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

Report by the Director General

Summary

In response to General Conference resolutions GC(56)/RES/12 and GC(57)/RES/12, this document contains progress reports on the development of the sterile insect technique for the control or eradication of malaria-transmitting mosquitoes (Annex 1); support to the African Union's Pan African Tsetse and Trypanosomosis Eradication Campaign (AU-PATTEC) (Annex 2); strengthening the support to Member States in food and agriculture (Annex 3); the Renovation of the Nuclear Applications Laboratories (ReNuAL) project (Annex 4); nuclear energy activities (Annex 5); Agency activities in the development of innovative nuclear technology (Annex 6); producing potable water economically using small and medium sized nuclear reactors (Annex 7); and nuclear knowledge management(Annex 8).

Further information on the Agency's activities related to nuclear science, technology and applications can be found in the *Nuclear Technology Review 2014* (document GC(58)/INF/4), the *IAEA Annual Report 2013* (GC(58)/3), in particular the section on nuclear technology, and the *Technical Cooperation Report for 2013* (GC(58)/INF/5).

Recommended Action

It is recommended that the Board take note of Annexes 1-8 of this report and authorize the Director General to submit the report to the General Conference at its 58th session.

Development of the Sterile Insect Technique for the Control or Eradication of Malaria-Transmitting Mosquitoes

A. Background

1. In resolution GC(56)/RES/12.A.2, the General Conference noted with concern that malaria, transmitted by mosquitoes, causes about two million deaths a year and about 300–500 million cases of clinical malaria annually; that over 90% of the world's malaria cases occur in Africa, slowing down annual economic growth by 1.3%; and that malaria therefore constitutes a major obstacle to poverty reduction in Africa.

2. The General Conference also noted that the malaria parasite has continued to develop resistance to drugs and that mosquitoes 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, in line with the World Health Organization's Roll Back Malaria strategy, including integrated vector management, of not relying on any single approach to control malaria. 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, with 2.5 billion people living in areas where dengue viruses can be transmitted, and that insecticide-treated bed nets are not effective in combating dengue as the mosquito vectors are active during the day and other control tactics are urgently required.

3. The General Conference further noted that the suppression of disease-transmitting mosquitoes using the SIT will be suitable mostly in urban areas, where aerial spraying with insecticides is prohibited or not indicated, and that an area-wide approach over urban areas is required, which represents a novel and potentially powerful supplement to existing community-based programmes.

4. The General Conference noted with appreciation the interest shown by some donors and their support for research and development (R&D) on the SIT for combating malaria- and other disease-transmitting mosquitoes, and acknowledged the support given by the Agency to the development of the SIT for the control of malaria- and other disease-transmitting mosquitoes as outlined in the report by the Director General in document GC(56)/7, Annex 1.

5. The General Conference requested the Agency to continue and strengthen the research, both in the laboratory and in the field, required to use the SIT for the control of malaria- and other disease transmitting mosquitoes. It requested the Agency to increasingly involve scientific and research institutes in Africa and other affected developing Member States in the research programme, so as to lead to ownership by the affected countries. 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.

6. The General Conference requested the Agency to develop a thematic plan for the SIT and related genetic and biological control methods for disease-transmitting mosquitoes, and to increase its efforts to attract extrabudgetary funds to enable expansion of the mosquito research programme and field validation. Further, it invited donors to continue with their financial support and other Member States to make financial contributions to the research programme, and requested the Director General to

report on the progress made in the implementation of this resolution to the General Conference at its fifty-eighth session.

B. Progress since the 56th Session of the General Conference

7. In response to resolution GC(56)/RES/12, the Insect Pest Control Laboratory (IPCL) of the Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture in Seibersdorf continued to work on the development of the SIT package for disease-transmitting mosquitoes, i.e. the malaria vector *Anopheles arabiensis* and the vectors for dengue and chikungunya, *Aedes aegypti* and *Aedes albopictus*. The IPCL is currently maintaining cultures of *An. arabiensis* originating from Sudan and South Africa, *Ae. aegypt*i from Brazil and *Ae. albopictus* from China, France (La Réunion) and Italy.

8. A universal larval diet suitable for *Anopheles* and *Aedes* mosquitoes composed of ingredients that are widely and readily available was developed and further refined at the IPCL. The diet and standard operating procedure (SOP) for its proper use were transferred to China, Indonesia, Malaysia, Pakistan, the Philippines, South Africa, Sri Lanka and Thailand.

9. Adult mass-rearing cages that allow optimal production and collection of eggs, cage cleaning, blood feeding and sugar delivery were developed, validated and improved at the IPCL. The cage technology was transferred to Brazil, China, Mauritius and Sudan for testing under local conditions. Additional efforts are being made to make the manufacturing and operation of the equipment more cost effective.

10. Studies were pursued to standardize all steps of the mosquito production process. The aim is to provide SOPs to Member States that will optimize the rearing methods, whilst minimizing the factors that could negatively affect the quality and quantity of sterile males produced and therefore the efficacy of a mosquito control programme with an SIT component.

11. The insect greenhouse at the IPCL in Seibersdorf that simulates semi-field conditions has been used at full capacity for behavioural studies. This important tool offers a good surrogate for the natural environment and makes it possible to assess sterile male competitiveness, swarming, mating compatibility and dispersal. The insect greenhouse has been used for testing the effect of various sterile to wild male ratios and the age of the sterile males on their mating competitiveness. The preliminary data obtained provided information which may lead to improvements in the production processes and thereby the competitiveness of the sterile males, which is a crucial factor for the success of an SIT programme.

12. The Agency continued to manage the coordinated research project (CRP) entitled ‘Biology of Male Mosquitoes in Relation to Genetic Control Programmes’ involving 20 Member States. The final Research Coordination Meeting (RCM) took place from 4 to 8 March 2013 in Juazeiro, Brazil. The final CRP report describes the excellent progress made in advancing the understanding of male swarming and mating behaviour. The results of the research were published in 2014 as a special issue of the peer-reviewed journal *Acta Tropica*.

13. The Agency continues to address the challenge of developing effective and productive genetic sexing strains (GSSs) that allow easy and safe elimination of females on a mass-rearing scale (so that only male mosquitoes are released, since it is the female mosquitoes that can be vectors of the disease). A GSS of *An. arabiensis* that requires the use of the insecticide dieldrin to kill all the female mosquitoes has been available for several years and its potential use for field releases was assessed. The strain showed several limitations such as low natural productivity and the produced males, after

being treated with dieldrin, were found to contain insecticide residues, which is not acceptable for an environmentally friendly approach like the SIT. New efforts are now being made to identify markers for *An. arabiensis* in order to develop an adequate GSS at the IPCL. Funding limitations have so far not made it possible to embark on similar efforts to develop a GSS for *Ae. aegypti* and *Ae. albopictus*.

14. In view of the urgency to develop GSSs as prerequisites for the application of the SIT against mosquitoes, a new CRP has been initiated entitled "Exploring Genetic, Molecular, Mechanical, and Behavioural Methods of Sex Separation in Mosquitoes". The first RCM was held in Vienna, Austria, in October 2013. Twenty-three participants from Africa, Asia, South/Central America, Europe and the USA attended the first RCM and future work plans were discussed and developed.

15. Also, a chemical method of separating the sexes for *An. arabiensis* was tested at the IPCL. Adding the chemical ivermectin to the blood meal offered to the female mosquitoes for feeding allowed complete elimination of the females from a laboratory population. This method will provide a temporary solution for eliminating female *An. arabiensis* until a new GSS has been developed.

16. A Thematic Plan for the Development and Application of the Sterile Insect Technique (SIT) and Related Genetic and Biological Control Methods for Disease Transmitting Mosquitoes was developed by the Agency. Experts from Brazil, Burkina Faso, China, Germany, Italy, Mexico, Paraguay, Sweden, Switzerland, Thailand, Trinidad and Tobago and the USA convened in Vienna, Austria, in June 2014. The experts reviewed in detail the control tactics that are currently available, advised on knowledge gaps and the potential for other innovative control approaches, advised on priorities in terms of R&D, and addressed the potential future role of the Agency in the development and application of the SIT as part of area-wide integrated pest management approaches to mosquito vectors of major diseases. The experts recommended continuing the activities for the control of mosquito species which transmit malaria, dengue, chikungunya and yellow fever through the support and funding of initiatives towards the development of the SIT and other related genetic and environmentally friendly methods. The experts also recommended the formulation of interregional and regional technical cooperation projects for the 2016–2017 technical cooperation cycle to enhance the capacities of Member States of Africa, Asia and the Pacific and Latin America regions, and to share experiences and knowledge in coping with the challenges of mosquito-borne diseases.

17. The Agency has been providing support to Member States through five national technical cooperation projects launched in 2012 for Mauritius, Pakistan, South Africa, Sri Lanka and Sudan (MAR/5/019, PAK/5/049, SAF/5/013, SRL/5/044, and SUD/5/034) and one regional technical cooperation project in the Indian Ocean region (RAF/5/065), including Madagascar, Mauritius and Seychelles, as well as La Réunion, France. All six technical cooperation projects focus mainly on capacity building. In addition, studies to determine the feasibility of applying the SIT were undertaken in South Africa and Sudan. Furthermore, since the 56th session of the General Conference, fellows from China, Madagascar, Seychelles, South Africa, Sri Lanka, and Sudan have received training at the IPCL on mosquito rearing and related activities under the Agency's technical cooperation programme. Topics included mass-rearing of mosquitoes, the use of GSSs, the use of the new larval diet, mating studies, radiation biology and quality control procedures. For the biennium 2016–2017, six concepts for national and regional technical cooperation projects have been received from Member States.

18. In response to Member States' requests related to the recent spreading of dengue/chikungunya, two new regional technical cooperation projects were launched in 2014: one in the Asia and the Pacific region (RAS/5/066), including China, Indonesia, Malaysia, Pakistan, the Philippines, Sri Lanka and Thailand, and another one in the Indian Ocean region (RAF5072), including Madagascar, Mauritius, Seychelles and La Réunion (France), in line with sustainable development of the Indian Ocean islands. The objective of these projects is to integrate environmentally friendly mosquito control methods within the existing control strategy adopted. The projects focus on networking,

sharing of expertise and capacity building to establish standard operating procedures for mosquito surveillance, mass rearing and overall control of vector population by incorporating SIT in an integrated vector management strategy. Staff of countries participating in these new projects will be trained at the IPCL on mosquito rearing and related activities under the Agency's technical cooperation programme. Mosquito surveillance in pilot sites has already been initiated in most of these countries. A financial contribution of €55 000 has been provided by the French Government to this phase of the project to control dengue and chikungunya epidemics in the Indian Ocean region.

