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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(58)/RES/13 and GC(59)/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); renovation of the Nuclear Applications Laboratories (ReNuAL) (Annex 2); the development of the sterile insect technique for the control or eradication of malaria-, dengue- and other disease-transmitting mosquitoes (Annex 3); strengthening the support to Member States in food and agriculture (Annex 4); nuclear energy activities (Annex 5); Agency activities in the development of innovative nuclear technology (Annex 6); plan for producing potable water economically using small and medium-sized or modular reactors (Annex 7); approaches to supporting nuclear power infrastructure development (Annex 8); and nuclear knowledge management (Annex 9).
- Further information on the Agency's activities related to nuclear science, technology and applications can be found in the *Nuclear Technology Review 2016* (document GC(60)/INF/2), the *IAEA Annual Report 2015* (GC(60)/9), in particular the section on nuclear technology, and the *Technical Cooperation Report for 2015* (GC(60)/INF/4).

Recommended Action

- It is recommended that the Board take note of Annexes 1-9 of this report and authorize the Director General to submit the report to the General Conference at its 60th regular session.

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

A. Background

1. In resolution GC(59)/RES12/A.1, the General Conference recognized that tsetse flies and the trypanosomosis problem they cause are increasing and constitute one of the greatest constraints on the African continent's socioeconomic development, affecting the health of humans and livestock, limiting sustainable rural development and thus causing increased poverty and food insecurity.
2. The General Conference requested the Secretariat to support Member States through technical cooperation projects on baseline data collection, development of full project proposals and implementation of operational tsetse eradication projects underpinned by on-site based experts, with priority given to genetically isolated tsetse populations. The General Conference requested the Agency and other partners to strengthen capacity-building in Member States for informed decision-making regarding the choice of T&T strategies and the cost-effective integration of SIT operations in area wide insect pest management (AW-IPM) campaigns.

B. Progress since the 59th General Conference

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

3. The Agency was represented at the 33rd meeting of the International Scientific Council for Trypanosomiasis Research and Control (ISCTRC), the 14th meeting of PATTEC National Coordinators and the 4th PATTEC Steering Committee Meeting which were all held concurrently in N'djamena, Chad, in September 2015. A presentation was given to update AU-PATTEC members and participants of the ISCTRC on the current status of activities of the Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture and the Department of Technical Cooperation in support of tsetse and trypanosomosis control. The meeting was informed that the Agency's General Conference continues to recognize that the tsetse and trypanosomosis problem constitutes one of the greatest constraints for socio-economic development of the African continent and welcomed the continuing close collaboration of the IAEA with AU-PATTEC in its goal to eliminate tsetse flies and trypanosomosis through the creation of sustainable tsetse and trypanosomosis free areas. During the course of the meeting, the Agency was presented with a certificate recognizing its contribution to PATTEC over previous years.

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

4. The Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture and the Department of Technical Cooperation have continued to respond to Member States' requests for support in incorporating SIT in area-wide integrated pest management (AW-IPM) approaches to eliminate or control tsetse-transmitted trypanosomiasis, which is a major constraint to both livestock and agricultural crop production in sub-Saharan Africa. This support comes through the provision of technical advice, procurement of equipment and materials, training courses and workshops, fellowships and scientific visits, research conducted at the Nuclear Applications Laboratories in Seibersdorf, and CRPs that address gaps in scientific knowledge.

5. The Agency has continued to support and strengthen capacity building in Member States, enabling them to obtain and analyse baseline data that contributes to informed decision-making regarding the choice and feasibility of available tsetse and trypanosomiasis suppression or eradication strategies, including the cost-effective integration of SIT operations into AW-IPM campaigns. Since the 59th General Conference support in this area has been given to Angola, Burkina Faso, Chad, Ethiopia, Ghana, Mozambique, Niger, Senegal, South Africa, Swaziland, Tanzania, Uganda, Zambia and Zimbabwe.

6. A regional training course on the 'Use of GIS and Population Genetics to Identify Isolated Tsetse Populations' was held in Addis Ababa, Ethiopia from 21 September to 2 October 2015. A total of 22 participants from 18 Member States attended the course.

7. Since September 2015, the Agency has supported more than 17 fellowships and scientific visits. The fellowships provide training through individual work experience at specialized institutions and provided training for a total duration of more than 300 days. A significant number of these fellowships and scientific visits included periods spent at the Insect Pest Control Laboratory (IPCL) in Seibersdorf, Austria.

8. Research activities at the IPCL have focused on the development and validation of technologies that can significantly contribute to the cost reduction and simplification of the application of the SIT against major tsetse species.

9. First positive results on using infrared scanners for the sex separation of tsetse pupae have been obtained and submitted for publication. This is essential to be able to retain females for colony build-up, while shipping sterile males as pupae to target sites for fly emergence and release.

10. Conditions for long distance shipments of chilled sterile male pupae have been improved by adjusting environmental conditions inside the transport box and mitigating vibrations during transport. Both achievements will significantly contribute to developing regional mass-rearing facilities that will provide sterile pupae to field projects in sub-Saharan Africa. Protocols were developed and validated in West Africa to assess and ensure the biological quality of sterile male flies that are shipped long distances as pupae.

11. An unmanned aerial system (UAS), designed to provide a more economical means of releasing sterile male tsetse in SIT operations, has been equipped with a prototype of a chilled adult release machine and tested under controlled conditions and has shown acceptable endurance and payload capacity for use in operational programmes. The UAS will be field tested in Ethiopia once official authorization for its use has been obtained from the Ethiopian government. It is anticipated that this system will significantly reduce costs of the SIT component of AW-IPM projects.

12. A model was developed using genetic distance between tsetse populations in West Africa and remotely sensed environmental data to identify natural barriers of tsetse populations that can be targeted for eradication programmes. The method can be used to prioritize intervention areas under the PATTEC initiative.

13. Molecular tools have been developed, based on nuclear, microsatellite and mitochondrial markers, for cost-efficient identification of tsetse species with very similar morphology, such as *Glossina morsitans morsitans*, *G. m. centralis* and *G. swynnertoni*.

14. Fifteen countries continued to participate in research on inhibition of trypanosome transmission through symbiotic microbes under the CRP entitled: *Enhancing Vector Refractoriness to Trypanosome Infection*. A Research Coordination Meeting for this Project was held in France in May 2016, reflecting good progress in understanding interactions between tsetse symbionts, parasites and pathogens.

15. 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 contributes a significant proportion of the annual publications in the field of tsetse and trypanosomosis both in journals and through published guidelines and manuals or standard operating procedures (SOPs) which are available on the IAEA website. During the reporting period these publications have included: SOP to *Detect and Manage Salivary Gland Hypertrophy Virus (GpSGHV) in Tsetse Fly 'Factories'* and SOP on *Sterile Male Tsetse Shipment and Handling for Release* and a user's manual: *Blood Processing Database for Kality, Ethiopia*.

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

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

16. Technical support has been provided to the Government of Senegal in its programme to eradicate *Glossina palpalis gambiensis* in the highly productive agricultural region of the Niayes, 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. Sterile male releases ceased at the end of 2014 in block 1 as no wild tsetse flies had been detected in monitoring traps since mid-2012 and it is assumed that the tsetse population has been successfully eradicated. After a period of tsetse population suppression, aerial releases of sterile males were initiated in early 2015 in block 2, and have resulted in a significant decrease in the tsetse fly population in that area. Releases of sterile males were initiated in mid-2016 in Block 3 and are scheduled to continue until reaching eradication in the entire project area.

17. The successful elimination or suppression of the tsetse population so far achieved in blocks 1 and 2 have resulted in a substantial decrease in the prevalence of the disease trypanosomosis in cattle in those areas. A cost-benefit analysis indicated that eradication of the target tsetse population will be highly cost-effective with estimated annual increases of cattle sales of ~ €2,800/km² compared to a total cost of ~ €6,400/km² of the eradication campaign. Other benefits attributed to the project include a reduction of grazing pressure on the region's fragile ecosystems. The Senegalese government has plans to introduce more exotic livestock breeds enabling a modern meat and dairy sector to be created that will serve the nearby capital city of Dakar.

18. This project continued to benefit from financial support from the USA, through the Peaceful Uses Initiative (PUI), and through the secondment of a scientist by the French International Cooperation Centre of Agricultural Research for Development (CIRAD).

19. In 2015, the Agency signed a Practical Arrangement with the CIRAD aimed at furthering the successful collaboration achieved in Senegal to other tsetse-transmitted trypanosomosis control projects in Africa. As a result of this agreement, a scientist was seconded to the PATTEC Headquarters in Addis Ababa in August 2015 to provide support to tsetse and trypanosomosis control in the region.

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

20. 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 Ethiopian Rift Valley. A significant development in 2015 was the formal creation of the National Institute for Control and Eradication of Tsetse and Trypanosomosis (NICETT) by the Ethiopian Government. NICETT was established in mid-2015 and assumed responsibility for the Southern Rift Valley Tsetse Eradication Project (STEP) in accordance with the Ethiopian government decision that the new institution be responsible for all tsetse and trypanosomosis control activities in the country.

21. In May 2016, the 6th International Management Advisory Committee (IMAC) meeting of the project took place in Addis Ababa in conjunction with the 9th High Level Meeting. The Ethiopian government increased its financial support to NICETT to 75 million Birr for the 2016-2017 financial year (approximately €3.1 million).

22. As a result of the rigorous implementation and adherence to standard procedures developed by the Agency, the Salivary Gland Hypertrophy Virus that had been affecting the growth of colonies of tsetse flies maintained at the Kality mass-rearing facility in Addis Ababa has now been controlled.

B.3.3. Burkina Faso (RAF/5/070)

23. In collaboration with the Agency, CIRDES, Bobo Dioulasso, Burkina Faso is supporting the Government of Senegal with their efforts to eradicate a tsetse population in the Niayes region through the weekly supply of sterile male tsetse flies. In addition, the Agency is providing technical support for the preparation of a tsetse control programme in Burkina Faso under the PATTEC.

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

24. The Agency has provided equipment to Uganda to support the implementation of suppression and eradication of *G. f. fuscipes* on the Kalangala Islands in Lake Victoria. This support includes the provision of *G. f. fuscipes* pupae from the IPCL, Seibersdorf, that are being used to develop and improve tsetse feeding techniques used in Uganda. This will enable the project to test and compare the competitiveness of wild and sterile male tsetse.

B.3.5. Zambia (RAF/5/070)

25. In 2015, support was given to the Tsetse and Trypanosomiasis Control Unit in the Zambian Department of Veterinary Services to establish a diagnostic laboratory using the Polymerase Chain Reaction (PCR) technique for accurate identification of trypanosome infections. This support included provision of scientific equipment and training in its use and interpretation of results obtained. This will contribute to assessing the feasibility of integrating the SIT into control and eradication of tsetse-transmitted trypanosomosis to both humans and livestock in affected areas of Zambia.

B.3.6. Zimbabwe (ZIM/5/019)

26. 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, as well as through scientific visits to the Agency-

supported tsetse eradication project in Senegal. Training and equipment was provided jointly by IAEA and FAO to build capacity in the use of geographic information systems (GIS) for managing and planning tsetse control activities using the SIT where feasible.

B.3.7. Angola (ANG/5/012)

27. In Angola, the Agency is supporting a feasibility study for using the SIT as part of an AW-IPM approach to eradicate *Glossina morsitans centralis* from an area of 32,000 km². A mobile sampling device was developed that can be installed on a 4WD vehicle for cost-effective entomological surveys. This method has been used to initiate a survey to assess the distribution and abundance of tsetse over the proposed project area. If sufficient tsetse fly samples can be obtained the IAEA will provide support to produce predictive tsetse distribution maps for this region of Angola and to create a microsatellite bank for genetic analysis of *G. m. centralis* strains. Training on sterile male handling and release has been provided through fellowships implemented in Senegal.

B.3.8. Swaziland

28. Swaziland has recently joined the regional TC project (RAF/5/0/69) entitled: “*Supporting a Feasibility Study to Eradicate Tsetse from Southern Mozambique, South Africa and Swaziland*”. A participant from Swaziland attended the regional training course on GIS and population genetics held in Addis Ababa, Ethiopia in September 2015.

B.3.9. Chad (CHD/5/003)

29. The Agency extended its technical cooperation project with Chad and has supplied laboratory and field equipment to support, Chad conducting entomological monitoring activities in the Mandoul area.

C. Conclusion

30. African trypanosomiasis 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 and other parasitic diseases are prevalent. Where technically feasible, the SIT becomes a significant tool for alleviating this constraint as a component of area-wide integrated pest control interventions. In such situations, it provides an environmentally friendly means of eradicating the tsetse fly vector populations, removing the risk not only of animal trypanosomiasis but also of human trypanosomiasis (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 significantly improve the livelihoods of rural populations. The Agency has played a significant role in building this capacity within Member States in sub-Saharan Africa.

31. The major constraints to successful and more widespread application of the SIT in suitable areas are twofold; firstly, the lack of mass-rearing infrastructure, particularly of facilities for tsetse in Africa that are needed to supply sterile male flies. The second is the lack of appropriate management structures that are capable of organising and maintaining technically demanding area-wide operations.

Renovation of the Nuclear Applications Laboratories (ReNuAL)

A. Background

1. During the 56th regular session of the General Conference in 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(59)/RES/12.A.4, the General Conference requested the Director General to report on progress made in implementing the resolution at its 60th regular session.

B. Progress Since the 59th General Conference

B.1. Revised Cost Estimates and Project Scope

2. In September 2015, the functional designs for the new Insect Pest Control Laboratory (IPCL), Flexible Modular Laboratory (FML), bunker for a medical linear accelerator (LINAC) for the Dosimetry Laboratory and site infrastructure were completed. This concluded a year-long design development process that began with work on conceptual designs starting in August 2014. The functional designs provided a high-level of detail and updated cost estimates. As these provided estimated costs that would exceed ReNuAL's €31 million budget, the project's scope has been adjusted to allow for its implementation within this budget.

3. Ahead of the March 2016 meeting of the Board of Governors, the Secretariat issued GOV/INF/2016/4, *"The Renovation of the Nuclear Applications Laboratories Project (ReNuAL)"*, to Member States, which described the revised scope in detail. It included the following elements: the structure of the IPCL to be constructed in full and as much of its interior as possible to be provided within the budget of €11.9 million, and; two of the three originally planned laboratory wings of the FML (the Food and Environmental Protection Laboratory and the Soil and Water Management and Crop Nutrition Laboratory) to be fully finished and furnished within the budget of €12.0 million.

4. Construction of the third planned wing of the FML, the Terrestrial Environment Laboratory, the remaining finishing and furnishings of the IPCL, a bunker to house a LINAC for the Dosimetry Laboratory, some components of the new site infrastructure that are not required to support the operations of the IPCL and FML within the adjusted scope, and all remaining unfunded equipment needs were moved to ReNuAL Plus (ReNuAL+) to keep ReNuAL within the €31 million budget. Approximately €1.5 million in extrabudgetary funds have already been contributed to support the procurement of a total of 12 items for five of the eight NA laboratories in Seibersdorf. These items have been procured and have improved the capabilities of these laboratories, with the remaining

€3.5 million of equipment that was originally in ReNuAL moved to ReNuAL+. All postponed elements of ReNuAL are now part of ReNuAL+, which was originally defined in GOV/INF/2014/11/Add.1, “*Strategy for the Renovation of the Nuclear Science and Applications Laboratories in Seibersdorf*”.

5. These adjustments to the scope of ReNuAL are consistent with key recommendations of the Standing Advisory Group for Nuclear Applications to prioritize new and expanded space and infrastructure over items such as equipment in implementing ReNuAL.

B.2. Implementation Schedule

6. After completion of the functional designs and the delivery of the revised cost estimates in September 2015, the procurement for ReNuAL’s construction contract began in October 2015. The contract was awarded in March 2016, and the first step in the contract was the review and finalization of the functional designs to provide construction-ready designs and final costs. These costs were in-line with the functional design estimates, allowing for construction to proceed as planned under the revised project scope and within the €31 million budget.

7. While the designs were finalized, the new electrical infrastructure required to support the new buildings was built from March 2016 to June 2016 and was completed on time and on budget. This ensures that the necessary power supplies will be available on site to support building construction.

8. Work on both the IPCL and FML began in July 2016. The IPCL will be built with full shell and core and an estimated 60% of the interior to be completed, and this work is planned for completion by December 2017. The completion of two wings of the FML planned for construction under the revised scope is currently planned for mid-2018. The associated infrastructure will be built concurrently with the buildings.

B.3. Financial Status and Resource Mobilization

B.3.1. Financial Status

9. Of the €31 million needed for ReNuAL, one-third is provided through the regular budget and two thirds are required through extra-budgetary funding. Since the start of the 59th General Conference, 20 financial contributions to ReNuAL have been announced, pledged or provided bilaterally by 18 Member States, and collectively in the case of AFRA, the African Regional Cooperative Agreement for Research, Development and Training Related to Nuclear Science and Technology, which consists of 39 Member States. These contributions total approximately €13.2 million and bring the total extrabudgetary funds announced, pledged or provided to date to the €20.6 million in extrabudgetary funds required to fund ReNuAL fully. In total, 25 Member States made bilateral financial contributions, along with the collective contribution of the 39 Member States of AFRA, to reach this funding target.

10. Regarding regular budget funds, €7.9 million have been allotted to date from the Major Capital Investment Fund (MCIF), with a further €2.5 million planned in the 2017 MCIF, which will fulfil the €10.4 million in total regular budget funding that was planned for ReNuAL.

B.3.2. Resource Mobilization Strategy

11. 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 more targeted resource mobilization products were developed, including Member State-specific briefs on assistance provided by the laboratories that were prepared for a large number of interested donors,

and focused information on specific areas of the laboratories' activities that was provided at the request of interested donors. Laboratory tours continued to be a significant tool for outreach and resource mobilization, with approximately 60 Member State tours in 2015.

12. Additionally, the ReNuAL webpages were fully redesigned with new content provided and are continually being updated with new information, and the Secretariat continues to publish a quarterly news brief that reports on the status of the project and promotes awareness of its requirements.

B.3.3. Resource Mobilization Efforts with Member States

13. The Secretariat has continued to engage in bilateral discussions with a wide number of Member States to support fundraising. In this context, the Friends of ReNuAL, co-chaired by Germany and South Africa, and which is an informal group open to all Member States, have continued to play an important role. 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 meeting of the Friends of ReNuAL was held in May 2016 to call for additional contributions to close ReNuAL's extrabudgetary funding gap.

14. The Secretariat's recent fundraising efforts have also been complemented by a more regional approach to engaging with Member States. In February 2016, with support from the Government of the State of Kuwait, the Kuwait Foundation for the Advancement of Science and the Kuwait Institute for Scientific Research, the Secretariat organized a symposium in Kuwait entitled, "*Nuclear Applications for Sustainable Development in GCC Member States*", with ReNuAL as the key theme of the symposium. The Secretariat has also engaged with AFRA and the Regional Cooperative Agreement for the Promotion of Nuclear Science and Technology in Latin America and the Caribbean (ARCAL), which has 21 Member States, to seek financial support for ReNuAL.

