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(GC(62)/1 and Add.1)

# 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(61)/RES/11 and GC(60)/RES/12 this document contains progress reports on:

- Part A.: Non-power nuclear applications
  - General (Annex 1)
  - Support to the African Union's Pan African Tsetse Trypanosomosis Eradication Campaign (AU-PATTEC) (Annex 2);
  - Development of the sterile insect technique for the control or eradication of malaria, dengue, Zika and other disease-transmitting mosquitoes (Annex 3);
  - Strengthening the support to Member States in food and agriculture (Annex 4);
  - Renovation of the Agency's Nuclear Applications Laboratories at Seibersdorf (Annex 5);
  - Plan for producing potable water economically using small and medium sized or modular reactors (Annex 6);
- Part B: Nuclear power applications
  - General (Annex 7)
  - Communication and Agency cooperation with other agencies (Annex 7)
  - Operation of existing nuclear power plants (Annex 7)
  - Agency activities in the development of innovative nuclear technology (Annex 8);
  - Approaches to supporting nuclear power infrastructure development (Annex 9); and

- Nuclear knowledge management (Annex 10).

Further information on the Agency's activities related to nuclear science, technology and applications can be found in the *Nuclear Technology Review 2018* (document GC(62)/INF/2); the *IAEA Annual Report 2017* (GC (62)/3), in particular the section on nuclear technology; and the *Technical Cooperation Report for 2017* (GC(62)/INF/4).

## Recommended Action

- It is recommended that the Board take note of Annexes 1 – 10 to this report and authorize the Director General to submit the report to the General Conference at its 62nd regular session.

# General

## A. Background

1. In resolution GC(61)/RES/11. A.1., the General Conference requested the Director General, in conformity with the Statute, to continue to pursue, in consultation with Member States, the Agency's activities in the areas of nuclear science, technology and applications, with special emphasis on supporting the development of nuclear applications in Member States with a view to strengthening infrastructures and fostering science, technology and engineering for meeting sustainable growth and development needs of Member States in a safe manner.

2. The General Conference recommended that the Director General report on the progress made in the areas of nuclear science, technology and applications to the Board of Governors and to the General Conference at its 62nd (2018) regular session. This report has been prepared in response to that request.

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

3. In resolution GC(59)/RES/12, the Secretariat was requested by Member States to organise a Ministerial Conference in 2018 on nuclear science, technology and applications for peaceful uses, and their delivery to Member States through the Agency's technical cooperation programme, while highlighting their future contribution to sustainable development. The call was further reiterated in GC(60)/RES/12 and GC(61)/RES/11 in 2016 and 2017 respectively. In response to these resolutions and in preparation for the Ministerial Conference on Nuclear Science and Technology: Addressing Current and Emerging Development Challenges to be held in Vienna, Austria from 28-30 November 2018, the Co-Chairs of the Ministerial Conference have held several open-ended informal consultations with Member States during which the draft programme of the Conference and a draft outcome document were discussed.

4. The Agency continued to collaborate with designated Member State institutions to implement the Agency's programmatic activities and promote the practical use of nuclear techniques. These Collaborating Centres, focus on research and development and assists Member States with the implementation of the 2030 Agenda for Sustainable Development. To date, the Agency has 34 designated Collaborating Centres.

5. The Agency further strengthened its support to Member States in facilitating effective research activities in the areas of nuclear science, technology and applications, through Coordinated Research Projects (CRPs) which continue to allow research institutes in both developing and developed Member States to collaborate on research topics of common interest. There are currently 135 active CRPs ongoing at the Agency.

6. A comprehensive feasibility study and questionnaire of Member States' priorities and requirements regarding an ion beam accelerator project and the establishment of a DD and DT compact accelerator-based neutron source for demonstration and training in the Nuclear Science and Instrumentation Laboratory is ongoing. A new ion source has been procured which will be installed at

the Ruder Boskovic Institute ion beam facility in Zagreb, Croatia, which will allow dual beam capability for fusion related materials research. A CRP on Facilitating Experiments with Ion Beam Accelerators has been initiated which will facilitate scientists without access to accelerator facilities to conduct experiments using accelerator-based ion-beam analytical techniques. This will be accomplished through the identification and selection of participating institutions (hosts) which will provide access to ion beam laboratories and expertise in ion beam analytical techniques. The IAEA Accelerator Knowledge Portal: has been enhanced and the electrostatic accelerators, synchrotron light sources and spallation neutron sources database has been updated. A new database on neutron scattering instruments has been created.

7. The Agency continued to provide support services to requesting Member States for the rapid and economic mapping of radioactivity on the Earth's surface. Two expert missions were held in Indonesia in December 2017 on Radiological Characterization of Environmental Contamination by NORM in Bangka Belitung Islands and in Uzbekistan in June 2018 on Radiation Measurements for the Release of FOTON RTC Site after the Radioactive Waste Disposal. Assistance continued to the project on Fukushima Prefecture in the integrated approach regarding remediation, decontamination, waste management and radiation monitoring. The Nuclear Science and Instrumentation Laboratory was responsible for the 'Integration and Mapping of Radiation Measurement Data' collected using their unmanned aerial vehicle.

8. The Agency participated in the OECD High Level Group on the Security of Supply of Medical Radioisotopes (HLG-MR) meeting held in Paris in February 2018. The meeting focused on the accomplishments of the group to date, a review of the Mo-99 supply situation worldwide, and the future outlook.

9. A new CRP was initiated on 'New way of producing Tc-99m and Tc-99m generators (Beyond Fission and Cyclotron Methods)'. The CRP aims at developing the technology of producing Mo-99 in linear accelerators and Tc-99m generators using low to medium specific activity of Mo-99. Support has also been provided to Member States through the Technical Cooperation Programme, to national and regional efforts aimed at the production of Mo-99 by the neutron activation of Mo targets in Research Reactors.

10. The Agency continued to support more than 60 national and regional projects in Member States aimed at the production of medical radioisotopes and radiopharmaceuticals through the Technical Cooperation Programme. A workshop was held in Poland, 4-8 June 2018, aimed to assist Member States in the Eastern European region, with the theoretical and practical knowledge on the production of peptides labelled with theranostic radioisotopes.

11. A Training Workshop on Inter-Comparison Feedback of NAA Proficiency Tests Performed in 2017 was held in Slovenia in November 2017. Assistance to Member States was continued in developing strategic plans for utilization of existing and planned RRs. In December 2017, the Agency published a TECDOC on *Proficiency Testing by Interlaboratory Comparison Performed in 2010–2015 for Neutron Activation Analysis and Other Analytical Techniques* (IAEA-TECDOC-1831), presenting the findings and lessons learned from tests performed. A worldwide round robin exercise to test resolution and contrast of neutron imaging facilities was held in July 2018.

12. Agency staff attended the ITER Council Meetings in November 2017 and May 2018 respectively and discussions with ITER are underway to sign a detailed workplan within the Cooperation Agreement between the IAEA-ITER. Two new CRPs on Development of Compact Steady-State Fusion Neutron Sources and Network of Small and Medium Size Magnetic Confinement Fusion Devices for Fusion Research have been launched. The 5th IAEA Demonstration Fusion Power Plant (DEMO) Programme Workshop was held from 7–10 May 2018 and substantial progress on the Fusion Technical Roadmap was made. The 1st IAEA Workshop on Fusion Enterprises was held from 13-15 June 2018 and interest

from industry and private investors was observed. The site visit, scientific programme and selection of participants has been completed for the 27th Fusion Energy Conference (FEC 2018) which will take place from 22-27 October in Gandhinagar, India.

13. The Agency continued to assist Member States in setting guidelines in radiation medicine through several technical publications that were issued in the areas of nuclear medicine and diagnostic radiological imaging, and dosimetry and medical radiation physics. The first international code of practice dedicated to the dosimetry of small static fields used in radiotherapy was published in 2017, with significant downloads to date and the current CRP on the Implementation of the above Code of Practice was initiated and will conclude in 2019. To support advanced brachytheraphy techniques, publication of the Training Material on The Transition from 2-D Brachytheraphy to 3-D High Dose Rate Brachytheraphy was completed. Other examples for such support, include completion of the CRP entitled 'Development of Quality Audits for Advanced Technology (MRT) in Radiotherapy Dose Delivery' in 2018 that resulted in 19 publications in peer-reviewed journals.

14. The Agency continues to strengthen its existing relationship with the World Health Organization (WHO) through cooperation in various areas and joint initiatives, including neurological diseases such as Alzheimer's disease, the Joint Global Programme on Cervical Cancer Prevention and Control, IAEA/WHO TLD postal dose audits conducted by the Dosimetry Laboratory, the IAEA-WHO Secondary Standards Dosimetry Laboratory network, and cooperation in nutrition. In November 2017, the IAEA, WHO and UNICEF held the first meeting in nutrition organized by the three international organizations bringing together 50 researchers and public health professionals to explore, among other topics, the role of nuclear techniques in addressing the double burden of malnutrition.

15. The Agency held a Technical Meeting on the 'Regulatory Aspects of Radiopharmaceutical Production' in October 2017 focusing on the regulatory requirements related to radiopharmaceutical production with an aim to harmonize and provide guidance. The Agency also continued to assist Member States with capacity-building efforts in the use of radiation technology in industries and also initiated a new CRP on 'Radiation inactivation of bio-hazards using high powered electron beam accelerators'. Technical meetings were also held in March and June 2018 respectively, with a focus on developing radiation technology guidelines in 'Standards for Sealed Sources (column scanning) applications' and on 'Developing a tool package for Flow-Rate Measurement using Cross-Correlation method'.

16. The Agency continues to support Member States through several national and regional Technical Cooperation projects aimed at the installation of gamma irradiators, electron beam accelerators and installations to produce medical and industrial radioisotopes and radiopharmaceuticals. A new CRP was initiated entitled 'Radiation inactivation of bio-hazards using high powered electron beam accelerators'. In addition, various workshops have been held aimed at increasing the theoretical and practical training of participants from Member States in radiation technologies.

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

## A. Background

1. In In resolution GC(61)/RES/11/A. 2., the General Conference recognized that tsetse flies and the trypanosomosis problem that they cause are increasing and constitute one of the greatest constraints on the African continent's socio-economic development, affecting the health of humans and, in particular, of livestock. This undermines sustainable rural development and leads to increased poverty and food insecurity.

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

3. The General Conference requested the Director General to report on the progress made in the implementation of GC(61)/RES/11/A.2. resolution to the Board of Governors and to the General Conference at its 62nd (2018) regular session.

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

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

4. The Agency was represented at the 16th meeting of National Coordinators for the African Union Pan African Tsetse and Trypanosomosis Eradication Campaign (AU-PATTEC), at the sixth meeting of the AU-PATTEC Steering Committee and at the 34th Conference of the International Scientific Council for Trypanosomiasis Research and Control, which were held in Livingstone, Zambia, in September 2017. A presentation was given to update AU-PATTEC members on the status of activities of the Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture and the Agency's assistance provided under the Technical Cooperation Programme in support of tsetse and trypanosomosis control. The Agency continued to recognize that the tsetse and trypanosomosis problem constitutes one of the greatest constraints for socio-economic development of the African continent, and reported that it will continue close collaboration with AU-PATTEC in its goal to eliminate tsetse flies and trypanosomosis through the creation of sustainable tsetse and trypanosomosis free areas.

5. The Agency continued its collaboration with the Food and Agriculture Organization of the United Nations (FAO) in support of the AU-PATTEC initiative by developing further the national atlases of tsetse and trypanosomosis in Ethiopia and Zimbabwe and through participation in the ad-hoc Meeting on the Progressive Control Pathway for African animal trypanosomosis organized in Rome, in December 2017, by the Programme Against African Trypanosomosis. The cooperation with the African Union Commission (AUC) has now been expanded through the signing of a practical agreement (AUC/IAEA) in February 2018 expanding areas of cooperation and including PATTEC.

6. The Agency continued to support the AU-PATTEC initiative through the Technical Cooperation Programme regional project (project RAF/5/080) by providing expert services for the development of a communication and resource mobilization strategy and by organizing meetings to develop sub-regional strategies.

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

7. The Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture and the Agency's Department of Technical Cooperation have continued to respond to Member States' requests for support in incorporating SIT into area-wide integrated pest management (AW-IPM) to eliminate or control tsetse-transmitted trypanosomosis. The disease has been recognized as a major constraint to both livestock and agricultural crop production in sub-Saharan Africa. The support comes through the provision of technical advice; procurement of equipment and materials; training courses and workshops; fellowships and scientific visits; and research conducted at the IAEA Nuclear Applications Laboratories in Seibersdorf. In addition, experts participated in a number of coordinated research projects (CRPs) that address gaps in scientific knowledge.

8. The Agency's support strengthened capacity in Member States, enabling them to obtain and analyse baseline data that can contribute to informed decision-making regarding the choice and feasibility of available tsetse and trypanosomosis suppression or eradication strategies, including the cost effective integration of SIT operations into AW-IPM campaigns. Since the 61st regular session of the General Conference, support in this area has been provided to Burkina Faso, Chad, Ethiopia, Senegal, South Africa, Uganda, the United Republic of Tanzania and Zimbabwe.

9. Since September 2017, the Agency has supported five fellowships and scientific visits. The fellowships provided individual training at specialized institutions for a total duration of more than 190 days. The Insect Pest Control Laboratory (IPCL) in Seibersdorf has hosted three PhD students whose research on tsetse microbiome has been mentored by senior scientists.

10. Research activities at the IPCL have continued to focus on the development and validation of technologies that can substantially contribute to the cost reduction and simplification of the application of the SIT against major tsetse fly species.

11. A cost effective methodology for the surveillance of tsetse savannah species has been validated in Tanzania and applied to conduct a comprehensive survey of *Glossina swynnertoni* at the national level. The information obtained during the survey has been modelled to produce a predicted distribution, showing a drastic reduction and fragmentation of the areas infested by this species. This methodology allows comprehensive entomological surveillance of savannah species in large areas with reduced efforts in terms of human and logistic resources.