19. The Agency continued its support to a project in Sudan through technical cooperation project SUD/5/034 that aims to assess the feasibility of integrating the SIT against *An. arabiensis*. The project is also supported by the Islamic Development Bank (IDB) through a $4.8 million loan to the Government of Sudan. Sudanese representatives visited the Agency on several occasions and Agency staff continued to provide technical support on-site. During various meetings, Agency staff recommended that the project should adhere to a "phased conditional approach" and initially focus on conducting a pilot trial (3–4 years) in a small representative area along the Nile to assess the feasibility of the integrated use of the SIT on mosquitoes in Sudan. The main activities focused on testing of the diet, the collection of baseline data on larval breeding sites, and the development of a model that aims to predict temporal and spatial fluctuations of adult populations in the target area (work done in collaboration with the French National Institute for Research in Computer Science and Control (INRIA)). In 2013–2014, field studies carried out in a 20 km^2 pilot site aimed at improving male trapping systems so that the efficacy of future releases can be measured. Following the purchase of three vehicles by the IDB, mosquito surveillance has started in the 20 km^2 pilot site and releases of sterile males began in an initial area of 100 hectares. In addition, a group of four experts helped the staff of the Tropical Medicine Research Institute and a Sudanese engineering company to design a plan for an IDB-funded mosquito mass-rearing facility that will be constructed in Khartoum.

20. The Agency has continued providing technical support to a four-year project in La Réunion, France, under which a feasibility study on the use of the SIT to control the malaria vector *An. arabiensis*, and the chikungunya/dengue vector *Ae. Albopictus* is being carried out. This project is a collaborative effort between the Centre for Research and Intelligence on Emerging Diseases in the Indian Ocean, the French Institute of Research for Development (IRD) and the Agency. The project is funded by the French Ministry of Health, the Regional Council of La Réunion and the IRD, with scientific support provided by the International Cooperation Centre of Agricultural Research for Development and the University of La Réunion. The Agency has supported the project with the development of mass-rearing technologies, sex separation methods, sterilization and release procedures for *An. arabiensis* and *Ae. albopictus*. The project has been extended until the end of 2014 with a focus on *Aedes* mosquitoes, which represent the main health threat (chikungunya) in La Réunion. Ministry of Health officials requested that studies be carried out to assess the acceptance of the SIT by the human population in order to develop a public relations campaign. Surveillance of *Ae. albopictus* and *Ae. aegypti* has started in three different pilot sites in semi-urban and uninhabited areas in order to collect sufficient data on their abundance and seasonal fluctuations. A proposal for a second phase (2015–2018) consisting of sterile male releases in the three pilot sites for proof of concept has been submitted to the Ministry of Health, the Regional Council and the European Union (EU).

21. Financial support for the mosquito related activities of the IPCL has been provided by France; and China and the USA have provided cost-free experts who have made important contributions in the areas of sex separation, radiation biology, and development of GSS and field cage studies.

C. Conclusion

22. Mosquito-borne diseases such as malaria, dengue, yellow fever and chikungunya remain among the most severe threats to the health of millions of people worldwide. Due to globalization and climate change, many species of mosquitoes are expanding their distribution and have been spreading to previously mosquito-free areas. 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 resistance in the mosquitoes.

23. The SIT is part of an area-wide integrated pest management approach. Despite the good progress that has been made in developing this environmentally friendly control method, there are still some significant bottlenecks in the development of the SIT package for mosquitoes, requiring a long term strategy with adequate human and financial resources to develop the tools required for the implementation of a fully operational programme in Member States. The main challenge that needs to be addressed in the coming years is the development of good, productive genetic sexing strains that allow easy and safe elimination of the female segment of the production line, as well as better field surveillance tools to be able to monitor the presence and distribution of wild and sterile mosquitoes.

24. While the Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture 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 or dengue. The development of the SIT package for mosquitoes is a long term initiative and its final successful implementation will also largely depend on the technical and managerial efforts of the affected Member States.

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

A. Background

1. In resolution GC(57)/RES/12/A.3, the General Conference recognized that the tsetse and trypanosomosis (T&T) problem constitutes one of the greatest constraints on the African continent's socio-economic development. It recognized the importance of livestock development in rural communities affected by T&T, in which the disease has a direct impact on food security and thereby increases poverty levels. It further recognized that trypanosomosis continues to claim tens of thousands of human lives and millions of livestock every year, while threatening over 60 million people in 37 African countries, the majority of which are Agency Member States.

2. The General Conference welcomed the continuing close collaboration of the Secretariat with AU-PATTEC, whose main objective is to eradicate tsetse flies and trypanosomosis by creating sustainable tsetse and trypanosomosis free areas by suppression and various eradication techniques, while ensuring that the reclaimed land areas are sustainably and economically exploited. The General Conference welcomed the adoption of the AU-PATTEC Strategic Plan for the period 2012–2018 on 12 December 2012 and looked forward to its effective implementation.

3. The General Conference also recognized that that tsetse fly and trypanosomosis suppression and eradication are unique, complex and logistically demanding exercises that require flexible, innovative and adaptable approaches in the provision of technical support. The General Conference also welcomed the Agency's work under the Joint FAO/IAEA Programme of Nuclear Techniques in Food and Agriculture, and with the support of the Agency's Technical Cooperation Fund, in developing the SIT for use against tsetse flies and providing assistance to Member States in applying the SIT as part of area-wide integrated pest management (AW-IPM) approaches. The General Conference appreciated the contributions made by various Member States and United Nations specialized agencies toward T&T control efforts in West Africa, especially those made by the United States of America through the Peaceful Uses Initiative (PUI) for the control of T&T in Burkina Faso and Senegal.

4. The General Conference urged the Secretariat to continue to assign high priority to agricultural development in Member States, including efforts to build capacity and further develop techniques for integrating the SIT with other techniques in creating tsetse-free zones in Africa. It called upon Member States to strengthen the provision of technical, financial and material support to African Member States in their efforts to create tsetse-free zones, while stressing the importance of a needs-driven approach to applied research and methods development and validation for serving field projects.

5. The General Conference requested the Agency and other partners to strengthen capacity building in Member States for informed decision-making regarding the choice of T&T strategies and the cost-effective integration of SIT operations in AW-IPM campaigns. It requested the Secretariat, through harmonized, synergistic cooperation with Member States and other partners, to maintain funding through the Regular Budget and the Technical Cooperation Fund for operational SIT field projects, stressing the importance of baseline data collection and data management, and to strengthen support for technology transfer and demand-driven applied research and development in African Member

States to complement their efforts in creating and expanding the tsetse-free zones. The General Conference urged the Secretariat and other partners to support the establishment and operation of regional centres for providing large numbers of sterile male tsetse flies and for coordinating SIT operations as an important component of AW-IPM campaigns against the T&T problem.

B. Progress since the 57th Session of the General Conference

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

6. The 32nd International Scientific Council for Trypanosomiasis Research and Control (ISCTRC) Conference was held in Khartoum, Sudan, from 8 to 12 September 2013. More than one hundred presentations (78 oral and 54 posters) were given, including an overview by a representative of the Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture on the activities carried out since the 31st ISCTRC Conference in support of Member States in addressing the T&T problem.

7. The Agency participated in the twelfth meeting of the PATTEC national coordinators from 25 to 27 November 2013, which was organized by the African Union Commission (AUC) in Dakar, Senegal, and hosted by the Ministry of Livestock. The meeting brought together approximately 70 national PATTEC coordinators and focal points from 29 T&T-affected African countries, representatives from international organizations, research institutions, non-governmental organizations (NGOs) and the private sector. At the end of the meeting, participants had the opportunity to visit the tsetse eradication project in the Niayes area of Senegal that is currently being implemented by the Ministry of Agriculture and Rural Equipment and supported by the Agency. The Director of the Joint FAO/IAEA Division participated in the second meeting of the PATTEC Steering Committee, which was organized by the AUC in Dakar on 28 November 2013, with the participation of international organizations, NGOs, donors, and the private sector. The meeting reviewed the AU-PATTEC Strategic Plan for 2012–2018 and recommended that AU-PATTEC should take a leading role in advising T&T-affected countries on the formulation of realistic targets and objectives of the selected control options.

8. In 2012, the 66th World Health Assembly in resolution WHA66.12 urged Member States to implement WHO's roadmap for Accelerating Work to Overcome the Global Impact of Neglected Tropical Diseases which targets the elimination of human African trypanosomosis (HAT) by 2020. As a follow-up to this resolution, the World Health Organization (WHO) held the first meeting of stakeholders on the elimination of HAT caused by the protozoan parasite *Trypanosoma brucei gambiense* from 25 to 26 March 2014 in Geneva, during which a common agenda in pursuit of this global objective was discussed. The participants included national control programme coordinators, international organizations, NGOs, scientific groups, and public and private donors. A representative of the Agency attended the meeting and made a presentation entitled "The role of the IAEA in tsetse and trypanosomosis control". The meeting decided to establish a network, to be coordinated by WHO, to ensure harmonized, strengthened and sustained efforts to eliminate HAT.

9. In view of the successful collaboration between the French International Cooperation Centre of Agricultural Research for Development (CIRAD) and the Agency on the tsetse eradication project in Senegal, both parties decided to formalize this cooperation model through a Practical Arrangement to extend the collaboration to other projects in the areas of insect pest control and animal health.

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

10. As a response to the demand for further capacity building on geographic information systems (GIS) and data management from AU-PATTEC and several national PATTEC coordinators, a regional training course on free open source software for GIS and data management applied to tsetse and trypanosomosis control programmes was jointly organized by the FAO, AU-PATTEC and the Agency in Addis Ababa, Ethiopia, from 12 to 23 May 2014. The training course was hosted on the premises of the African Union and included a visit to the Southern Rift Valley Tsetse Eradication Project (STEP) tsetse mass rearing facility in Kality. The tutorial DVD developed in 2013 by the Joint FAO/IAEA Division was the basis for the training and was delivered to the participants enabling them to install and use the free GIS software on their own laptops. A second training course will be organized at the end of 2014 for francophone trainees in West Africa.

11. Capacity building is one of the main components of the technical cooperation projects in this field, both at the regional level (RAF/5/59, RAF/5/64 and RAF/5/70) and national level in Angola, Chad, Ethiopia, Senegal, Uganda and Zimbabwe (ANG/5/33, CHD/5/03, ETH/5/16, ETH/5/18, SEN/5/33, UGA/5/33, UGA/5/36, ZIM/5/17 and ZIM/5/19). Since September 2013, the Agency provided training in the form of fellowships and scientific visits to 34 staff from 11 T&T affected countries with an overall duration of 286 weeks. Some of this training was provided at the Agency's Insect Pest Control Laboratory in Seibersdorf.

12. The major findings of the coordinated research project (CRP) entitled "Applying GIS and Population Genetics for Managing Livestock Insect Pests", whose final research coordination meeting (RCM) was held in 2013, were summarized in 13 scientific papers and published in June 2014 in a special issue of the journal *Acta Tropica*.