15. To keep Member States apprised of the status of the project and to request further financial support, the Secretariat conducted informal technical briefings in December 2015 and February 2016. Also in February 2016, the Secretariat issued GOV/INF/2016/4 to provide a detailed update on the status of ReNuAL and its funding requirements.

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

16. The Secretariat has made a variety of efforts since the 59th General Conference to attract support from non-traditional donors, including equipment manufacturers, foundations, and industry associations. Significant progress has been made in working with manufacturers to develop a modality for the cost-free lending of equipment, and a key objective of these efforts is to establish a model agreement that can standardize such arrangements and simplify the process of establishing them with manufacturers. The Secretariat will continue to pursue opportunities to expand its engagement with non-traditional donors.

C. Next Steps

17. Resource mobilization efforts are continuing with the first priority of mobilizing the resources required to complete the elements of ReNuAL that were moved to ReNuAL+ in GOV/INF/2016/4, and in particular, full completion of the IPCL and FML, together with their supporting infrastructure, as well as construction of the bunker for the Dosimetry Laboratory. The equipment items moved to

ReNuAL+ will also be sought as part of these efforts. Planning for the initial elements of ReNuAL+, as defined in GOV/INF/2014/11/Add.1, will now proceed.

18. The importance of moving forward with the remaining needs of the laboratories is highlighted by the steady growth in demands on the laboratories from Member States, which is particularly relevant in the context of achieving the Sustainable Development Goals, and by the increasingly frequent occurrence of emergencies, such as the Zika virus outbreak of 2015, that require rapid responses from the laboratories. Given that both of these trends are expected to continue, it is essential that all the NA laboratories in Seibersdorf be made as fit-for-purpose as possible.

Development of the Sterile Insect Technique for the Control or Eradication of Malaria-, Dengue- and Other Disease-Transmitting Mosquitoes

A. Background

1. In resolution GC(58)/RES/13.A.2, the General Conference noted with concern that malaria, transmitted by mosquitoes, causes about 630 000 deaths a year and affects about 207 million people, mainly in Africa, where it is slowing down economic growth by 1.3% annually, thus constituting a major obstacle to poverty eradication in Africa. The General Conference also noted that the malaria parasite has continued to develop resistance to available drugs and that mosquitoes too have continued to develop resistance to insecticides, and that it is envisaged that the sterile insect technique (SIT) would be used under specific conditions as an adjunct to conventional technologies, conforming to the World Health Organization's roll-back strategy, including integrated vector management, of not relying on any single approach to control malaria.
2. The General Conference also noted with serious concern that mosquito-transmitted dengue has become in recent years a major international public health concern due to the increasing spread of invasive mosquito species. There are 2.5 billion people living in areas where dengue viruses can be transmitted and that insecticide-treated bed nets are not effective in combating dengue as the mosquito vectors are active during the day and therefore, other control tactics are urgently required. The General Conference also noted with concern an increase in mosquito-transmitted chikungunya in the Latin American region, and that currently there is no treatment available for these mosquito-borne diseases.
3. The General Conference further noted that the suppression of disease-transmitting mosquitoes using the SIT will be most suitable in urban areas where aerial spraying with insecticides is prohibited or not suitable, and that an area-wide control strategy over urban areas is required, which represents a novel and potentially powerful supplement to existing community-based programmes.
4. The General Conference noted with appreciation the interest shown by some donors and their support for R&D to further the development and implementation of the SIT for combating malaria, dengue, and other disease-transmitting mosquitoes, and acknowledged the support given by the Agency to development of the SIT for the control of malaria-, dengue- and other disease-transmitting mosquitoes as outlined in the report by the Director General in document GC(56)/7, Annex 1.
5. The General Conference requested the Agency to continue and strengthen the required research, both in the laboratory and in the field, required to use the SIT for the management of malaria, dengue, and other disease-transmitting mosquitoes. It requested the Agency to increasingly involve scientific and research institutes of developing Member States in the research programme in order to secure their ownership. The General Conference also requested the Agency to increase its efforts to develop and transfer more efficient sex separation systems that allow complete removal of the female mosquitoes

in production facilities and to develop cost-effective methods to release and monitor sterile males in the field.

6. The General Conference requested the Agency to allocate adequate resources and to attract extra-budgetary funds to enable an expansion of the mosquito research programme and related laboratory/office space and staffing. The General Conference also requested the Agency to strengthen capacity building and networking in Latin America, Asia and Africa through regional TC projects and to support field projects against *Aedes* and *Anopheles* mosquitoes through national TC projects for assessing the potential of the SIT as an efficient control tactic for disease-transmitting mosquitoes.

7. The General Conference invited the Agency to act upon the recommendation made by the experts of the “Thematic Plan for the Development and Application of the Sterile Insect Technique (SIT) and Related Genetic and Biological Control Methods for Disease-Transmitting Mosquitoes” organized by the Agency in Vienna in June 2014 to invest in supporting the control of the mosquito vector species through continuous funding of the development of the SIT and related genetic and environment-friendly methods. The General Conference also called on Member States to support the construction of the new Insect Pest Control Laboratory (IPCL) in Seibersdorf under the ReNuAL initiative and make adequate financial contributions to support its growing research and technology transfer programme.

8. The General Conference requested the Agency to continue to solicit extra-budgetary resources, including through the IAEA Peaceful Uses Initiative, to enable validation of the SIT package for disease-transmitting mosquitoes through operational projects in the field; and requested the Director General to report on the progress made in the implementation of this resolution to the General Conference at its 60th session (2016).

9. In response to the outbreak of the Zika virus in Latin America and the Caribbean, Member States called on the Agency for assistance with Zika detection and diagnosis. Zika is a disease transmitted through by infected *Aedes aegypti* mosquitoes. The early, fast and accurate detection of Zika is crucial in order to manage outbreaks. The virus has been associated with serious birth defects and neurological disorders in adults.

B. Progress since the 58th General Conference

10. In response to resolution GC(58)/RES/13, the IPCL in Seibersdorf continued to work on the development of the SIT package for disease-transmitting mosquitoes, i.e. the malaria vector *Anopheles arabiensis* and the vectors for dengue and chikungunya, *Aedes aegypti* and *Aedes albopictus*. The IPCL is currently maintaining mosquito colonies originating from Brazil, China, France (La Reunion), Indonesia, Italy, Mauritius, Sudan, Thailand, and the USA. In addition, the IPCL is maintaining several mosquito lines with morphological markers required for the development of genetic sexing strains (GSS) which facilitate the separation of males and females and allow male-only sterile mosquito releases, as well as lines carrying the symbiont *Wolbachia*¹ which are suitable for the combined SIT and incompatible insect technique (IIT) population suppression approach (SIT/IIT).

11. An automated larval feeder has been designed and constructed and will be validated at the IPCL. Egg productivity of both malaria and dengue/chikungunya vectors was improved using the newly developed adult mass-rearing cages. One million *Anopheles arabiensis* and *Aedes aegypti* eggs were

¹ A bacterium that can result in the incompatibility of a sperm and an egg, preventing the production of viable offspring

produced per cage over 15 and 21 days, respectively. The IPCL continues to make efforts to reduce the manufacturing and operational costs of the equipment.

12. Standardized methods were developed to quantify mosquito eggs and a standard operating procedure for egg hatching was developed and transferred to Member States. The insect greenhouse at the IPCL in Seibersdorf was extensively used for experimental work and validation of SIT-based mosquito population suppression approaches. The insect greenhouse was also used for large cage suppression trials to validate the combined SIT/IIT approach using a *Wolbachia*-infected *Ae. albopictus* strain from China.

13. Recognizing the increasing challenges associated with using isotopic irradiators for the irradiation of mosquitoes and the anticipated rapid expansion of mosquito suppression projects, the Agency is developing a new small scale X-ray irradiator in China. The Agency provided the design details and worked with a Chinese company to validate the new irradiator, which appears capable of irradiating up to 7 million pupae per day, sufficient for research and development work and for small operational programmes.

14. The Agency continues the efforts to develop robust and efficient methods for sex separation, including genetic sexing. A former GSS of *An. arabiensis* that was developed based on the insecticide dieldrin was found not suitable, and therefore new efforts have been initiated to identify suitable markers. Morphological markers related to larval body colour or adult eye colour have been isolated and several lines have been established and are being evaluated for their suitability for the development of GSS.

15. The current lack of genetic sexing or other fail-proof methods for sex separation prompted the development of an innovative proposal that integrates the SIT with the *Wolbachia*-based IIT. The combined SIT/IIT approach eliminates the risk of accidental releases of fertile and pathogen-transmitting females during SIT operations, and thus represents a biosafe and biosecure approach for the suppression of mosquito populations. Several lines of *Ae. aegypti* and *Ae. albopictus* suitable for the combined SIT/IIT approach have been developed and characterized and are being used in pilot release trials in China and in Thailand.

16. In parallel, the Agency continued to manage the co-ordinated research project (CRP) on “Exploring Mechanical, Molecular, Behavioural or Genetic Methods of Sex Separation in Mosquitoes” which started in October 2013 with twenty-three researchers from Africa, Asia, Europe, South/Central America, and the USA. The second research coordination meeting (RCM) was held in Brazil in March 2015 and the progress made was discussed and future work plans developed.

17. As part of the mosquito SIT package, the Agency is addressing key issues related to the handling, transport, and release of sterile male mosquitoes without causing significant impact to their survival or post-release performance, as well as a means to monitor their performance after release. Mosquito population monitoring methods are required so that the releases can be scaled to the target population, and to assess the progress and impact of the releases on the target population. In view of the urgency to develop appropriate and affordable release and monitoring tools, the Agency started a new CRP on “Mosquito Handling, Transport, Release and Male Trapping Methods” and the first RCM was held in Vienna, Austria in November 2015. Twenty-one researchers from Africa, Asia, Europe, South/Central America, and the USA attended the first RCM and future work plans were discussed and developed.

18. In response to Member States’ needs for new sterile male mosquito release methods, the Remotely Operated Mosquito Emission Operation (ROME0) was developed. ROME0 uses an unmanned aerial release vehicle (UAV) to transport and release sterile male mosquitoes by air. The concept was proposed by the Agency, in partnership with the Food and Agriculture Organization of

the United Nations (FAO), and constructed in collaboration with the German drone manufacturer Height Tech. ROMEO was one of two IAEA-supported projects submitted to the 2016 United Arab Emirates Drones for Good Award competition. This innovative concept won fourth place in the competition, which received over 1000 entries from more than 160 countries.

19. Following the recommendations made in the “Thematic Plan for the Development and Application of the Sterile Insect Technique (SIT) and Related Genetic and Biological Control Methods for Disease-Transmitting Mosquitoes” a TC project (INT5155) “*Sharing Knowledge on the Sterile Insect and Related Techniques for the Integrated Area-Wide Management of Insect Pests and Human Disease Vectors*” began in 2016 and the kick-off meeting took place in Tapachula, Mexico in July 2016 with more than fifty countries represented.

20. The Agency continued to provide support to Member States through four national TC projects in Mauritius, South Africa, Sri Lanka and Sudan (MAR/5/019, SAF/5/013, SRL/5/044, and SUD/5/034,) and one regional TC project in the Indian Ocean region (RAF/5/065), including Madagascar, Mauritius and Seychelles, as well as La Reunion, France. The Agency has started to provide support to Member States through six national TC projects for Marshall Islands, Mexico, Philippines, South Africa, Sri Lanka and Sudan (MHL5001, MEX/5/031, PHI/5/033, SAF/5/014, SRL/5/047 and SUD/5/038).

21. Related to the spreading of dengue and chikungunya, the Agency is implementing two regional TC projects in the Asia/Pacific region (RAS/5/066), and in the Indian Ocean region (RAF/5/072) from 2014 to 2016. Through workshops, training courses and networking, these projects have promoted sharing of expertise and capacity building and the establishment of Standard Operating Procedures (SOPs) for mosquito surveillance, mass rearing and overall management of vector populations. Personnel from participating countries was trained at the IPCL on mosquito rearing and SIT related activities and the knowledge gained used for mosquito surveillance in pilot sites. A significant amount of baseline data is now available for a better understanding of the biology of *Aedes* mosquito in the field and for the development of efficient management strategies.

22. In response to numerous Member States’ requests related to the recent spread of Zika in the Americas, a new off-cycle regional TC project (RLA/5/074) was developed for the Latin American and the Caribbean region to support the transfer of SIT as a component of integrated vector management (IVM) approaches. This project was approved by the Board of Governors in March 2016 and focusses on capacity building including mosquito surveillance, mass rearing, sex separation, irradiation, handling, transport and release methods, and monitoring, including pilot trials in several Member States. The project was launched with a regional meeting in Tachpahula, Mexico. National work plans were developed for fourteen Member States. A follow on meeting to define pilot test site selection criteria and methodology took place in Vienna in August 2016. The meeting was also attended by experts from the USA to harmonize the regional approach and create technical and strategic partnerships.

23. A new PUI project was simultaneously developed in March 2016 to support the mosquito research and technology activities at the IPCL required to provide the technical support for the above TC projects and to better respond to the increasing demands for the development and application of SIT-based approaches for the management of Zika transmitting *Aedes* species. Financial contributions were provided by the Governments of Japan and USA to support the expansion of mosquito activities at the IPCL.

24. In response to Member States’ requests related to the spread in Europe of invasive mosquito species such as *Ae. albopictus*, the Agency developed a footnote-a regional TC project RER/5/022 “*Establishing Genetic Control Programmes for Aedes Invasive Mosquitoes*” . Mosquito populations

are expanding into new areas in Europe, increasing the threat of transmission of diseases such as dengue and chikungunya. The project was approved for the 2016-17 TC cycle in November 2015. A kick-off meeting took place in Vienna, Austria in August 2016 with more than twenty countries represented.

25. TC projects in Sudan (SUD/5/034 and SUD/5/038) continue to assess the feasibility of integrating the SIT against *An. arabiensis*. The initiative is supported by the Islamic Development Bank (IDB) through a soft loan to the Government of Sudan. Mosquito surveillance in the field and limited releases have been carried out in a 20 km² pilot site since 2015 to study the dispersal of the sterile males and their participation in swarms. In addition, the Agency provided assistance to staff of the Tropical Medicine Research Institute (TMRI) and a Sudanese engineering company to finalize the design of the IDB-funded mosquito mass-rearing facility. Its construction began in April 2016 in Soba on the periphery of Khartoum. Furthermore, the Agency has initiated the process to procure an IDB funded gamma irradiator.

26. More information on the achievements and status of development of the SIT for the control of disease-transmitting mosquito vectors can be found in document GOV/INF/2016/5.

C. Conclusion

27. Mosquito-borne diseases such as malaria, dengue, yellow fever, chikungunya, Zika and others remain among the most severe threats to the health of millions of people worldwide. Due to globalization and climate change, the distribution of many species of mosquitoes is spreading to areas previously free of vectors of these diseases. This has resulted in more frequent outbreaks of these diseases in the past decade. Most of these mosquito populations are currently being controlled using insecticide-based methods, which result in other health threats and build resistance in the mosquitoes.

28. The SIT is part of an area-wide integrated vector management approach. The Joint FAO/IAEA Division and the IPCL in Seibersdorf have continued with the development, validation and optimisation of the SIT package as a complementary tool for the management of mosquito populations. The main challenge remains the lack of an efficient sex separation method which would allow male-only releases. This bottleneck can be overcome by combining the SIT with the IIT as this eliminates the risk of accidentally releasing fertile and pathogen transmitting females during SIT applications. The SIT/IIT approach is therefore a safe, biosecure and responsible approach to manage mosquito populations as the suppression of *Aedes* populations below a certain threshold will limit or avoid the transmission of all these diseases (dengue, chikungunya, Zika, yellow fever or any new or re-emerged ones).

29. This novel technology was published in the scientific literature and was presented by staff members at several international meetings in Brazil, China, France (French Polynesia), Mexico, Singapore, Sri Lanka, Thailand, USA as well as in meetings organized by WHO in Geneva, Switzerland and the Pasteur Institute in Paris, France.

30. The first strains for the combined SIT/IIT approach are now available for *Aedes* mosquitoes and are being tested in small scale pilot trials (China and Thailand) while others are planning to initiate releases soon (Brazil, Singapore and Mexico). The ultimate aim will be to use this approach to protect humans in villages, small towns or even larger cities.

31. While the Agency has continued increasing its efforts to develop the SIT for disease-transmitting mosquitoes, it should be noted that these efforts do not include the development of methods to directly

control diseases such as malaria, dengue, chikungunya or Zika. The development of the SIT package for mosquitoes is a long-term initiative and its final successful implementation will also largely depend on the technical and managerial efforts of the respective Member States.

Strengthening the Support to Member States in Food and Agriculture

A. Background

1. In resolution GC(58)/RES/13.A.5, the General Conference recognized the central role of agricultural development in accelerating progress towards several key Millennium Development Goals (MDGs), in particular to eradicate extreme poverty and hunger. It recognized that demand from Member States for technical assistance in the area of nuclear applications in food and agriculture remained high. It consequently urged the Secretariat to further expand its efforts to address food insecurity in Member States and to further increase its contribution to raising agricultural productivity and sustainability through the development and integrated application of nuclear science and technology. It further encouraged the Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture to continue responding to the major global trends framing agricultural development in order to ensure to the maximum extent possible an increased resilience of livelihoods to threats and crises in agriculture.
2. The General Conference recognized that the major global trends that will frame agricultural development over the medium term include: rising food demand, lingering food insecurity, malnutrition, and the impact of climate change. It urged the Secretariat to address the impacts of climate change on food and agriculture through the use of nuclear technologies, with priority on adaptation to and mitigation of the effects of climate change, including, in soil and water management, through the establishment of benchmark research sites around the world. It also requested the Secretariat to carry out new activities for addressing the climate change challenges under the thematic heading of 'climate-smart agriculture'.
3. The General Conference further urged the Joint FAO/IAEA Division to continue its development of laboratory networks to strengthen support for the control and eradication of transboundary animal diseases (e.g. VETLAB) and for analysis and regulation of food safety, including the application of appropriate and competitive nuclear and nuclear-related techniques in animal health and food safety, and, with the participation of multiple stakeholders, to strengthen national programmes and enhance laboratory networks.
4. Appreciating the continuing activities of the Secretariat in relation to nuclear and radiological emergency preparedness and response, especially in the areas of agricultural countermeasures and remediation strategies to mitigate immediate and longer-term effects arising from radionuclide contamination, the General Conference urged the Secretariat to develop technologies, manuals, protocols and guidance to strengthen the capacity of Member States to deal with radionuclide contamination in the area of food and agriculture. It also urged the Secretariat to further strengthen its

effort to seek extrabudgetary funding for strengthening its research activities in the preparedness and response to nuclear emergencies, with a particular focus on the area of food and agriculture.

5. The General Conference requested the Director General to report on the progress made in the implementation of resolution GC(58)/RES/13.A.5 to the General Conference at its 60th (2016) regular session.