12. The development of molecular tools to identify tsetse fly species has continued during the past year. The full genome sequences of six tsetse species have been completed and mitochondrial DNA has been sequenced for one additional tsetse species.

13. The final Research Coordination Meeting for the CRP entitled 'Enhancing Vector Refractoriness to Trypanosome Infection' was held in the United Republic of Tanzania in November 2017 with participants from nineteen countries that developed research on the inhibition of trypanosome transmission through symbiotic microbes. The research conducted during this project pioneered the study of symbiotic bacteria and pathogens associated with tsetse flies. The final results will be published in 2018 in a special issue of BMC Microbiology and will comprise at least 23 scientific papers.

14. Molecular laboratories have been equipped in Burkina Faso, Zambia and Zimbabwe to enable tsetse field intervention programmes to apply molecular tools to identify and diagnose trypanosomes and tsetse species.

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 issues a number of significant publications on tsetse and trypanosomosis both in journals and through published guidelines, manuals and standard operating procedures (SOPs). During the reporting period, two SOPs for blood processing procedures in tsetse mass-rearing insectaries and for identification of tsetse species with molecular tools were published. These SOPs summarize the main findings and recommendations from the research conducted in the previous year.

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

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

16. The Agency has continued to provide technical support to the Government of Senegal in its programme to eradicate the tsetse fly *Glossina palpalis gambiensis* from the highly productive agricultural region of Niayes, to the north-east of Dakar, using an AW-IPM approach with an SIT component. The target area was divided into three operational blocks that are being treated sequentially. Entomological monitoring has continued in Block 1 and the area has remained tsetse free since mid-2012, indicating that the wild fly population in Block 1 has been eliminated. In Block 2, releases of sterile males have continued with sporadic catches of wild flies in two hot spots. In Block 3, the fly population remains suppressed and sterile male fly releases will be resumed once the hot spots have been eliminated in Block 2.

### B.3.2. Ethiopia (ETH/5/021)

17. The Agency has continued to support the Ethiopian Government in integrating the SIT into its programme to eliminate *Glossina fuscipes fuscipes* from the Deme River Basin in the Southern Rift Valley. The releases of sterile males in Deme were discontinued for several months leading to the recovery of the wild population that had been suppressed to very low levels in the previous year.

18. The permission to use remotely piloted aircraft systems (RPAS) for the release of sterile flies in Deme has been issued by the Ethiopian Civil Aviation Authority. An RPAS is being procured by the Agency; it is anticipated that it will be operated in Deme in 2018 and will contribute significantly to the cost reduction of the SIT component of the project.

### B.3.3. Burkina Faso (RAF/5/080, BKF/5/018 and BKF/5/020

19. The Agency has provided technical support, capacity and equipment for the Insectary of Bobo-Dioulasso (IBD) in Burkina Faso. This insectary, inaugurated in February 2017, is the largest insectary in West Africa. The size of the colony of *G. palpalis gambiensis* is currently being upgraded and has reached a level of 800,000 females. Pilot releases of sterile males will be conducted during 2018.

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

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

21. After the issuance of the mandatory licences by the relevant authorities to import and operate a remotely piloted aerial system to release sterile tsetse flies, a regional training course on the operation and maintenance of a RPAS for release of sterile tsetse flies was conducted on Kalangala Island in Lake Victoria with the participation of ten trainees from six tsetse affected countries. A release machine embedded in the RPAS was developed and tested to conduct georeferenced releases of sterile flies with fully automated missions. The impact of the use of this equipment is significant as not only is it more environmentally friendly, but it also reduces drastically the cost of local logistics.

22. Mating compatibility between the laboratory-reared and local wild strains of *G. fuscipes fuscipes* was demonstrated in the laboratory and in the open field.

## C. Conclusions

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

24. The major constraints to successful and more widespread application of the SIT in suitable areas are the shortage of mass rearing capacity in Africa and the appropriate management structures for mass rearing and area-wide pest control operations.

# Development of the sterile insect technique for the control or eradication of malaria, dengue, Zika and disease-transmitting mosquitoes

## A. Background

1. In resolution GC(60)/RES/12. 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, based on an integrated vector management approach instead of relying on any single tactic 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. According to the World Health Organization, there are 3.9 billion people living in 128 countries at risk of dengue virus transmission and 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 Latin America and the Caribbean, 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 needed, to supplement existing community-based programmes.

4. The General Conference noted with appreciation the interest shown by some donors and their support for research and development to further develop the SIT package for combating malaria, dengue, and other disease-transmitting mosquitoes, and acknowledged the support given by the Agency as outlined in the report by the Director General in document GC(60)/5, Annex 3.

5. The General Conference requested the Agency to continue and strengthen the research, both in the laboratory and in the field, necessary to use the SIT for the management of disease-transmitting mosquitoes. It requested the Agency to increasingly involve scientific and research institutes of developing Member States in the research programme 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 extrabudgetary funds to enable an expansion of the mosquito research programme and related laboratory and office space and staffing. The General Conference also requested the Agency to strengthen capacity building and networking in Latin America and the Caribbean, Asia and the Pacific, and Africa through regional Technical Cooperation (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 environmentally friendly methods.

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.

9. The General Conference requested the Director General to report on the progress made in the implementation of GC(60)/RES/12. A.2. resolution to the General Conference at its 62nd (2018) regular session.

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

10. In response to resolution GC(60)/RES/12, the IPCL in Seibersdorf continued to work on the development of the SIT package for disease-transmitting mosquitoes, i.e. *Anopheles arabiensis*, a vector of malaria, *Aedes polynesiensis*, a vector of dengue, and *Aedes aegypti* and *Aedes albopictus*, vectors of dengue, Zika, chikungunya and yellow fever. The IPCL is currently maintaining mosquito colonies originating from Brazil, Cameroon, China, France (La Reunion), Indonesia, Italy, Mauritius, Mexico, Pakistan, South Africa, Singapore, Sri Lanka, Sudan, Thailand, and the USA. In addition, the IPCL is maintaining several mosquito strains, including strains with morphological and other markers, which are currently being evaluated for their potential use in SIT-based approaches.

11. A new design of an adult holding cage is being validated for *Aedes aegypti.* The cost of the new cage is one tenth of the cost of the reference cages presently in use. Productivity of the mosquitoes is similar to the standard Agency reference cage.

12. An automatic larval counter developed in collaboration with a Hungarian private company, enables the counting of young *Aedes aegypti* larvae. This accurate larval counter improves the mass rearing of *Aedes* species through a better estimation of the density of young larvae in the larval trays.

13. New larval diets based on insect proteins, allowing for a cost reduction of more than 50%, have been tested successfully for *An. arabiensis, Ae. albopictus* and *Ae. aegypti* at the laboratory scale and validated under mass-rearing conditions for *Aedes aegypti*.

14. 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 has assessed the relative efficiency of X rays- and Gamma-rays to induce sterility in *An. arabiensis*, Ae. *albopictus* and *Ae. aegypti*. Also investigated were, the impact of environmental conditions such as anoxia (no oxygen) and insect density on induced sterility to produce irradiation protocols and guidelines for operational programmes in Member States.

15. The Agency continues its efforts to develop robust and efficient methods for sex separation, including genetic sexing. *An. arabiensis* lines containing variants of the larval body or adult eye colour or a temperature sensitive lethal gene have been established and are being evaluated as potential markers for the development of genetic sexing strains (GSS). In addition, *Ae. aegypti* lines carrying the morphological mutations red and white eye, have been characterized and are being used for the construction of GSS for SIT applications. The *Ae. aegypti* redeye strain has been characterized under both small-scale and mass-rearing conditions at the IPCL, and it has been shown to be adequately genetically stable exhibiting low recombination rates. The red eye marker allows sorting of males and females at the pupal stage based on an image analysis of the eye colour marker in combination with the sexual pupal size dimorphism thus ensuring male only releases and the open field implementation of safe and bio secure small-scale pilot SIT applications. The red eye strain has been introgressed in different local genomic backgrounds and was sent to Mexico and will be transferred to Brazil for field testing in the frame of technical cooperation projects.

16. A sexsorter based on sexual dimorphism of pupal size, developed in cooperation with the private sector, was validated at the IPCL using various strains of *Ae. aegypti*, *Ae. albopictus* and *Ae. polynesiensis*.

17. A rapid quality control test that measures flight ability has been developed and validated for *Ae. aegypti* and *Ae. Albopictus,* and will allow the assessment of the quality of mass-produced sterile males It will be transferred to Member States that are or will be initiating SIT-based pilot trials in the field (Brazil, Cuba, France, Mexico, Singapore, Spain, USA) as well as to two Agency collaborating centres.

18. Molecular tools to diagnose mosquito-borne diseases and pathogens in mosquito colonies were developed as a part of the quality control measures to be delivered to the Member States.

19. The Centro Agricoltura Ambiente ‘G.Nicoli’ in Italy and Moscamed in Brazil have been designated as Agency collaborating centres since September 2017 and March 2018 respectively. Both institutes are working on the development and implementation of the sterile insect technique against *Aedes* mosquitoes.

20. In parallel, the Agency continued to manage the coordinated research project ‘Exploring Mechanical, Molecular, Behavioural or Genetic Methods of Sex Separation in Mosquitoes’, which started in October 2013 with 23 researchers from Africa, Asia, Europe, South and Central America, and the USA. The final research coordination meeting was held in Thailand in February 2018 during which the overall progress made was evaluated and potential future research and development activities were discussed.

21. In response to Member States’ needs for new sterile male mosquito release methods, the Agency collaborated with a Swiss American NGO in the cooperation framework with the United States Agency for International Development to develop a release system with a carrying capacity for 50 000 sterile male mosquitoes. This system, which can be mounted on a remotely piloted aircraft system. This system was tested and validated in the field in Brazil.

22. 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’, was initiated in 2016 and the mid-term review meeting took place in Bologna, Italy, in May 2018.This project continues to be a fundamental strategic platform for the exchange of knowledge and experiences worldwide.

23. The Agency continued to provide support to Member States through eleven national TC projects in Brazil, Cuba, Mauritius, Mexico, the Philippines, South Africa, Sri Lanka and Sudan and four regional TC projects covering the Indian Ocean region (RAF5065), which includes Madagascar, Mauritius and Seychelles; the European region (RER5022) which includes Albania, Bulgaria, Cyprus, the Former Yugoslav Republic of Macedonia, Greece, Montenegro, Serbia and Turkey; the Asia Pacific region (RAS5066); and Latin America and the Caribbean, (RLA5074) which includes Argentina, Bahamas, Bolivia, Brazil, Cuba, the Dominican Republic, Ecuador, Guatemala, Honduras, Jamaica, Mexico, Panama, Paraguay, Trinidad and Tobago, and Uruguay.

24. In matters related to the spreading of dengue and chikungunya, the Agency implemented two regional TC projects in the Asia Pacific region (RAS/5/066), and in the Indian Ocean region (RAF/5/072) from 2014 to 2017. Through workshops, training courses and networking, these projects have promoted the sharing of expertise and capacity building and the establishment of Standard Operating Procedures for mosquito surveillance, mass-rearing, overall management of vector populations and implementation of pilot trials. Personnel from participating countries were trained at the IPCL on mosquito rearing and SIT related activities and the knowledge gained was 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. The follow-up regional TC project in the Asia Pacific region (RAS/5/082) was launched in February 2018 with a kick-off meeting organized in Thailand and a workshop, 'Recent developments and impact assessment of sterile and incompatible insect techniques for mosquito control' in Singapore in June 2018. This project aims to further promote the sharing of expertise and capacity building through workshops, training courses and networking, and to support the implementation of small-scale pilot trials to validate SIT as a component of integrated vector management programmes.

25. In response to Member States' requests related to the spread of Zika in the Americas, an off-cycle regional TC project (RLA/5/074) was developed for Latin America and the Caribbean to support the transfer of the SIT package for *Aedes* mosquitoes as a component of integrated vector management approaches. This project follows a phased conditional approach establishing capacity building that included mosquito surveillance, mass-rearing, sex separation, irradiation, handling, transport and release methods, monitoring, and community engagement activities, and anticipates pilot trials in several Member States (Brazil, Cuba, Mexico and Panama) in 2018 and early 2019. Meetings, workshops and regional training courses on specific topics were held to support the advancement of the various Members States to the next phases. Member States in their initiation phase have all received an expert to support and guide the initial steps needed to get started. More advanced Member States are receiving, or have received an expert to review the progress made before advancing them to the next phase of the project activities. Team members of the Member States currently in Phase II of the project will begin three-month fellowships, hosted by the piloting Member States, to receive training in all aspects related to pilot release trials, and will in turn assist these countries during their piloting phase.

26. Mosquito populations are expanding into new areas in Europe, increasing the threat of transmission of diseases such as dengue and chikungunya. In response to Member States' requests related to the spread in Europe of invasive mosquito species such as *Ae. albopictus*, the Agency approved for the 2016-2017 TC cycle a regional TC project RER5022, 'Establishing Genetic Control Programmes for *Aedes* Invasive Mosquitoes'. This project focusses on capacity building including mosquito surveillance, mass-rearing, sex separation, irradiation, handling, transport and release methods, and monitoring, and includes pilot trials in several Member States. A meeting to update the workplan and define pilot test sites took place in Chania, Crete in December 2017. The meeting was also attended by experts from Italy and Germany to harmonize the regional approach and to create technical and strategic partnerships.

27. 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. Conclusions

28. 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.

29. 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 optimization of the SIT package as a complementary tool for the management of mosquito populations. The main challenge remains the development of an efficient sex separation method that would allow male-only releases. Some, good progress, however, has been made in this area through the development of a sexing prototype based on image analysis of the size of pupae of *Ae. albopictus*, *Ae. aegypti* and *Ae. polynesiensis* and the development of a genetic sexing strain in *Ae. aegypti*. The present developments on sexing will allow testing the SIT approach in pilot trials to demonstrate that it is a safe, bio secure and responsible approach to managing mosquito populations, 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-emerging ones).

30. The development and validation of a mosquito release system mounted on remotely piloted aircraft is a great achievement that paves the way for large-scale and cost efficient releases over sparsely or densely populated areas.