13. Fifteen countries continued to participate in research on inhibition of trypanosome transmission through symbiotic microbes under the CRP entitled "Enhancing Vector Refractoriness to Trypanosome Infection". The second RCM of this CRP will be held in December 2014 in Addis Ababa, Ethiopia.

14. During the past year, demand-driven research activities in the Insect Pest Control Laboratory have focused on the development and validation of technologies that can significantly contribute to the cost reduction and simplification of the application of the SIT, such as the use of ultraviolet irradiation for blood processing and infrared scanners for the sex separation of tsetse pupae. The Insect Pest Control Laboratory also contributed to the international initiative with WHO that led to the sequencing of the genome of the tsetse fly *Glossina morsitans*, which was featured in the April 2014 edition of *Science*. This scientific breakthrough will enable a better understanding of the biological and genetic potential of the tsetse flies, their nutrition, reproduction, immunity and vectorial capacity.

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

15. The Agency continued to provide technical assistance to STEP through the national and regional technical cooperation projects ETH/5/016 and RAF/5/064 and their extensions ETH/5/018 and RAF/5/070. The Ethiopian Government allocated in support of the national project a budget of 39.6 million Birr (approximately $2.14 million) for the current financial year 2013–2014 and proposed a budget increase to 50 million Birr for 2014–2015. The third meeting of the international management and advisory committee was held in Addis Ababa on 11 March 2014, with the participation of the Minister of Science and Technology of the Ethiopian Government and the Agency's Deputy Director General, Head of the Department of Technical Cooperation. During the meeting, senior management staff of the project, officers of the Agency and an international expert reviewed the current status of

the project. The benefits of tsetse suppression are clearly visible: farming communities (116 000 farmers and 2.5 million cattle) benefit from improved living conditions, which include the availability of oxen to plough the land, donkeys to pull carts to transport agricultural products to market, and meat and milk to improve human nutrition.

16. The rearing of the two tsetse colonies at the Kality mass rearing facility continued. A stock of 26 500 litres of high quality tested and irradiated blood has been accumulated and maintained, which allows for better production planning. Procedures to manage the salivary gland hypertrophy virus are being implemented in the entire *Glossina pallidipes* colony, resulting in a drop in the prevalence of the virus from an average of 19.25% of flies in 2012 to 0.27% in October 2013; an extremely low prevalence that no longer poses a threat to colony rearing. The construction of the building and installations for the industrial irradiator were completed and the irradiator became operational at the end of July 2014.

17. Successful ground suppression of the tsetse populations has continued to be applied mainly using insecticide impregnated traps and pour-on solution for cattle on the 25 000 km^2 of the STEP area and has expanded to cover hotspots in an additional area of 35 000 km^2, significantly reducing fly populations in the areas outside the national parks. However, the expansion of the suppression areas has not been matched by an increase in the resources for the field team activities. In the Deme basin, where aerial releases of sterile males have continued during the year, a recent comprehensive baseline entomological survey has been conducted as part of an agreed field action plan to compensate for the scarcity of entomological field data on the effect of the sterile releases. This survey has revealed the presence of some hotspots with high wild fly population densities, where suppression activities have now been reinforced. The target barrier deployed in the Deme gorge has also been reinforced to prevent reinfestation of wild flies from the Omo river area. All field activities are now being recorded and analysed with GIS software in order to ensure an area-wide approach. Two four-wheel drive vehicles were procured and an expert was engaged to support the strengthening of the field action plan through the technical cooperation programme.

18. An informative film on the STEP entitled “Paving the Way for Tsetse Eradication — Ethiopia's Journey” was produced by the Agency’s Office of Public Information and Communication. The film, intended for a broad public audience, describes the achievements of the project and remaining work ahead in non-technical language.

19. In Senegal, the project that aims to eradicate *Glossina palpalis gambiensi*s from the Niayes area near Dakar has made excellent progress. The project, implemented by the Directorate of Veterinary Services of the Ministry of Agriculture and Rural Equipment of the Government of Senegal in collaboration with the Senegalese Institute for Agricultural Research, has continued benefiting from Agency support through the national and regional technical cooperation projects SEN/5/033 and RAF/5/06, and from support from the USA (through the PUI), and France (through the deployment of a CIRAD staff member on-site in Senegal). The entire project area was divided into three operational blocks in which the activities are carried out sequentially. After completing the suppression activities in Block 1 using insecticide impregnated traps and pour-on solutions for cattle, sterile males were released, first from the ground and later by air. Since April 2012, no wild flies have been trapped in the monitoring traps. Releases of sterile flies will continue in Block 1 until the end of 2014, when eradication of the tsetse population in this area is expected to be announced. In Block 2, monitoring and population suppression activities were optimized based on a newly developed population distribution model. Monitoring data indicate excellent suppression in Block 2 (during monitoring in December 2013, wild flies were only trapped in 2 of the 72 monitoring traps). Aerial releases of sterile males were initiated over the eastern part of Block 2 in February 2014, using the automated chilled adult release machine that was developed last year. The machine has proven to produce very limited damage to the adult flies and is capable of releasing them at variable rates over the target area.

20. Based on the socio-economic data collected, a cost–benefit analysis was carried out that indicated that the project was highly cost-effective with estimated annual increases of cattle sales of approximately €2800/km^2 compared to the total cost of the eradication campaign of approximately €6400/km^2. In addition to an increase in farmers' income, the benefits of the eradication of the *G. p. gambiensis* population include a reduction of grazing pressure on the various ecosystems.

21. Under technical cooperation project RAF/5/070, an entomological and socio-economic update of the surveys conducted in 1999 and 2003 was initiated in July 2014 in Zanzibar, United Republic of Tanzania, with the primary purpose of assessing changes in livestock and agricultural development and its economic impact 15 years after the eradication of tsetse was declared.

22. In Zimbabwe, the Agency continues to support the feasibility study for the eradication of the tsetse fly in the Matusadona National Park under technical cooperation project ZIM/5/017 and its extension ZIM/5/019. Three Agency expert missions were carried out to assist counterparts with the management of collected data through the use of GIS and georeferenced databases; to verify the level of suppression achieved after the intensive use of ground sprays and the deployment of insecticide treated targets; and to assess the status of the field insectarium and the supplied equipment. An environmental impact assessment has been contracted to an independent organization for the authorization of further suppression and eradication activities inside the National Park by the Environmental Management Agency. Tests in field cages of the mating compatibility between the local strain and laboratory reared males from Slovakia are scheduled to be conducted at the end of this year.

23. Swaziland has become a Member State of the Agency and is now included in regional project RAF/5/069 entitled "Supporting a Feasibility Study to Eradicate Tsetse from Southern Mozambique, South Africa and Swaziland".

24. The Agency has extended the duration of the technical cooperation project with Chad (CHD/5/003) to the end of 2014 and has supplied laboratory and field equipment under this project. Counterparts in Chad have shared a report on the entomological monitoring and sensitization of the population activities in the Mandoul area.

25. In Angola, the Agency is supporting a feasibility study for using the SIT as part of area-wide integrated pest management of *G. morsitans centralis* in the provinces of Malanje, Kuanza-Norte and Kuanza-Sul. In a joint effort with an FAO expert on GIS, the available entomological data in this area were compiled and analysed with GIS and specific software to produce a predicted distribution of the pest in this area. This prediction was used to design an efficient entomological baseline survey. Once the information from this survey is available, an accurate map at a more detailed scale will eventually allow the identification of isolated pockets of the pest, which will need to be confirmed with genetic population studies.

C. Conclusion

26. Tsetse flies and trypanosomosis remain major obstacles to rural development in large areas of Africa. In several areas in which intervention measures are yet to be implemented, tsetse fly species are spreading. As no new methods have emerged to eradicate the various tsetse species in an area-wide and sustainable manner, the SIT, as part of an area-wide integrated pest control approach, maintains its appeal as a unique and environmentally friendly nuclear application. Nevertheless, there remain challenges, including the lack of infrastructure and the need to establish appropriate management

structures to deal effectively with such complex and logistically demanding projects. There is also the need to develop the SIT for different species with different biologies, and to adapt each project to unique ecological and socio-economic conditions and requirements. The scarcity of sterile male tsetse production facilities in Africa continues to be the most critical bottleneck for the expanded application of the SIT against the tsetse fly, with only five institutes holding seed or back-up tsetse fly colonies, and only one large, active tsetse mass-rearing centre located in Addis Ababa, Ethiopia.

Strengthening the Support to Member States in Food and Agriculture

A. Background

1. Following the report to the General Conference at its 56th session in September 2012, the General Conference, through resolution GC(56)/RES/12.A.4, recognized that the demand from Member States for technical assistance in the area of nuclear applications in food and agriculture remains high. It urged the Secretariat to expand its efforts to address food insecurity in Member States and to increase its contribution to raising agricultural productivity and sustainability through the development and integrated application of nuclear science and technology.

2. The General Conference further urged the Secretariat to address the impacts of climate change on food and agriculture through the use of nuclear technologies, with priority on adaptation and mitigation of climate change in the areas of soil and water management, insect pest control, plant breeding, livestock production and food safety; to continue strengthening its activities in the field of food and agriculture through interregional, regional and national capacity building, to facilitate the transfer of technologies to developing Member States; to develop technologies in relation to emergency preparedness and response to nuclear incidents to strengthen the capacity of Member States in emergency situations to deal with radiological contamination in the area of food and agriculture; and to seek extrabudgetary funding for infrastructure improvement and modernization of the Seibersdorf laboratories, especially the FAO/IAEA Agriculture and Biotechnology Laboratories.

3. The General Conference encouraged the Secretariat to further strengthen its partnership with the FAO and to continue adjusting and adapting its technology development, capacity building and technology transfer and services in response to Member States' demands and needs in food and agriculture; and requested the Secretariat to work towards the modernization of the FAO/IAEA Agriculture and Biotechnology Laboratories in Seibersdorf, in conjunction with the other programmatic entities of the laboratories of the Department of Nuclear Sciences and Applications, in order to assist Member States' research and development activities. Finally, the General Conference requested the Director General to report on the progress made in the implementation of this resolution to the Board of Governors and the General Conference at its 58th regular session.

B. Progress since the 56th Session of the General Conference

4. During the past biennium, the Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture (Joint Division) continued supporting Member States in using nuclear and related techniques to improve food security and sustainable agriculture through international cooperation in research, training and outreach activities. These techniques enable farmers, food manufacturers and government agencies to provide more, better and safer food, while reducing agricultural inputs, such as pesticides and fertilizers, and conserving soil and water resources and the biodiversity on which these products depend. Through these activities, the Joint Division continues to contribute to achieving the Millennium Development Goals. The most notable achievements are highlighted below.