B. Progress since the 58th Session of the General Conference

6. The Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture currently coordinates 28 coordinated research projects (CRPs) involving approximately 500 research institutions and experimental stations in Member States, and is responsible for providing scientific and technical support to 278 national, regional and interregional technical cooperation (TC) projects. During the period 2014–2016, 172 workshops, seminars and training courses were held with the participation of 2682 trainees from developing countries. In addition, the Joint FAO/IAEA Division published 99 technical documents, newsletters, guidelines and books, 175 articles in scientific journals and seven special issues in peer reviewed scientific journals.

7. Demand-driven research and development activities continue at the Nuclear Applications Laboratories in Seibersdorf in response to Member States' requests, including the use of isotopes in climate smart agriculture and food traceability, authenticity, and contaminant control, the investigation of irradiated animal vaccines, and the enhancement of animal disease diagnostic applications.

8. To promote food safety, the Joint FAO/IAEA Division continued to build and facilitate laboratory networks to enable Member States to share technical expertise, experience and resources. One of the major achievements was the further expansion of the *Red Analitica de Laboratorios de Latino America y El Caribe* (RALACA) laboratory network, established to optimize the transfer of food and environmental safety technology to countries in the Latin American region. Its membership, now comprising over 50 institutes in 21 countries, held its first general meeting in Chile in May 2015. More than 80 participants attended this meeting, which was an important milestone in gaining further international recognition. In 2015 this successful initiative was extended to both Africa and Asia.

9. In 2015, the Agency held 36 training courses and workshops related to food safety, quality, authenticity and traceability. It also hosted, developed and maintained the Food Contaminant and Residue Information System (FCRIS). This free on-line resource provides information on different methods of analysis on food contaminants and residues, including chemical and toxicological data on pesticides and veterinary drugs, and supports the Codex Committees on Residues of Veterinary Drugs in Food and on Pesticide Residues. At the end of the year, 110 veterinary drug or pesticide residue analysis methods were available on FCRIS, an increase of over 20% compared with 2014.

10. Standards and guidelines developed through the Joint FAO/IAEA Division in collaboration with Member States and other international organizations provide the framework for promoting trade in irradiated foods. Fifteen irradiation treatment methods included in International Plant Protection Convention (IPCC) standards were developed through CRPs. The Joint FAO/IAEA Division also published a new *Manual of Good Practice in Food Irradiation: Sanitary, Phytosanitary and Other Applications* (Technical Reports Series No. 481) to support the uptake and implementation of the technology. The increasing commercial use of irradiation as a phytosanitary treatment is helping producers overcome insect pest related trade restrictions and reach markets that would otherwise be closed to them.

11. National networks for food safety monitoring have also been supported, such as the Red Nacional de Laboratorios de Alimentos del Paraguay (REN LAP). The network of 10 national laboratories received technical support through TC project PAR/0/010, “Strengthening the National Network of Laboratories Involved in Chemical Risk Analysis to Ensure Food Safety Through the Use of Nuclear and Complementary Non-Nuclear Techniques”. This project significantly increased food safety monitoring capacity in Paraguay and awareness on food safety. Food safety legislation is being drafted by the IAEA project team at the request of Paraguay’s Parliamentary Health Commission and will shortly be submitted for approval.

12. The Agency supported Costa Rica through TC project COS/5/032 “Enhancing the Capacity to Control Contaminants and Residues of Veterinary Medicines and Pesticides in Foodstuffs of Animal Origin Using Nuclear and Conventional Analytical Techniques” aimed at enhancing food safety and security and improving soil and water quality in the highly agricultural Cartago region using isotopic, nuclear and related analytical techniques. Through education, training and procurement of state-of-the-art instrumentation, Costa Rica’s Environmental Pollution Research Center (CICA/UCR) now has enhanced capacity to monitor food and environmental samples for toxic residues and pollutants.

13. An online, interactive, multi-media and self-study course on *Food Irradiation - Technology, Applications and Good Practices* was developed by the Joint FAO/IAEA Division and has been available to Member States since May 2015. In the first six months, the E-Learning course was visited by hundreds of individuals from more than 40 Member States. The course is now being used at various irradiation facilities as a training tool. As part of TC project RLA/5/066, a Spanish version of the course will become available in 2016.

14. In 2016, “Criteria for Radionuclide Activity Concentrations for Food and Drinking Water” (TECDOC-1788) was published, highlighting current international standards in the management of food and drinking water in the aftermath of a nuclear or radiological emergency, as well as guidance on establishing national criteria for radionuclide activity concentrations for food and drinking water in normal, non-emergency situations. This document has been distributed to Member States through the Codex Secretariat and will guide further discussions on establishing new guidelines by the Codex Alimentarius as well as individual national authorities.

15. Through TC project PAK/5/048 “Strengthening Capabilities to Monitor and Control Veterinary Drug Residues in Foodstuffs” technical support was provided to the Pakistan Nuclear Institute for Agriculture and Biology that resulted in the successful launching of the country’s first analytical service on veterinary drug residues. Both public and private sectors are benefiting from access to standardized veterinary drug residue tests that increase domestic food security, safety and quality and that will facilitate the export of agricultural products to other countries.

16. As part of a multi-year eradication programme, the Niayes region of Senegal is now almost free of the tsetse fly. The tsetse fly was responsible for the transmission of the debilitating disease nagana, which used to decimate livestock in the area. The fly population has been eradicated in the first block of the target area, and successfully suppressed by 90-98% in two of the remaining areas in Niayes infested with tsetse. This project was selected from among 749 proposals as one of 18 “*Best Sustainable Development Practices on Food Security*” at EXPO Milan 2015.

17. The stable fly (*Stomoxys calcitrans*) affects the Costa Rican livestock industry, causing major losses to animal productivity. Through TC project COS/5/030 “Supporting Biological Control of Stable Flies (*Stomoxys calcitrans*) through the Use of Parasitoids Reproduced on Fruit Flies” the Agency worked with Costa Rican counterparts to build capacity to mass-rear *Spalangia endius* wasps as a means of biological pest control. *Spalangia endius* is a parasite of the stable fly and naturally

suppresses stable fly populations. The wasps are produced on irradiated stable fly larvae so that larvae that are not parasitized cannot become fertile flies when released together with the parasitoids.

18. A CRP entitled “Resolution of Cryptic Species Complexes of Tephritid Pests to Overcome Constraints to the Application of the Sterile Insect Technique and International Trade” was completed in 2015. This CRP aimed to accurately align biological species of pest fruit flies with taxonomic names, which is crucial for both overcoming technical barriers to the application of SIT, and to facilitating international agricultural trade between countries and regions.

19. The use of area-wide integrated fruit fly suppression methods has reduced infestation of Mediterranean fruit fly larvae in mandarin export shipments from the Neretva Valley to 0.2% and resulted in a 20 000 litre reduction in insecticide use per year.

20. Facing loss of export revenue due to an import ban, the Ministry of Agriculture of the Dominican Republic launched an emergency Mediterranean fruit fly eradication programme in early 2015. The IAEA, FAO and other partners supported an intense surveillance and eradication programme, including the release of sterile male Mediterranean fruit flies with the goal of eradicating the insect from the country. This resulted in a lifting of the ban in 23 of 30 provinces within only ten months.

21. The Agency continued its contributions to strengthening regional capacities for early detection of emerging and re-emerging zoonotic diseases in wildlife and livestock, and the establishment of early warning systems. Particular attention was given to the Ebola virus disease (EVD) and the highly pathogenic H5N1 avian influenza. At its March 2015 meeting, the Agency’s Board of Governors approved an off-cycle TC project targeting emerging zoonotic diseases (including EVD).

22. Globally, outbreaks of H5N1 have killed millions of birds, and 60% of all humans infected with this deadly virus have died. In early 2015, a highly pathogenic H5N1 strain re-emerged in western Africa. In response to requests by Member States in the region, the Agency provided support through the Veterinary Diagnostic Laboratory (VETLAB) network of veterinary institutions and laboratories and through the technical cooperation programme. The VETLAB network has now been extended to 40 Member States in Africa and 17 Member States in Asia, and four of the labs in the network (Botswana, Ivory Coast, Ethiopia and Cameroon) serve as reference centres of excellence. TC reserve fund projects were approved to provide targeted support to combat H5N1 in Burkina Faso, Côte d’Ivoire, Ghana, Niger and Nigeria.

23. Avian influenza experts and staff of the Joint FAO/IAEA Division were sent to Burkina Faso, Côte d’Ivoire, Ghana, Mali, Niger, Nigeria, Senegal, Togo and other countries in the region, to address diagnostic needs. These missions proved to be very successful in the rapid diagnosis of the disease. As part of the emergency response, the Agency, in collaboration with FAO, provided diagnostic toolkits, validated guidance and standard operating procedures, and supplied on-line support for the expert missions.

24. Sponsored in part by the Agency, 300 scientists in the Bovine Genome Sequencing Consortium and the Bovine HapMap Consortium from 25 countries have succeeded in sequencing the full cow genome. This is generating extensive excitement among scientists, cattle breeders and farmers globally because it offers the chance to identify and utilize favourable traits, such as disease resistance, heat tolerance and the ability to produce more and better quality milk and meat.

25. The regional TC project RAS/5/056 “Supporting Mutation Breeding Approaches to Develop New Crop Varieties Adaptable to Climate Change” was completed in 2015. Within this four-year project, 28 new mutant varieties with climate change related traits were officially released and disseminated to farmers in Asia. Furthermore, hundreds of advanced mutant lines have been developed and many are in the pipeline for national yield trials and for being released. Among them

are two advanced rice mutant lines in Malaysia that are high yielding under minimal water conditions and are suitable as 'Aerobic Rice'. A technology package provided to farmers including the mutant variety and a biofertilizer doubled the yield of rice on two experimental sites.

26. Through TC project BDG/5/028 entitled "Assessing Crop Mutant Varieties in Saline and Drought Prone Areas Using Nuclear Technique" in 2015, 13 mutant varieties of rice were developed applying mutation breeding techniques. The development of a number of high yield crop varieties helped farmers in the country to adapt to changing climatic conditions, thus mitigating the effects of failed or low yield harvests. The increased food and economic security resulting from these crop varieties are already having a positive effect on the livelihoods of farmers in the country.

27. Guidelines for using fallout radionuclides (FRN) to assess soil erosion and the effectiveness of soil conservation strategies have been published. The publication, which has already been downloaded and distributed more than 2000 times, summarizes the experience and knowledge of the Joint FAO/IAEA Division's research networks in the use of FRN. Currently, FRN techniques are being disseminated in 65 Member States across all continents.

28. The Joint FAO/IAEA Division celebrated the *International Year of Soils* (IYS) with a side event on 16 September 2015 at the 59th IAEA General Conference on 'Managing Soils for Climate-Smart Agriculture' and with a one-day conference on 7 December 2015 on 'Celebration of the 2015 International Year of Soils: Achievements and Future Challenges', in collaboration with the International Union of Soil Science (IUSS). In December 2015 an article on the Agency's work in this area was published in *National Geographic*, highlighting the role of nuclear techniques in assessing and curtailing the worldwide threat of soil erosion.

29. In 2015, the Agency used nuclear techniques to identify the sources of soil erosion, and to quantify soil erosion rates, for 27 study sites in a 10 000 km² area of Lam Dong Province in the southern part of the central highlands of Viet Nam. The study showed that soil losses from erosion could be reduced by 47% through intercropping on coffee or tea tree plantations; using vetiver grass hedgerows and green manure management; creating water catchment basins at the base of coffee trees; and using contour and terraced farming. If applied to the total area of land affected by soil erosion in Viet Nam, these practices would also result in a reduction of fertilizer use totalling US \$74 million.

30. The Joint Division continued to expand its set of animated infographics videos. In addition to those on the *Joint FAO/IAEA Division* and on *SIT*, it has now completed a further seven animated infographics, on *Plant Mutation Breeding*, on *Fallout Radionuclides in Soil Erosion*, on *Food Traceability*, on *Food Irradiation*, on *Mosquito SIT*, on *Avian Influenza* and on *Managing Nitrogen*. The animated SIT infographics, when released on Facebook received 46 000 hits in less than four days.

31. The Joint FAO/IAEA Division developed a prototype of an online food safety information system for nuclear and radiological emergencies through a CRP on "Response to Nuclear Emergencies Affecting Food and Agriculture". This information system will help improve nuclear emergency preparedness and response in food and agriculture, including the collection (sampling and analysis), management and visualization of appropriate data from affected areas, for timely dissemination and communication to stakeholders and the general public.

B.1. Strengthening the FAO/IAEA Partnership

32. The FAO/IAEA Joint Division continues to strengthen its efforts towards global hunger reduction, improved food security and the achievement of sustainable agriculture.

33. To further strengthen the FAO-IAEA partnership, the Joint FAO/IAEA Division in 2015 participated actively and organized side events at the biennial FAO regional conferences for Africa, Europe and Central Asia, and Latin America and the Caribbean. In this context, information materials were generated illustrating in facts and figures and select impacts of its work in each region. These materials were well received both among FAO and Agency's colleagues as well as among stakeholders participating in these regional conferences.

34. The 50th anniversary of the cooperation and partnership between the FAO and the Agency through the Joint Division in 2014 marked a good occasion to look back on the numerous successes of the partnership, to highlight major achievements of the Joint Division towards global food security and sustainable agricultural development and to reflect on the many important contributions of the Nuclear Applications Laboratories, which represent one of the primary assets of the partnership between FAO and IAEA in addressing challenges of global food security. Close to one hundred of these successes, achievements and contributions are highlighted in outreach materials generated during the past biennium.

B.2. Securing Extrabudgetary Funding for the Joint FAO/IAEA Programme

35. The Agency has been successful in securing extrabudgetary funding. Substantial extrabudgetary funds were secured during the last biennium from various initiatives, including the Peaceful Uses Initiative (PUI), the African Renaissance and International Co-operation Fund of South Africa, and the OPEC Fund for International Development (OFID). In addition, through FAO, the Joint Division receives funding for projects from the European Commission and the United States Department of Agriculture.

C. Conclusions

36. Major global trends that will frame agricultural development over the medium term include rising food demand, lingering food insecurity, malnutrition and the impact of climate change in conjunction with the increasing spread of invasive animal and plant pests and diseases across regions. The Joint Division will continue to respond to these trends, with a focus on improving the sustainable intensification of agricultural productivity, ensuring food safety and quality, and attaining better adaptation to and mitigation of climate change in agriculture.

Nuclear Energy Activities

A. General

1. This Annex highlights a number of nuclear energy activities undertaken by the Agency as requested in GC(59)/RES/12 Section B. Nuclear Power Applications.
2. Regarding the dissemination of balanced information on nuclear energy; the Agency annually updates its low and high projections for global growth in nuclear power in its publication *Energy, Electricity and Nuclear Power Estimates for the Period up to 2050* (Reference Data Series No. 1). The updated low projection of 2015 shows growth in nuclear power capacity of 2% by 2030, while the high projection shows 68% growth by 2030. The Agency also annually publishes its report *Nuclear Power Reactors in the World* (Reference Data Series No. 2), which presents the most recent data on nuclear power reactors across the world. The 2016 edition contains summary information as at the end of 2015 on power reactors operating, under construction and shut down, as well as performance data on reactors operating in the Agency's Member States. Country Nuclear Power Profiles and a publication to capture *Operating Experience with Nuclear Power Stations in Member States* was completed in August 2016.²
3. Preparations for the Ministerial Conference on Nuclear Power in the 21st Century in the United Arab Emirates are underway. The Conference, scheduled for 30 October to 1 November 2017 is expected to attract over 600 high level delegations from 40 Member States. The Conference will engage in high-level dialogue on the role of nuclear power in meeting future energy demand, contributing to sustainable development and mitigating climate change as well as to discuss and exchange views on the main issues that are key for the development of nuclear power.³
4. Support to countries considering or embarking on nuclear power programmes continued to be coordinated through "Core Teams" involving all departments using "Country Nuclear Infrastructure Profiles" (CNIPs) and "Integrated Work Plans" (IWPs). The CNIP is a dynamic database used to reflect the status of the country resulting from an Integrated Nuclear Infrastructure Review (INIR) mission. The 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. Since October 2015, the CNIPs of 15 countries and IWPs of 7 countries have been updated. To support activities in countries considering expanding existing nuclear power programmes, the Agency is developing and testing analytic (macro-economic) tools for Member States to assess the economic and social impacts of nuclear power programmes at various scales. Publications and teaching materials are being prepared including a joint IAEA/NEA publication on the macroeconomic benefits of nuclear power and a Non-Serial publication: *Measuring Employment in Electricity Generation*. Also, a Coordinated Research Project (CRP) for evaluating macroeconomics of nuclear programme is in progress (planned to run until 2017). Within this project, participants from 11 Member States will review, test and apply quantitative models to analyse the macroeconomics of nuclear programmes at the national and regional levels. It is expected that this CRP will assist policymakers, in particular from Member States

² This relates to operative paragraph 1 of GC(59)/RES/12.B.1

³ This relates to operative paragraph 2 of GC(59)/RES/12.B.1

with limited experience in macroeconomic analysis ('newcomers'), in understanding the key implications of nuclear projects. The second Research Coordination Meeting (RCM) was held in June 2016.⁴

5. A meeting is being organized in October 2016 to explore, in consultation with interested Member States, the need for closer collaboration in technology development for advanced reactor lines with the aim of considering launching a new project on sharing information about the development of next generation reactors. One of the anticipated outcomes is to encourage the IAEA to launch a new project on Molten Salt Reactors.⁵

6. The Secretariat continued to pursue, in consultation with interested Member States, activities in the areas of innovative nuclear technologies. The Agency is developing a publication *Research Reactors for Development of Materials and Fuels for Innovative Nuclear Energy Systems - a Compendium* to highlight to nuclear power design researchers the capabilities available at research reactors for material testing. As resources permit, a technical meeting will be implemented to share and promote this resource. A Technical Meeting on the International Collaborative Standard Problem on a Numerical Benchmark Database for Pressurized Heavy Water Reactor Transients was held in Canada in August 2016. The first kick-off RCM of the CRP on Radioactive Release from the Prototype Fast Breeder Reactor under Severe Accident Conditions was held on 3-6 May 2016, in Vienna. The detailed CRP programme includes participants' responsibilities and work distribution among three working packages. India and China proposed to host the next RCM. The 4th (and final) RCM of the CRP on Benchmark Analyses of an EBR-II Shutdown Heat Removal Test was held in Vienna on 26-29 April 2016. The final benchmark results were presented, the TECDOC was drafted and is due to be published in early 2017. The 3rd RCM of the CRP devoted to the Application of Computational Fluid Dynamics Codes for Nuclear Power Plant Design was hosted in Korea from 28 to 30 June 2016. The 3rd RCM of the CRP on High Temperature Gas Cooled Reactor Physics, Thermal-Hydraulic and Depletion Uncertainty was held in the USA from 9 to 12 May 2016. A Nuclear Energy Series Technical Report on *Experimental Facilities in support of Liquid Metal Cooled Fast Neutron Systems* was finalized and is undergoing internal review.⁶

7. A training workshop on the IAEA's FinPlan model was held in May 2016, which was attended by 30 participants from 24 Member States. The Agency also contributed to a Nuclear Finance Conference organized under IFNEC in May 2016.⁷

8. Support to Member States expanding or considering nuclear programmes includes a Technical Meeting held on Strategic Partnerships and Contract Models for the expansion/introduction of a Nuclear Power Programme. It took place in February 2016 and was attended by 48 participants from 18 Member States. A Technical Meeting on Establishing a National Position for New Nuclear Power Programmes and Pre-Feasibility Studies was held in October 2015 with 50 participants from 31 Member States attending. A Technical Meeting on Challenges and Issues related to the Siting of Nuclear Installations was held in June with 38 participants from 22 Member States attending. A Technical Meeting on the Environmental Impact Assessment Process and Experience for Nuclear Power Programmes was held in May 2016 with 61 participants from 32 Member States. Preparations are underway for a Technical Meeting on the responsibilities of owners/operators in new and expanding nuclear power programmes which will be held in December 2016.