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 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(60)/RES/12. A.5., the General Conference recognized the central role of agricultural development in accelerating progress towards several Sustainable Development Goals (SDGs), in particular to end hunger, achieve food security and improved nutrition and promote sustainable agriculture. It consequently urged the Secretariat to further expand, in an integrated and holistic manner, its efforts to address, inter alia, 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, including the adaptation to and mitigation of the effects of climate change.

2. The General Conference further 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 consequently 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 development of tools and technology packages to build soil resilience and address land degradation, and 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 encouraged the Secretariat, in view of the global trend of antimicrobial resistance (AMR) and its impact on human and animal health, to join the international community in efforts to address the global AMR concern, e.g. through investigation of AMR using nuclear/isotopic-derived methods/tools and molecular techniques.

4. Acknowledging the worldwide leading role of the Nuclear Applications Laboratories at Seibersdorf in the establishment of global laboratory networks in several areas, such as the animal disease control networks supported through the Peaceful Uses Initiative, the African Renaissance and International Co-operation Fund and numerous other initiatives, the General Conference urged the Joint FAO/IAEA Division to continue developing laboratory networks in order to strengthen support for the control and eradication of transboundary animal and zoonotic diseases (e.g. the Veterinary Diagnostic Laboratory Network (VETLAB)) and for food safety, including the application of appropriate and competitive nuclear and non-nuclear techniques in animal health and food safety, and, with the participation of multiple stakeholders, to strengthen national programmes and enhance laboratory networks.

5. Welcoming the demand-driven research activities on the development of communication tools to improve decision-making in agricultural water management in Africa, and the new visualization platform for nuclear and radiological emergency preparedness and response for food and agriculture, the General Conference 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.

6. The General Conference requested the Director General to report on the progress made in the implementation of resolution GC(60)/RES/12. A.5. to the General Conference at its 62nd (2018) regular session.

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

7. The Joint FAO/IAEA Division currently oversees 30 coordinated research projects (CRPs) involving approximately 440 research institutions and experimental stations in Member States, and is responsible for providing scientific and technical support to 229 national, regional and interregional technical cooperation (TC) projects. During the 2016–2017 biennium, 222 demand-driven workshops, seminars and training courses were held with the participation of 4738 trainees from developing countries, mainly supported through the Agency's technical cooperation (TC) programme. In addition, the Joint FAO/IAEA Division published 91 technical documents, newsletters, guidelines and books, 178 articles in scientific journals, 84 conference papers and nine special issues in peer reviewed scientific journals.

8. Demand-driven research and development activities continue at the FAO/IAEA Agriculture & Biotechnology 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, the development of radiation hybrid maps for animal breeding and the enhancement of animal disease diagnostic applications.

9. The development and further enhancement of laboratory networks with the participation of multiple stakeholders in order to strengthen national programmes continued to be a primary focus, in particular to strengthen support for the timely diagnosis, control and eradication of transboundary animal and zoonotic diseases (e.g. the VETLAB Network) and for food safety (e.g. the Latin American and Caribbean Analytical Network (RALACA)), including the application of appropriate and competitive nuclear and non-nuclear techniques in animal health and food safety.

10. Within the VETLAB Network, which comprises 44 African and 19 Asian countries, an iVETNet information platform was developed to support Member State laboratories in the implementation and maintenance of quality assurance and the ISO 17025 standard, and the sharing of validated techniques, and to act as a platform for quality assurance and quality control of critical testing parameters. Currently, iVETNet contains records for 1034 veterinary or veterinary related institutions, 1868 contact points within these institutions, and nearly 200 standard operating procedures (SOPs) available to counterparts in Member States. The platform is currently being evaluated for IT security compliance prior to hosting it on the IAEA cloud.

11. RALACA has expanded to include 54 institutions in 21 countries, with 56 new individual members enrolled in 2017, while the African Food Safety Network (AFoSaN) continued to grow with laboratories, research and food control organizations in 36 participating countries. The Food Safety Asia Network(FSA) has been launched, currently involving 16 countries in the Asia Pacific region, and about 70 scientists undertook group training on radioreceptor assay techniques in Thailand and Singapore. A web platform for knowledge exchange has been developed and is hosted by the University of Peradeniya, Sri Lanka.

12. Assistance was provided to Member States on the use of nuclear-derived techniques to quickly and effectively identify and characterize transboundary animal and zoonotic diseases, such as Ebola virus disease, highly pathogenic avian influenza, Crimean-Congo haemorrhagic fever and Rift Valley fever. At training sessions held in Cameroon, the Democratic Republic of Congo, Sierra Leone and Uganda scientists, veterinarians and field workers were taught how to protect themselves and prevent the further spread of such diseases to animals and humans, an essential prerequisite to undertaking zoonotic diagnostic tests on animals. The identification, diagnosis and characterization, in less than eight days of the recent outbreak of highly pathogenic avian influenza in the Democratic Republic of the Congo demonstrated the impact of the VETLAB Network in participating countries.

13. Since the outbreak of Zika- a mosquito-borne viral disease- in 2015, the virus has spread to more than 34 countries and territories in the Americas. The FAO/IAEA Joint Division provides support in vector management through sterile insect technique (SIT) based tools. Activities under an extra-budgetary funded project enabled the refurbishment of shipping containers to create laboratory space, procurement of critical equipment and hiring of four technicians and four professional staff, hence allowing for more efficient research on the development of the SIT package against *Aedes* vector mosquito species.

14. Fourteen SOP manuals and guidelines were published in relation to area-wide integrated pest management for use by national plant protection and animal health organizations. These include: fruit sampling guidelines for fruit flies; guidelines for sterile fly packing, shipping and release; guidelines for standardized tsetse male handling and mosquito colony maintenance; and technical specifications for an Xray system for the irradiation of insects.

15. A novel methodology of authenticity was developed and transferred to 25 Member States for testing of high-value products. Technological capacity was established and/or enhanced for food authenticity, in order to support food safety control systems through the use of nuclear and related analytical techniques in 11 countries in Southeast Asia. The Regional TC project RAS5062 assisted Member States in the region to combat fraudulent practices in trade by implementing sustainable analytical tools that permit independent verification of paper-based traceability systems for food commodities. The project also resulted in remarkable success in attracting national funding for research on food traceability in Member States.

16. The Third FAO/IAEA International Conference on Area-wide Management of Insect Pests: Integrating the Sterile Insect and Related Nuclear and Other Techniques, held in Vienna, Austria, from 22 to 26 May 2017, was attended by 360 delegates from 81 countries, six international organizations, and nine exhibitors. It covered the area-wide approach, including the development and integration of many non-SIT technologies. The concept of area-wide integrated pest management is central to the effective application of the SIT and is increasingly being considered for related genetic, biological and other pest suppression technologies.

17. In July 2017, the Dominican Republic announced the successful eradication of the Mediterranean fruit fly, achieved using SIT with the support of the IAEA, FAO, the Guatemala, Mexico, USA Mediterranean Fruit Fly Programme, the United States Department of Agriculture (USDA), the International Regional Organization for Plant and Animal Health, and the Inter-American Institute for Cooperation on Agriculture. As a result of the eradication, export markets have reopened and the net revenues of the rapidly growing horticultural sector have been re-established.

18. In a significant scale-up in the fight against tsetse flies, Burkina Faso, in March 2017, inaugurated the largest insect rearing facility in West Africa, the Insectary of Bobo-Dioulasso, to apply the SIT to suppress the tsetse fly. The facility was built with the support of the IAEA, in cooperation with FAO, as part of efforts to help control nagana, one of Africa's most devastating cattle diseases. The facility

will be able to produce 300 000 sterile male tsetse flies per week. Technical staff were trained to rear, irradiate and release the insect, and technical advice and equipment was provided.

19. A protocol for pre-field screening for heat tolerant mutants in rice was developed under the CRP on Genetic Improvement for Adaptation to High Temperatures in Drought Prone Areas and Beyond. This protocol will facilitate the screening of heat tolerant mutants in efforts to develop rice varieties resilient to temperature variations and climate change. Other screening protocols developed and now available to Member States include a greenhouse/pre-field Striga screening protocol for rice and sorghum.

20. A molecular marker was successfully developed for feed quality trait in barley, as was a low-cost, user-friendly protocol for marker assisted selection to speed up mutation breeding.

21. Climate change and rainfall variability, water scarcity and the inaccessibility of water sources are major contributors to crop failure. The Joint FAO/IAEA Division and the Agricultural Research Corporation in Sudan introduced drip irrigation technology in eastern Sudan that improved the livelihoods of more than 1000 rural women, making them more resilient to climate change.

22. 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.

23. Good progress was made on the development of the online Decision Support System for Nuclear Emergencies Affecting Food and Agriculture (DSS4NAFA). SOPs are currently being compiled for the sampling and analysis of soil and foodstuffs in case of a nuclear or radiological emergency affecting food and agriculture, protocols are being prepared to support largescale sampling and radionuclide concentration analysis of foodstuffs and DSS4NAFA has undergone further development. The beta version of DSS4NAFA for extended independent was tested in July 2018.

24. The Joint FAO/IAEA Division successfully participated in the Level 3 Convention Exercise, a largescale international nuclear emergency exercise involving 82 countries and 11 international organizations.

25. The Joint FAO/IAEA Division continued to expand its set of animated infographics videos During the reporting period it completed five animated infographics, on Area-wide Integrated Pest Management; Using Nuclear Science to Expand the Vaccines Portfolio; Decision Support System for Nuclear Emergencies Affecting Food and Agriculture; Food Irradiation and the Changing Climate; and Using Nuclear Science to Measure Greenhouse Gases.

## B.1. Strengthening the FAO/IAEA Partnership

26. The FAO/IAEA Joint Division continued to strengthen its efforts on global hunger reduction, improved food security and the achievement of climate-smart sustainable agriculture.

27. To further strengthen the partnership, the Joint FAO/IAEA Division participated actively in the biennial FAO regional conferences for Africa, Asia and the Pacific, Europe and Central Asia, and Latin America and the Caribbean. Information materials were produced illustrating nuclear and nuclear-related technologies and select impacts of these in each region. The materials were well received both among FAO colleagues and among stakeholders participating in the regional conferences.

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

28. Substantial extrabudgetary funds were secured during the reporting period from various initiatives, including the IAEA Peaceful Uses Initiative, the African Renaissance Fund of South Africa, the Emerging Pandemic Threats 2 programme of the USDA, and the OPEC Fund for International Development. In addition, through FAO, the FAO/IAEA Joint Division received funding for projects from the European Commission and the USDA.

# C. Conclusion

29. 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 FAO/IAEA Joint Division will continue to respond to these trends, with a focus on improving the sustainable intensification of agricultural productivity through climate-smart agricultural practices, ensuring food safety and quality, and attaining better adaptation to and mitigation of climate change in agriculture.

# Renovation of the Agency's Nuclear Applications Laboratories at Seibersdorf

## A. Background

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

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

3. ReNuAL and ReNuAL+ aim to deliver significant enhancements for all eight NA laboratories in Seibersdorf to ensure that they continue to be able to respond to growing and evolving Member State needs. The successful conclusion of these projects will enhance the Agency's capacity to assist Member States in their efforts to achieve the Sustainable Development Goals through the peaceful uses of nuclear science and technology in the areas of food and agriculture, human health, the environment and the development and use of nuclear scientific instrumentation.

4. The General Conference requested the Director General to report on the progress made in the implementation of resolution GC(61)/RES/11.A.4. to the General Conference at its 62nd (2018) regular session.

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

### B.1. Implementation Status

5. Building construction has made steady progress since it commenced in July 2016 and remains on track with ReNuAL elements fully completed and the ReNuAL+ elements well under way. The move into the new Insect Pest Control Laboratory (IPCL) building started in July 2018 and the building is scheduled to be operational by the end of 2018.

6. Major construction for all three planned laboratories of the new Flexible Modular Laboratory (FML) will be complete by the end of 2018. The fit-out of the FML will be continued into the third quarter of 2019. The installation of new site infrastructure to support the operations of the IPCL and FML has been proceeding simultaneously with building construction.

7. This site infrastructure includes an 'energy centre' to supply the heating and cooling to the new IPCL and FML. Inclusion of an integrated energy centre to meet long-term heating and cooling needs offers decisive advantages, including: improved energy efficiency; more precise management of the environmental conditions required in each laboratory, optimized for the complexity of the IPCL, and a more flexible infrastructure that could be enhanced in the future.

8. Construction of the new bunker for the Dosimetry Laboratory (DOL) to house a medical linear accelerator is underway.

## B.2. Financial Status and Resource Mobilization

### B.2.1. Financial Status

9. The total target for funding ReNuAL and ReNuAL+ is €57 million. Full funding of the ReNuAL project's €31 million budget was achieved in September 2016. It comprises €10.4 million from the Major Capital Investment Fund (MCIF) and €20.6 million of extrabudgetary funding.

10. Over €32 million in extrabudgetary funds has been raised for ReNuAL and ReNuAL+ to date, with financial and in-kind contributions received from 34 Member States and from other donors. An additional €10.5 million in extrabudgetary funds is still required to complete the resource mobilization requirements under the ReNuAL+ project.

### B.2.2. Funding Priorities

11. Immediate priority is to complete the fit out of the energy centre to meet heating and cooling needs of the IPCL and FML with an estimated cost of €0.75 million. In addition, €3 million is required to equip and set up the new laboratory buildings in order for them to be fully functional.

12. Once these immediate funding requirements have been met, the next objective will be to obtain funding for the targeted enhancement of the original facility, which will be utilized by the four laboratories (Terrestrial Environment Laboratory, the Plant Breeding and Genetics Laboratory, the Nuclear Science and Instrumentation Laboratory, and the Dosimetry Laboratory) that will remain in the existing buildings.

### B.2.3. Resource Mobilization Strategy

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

14. The ReNuAL/ReNuAL+ web pages are continuously updated with new information. Furthermore, the Secretariat continues to publish periodic news briefs that report on the status of the project and promote awareness of its requirements. Laboratory tours continue to play an essential role in fundraising efforts, with over 80 tours conducted and 700 visitors received since the 61st regular session of the General Conference. Furthermore, special events organized by the Secretariat are an additional and valuable resource mobilization activity. As part of these events, a donor wall indicating the Member States that have contributed to the project was unveiled on the opening day of the last

General Conference, and the IPCL was inaugurated the following week. Future donors will have their names reflected on the Donor Wall.