5. The Joint Division currently coordinates 33 coordinated research projects involving approximately 500 research institutions and experimental stations in Member States, and is responsible for providing scientific and technical support to more than 286 national, regional and interregional technical cooperation (TC) projects. During the period 2012–2013, 156 workshops, seminars and training courses were held with the participation of about 2544 trainees from developing countries, with more than 90% being held in developing countries. In addition, the Joint Division has published 96 technical documents, newsletters, guidelines and books and 179 articles in scientific journals.

6. New demand-driven research and development (R&D) activities continue at the FAO/IAEA Agriculture and Biotechnology Laboratories in Seibersdorf in response to Member States' requests, including the development of the sterile insect technique to control mosquitoes, the use of isotopes in food traceability, the investigation of irradiated animal vaccines, the application of stable isotopes in tracing technologies, and the enhancement of animal disease diagnostic applications.

7. One of the major achievements of the Joint Division during the current biennium is the development of twelve advanced mutant wheat lines from five countries (Algeria, Kenya, Syrian Arab Republic, Uganda and Yemen) that show resistance to Ug99, a black stem rust disease of wheat that potentially causes 80–100% yield loss and is currently spreading across Africa, Asia and the Middle East causing major concern globally. Two of these resistant mutant lines have already successfully passed national performance trials in Kenya. These lines have potentially significant economic impacts. Wheat black stem rust currently destroys 8.33 million tonnes of wheat per year worth $1.23 billion. A further $2.5 billion/year is incurred in pesticide spraying costs. Furthermore, there is the unassessed cost of environmental pollution through the increasingly intensive use of fungicides.

8. The Agency responded rapidly and effectively to Member States' requests in their fight against the new avian influenza strain, H7N9. Since March 2013, the Agency, in collaboration with the avian influenza research community, has worked to address the identification, characterization and tracing of this strain and was involved in the development and validation of diagnostic procedures, the transfer of technologies and the provision of expert support to Member States. Upon Member States' requests, the Agency organized two training courses attended by 46 participants from 31 Member States from Asia and Europe comprising lectures on epidemiology, risk assessment, differential diagnosis and practical training on current, rapid, nuclear-based techniques for the identification and characterization of the H7N9 virus.

9. A mobile laboratory apparatus which allows for the early and rapid diagnosis of a range of animal infectious diseases, including peste des petits ruminants, newcastle disease, avian influenza H5N1, and foot-and-mouth disease, was successfully evaluated in the field in Cameroon, Ghana, Namibia, Pakistan, the United Republic of Tanzania and Uganda. The apparatus and its associated validated procedures and written standard operating procedures are now ready to be transferred to Member States.

10. Several enzyme preparations were tested in 14 Member States for their effectiveness in stimulating in vitro fermentation to improve the nutritive value and reduce the greenhouse gas emission of locally available animal feed resources. Nine scientists from four Member States were trained on animal feed analysis and 35 professionals from Eritrea were trained on animal feed formulation and participatory research techniques. The findings, of an increase of up to 20% in fibre digestibility and a 15% reduction in methane production, have stimulated plans to proceed with the conduct of in vivo studies.

11. Artificial insemination centres were developed and capacities strengthened in 15 Member States through national and regional TC projects to provide enhanced quality services to livestock keepers,

and 111 scientists were trained on artificial insemination, radioimmunoassay and advanced reproductive management practices in large and small ruminants.

12. The Agency continues to provide extensive support to Member States in the application of the sterile insect technique (SIT). Croatia is being supported in applying the sterile insect technique in the Neretva Valley to control the Mediterranean fruit fly on citrus. This pest causes major losses if not controlled, and hinders exports due to quarantine restrictions and pesticide residues on fruits. Results obtained in 2013 showed the number of larvae in fruit was reduced by 97% in the SIT treated area, and infestation in export shipments of mandarins decreased from 4.1% in 2011 (pre-SIT) to currently 0.2%.

13. The draft International Standards for Phytosanitary Measures on determination of host status of fruit to fruit flies (Tephritidae) and on control measures for an outbreak within a fruit fly-pest free area, developed in support of the International Plant Protection Convention (IPPC), were approved and recommended for adoption by the Commission on Phytosanitary Measures.

14. In Ethiopia's Southern Rift Valley, tsetse suppression activities have resulted in a substantial reduction in the prevalence of trypanosomosis among livestock, and farming communities (116 000 farmers and 2.5 million cattle) benefit from improved living conditions, which include the availability of oxen to plough the land, donkeys to pull carts to transport agricultural products to market, and meat and milk to improve human nutrition. The Agency has been supporting this programme since its inception with ongoing pilot-scale releases of sterile males in the Deme basin.

15. The Joint Division helped to reduce fruit fly damage through the establishment of areas of low prevalence and pest free areas and the promotion of pest-free produce for export, which has greatly facilitated the export by countries in Central America of tomatoes, peppers, papaya and dragon fruit. Tomato exports have increased 10 fold in the past five years reaching in 2013 a value of $40 million. At the same time, several hundred jobs have been generated and complementary industries in the packing and transportation services have been developed and strengthened.

16. Building on its expertise in the detection of trace amounts of materials in foods and commodities, the Joint Division has started research to support food traceability and authenticity. This initiative was embraced in 20 developing countries in 2012–2013, with stable isotope and other methods being developed and implemented to support food control systems. In addition, laboratories in 12 Member States in South East Asia have networked to build awareness and capacity for implementing control systems for food integrity and verification of origin.

17. By leveraging its laboratory expertise and through its networks of expert institutes, the Agency successfully developed and transferred technology packages integrating bioassays/biomonitoring screening tests and physico-chemical and isotopic methods for analysing food and environmental contamination. The methodology is designed to provide feedback to food chain stakeholders in order to optimize the use of agrochemicals, avoiding unnecessary expenditure and improving both environmental sustainability and food safety. The methods have been implemented in Argentina, Chile, Costa Rica and Uruguay, while eight additional countries are testing or validating the technology for implementation in their laboratories. Work in this area is also supported by a four-year regional follow-up project, initiated to develop indicators for determination of the effects of pesticides, heavy metals and emerging contaminants on continental aquatic ecosystems important to agriculture and the agro-industry.

18. With expert assistance from the Joint Division, ten laboratories in Latin America and the Caribbean received formal accreditation of their methods for the analysis of pesticide residues, heavy metals and mycotoxins in food and environmental samples.

19. The use of irradiation as a treatment to ensure that fresh produce is free of insect pests is expanding. Australia, India, Mexico, New Zealand, Pakistan, South Africa, Thailand, the USA, and Viet Nam are trading irradiated fresh fruit and vegetables for international trade. The quantities of these irradiated exports are increasing because irradiation is proving to be technically and economically viable as countries require alternative post-harvest pest control methods that avoid the use of potentially harmful chemical pre-shipment treatments. Research supported by the Joint Division has to date resulted in 14 phytosanitary irradiation treatments being accepted as IPPC standards, with a further four new treatments currently undergoing review by the IPPC for consideration as standards.

20. Guidelines for the Audit and Accreditation of Irradiation Facilities used for Sanitary and Phytosanitary Treatment of Food and Agricultural Products were produced through an FAO/IAEA Asia and the Pacific regional technical cooperation project. These guidelines were considered by the Standards Committee of the Asia and Pacific Plant Protection Commission (APPPC) and received approval as a new APPPC regional standard in 2013.

21. A good irradiation practice manual for phytosanitary, food safety and quality applications of food irradiation technology has been reviewed and finalized through a collaborative project involving food and plant health specialists from 17 countries in the Asia and the Pacific region. The manual complements efforts to disseminate and expand the application of international standards and the operation of food irradiation facilities.

22. During the past two years staff members of the Joint Division participated in international experts' meetings to analyse all relevant technical aspects pertinent to emergency preparedness and response to nuclear incidents, including the accident at the Fukishima Daiichi nuclear power plant. They were part of the expert panel meetings convened by the World Health Organization that resulted in the publication of the *Preliminary dose estimation from the nuclear accident after the 2011 Great East Japan Earthquake and Tsunami* report. In addition, the Joint Division staff participated and contributed to the major study and assessments by the United Nations Scientific Committee on the Effects of Atomic Radiation of the levels and effects of radiation exposure due to the Fukushima Daiichi accident.

23. Integrated technology packages involving legume cover crops, crop residue retention and minimum tillage to improve agricultural production, soil fertility and soil quality were introduced in ten countries in Latin America and six countries in the Asia and the Pacific region. In Cuba, for example, the use of 45-50 tonnes/ha of green manure for rice crops increased yield from 3.6 to 4.7 tonnes/ha, providing economic benefits of up to $450 per hectare per year to farmers.

24. Soil and water management practices that reduce soil evaporation and increase crop water productivity were successfully implemented in eight countries. In Viet Nam, coffee branches used as mulch cover to a depth of 5 to 7 cm and changing irrigation practices from furrow to drip reduce soil evaporation from 17% to 5%. With a total coffee growing area of 290 000 ha, approximately 62 million m^3 of irrigation water could potentially be saved.

25. Three types of water conservation systems (farm ponds, wetlands and riparian buffer zones) were evaluated in eight countries (China, Estonia, the Islamic Republic of Iran, Lesotho, Nigeria, Romania, Tunisia and Uganda) to capture and store run-off water and nutrients such as nitrogen and phosphorus from agricultural catchments. For example, in Tunisia, a farm pond occupying approximately 3% of the catchment area (272 ha) was able to capture surface run-off and subsurface water (up to 140 000 m^3) and associated nitrogen (up to 280 kg) generated from the catchment. The captured water and nitrogen were used for growing high value vegetable crops of six tonnes per ha per year and has the additional benefit of reducing nitrogen contamination in downstream water. The findings help policymakers optimize water conservation strategies in regions where water scarcity is a major issue

and farmers rely on captured water to irrigate crops. Furthermore, nutrients captured from run-off and drainage help meet crop demand for nutrients while at the same time reducing nitrate loading to rivers and streams by up to 90%.

B.1. Strengthening the FAO/IAEA Partnership

26. In June 2013, the Agency and FAO signed Revised Arrangements regarding the work of the Joint Division, reconfirming the commitment of both organizations to the long-standing partnership between the two organizations. The Revised Arrangements aim at strengthening the joint effort to reduce hunger, improve food security and achieve sustainable agriculture.

27. The FAO has recognized the importance of the Renovation of the Nuclear Applications Laboratories (ReNuAL) project to the Joint Division's work and has pledged to share the extensive experience in mobilizing extrabudgetary resources by having relevant FAO staff work with Agency staff on resource mobilization efforts. The Agency organized a briefing for FAO's member countries in Rome in March 2014.

28. This year marks the 50th anniversary of the cooperation and partnership between the FAO and the Agency through the Joint Division and the two organizations will celebrate the success of this partnership. This occasion provides an opportunity to look back on the numerous successes of the partnership and highlight major achievements that the Joint Division contributed to global food security and sustainable agricultural development. It is also an opportunity to reflect on the many important contributions of the FAO/IAEA Agriculture and Biotechnology Laboratories, which represent one of the primary assets of the partnership in addressing the challenges of global food security. The 50-year anniversary will be celebrated with Member States at a special event on 29 September 2014.