⁴ This relates to operative paragraphs 3 and 5 of GC(59)/RES/12.B.1

⁵ This relates to operative paragraph 6 of GC(59)/RES/12.B.1

⁶ This relates to operative paragraph 7 of GC(59)/RES/12.B.1

⁷ This relates to operative paragraph 8 of GC(59)/RES/12/B.1 and operative paragraph 14 of GC(59)/12/B.4

9. Specific support related to education, training and human resources development included a Training Course/Workshop on Feasibility Studies for Nuclear Power Projects in March 2016 which was attended by 22 participants from 13 Member States. A workshop on establishing national technical requirements for a nuclear power plant project was organized in Nigeria via a national project. Also, an Interregional Nuclear Summer Institute to engage young professionals and students in a five-week training programme was implemented within a European regional project via USA extra budgetary funding. The Technical Working Group on Managing Human Resources in the Field of Nuclear Energy (TWG-MHR) meeting took place in June 2016 and was attended by 21 participants from 17 Member States. Recommendations from the meeting include sharing of information, lessons learned and experiences, both within the nuclear community and across different industries, further development of e-learning tools and improvement of accessibility, development of approach to stress management and resilience, and continuation of activities directly impacting personnel training and development. A Technical Meeting on Evaluating the Effectiveness of Training and Return on Investment took place in April 2016 and was attended by 23 participants from 12 Member States. A Regional Training Course on Understanding the Physics and Technology of Pressurized Water Reactors (PWRs) using Basic Principle Simulators was hosted by the Korea Atomic Energy Research Institute in Daejeon in cooperation with the Agency and conducted in May 2016 for 17 participants from 10 Member States. An Interregional Training Course on Supporting Nuclear Power Infrastructure Capacity Building in Member States Introducing and Expanding Nuclear Power, was held in July-August 2016 in Republic of Korea, and support was provided for two IAEA staff and two international experts (19 participants from 13 Member States).⁸

10. The Agency continued its support of Member States to develop effective management systems to ensure the safety, effectiveness and sustainability of nuclear power programmes. A Technical Meeting on Quality Control and Quality Assurance and on Their Relationship with Management Systems was held in May 2016 and was attended by 51 participants from 26 Member States and two international organizations. Also, the 14th IAEA-FORATOM Management System Workshop - Leadership and Management: From Standards to Practices will be held in December 2016.⁹

11. Since the 59th General Conference, the IAEA has organized and/or supported a set of training workshops in the area of utilization and applications of Research Reactors (RRs). The six-week Eastern European Research Reactor Initiative (EERRI) Group Fellowship Training course on RRs was hosted by RRs in Austria and Hungary and included lecturers from Slovenia from September to November 2015 (11th EERRI course). Eighteen students from 8 Member States (Ghana, Jordan, Nigeria, Pakistan, Saudi Arabia, South Africa, Tanzania and Tunisia) were trained via the EERRI programme in 2015 (a total of 86 students have been trained since the first course in 2009). Within the framework of supporting capacity building in Member States, the kick-off meetings of the Internet Reactor Laboratory (IRL) projects in Latin America and in Europe & Africa took place, in cooperation with CNEA (Argentina) and CEA (France) respectively, in September (Bariloche, Argentina) and October (Saclay, France) 2015. Professors from the guest institutions (universities), which will receive the broadcasts of the reactor physics exercises via the internet, were trained at the host reactors and the schedule for the live transmission of the exercises in 2016 was established. Similarly, a hands-on training course on research reactors in Asia & the Pacific Region was organized by reactor facilities at BATAN (Indonesia) and MNA (Malaysia) in cooperation with the IAEA. Following the establishment of the IAEA designated International Centre based on Research Reactor (ICERR) scheme in 2014, the IAEA Director General designated the French CEA (Research Centres of Saclay and Cadarache) as the first ICERR, during the 59th IAEA General Conference in September 2015. Additional

⁸ This relates to operative paragraphs 10 and 11 of GC(59)/RES/12.B.1 and paragraph 1 of GC(59)/RES/12.B.3

⁹ This relates to operative paragraph 12 of GC(59)/RES/12.B.1

applications for such designations are expected to be received from Member States in 2016. The 2nd Training Workshop on Advanced Use of Neutron Imaging for Research and Applications (AUNIRA-2) took place in September 2016. The workshop included hands-on-training on PSI neutron and X-ray imaging instruments. It was attended by 24 participants and 8 lecturers from 20 Member States. A training workshop on Research Reactor Related Modelling from Core Optimization to Safety Analysis Various Applications was held in October 2015. The workshop was attended by 46 participants from 27 Member States. The Research Reactor Data Base (RRDB), which provides technical and utilization information on over 750 research reactors, including critical and sub-critical assemblies, in 69 countries plus Taiwan, China and the European Union, received 28 updates. Two IAEA/ICTP Schools on Nuclear Data for Neutron Dosimetry and Analytical Methods by Applying Research Reactors in April and on Nuclear Data Measurements for Science and Applications in October were both held in Trieste, Italy.¹⁰

12. To assist Member States planning a new RR within the framework of the IAEA developed RR Milestones Approach and to develop the necessary support infrastructure, a Training Workshop on Assessment of the National Nuclear Infrastructure to Support a New Research Reactor Project was organized from May 2016 as cross-cutting activity among IAEA technical departments. It was attended by 27 participants representing 22 Member States. In May 2015 a training workshop on Milestones and Infrastructure for New Research Reactor Projects was organized in cooperation with the Arab Network of Nuclear Regulators (ANNuR) and Forum of Nuclear Regulatory Bodies in Africa (FNRBA) in Cairo, Egypt. The workshop was attended by 18 participants from 11 Member States. To continue supporting Member States in their efforts to build new RRs, in 2015 the IAEA launched a cross-cutting activity to prepare guidelines on *Preparation of the Feasibility Study for a new RR Project*. Also, development of guidelines for the *Project Management in RR construction* was initiated. A new Integrated Research Reactor Infrastructure Assessment (IRRIA) peer review mission was also established to assist Member States embarking on new RR projects to assess the status of their national infrastructure needed to support such projects. The mission is expected to be carried out in a cross-cutting manner, involving Agency staff from all three technical Departments and the Department of safeguards. The first ever pre-IRRIA mission was provided to Mongolia in April 2016. A graded approach will be applied to tailor each mission to the specific needs of Member States embarking on RR projects. Finally, the revision of the TECDOC-1212 *Strategic Planning for Research Reactors* was finalized and the document is currently in print as Nuclear Energy Series No NG-T-3.16.¹¹

13. The Agency continued supporting Member States in optimizing research reactor operational performances through shared operating experience, as well as the development and implementation of operational and maintenance (O&M) plans, ageing management plans, training programmes and Operation and Maintenance Assessment for Research Reactors (OMARR) peer review missions. In April 2015, a meeting on the Implications of the Fukushima-Daiichi Accident on Research Reactors was held in Tel Aviv, Israel, and attended by 29 participants from 10 Member States. In June 2015, a new CRP on Options and Technologies for Managing the Back End of the Research Reactor Fuel Cycle to explore viable strategies, and to develop guidance on how to choose a national strategy to manage the back end of the Research Reactor Fuel Cycle was initiated and the first RCM was held in June 2015 with the participation of 15 Member States. The IAEA organized an International Conference on Research Reactors: Safe Management and Effective Utilization. It took place at the IAEA Headquarters in Vienna in November 2015. Over 300 participants from 56 Member States and two international organizations (OECD/NEA and the Arab Atomic Energy Agency) took part in this

¹⁰ This relates to operative paragraphs 9, 11, 16 and 19 of GC(59)/RES/12.B.1

¹¹ This relates to operative paragraph 17 of GC(59)/RES/12.B.1

week-long event. Overall, 157 contributions were presented orally and via posters. The Agency's work in the field of RRs was appreciated by the Conference participants who called on the IAEA to continue its support to Member States in planning and building new research reactors, in the production and supply of radioisotopes, in improving research reactor operational performances and managing ageing facilities, in addressing research reactor fuel cycle issues, and to provide assistance in the development of research reactor decommissioning plans.¹²

14. Under the Russian Research Reactor Fuel Return (RRRFR) programme, launched in 2002 by the Agency, the Russian Federation and the United States of America, a total of 2166.6 kg of Russian supplied high enriched uranium (HEU) spent and fresh research reactor fuel has been transferred back to the Russian Federation from 15 countries in 62 separate shipment operations. The Agency, upon request, supports the RRRFR programme through a broad range of technical advice and organizational support, and by providing training in the conversion of research reactors from high to low enriched uranium fuel. The Agency continues to support two annual international meetings to foster collaboration on development of high density Low Enriched Uranium (LEU) research reactor fuel and targets: the Reduced Enrichment for Research and Test Reactors (RERTR) meeting, and the Research Reactor Fuel Management (RRFM) meeting. The Agency is also coordinating the development of four publications related to LEU fuel, *Post Irradiation Examination (PIE) Methods and Processes for Research Reactor Fuel*, *Materials Properties of Un-irradiated Uranium-Molybdenum Fuel*, *Uranium-Molybdenum (U-Mo) Dispersion Fuel for Research Reactors* and *Analysis of the Impact of Fuel Density on the Cost of the Research Reactor Fuel Cycle*. Additionally, the Agency supports Member States' requests for assistance in converting research reactor fuel from HEU to LEU and removing the HEU from the research reactor facility. Active conversions are presently in progress to support Ghana and Nigeria. In September 2015, 26.6 litres of HEU fuel were successfully transferred from Uzbekistan's IIN-3M "FOTON" research reactor to the Russian Federation. In December 2015, 1.9 kg of fresh HEU were repatriated from the 'Breeder-1' neutron source facility in Tbilisi, Georgia to the Russian Federation.¹³

15. The Agency continued to foster information exchange on research and development addressing safety issues including those 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 IAEA Report on *Strengthening Research and Development Effectiveness in the Light of the Accident at the Fukushima Daiichi Nuclear Power Plant* was published in September 2015. A list of some 140 recommendations and suggestions for further R&D activities was agreed with the relevant Member States and stakeholders. It will constitute the basis for IAEA activities and CRPs to be launched in coming years. A Technical Meeting on Severe Accident Mitigation through Improvements in Filtered Containment Venting for Water Cooled Reactors was held in September 2015 and attended by 50 participants from 26 Member States. The information exchanged during the meeting is captured in a TECDOC to be published in 2016. The Severe Accident Management Guideline Development (SAMG-D) toolkit was released in July 2015. It is designed to help utilities select or develop a proper set of SAMG for their specific plant(s). The First Training Workshop on the Development of Severe Accident Management Guidelines was held in October 2015. The update and maintenance of the SAMG-D toolkit will be carried out in the second half of 2016 with the support of a CFE from Bulgaria. A Training Meeting on Post-Fukushima Research and Development Strategies and Priorities was held in December 2015, and attended by 20 participants from 14 Member States and one international organization. A Technical Meeting on Phenomenology and Technologies Relevant to In-Vessel Melt Retention and Ex-Vessel Corium Cooling will be held in

¹² This relates to operative paragraph 18 of GC(59)/RES/12.B.1

¹³ This relates to operative paragraph 20 of GC(59)/RES/12.B.1

October 2016. The Second Regional Training Workshop on the Development of Severe Accident Management Guidelines is scheduled for December 2016, pending the availability of funds. The First Research Coordination Meeting of the CRP on Severely Damaged Fuel and Corium will be held in September 2016.¹⁴

16. Further work has been carried out in support of the IAEA Action Plan on Nuclear Safety through two CRPs, respectively entitled Fuel Modelling in Accident Conditions (FUMAC) and Analysis of Options and Experimental Examination of Fuels for Water-Cooled Reactors with Increased Accident Tolerance (ACTOF). The first RCM of the CRP ACTOF was held in November 2015 with the participation of some 14 organizations from 11 Member States. The second RCM of CRP FUMAC was held in June 2016, with the participation of 26 experts from 18 Member States, who presented individual status reports on the work done during the first phase of the project and discussed and agreed on actions and a work-plan for the second phase of the project. This project is being implemented in collaboration with the joint OECD/NEA–IAEA International Fuel Performance Experiments Database. In November 2015, the Agency published *Modelling of Water Cooled Fuel Including Design Basis and Severe Accidents* (IAEA-TECDOC-CD-1775), the proceedings of a Technical Meeting held in 2013, that focused on lessons learned from the accident at the Fukushima Daiichi nuclear power plant, and, in December 2015, the final report (TECDOC-1781) of the CRP entitled *Evaluation of Conditions for Hydrogen-Induced Degradation of Zirconium Alloys during Fuel Operation and Storage*, which brought together 15 partners from 14 Member States (from 2011 to 2015) and produced consistent sets of data on the initial stages of crack development that define conditions where fuel integrity can be lost. A Technical Meeting on Achieving Zero Fuel Failure Rates: Challenges and Perspectives, was held in October 2015, with 16 participants from 10 Member States with the objective of discussing fuel reliability issues and methods of assuring failure-free operation of both light and heavy-water cooled reactors.¹⁵

17. The Agency continued to strengthen its efforts relating to nuclear power, fuel cycle and radioactive waste management. The second Research Coordination Meeting of the CRP entitled Reliability of High power, Extended burn up and Advanced PHWR Fuels was held in May 2016 to discuss and assess the work programme achievements based on the research proposals submitted by the six participating Member States (Argentina, Canada, India, Indonesia, Republic of Korea and Romania). The experts also discussed the future programmes of activities to be performed up to the 3rd RCM that will tentatively take place in Romania in September 2017. The meeting was complemented by a technical visit to the CONUAR fuel and special alloys tubes fabrication plants. The Agency conducted the International Conference on Advancing Global Implementation of Decommissioning and Environmental Remediation (Madrid, Spain, May 2016). Some 540 delegates from 54 Member States and 4 international organizations participated. The International Conference on the Safety of Radioactive Waste Management is being organized by the Department of Nuclear Safety and Security, with support from NEFW and over 200 abstracts received.

18. The Agency supports over 80 national and regional projects related to radioactive waste. Some notable examples include: the early 2016 launch of a regional project to address radioactive waste management programme alignment with national policy, disposal options and waste acceptance criteria, with the participation of some 25 Member States; the first coordination meeting of the regional project Strengthening Cradle to Grave Management of Radioactive Sealed Sources in the Caribbean Region, with the participation of 9 Member States; successful missions to Lebanon in late 2015, Tunisia early in 2016 and Cameroon in mid-2016 resulted in the repatriation of four high

¹⁴ This relates to operative paragraph 15 of GC(59)/RES/12.B.1

¹⁵ This relates to operative paragraph 21 of GC(59)/RES/12.B.1

activity disused sealed radioactive sources. An additional mission to Lebanon is scheduled for August 2016 for the repatriation of one high activity disused sealed radioactive source; support to the implementation of borehole disposal systems in Malaysia, Ghana and Philippines—all via national projects; support to Uzbekistan with comments by external experts in support of the completion of a decommissioning plan for one of their research reactors (WWR-SM); a Workshop on Underground Research Facility design, implementation and associated R&D programme in China, under a national project. Furthermore, the Agency developed a comprehensive peer review service for radioactive waste and spent fuel management, decommissioning and remediation programmes (ARTEMIS). Several requests from Member States for peer reviews have been received. A workshop with over 40 participants from EC member states was held in July 2016, to share the guidelines on ARTEMIS as they relate to reviews in support of the EC Radioactive Waste Management Directive, EURATOM 2011/70.

19. Recent Publications on topics including multinational disposal, decommissioning and environmental remediation include: *Framework and Challenges for Initiating Multinational Cooperation for the Development of a Radioactive Waste Repository NW-T-1.5*; *Advancing Implementation of Decommissioning and Environmental Remediation Programmes NW-T-1.10*; *Managing the Unexpected in Decommissioning NW-T-2.8*. Also, the Coordinated Research Project on Treatment of Irradiated Graphite to Meet Acceptance Criteria for Waste Disposal was completed with a forthcoming TECDOC publication based on participant contributions. To further support Member States in waste graphite management up to industrial implementation of processing technologies the IAEA launched in February 2016 the International Project on Irradiated Graphite Processing Approaches (GRAPA) which involved 16 Member States. Finally, a Consultants' Meeting on Cooperative Approaches to the Back End of the Nuclear Fuel Cycle: Drivers and Institutional, Economic and Legal Impediments was held in May with 6 participants from 4 Member States. Finally, the IAEA continues to cooperate strongly with the OECD-NEA and the EC on the development of an IAEA report entitled *Status and Trends in Spent Fuel and Radioactive Waste Management*. The goal of this tripartite report is to provide a comprehensive, global inventory of Spent Nuclear Fuel and Radioactive Waste, thus enabling greater sharing and visibility of relevant good practices in the field. At the date of writing (22 June 2016), Status and Trends had received authorized data contributions from 44 Member States, accounting for over 90% of operating global NPPs. This work is supported by the well-established Net-Enabled Waste Management Database (NEWMDB).¹⁶

20. A suite of reports is under development, to provide Member States with an introduction to (i) typical radioactive waste disposal facility concepts; (ii) how to manage the construction of a disposal facility; (iii) how to manage operations of a disposal facility; and, (iv) how to establish a radioactive waste management organization. In addition, more recent projects to develop a method to estimate the costs of a disposal project, and develop a generic project plan to establishing a geological disposal facility. Specifically these include (with estimated publication date): (i) *Design Principles and Approaches for Radioactive Waste Repositories* (2018); (ii) *Radioactive Waste Repositories: Construction Management, Draft* (2018); (iii) *Radioactive Waste Repositories: Operation* (2018); (vi) *Establishing and Managing a Radioactive Waste Management Organisation with Responsibility for Repository Development* (2017); (v) *Communication and Stakeholder Involvement in Radioactive Waste Disposal* (2018); (vi) *Costing Methods and Financing Schemes for Radioactive Waste Disposal Programs* (2019); (vii) *Disposal of Radioactive Waste Resulting from a Nuclear Accident*, , estimated

¹⁶ This relates to operative paragraphs 8, 22, 24, 25, 27 and 28 of GC(59)/RES/12.B.1

publication date (2017); and (viii) *Roadmap for Development of a Geological Disposal Facility* (2019).¹⁷