### B.2.4. Resource Mobilization Efforts with Member States

15. The Secretariat has continued to engage in bilateral discussions with a wide number of Member States to support fundraising, resulting in 34 Member States contributing towards the project to date. The goal of these activities is to maximize both the amount of funds raised as well as the number of contributing Member States. In this context, the Friends of ReNuAL, an informal group open to all Member States and co-chaired by Germany and South Africa, has continued to play an important role.

16. Members of the group, which last met in March 2018, have been significant bilateral contributors to the project, and the group remains an important vehicle for maintaining and increasing awareness of ReNuAL/ReNuAL+ among Member States and for generating Member State support for the project.

### B.2.5. Resource Mobilization Efforts with Non-traditional Donors

17. The Secretariat has continued its efforts to attract support from non-traditional donors, with the primary focus remaining on equipment manufacturers in order to help meet the equipment needs of the laboratories. Since the 61st regular session of the General Conference, the Secretariat engaged with several companies to discuss potential partnerships.

18. Following the successful finalization of the partnership agreement for a linear accelerator with Varian Medical Systems, the Agency also signed a Memorandum of Cooperation with the Shimadzu Corporation for the donation of a liquid chromatograph, through the IAEA Peaceful Uses Initiative, for activities to better support Member States in the area of research on food safety and training.

19. Given the large remaining equipping requirements and based on the successful partnerships already achieved, resource mobilization efforts have been expanded by introducing an initiative to seek further private sector partners utilizing the United Nations Global Marketplace (UNGM) portal. Such efforts will continue to obtain the required equipment for the NA laboratories at the lowest possible cost.

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

## C. Next Steps

21. The move into the new IPCL started in July 2018 and the building is scheduled to be fully operational by the end of the year. Major construction of the FML will be completed by the end of 2018. The DOL bunker will be operational by November 2018.

22. Resources must be mobilized by the end of November 2018 to complete the energy centre and for the equipping and set up of the new laboratory buildings to make them fully operational on schedule.

23. Once the necessary funds have been raised for the energy centre and the equipment and set up requirements of the new buildings, resource mobilization efforts will shift to focus on refurbishment, or “targeted enhancement”, of the existing laboratory facility.

24. Targeted enhancement to improve and expand space vacated by the laboratories that are moving into new buildings to meet the evolving needs of the four laboratories that will remain there, will be

addressed beginning in 2019, and can be implemented through a phased approach, in line with the availability of funding.

25. The first ever Ministerial Conference on Nuclear Science and Technology will take place in November 2018, and will present an excellent opportunity for the ReNuAL and ReNuAL+ milestones to be showcased. The operation of the IPCL and the Linear Accelerator Facility will be highlighted and the FML will be inaugurated during the conference. All new contributions received by this time will be recognized on the donor wall during the Ministerial Conference.

# Plan for Producing Potable Water Economically Using Small and Medium Sized or Modular Reactors

## A. Background

1. In resolution GC(60)/RES/12.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; 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 the activities on nuclear desalination, water management, and nuclear cogeneration carried out by the Agency are appreciated. The General Conference stressed the need for international cooperation in the planning and implementation of nuclear desalination demonstration programmes through national and regional projects open for the participation of any interested country.

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) 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 (SMR) and to undertake further activities aimed at better establishing how existing reactors may offer options for cogeneration; (b) issue a technical report addressing responsibilities of vendors and users involved in nuclear desalination projects, and assessing different scenarios for cogeneration; and (c) increase the Secretariat's activities in capacity building (including training and education) on nuclear desalination projects to bridge the gap among users/vendors/operators/regulators. The General Conference invited the Director General to raise funds from extrabudgetary sources in order to catalyse and contribute to the implementation of all Agency activities relating to nuclear desalination and cogeneration, and the development of innovative SMRs. The General Conference requested the Director General to note the high priority given by a growing number of interested Member States to the nuclear desalination of sea water in the process of 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 sixty-second (2018) regular session under an appropriate agenda item.

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

3. The Agency continued to support Member States in activities relating to seawater desalination using nuclear energy and to collaborate with international organizations in this area. Over the reporting period, ten technical and consultancy meetings were held on this topic. The Agency also participated in

several major international activities (conferences) such as the second International Conference on Desalination and Environment, Qatar, January 2016; the ninth International Desalination Workshop, Abu Dhabi, November 2016; the tenth World Congress on Water Resources and Environment (EWRA), Greece, July 2017; the IDA 2017 World Congress on Water Reuse and Desalination, São Paulo, October 2017; and in cooperation with German global desalination company DME GmbH, organized a workshop on 'Desalination Powered by Nuclear Energy' that took place on 12 April 2018. Together with the International Desalination Association (IDA), significant collaborative efforts were made to present, showcase and promote nuclear desalination and Agency activities in this area.

4. The Technical Working Group on Nuclear Desalination (TWG-ND) continued its function as a forum for advice and review of nuclear desalination activities. At its sixth meeting, in November 2017, recommendations were made to: address the need to examine the techno-economics and opportunities for non-electrical applications with an emphasis on nuclear desalination using micro and small modular reactors; assess the importance of licensing and other issues relevant to the coupling of nuclear and water production systems, and explore interlinks between comprehensive integrated water resources management and nuclear desalination practices; promote the advantages of nuclear desalination and the coupling for cogeneration applications of clean nuclear power options as climate change mitigation and carbon-free energy and water production; encourage sustained and constructive interaction between vendors, utilities, and various end users in sharing relevant technical information and licensing considerations. The TWG-ND also recommended that the Agency consider including selected topics on non-electric nuclear power applications, such as industrial heat, hydrogen production, and district heating, in the scope of future TWG-ND meetings; and, based on availability of financial support, consider initiating a new coordinated research project (CRP) to examine the specific benefits of SMRs and, particularly, the advanced high temperature reactor for nuclear desalination and other non-electric applications.

5. In November 2017, a Technical Meeting on the Responsibilities of Users and Vendors in Nuclear Desalination Projects was organized to bring together vendors and users considering nuclear cogeneration for desalination to discuss common challenges and concerns related to the design and operation of nuclear cogeneration plants, and establish a common understanding of users' requirements and the terms under which vendors can supply suitable reactor designs and desalination technologies.

6. The third and final Research Coordination Meeting (RCM) of the CRP on Application of Advanced Low Temperature Desalination Systems to Support Nuclear Power Plants and Non-Electric Applications was held in November 2016 to review the progress made towards reaching the CRP objectives. Some of the achievements reported include: 17 publications/conference papers and 13 graduate and undergraduate students trained on topics related to the CRP; thermodynamic analysis of various configurations for nuclear power plants (NPPs) using different NPP technologies (such studies will be utilized in the near future to update the Agency's Desalination Thermodynamic Optimization Program (DE-TOP) software); a techno-economic feasibility study on utilizing large scale heat pumps for nuclear district heating application; several studies on advanced low temperature desalination technologies, including experiments on modular plate multi-effect evaporator, and modelling and simulation aimed at optimizing the design of coupling schemes for nuclear desalination.

7. To discuss prospects and challenges for future nuclear cogeneration and the potential of SMRs and other potential advanced power reactors for non-electric applications, a Technical Meeting to Examine the Techno-Economics of and Opportunities for Non-Electric Applications of Small and Medium Sized or Modular Reactors was held in May 2017. The meeting participants discussed the main challenges facing the deployment of nuclear cogeneration, and the techno-economic aspects of non-electric applications based on SMR technologies and other potential advanced power reactors. It was concluded that NPPs are suitable for cogeneration applications, but that other issues that affect the economics of the system need to be further considered, including load following and safety coupling.

8. A Technical Meeting on the Socio-Economic Aspects of Nuclear Cogeneration was held in November 2016. The meeting discussed the common concerns and challenges related to nuclear cogeneration with focus on using advanced nuclear reactor technologies, mainly small modular reactors. In April 2018, a Technical Meeting on the Deployment of Non-Electric Applications Using Nuclear Energy for Climate Change Mitigation was held, and discussed the socio-environmental effects of the deployment of non-electric applications of nuclear energy and the role of nuclear cogeneration towards mitigating climate change.

9. In September 2017, the Agency organized a Training Workshop on Efficient Water Management in Water Cooled Reactors Using the IAEA's Water Management Program in Nuclear Power Plants (WAMP). In June 2018, the Technical Meeting on Efficient Energy and Water Management in Nuclear Power Plants: Strategies, Policies and Innovative Approaches was held. Its purpose was to discuss the link between water and energy in NPPs with an emphasis on the role of nuclear desalination and water management in order to achieve sustainability in both energy and water sectors. Following a consultancy meeting in December 2016 to discuss the upgrade of the Agency's WAMP tool and the potential update of the related Nuclear Energy Series publication *Efficient Water Management in Water Cooled Reactors* (IAEA Nuclear Energy Series No. NP-T-2.6), a new version of WAMP was released in January 2018.

10. In September 2016, the Agency organized a Technical Meeting on Technology Assessment of SMRs for near term deployment providing a forum for embarking countries in the Asia Pacific region to discuss the status of SMR designs and of commercially available technologies and/or for near term deployment, and approaches to technology assessment. One of the main recommendations of this meeting was to launch a CRP on the appropriate sizing of the emergency planning zone for SMRs. This recommendation was followed up and the first RCM was held in May 2018 with 25 participants from 14 Member States. In December 2016, the Agency organized a Technical Meeting at the Chashma site, in Pakistan providing the embarking countries with information about the design and operational aspects of pressurized water reactor (PWR) type SMRs, through understanding of the general design features and the operating limits and conditions of the 300 MW(e) SMRs. In October 2017, a Technical Meeting was organized for embarking countries in the Middle East and North Africa region to discuss specific areas of SMR technology assessment, including unit size, proven technology, standardization, constructability, inspectability and maintainability, safety, regulatory and licensing issues, project schedule, site and grid considerations, and plant economics.

11. Efforts to secure funds from extrabudgetary sources for Agency activities relating to nuclear desalination and cogeneration and the development of innovative SMRs were made via TWG-ND members and at technical and international meetings and fora.

12. The Agency also published two Nuclear Energy Series documents in 2017. The publication *Opportunities for Cogeneration with Nuclear Energy* (IAEA Nuclear Energy Series No. NP-T-4.1) presents a comprehensive overview of various aspects relating to the application of cogeneration with nuclear energy, which may offer advantages such as increased efficiency, better cost effectiveness, and reduced environmental impact. It also provides details of experiences, best practices and expectations for the foreseeable future of cogeneration with nuclear power technology and serves as a guide for newcomer countries. It includes information on systems and applications in various sectors, feasibility aspects, technical and economic details, and case studies. The publication *Industrial Applications of Nuclear Energy* (IAEA Nuclear Energy Series No. NP-T-4.3) provides a detailed overview of the potential use of nuclear energy for industrial systems and/or processes which have a strong demand for process heat/steam and power, and on the mapping of nuclear power reactors proposed for various industrial applications. It also provides analyses of industrial energy demand based on current practices, and describes the technical concepts for combined nuclear–industrial complexes that are under consideration.

# General, Communication and Agency Cooperation with other Agencies, and Operation of Existing Nuclear Power Plants

## A. Background

1. The General Conference noted that the Agency's statutory functions include "to encourage and assist research on, and practical application of, atomic energy for peaceful uses", "to foster the exchange of scientific and technical information" and "to encourage the exchange and training of scientists and experts in the field of peaceful uses of atomic energy", including the production of electric power, with due consideration for the needs of developing countries. It also acknowledged that actions have been taken by the Secretariat and Member States with nuclear power, drawing upon the lessons learned from the Fukushima Daiichi accident, endeavouring to enhance the robustness of nuclear power plants and fuel cycle facilities, as well as human and organizational effectiveness, and emphasized the need for ensuring competent technical support at every stage of the lifetime of a nuclear power plant for safe and reliable operations.

2. The General Conference noted that significant concerns related to energy resource availability, the environment, energy security, climate change and its impacts, which have been reflected in the Sustainable Development Goals (SDGs) by the Member States of the United Nations in September 2015, suggest that a wide variety of energy options needs to be addressed in a holistic manner in order to promote access to competitive, clean safe, secure and affordable energy, so as to support sustainable economic growth in all Member States; and further noted that nuclear power does not produce either air pollution or greenhouse gas emissions during normal operation, which makes it one of the low carbon technologies available to generate electricity.

3. The General Conference also recalled that that launching new, as well as maintaining and expanding existing nuclear power programmes, require the development, implementation and continuous improvement of appropriate infrastructure to ensure the safe, secure, efficient and sustainable use of nuclear power, and implementation of the highest standards of nuclear safety, taking into account relevant Agency standards and guidance and relevant international instruments, as well as a strong and long-term commitment of national authorities to creating and maintaining this infrastructure. It also recalled that the development of innovative fast neutron systems, closed fuel cycles and alternative fuel cycles (e.g. thorium, recycled uranium) are regarded as steps towards a long-term sustainable energy supply that can extend the lifetime of nuclear fuel resources and contribute to effective solutions for nuclear waste management

4. The General Conference recalled the importance of human resource development, education and training and knowledge management and stressing the Agency's unique expertise and capacity to assist Member States in building their national capacities to support the safe, secure and efficient use of nuclear power and its application, inter alia through its technical cooperation programme

5. The General Conference recognized the role that the effective management of spent fuel and radioactive waste should play in avoiding imposing undue burdens on future generations, and recognizing that, while each Member State should, as far as is compatible with the safe management of such material, dispose of the radioactive waste it generates, in certain circumstances the safe and

efficient management of spent fuel and radioactive waste might be fostered through agreements among Member States to use facilities in one of them for their mutual benefit

6. The General Conference noted the increasing number of requests from Member States for advice on the exploration of uranium resources and on mining and milling for safe, secure and effective uranium production while minimizing the environmental impact, and acknowledged the importance of the Agency's assistance in this field.