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

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

C. Conclusions

30. 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. The Joint Division will continue to respond to these trends with a focus on improving the intensification of agricultural productivity, ensuring food safety and quality, and better adaptation to and mitigation of climate change in agriculture.

The Renovation of the Nuclear Applications Laboratories (ReNuAL) Project

A. Background

1. During the 56th regular session of the General Conference in 2012, the Director General called for an initiative to modernize and renovate the eight laboratories of the Department of Nuclear Sciences and Applications 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. At the 57th regular session of the General Conference in 2013, the Director General reported on preparations made for a new project for the modernization and renovation of the laboratories as requested in the resolution.

2. In resolution GC(57)/RES/12.A.6, the General Conference subsequently requested that the Secretariat move forward with developing a concrete strategy for this project, the Renovation of the Nuclear Applications Laboratories (ReNuAL), which officially began on 1 January 2014. The resolution further requested the Secretariat to present this strategy, including resource mobilization approaches for targeting traditional and non-traditional donors, in 2014. The General Conference requested the Director General to report on progress made in implementing resolution GC(57)/RES/12.A.6 at its 58th session.

B. Progress since the 57th Session of the General Conference

B.1. Project Governance and Management

3. The ReNuAL project board was established in January 2014, when the ReNuAL project officially began. In keeping with best practices currently applied with other similar Agency projects, the project board, led by the Deputy Director General, Head of the Department of Nuclear Sciences and Applications, consists of stakeholders throughout the Secretariat responsible for overseeing the ReNuAL project activities and approving strategic decisions related to project planning, resourcing, implementation and communication. The project is being supported on a part-time basis by some members of the Project Management Group of the Enhancing Capabilities of Safeguards Analytical Laboratories (ECAS) project, who will formally move from ECAS to ReNuAL in the first quarter of 2015. Their participation will ensure that the experience and lessons learned from the ECAS project are applied in the implementation of the ReNuAL project.

B.2. Developing the Strategy for the ReNuAL Project

4. From the third quarter of 2013 to the second quarter of 2014, the Secretariat engaged external architectural and engineering experts to conduct a series of four technical studies to support planning for the ReNuAL project. These studies assessed building conditions and materials and the feasibility of meeting the needs that had been identified by the laboratories through refurbishment and/or new construction options. The findings of these studies were presented to Member States at a technical briefing held on 26 February 2014, along with a collection of laboratory briefs that outline the vision, needs and future role of each of the eight laboratories.

5. Based on the findings of the technical studies, the Secretariat identified potential elements of the ReNuAL project and an overall approach for its implementation. The proposed elements and implementation approach were presented in April 2014 to an external advisory group consisting of some members of the Standing Advisory Group on Nuclear Applications. This group validated the proposed elements and overall approach for the ReNuAL project, after which the strategy was prepared and presented to Member States at a technical briefing on 22 May 2014. Subsequently, the strategy document was also circulated at the June meeting of the Board of Governors. [1]

C. Next Steps

C.1. Resource Mobilization

6. To raise funds for the project, the Secretariat is engaging with traditional and non-traditional donors, including Member States, key partners, such as the Food and Agriculture Organization of the United Nations (FAO), private companies and foundations. The FAO, which has extensive experience in mobilizing extrabudgetary resources, has pledged to share this expertise by having relevant FAO staff work with Agency staff on resource mobilization efforts. In March 2014, Agency staff conducted a briefing on the ReNuAL project for FAO member countries in Rome to raise awareness of the project and further resource mobilization efforts.

7. A number of equipment manufacturers have already expressed interest in supporting the project, whether through potential donations or price discounts. The Secretariat will explore these possibilities, as well as possibilities for the low-cost leasing of equipment. To facilitate such arrangements, the Secretariat is developing guidelines for working with the private sector to ensure that the ReNuAL project can engage with the private sector in a manner consistent with the Agency's regulations and policies.

8. A Resource Mobilization Officer will join the project team in the third quarter of 2014 to further develop and guide resource mobilization activities. Targeted stakeholder engagement to promote and gain support for the project will continue throughout the project's lifetime. The Secretariat will continue to meet potential donors, produce progress reports and information packages, and conduct technical briefings.

9. To date, financial donations have been received from Japan, Kazakhstan, the Republic of Korea and the United States of America. Cost-free experts have also been provided by China and the United States of America. Given the limited Regular Budget funding available to support the project, the project's success will depend heavily on the availability of extrabudgetary resources.

C.2. Initial Implementation Activities

10. In preparation for construction under the ReNuAL project, the master plan for the entire Seibersdorf site is being updated to include the changes proposed under the project, and to be prepared for any future changes that may be required. Simultaneously, external experts are developing the conceptual designs for the new buildings to be constructed under the project.

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[1] Please refer to document GOV/INF/2014/11, *Strategy for the Renovation of the Nuclear Sciences and Applications Laboratories in Seibersdorf*, for further details.

11. Once the conceptual designs are completed, external experts will be contracted to develop detailed designs for the new buildings, as well as for the changes to the existing site infrastructure. The detailed design process will continue throughout the project concurrently with construction, with project elements being constructed as their detailed designs are completed. Due to the time needed to procure detailed design teams and to develop these designs, and to the onset of the winter season, construction is scheduled to begin in early 2015. The ground-breaking ceremony for the project is planned for 29 September 2014 in Seibersdorf.

Nuclear Energy Activities

1. This Annex summarizes highlights of Agency nuclear energy activities not covered in Annexes 6 to 8, which address innovative nuclear technology, potable water production using nuclear reactors, and nuclear knowledge management, respectively.

2. The Agency annually updates its low and high projections for the global growth in nuclear power in its publication *Energy, Electricity and Nuclear Power Estimates for the Period up to 2050* (Reference Data Series No. 1). In 2013, the updated low projection shows growth in nuclear power capacity of 17% by 2030 and the high projection shows 94% growth by 2030. The Agency also annually publishes its report *Nuclear Power Reactors in the World* (Reference Data Series No. 2), which presents the most recent data on nuclear power reactors across the world. The 2014 edition contains summary information as of the end of 2013 on power reactors operating, under construction and shut down, as well as performance data on reactors operating in the Agency's Member States.

3. For the 19th session of the Conference of the Parties to the United Nations Framework Convention on Climate Change (COP19), held in Warsaw, Poland, between 11 and 22 November 2013, the Agency published its report *Climate Change and Nuclear Power 2013*. The report has been substantially revised, updated and extended since the previous edition (2012). It summarizes the role of nuclear power in mitigating global climate change and how nuclear power contributes to other development and environmental challenges. It also examines broader themes relevant to climate and nuclear energy issues such as cost, safety, waste management and non-proliferation. The 2013 edition also includes a section on prospects for nuclear power, highlighting new developments in resource supply and innovative nuclear technologies, including fusion and advanced fuel cycles. At COP19, the Agency maintained an information centre to explain the linkages between nuclear power and climate change mitigation, sustainable energy development and other related issues. In addition, the Agency helped to organize a United Nations system side event on the economics of mitigation and delivered a presentation on mitigation in the energy sector at that side event.

4. From 12 to 16 May 2014, the Agency hosted the International Conference on Human Resource Development for Nuclear Power Programmes: Building and Sustaining Capacity, which focused on the global challenges of capacity building, human resource development, education and training, nuclear knowledge management and the establishment of knowledge networks, all of which are topics raised in the IAEA Action Plan on Nuclear Safety. It also considered the challenges of preparing the next generation of nuclear professionals.

5. The Agency organized the International Symposium on Uranium Raw Material for the Nuclear Fuel Cycle: Exploration, Mining, Production, Supply and Demand, Economics and Environmental Issues from 23 to 27 June 2014. Participants shared information about new developments in uranium geology, exploration, mining and processing, as well as in the environmental and social requirements pertaining to uranium operations and site decommissioning. They also considered uranium supply and demand scenarios. The publication Uranium 2014: Resources, Production and Demand, which is also referred to as the Red Book and was prepared jointly by the IAEA and the Nuclear Energy Agency of the Organisation for Economic Co-operation and Development (OECD/NEA), appeared in July 2014. It provides information on uranium resources, production and demand worldwide.

6. Partitioning and transmutation (P&T) is a multidisciplinary approach to the management of spent fuel, where closer collaboration and a better integration of the different disciplines involved would improve the chances of successful implementation. Twenty-two experts from 11 Member States and international organizations participated in the Technical Meeting on Advanced Actinide Recycle

Technologies from 18 to 20 November 2013. They presented and discussed the various issues and challenges, including technological problems, involved in the large scale implementation of P&T related technologies.

7. At the 12th IAEA–FORATOM Management System Workshop — Journey to Excellence in a Changing Environment, held from 20 to 22 November 2013, 32 Agency Member States were represented by 125 senior managers and experts on management systems. They discussed how to adapt their systems to ensure the safe management of nuclear facilities in a changing environment.

8. As in previous years, the Agency continued to maintain and update a number of databases that serve the nuclear community and other stakeholders, including: the Power Reactor Information System, which contains performance and technical design data on nuclear power reactors in operation, under construction, or in the process of being decommissioned; the Net Enabled Waste Management Database, which contains information on national radioactive waste management programmes, radioactive waste inventories, radioactive waste disposal, relevant laws and regulations, waste management policies, and relevant plans and activities; the Research Reactor Database, which provides extensive information on research reactors all over the world; and the Research Reactor Ageing Database, which is intended to assist Member States in sharing information and experiences specific to the management of technical issues related to research reactor ageing, as well as in the development and implementation of comprehensive ageing management programmes. Other computer based databases and resources that were updated were the Integrated Nuclear Fuel Cycle Information System, the two online databases World Distribution of Uranium Deposits and World Thorium Deposits and Resources, the Nuclear Fuel Cycle Information System, the Post Irradiation Examination Facilities Database, the Minor Actinide Property Database, and the Nuclear Fuel Cycle Simulation System.

9. In December 2013, the Agency organized a major international workshop in Malaysia on the macroeconomic impacts of a nuclear power programme in South-East Asia. Thirty-five senior level participants identified lessons learned from recent national experience with quantitative tools and developed strategies to further improve quantitative analysis in South-East Asia through the assessment of regional impacts. With support from the Korea Nuclear Association for International Cooperation, the Agency held a workshop in Seoul from 17 to 21 March 2014, which addressed nuclear power and energy policy, and provided guidance and training on conducting energy assessments, pre-feasibility and feasibility studies for the introduction of nuclear power in a national energy mix.

10. An Integrated Nuclear Infrastructure Review (INIR) mission was undertaken in Turkey in November 2013 to review the status of the country's nuclear infrastructure. The mission made several recommendations to support the development of the nuclear power programme in Turkey.