21. Around 400 experts from over 30 countries were trained in uranium geology, exploration, mining and processing in various interregional and regional courses and workshops held in Argentina, Austria, Brazil, Egypt, Ethiopia, Indonesia, Mongolia, Morocco, Namibia, Philippines and Sri Lanka. The technical cooperation project Supporting Sustainable Development of Uranium Resources continued to support 30 countries through activities designed to tackle common priority needs in Africa related to uranium exploration, mining, processing and regulation using available infrastructure and expertise, thereby enhancing regional cooperation. A new interregional technical cooperation project Deploying Technology and Management of Sustainable Uranium Extraction Projects, intending to support activities related to the extraction of uranium and other valuable commodities, like rare-earth elements (REEs), and to the recycling/reusing of residues (waste) in one integrated process, held two workshops in Brazil and Mongolia, involving 40 Member States. Another new regional Asia-Pacific technical cooperation project on Conducting the Comprehensive Management and Recovery of Radioactive and Associated Mineral Resources has the participation of 12 Member States and held two workshops in Indonesia and Sri Lanka. This project is aimed at supporting Member States of the Asia – Pacific region in sustainable mining and production of minerals that are found associated with radioactive minerals. To assist Member States in identifying and extracting uranium resources, the Agency organized a series of meetings, workshops and training courses. The 52nd Meeting of the Joint OECD/NEA–IAEA Uranium Group was held in November 2015. Forty-eight delegates from 30 Member States discussed the latest estimates of worldwide uranium supply and demand as a contribution to the 26th edition of the ‘Red Book’ *Uranium 2016: Resources, Production and Demand*, in collaboration with the OECD-NEA. A joint Consultants’ and Technical Meeting on Uranium Deposits Associated with Sedimentary Environments was held in September 2015, with 24 participants from 14 Member States. A training workshop on the Uranium Potential of Asia and The Pacific, undertaken with extrabudgetary funds from Japan, was held in October 2015. It was specifically directed at relative newcomer states in the early phases of uranium production cycle in southeast Asia, and attracted more than 30 participants. In November 2015, a joint Consultants’ and Technical Meeting on Spatial and Quantitative Uranium Resource Assessments was held. Thirty-five delegates from 21 Member States discussed methodologies for defensible estimates of ‘undiscovered’ resources, developed for other minerals, and how they can and could be applied to creating estimates for uranium resources. The Agency also completed assistance focused on francophone African Member States, through the PUI project entitled Supporting Sustainable Uranium Mining in Less Prepared Areas with a final workshop held in November 2015. Fifteen experts from 7 Member States discussed the pressing need to strengthen their countries’ current capabilities in order to optimize production, implement good practices and ensure effective management of their region’s uranium endowment to match the predicted future growth in uranium activities. As a legacy of this USA-funded PUI project, a series of training presentations in French are available for download by interested Member States. In December 2015, 34 delegates and experts from 18 countries met to discuss Public and Community Acceptability of Uranium Mining and Milling. The meeting provided a valuable exchange of experiences between established, new and potential uranium mining countries, considering generally applicable ways of stakeholder liaison, and examples of highly site-specific liaison in diverse geographical, social and national settings. In April 2016, a training workshop on ‘Uranium Exploration Methods’ was organized, attracting 71 participants from 14 Member States. This workshop covered several topics related to uranium exploration including: uranium physical and chemical properties, deposit and resource classification, production and processing, geophysical

¹⁷ This relates to operative paragraphs 26 and 29 of GC(59)/RES/12.B.1

methods for exploration, etc. The Agency also supported two conferences related to the uranium production cycle: the ASTM Meeting on Secondary Sources of Uranium Supply, held in June 2016 in Vienna, and NORMSEM 2016 (Nordic Seminar on enhancing competence within uranium production activities), which is due to be held in Copenhagen, Denmark, in September 2016.¹⁸

B. Communication and IAEA Cooperation with Other Agencies

22. The Agency is preparing a report on *Nuclear Power and Sustainable Development* and a report on *Indicators for Sustainable Development* of the power sector (estimated publication date is 2017). In addition, Agency staff participated in a national workshop on integrated analysis to support sustainable energy development in Mauritius in May 2016, organized by the World Bank, and, also in May 2016 in collaboration with the World Bank, delivered a workshop in Kenya on detailed integrated assessment with the climate, land, energy, water (CLEW) framework, which was attended by 25 participants from various government ministries, the World Bank, the UNDP, scientific institutes and other organizations. Furthermore, the Agency is preparing a CLEW synthesis report as the culmination of a completed CRP entitled ‘Assessing Interdependencies between Energy, Water, Land-use and Climate Change.’ The Agency is a member of the Vienna Energy Club and participated in the April 2016 meeting hosted by the OPEC Fund for International Development (OFID), briefing Club members on the Agency’s contribution to Sustainable Development Goals.¹⁹

23. During the 21st session of the Conference of the Parties to the United Nations Framework Convention on Climate Change (COP21) held in Paris, France, from 30 November to 12 December 2015, the IAEA co-hosted side events with other UN organisations and the OECD-NEA. The Agency had an exhibit in the ‘One UN Exhibit Area’ for the two weeks where it displayed and disseminated Agency publications on climate change, sustainable energy development, energy planning and capacity building, techno-economic assessments as well as nuclear applications in climate change monitoring and adaptation (agriculture, water, oceans, etc.). Agency staff were present at the exhibit booth to interact with national delegates, observers and media representatives on the potential of nuclear energy and its techniques for combating climate change. The UN co-hosted a joint side event with UNIDO, UNECE and UNEP was entitled Pathways to Sustainable Energy for a Climate Friendly World, which was followed by a high-level panel discussion in which the Agency also participated. The joint side event co-hosted with the NEA was entitled ‘Why the Climate Needs Nuclear Energy’. The event offered yet another opportunity to learn more about the contribution of nuclear energy to emissions abatement and sustainable development. The Climate Change and Nuclear Power 2016 report and a special brochure on the Paris Agreement reached during the COP21 and its impacts on Nuclear Power will be published before November 2016 (COP22). A study is being prepared on Economic Opportunities for Using Nuclear Energy in Future Power Markets with Increasing Deployment of Renewable Energy to reduce climate change. Agency staff also participated in the US DOE ‘Hybrid Energy System Workshop’ held in June. A new CRP on ‘Assessments of the Potential Role of Nuclear Energy in National Climate Change Mitigation Strategies’ was initiated in 2016. The expected outcome is to contribute to the development of future Nationally Determined Contributions under the Paris Agreement. A regional training course on ‘Assessing the Role of Cost-Effective Energy Technologies including Nuclear Power as Nationally Determined Contributions for Climate Change Mitigation’ will take place/took place on 1-5 August 2016 at Argonne, USA. At the request of

¹⁸ This relates to operative paragraph 30 of GC(59)/RES/12.B.1

¹⁹ This relates to operative paragraph 1 of GC(59)/RES/12.B.2

the Association des Ingénieurs en Génie Atomique du Maroc (A.I.G.A.M.), the Agency will attend a meeting on the role of nuclear power in mitigating climate change in Morocco, in September, 2016. The meeting falls within the scope of the preparations for COP22. The objective of the meeting is to gather national and outside experts to discuss the role of nuclear power in Morocco's long term climate change mitigation strategy. The outcomes of the meeting are intended to be used for a side event during COP22, which will be planned with other UN and interested organizations including the Nuclear Society of Morocco. Consideration will be made for potential high level representatives from organisations.²⁰

C. Operating Existing Nuclear Power Plants

24. The Agency continued to support nuclear operators for the promotion of networking and experience sharing in nuclear power plant operation as a tool to enhance safety and promote effective operation. Examples include: a technical meeting on 'Country Nuclear Power Profiles' held in May 2016 and attended by 94 participants from 13 Member States; a technical meeting on 'Evaluating the Effectiveness of Training and Return on Investment' held in April 2016 and attended by 23 participants from 12 Member States; a Technical Meeting on Fatigue Assessment in Light Water Reactors for Long Term Operation: Good Practices and Lessons Learned, held in July with 65 participants from 25 Member States, will lead to a new Nuclear Energy Series publication on *Fatigue Assessment*; A Technical Meeting on Developing Public Communication, Consultation and Participation in Nuclear Power Programmes will be held in September 2016; the 6th Nuclear Operating Organization Forum is planned to be held during the 60th session of the General Conference 2016; a Technical Meeting on Leadership for Strengthening Excellence in NPP Operations' will be held in September 2016; a Technical Meeting on the IAEA's Power Reactor Information System is planned for October 2016. The Agency is working to deliver support in 2016 to operating nuclear power plants in Europe via a regional project. The work will focus on five areas: outage management, non-destructive examination/in-service inspection (NDE/ISI), economic assessment of long-term operation (LTO), monitoring systems during severe accident conditions and procurement engineering.²¹

25. The Agency continued its support to interested Member States to strengthen their knowledge, experience and capacity in ageing and plant life management, in particular in response to growing interest in life extension programmes for nuclear power plants. The 4th International Conference on Plant Life Management is planned to take place in Lyon, France, in October 2017. Also, support for human resource aspects of Safety Aspects of Long Term Operation of Water Moderated Reactors (SALTO) continued. SALTO missions for Argentina and Armenia are planned for September and November 2016 respectively.²²

26. The Agency continued to support interested Member States to maintain appropriate organizational structures while nuclear power plants are in long-term shutdown, or in transition to decommissioning. A Technical Meeting on Plant Life Management during the Transition from Operation to Decommissioning of Nuclear Power Plants was held in August 2016. The development

²⁰ This relates to operative paragraphs 2 and 3 of GC(59)/RES/12.B.2

²¹ This relates to operative paragraph 2 of GC(59)/RES/12.B.3

²² This relates to operative paragraph 3 of GC(59)/RES/12.B.3

of a new Nuclear Energy Series publication on the Transition Management from Operation of Nuclear Power Plants is under preparation and is planned to be published in 2018.²³

27. The Agency also continued its support related to identifying and promoting, through Technical Documents and Guides, best practices and lessons learned, with respect to procurement and supply chain issues, including bidding and contract evaluation processes, and also to support experience sharing related to quality control and quality surveillance activities related to nuclear construction, component manufacturing, and modifications. A Technical Meeting on Procurement Activities and on Counterfeit, Fraudulent and Substandard Items: Legal and Safety Aspects of Procurement will be held in September 2016. Also, Phase 1 of a project to develop a new Nuclear Energy Series publication on a *Procurement Engineering and Bidding Evaluation Toolkit* has been finished. The release of the toolkit is expected in late 2016. Finally, a crosscutting CRP, supported by both the Departments of Nuclear Safety and Security and Nuclear Energy, on Organizational Cultural Basis for the Successful (Safety) Performance in Nuclear Facilities was approved in December 2015. Eleven proposals have been received and the first consultancy meeting to kick off the project will take place in October 2016.²⁴

²³ This relates to operative paragraph 4 of GC(59)/RES/12.B.3

²⁴ This relates to operative paragraph 4 of GC(59)/RES/12.B.3

Agency Activities in the Development of Innovative Nuclear Technology

A. Background

1. In resolution GC(59)/RES/12, adopted on 18 September 2015, 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. It was further noted that membership of the Agency's International Project on Innovative Nuclear Reactors and Fuel Cycles (INPRO), which was launched in 2000, is continuing to grow and its membership now comprises 41 Agency Member States and the European Commission, with Mexico joining in 2016. Resolution GC(59)/RES/12 also called upon the Secretariat and Member States in a position to do so to investigate new reactor and fuel cycle technologies with enhanced proliferation resistance, including those needed for the recycling of spent fuel and the use of such recycled fuel in advanced reactors under appropriate controls and for the long term disposition of remaining waste materials, taking into account, inter alia, economic, safety and security factors.

3. The General Conference recommended that the Secretariat consider establishing, through the consolidation of available resources and assistance from interested Member States, regular training courses and workshops on advanced and innovative nuclear technologies to exchange knowledge and experience in the area of innovative, globally sustainable nuclear energy systems. The Director General was requested to report on progress made in the implementation of this resolution to the Board of Governors and to the General Conference at its 60th regular session. This report has been issued in response to that request.

B. Activities of the Agency

4. The Agency continued to support Member States with broad energy planning and long-range nuclear energy planning, economic analysis and techno-economic assessments, Nuclear Energy System Assessments (NESAs) and assessments of transition scenarios to sustainable nuclear energy systems using, inter alia, the analytical framework developed within the INPRO sub-Programme. Staff are performing a nuclear cost model benchmark with the Generation IV International Forum Economic Modelling Working Group (EMWG). The benchmark includes open and closed nuclear fuel cycles using INPRO's Nuclear Economics Support Tool (NEST) model and EMWG's Economic Evaluation Tool for Generation IV Reactor Systems (G4ECONS). A "Regional Training Course on Nuclear Energy System Modelling and Assessment Using the INPRO Methodology" for sustainability assessment of nuclear energy systems was held in Rabat, Morocco in April 2016. Twenty-four experts from 15 Member States participated. Review missions were conducted to China and India in May 2016 to discuss progress on limited scope NESAs on sodium cooled fast reactor designs. Computer-based databases and resources were updated, namely the Integrated Nuclear Fuel Cycle Information System, consisting of online databases World Distribution of Uranium Deposits and World Thorium

Deposits and Resources, the Nuclear Fuel Cycle Information System, the Post Irradiation Examination Facilities Database, the Minor Actinide Property Database, and the fuel cycle simulation code, Nuclear Fuel Cycle Simulation System.²⁵

5. Agency staff continued to develop and evaluate various nuclear energy scenarios and roadmaps that could lead to sustainable nuclear energy development in the 21st century. This work included key indicator sets, consistent with the INPRO methodology, to further examine the application of multi-criteria decision analysis to develop comparative evaluation approaches. One Technical Meeting in October 2015 with 39 participants from 23 Member States and two Consultants' Meetings in December 2015 and April 2016 were held on the INPRO collaborative project Roadmaps for a transition to globally sustainable nuclear energy systems (ROADMAPS). These meetings achieved substantial progress on the detailed structure of collaborative project including the development of a white paper on "options" for enhancement of sustainability. Also, the final report of the SYNERGIES collaborative project was approved for internal coordination in May 2016. A Consultants' Meeting held in December 2015 developed prototypical tools for multi-criteria analysis.²⁶

6. Support continued regarding the promotion of collaboration among interested Member States in developing innovative, globally sustainable, nuclear energy systems, including the establishment of effective collaboration mechanisms and the use of Research Reactors to support development. The report of the INPRO activity on dissemination of good practices in enhancing collaboration in innovations is being drafted. Also, the Technical Working Group on Fast Reactors (TWG-FR) held its 49th meeting in May 2016. The TWG-FR produced important recommendations related to 2018-19 programme and budget planning. A publication *Research Reactors for Development of Materials and Fuels for Innovative Nuclear Energy Systems - a Compendium* is being developed to highlight the capabilities available at research reactors for material testing. A technical meeting to disseminate this effort is planned subject to availability of resources.²⁷

7. Regarding sustainability considerations and the back end of the fuel cycle, including opportunities for potential waste burden minimization, the Agency organized a Consultants' Meeting and a Technical Meeting of INPRO collaborative project on Cooperative Approaches to the Back-End of Nuclear Fuel Cycle in November 2015 and May 2016, respectively. Forty-eight experts from 25 Member States participated in the technical meeting. The meetings refined the specific scenarios and issues to study. In June 2016 a Technical Meeting on 'Advanced Fuel Cycles for Waste Burden Minimisation' was held in Vienna. Representatives from China, Hungary, India, Japan, Republic of Korea, Russian Federation and USA discussed spent fuel reprocessing technologies in terms of waste minimization strategies, the technological readiness of various fuel cycle options and the challenges involved in their implementation as well as to examine innovative methods for recycling/reusing the useful materials.²⁸

8. INPRO Dialogue Forums continued to serve as an international forum to exchange information and examine the role that technological and institutional innovations can play in improving nuclear power infrastructure and enhancing nuclear safety, security and non-proliferation. INPRO Dialogue Forum 11 "Roadmaps for a transition to globally sustainable nuclear energy systems" was held in October 2015 (39 experts participated from 23 Member States). INPRO Dialogue Forum 12 on Generation IV Nuclear Energy Systems was held in April 2016 and included presentations from GIF

²⁵ This relates to operative paragraph 3 of GC(59)/RES/12.B.4

²⁶ This relates to operative paragraphs 4, 6 and 19 of GC(59)/RES/12.B.4

²⁷ This relates to operative paragraphs 5 and 11 of GC(59)/RES/12.B.4

²⁸ This relates to operative paragraphs 7, 17 and 19 of GC(59)/RES/12.B.4

and Agency staff on the different GEN-IV nuclear systems, education and training and knowledge management (54 experts participated from 33 Member States, the EC and the OECD/NEA). The INPRO Dialogue Forum 13 on Legal and Institutional Issues in the Global Deployment of Small Modular Reactors is planned for October 2016 and approximately 80 participants are expected to attend.²⁹

9. Regular training and workshops, including distance learning, in the area of innovative, globally-sustainable nuclear energy systems continued. Efforts on training, including distance learning, on development of innovative nuclear technology continued. ELearning material for IAEA's energy models is being updated. English and French versions of the eLearning package for the SIMFACTS model have been completed while the Spanish version is being developed. Distance learning has been performed on an ad hoc basis using web-based teleconferencing. "Modelling Nuclear Energy Systems with MESSAGE: A User's Guide", IAEA NE Series No. NG-T-5.2—*A reference for training on the MESSAGE economic model*—was published. A training course on nuclear energy system modelling and assessment using the MESSAGE model and INPRO methodology, was held in April 2016. The Joint ICTP-IAEA Workshop on Physics and Technology of Innovative Nuclear Energy Systems for Sustainable Development, is planned for 29 August to 2 September 2016 in Trieste, Italy. The workshop programme has been distributed and is being promoted via a dedicated web site.³⁰

10. Agency continued work to integrate lessons learned from the Fukushima Daiichi accident into work related to innovation and the long term sustainability of nuclear power technologies. A revised publication entitled *INPRO Methodology for Sustainability Assessment of Nuclear Energy Systems: Environmental Impact from Depletion of Resources* was published in December 2015 (IAEA Nuclear Energy Series No. NG-T-3.13). A Technical Meeting on the new edition of the INPRO methodology was held in May 2016. The work focused on environmental stressors and waste management. Further work has been carried out in support of the IAEA Action Plan on Nuclear Safety through two CRPs, respectively entitled Fuel Modelling in Accident Conditions (FUMAC) and Analysis of Options and Experimental Examination of Fuels for Water-Cooled Reactors with Increased Accident Tolerance (ACTOF). The first RCM of CRP ACTOF was held in November 2015 with the participation of some 14 organizations from 11 Member States.³¹

11. A Consultants' meeting on the INPRO Case Study for the Deployment of a Factory Fuelled Small Modular Nuclear Reactor (SMR) was held in January 2016. Also, a Technical Meeting on Technology Assessment of Small Modular Reactors for Near Term Deployment is planned to take place in September 2016. These activities will help Member States to make informed decisions for their deployment.³²

12. To ensure synergies with other international endeavours pursuing nuclear technology innovation, the Agency successfully conducted the 10th GIF-INPRO/IAEA Interface Meeting, in April 2016. The meeting included presentations given by representatives of the Generation IV International Forum (GIF) as well as staff from several Agency Sections. INPRO staff also participated in the GIF Proliferation Resistance & Physical Protection Working Group (PRPPWG) in Berkeley, California, USA, in November 2015. Also, staff supported nuclear cost model benchmarking of INPRO's NEST

²⁹ This relates to operative paragraph 8 of GC(59)/RES/12.B.4

³⁰ This relates to operative paragraphs 10 and 18 of GC(59)/RES/12.B.4

³¹ This relates to operative paragraphs 12 and 16 of GC(59)/RES/12.B.4

³² This relates to operative paragraph 13 of GC(59)/RES/12.B.4

model with the GIF Economic Modelling Working Group G4ECONS model. Benchmarks were conducted on both open and closed fuel cycles demonstrating excellent agreement.³³

13. Activities in the specific technical areas of innovative nuclear technologies continued. The Sixth Joint IAEA–GIF Technical Meeting/Workshop on the Safety of Sodium Cooled Fast Reactors will be held in Vienna in November 2016. The Second Research Coordination Meeting on Modular High Temperature Gas Cooled Reactor Safety Design was held in June 2016 and was attended by 12 participants from 9 Member States. A Technical Meeting on Light Water Reactor Fuel Enrichment Beyond 5% Limit: Perspectives and Challenges was held in October 2015. Twenty-three participants from 13 Member States discussed technological options and corresponding challenges for fuel and core design, safety analysis and assessment, and other aspects related to the use of LWR nuclear fuel enriched beyond 5%. A Technical Meeting on Heat Transfer, Thermal-Hydraulics and System Design for Supercritical Water Cooled Reactors is going to be held in August 2016. A Technical Meeting on Materials and Chemistry for Supercritical Water Cooled Reactors will be held in October 2016. A Technical Meeting on technologies to reduce waste from Gas Cooled Reactors was been postponed to 2017 due to competing priorities.³⁴

³³ This relates to operative paragraph 14 of GC(59)/RES/12.B.4

³⁴ This relates to operative paragraph 20 of GC(59)/RES/12.B.4

Plan for Producing Potable Water Economically using Small and Medium-sized or Modular Reactors

A. Background

1. In resolution GC(58)/RES/13.A.4, the General Conference noted that potable water shortages are of growing concern in many regions of the world, due to population growth, increased urbanization and industrialization and the effects of climate change, that seawater desalination using nuclear energy has been successfully demonstrated through various projects in some Member States for both drinking water and plant operated service water and is generally cost-effective, and that the activities on nuclear desalination, water management, and nuclear cogeneration carried out by the Agency are appreciated.