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

8. The General Conference requested the Secretariat to report to the Board of Governors as appropriate and to the General Conference at its sixty-second (2018) session on developments relevant to this resolution. This Annex highlights a number of activities undertaken by the Agency as requested in resolution GC(61)/RES/11.B and not covered in Annexes 8-10.

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

## B.1. General

9. A CRP on Assessments of the Potential Role of Nuclear Energy in National Climate Change Mitigation Strategies, was launched in 2017. The CRP is expected to contribute to the development of Nationally Determined Contributions (NDCs) under the Paris Agreement. Research includes an assessment of the potential role of low-carbon electricity generation projects in supporting long-term national greenhouse gas mitigation strategies. A Technical Meeting on the Deployment of Non-Electric Applications Using Nuclear Energy for Climate Change Mitigation was held in April.[1]

10. The Agency continued providing support to interested Member States for the development of national capacities in the operation of nuclear power plants (NPPs) and in embarking on new nuclear power programmes. Capacity building activities on energy planning and economics, for example, were held for 21 newcomer countries and in six Member States considering an expansion of their nuclear power programmes. The training served to strengthen the locally available expertise to assess investments in new nuclear power plants and their role within the wider energy mix. In addition, participants of the third RCM on Assessing the Economic Impacts of Nuclear Power Plant Programmes, held in Vienna in December 2017, discussed potential economic benefits of introducing an NPP programme at the country level during construction and operation phases. In addition, methodologies and tools for assessing investments in energy technologies (including nuclear power) were improved to allow for the modular nature of small modular reactors.[2]

11. The online publication of the Nuclear Infrastructure Competency Framework database facilitated access by and increased information sharing with interested parties from the Agency and Member States. The Agency continued to promote the use of the database at Agency meetings. Feedback was used to

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[1] This relates also to operative paragraphs 2 and 6 of resolution GC(61)/RES/11.A.1.

[2] This relates also to operative paragraphs 2 and 6 of resolution GC(61)/RES/11.A.1

further refine the content and structure of the database in 2018. Through focused interregional, regional and national workshops, training courses and fellowships, the Agency provided the staff of nuclear power development projects, regulatory bodies and technical support organizations with substantive training on various infrastructure issues. The Agency supported participation from newcomer Member States and lectured at several interregional training courses related to nuclear infrastructure hosted by Finland, Japan, the Republic of Korea, Mexico, the Russian Federation and the United States of America, as well as in Vienna, within the framework of technical cooperation project INT2/018 and national, regional and interregional technical cooperation projects. Additionally, five workshops were held on human resource modelling and workforce planning for new nuclear power programmes with the support of the Nuclear Power Human Resources workforce modelling tool. The above-mentioned Technical Meeting on Topical Issues in the Development of Nuclear Power Infrastructure continues to be the main forum for both newcomer and experienced Member States to share good practices and lessons learned in establishing the infrastructure required for a safe and successful nuclear power programme.

12. In 2016 and 2017, the Nuclear Energy Management (NEM) School at Trieste provided training to nearly 80 participants from more than 30 Member States on various topics relating to nuclear energy and its development. Between September 2016 and September 2018, a total of ten NEM Schools were conducted. Member States needs for NEM continues to grow and a new strategic approach to address the review's findings and these growing needs is being developed. The number of students and professionals interested in NKM Schools has been sustained, with a record number of applicants (290) and participants (65) for the 2017 core NKM School held at the International Centre for Theoretical Physics (ICTP) in Trieste, Italy, in September. National NKM Schools have been implemented through technical cooperation projects in the Latin American region, in Brazil and Argentina, in 2016 and 2017 respectively. The 2018 NKM School, organized in conjunction with the ICTP, was held in Trieste, from 30 July to 3 August.[3]

13. Efforts have been maintained to contribute to greater understanding and a well-balanced perspective of the role of nuclear science and technology in sustainable global development, including the Kyoto commitments, and future efforts to address climate change through participation in key forums. In this regard, the Agency participated in CoP23 (November 2017) and was responsible for either organizing or contributing to four side events: Connecting roadmaps for innovative nuclear energy to the NDC timeline (Agency event); How can nuclear power contribute to climate change mitigation? (Agency event); Energy policy trade-offs within the broader sustainable development challenge (United Nations event co-organized with UNIDO and UNDESA); and Ocean and climate: A resilient ocean for future generations (United Nations event). In addition, the Agency participated in other relevant international events including the 46th Session of the IPCC (September 2017), the Global SDG 7 Conference (February 2018), and the SE4All Forum (May 2018). Specific publications — *Climate Change and Nuclear Power* and *Nuclear Power for Sustainable Development* and *Nuclear Power and Market Mechanisms under the Paris Agreement* — were both produced ahead of the CoP23 meeting. The Agency contributed to the Energy Club meetings hosted by the Renewable Energy and Efficiency Partnership (REEP) and Sustainable Energy for All in Vienna.[4]

14. The Agency continued support of the Eastern Europe Research Reactor Initiative with a six-week group fellowship training course. The 2017 course was held at the research reactor facilities in Austria and Hungary, and was attended by 13 young professionals from 13 Member States. In the framework of the Internet Reactor Laboratory project, distance training on research reactors exercises was provided by the host research reactors in Argentina and France to university students in Africa, Europe and Latin

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[3] This relates also to operative paragraph 4.iv, 6 and 8 of resolution GC(60)/RES/12.C

[4] This relates also to operative paragraphs 2 and 6 of resolution GC(61)/RES/11.A.1

America. Further expansion of the project is planned for Africa (with the host research reactor in Morocco) and for the Asia Pacific (with the host research reactor in the Republic of Korea). The Belgian Nuclear Research Centre SCK•CEN and the United States Department of Energy (USDOE) Idaho National Laboratory and Oak Ridge National Laboratory were designated as International Centres based on research reactors (ICERRs) in September 2017 and will thus provide additional opportunities for Member States to have access to advanced and specific training. [5]

15. The first ever Integrated Nuclear Infrastructure Review mission for Research Reactors (INIR-RR) was held in Nigeria in February 2018 and a preparatory INIR–RR mission will be conducted in Zambia in September 2018. In June 2018, a technical meeting on the Role of Research Reactors in Human Capacity Building in Support of Nuclear Technology was held to share information and feedback on training activities at research reactors in human capacity building, including for the NPP workforce.[6]

16. Three preparatory Operation and Maintenance Assessment for Research Reactors (OMARR) missions were conducted at TRICO II research reactor in the Democratic Republic of the Congo; at BTRR research reactor in Bangladesh and at the Portuguese Research Reactor (RPI) in Sacavem, the latter combined with non-destructive examination (NDE) and in-service inspection (ISI) support. The main OMARR mission was conducted in March 2018 for WWR-SM research reactor in Tashkent, Uzbekistan, and another is planned for BTRR in Bangladesh in November 2018. The Agency continued updating of the Research Reactor Ageing Database (RRADB) and additional reports from Member States were uploaded. A training workshop on Online Monitoring, Non-Destructive Examination and In-Service Inspection was held in June 2018 in Vienna.

17. In the area of minimization of the civilian use of highly enriched uranium (HEU), the following activities took place: The Eighth Annual Technical Meeting on the Conversion of Miniature Neutron Source Reactors from HEU to low enriched uranium (LEU) Fuel was held in Vienna 6-7 December 2017. The Agency provided assistance for the conversion of the Ghana Research Reactor-1 (GHARR-1) in Accra and the repatriation of irradiated fuel to China (project completed in August 2018) and for the conversion of the Nigerian Research Reactor (NIRR-1) research reactor in Zaria and repatriation of the irradiated fuel to China (project expected to be completed by the end of 2018). The annual Technical Meeting on Lessons Learned from HEU Take-back Programmes was held in Beijing, China, 11-14 June 2018. The Agency also cooperated with Norway for the organization of the Third HEU Minimization Symposium held in June 2018 in Oslo, Norway. An update of the Agency's activities to support Member States to produce Mo-99 without the use of HEU was presented at the Topical Meeting held in September 2017 in Montreal, Canada.[7]

18. The Secretariat continued to improve the ability of policy makers and experts to access information on the Agency web site in support of the Agency's work by migrating technical information from the legacy web site to iaea.org, and by making it accessible under the topic structure as well as through the search function.

19. As part of efforts to assist Member States interested in uranium production to develop and maintain sustainable activities, a Technical Meeting of the Uranium Mining and Remediation Exchange Group (UMREG) was held in Bessines-sur-Gartempe, France, in October 2017. Over 40 experts from 20 Member States and an international organization discussed the management of legacy situations, and the safe and appropriate development of uranium resources. Participants highlighted the importance of considering post-mining and post-processing issues during the planning and operational stages of a

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[5] This relates also to operative paragraph 17 of resolution GC(61)/RES/11.A.1.

[6] This relates also to operative paragraph 18 of resolution GC(61)/RES/11.A.1.

[7] This relates also to operative paragraphs 15 of resolution GC(61)/RES/11.A.1.

project. The 54th meeting of the Joint OECD/NEA–IAEA Uranium Group was held in Paris in November 2017, with 48 delegates from 33 countries. Participants discussed the latest estimates of worldwide uranium supply and demand, to be included in Uranium 2018: Resources, Production and Demand (the *Red Book*).

20. The International Symposium on Uranium Raw Material for the Nuclear Fuel Cycle: Exploration, Mining, Production, Supply and Demand, Economics and Environmental Issues (URAM-2018), held on 25–29 June 2018 in Vienna, gathered 234 participants from 49 countries and 4 international organizations to discuss current and future challenges of the uranium market. Although sufficient uranium is discovered to cover nuclear fuel requirements for many decades, the time and effort to bring new projects into production is considerable, and avoiding any possible future tightness of supply may depend on the continuation of exploration, feasibility studies and licencing activities through this period of low uranium prices.

21. In November 2017, the third RCM of the CRP on Fuel Modelling in Accident Conditions (FUMAC) was held in Vienna. The 24 project partners from 18 Member States evaluated the final results of the CRP, aimed at better understanding the behaviour of nuclear fuel in accident conditions in order to enhance nuclear safety. The report of the CRP will compile the results of several benchmark exercises against separate-effect tests, out-of-pile single rod and bundle tests, and in-reactor tests under Loss-of-Coolant Accident (LOCA) conditions, as well as results of uncertainty analyses and sensitivity studies, analysed by different fuel performance codes.

22. A large number of activities on the management of spent fuel have been undertaken since last year including the Agency-hosted first RCM of the CRP on Ageing Management Programmes for Dry Storage Systems in October 2017. Meeting participants exchanged the latest research and development and experience related to the ageing of systems, structures and components, and to monitoring, inspection and surveillance programmes of spent fuel dry storage. The 16th Meeting of the Technical Working Group on Nuclear Fuel Cycle Options and Spent Fuel Management was held on 17-19 April 2018, attended by 18 representatives from 15 Member States, who provided advice and guidance on the implementation of the Agency's programmatic activities in the areas of nuclear fuel cycle and spent fuel management.

23. The report, *Status and Trends in Spent Fuel and Radioactive Waste Management* (NW-T-1.14), was published in January 2018. The second cycle of work is progressing. Work on these reports remains an active and important area of tripartite cooperation with the OECD–NEA and the EC.

24. The CRP on Management of Alpha-Bearing Waste was launched in 2017. The Technical Meeting on Funding for Waste Management and Decommissioning was held in July 2018, and focused on prospective capital and operating expenditures associated with the back end of the nuclear fuel cycle (from spent fuel storage to final disposal), other operational waste and the waste emerging from decommissioning of nuclear power plants and other nuclear facilities. Progress was made in the preparation of publications on cost assessment methodologies for the back end of the fuel cycle and on cost estimation methods and funding schemes for radioactive waste disposal programmes.

25. Two TECDOCS were published in 2017 — *Use of the Benchmarking System for Operational Waste from WWER Reactors* (IAEA-TECDOC-1815) and *Selection of Technical Solutions for the Management of Radioactive Waste* (IAEA-TECDOC-1817).

26. Progress was made in the development of publications on lessons learned in predisposal management of radioactive waste in the aftermath of nuclear accidents, and on disposal of large volumes of waste following a nuclear accident. The draft report, *Disposal of Large Volumes of Waste Following a Nuclear Accident*, is being adjusted to avoid duplications and to ensure consistency with a report on predisposal management of post-accident waste also under preparation. Work also continued on the

development of publications addressing legacy waste challenges: a technical meeting was held in November 2017 in Canada, attended by 25 participants from 15 Member States, to prepare the draft publication, *Roadmap for developing a geological disposal programme*. A Technical Meeting on Methodologies and Approaches to Address Challenges in Managing Radioactive Waste from Past Activities was also held in March 2018 with 22 participants from 17 Member States. Draft reports on the TECDOC *Current Status of the Predisposal Management of Institutional Radioactive Waste*; *Radiation Effects in Nuclear Waste Forms*; *Conditioning of Low and Intermediate Level Liquid*; and *Decontamination Methodologies and Approaches* are all in progress.

27. The following documents are at different stages of preparation for publication: *Contracting and Partnering in Decommissioning and Environmental Remediation (NE Series)*; *Lessons Learned from Deferred Dismantling of Nuclear Facilities (NE Series)*; and *Addressing Uncertainties in Cost Estimates for Decommissioning Nuclear Facilities (OCED Publication in 2017)*.

28. The Agency continues to engage in discussions on the development of multilateral approaches to the nuclear fuel cycle through participation in various activities such as the World Nuclear Association International Cooperation in Developing High-Level Waste Repositories held in January 2018 in London, United Kingdom and relevant activities of The International Framework for Nuclear Energy Cooperation (IFNEC).

29. Draft ARTEMIS guidelines have been placed on the ARTEMIS web site. Between September 2017 and September 2018, five ARTEMIS reviews were completed (Italy, Poland, France, Luxemburg and Bulgaria), with a total of 17 having been requested. The service has been drawn to the awareness of Member States at all suitable opportunities, including bilateral meetings, conferences and technical working groups.