11. In January 2014, the Integrated Nuclear Infrastructure Group within the Division of Nuclear Power was upgraded to become the Nuclear Infrastructure Development Section in order to provide newcomer Member States with improved services for supporting infrastructure development. The INPRO Group was at the same time also upgraded to Section status.

12. Since the last regular session of the General Conference in September 2013, the Nuclear Infrastructure Development Section has updated the IAEA Catalogue of Services for Nuclear Infrastructure Development, which is a comprehensive list of all the Agency services that support new and expanding nuclear power programmes. It helps Member States to identify and request Agency assistance for national organizations at different stages of the development or expansion of a nuclear power programme.

13. The first Research Coordination Meeting (RCM) of a coordinated research project on financing nuclear energy investments was held in Vienna from 18 to 21 November 2013. Participating Member States included Bulgaria, Chile, China, Jordan, Kenya, Pakistan and Uruguay. The purpose of the RCM was to allow Member States with different degrees of experience in identifying sources of potential financing for nuclear energy projects to share their experiences and highlight lessons learned.

14. The Nuclear Power Engineering Section, together with the new Nuclear Infrastructure Development Section, expanded the current e-learning resources to include modules on the systematic approach to training, feasibility studies, and management systems. These new e-learning modules were posted on the Agency's website in early 2014 and they are based on the Agency's Milestones approach. Additional modules on safety infrastructure, emergency preparedness and response, and safeguards were also completed by September 2014, bringing the total number of modules available to Member States to 11. They target a variety of stakeholders in Member States interested in, or embarking on, a nuclear power programme.

15. The annual Technical Meeting on Topical Issues in the Development of Nuclear Power Infrastructure was held from 4 to 7 February 2014 and gathered around 100 participants from 41 Member States, representing government ministries, organizations responsible for nuclear power programme planning in newcomer countries, current and future owner/operator organizations, vendors, technical support organizations, universities and regulatory agencies. The meeting provided opportunities for participants from operating and newcomer countries to share their experiences related to common infrastructure development issues such as funding, stakeholder involvement and setting up an appropriate legislative and regulatory infrastructure. In June 2014, a Technical Meeting on Building a National Position on a New Nuclear Power Programme was held in Vienna.

16. The Nuclear Infrastructure Development Section initiated a revision of *Milestones in the Development of a National Infrastructure for Nuclear Power* (IAEA Nuclear Energy Series No. NG-G-3.1). This revision incorporates feedback received from Member States currently using the Milestones approach, lessons learned from the Fukushima Daiichi accident, and evolutions in the nuclear power plant (NPP) bidding and ownership processes. The revision of this publication is expected to be completed by September 2014.

17. How future owners/operators of NPPs can become 'knowledgeable customers' was the focus of a Technical Meeting held in Obninsk, Russian Federation, from 7 to 11 April 2014. It was hosted by the Russian Government through the State Atomic Energy Corporation "Rosatom" and provided an opportunity for the exchange of information among countries which are developing their nuclear power programmes as well as sharing experiences from case studies and existing nuclear power programmes. A Technical Meeting on Procurement Activities and on Counterfeit, Fraudulent and Substandard Items: Experiences and Lessons Learned is planned for September 2014 in Vienna.

18. The importance of helping newcomer countries to establish a strong safety and security culture from the very beginning was highlighted at a Technical Meeting on the Factors That Can Influence Safety and Security Culture in the Development of a National Nuclear Power Programme, which was held from 18 to 21 February 2014. It was attended by 16 participants from 10 countries and has already resulted in requests for national workshops to further develop the ideas shared at the meeting.

19. The second RCM on Qualification, Condition Monitoring and Management of Ageing of Low Voltage Cables in Nuclear Power Plants was held at Knoxville, Tennessee, United States of America, from 8 to 10 July 2013, to discuss the benchmark baseline test results and prepare a draft report on condition monitoring techniques for cable ageing management for long term operation of NPPs. A total of 65 participants from 15 countries participated in this RCM and shared the results of their research on monitoring and ageing management of low voltage cables.

20. In support of NPP operation, maintenance and management, in November 2013 a Technical Meeting was organized jointly with the European Commission's Joint Research Centre on current issues and future challenges in the field of material degradation. It was attended by over 80 participants from 29 countries. Another Technical Meeting was held on strategic supply chains and national industrial involvement for nuclear power in Dijon, France, in November. The 56 meeting participants from 30 countries also visited relevant French manufacturing and training facilities.

21. The Agency has been active in the field of digital system reliability and computer security for a long time in order to respond to growing concerns and demand for assistance from Member States, as malicious attacks on instrumentation and control (I&C) systems could have serious effects on plant safety. In addition, vulnerabilities can exist in the tools used to design and test I&C systems. To serve as an international forum for sharing best practices and strategies used in the engineering and design of computer security measures for I&C systems at NPPs, as well as for discussing the challenges and issues that need to be resolved in this area, a Technical Meeting will be organized in Garching, Germany, from 3 to 5 September 2014.

22. The Agency dispatched two international peer review missions to Japan in the last quarter of 2013. The Follow-up IAEA International Mission on Remediation of Large Contaminated Areas Off-Site the Fukushima Daiichi Nuclear Power Plant was undertaken from 14 to 21 October 2013. At the request of the Japanese Government, it evaluated the progress of remediation work since the Agency's international expert mission on remediation issues that was conducted in October 2011. The second mission was organized from 25 November to 4 December 2013 and involved an international team of 16 experts. It examined a variety of issues related to decommissioning of the Fukushima Daiichi NPP, with a focus on the removal of fuel assemblies from the spent fuel pool of Reactor Unit 4 and on contaminated water management issues. It also considered Japan's efforts to monitor radiation conditions in the marine environment, including seawater, sediments, and biota.

23. A number of cross-cutting activities were carried out to familiarize Member States considering their first research reactor with the guidance and approaches contained in *Specific Considerations and Milestones for a Research Reactor Project* (IAEA Nuclear Energy Series No. NP-T-5.1). Such activities were conducted in Kuwait (18–22 May 2014), Saudi Arabia (27–30 January 2014), and the United Republic of Tanzania (26–30 May 2014). In addition, a Training Workshop on Specific Considerations and Milestones for a Research Reactor Project was organized in Vienna from 12 to 16 May 2014. It provided Member States with practical information and knowledge relating to the aforementioned IAEA Nuclear Energy Series publication, as well as to other documents referenced in that publication, and was attended by 50 participants representing 30 Member States.

24. Under the Russian Research Reactor Fuel Return (RRRFR) programme, launched in 2002 by the Agency, the Russian Federation and the United States of America, a total of 2060 kg of Russian-supplied high enriched uranium (HEU) has been transferred back to the Russian Federation from 14 countries in 56 separate shipment operations. The Agency actively supports the RRRFR programme through a broad range of technical advice and organizational support, and by providing training in the conversion of research reactors from high to low enriched uranium fuel. In October and November 2013, the latest batch of 49.2 kg of HEU contained in spent nuclear fuel that had been irradiated in the Budapest Research Reactor was flown to the Russian Federation in three air shipment operations. The three recent shipments bring the total amount of HEU removed from Hungary to 239.1 kg. A Technical Meeting on lessons learned from the RRRFR programme was held in Da-Nang City, Viet Nam, from 18 to 20 June 2014.

25. In order to reflect the current status and trends in research reactor utilization and management, a group of international experts reviewed 31 strategic plan documents submitted by managers from all over the world. As a follow-up to this review, an interregional workshop was organized in July 2013.

It gave the 27 participants from 20 Member States the opportunity to share experiences, lessons learned and good practices in developing and implementing strategic plans at their facilities.

26. In 2014, the Agency launched a new peer review service for its Member States which deals with radioactive waste and spent fuel management, decommissioning and remediation of sites contaminated by radioactive materials. The service is called ARTEMIS and may be directed towards national frameworks, regulatory systems and/or aspects of national programmes. It can also provide detailed assessment and technical advice on the implementation of specific programmes and project activities, with an emphasis on technology or on safety, or both. ARTEMIS is being managed by the Department of Nuclear Energy and the Department of Nuclear Safety and Security.

27. The Agency continued to assist Member States in training and capacity building in radioactive waste management, including through the activities of the three networks which are directly concerned with these issues: the Underground Research Facilities Network (geological disposal of high level waste and long lived intermediate level waste), the International Low Level Waste Disposal Network, and the International Network of Laboratories for Nuclear Waste Characterization. The Network on Environmental Management and Remediation is also available to support Member States in the area of environmental remediation of sites contaminated with radioactive materials, whilst the International Decommissioning Network supports the implementation of decommissioning programmes.

28. With a workshop on project outcomes held in Vienna in February 2014, the two-year Connecting the Network of Networks for Enhanced Communication and Training project, which was co-sponsored by the European Commission, was formally completed. The project resulted in the establishment of a fully operational web-based platform, the development of more than 20 e-learning modules covering the radioactive waste disposal area, and the development of a wiki-structured information resource for Member States with initial content in the area of decommissioning. The e-learning material will be officially launched in November 2014.

29. Successful missions to Bosnia and Herzegovina, Costa Rica, Morocco and Sudan took place in late 2013 and the first half of 2014, resulting in the repatriation and/or recycling of 15 high activity disused sealed radioactive sources (DSRSs). Methods to facilitate the disposal of DSRSs are being initiated to provide additional options and tools for addressing the disposal and long term storage of DSRSs. This includes the implementation of the borehole disposal concept, with a pilot project in Ghana now under way.

30. Operated in collaboration with 129 Member States and 24 international organizations, the International Nuclear Information System (INIS) is the Agency's largest document database. It now comprises over 3.6 million records and more than 481 000 full texts not readily available through commercial channels. There are over 120 000 visits to the INIS Collection each month from all over the world. The International Nuclear Library Network increased its membership to 50 research institutes, libraries and nuclear regulatory bodies from 31 countries. The NE News app for iPad, iPhone and Android was launched in 2013, allowing users to access newsletters, brochures and social media channels through a single mobile application. The number of electronic journals available through the IAEA Library reached 20 000. Over 14 300 people visited the IAEA Library in 2013, and library loans rose to more than 30 000.

Agency Activities in the Development of Innovative Nuclear Technology

A. Background

1. General Conference resolution GC(57)/RES/12, adopted on 19 September 2013, referred to the role of innovative technologies in addressing improved nuclear safety, which is relevant to Action 12 in the IAEA Action Plan on Nuclear Safety. It also noted the progress achieved in a number of Member States in the development of technology for innovative nuclear energy systems and the high technical and economic potential of international collaboration in the development of such technology.