2. The General Conference requested the Director General to continue consultations and strengthen interactions with interested Member States, the competent organizations of the United Nations system, regional development bodies and other relevant intergovernmental and non-governmental organizations in activities relating to seawater desalination using nuclear energy. The General Conference requested the Director General, subject to the availability of resources, to: (a) encourage and facilitate Technical Meetings between technology users and developers to assess and evaluate cogeneration options for using nuclear power for seawater desalination that would enhance a common understanding of the needs and requirements of each side; and (b) continue to hold regional training workshops and Technical Meetings and to use other available mechanisms for disseminating information on nuclear desalination and water management using small and medium-sized or modular reactors (SMRs) and to undertake further activities aimed at better establishing how existing reactors may offer options for cogeneration. The General Conference requested the Director General to note the high priority given by interested Member States to the nuclear desalination of seawater when preparing the Agency's Programme and Budget; and to report on the progress made in the implementation of this resolution to the Board of Governors and to the General Conference at its sixtieth (2016) regular session under an appropriate agenda item and thereafter every two years.

A.1. Activities of the Agency³⁵

3. The Technical Working Group on Nuclear Desalination (TWG-ND) was established in 2009 and periodic meetings of the Group have taken place since. It has provided valuable advice for programme development and implementation. The TWG-ND held its fifth meeting in May 2016 and provided an objective review of the status of nuclear desalination and areas of guidance to Member States. These aim to strengthen the viability of nuclear desalination in the light of the increasing demand for water and overall economic growth, to enhance public awareness of nuclear desalination and related IAEA activities through collaboration with industry and international water and desalination organizations, to enhance and foster education and training in the field of nuclear desalination through further publications, workshops, conferences, and networks.³⁶ Based on advice from the TWG-ND, the IAEA is planning to update the Technical Report Series No. 400 *Introduction to Nuclear Desalination* –

³⁵ This section relates broadly to operative paragraphs 1, 2, 3 and 4 of GC(58)/RES/13.

³⁶ This relates to operative paragraph 2 of GC(58)/RES/13.

A Guidebook to reflect the lessons learned from currently demonstrated desalination projects, particularly to include some technical aspects of the retrofitting process for desalination systems with operating nuclear power plants. This update shall also include up-to-date information to be provided by Member States on chemistry requirements for operating nuclear desalination systems.

4. In 2015, the Agency published IAEA-TECDOC-1753 on *New Technologies for Seawater Desalination Using Nuclear Energy*. This publication documents the results of the Coordinated Research Project (CRP) on *New Technologies for Seawater Desalination Using Nuclear Energy*, conducted from 2009 to 2011 with research participation from nine Member States: Algeria, Egypt, France, India, Indonesia, Pakistan, the Syrian Arab Republic, United Kingdom, and the United States of America. The aim of this publication was to provide a review of the innovative technologies for seawater desalination which could be coupled to the main types of existing nuclear power plants. Such coupling is expected to help making nuclear desalination safer and more economical, and thus more attractive for those newcomer countries interested in nuclear desalination.

5. In 2015, two Technical Series Reports entitled *Opportunities for Cogeneration with Nuclear Energy* and *Industrial Applications of Nuclear Energy* were submitted for publication. They are expected to be published in 2016 and discuss the potential options for cogeneration of potable water, industrial water, hydrogen, process heat and electric power from nuclear power plants. In addition and in response to a request made in GC(58)/RES 13 A.4 para 4(a), a generic report on nuclear cogeneration is in the process of being compiled and drafted. The report will provide guidance and support to Member States interested in nuclear cogeneration.

6. The IAEA tools on nuclear desalination have been maintained and improved. The Desalination Economic Evaluation Program (DEEP) software and the Desalination toolkit have been updated. A new version of DEEP (DEEP 5.1) was released in January 2015. All the features available in previous versions, such as sensitivity analysis and case comparison, have been reworked and optimized for faster and easier access. The default parameters have also been updated to reflect generic cases in accordance with the most recent developments. An up-to-date version of the IAEA toolkit on nuclear desalination, intended for Member States considering nuclear power for seawater desalination, was also released in December 2015. The new toolkit provides links to the latest information available on the IAEA project on non-electric applications of nuclear energy, and has new features providing the latest news on IAEA activities relating to nuclear desalination. This is also more efficient as it eliminates the need to publish hardcopies of the desalination newsletter.

7. The Agency organized two RCMs in September 2014 and December 2015 in connection with the (CRP) on Application of Advanced Low Temperature Desalination Systems to Support Nuclear Power Plants. Several innovative and novel technologies were proposed by participants at these meetings as a result of research work on nuclear desalination technologies using reactor waste heat or for coupling with low temperature reactors. Another meeting is planned in November 2016 to develop a technical document on low temperature desalination technologies.

8. In June 2015, a Technical Meeting on Advances in Non-Electric Applications of Nuclear Energy and on Efficiency Improvement at Nuclear Power Plants was held in Istanbul, Turkey. The purpose of this meeting was to exchange information on prospects and challenges relating to non-electric applications of nuclear power, to assess the technical and economic merits of cogeneration in nuclear power plants for electricity generation and process heat production, and, also, to discuss the potential re-use of low-temperature waste heat and suitable technologies to increase overall efficiency at NPPs and ensure better energy utilization.

9. In March 2016, a Technical Meeting on the User–Vendor Interface in Cogeneration for Electricity Production and Seawater Desalination was held in Vienna. The purpose of the meeting

was: to bring users and vendors together to discuss common concerns and challenges related to the design and operation of nuclear cogeneration plants; to establish a common understanding of user requirements and the terms under which vendors can supply suitable reactor designs and desalination technologies; to facilitate the free exchange of important design-, operational and infrastructure-related information; and to establish a link between the user and vendor communities that will help to resolve some pressing issues regarding the requirements for, and feasibility of, coupling seawater desalination technologies to NPPs for cogeneration applications. There was a recommendation to the Agency to organize a technical meeting which could focus on the development of a road map for users and vendors in the field of nuclear desalination in order to gain a better understanding of the considerations, requirements, and pressing issues for both parties.

10. In May 2016, a Technical Meeting on Operating Experience with, and Project Feasibility of, Process Heat Applications was held in Budapest, Hungary. The purpose of the meeting was to exchange information on the operating experience acquired from proven nuclear cogeneration projects, to reassess various techno-economic aspects of the feasibility of nuclear cogeneration projects, and to discuss the prospects for future nuclear cogeneration, particularly in relation to seawater desalination and district heating in residential and commercial buildings, industrial process heat supply, and fuel synthesis.

A.2. Activities in Member States

11. The following paragraphs summarize activities in a number of Member States:

12. In Algeria, a study to assess the potential of nuclear energy for electricity and potable water production was launched, and a national strategy to deal with water concerns implemented. Seawater desalination is a key part of this strategy with total capacity that could reach 1.5 million m³/d by the end of 2016. Consequently, seawater desalination is set to become an expanding industry over the next years. As this virtually unlimited water resource consumes a huge amount of energy, and because energy is derived from fossil origin sources in Algeria, a diversification of energy sources is foreseen for the future. An agreement with the Russian Federation was signed in 2014 to supply Algeria with nuclear technology and assistance which could also include nuclear desalination. The first nuclear power plant in Algeria could be operating in 2027.

13. In Argentina, the impact of coupling a reactor to a desalination plant has been factored into the safety evaluation and DEEP was utilized to assess Reverse Osmosis (RO) plant coupled to the CAREM Reactor (SMR developed in Argentina). Considering that CAREM is close to be licensed for construction, after getting experience from other Member States and having taken advantage of the abundant published technical literature by IAEA and other sources, the National Program on nuclear desalination focuses on: (i) the technical coupling of Multi-Effect Desalination (MED) plant with SMR; a capacity of 4000-4300 m³/d of product water is achieved in cogeneration with electric power which is enough to community with population of 80.000. A hybrid RO and MED system is also considered for better performance, (ii) the gain of experience in the design and operation of both compact MED plate heat exchanger and RO technologies in cogeneration through an experimental test rig, (iii) support the existing CNEA projects and provide the required assistance regarding the needed expertise in cooling water systems, water management, release of chemicals to the environment, and prepare the required documents.

14. In Canada, a coupling scheme to integrate the CANDU reactor with Reverse Osmosis (RO) desalination technology was developed, which uses waste heat from the reactor, discharged primarily through the condenser cooling system in water-cooled reactors; to preheat the RO system feed water above ambient seawater temperature. This would result in higher overall operating efficiency and reduce heat loss from the nuclear reactor.

15. In China, the IAEA DEEP tool was used to evaluate the economic viability of nuclear desalination. According to the results, China would have both the capability and capacity to eliminate water scarcity using nuclear energy by the year 2030. These results are based on a forecast of 23.1 billion m³/year of water produced at a cost of \$0.86/m³. This technology is believed to be affordable not only for the major cities but also for lower income and rural areas with the supply chain costing \$0.99/m³ to \$1.79/m³. A nuclear desalination technology project for offshore platforms, supported by the Ministry of Science and Technology, has been put forward. The main aims of this project are to satisfy the demand for water and power on the drilling platform itself, to save on oil/gas consumption and reduce emissions. The Multi-Effect Desalination (MED) plant would be coupled with the offshore platform nuclear power plant. Research includes the safety analysis, design of the desalination system and performance optimization under ocean conditions.

16. In Egypt, an MOU to develop a design for a Pressurized Water Reactor (PWR) for power and desalination purposes was signed between Egypt and Russia in 2015. Two PWRs with Multiple-Effect Distillation (MED) plant are being considered. The plant is expected to produce 170,000 m³/d of fresh water using 850 MWh of nuclear electric power.

17. In India, there are two proposed integrated systems for seawater desalination using Advanced Heavy Water Reactor (AHWR) technology. The first system is based on Multi-Effect Desalination with Thermal vapour Compression (MED-TVC) technology. The capacity of this plant is 3×800 m³/day. The other system is based on Low Temperature Evaporation (LTE) technology using waste heat from the main heat transfer purification circuit, with a capacity of 250 m³/day.

18. In Japan, there are currently 55 nuclear power plants, located on the coast, which utilize the ocean as a heat sink. Eight of these plants are hooked up to desalination plants used mostly for fulfilling the need of freshwater for the boiler of the reactor, as well as potable water and household water. These plants have a capacity ranging from 1000-1300 m³/day and use Multi-Stage Flash Distillation, Multi-Effect Distillation, and Reverse Osmosis (RO) technologies. With over 30 years of successful operation, there has been no contamination of steam or water and no negative effects on the environment. They are looking at the potential to add even more desalination plants in the future.

19. In Kazakhstan, the National Nuclear Company, Kazatomprom, has approved a Research and Development (R&D) programme on advanced low temperature distillation desalination, to work in cooperation with Rusatom Overseas Company. Software for calculation of design characteristics of advanced distillation equipment has been developed under the R&D programme.

20. In Pakistan, the utilization of the waste heat of the discharge of the Nuclear Desalination Demonstration Plant (NDDP), coupled with the Karachi nuclear power plant, is already achieved. It is used as raw feed water input to the forthcoming sea water Reverse Osmosis (RO) plant. Feasibility study for inclusion of nuclear thermal desalination plant in Karachi coastal Power projects is being considered. It is a feasible opportunity for deploying another nuclear desalination plant for the two upcoming 2x1100 MW_e PWR Karachi coastal projects. This considers the utilization of waste heat from the PWR to preheat the feed water of the RO plant.

21. In Russia, a business of selling nuclear technologies to other countries has been developed. Russian technology is currently being considered for Iran's planned nuclear plant Bushehr and is already in use in plants such as in Kazakhstan. There are also investigations into new technologies such as the use of Small Modular Reactors for desalination and the possibility of floating power plant station desalination – proposing that the latter could produce up to 240,000 m³/d of fresh water.

22. In Saudi Arabia, desalination became a strategic choice for the Kingdom of Saudi Arabia which ranks first in the production of desalinated water with about 16.5% of world production. The main challenges that are driving Saudi Arabia's power and desalination programme are: the rapid increase

in population, increase in water demand, high per-capita consumption, and scarce natural water sources and rapid industrialization. Currently, there are 32 operating desalination plants in the Kingdom. In 2014, officials announced the construction of 16 nuclear power reactors to be completed by 2035, with the first only taking 8 years. Since March 2015, discussion on implementing two of Korea's SMART 330 MW_{th} pressurized water reactors has been underway per an MOU.

23. In the USA, large-scale desalination of seawater is gaining momentum, especially in Southern California and Florida. The USA considers integrating desalinated water from the twin PWRs of Diablo Canyon NPP into public water systems in California. In addition, a study in the US finds small modular reactors (SMRs) in the near-term, and advanced reactors in the long-term, may offer opportunities for co-location of power and water production plants. These reactors have the potential to meet the needs of small and medium size communities and a variety of industrial operations. Common challenges for such reactors include: licensing issues, unfavourable economics, and unresolved nuclear waste issues. Once these are overcome, the viability of site-specific nuclear cogeneration should be assessed.

24. In other parts of the world where nuclear desalination programmes are being studied or considered, efforts are proceeding on either a national or multilateral basis. Examples of these countries are Indonesia, Jordan, and the United Arab Emirates.

Approaches to Supporting Nuclear Power Infrastructure Development

A. Background

1. In resolution GC(59)/RES/12, the General Conference recognized that the development and implementation of an appropriate infrastructure to support the successful introduction of nuclear power and its safe, secure and efficient use is an issue of great importance, especially for countries that are considering and planning for the introduction of nuclear power. The General Conference noted the establishment of the Nuclear Infrastructure Development Section and its internal coordination and holistic approach to nuclear infrastructure development, and encouraged the Secretariat to strengthen and tailor the services provided to countries introducing new nuclear power programmes. The General Conference welcomed the publication of the revision of the *Milestones in the Development of a National Infrastructure for Nuclear Power* publication, which involved consultations between more than 150 contributors coming from numerous Member States during its revision and, in this context, ensured enhanced consistency among related nuclear power infrastructure publications and multimedia products (web sites, e-learning modules, etc.). The General Conference recognized the continuing value of the Agency's Integrated Nuclear Infrastructure Review (INIR) missions, which provide expert and peer-based evaluations in helping requesting Member States to determine their nuclear infrastructure development status and needs. The General Conference requested the Secretariat to continue monitoring the results of INIR missions and enhance the effectiveness of this vital review service, and encouraged the Secretariat to finalize the development of Phase 3 (before commissioning) INIR missions, taking into account the synergy with other Agency review services. The General Conference commended the work of the Technical Working Group on Nuclear Power Infrastructure that provides guidance to the Agency on approaches, strategy, policy and implementing actions for the establishment of a national nuclear power programme.

2. The General Conference requested the Director General to report on the progress made in the implementation of the above-mentioned resolution to the Board of Governors and to the General Conference at its sixtieth (2016) session under an appropriate agenda item. This report has been prepared in response to that request.

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

B.1. General

3. In 2015-2016, 27 Member States were actively considering or planning a nuclear power programme. Belarus and the United Arab Emirates have continued construction of their first nuclear power plants (NPPs), while Turkey has signed contracts and is actively preparing for construction. Other countries are in the process of establishing the necessary nuclear infrastructure following a national decision to develop a nuclear power programme.

4. The Agency continued to support these embarking countries in establishing the appropriate legislative and regulatory framework, strengthening coordination among national institutions, drafting and reviewing human resource development plans, and developing radioactive waste management policies and strategies. Through focused interregional, regional and national workshops, training courses and fellowships, the Agency provided substantive training in various infrastructure issues to organizations involved in nuclear power development, regulatory bodies and technical support organizations. More than 15 events (either technical meetings, roadmap discussions, self-evaluation support and expert missions/workshops) took place in 2015-2016 focused on increasing Member States' awareness and understanding of the 'Milestones' approach and key infrastructure issues such as national position, management, human resource development, funding and financing and radioactive waste management.

5. Technical Meetings on Environmental Impact Assessments for Nuclear Power Programmes and Challenges and Issues related to Siting for Nuclear Installations respectively provided forums to discuss lessons learned and good practices and enhance Member States' understanding in these areas.

6. Stakeholder involvement continued to be an important area of focus for countries at all stages of nuclear infrastructure development. The Agency facilitated expert missions or workshops related to stakeholder involvement in Egypt, Ghana, Indonesia, Kenya, Nigeria, Saudi Arabia, Turkey and Viet Nam, as well as workshops in Finland and Japan.