30. Close cooperation continued with EC and OECD–NEA to define and implement the next version of IAEA Online Information Resource for Radioactive Waste Management (NEWMDB, eventually to be renamed ‘SWIFT’ — Spent Fuel and Radioactive Waste Information Tool). The Agency also contributed to an NEA Workshop (Boulogne, France, February 2018) on Implementation of the Methodology for Presenting National Radioactive Waste and Spent Fuel Inventories in National Management Programmes. The Agency reported on the development of the NEWMDB and discussed how the NEA methodology would be integrated into the NEWMDB.

31. The concept of Qualified Technical Centres for the management of Disused Sealed Radioactive Sources (DSRS), was launched through a Side Event at GC(61) in September 2017. Further actions to develop the concept, particularly the designation process, have been addressed in two consultancy meetings held on December 2017 and on March 2018 in Vienna.

32. Continued and extensive development of management options for DSRS include the following selected examples: (1) development of a Mobile Tool Kit Facility to support Member States in dismantling devices and in conditioning the resulting DSRS; (2) procurement and training of operators in specialized welding equipment to support borehole disposal; (3) several expert missions and national training courses, implemented in the framework of the Agency Technical Cooperation Programme, to build capacity and assist in collecting information to complete national inventories, develop national strategies for managing DSRS, including borehole disposal, search, recovery and conditioning of DSRS and orphan sources; (4) development, jointly with the South African Nuclear Energy Corporation (NECSA), of Mobile Hot Cells to interface with the borehole disposal system; and (5) support provided for the removal of several tens of disused highly radioactive sources.

33. The Fourth International Ministerial Conference on Nuclear Power in the 21st Century, organized in cooperation with OECD/NEA and hosted by the Government of the United Arab Emirates, was held in Abu Dhabi from 30 October 2017 to 1 November 2017, and attended by 686 participants from

68 Member States and 6 Organizations, including over 30 Ministers and high-level participants. The conference provided a forum for exchange of information between Member States on current and future challenges and prospects for nuclear power, and confirmed that it plays an important role in climate change mitigation.

34. A Technical Meeting on Management and Leadership of Nuclear Power Projects from New Build to Decommissioning was held on 7–10 August 2017 in Vienna with 40 participants from 26 Member States. During the meeting, participants had the opportunity to share experiences and lessons learned in areas of leadership, project management, management systems, and quality related to nuclear power projects. In 2018, five expert missions/national workshops were conducted in four Member States (Turkey, Poland, Ghana and Jordan) to improve the understanding within regulatory authorities and owner-operator organizations of the requirements for successful leadership and management for new nuclear power programmes.

35. The publication, *Energy, Electricity and Nuclear Power Estimates for the Period up to 2050* (RDS No. 1), was substantially improved by including more information, creating separate sections to address global development and region-specific trends. Starting in 2017, the publication began using regions as defined by the United Nations. In response to Member States' requests, new figures and explanatory text were added to describe additions vs. retirements of nuclear power plants. The document size was increased to improve readability. The newly formatted publication was presented during the International Nuclear Workshop organized by USDOE Energy Information Administration as well as at Atomexpo 2018. News articles covering the 2017 report appeared on multiple media sites. Among them are *Power* magazine and the NASDAQ web site.

36. An IAEA Nuclear Energy Series report, *Economic Assessment of Long-Term Operation of Nuclear Power Plants: Approaches and Experience*, has been developed and is currently in the publication process. An accompanying analytical tool called FinLTO (Analytical Tool for Financial Analysis of Long-term Operation (LTO) of Existing Nuclear Power Plants) has been further improved. Training on LTO is being provided through this tool.

37. The Technical Meeting on the Responsibilities and Capabilities of Owners and Operating Organizations in New Nuclear Power Programmes was held in July 2018, in Vienna. The revised version of *Initiating Nuclear Power Programmes: Responsibilities and Capabilities of Owners and Operators* (IAEA, Nuclear Energy Series No. NG-T-3.1 (Rev.1)), currently available on the IAEA web site as working material pending its publication, was presented during the meeting. The publication covers strategies to develop competencies for the owner/operator and elaborates on the roles of the organization during Phases 2 and 3 of nuclear power infrastructure development. Around 100 participants from embarking and operating countries and international organizations attended the annual Technical Meeting on Topical Issues in the Development of Nuclear Power Infrastructure, held from 30 January to 2 February 2018, in Vienna. The Technical Meeting on Resource Requirements for Nuclear Power Infrastructure Development was held in December 2017. The meeting helped gather, from Member States that have undertaken activities in at least one of the areas necessary to develop the infrastructure for a nuclear energy programme, data on the resources needed to carry out those activities. *Managing the Financial Risk Associated with the Financing of New Nuclear Power Plant Projects* (IAEA Nuclear Energy Series No. NG-T-4.6) was published in 2017. Further, a Technical Meeting on Nuclear Power Cost Estimation and Analysis Methodologies was held in April 2018, in Vienna. The discussions focused on estimating and managing the costs attached to new build nuclear power projects, identifying their drivers and exploring means of optimization. State of the art methodologies for cost estimation, cost analysis and cost management were shared with the participants.[8]

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[8] This relates also to operative paragraph 14 of resolution GC(61)/RES/11.B.5.

## B.2. Communication and Agency Cooperation with Other Agencies

38. The status and trends reports represent an important example of tripartite cooperation between OECD/NEA, the EC and the Agency. An OECD/NEA representative attended the Technical Meeting on Resource Requirements for Nuclear Power Infrastructure Development, held from 5-7 December 2017 in Vienna. Agency representatives participated as observers in the Sixth Joint OECD/CNRA/CSNI Ad-Hoc Group on Safety of Advanced Reactors (GSAR), 9–11 October 2017, Paris, France, and also as observers in the First Joint OECD/CNRA Working Group on Safety of Advanced Reactors (WGSAR) on 16–18 April 2018, Boulogne-Billancourt, France. The OECD/NEA is an observer in several Agency technical working groups (TWGs), and the Agency is an observer in several NEA Working Parties. Agency staff participated in the World Association of Nuclear Operators (WANO) New Build Conference in Minsk, Belarus, at the end of May 2017, as well as in the WANO Biennial General Meeting in Gyeongju, Korea, from 15-18 October 2018. Close cooperation has continued with the Generation IV International Forum (GIF). The Agency organized the Seventh Joint IAEA–GIF Workshop on Safety of Liquid Metal Cooled Fast Reactors; (27–29 March 2018, Vienna) and the 2018 IAEA–GIF Interface Meeting (25–26 March 2018, Vienna).

39. The Agency participated as an expert reviewer of the IPCC Special Report on Global Warming of 1.5ºC, and reviewed the IPCC Special Report on the Ocean and Cryosphere in a Changing Climate.

40. A representative of the Director General attended key UNFCCC meetings and moderated the Agency side event on connecting roadmaps for innovative nuclear energy to the NDC timeline. The Agency also attended the United Nations side event, Energy Policy Trade-offs within the Broader Sustainable Development Challenge, coordinated by the Agency. The Agency also attended the Paris Committee of Capacity Building (PCCB) in May 2017.

## B.3. Operation of Existing Nuclear Power Plants

41. In the interests of promoting collaboration between Member States for strengthening excellence in nuclear power plant operation and to establish effective collaboration mechanisms, the Agency has organized a variety of meetings and activities. A regional workshop on Relevant Issues with Instrumentation and Control Systems for Nuclear Power Plants was held in September 2017 in Portoroz, Slovenia, to support strengthening nuclear power plant lifetime management for long-term operation in the Eastern European countries. National workshops were held on the Application of Digital Technologies in the Modernization of Instrumentation and Control Systems at NPPs in August 2017 in Portoroz, Slovenia, and on Application of ZYNQ System-On-Chip FPGAs in the development of Nuclear Electronics in November 2017 in Ocoyoacac, Mexico, to support proactive ageing management for the long-term operation of the Laguna Verde Nuclear Power Plant. A national workshop on Verification and Validation of Software for Digital Instrumentation and Control Systems at Nuclear Power Plants was held in May 2018 in Islamabad, Pakistan, to support strengthening and enhancing capabilities of Pakistan's National Institutions to support a safe, reliable and sustainable nuclear power programme. A Technical Meeting in China was held in July 2018 on Integrated Risk Management: Risk Informed Processes and Programmes during the Lifetime of a Nuclear Power Plant. A Technical Meeting on the Agency's Power Reactor Information System (PRIS), was held in Vienna in May 2017 and was attended by 33 experts from 23 Member States and 2 international organizations. Collecting information on operating experiences and performance data from operating nuclear power plants in Member States for the Agency's PRIS database is an ongoing activity that results in annual updates of the *Nuclear Power Reactors in the World* (RDS No. 2).

42. Maintaining its support to interested Member States through strengthening their knowledge, experience and capacity in the management of ageing and plant life management, the Agency has continued to offer safety review services (the Safety Aspects of Long Term Operation (SALTO) and Pre-SALTO) and to make provisions for the sharing of experience and good practices by developing a new SALTO Mission database (SALMIR) and an International Reporting System for Operating Experience (IRS). In addition, the Agency will support Member States as they prepare for SALTO missions, with training, workshops, and fellowships where appropriate. The fourth international conference on plant life management in nuclear power plants was held in Lyon, France, in October 2017 and brought together 420 participants from 38 Member States and 4 international organizations. The conference demonstrated the value of an open exchange of information between experts from different countries and different organizations. The information collected in the various venues of the conference play a critical role in the development of new and effective approaches to plant life management for long-term operation. Long-term operation of nuclear power plants prepares for the future with an energy mix combining nuclear and renewable sources to secure a sustainable, safe, clean and competitive power output. In April 2018, a Technical Meeting on Maintenance Training — Future Challenges and Opportunities was held in Russian Federation. A *Handbook on Ageing Management for Nuclear Power Plants* (IAEA Nuclear Energy Series No. NP-T-3.24) was published in 2017 and a draft document on the *Optimization of Maintenance of NPPs* was approved for publication in May 2018.

43. A variety of activities to disseminate best practices and experience regarding the life cycle of facilities has been undertaken over the past year. In August 2017 a Technical Meeting on Human Performance Reliability and Resilience in Nuclear Power Plant Operations, hosted by Oak Ridge National Laboratory (ORNL), was held in the United States with 40 participants from 18 Member States. In September 2017, a Technical Meeting on Roles, Responsibilities and Interfaces between Design Authority, Responsible Designers and TSOs was hosted by EC-JRC/IET in Amsterdam, the Netherlands, and during the 61st regular session of the General Conference in Vienna, the Nuclear Operators' Forum was held, focusing on challenges and opportunities of human resource management for sustainable nuclear power plants. A Technical Meeting on Nuclear Training Accreditation Models and Activities in October 2017 attracted 30 participants from 19 Member States. In November 2017, a Technical Meeting on Recent Developments in International and National Management System Standards including Quality Management Aspects was held . *Leadership, Human Performance and Internal Communication in Nuclear Emergencies* (IAEA Nuclear Energy Series No. NG-T-1.5) was published in 2018.

44. The Agency continued to provide support to Member States interested in the application of advanced instrumentation and control systems. The third RCM of the CRP on the Application of Wireless Technologies in NPPs Instrumentation and Control Systems was held in Korea in October 2017. A new NES document NP-T-3.19, *Instrumentation and Control Systems for Advanced Small Modular Reactors*, was published in July 2017 and the draft document, *Dependability Assessment of Software for Safe Instrumentation and Control System at NPPs*, was approved for publication in May 2018.

45. The Technical Meeting on Operational Experiences with Implementation of Post-Fukushima Actions in Nuclear Power Plants was attended by 38 owner/operators and technical support organization experts from 19 Member States and 4 international organizations in Vienna in March 2017.

46. The Third International Conference on Human Resource Development for Nuclear Power Programmes: Meeting Challenges to Ensure Future Nuclear Workforce Capability was held in Gyeongju, Republic of Korea, on 28–31 May 2018 and attended by approximately 500 participants including representatives of 10 international organizations. The Conference confirmed the need of many countries and organizations to network to share ideas and tackle the challenge of maintaining high standards as they develop the next generation of engineers and scientists. One unique aspect of the

conference is an international student competition. Fostering the young generation's interest in nuclear science and technology, the Agency held an international competition for high school students and received 188 entries from 31 countries.

47. The Technical Meeting on Managing Obsolescence, Spare Parts and Replacement in Operating Nuclear Power Plants was held in Shanghai, China, in June 2017. The purpose of the meeting was to share experiences and lessons learned in addressing inventory control of spare parts and obsolescence management associated with the construction and operation of nuclear power plants. The Technical Meeting on Managing Obsolescence, Spare Parts and Replacement in Operating Nuclear Power Plants was held in Shanghai, China, in June 2017. The purpose of the meeting was to share experiences and lessons learned in addressing inventory control of spare parts and obsolescence management associated with the construction and operation of nuclear power plants.

# Agency Activities in the Development of Innovative Nuclear Technology

## A. Background

1. In resolution GC(61)/RES/11.B.4, adopted in September 2017, the General Conference noted the progress achieved in a number of Member States in the development of technology for evolutionary and innovative nuclear energy systems and the high technical and economic potential of international collaboration in the development of such technology. This Annex highlights the activities undertaken by the Agency as requested by the General Conference in resolution GC(60)/RES/11.B.4 on Agency activities in the development of innovative nuclear technology.

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

2. As part of efforts to promote collaboration among interested Member States in developing innovative, globally sustainable nuclear energy systems and to support the establishment of effective collaboration mechanisms to exchange information on relevant experiences and good practices, the 26th International Project on Innovative Nuclear Reactors and Fuel Cycles (INPRO) Steering Committee (15–17 November 2017) endorsed the development of a new service on the use of INPRO tools. Subsequently, the Agency initiated development of a top-level document describing the contents and purpose of the service, which includes nuclear energy system scenario modelling, multi-criteria decision analysis and road mapping.

3. As part of the INPRO collaborative project, Comparative Evaluation of Nuclear Energy System Options (CENESO), work started on case studies using the multi-criteria decision analysis (MCDA) tool developed under the Key Indicators for Innovative Nuclear Energy Systems (KIND) Collaborative Project.