2. It was further noted that the membership of the Agency's International Project on Innovative Nuclear Reactors and Fuel Cycles (INPRO), which was launched in 2000, is continuing to grow and now comprises 39 Agency Member States and the European Commission. Resolution GC(57)/RES/12 also called upon the Secretariat, and upon Member States in a position to do so, to investigate, while taking into account, inter alia, economic, safety and security factors, new reactor and fuel cycle technologies with enhanced proliferation resistance, including those needed for the recycling of spent fuel and the use of such recycled fuel in advanced reactors under appropriate controls and for the long term disposition of remaining waste materials.

3. The General Conference recommended that the Secretariat consider establishing, through the consolidation of available resources and assistance from interested Member States, regular training courses and workshops on innovative nuclear technologies to exchange knowledge and experience in the area of innovative, globally sustainable nuclear energy systems. The Director General was requested to report on progress made in the implementation of this resolution to the Board of Governors and to the General Conference at its 58th regular session in September 2014. This report has been issued in response to that request.

B. Activities of the Agency

4. In line with resolution GC(57)/RES/12, INPRO, through its Task 1 ("Global Scenarios"), has progressed with the development and evaluation of various nuclear energy scenarios and roadmaps for transitioning to sustainable nuclear energy systems, based on synergistic collaboration among the countries involved. The final report of the INPRO collaborative project Global Architecture of Innovative Nuclear Energy Systems Based on Thermal and Fast Reactors Including a Closed Fuel Cycle (GAINS) was published as *Framework for Assessing Dynamic Nuclear Energy Systems for Sustainability: Final Report of the INPRO Collaborative Project GAINS* (IAEA Nuclear Energy Series No. NP-T-1.14). A brochure entitled *Analytical Framework for Analysis and Assessment of Transition Scenarios to Future Sustainable Nuclear Energy Systems* was prepared to facilitate application of the INPRO-developed analytical framework in studies of national and regional nuclear energy evolution scenarios in Member States.

5. A Technical Meeting under the INPRO collaborative project Synergistic Nuclear Energy Regional Group Interactions Evaluated for Sustainability (SYNERGIES) was conducted in November 2013 and progress was made in documenting and analysing 30 case studies, carried out by

participants from 15 Member States, and exploring 'win-win' strategies of collaboration among countries interested in the back end of the fuel cycle to amplify sustainability benefits resulting from synergies between the various nuclear energy system technologies. A draft report of the SYNERGIES project is expected to be prepared by the end of 2014.

6. During the implementation of the SYNERGIES project it was noted that there are particular legal and institutional impediments to collaboration among countries on activities related to the back end of the nuclear fuel cycle. Examining these impediments and outlining ways of overcoming them would be an important step in the near term to ensure the long term sustainability of nuclear energy systems. The launch of a cross-cutting study on legal and institutional issues pertaining to collaboration among countries on activities related to the back end of the nuclear fuel cycle is being considered and the Secretariat presented the relevant proposal to the INPRO Steering Committee at its meeting in June 2014.

7. Preparatory activities for the new INPRO collaborative project Roadmaps for a Transition to Globally Sustainable Nuclear Energy Systems (ROADMAPS) were carried out, resulting in draft terms of reference and the outline of a project report. The ROADMAPS project has the objective of developing a structured approach for achieving globally sustainable nuclear energy systems, providing models of cooperation among countries and a template for documenting actions, scopes of work, and timeframes for specific collaborative efforts by particular stakeholders. The annexes to the project report will include roadmaps developed by Member States by the time the report is prepared. The start-up Technical Meeting for the project is scheduled for November 2014.

8. Preparatory activities for the new INPRO collaborative project Key Indicators for Innovative Nuclear Energy Systems (KIND) were carried out, resulting in draft suggestions for a set of key indicators and the assessment method and a preliminary selection of expert judgement aggregation methods. The objective of the KIND project is to develop guidance and tools for comparative evaluation of the status, prospects, benefits and risks associated with the development of innovative nuclear technologies for a more distant future. The target is to help Member States prioritize and adjust the allotment of resources within national programmes on innovative nuclear technology development. The project will start with a Technical Meeting in July 2014.

9. Under INPRO Task 2 ("Innovations"), several new collaborative projects are being initiated to address the specific issues of innovative nuclear energy systems as well as institutional and infrastructure innovations. A collaborative project on the dissemination of good practices in enhancing collaboration in innovations to support sustainable nuclear energy systems has been initiated through a Technical Meeting convened in April 2014. The objectives of this project are to disseminate to Member States worldwide good practices in establishing effective mechanisms for collaboration in research and development (R&D) that are particularly applicable to the nuclear energy field, including the area of nuclear energy systems, and to investigate options for further support to Member States in pursuing innovations, in particular, for the development and deployment of sustainable nuclear energy systems. The final report is due in 2015.

10. Preparatory activities for the new INPRO collaborative project Review of Innovative Reactor Concepts for Prevention of Severe Accidents and Mitigation of their Consequences (RISC) have been conducted, resulting in the definition of the scope of work. The objective of this project is to demonstrate that the evolution of safety requirements and related technical and institutional innovations in nuclear technologies are contributing to ongoing progress, which will ultimately make it possible to avoid relocation or evacuation measures outside nuclear power plant (NPP) sites in case of a severe accident. The first consultancy meeting was held in April 2014, and a second consultancy meeting is planned for October 2014.

11. The new INPRO collaborative project Nuclear Fuel and Fuel Cycle Analysis for Future Nuclear Energy Systems started with a Technical Meeting in June 2014. The objectives are to carry out feasibility analyses of advanced and innovative fuels for different reactor systems to better understand impacts and interfaces of such fuels on the development of future nuclear energy systems, and to analyse spent fuel management options for advanced and innovative fuel cycles, while addressing potential technology improvements. The final report is due in 2016.

12. The new INPRO collaborative project Waste from Innovative Types of Reactors and Fuel Cycles (WIRAF) will identify any problematic waste arising from innovative reactor designs and corresponding nuclear fuel cycles which could influence the development and deployment of future nuclear energy systems. WIRAF will also analyse problematic waste streams that may require either further enhancement of existing waste management processes and technologies or the development of new ones, and will discuss the technologies needed for the processing of such waste streams. The project was launched at a Technical Meeting in May 2014, and the final report is expected to be delivered in 2015.

13. Following the publication of *Legal and Institutional Issues of Transportable Nuclear Power Plants: A Preliminary Study* (IAEA Nuclear Energy Series No. NG-T-3.5) in 2013, preparations for initiating the second phase of the study presented there are under way. The topic being considered for this second phase is the development of a case study for the deployment of a factory fuelled small sized reactor; however, this could still be modified subject to the expressions of interest received from INPRO Members. The proposal was supported by INPRO Steering Committee meeting in June 2014.

14. Under INPRO Task 3 ("Sustainability Assessment and Strategies"), a Nuclear Energy System Assessment (NESA) is being carried out in Romania in coordination and integration with energy planning services. The INPRO activities include nuclear energy system modelling and long range planning based on the results of this modelling, and application of the INPRO sustainability assessment methodology in the areas of economics, infrastructure and waste management. In the second phase of the Romanian NESA, other assessments using the INPRO methodology will be performed.

15. Ongoing discussions with Kazakhstan regarding the provision of services are being fully coordinated among the relevant parts of the Secretariat. A joint fact-finding mission was concluded in April 2014. It focused on defining how and what services offered by the Department of Nuclear Energy could be provided to Kazakhstan.

16. A NESA for Indonesia is also ongoing and has now entered its final phase. A NESA for Ukraine has been delayed. The final report of the NESA for Belarus has been published as *INPRO Assessment of the Planned Nuclear Energy System of Belarus* (IAEA-TECDOC-1716).[2]

17. Experts from China, India and the Russian Federation are cooperating under INPRO Task 3 to develop terms of reference for bilateral limited scope NESA projects focusing on the detailed designs of liquid metal cooled fast reactors. The primary purpose of these bilateral NESA projects will be to test the applicability of the INPRO methodology for the assessment of detailed innovative reactor designs (to date, full scope assessments have only been performed for nuclear energy systems based on evolutionary reactors).

18. Under INPRO Task 3, all nine volumes of *Guidance for the Application of an Assessment Methodology for Innovative Nuclear Energy Systems: INPRO Manual* (IAEA-TECDOC-1575 Rev. 1), which was published in 2008, are in the process of being revised. This effort is being performed as an

[2] Available at: http://www-pub.iaea.org/MTCD/Publications/PDF/TE-1716_web.pdf.

INPRO consultancy task with the participation of Member State experts, all relevant Sections of the Agency, and expert consultants. Currently, two manuals in the areas of economics and infrastructure have been revised and accepted for publication in the IAEA Nuclear Energy Series. In addition, the revised manual on resource depletion is at the final editing stage. The draft revised manuals on reactor safety, and environmental stressors are undergoing an internal coordinated review involving all relevant Sections of the Department of Nuclear Safety and Security and the Department of Nuclear Sciences and Applications. Initial drafts of the revised manuals on waste management, proliferation resistance, and safety of the nuclear fuel cycle have not yet been completed.

19. The Agency provides the Scientific Secretary for the annual coordination meeting between the Generation IV International Forum (GIF) and the Agency. The Eighth GIF–INPRO Interface Meeting was held in Vienna in March 2014. In addition, INPRO Task 3 includes projects conducted jointly with GIF on proliferation resistance and, more recently, on economics. In the area of economics, the Agency is cooperating with the GIF Economic Modelling Working Group (EMWG) to perform benchmark comparisons between the INPRO methodology-based macroeconomics estimator code, the Nuclear Economics Support Tool, and the comparable EMWG modelling tool. In the area of reactor safety, the Agency provides the principal Scientific Secretary and co-Scientific Secretary for the series of joint GIF–Agency workshops on safety design criteria for sodium cooled fast reactors.

20. Under INPRO Task 4 ("Policy and Dialogue"), the practice of conducting two INPRO Dialogue Forums annually continues. The objectives of the INPRO Dialogue Forums are to bring together nuclear technology users, technology holders and newcomers from among all interested Agency Member States to discuss urgent topics related to nuclear energy sustainability. The Seventh INPRO Dialogue Forum was convened in November 2013 and addressed the topic of sustainability of nuclear energy systems based on evolutionary reactors. The event was attended by representatives from 32 technology holder and technology user countries and 12 reactor designers and experts on evolutionary reactor technologies from AREVA, Candu Energy, GE Hitachi Nuclear Energy, the KEPCO Engineering & Construction Company, the Korea Hydro & Nuclear Power Company, Mitsubishi and the State Atomic Energy Corporation "Rosatom". All materials of the Dialogue Forum, including the proceedings, are available at: http://www.iaea.org/INPRO/7th_Dialogue_Forum/index.html.

21. In August 2014, the eighth INPRO Dialogue Forum addressed issues related to economics, resource availability and institutional arrangements in support of achieving nuclear energy system sustainability. The ninth forum, the INPRO Dialogue Forum on International Collaboration on Innovations: Towards Globally Sustainable Nuclear Energy, will be convened in November 2014.

