.5.

[59] This relates to operative paragraph 7 of resolution GC(60)/RES/12.B.5.

[60] This relates to operative paragraph 9 of resolution GC(60)/RES/12.B.5.

in relation to the 19 infrastructure development issues identified under the Agency's Milestones approach, and to provide updates on the status of their nuclear infrastructure. The annual meeting of the Technical Working Group on Nuclear Power Infrastructure (TWG-NPI) is another mechanism for sharing experience and lessons learned between newcomer countries and those with established nuclear power programmes.[61]

6. During 2016, the competency framework database was converted from an Excel format to an Access format, and its use was explained during a number of interregional training workshops and the TWG-NPI meeting. The database has been made available to Member States for use on a trial basis and further refinement of the database has been planned for 2017. A meeting to review the nuclear infrastructure bibliography was held from 22 to 26 May 2017 at which a revised bibliography was issued and a plan was made for the development/revision of future publications.[62]

7. In 2016, two e-learning modules on building a national position and culture for safety were completed and made available to Member States. Since 2013, 16 interactive e-learning modules for nuclear newcomers have been developed and made available to Member States through the website https://www.iaea.org/NuclearPower/Infrastructure/elearning. One new module on legal framework and procurement is progressing to the final review stage, while the development of a module on industrial involvement has been initiated.[63]

8. A revision of *Initiating Nuclear Power Programmes: Responsibilities and Capabilities of Owners and Operators* (IAEA Nuclear Energy Series No. NG-T-3.1) is currently being undertaken. A Technical Meeting on the Responsibilities of Owners/Operator in New and Expanding Nuclear Power Programmes was held in Atlanta, USA, 12–16 December 2016. The meeting included a discussion and gathered comments on further improvements to the draft revision of NG-T-3.1. The annual Technical Meeting on Topical Issues in the Development of Nuclear Power Infrastructure, held in February 2017, included a session on the role and responsibilities of the owner/operator. The Agency also organized a Technical Meeting on Developing a Systematic Education and Training Approach Using Personal Computer Based Simulators for Nuclear Power Programmes in Vienna, Austria, 15–19 May 2017. The meeting provided a forum for information exchange between 32 participants from 21 Member States through presentations and discussions on their experiences to identify the needs and challenges in education/training approaches using PC based basic principle simulators. The topical sessions covered presentations and discussions on systematic human capacity building through education and training with basic principle simulators integrated into national nuclear power programmes, reactor technology teaching with basic principle simulators, and desktop educational software examples.[64]

9. Member States are encouraged to share non-commercial information related to activities and support from other sources that are not channelled through the Secretariat in the Integrated Work Plans (IWPs) developed jointly by the Agency and the Member State. Since some of these activities might be of a commercial nature and/or related to support from a vendor, it is the decision of the Member State whether the information is included in the IWPs. A session on the concept of soft coordination

[61] This relates to operative paragraph 10 of resolution GC(60)/RES/12.B.5.

[62] This relates to operative paragraph 11 of resolution GC(60)/RES/12.B.5.

[63] This relates to operative paragraph 12 of resolution GC(60)/RES/12.B.5.

[64] This relates to operative paragraph 13 of resolution GC(60)/RES/12.B.5.

was held during the February 2017 Technical Meeting on Topical Issues in the Development of Nuclear Power Infrastructure.[65]

[65] This relates to operative paragraph 15 of resolution GC(60)/RES/12.B.5.

Small and Medium-sized Nuclear Reactors — Development and Deployment

1. In May 2017, two new CRPs were approved by the Committee for Coordinated Research Activities, namely Design and Performance Assessment of Passive Engineered Safety Features in Advanced Small Modular Reactors (2017–2019), and Development of Approaches, Methodologies and Criteria for Determining the Technical Basis for Emergency Planning Zone for Small Modular Reactor Deployment (2018–2020) as a joint CRP between the Department of Nuclear Energy and the Department of Nuclear Safety and Security.[66]

2. A Technical Meeting to Examine the Techno-Economics of and Opportunities for Non-Electric Applications of Small and Medium Sized or Modular Reactors was held in Vienna in May 2017 with the participation of 22 participants from 20 Member States. The meeting participants discussed the prospects for future nuclear cogeneration, reassessed the techno-economic aspects of nuclear cogeneration for non-electric applications based on small and medium sized or modular reactor (SMR) technologies and other potential advanced power reactors, exchanged information on practical aspects and challenging issues for the deployment of cogeneration with SMRs, and discussed hybrid energy systems and their potential coupling for non-electric applications.[67]