4. Through the Collaborative Project, Multinational Approaches to the Back End of the Nuclear Fuel Cycle, the Agency organized a technical meeting (17–20 October 2017) on the INPRO study, Cooperative Approaches to the Back End of the Nuclear Fuel Cycle: Drivers and Institutional, Economic and Legal Impediments.

5. The 15th INPRO Dialogue Forum on Development of Sustainable Supply Chains for Advanced Nuclear Power Systems was held on 2–4 July 2018 in Vienna.

6. In 2017 the Agency published a Technical Document (TECDOC) entitled *Experience in Modelling Nuclear Energy Systems with MESSAGE: Country Case Studies*. The document summarizes six country studies on modelling and scenario analysis of nuclear energy systems for evaluation of

innovative nuclear energy technologies for enhanced sustainability using an enhanced version of Agency energy modelling tool MESSAGE. To expand the capacity building support to Member States for energy and nuclear power planning, a Cloud Service was launched that facilitates finding reliable information, receiving energy system modelling support and obtaining experts' guidance for application of energy. The Agency also provided distance learning and training on tools, including the GAINS Framework, MESSAGE-NES, KIND-MCDA, ROADMAPs Template, and NEST, covering all aspects of nuclear energy system modelling (including trade effects), multi-criteria decision analysis, and long-term road mapping, and system cost modelling for transition to innovative nuclear energy system. Over the reporting period, training on INPRO Methodology for sustainability assessments of Nuclear Energy Systems was provided through WebEx.

7. A technical meeting for the review of the drafts of the INPRO Methodology publications in the areas of proliferation resistance and methodology overview was held on 10–12 October 2017. The meeting participants confirmed that the manual on proliferation resistance should be revised. In addition, the INPRO Steering Committee confirmed this finding in its 26th meeting.

8. Work on the INPRO Case Study for the Deployment of Factory Fuelled Small Modular Reactors (SMRs) has continued. A TECDOC on Prepared Generic Deployment Case Studies is under preparation, and will include emerging industrialized economies (large and small land areas), highly developed infrastructure economies, rapid growth economies, desalination, and SMR vendor countries. The Agency also prepared a TECDOC on Deployment Indicators for Small Modular Reactors that provides a methodology for Member States to evaluate the potential for deployment of SMRs in a national energy portfolio.

9. The 12th GIF–IAEA Interface Meeting took place in March 2018. Participants (including representatives from OECD/NEA, the European Union and Generation IV International Forum) provided an update on the current status of the six generation IV systems as well as several cross-cutting activities. Information was shared on the related Agency activities on technology development, safeguards, economic modelling, and education and training, and the cooperation matrix and joint activities were reviewed. In addition, the Seventh Joint IAEA–GIF Technical Meeting on the Safety of Liquid Metal Cooled Fast Reactors was held in March 2018. The 51st meeting of the Technical Working Group on Fast Reactors (TWG-FR) was conducted in Hefei, China, in May 2018.

10. A Joint ICTP–IAEA Workshop on Physics and Technology of Innovative Nuclear Energy Systems was conducted from 20 to 24 August 2018 in Trieste, Italy. The scope of the workshop included the review of state-of-the-art design concepts as well as nuclear fuel cycle options including design and technological features of various innovative reactors.

11. The first RCM of the CRP on Methodology for Assessing Pipe Failure Rates for Advanced Water-Cooled Reactors was held in Vienna in June 2018. The CRP on HTGR Reactor Physics, Thermal-Hydraulics and Depletion Uncertainty Analysis has been extended until 2019, and methodologies and uncertainty are being quantified for steady state and transient analysis; the fifth RCM of this CRP took place in May 2018. The fourth RCM of the CRP on Modular High Temperature Gas Cooled Reactor Safety Design was held in June 2018. The second RCM of CRP on Radioactive Release from the Prototype Fast Breeder Reactor under Severe Accident Conditions was conducted in November 2017 at the Indira Gandhi Centre for Atomic Research (IGCAR), Kalpakkam, India. The CRP on Neutronics Benchmark of CEFR Start-up Tests was approved in December 2017 and the first RCM was conducted in June 2018.

12. At the third RCM of the CRP, Reliability of High Power, Extended Burnup and Advanced PHWR Fuels, held in Vienna in October–November 2017, the participants evaluated the final results of this

CRP, which seeks to resolve some challenges involved in deploying advanced pressurized heavy water reactor fuels.

13. The 16th Meeting of the Technical Working Group on Fuel Performance and Technology was held in Vienna on 23–24 April 2018 and provided advice and expertise in the area of nuclear power reactor fuel engineering and support to Agency programme implementation through a global network of excellence. The Agency organized and conducted the third RCM of the CRP on Uranium/Thorium Fuelled High Temperature Gas Cooled Reactor Applications for Energy Neutral and Sustainable Comprehensive Extraction on 2–6 July 2018. A Technical Meeting on Light Water Reactor Fuel Enrichment beyond the 5% Limit: Perspectives and Challenges took place on 27–30 August 2018.

14. During the reporting period, in the framework of the Planning and Economic Studies Section (PESS) Planning and Capacity Building project, 45 training events were organized and attended by over 695 professionals from 70 countries to enhance their expertise in conducting national energy planning studies and in assessing the potential role of nuclear power. Training courses were also held on economic competitiveness of energy technologies, including nuclear power, as Nationally Determined Contributions for greenhouse gas mitigation. Studies on the Global Review of Integration of Renewable Generation in the Electricity Markets and on Disruptive Market Prospects for Advanced Nuclear Technologies have been prepared.

15. Work continued on the implementation of the International Centre based on Research Reactors scheme as a tool to promote cooperation among world-class research reactor facilities to support research and development for Innovative Nuclear Energy Systems and information sharing through the research reactor database. The NES publication, Research Reactors for Development of Materials and Fuels for Innovative Nuclear Energy Systems, was issued in 2017.

# Approaches to Supporting Nuclear Power Infrastructure Development

## A. Background

1. In resolution GC(61)/RES/11.B.5, adopted in September 2017, the General Conference noted the efforts and initiatives undertaken in the area of nuclear power infrastructure development and encouraged the Secretariat to pursue its activities. This Annex highlights a number of activities undertaken by the Agency within the area of nuclear power infrastructure development as requested by the General Conference in resolution GC(61)/RES/11.B.5.

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

2. The Secretariat continued its efforts on integrating Agency assistance for Member States embarking on or expanding their nuclear power programmes through oversight by the Nuclear Power Support Group at the Divisional Director level, a new interdepartmental Infrastructure Coordination Group at the Section Head level established in 2017, and existing 'core teams' at the operational level, each with representatives from across the Agency. Member State-specific core teams participated in bilateral meetings with the respective Member States to develop or update their national integrated work plans (IWPs) and Country Nuclear Infrastructure Profiles in order to tailor Agency assistance to the current needs of each respective Member State and monitor the progress of national infrastructure development following an Integrated Nuclear Infrastructure Review (INIR) mission.

3. The Secretariat continued to encourage broad international participation in technical meetings, workshops and conferences on nuclear infrastructure development, and is appreciative of in-kind support provided by Member States through their cost-free participation in consultancy and technical meetings, the provision of experts for national workshops, expert and review missions and the hosting of regional and interregional workshops, as well as training courses and fellowships within the framework of technical cooperation project INT2018, 'Supporting Knowledgeable Decision-making and Building Capacities to Start and Implement Nuclear Power Programmes'.

4. The Secretariat continued to apply the 'Milestones Approach' (IAEA Nuclear Energy Series No. NG-G-3.1 (Rev.1), Vienna, 2015) to support the development of nuclear infrastructure in Member States interested in or embarking on new nuclear power programmes. Four main INIR missions and their associated pre-INIR missions were conducted at the request of the respective Member States: Niger (Phase 1), the United Arab Emirates (Phase 3), Saudi Arabia (Phase 2) and Sudan (Phase 1). Two missions to support Member States in the development of their self-evaluation reports were also conducted, while IWPs were established or updated in conjunction with seven Member States.

5. In September 2017, the revised INIR guidelines were published as *Guidelines for Preparing and Conducting an Integrated Nuclear Infrastructure Review (INIR)* (IAEA Services Series No. 34), which incorporated modifications to the process taking into account experiences and lessons learned during the 22 main and four follow-up missions conducted since launching INIR in 2009. The publication provides guidance on the steps, structure and process of the INIR service.

6. The evaluation methodology for INIR Phase 3 missions was applied in a pilot mission hosted by the United Arab Emirates from 24 June to 1 July 2018. Upon completion of the second pilot mission, planned to be hosted by Belarus in 2019, the methodology will be refined and published, incorporating the practical lessons learned.

7. The Secretariat continued to conduct INIR missions, in English and other official language of the United Nations, where appropriate. For example, the INIR Mission to Niger was conducted in English and French, with translation where needed. The training of 11 external experts from nine Member States and six staff members from the Departments of Nuclear Energy and Nuclear Safety ensures the continued sustainability of the INIR service and the availability of a broad pool of experts. The Secretariat continued to ensure that the use of external experts for INIR missions did not constitute a conflict of interest or provide commercial advantage.

8. The participation in Agency activities of representatives from newcomer countries and Member States with established nuclear power programmes is continuously encouraged to facilitate the sharing of information on experiences, lessons learned and challenges among Member States with different levels of experience. Inter alia, six technical meetings, the annual Technical Working Group on Nuclear Power Infrastructure as well as the fourth International Ministerial Conference on Nuclear Power in the 21st Century, held from 30 October to 1 November 2017 in Abu Dhabi, the United Arab Emirates, provided valuable opportunities for exchanges between newcomer and experienced Member States.

9. The Secretariat undertook a review of the Nuclear Infrastructure Bibliography, identified areas not covered by existing IAEA publications and identified existing publications in need of revision. An implementation timeline, including priority activities and publications that will further enhance IAEA guidance for Member States embarking on a nuclear power programme, was developed and is being implemented.

# Nuclear Knowledge Management

## A. Background

1. In resolution GC(60)/RES/12.C, the General Conference commended the Director General and the Secretariat for their significant, interdepartmental efforts in addressing issues of preservation and enhancement of nuclear knowledge, and encouraged the Director General and the Secretariat to continue to strengthen their current and planned efforts in this area, in a holistic, interdepartmental manner, while consulting and engaging Member States and other relevant international organizations, and to further increase the level of awareness of efforts in managing nuclear knowledge.

2. The General Conference requested the Secretariat to continue to gather, and make available to Member States, nuclear data, information and knowledge resources on the peaceful use of nuclear energy, including the International Nuclear Information System (INIS) and other valuable databases as well as the IAEA Library and the International Nuclear Library Network. The General Conference also called on the Secretariat to continue to focus, in particular, on activities aimed at helping interested Member States assess their human resource needs and to identify ways to address those needs, inter alia by encouraging the development of new tools and opportunities to gain practical experience through fellowships.

3. The General Conference also invited the Secretariat, in consultation with Member States, to further develop and disseminate guidance and methodologies for planning, designing, implementing, and evaluating nuclear knowledge management programmes and practices, and encouraged the Secretariat to facilitate the establishment of effective human resource and knowledge management (HRKM) networks in developing countries, and where appropriate in collaboration with other United Nations organizations and with the support of existing such networks in developed countries.

4. The General Conference requested the Director General to take into account the continuing high level of interest of Member States in the range of issues associated with nuclear knowledge management when preparing and carrying out the Agency's programme, and to report on progress made to the Board of Governors and to the General Conference at its sixty-second session. This report has been prepared in response to that request.

## B. Strengthening Nuclear Knowledge Management

5. During the reporting period, the second and third meetings of the Technical Working Group on Nuclear Knowledge Management took place in June 2016 and June 2017, respectively. Technical Working Group members discussed the main activities and existing initiatives of the Nuclear Knowledge Management Section (NKMS) and provided valuable inputs to move forward. Participating Member States reiterated that nuclear knowledge management (NKM) is an increasing priority; therefore, demands on national NKM programmes are expected to continue to grow. Consequently, demand for the Agency's NKM support for Member States is also expected to increase steadily. Technical Working Group members welcomed the cross-cutting, interdepartmental contribution to the implementation of the Agency's activities on NKM. NKMS will also support regular Safety Aspects of

Long Term Operation (SALTO) missions in the future by covering SALTO area F (Human Resources, Competence and Knowledge Management for Long Term Operation) and cooperate on the training of new reviewers and further develop the methodology for SALTO area F.

6. The proceedings of the Third International Conference on Nuclear Knowledge Management: Challenges and Approaches (November 2016) are in the process of being finalized.

# C. Building Capacity and Implementing Nuclear Knowledge Management

7. During the reporting period, the following Knowledge Management Assist Visits (KMAV) were conducted: Shanghai Nuclear Engineering Research and Design Institute, China, on design knowledge management and plant information model; Atomstroyexport, Russian Federation, on design knowledge management; Ignalina NPP, Lithuania, on decommissioning; Daya Bay NPP, China, Temelin NPP, Czech Republic, and Mochovce NPP, Slovakia, on knowledge management programme maturity assessment; and Emirates Nuclear Energy Corporation, Abu Dhabi, United Arab Emirates, for a knowledge management expert mission. Additional KMAVs are scheduled: the National Nuclear Energy Agency, Indonesia, review of its knowledge management programme;and Kozloduy NPP, Bulgaria, in preparation for the review of SALTO area F. The guidance document for developing and implementing KMAVs for university missions has been developed as part of KMAV support/review missions. Pilot applications of the University Assist Visits and Peer Review Assessments are being organized with potential hosts in Bulgaria and Belarus.

8. Agency efforts are ongoing to include knowledge management areas for review in SALTO/Operational Safety Review Team missions as well as to support the long term operation of NPPs.