7. Extrabudgetary contributions to the Agency in support of nuclear power infrastructure have increased. In particular, contributions since 2011 to Agency infrastructure projects from donors to the Peaceful Uses Initiative (PUI) have exceeded EUR 8 million. PUI funding has enabled support to Member States self-evaluations activities, INIR and INIR-Follow-up missions and the training of experts to undertake INIR missions, as well as the preparation of guidance documents and organization of training events on several topics, including design review, feasibility studies, and technology assessment. Stakeholder involvement activities, including the development of modern e-learning materials have also been supported through PUI funding. Extrabudgetary resources have also directly supported nuclear power infrastructure in Member States through technical cooperation footnote a/ projects, for example training and capacity building for Kenya in the area of workforce planning and stakeholder involvement.³⁷

8. The annual Technical Meeting on Topical Issues in the Development of Nuclear Power Infrastructure was held in February 2016 with 80 participants from around 35 Member States, representing government ministries, organizations responsible for nuclear power programme planning in newcomer countries, current and future owner/operator organizations, vendors, technical support organizations, universities and regulatory agencies. The 2016 meeting focused on INIR missions, considerations regarding the first nuclear power programme licensing, new developments in nuclear power plant investment and financing, the coordination of human resource development and capacity building, management systems and pre-construction/construction management, initial considerations for a nuclear power programme, as well as customers and agency guidance. A special workshop, focused on the lessons learned from stakeholder involvement, was included in the meeting. The increasing importance/influence of stakeholder involvement was acknowledged during the special workshop, in which participants were able to share valuable insights, experiences and approaches. Breakout sessions offered opportunities to use case studies from newcomer countries to highlight specific aspects and challenges of infrastructure development.

³⁷ This relates to section B.5, operative paragraph 18 of GC(59)/RES/12

B.2. Technical Working Group on Nuclear Power Infrastructure

9. The Technical Working Group on Nuclear Power Infrastructure (TWG-NPI) was established in 2010 to provide advice to the Agency on the development and implementation of national nuclear power programmes. The TWG-NPI convened in October 2015 and made a number of recommendations to the Agency on approaches, strategies, policies and actions to be implemented for the establishment of a national nuclear power programme. The recommendations covered aspects such as the continued enhancement of the INIR programme including INIR Phase 3 missions, the revision of guidance documentation to be consistent with the revision of the Milestones publication (NG-G-3.1 rev 1), and holistic Agency support through the Integrated Work Plans (IWPs) for the respective Member States.

B.3. Technical Cooperation

10. There are currently over 50 national, regional and interregional technical cooperation projects supporting countries considering or planning nuclear power. To better coordinate assistance to newcomer countries, the Agency consolidated coordination mechanisms such as Country Nuclear Infrastructure Profiles (CNIPs) and IWPs. Taking into account the recommendations from the INIR missions, complemented by the results of other Agency review services and technical cooperation projects, the CNIPs and IWPs of several countries have been updated in consultation with the Member States concerned. This process has permitted all departments involved in infrastructure development projects to integrate their efforts to develop jointly an appropriate package of services and advice commensurate with a Member States status of progress, and available Agency resources.

B.4. Assessment of Nuclear Infrastructure

11. The Agency's Integrated Nuclear Infrastructure Review (INIR) missions continue to be in high demand by embarking Member States. These missions provide governments and nuclear programme stakeholders with an overall, integrated view of the status of all 19 infrastructure issues of the 'Milestones' approach to introducing a nuclear power programme. Agency experts from the departments of Nuclear Energy, Nuclear Safety and Security, Safeguards and the Office of Legal Affairs, together with international experts, review the progress in infrastructure development achieved by the host country and make recommendations and suggestions as to how it can advance further. INIR recommendations enable Member States to determine which infrastructure areas require further development to meet programme needs and schedule requirements.

12. Seventeen of these missions have been conducted since the first INIR mission in 2009. Subsequent to the 2015 General Conference, an INIR Phase 1 mission has been conducted in Morocco, while INIR Follow-up missions have been conducted in Bangladesh and Poland. Self-evaluation support and Pre-INIR missions were conducted in Ghana, Malaysia and Kazakhstan. In accordance with the requests of Member States, INIR Phase 1 missions are planned for Ghana, Kazakhstan and Malaysia before end January 2017.

13. A training workshop was held in 2016 to enlarge the pool of experts available to participate in INIR missions. The workshop described the INIR mission process, from the review of a Member State's self-evaluation report through to the conducting of the INIR mission and the preparation of the mission report. The training workshop comprised of presentations and actual exercises that simulated a real INIR mission. Twelve experts from operating and newcomer countries, as well as vendor countries, participated in this one-week workshop.

14. The INIR process has been further strengthened through advice to Phase 1 countries for the development of a strategic roadmap for introducing a nuclear power programme and through support to Member States for the preparation of their Self Evaluation Report.

15. To enhance internal coordination and foster a holistic approach to nuclear infrastructure development, the “Country Nuclear Infrastructure Profiles (CNIP)” and “Integrated Work Plans ” have been used to guide and tailor services provided to Member States, while taking into account the results acquired over six years of INIR experience as reflected in the study conducted by the Secretariat and published in the document *Integrated Nuclear Infrastructure Review (INIR) Missions: The First Six Years*”.

16. During the year, steps were taken to finalize the concept for INIR Phase 3 missions as called for in several General Conference resolutions.³⁸ The evaluation methodology for INIR Phase 3 missions was tested and refined by partially undertaking the equivalent of a Phase 3 self-evaluation, the results of which will be used, upon request, to conduct INIR Phase 3 missions. Consultations were held with advanced newcomer countries regarding the undertaking of INIR Phase 3 missions before Milestone 3.

B.5. Support for Human Resource Development³⁹

17. Human resource development continues to be a high priority for both Member States and the Agency, and there are several ongoing activities in this area.

18. The Agency continued its support to the KEPCO International Nuclear Graduate School (KINGS) Master Degree Course in nuclear power engineering.

19. The Agency also supported a Mentoring Training Course on Nuclear Power held at Argonne National Laboratory in April 2016. The main objective of this training course was to foster dedicated teams of instructors in Member States considering the introduction of nuclear power that will develop and implement indigenous training programmes in their respective countries through lectures, exercises and curricula. The training course included a series of presentations by Agency staff, international experts, management and technical specialists of the Argonne National Laboratory, the U.S. nuclear community, and invited participants.

20. Within the framework of a project financed by extrabudgetary funds from the Republic of Korea under the PUI, several e-learning modules based on existing Agency publications on nuclear infrastructure development, as well as on relevant feedback from Member States, have been developed. Seventeen modules are available on the Agency website. Since September 2015, modules on Siting, Legal Framework, National Position, and Culture for Safety have been completed. Statistics show that the e-Learning modules are being used by individuals in 49 Member States (newcomer and operating countries, but also countries with no plans for nuclear power), with approximately 13 500 on-line sessions in the period April 2013 to May 2016. The development of additional modules covering, *inter alia*, procurement, radiation protection and industrial involvement are currently under development.

B.6. Conferences and Workshops

21. A Technical Meeting on Establishing a National Position for New Nuclear Power Programmes and the Pre-Feasibility Studies was held from 27 to 30 October 2015 with 50 participants from 31 Member States attending.

22. The Agency organised a Technical Meeting on Environmental Impact Assessment Process for Nuclear Power Programmes in Vienna, on 17-20 May 2016, to facilitate the sharing of experiences, discuss challenges and their solutions, and identify good practices when undertaking environmental

³⁸ This relates to operative paragraph 9 of resolution GC(59)/RES/12.B.1.

³⁹ This relates to operative paragraph 11 of resolution GC(59)/RES/12.B.1.

impact assessments for nuclear facilities. Sixty-one participants from 32 Member States attended the meeting, indicative of the importance that Member States attached to this topic.

23. An Agency Technical Meeting on Challenges and Issues related to the Siting of Nuclear Installations was hosted by China, on 20-24 June 2016, providing a forum for the exchange of views on experiences and good practices when siting nuclear facilities. Thirty-eight participants from 22 Member States attended the meeting and shared their experiences of the challenges and issues related to siting.

24. Preparations are underway for the Technical Meeting on the Responsibilities of Owners/Operators in New and Expanding Nuclear Power Programmes which will be held in Atlanta, USA from 12 to 16 December 2016.

25. The Technical Meeting on Developing an Effective Organisational Culture for Nuclear Power Programmes will be held from 6 to 9 December 2016.

B.7. Databases and Publications

26. In 2015, a review of the nuclear infrastructure development bibliography was conducted to identify the infrastructure issues where no guidance documents exist and where guidance documentation requires updating. Plans have been developed to address the identified gaps.

27. The Agency initiated the development of a Nuclear Infrastructure Development Activity and Competency Framework aimed at describing the key activities and competencies required to address the 19 infrastructure issues in each phase of the Milestones Approach. The Secretariat is also considering introducing some standardized projects for each Milestones phase based on the above initiative. This will allow Member States, as well as the technical and managerial staff involved in infrastructure projects, to have a more consistent and harmonized approach to planning activities under TC projects for various phases.

B.8. Documents Published and under Preparation

28. Drawing on lessons learned from completed INIR missions, and taking into account the updated version of *Milestones in the Development of a National Infrastructure for Nuclear Power (IAEA Nuclear Energy Series No. NG-G-3.1)* published in 2015, the Agency has revised *Evaluation of the Status of National Nuclear Infrastructure Development (IAEA Nuclear Energy Series No. NG-T-3.2)*. The evaluation approach contained in this publication provides a comprehensive means of determining the status of the infrastructure conditions covering all of the 19 issues identified in the Milestones approach.

29. In 2015, an analysis of INIR mission recommendations and suggestions made since 2009 was carried out and presented in *Integrated Nuclear Infrastructure (INIR) Review Missions: The First Six Years (IAEA TECDOC 1779)*, published in December 2015. The analysis of the outcomes from the review missions provide an overview of the challenges faced by countries hosting INIR missions and the approaches that they have developed to address these challenges. A Technical Meeting in December 2015, attended by 32 participants from 21 Member States discussed the analysis and the approaches outlined in the publication.

30. There are two new IAEA NE Series publications entitled *Building a National Position for a New Nuclear Power Programme (IAEA Nuclear Energy Series No. NG-T-3.14)*, issued in June 2016, and *Developing Industrial Involvement to Support a National Nuclear Power Programme*, which is due for publication soon.

31. The brochure *Considerations to Launch a Nuclear Power Programme* was updated and published as a leaflet *Introducing Nuclear Power: The Role of National Leadership*. It highlights the important role of government in developing the national position regarding nuclear power.

32. Additional IAEA Nuclear Energy Series publications and/or IAEA Technical Documents on *The Macroeconomic Benefits of Nuclear Power* and the *Responsibilities and Capabilities of a Nuclear Energy Programme Implementing Organization* are being developed and are expected to be issued in 2017.

Nuclear Knowledge Management

1. In resolution GC(58)/RES/13, the General Conference, recognized preserving and enhancing nuclear knowledge is vital to the sustainability of all aspects of the continued and expanded peaceful, safe and secure utilization of nuclear science and technology. The General Conference also recognized that nuclear knowledge management (NKM) includes approaches—including; inter alia, education and training as well as succession planning—that create, use, share and preserve knowledge in the use of nuclear technology.
2. Recognizing that nuclear knowledge management is a cross-cutting issue that is important to all activities of the Agency and its Member States, the Secretariat was requested to continue strengthening its current and planned efforts in this area. The Secretariat was also encouraged to increase awareness regarding the creation, preservation and sharing of nuclear knowledge and experience.
3. The General Conference requested the Director General to report on progress made to the Board of Governors and to the General Conference at its sixtieth session. This report responds to that request.

A. Strengthening nuclear knowledge management

4. The Agency continued its nuclear knowledge management activities focused on formulating and providing guidance and services, facilitating knowledge sharing networks, developing pilot projects, and fostering and supporting nuclear education and training. Current activities take into account the elements of the IAEA Action Plan on Nuclear Safety related to capacity building, including human resources development, education and training, knowledge management and knowledge networks. The nuclear safety and security knowledge management process has been updated to preserve and capture the Secretariat's knowledge in nuclear safety and security, including enhancing internal knowledge transfer.
5. The Technical Working Group on Nuclear Knowledge Management (TWG-NKM) was established in 2014 and annual meetings have taken place since. It continued to provide valuable advice for programme development and implementation.
6. In response to requests arising from the fifty-eighth General Conference to ensure “sustainability of nuclear education and training”, two meetings were held by the Agency, one in 2015 and the second in 2016. Both addressed three interrelated topics. The first is an IAEA NE Series Publication *A Framework for Sustainable Nuclear Education: Education Capability Assessment and Planning (E-CAP)*, which was piloted at regional and national levels including at the African Network for Nuclear Education, Science and Technology (AFRA-NEST), as well as in several developing countries including Saudi Arabia, South Africa and Tanzania. The second related initiative focuses on establishing and strengthening national education networks for Human Resources and Knowledge Development (HRKD) networks. The third initiative captures best practices in Knowledge Innovation and Collaboration for Science and Technology Adoption, Resourcing and Transfer (KIC-START) through university led innovation hubs. The new initiatives, which were launched in 2014/15, focus on sustainable education issues and approaches, particularly in developing countries.

7. Recognizing the need of promoting the use of state of the art knowledge management technologies and the provision of support to interested Member States, the Secretariat has been closely following the development of semantic information technology and its potential use in the nuclear domain to enhance safety and economics, and initiated several related activities. Rapid advances in information technologies have been possible by representing knowledge in formats that computers can interpret (so-called Knowledge Organization Systems, KOS's). Knowledge organization systems (e.g. taxonomies, thesauri, glossaries, ontologies) that are built observing the international standards set by the World Wide Web Consortium (W3C) form knowledge bases which may be published on the Web, linked with other KOS's to form knowledge networks, and navigated and queried by users. Such technologies, which are referred to as "semantic technologies", provide a firm ground for developing knowledge bases and knowledge-based applications. Recognizing the potential of these technologies, the Secretariat initiated several activities which focus on constructing domain-specific knowledge bases. With the participation of subject matter experts, these technologies were applied to i.e. automatically extract the main concepts from documents, improve searches ("semantic search") in knowledge portals, and support educational curricula. Moreover, the Secretariat initiated a project entitled "International Nuclear Terminology Repository Platform (INTERP)" which is aimed at eliminating inconsistency in the interpretations of standards and licensing documents, by providing one single access point to credible nuclear glossaries showcasing multiple definitions of terms, with traceability to the sources and related information. At the same time, this platform offers a forum for glossary owners to exchange information and discuss concepts.

8. Recognizing the increasing importance of maintaining design knowledge through different phases of the application of nuclear science and technology, the Secretariat is preparing a document entitled *Managing Nuclear Design Knowledge Over the Life Cycle – Stakeholder Perspectives, Challenges and Approaches*. The document is expected to raise awareness in nuclear organizations of the need to develop a strategic approach to manage the risks of design knowledge loss, to enable the retention, transfer and utilization of this knowledge, and to develop and maintain the competences of new and existing personnel. Meetings on this topic and on modern Plant Information Models (PIM) took place in 2014 and 2015 and others are scheduled for 2016 and 2017. A further document on *Application of the Modern Plant Information Models to Support and Manage Design Knowledge throughout the NPP Life Cycle (PIM)* is also in preparation. The Agency also developed a systematic approach for Member State nuclear organizations to periodically conduct Knowledge Loss Risk Assessments (KLRAs) to identify critical knowledge at risk of being lost in their nuclear organizations. It has also produced a new update, entitled 'Approaches to Management of the Risk of Knowledge Loss in Nuclear Organizations', which describes KLRAs. Based on Member States' feedback, an initiative was launched at the end of 2015 on capturing and sharing best practices in applying methods and approaches intended to retain critical and uncodified knowledge in nuclear organizations which also avoid the risk of knowledge loss due to employees retiring or changing positions.

B. Building capacity and implementing nuclear knowledge management

9. The Nuclear Energy Management (NEM) School at the International Centre for Theoretical Physics (ICTP), Trieste, Italy, is an annual event to introduce young professionals from both developing and developed countries to the principles of effective nuclear energy programme management. This event witnessed growing interest since it was first held in 2010. To date, 260 participants from 68 countries have graduated from the NEM School. The Agency received over 200

applications for the NEM School at ICTP in October 2016. Since 2011, Japan has been hosting an NEM School on an annual basis mainly for the Asia region. In 2014, Japan took over the organization of the School and it became the annual Japan-IAEA Joint NEM School, and represents an excellent example of a sustainable IAEA cooperation. The School is organized by the Japan Nuclear Human Resource Development Network with the support of the Japanese Government. In 2015 a total of 35 participants from 15 countries attended the school. In addition, to cater to the growing needs in the Asia and Pacific region, the United Arab Emirates (UAE) also hosted their second NEM School in 2015, through the support of IAEA TC project RAS2015 entitled Supporting the Introduction of Nuclear Power for Electricity Generation and Seawater Desalination. The school, hosted by Khalifah University, was opened to the participation of IAEA Member States in the region with a total of 46 participants. Moreover, the UAE plans to host a third NEM School in 2017. South Africa will host an NEM School in October 2016 with participants from the AFRA region. Other Member States have approached the Agency expressing great interest to host NEM Schools for their regions in the near future, including China and the Russian Federation. A consistent long-term strategy and sustainable approach to the IAEA's ongoing support for an appropriate number of regional NEM Schools is being developed. All Agency departments actively contribute to the ongoing success of the NEM Schools.

10. The Agency, in cooperation with the OECD Nuclear Energy Agency, will be hosting the Third International Conference on Nuclear Knowledge Management - Challenges and Approaches, on 7-11 November 2016, at IAEA headquarters in Vienna. The conference will provide an opportunity to share experiences, lessons learned and practical approaches to KM in the nuclear sector. A broad range of topics related to specific human competencies, methodological or process knowledge and technology-related knowledge will be addressed. It is expected that the conference will attract over 350 participants from over 50 countries and many international organizations. It is a follow-up to IAEA international conferences organized in 2004 in Saclay, France, and in 2007 in Vienna, Austria. It also builds on the outcomes of the 2010 IAEA-organized international conferences on human resource development held in Abu Dhabi, United Arab Emirates, and in Vienna, Austria in 2014.

11. In the area of human health, several initiatives were developed to preserve and enhance knowledge. E-learning modules in nuclear medicine were created. New training material on medical physics was published. Finally, regular training programmes in the area of nuclear instrumentation were provided. Currently, e-learning tools for neutron activation analysis are under development, targeting young specialists or beginners and aiming to preserve, share and transfer knowledge as well as develop expert communities to help ensure neutron activation analysis technique sustainability.

12. The annual School of Nuclear Knowledge Management represents a successful cooperative initiative between IAEA and ICTP. The School is enjoying growing popularity, receiving over 160 applications annually. Between 30 and 40 young professionals from both developing and developed countries are trained each year, depending on funds available. The School uses blended teaching techniques and provides a good overview of NKM tools and challenges, as well as opportunities for sharing experiences and good practices with peers and experts. In the last 12 years, more than 350 young professionals attended. Responding to Member States requests, the NKM Schools have been organized regionally within the framework of Technical Cooperation. The Republic of Korea hosted the First Regional NKM School at KAERI in 2014. An advanced version of the NKM School targeted at experienced practitioners is being piloted.