3. A meeting to review and finalize the report on the SMR deployment indicator study was held from 17-19 November 2015 with 12 participants from 5 Member States. The publication aims to provide Member States with an approach to perform an assessment of SMR deployment given a set of broad indicators, particularly energy supply security and economics.[68]

4. A draft TECDOC provisionally entitled *Deployment Indicators for Small Modular Reactors — Methodology, Analysis of Key Factors, and Baseline Pre-Assessment* has undergone in-house review and is planned to be published in 2017–2018.[69]

5. During the fourth quarter of 2016, the draft TECDOC on Status of Environmental Impact Assessment for Small Modular Reactor Deployment was finalized. The objective is to discuss specific technical and siting features of SMRs that may affect the content and process of Environmental Impact Analysis (EIA). The document will be submitted for internal review in the third quarter of 2017.[70]

6. A study on the applicability of IAEA Safety Standards Series No. SSR 2/1 to water cooled and gas cooled SMR designs was been carried out by the Agency. Two Consultancy Meetings on the IAEA RECDOC "*Study on the Applicability of Specific Safety Requirements (SSR) 2/1 on Design to SMRs"* were held, from 20–24 February 2017 and from 12-16 June 2017 respectively. The TECDOC will provide MS with a generic approach to the implementation of an EIA process to support SMR licensing.[71]

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[66] This relates to operative paragraph 2 of resolution GC(59)/RES/12.B.6.

[67] This relates to operative paragraph 3 of resolution GC(59)/RES/12.B.6.

[68] This relates to operative paragraph 4 of resolution GC(59)/RES/12.B.6.

[69] This relates to operative paragraph 5 of resolution GC(59)/RES/12.B.6.

[70] This relates to operative paragraph 6 of resolution GC(59)/RES/12.B.6.

[71] This relates to operative paragraphs 7 and 8 of resolution GC(59)/RES/12.B.6.

7. Training material for modelling SMRs within alternative energy mixes was developed in 2016. A draft demonstration case study for modelling energy systems to assess the economic competitiveness of SMRs using the Model for Energy Supply Strategy Alternatives and their General Environmental Impacts (MESSAGE) was prepared and disseminated to interested end users. A regional workshop on financial analysis of SMRs using the Model for Financial Analysis of Electric Sector Expansion Plans (FINPLAN) will be held in Vienna from 11-15 December 2017. A Technical Meeting on Technology Assessment of Small Modular Reactors for Near Term Deployment was held from 5 to 9 September 2016 in Beijing, China, and was hosted by the China National Nuclear Corporation. The purpose of the meeting was to provide a forum for Member States to discuss, in an integrated manner, the status of SMR designs and technologies commercially available or for near term deployment, and approaches for technology assessment. The meeting was attended by 29 participants from 17 Member States, including 7 embarking countries. A Technical Meeting on the Design and Operation Aspects of Pressurized Water Reactor Type Small and Medium Sized Reactors was held from 5 to 9 December 2016 in Islamabad, Pakistan, and was hosted by the Pakistan Atomic Energy Commission. The meeting enabled embarking countries to become aware of the design and operation aspects of pressurized water reactor (PWR)-type SMRs. The meeting was attended by 23 participants from 8 Member States. Direct assistance in capacity building and in future SMR (high temperature gas cooled reactor) deployment has been provided, through technical cooperation projects, especially to Indonesia through its experimental power reactor project.[72]

8. Two consultancy meetings on Finalizing the Nuclear Energy Series on *Technology Roadmap for Small Modular Reactor Deployments* were held from 14–17 March 2016, and from 28–30 November 2016. The publication has the key objectives to provide a review of current progress related to SMRs under construction and share lessons learned; and present several "model" roadmaps for SMRs to adopt as reference for strategic pathways in their national programmes on energy for electricity generation. *Design Safety Considerations for Water Cooled Small Modular Reactors Incorporating Lessons Learned from the Fukushima Daiichi Accident* (IAEA-TECDOC-1785) was published in March 2016. The 2016 edition of the booklet entitled *Advances in Small Modular Reactor Technology Developments*, which is a supplement to the Advanced Reactors Information System, was published for the 60th regular session of the General Conference in September 2016 and provided input to the draft technology roadmap publication for SMRs.[73]

[72] This relates to operative paragraph 13 of resolution GC(60)/RES/12.B.4 and to operative paragraph 9 of resolution GC(59)12.B.6.

[73] This relates to operative paragraph 10 of resolution GC(59)12.B.6.