9. Over the reporting period, activities included training and education workshops and courses on the physics and technology of advanced water-cooled reactors and severe accidents with practical learning using the Agency's computer-based basic principle NPP simulators and the Advanced Reactors Information System (ARIS) database. These courses focused on providing support to help Member States adopt the teaching concept of 'train the trainer' using the computer-based simulators. The course content provides not only theoretical teaching about various advanced water-cooled reactor technologies and design concepts, but also practical demonstrations of various operation conditions during normal and transient/accident states, group exercises and projects to ensure understanding of the concepts presented. In addition, these courses establish contextual ideas and support knowledge management for national sustainable education and training. The support provided by the Agency through these courses has contributed to improved knowledge about nuclear technology, specifically water-cooled reactors, the use of the Agency's computer-based basic principle simulators, and enhanced networking among the participants in the region.

# D. Applying Nuclear Knowledge Management to Development

10. Nuclear technology requires a high level of technical expertise and experience that must be developed and kept accessible to current and future generations. Assistance provided to African Member States in NKM aims to improve knowledge sharing in order to successfully leverage technical

knowledge and capacities within Member States. This is achieved through targeted interventions in higher education, training and related research in nuclear science and technology. The Agency's activities under the technical cooperation programme also focus on the creation of successful networks that serve as platforms for such knowledge management. Capacity building, human resource development and knowledge management are key to sustainability and a successful programme. The Agency assists with the development and management of nuclear knowledge in various fora, from promoting nuclear science and building interest in science, technology, engineering and mathematics among students, to establishing innovative platforms for Member States to exchange knowledge. In Europe, the Agency continues to provide assistance to improve the functioning of national nuclear institutions and other users of nuclear technology. Young professionals from the nuclear industry have been able to strengthen their skills and knowledge in the field of nuclear science and technology and nuclear power technology by participating in the Intercontinental Nuclear Institute. For many Member States, a lack of qualified personnel and an ageing workforce pose very concrete limitations, exacerbated by the long lead times required to develop qualified nuclear science and engineering professionals.

11. Capacity building activities conducted under project RAF0041, 'Sharing Best Practices in Preventive Maintenance of Nuclear Equipment', have resulted in a notable impact in terms of reduced equipment downtime due to improved maintenance skills and expertise, and the introduction of postgraduate programmes in nuclear instrumentation and engineering. Some countries also reported increased income generation from equipment maintenance activities in their centres. The programme focused on supporting Member States' efforts to improve the maintenance of medical and scientific instrumentation. This has taken the form of capacity development for repair services, preventive maintenance, provision of instrumentation infrastructure, and cost recovery through incomes generated from the provision of services. Group fellowship training was provided at Seibersdorf and several regional training courses were also held. The support provided by the Agency has contributed to the improvement of quality management practices, and thus to the sustainability of maintenance and repair activities. Support provided through the Agency's Seibersdorf laboratories' calibration services has enabled the establishment of measurement traceability.

12. The Agency has supported the technological refurbishment of national nuclear institutions in the Asia and the Pacific region under regional project RAS0065, 'Supporting Sustainability and Networking of National Nuclear Institutions in Asia and the Pacific Region,' by promoting regional networking to exchange expertise in areas of relative excellence and comparative technological advantage. The Agency actively seeks to promote the study of nuclear science and technology in secondary schools, and to encourage the interest of high school students in this area. As part of activities in this area, the Agency piloted A Compendium of Resources and Activities on Nuclear Science and Technology for Secondary School Teachers and Students in Indonesia, Malaysia, the Philippines and the United Arab Emirates. A training course to help teachers introduce nuclear science in secondary schools using innovative approaches was held in Quezon City, the Philippines, in August. Senior advisors, policy makers and stakeholders associated with school education in Member States also attended the course.

13. A regional training course on the development of e-learning courses for teachers was held in June 2016, in Lima, Peru, under technical cooperation project RLA0057, 'Enhancing Nuclear Education, Training, Outreach and Knowledge Management'. The course was developed using the 'blended learning' method, beginning with pretraining conducted through the educational portal of the Latin American Network for Education in Nuclear Technology (LANENT) and followed by an in-person training stage. The project also supported the participation of five professionals from Argentina, the Plurinational State of Bolivia, Brazil, Cuba and Mexico in the Joint ICTP-IAEA School on NKM held in Trieste, Italy, in September 2016.

14. In December 2016, the Agency organized the First National NKM School in Brazil. The curriculum and content of the Trieste School was adapted to the needs of the participating countries and organizations. The school itself took place in Rio de Janeiro, Brazil, in cooperation with Brazil's Institute of Radiation Protection and Dosimetry and LANENT. The event was intended to offer specialized training to professionals who have a role, or may have a role in the near future, in the development or implementation of NKM projects in their organizations. General information on knowledge management tools and methodologies was provided, as well as case studies based on examples from organizations in the region. The School brought together 48 professionals, almost half of them women, selected from 150 applicants from various institutions in the Brazilian nuclear sector, including universities, the National Nuclear Energy Commission, the Brazilian navy and the electronuclear industry.

15. Under technical cooperation regional project RAF0047, 'Promoting the Sustainability and Networking of National Nuclear Institutions for Development, Phase II', in 2017, 12 participants from Member States were trained in the development and implementation of strategic action plans to enhance the sustainability of national nuclear institutions. The participants included managers, high ranking decision-makers and strategic planners from participating Member States with responsibility for developing and managing the strategic action plans of their national nuclear institutions. Strategic action plan development and implementation is part of renewed efforts under the African Regional Co-operative Agreement for Research, Development and Training Related to Nuclear Science and Technology to help Member States sustain their national nuclear infrastructure.

16. In July 2017, a regional training course on the development of e-learning materials for teachers was organized by the LANENT under technical cooperation regional project RLA0057, 'Enhancing Nuclear Education, Training, Outreach and Knowledge Management'. The training, held in Costa Rica, was delivered using the blended-learning method. This included pretraining completed through the LANENT educational portal, followed by in-person training. The course was attended by 24 participants from nine Member States. In September 2017, the project supported seven professionals from Argentina, Brazil, Cuba, Costa Rica and Nicaragua to attend the Joint ICTP-IAEA School on NKM. The project also supported participation in the Second International Symposium on Education, Training and Knowledge Management in Nuclear Energy and its Applications in November 2017, in Buenos Aires, Argentina. In December 2017, the Agency supported the Second National Nuclear Knowledge Management School in Argentina, organized by LANENT and the National Atomic Energy Commission of Argentina. Forty-three professionals from the Argentinian nuclear sector attended the school.

17. The third General Assembly of the AFRA Network for Education in Science and Technology (AFRA-NEST) was held in Egypt, in May 2018. During the Assembly an action plan for the period 2018–2020 was established that includes the implementation of various NKM services. An AFRA-NEST workshop on establishing national networks for nuclear education, science and technology was held in Tanzania, in September 2016, during which participants (from Egypt, Ghana, Morocco, Nigeria, South Africa and Tunisia) were trained on the ECAP process.

# E. Applying Nuclear Knowledge Management to Nuclear Safety, Security and Safeguards

18. In order to capture good practices in managing nuclear safety knowledge, in 2017, the Secretariat organized a Technical Meeting on Nuclear Safety Knowledge Management, where participating

countries reviewed and finalized the draft Safety Report on *Managing Nuclear Safety Knowledge: National Experiences and Approaches*.

19. The Secretariat developed the Global Education and Training Resource (GETR) with the objective of establishing an easy-to-access knowledge base that displays information about nuclear safety training and educational resources from regulatory authorities, technical organizations, research institutions and universities around the world. So far, over 400 training packages have been shared through the platform. Moreover, a curriculum for a master's degree on nuclear safety and security is being finalized and is expected to be shared with Member States by the end of 2018.

20. In order to enhance Secretariat outreach and promotion of the Agency's Safety Standards, over 20 e-learning modules are accessible through the Global Nuclear Safety and Security Network. The e-learning modules cover topics such as: research reactors safety, safety assessment, licensing and safety of small modular reactors, and nuclear safety knowledge management.

21. In order to ensure wide dissemination of nuclear safety knowledge, the Secretariat developed a nuclear safety knowledge base under the Global Nuclear Safety and Security Network. It provides Member States with access to good practices, presentations and reports.

22. The Nuclear Safety and Security Online User Interface was published to provide users with easy access to the content of the Series established by the Agency's Nuclear Safety and Security Department. It facilitates direct access to the content of the Series and navigation within the Series. A user interface has also been introduced in addition to official communication channels, so that authorized users can provide feedback on the current set of publications in the Safety and Security Series.

23. The Knowledge Management Portal on the Observations and Lessons from the Fukushima Daiichi Accident was launched on the Global Nuclear Safety and Security Network (GNNSN) website during the General Conference in 2017. The objective of the portal is to build a strong knowledge base for listing and sharing the observations and lessons learned in a structured and consistent manner, to enable their use by all participating Member States and international organizations.

24. The Agency continued to assist Member States to build capacity in nuclear security, including by developing educational and training programmes. The International Nuclear Security Education Network, now comprising 170 institutions from 62 Member States, assists its member institutions and States in establishing and enhancing educational programmes on nuclear security based on international guidance and recommendations. During the period, the Agency convened the seventh and eighth International Schools on Nuclear Security in Trieste, Italy, in April 2017 and April 2018, and held four Regional Schools on Nuclear Security. The Agency also continued to respond to State requests for assistance with the development of national Nuclear Security Training and Support Centres (NSSCs), and to support the International Network for NSSCs, which facilitates sharing of information and resources to promote coordination and collaboration among States with an NSSC or interested in developing one. In addition, the Agency issued six Nuclear Security Series publications during the period, including *Sustaining a Nuclear Security Regime* (IAEA Nuclear Security Series No. 30-G) and *Building Capacity for Nuclear Security* (IAEA Nuclear Security Series No. 31-G), which includes specific guidance on knowledge management. In order to make training more readily available, 11 new e-learning courses were also deployed.

25. For the nearly 100 States with minimal or no nuclear activities or material, the *Safeguards Implementation Guide for States with Small Quantities Protocols* (IAEA Services Series No. 22) was published in April 2013 to enhance their understanding of relevant safeguards obligations. It was subsequently translated into French, Spanish, Russian and Arabic between 2015 and 2017. To provide States with a mechanism for sharing experience with, and good practices for, fulfilling various aspects of their obligations under their respective safeguards agreements, three Safeguards Implementation

Practices Guides were published between 2014 and 2016 in English, and two workshops based on these Guides were held in Vienna, in February and April 2016, to encourage information exchange among peers.

# F. Strengthening Networks related to Nuclear Education and Training and Nuclear Information

26. Support for and cooperation with educational networks continues across regions, with an increase in the number of Member States and institutions adhering to the networks and initiatives conducted. Initiatives developed by individual networks include, among others: the establishment and use of local instances of the CLP4NET platform, 'train the trainer' activities, e-learning courses, and national NKM Schools. An IAEA expert mission was conducted in September 2016 in South Africa to support national coordination and planning for the activities of a South African network for education in science and technology (SAN-NEST) and the implementation plan for a national technical cooperation project on the establishment of that network.

27. Expert missions on strengthening stakeholder networking for Human Resource and Knowledge Development (HRKD) took place in Japan, , Malaysia, South Africa and Turkey to share experiences, applied methodologies and challenges, as well as benefits from countries that are currently establishing or have established such networks; to assess the background, past and present status of key HRKD activities in the country related to nuclear power and/or nuclear technology; to assess the needs and opportunities for each HRKD network based on their current situation, activities and background; to identify and share ideas with members, along with possible framework/structure and activities, to strengthen HRKD networking; to progress further with the development of the case studies document that will capture detailed information about the interest in such networks and work done so far.

28. The CLP4NET platform achieved significant growth during this period as an Agency-wide service to promote in-house e-learning materials. The number of users increased to around 22 000 at the end of April 2018, and the number of courses hosted also achieved significant growth to around 540. The CLP4NET platform is effectively used to train participants of NEM and NKM Schools and it helps to deliver cost-effective training to large groups of applicants from several Member States. More IAEA sections/departments showed interest in hosting courses and using the platform to leverage the advantage of the e-learning platform. The platform has reached 142 Member States via the professional networks' sites it hosts.

29. The International Nuclear Information System (INIS) continues to be maintained and expanded as a repository of information on the peaceful uses of nuclear energy. Over 100 000 high-quality metadata records per year have been acquired — reaching a total number of over 4 million in 2017. The information was indexed and made freely available to Member States through the INIS Repository, which registers over 2.5 million online sessions every year. Cooperation with an open access publisher has been established, in support of open access to scientific research output. Major improvements in technical capacity included migration to a new open source search engine, Elasticsearch, and substantial improvement to the front end of the INIS Repository search, such as responsive design to enhance support for mobile devices. The INIS Thesaurus, a 'knowledge organization system' containing over 31 000 descriptors, has been further enriched with new relevant terms, taking into account input from Member States and the INIS Thesaurus Advisory Group. Thesaurus management software is currently being implemented to provide for semantic search using synonyms, relations, facets, and the enhancement of taxonomies and thesauri with ontology features.

30. The Agency's knowledge portals, catalogues and databases are applying the new opportunities for semantic search presented by knowledge organization systems. Fast Reactor Knowledge Organisation System (FR-KOS), i.e. fast reactor taxonomy, was implemented in the Fast Reactor Knowledge Portal (FRKP). The Agency is also developing the nuclear graphite taxonomy that will be used in the Nuclear Graphite Knowledge Database. The taxonomies represent tangible results beneficial to all Member States, in particular for those who agreed to manage collections of documents and other information that is considered at risk of being lost or destroyed. This documentation is typically in countries and locations that do not currently run active reactor development projects.[9]

31. The IAEA Library improved access to nuclear information by fully implementing a new Integrated Library System that includes a discovery layer connecting users to all information resources, including print (90 000+ items) and electronic formats (53 000+ electronic journal titles and 64 databases). The IAEA Library selected over 10 000 new and relevant items to add to the collection. The IAEA Library updated all International Nuclear Library Network information on the external website to include current member organizations' contact information and library catalogues, thereby optimizing information sharing.

32. The NKM wiki structure was developed and made publicly accessible. It currently has limited content based on information from NKM documents and requires the active engagement of knowledge management practitioners to add new content.

[9] This relates also to operative paragraph 20 of resolution GC(61)/RES/11.B.4.