13. The Knowledge Management Assist Visits (KMAVs) conducted by the Agency focus on activities aimed at helping interested Member State organizations assess their knowledge management approaches and identify ways to address needs by formulating country-specific or institution specific policies based on developed and recommended methodology. Such Assist Visits have recently been undertaken to the Nuclear Power Production and Development Company of the Islamic Republic of

Iran, the Smolenskaya Nuclear Power Plant in the Russian Federation and the KSU Training Centre at the Ringhals Nuclear Power Plant in Sweden.

14. The International Nuclear Management Academy (INMA) initiative, launched in 2015, supports international collaboration among nuclear engineering universities to develop a framework for delivering master's level education programmes in nuclear technology management (NTM). The initiative facilitates Member State and stakeholder involvement, including financial support for students and course material development. Specifically, the Agency, with extra-budgetary support from Japan, facilitated university collaboration to develop common learning outcomes (in terms of competency requirements) for full master's level degree programmes in nuclear technology management. The University of Manchester in the UK was the first to implement INMA. Several other universities are in the process of implementing INMA, including MEPhI University in the Russian Federation, whose master's programme will start in autumn 2016. Several other universities are developing and implement master's level NTM programmes for the nuclear sector. These programmes target education of present and future managers working in the nuclear sector. Texas A&M University in the USA, North-West University and the University of Witwatersrand in South Africa, The University of Tokyo in Japan, Tsinghua University and Harbin Engineering University in China, and the University of Ontario Institute of Technology in Canada are all in the process of implementing NTM programmes.

C. Applying nuclear knowledge management to development

15. A number of activities on knowledge management were included in national, regional and interregional TC projects, resulting in strengthening capacities in the area of nuclear knowledge management and exchange of information, development of skills in the use and maintenance of equipment, safety culture, NPP planning, development of regulatory infrastructure, networking and use of Information and Communication Technology (ICT) to support education and knowledge exchange. Some regional projects are mentioned here as examples:

16. In Africa, under the TC project RAF0043: "Enhancing Human Resources Development and Nuclear Knowledge Management (AFRA)", the Government of Zambia hosted the Second General Assembly of the AFRA-NEST, which took place in Lusaka from 07 to 11 December 2015. This meeting brought together leaders from education and training institutions in Africa to share experiences in the piloting of a national level nuclear Education Capability Assessment and Planning (ECAP) methodology, as well as to discuss policy objectives, benchmarks and strategic direction for further leveraging resources and building educational capability in the region.

17. Similarly, in June 2015 under the same TC project, the AFRA-NEST Working Group Workshop on National Level Nuclear Education Capability Assessment and Planning (ECAP) Framework was organized in Vienna, Austria. This workshop deliberated the needs and priorities for national level policy assessment, policy formulation and guidance and policy planning tools in nuclear science and technology education. The participants also discussed the needs and priorities for methods and tools for national level assessment of the current and future demand for nuclear science and technology education to support economic sustainability and growth, with particular emphasis on industrial, agricultural, medical, health, energy and research areas. Assistance is also provided to Member States to develop indicators and benchmarks for Nuclear Education, Science and Technology (NEST) Networks.

18. Finally, TC project RAF0043: “Enhancing Human Resources Development and Nuclear Knowledge Management (AFRA)” provided support to five professionals from the African region to be trained under the joint ICTP-IAEA School of Nuclear Knowledge Management.

19. The new (2016-17) TC project SAF0006 for Establishing a South African Centre of Excellence for Nuclear Education, Science and Technology (SACOE-NEST) aims at developing suitably qualified and experienced nuclear personnel employed by nuclear science and technology programmes in South Africa.

20. Under TC project RAF9056: Strengthening Education and Training in Radiation Safety and Sustaining Human Resources Development and Nuclear Knowledge Management, AFRA, in collaboration with the Government of South Africa and the IAEA will organize the first of its-kind in the region Joint South Africa-IAEA Nuclear Energy Management School from 17 to 28 October 2016 in Cape Town. The two-week course will help promote and foster knowledge on a wide range of issues related to the peaceful use of nuclear technology. It will provide the potential future leaders of nuclear energy programmes with a unique international educational experience and a worldwide networking opportunity.

21. TC project RAF0041, focuses on Sharing Best Practices in Preventive Maintenance of Nuclear Equipment (AFRA) among the participating countries including a maintenance programme, technical documentation and quality control procedures that can be shared among the professionals in the Member States. TC project, GHA0012 Establishing the Postgraduate School of Nuclear and Allied Sciences for the Preservation, Maintenance and Enhancement of Nuclear Knowledge, Phase II focuses on ensuring the safe and successful use of nuclear techniques. Six regional (AFRA), and six national training courses provided the support for sharing and transferring of knowledge.

22. In Asia and the Pacific, national and regional projects are making significant contributions to building capacities: AFG0004: Development of Nuclear Physics Laboratory for Bachelor and Master Students”; INS0019: Supporting the Training Programme of BATAN to Enhance Technical and Managerial Capabilities; RAS2016: Supporting Decision Making for Nuclear Power Planning and Development-Phase II; RAS9064: Strengthening the Transfer of Experience Related to Occupational Radiation Protection in the Nuclear Industry and Other Applications Involving Ionizing Radiation”. The TC project RAS0060: Enhancing Capacity for Effective Use and Maintenance of Nuclear Instrumentation’ supports the region through transfer of knowledge and provision of effective practical experience in order to carry out training, maintenance, repair, calibration and quality control of nuclear instrumentation. Additionally, the TC project RAS0064: Supporting Nuclear Education and Training through e-Learning and Other Means of Advanced Information Communication Technology (ICT) promotes the use of remote training in the region using the CLP4NET platform and thus enables projects to facilitate access to the educational resource and teaching experience. In early 2014, the Web Portal of the Asian Network for Education in Nuclear Technology (ANENT) was renewed in cooperation with the Korea Atomic Energy Research Institute (KAERI), which hosts the regional LMS (<https://ilms.kaeri.re.kr>). A new regional TC project RAS0075: Networking for Nuclear Education, Training, and Outreach Programmes in Nuclear Science and Technology in the Framework of ANENT (Asian Network for Education in Nuclear Technology) has started in 2016 for four years and is aimed at promoting the utilization of Nuclear Science and Technology and to enhance institutional capacity building in Asia and the Pacific Region through strengthening the Education and Training (E&T) network.

23. In the Latin America Region, TC project RLA0048: Networking for Nuclear Education, Training, Outreach and Knowledge Sharing, provides support to the projects of LANENT (Latin American Network for Education in Nuclear Technology); 30 professionals were trained under the joint ICTP-IAEA School of Nuclear Knowledge Management during the duration of the project

(2012-2015). A LANENT web page was developed, providing information on all aspects of preserving and promoting nuclear knowledge within this network, as well as an Integrated Data Base on Nuclear Education hosted in the region and used for information exchange by the main nuclear education networks acting worldwide. LANENT has also allowed the training of 250 professionals in the region through different on-line courses and other resources.

24. The *First International Symposium on Education, Training and Knowledge Management in Nuclear Energy and Applications* took place in Cusco, Peru, in November 2015, welcoming 102 participants from 15 countries.

25. A new regional project RLA0057: Enhancing Nuclear Education, Training, Outreach and Knowledge Management has been launched in January 2016, aiming at contributing to enhanced regional education and training in nuclear science, engineering and technology for the next 4 years.

26. In the Europe Region, under project CZR0007: Strengthening Human Resource Capacity and Nuclear Knowledge Preservation the capability of Czech national experts to manage nuclear installations, applications and techniques was enhanced by organizing four expert missions, two fellowships and three scientific visits. This project increased the pool of qualified Czech experts in the nuclear field and is being continued under CZR0008.

27. In addition, the interregional project for nuclear newcomer states INT2013: supporting nuclear power infrastructure capacity building in member states introducing nuclear power successfully enhanced and harmonized human resources capabilities for the introduction of nuclear power. By establishing a global network and forum for information exchange, transferring knowledge related to IAEA milestone issues, integrated management systems and project management through a “train the trainers” approach, the technical cooperation programme supported newcomers in enhancing their capabilities in the field of nuclear knowledge management.

D. Applying nuclear knowledge management to strengthen nuclear safety, security and safeguards

28. The Agency’s safety standards and security guidelines and the implementation of safeguards provide the basis for major NKM activities in nuclear safety and security, and safeguards. The Agency’s safety standards and security guidelines are developed through an open and transparent process for gathering, integrating and sharing the knowledge and experience gained from the actual use of technologies, including emerging trends and issues of regulatory importance.⁴⁰

29. Safety services such as the Integrated Regulatory Review Service (IRRS), Operational Safety Review Team (OSART), are based on the Agency Safety Standards, which further enhance knowledge management, information sharing and feedback. Most nuclear safety and security-implemented activities have contributed to fostering networking and exchange of information and sharing knowledge among the Member States.⁴¹

30. The integrated concept of Capacity Building (CB) includes four essential elements: education and training; human resource development; knowledge management; and knowledge networks.

⁴⁰ This relates to operative paragraph 1, 30 and 100 of resolution GC(59)/RES/9.

⁴¹ This relates to operative paragraph 1 and 100 of resolution GC(59)/RES/9.

Progress was made by developing guidance to conduct self-assessments for capacity building, in particular self-assessments of knowledge management within the organisations. The Agency has also developed a Fukushima Daiichi accident knowledge base to ensure that lessons learned are captured, retained and disseminated in a structured and consistent manner⁴².

31. The Education and Training Review Service (ETReS) has been developed and is being used by Member States. Its aim is to assist in key areas of the education and training safety programme of a Member State and it includes guidelines for self-assessment. Two Education and Training Review Service (ETReS) missions were conducted in the Philippines in August 2015 and in Thailand, September 2015. A preliminary ETReS mission took place in Kenya in April 2016 and a Regional Workshop on Integrated Capacity Building, including information on ETReS process and self-assessment, Knowledge Management and Education and Training Strategies was held in Tunisia, October 2015. Education and Training Appraisal (EduTA) missions to assess education and training in radiation safety were conducted in Greece (follow-up mission, October 2015), Lithuania (November 2015) and Peru (June 2016)⁴³

32. The 7th Steering Committee on Regulatory Capacity Building and Knowledge Management (hereafter SC) held its annual meeting in Vienna, December 2015 attended by delegates from 28 IAEA Member States and the European Commission. The SC discussed the assessment of the implementation of the Strategic Approach to Educating and Training in Nuclear Safety 2013-2020. It also addressed other issues relevant to education and training, such as knowledge management, the methodology and software tool of the systematic Assessment of Regulatory Competence Needs SARCoN and training for safety leadership⁴⁴

33. The Secretariat is assisting Member States in the area of knowledge management by developing national nuclear safety knowledge platforms. These platforms are intended to facilitate the organization, management and sharing of nuclear safety knowledge. A draft guidance document was endorsed by the 7th Global Nuclear Safety and Security Network (GNSSN) Steering Committee meeting and used by the Member States in order to complete their national platforms. Ten national platforms were already completed by the Member States, 4 of them during the reporting period. Another 18 national platforms are under development.⁴⁵

34. The Agency supported regulatory capacity building in Member States by holding a regional workshop on *Human Resource Development, Including Systematic Assessment of Regulatory Competence Needs* in the Philippines, November 2015. The Agency is also analysing Member States' experience in the use of the IAEA *Methodology for the Systematic Assessment of the Regulatory Competence Needs* (SARCoN). Two consultancy meetings and a survey intended to analyse the usability and operational capacities of SARCoN were conducted in Vienna, November 2015. The survey was completed by 150 users. Based on the results, a TECDOC on experience using SARCoN is under preparation⁴⁶

35. The Global Safety Assessment Network continues to be relied upon as both a repository of the Agency's safety assessment education and training knowledge and a system for online collaborative education. The safety assessment education and training (SAET) curriculum was expanded to include additional information on transient and accident analyses and severe accident phenomena. In October

⁴² This relates to operative paragraph 5, 100 and 102 of resolution GC(59)/RES/9.

⁴³ This relates to operative paragraph 5, 19, 100 and 102 of resolution GC(59)/RES/9.

⁴⁴ This relates to operative paragraph 5, 19, 100 and 102 of resolution GC(59)/RES/9.

⁴⁵ This relates to operative paragraph 5, 19, 100 and 102 of resolution GC(59)/RES/9.

⁴⁶ This relates to operative paragraph 5, 19, 100 and 102 of resolution GC(59)/RES/9.

2015 the IAEA in cooperation with the International Center for Theoretical Physics held a two week SAET essential knowledge workshop entitled The Nuclear Safety Institute⁴⁷

36. The Agency continued its cooperation with the Ibero-American Forum of Radiological and Nuclear Regulatory Agencies (FORO). A three-year joint project intended to strengthen regional capacity building programmes in line with the IAEA safety standards concluded. An IAEA Technical Document (TECDOC) based on this work was prepared in Spanish and presented to the Publication Committee.

37. The Postgraduate Educational Course in Radiation Protection and the Safety of Radiation Sources has continued to provide a pool of future experts in radiation protection. Short term training events covers a wide range of topics. The full list of training events for 2015 and 2016 is available on the Agency's website.⁴⁸

38. The Agency conducted three IAEA SSAC Advisory Service (ISSAS) missions in 2014 - in Kyrgyzstan, the United Arab Emirates and Uzbekistan. It also held seven international, regional and national training courses (two international, both in the U.S.; four regional, in Indonesia, Finland, Algeria and the Republic of Korea; one national in Oman) for personnel responsible for overseeing and implementing the systems of accounting for and control of nuclear material. The Agency participated in several other training activities organized by Member States on a bilateral basis. In total, more than 170 experts were trained on safeguards related topics. In 2014, the Agency also developed the first e-learning programme on safeguards that was developed in the framework of the interactive e-learning series explaining the IAEA's Milestones Approach to introducing a nuclear power programme. The e-learning programme is made available to Member States through the website of the Division of Nuclear Power.

39. The Division of Nuclear Power facilitated workshops with relevant Member States to develop or update "Integrated Work Plans (IWP)" to address recommendations and suggestions from Integrated Nuclear Infrastructure Review Missions. IWPs include, inter alia, activities to strengthen Member States knowledge and, where applicable, capacity building to implement the requirements for safety, security and safeguards related to introducing nuclear power programmes. Since October 2015, the departments of Nuclear Energy, Nuclear Safety and Security, Safeguards and the Office of Legal Affairs participated in IWP workshops for Belarus, Egypt, Jordan, Kenya, Nigeria, Turkey and the United Arab Emirates.

40. To assist States in building capacity for implementing their safeguards obligations, in 2014 the Agency published the *Safeguards Implementation Practices Guide on Facilitating IAEA Verification Activities* (IAEA Services Series 30), an updated version of the *Guidance for States Implementing Comprehensive Safeguards Agreements and Additional Protocols* (IAEA Services Series 21), the *International Safeguards in the Design of Nuclear Reactors* (IAEA NE/NP-T-2.9) and the *Safeguards Implementation Guide for States with Small Quantities Protocols* (IAEA Services Series 22) in French and Spanish. In 2015 the Agency published the second of four planned safeguards implementation practices guides, entitled *Safeguards Implementation Practices Guide on Establishing and Maintaining State Safeguards Infrastructure* (IAEA Services Series 31), and Spanish and Russian translations of *Guidance for States Implementing Comprehensive Safeguards Agreements and Additional Protocols* (IAEA Services Series 21). In 2014 and 2015 the Agency also held seminars on Safeguards for new diplomats of Embassies and Permanent Missions.

⁴⁷ This relates to operative paragraph 5, 19, 100 and 102 of resolution GC(59)/RES/9.

⁴⁸ This relates to operative paragraph 19, 100 and 102 of resolution GC(59)/RES/9.

E. Strengthening networks related to nuclear education and training and Nuclear Information

41. National, regional and inter-regional networks support NKM in facilitating the exchange of information, education and training and promoting human resources development. ANENT, LANENT, AFRA-NEST and STAR-NET, established in collaboration with the Agency in 2004, 2011, 2013 and 2015 respectively, cooperate in education, capacity building and knowledge management, supported by the Agency through seminars, workshops and training courses, organized either via regular budget or TC support, in the regions or at Agency headquarters.

42. Over the last four years, special attention has been given to initiating collaboration at the interregional level with other established nuclear education networks such as the European Nuclear Education Network (ENEN). Participation in, and activities of, the IAEA-facilitated regional nuclear education networks continued to grow, including with the AFRA Network for Nuclear Education, Science and Technology (AFRA-NEST), the Asian Network for Education in Nuclear Technology (ANENT) and the Latin American Network for Education in Nuclear Technology (LANENT). Close collaboration with the pre-existing European Nuclear Education Network (ENEN) has also continued. The Agency facilitated the establishment of a fifth regional network, the Regional Network for Nuclear Education and Training in Nuclear Technology (STAR-NET), with 12 universities from six countries in eastern Europe and central Asia.

43. In response to a General Conference request in 2012 to “further develop and utilize e-learning technologies and methods to make nuclear knowledge more broadly available in an efficient and effective manner”, the Cyber Learning Platform for Network Education and Training (CLP4NET) was further enhanced. The homepage of the CLP4NET now includes an Open Learning Management System (OLMS), for public access and self-study; a Password-protected Learning Management System (PLMS), for instructor led courses and an Integrated Database on Education and Training (IDB), as well as links to the regional and local installations of CLP4NET. The platform is recognized by the regional nuclear education networks as an effective learning management system platform to support capacity building and knowledge transfer in the nuclear sector. CLP4NET is used throughout the Agency to support the delivery of on-line e-learning materials to Member States. More than 262 separate courses and 1133 eLearning modules have already been deployed on the platform, though many are by registration only. Over 9000 users from more than 100 Member States use CLP4NET. Registration is free, and users may come back any time to continue exploring. Approved eLearning modules from some of the IAEA’s partner organizations in education and training are also available.

44. In the last few years a Comprehensive Curriculum Map on Spent Fuel and Radioactive Waste Management, Decommissioning and Environmental Remediation e-learning has been developed jointly by the Departments of Nuclear Energy and Nuclear Safety and Security. More than 60 e-learning lectures in the area of spent fuel, radioactive waste management and environmental remediation have been made publicly available through the CONNECT and CLP4Net web based platforms since November 2015, with further modules on decommissioning in an advanced stage of preparation. The work on e-learning continues and new lectures are being developed to cover other areas and to expand the existing e-learning material.

45. The International Regulatory Network (RegNet) IT platform, was developed for Member States to share information and documents in nuclear safety. New video lectures relating to various aspects of safety infrastructure were produced and provided through the Agency’s website and in DVD format. More than 80 different safety-related video lectures are currently available. These video lectures are intended to foster the exchange of knowledge and experience amongst Member States and support their knowledge and competence management.

46. Membership in the International Nuclear Information System (INIS) currently comprises 130 IAEA Member States and 24 international organizations. The INIS repository contains over 3.8 million bibliographic records and almost 400 000 full-text documents pertaining to nuclear science and technology. These documents are accessed online, free of charge, more than 1.5 million times per year. INIS' unique thesaurus contains over 30 000 descriptors covering the domain of nuclear knowledge. It is available in all 6 IAEA languages — Arabic, Chinese, English, French, Russian, and Spanish — as well as German and Japanese. The International Nuclear Library Network (INLN), managed by the IAEA Library, promotes cooperation among nuclear libraries and research institutes around the world and currently has 55 members.