22. Within the framework of INPRO, the Agency is taking steps to provide regular education and training services to Member States. In October–November 2013, a Training Meeting on Evaluation of Collaborative Scenarios of Transition to Sustainable Nuclear Energy Systems Using the IAEA's Energy Supply Model MESSAGE, was held in Yogyakarta, Indonesia, with 33 participants from Agency Member States. In 2013–2014, a series of video lectures on INPRO topics were delivered to staff members and students at Russian universities. A video course for lecturers at Armenian universities is scheduled for October 2014.

23. INPRO activities evoke strong interest from Member States, which is evidenced by the ever growing number of INPRO Members. The latest country to join INPRO in 2014 was Bangladesh, bringing the total number of INPRO Members to 40.

24. Reflecting the importance of sustainability issues for nuclear energy and recognizing the achievements of INPRO to date, a decision was made by the Director General to upgrade the INPRO Group to become the INPRO Section within the Division of Nuclear Power as of 1 January 2014.

25. The important role of fast reactors and related fuel cycles for the long term sustainability of nuclear power was reaffirmed at the International Conference on Fast Reactors and Related Fuel Cycles: Safe Technologies and Sustainable Scenarios (FR13), held in Paris, France, in March 2013. The proceedings from this conference are soon to be published. The benefits of fast reactor technology include a more efficient utilization of natural resources (uranium and thorium) and a reduction in the quantity and radiotoxicity of radioactive wastes. Fast neutron systems consequently offer significant benefits in making nuclear energy production more sustainable. Fast reactors are in operation in China, India, Japan (temporarily shut down) and the Russian Federation, and several innovative fast neutron system concepts to further refine the utilization of such systems are being developed, designed or constructed in the aforementioned countries as well as in Belgium, France, Italy, the Republic of Korea and the United States of America.

26. The Agency's activities on fast reactors, funded by the Regular Budget, are progressing using, as appropriate, advice provided by the Technical Working Group on Fast Reactors (TWG-FR), which also deals with accelerator-driven systems. The TWG-FR's membership has now increased to 22 countries. The TWG-FR collaborated with GIF on the development of safety design criteria for innovative sodium cooled fast reactors (SFRs), and the next phase of this activity, involving the participation of design organizations, was initiated in June 2014. A new coordinated research project (CRP) proposed by France on sodium properties and safe operation of experimental facilities was launched in 2013. The research results of other CRPs in this area were disseminated, including in the form of technical publications and papers on the Monju and Phénix reactors. The ongoing CRP on safety tests conducted at the Experimental Breeder Reactor-II is progressing as planned. Another CRP proposed by India on source term estimation for radioactivity release under severe accident scenarios in SFRs is under preparation. The Technical Meeting on Priorities in Modelling and Simulation for Fast Neutron Systems, held in April 2014, resulted in the elaboration of a comprehensive list of priorities in the different technical areas, which will guide future Agency programmes in this field. In addition to the above-mentioned publications on completed CRPs, the booklet *Status of Innovative Fast Reactor Designs and Concepts* and the IAEA Nuclear Energy Series publication *Design Features and Operating Experience of Experimental Fast Reactors* both appeared in 2013.

27. The results of three recently completed CRPs are presented in *BN-600 MOX Core Benchmark Analysis* (IAEA-TECDOC-1700), *Benchmark Analyses on the Natural Circulation Test Performed During the PHENIX End-of-Life Experiments* (IAEA-TECDOC-1703) and *Benchmark Analyses on the Control Rod Withdrawal Tests Performed during the PHENIX End-of-Life Experiments* (IAEA-TECDOC-1742).

28. In the innovative reactors arena, high temperature gas cooled reactors (HTGRs) have an inherent safety benefit whereby extremely high temperatures can be tolerated without fuel damage, and this also provides high temperature heat (≥750°C) that can be utilized for a variety of industrial applications as well as for cogeneration. As a result, HTGRs can contribute to the total energy market in addition to electricity generation. The smaller size and simplified design (with a small number of safety systems) make HTGRs potentially attractive to Member States with small electricity grids. Furthermore, the significant process heat options far exceed the capability of light water reactors and hence make them even more attractive. The construction of the High Temperature Reactor–Pebble Bed Module (HTR-PM) industrial demonstration power plant in China (with expected operation around the end of 2017) will also make such technology available for near term deployment.

29. Agency activities under the Regular Budget in support of HTGR technology development are being implemented through two new CRPs. The first will develop harmonized safety design procedures and make proposals on safety design criteria taking the unique inherent safety characteristics of HTGRs into account. The second will study the use of HTGR process heat in mineral processing, rare earth processing, and phosphate fertilizer production from phosphate rock,

while recovering the accompanying uranium and thorium impurities, which should make this a more sustainable and value adding proposition. The two ongoing CRPs in this area include studies of the irradiation creep behaviour of nuclear graphite (to predict plant lifetime and ensure that the graphite used as reactor core structural material can fulfil its safety functions) and uncertainty analysis in reactor physics, thermal hydraulics and burnup (to ensure adequate margins in operation and safety analysis). Other areas of study include the need for high-temperature qualification of materials and the development of 'deep burn' concepts based on HTGR designs using coated particle fuel for the incineration of nuclear waste, surplus fissile materials and disposition of plutonium.

30. In the area of water cooled reactors (WCRs), two CRPs have been launched relating to the development of new reactor designs and dealing with the use of computational fluid dynamics for reactor design and the study of thermal-hydraulics phenomena relevant to supercritical WCRs. The CRP entitled "Prediction of Axial and Radial Creep in Pressure Tubes" addresses the current and new generation of heavy water reactor (HWR) designs. The International Collaborative Standard Problem on natural circulation flow stability in the integral pressurized water reactor design and thermo-hydraulic coupling of containment and primary system during accidents affecting such reactors was completed in 2013. In the area of knowledge transfer, a Course on Physics and Technology of Water Cooled Reactors through the Use of PC-based Simulators was conducted jointly by Tecnatom and the Agency in Madrid, Spain, in November 2013, and a Joint ICTP–IAEA Course on Natural Circulation Phenomena and Passive Safety Systems in Advanced Water Cooled Reactors was held at the International Centre for Theoretical Physics (ICTP) in Trieste, Italy, in December 2013. In all these activities the Agency cooperated with international organizations such as the Nuclear Energy Agency of the Organisation for Economic Co-operation and Development, the World Nuclear Association and the European Commission.

31. In 2013 and 2014, the Agency saw an increase in the participation of Member States in its programme for the technology development of small and medium sized reactors. The current driving forces in the development of such reactors include: fulfilling the need for flexible power generation for a wider range of users and applications; replacing the ageing fossil fuel-fired power plants; enhancing safety performance through inherent and passive safety features; offering better economic affordability; suitability for non-electric applications; options for remote areas; and synergetic energy systems that combine nuclear and renewable energy sources. For newcomer countries, however, one of the challenges is how to reconcile the dilemma of advanced reactor designs versus proven technology. Recently, the trend of development has been towards design certification of small modular reactors (SMRs), which are defined as advanced reactors that produce less than 300 MW(e) of equivalent electric power and that have been designed to be built in factories and shipped to utilities for installation as demand arises. Some of them are to be deployed as multiple-module power plants. For water cooled SMRs, modularity is achieved by integrating major components of the primary systems into the reactor vessel. Several countries are pioneering the development and application of transportable NPPs, including floating and marine-based SMRs.

32. In 2013 and to date in 2014, three reactors in the SMR category are under construction in Argentina (CAREM 25, an industrial prototype), the Russian Federation (KLT-40S, a barge mounted floating power unit) and in China (HTR-PM, an industrial demonstration plant). Dozens of innovative SMR designs are under development for near term deployment, including in the United States of America (B&W mPower and NuScale's SMR design, both of which received government funding for design certification review, as well as the Westinghouse SMR and the Holtec SMR-160). The system-integrated modular advanced reactor from the Republic of Korea is the only design that has already obtained standard design approval from a national government. The China National Nuclear Corporation is developing the ACP100 design and will submit its preliminary safety analysis report to the National Nuclear Safety Administration in mid-2014 for construction in 2016.

33. In order to better address accident scenarios, the Agency published *Benchmarking Severe Accident Computer Codes for Heavy Water Reactor Applications* (IAEA-TECDOC-1727), and Technical Meetings were conducted to address HWR moderator sub-cooling requirements to demonstrate the backup heat sink capabilities of moderators during accidents, and the prediction of axial and radial creep in HWR pressure tubes. In support of the next generation of integrated light water reactors, the Agency published *Evaluation of Advanced Thermohydraulic System Codes for Design and Safety Analysis of Integral Type Reactors* (IAEA-TECDOC-1733).

34. In response to the R&D actions proposed in the IAEA Action Plan on Nuclear Safety, an international experts' meeting (IEM) is being planned to exchange information and experience on R&D activities related to severe accidents in NPPs. The IEM will assist Member States in planning and implementing R&D activities in nuclear safety, technology and engineering for existing NPPs and in the design of new NPPs. Secondly, a software-driven symptom-based accident management toolkit (SAMT) is being developed that will permit access to existing publications and present accident scenarios together with generic guidance. It is envisioned that the Agency will offer regional workshops to assist Member States in utilizing SAMT as a reference tool and in developing plant-specific severe accident management guidelines.

35. Further work is being carried out in support of the IAEA Action Plan on Nuclear Safety through a CRP entitled "Fuel Modelling in Accident Conditions" (FUMAC). The fuel modelling being considered under this CRP is an example of an 'enabling technology', facilitating not only an enhanced understanding of the behaviour of fuel under accident conditions, but also the development of innovative fuels with improved accident tolerance. Concurrent with the FUMAC project, a CRP on improving the accident tolerance of nuclear fuels has been opened for proposals, and a first Technical Meeting is now being planned for late 2014. Two IAEA Technical Documents, *Design, Manufacturing and Irradiation Behaviour of Fast Reactor Fuel* (IAEA-TECDOC-CD-1689) and *In-pile Testing and Instrumentation for Development of Generation-IV Fuels and Materials* (IAEA-TECDOC-CD-1726), have been published and work is progressing on the production of two further IAEA Technical Documents with the provisional titles *Trends in the Development of Advanced Fuels for Fast Reactors* and *Characterization and Thermophysical Properties of Advanced Fuels*.

Producing Potable Water Economically Using Small and Medium Sized Nuclear Reactors

A. Background

1. In resolution GC(57)/RES/12.A.4, the General Conference noted that in many regions of the world there was growing concern about potable water shortages created as a result of population growth, increased urbanization and industrialization and the effects of climate change. Seawater desalination using nuclear energy is a potential solution that could help alleviate such water shortages and the technology has been successfully demonstrated through various projects in some Member States. Seawater desalination using nuclear energy is generally cost-effective and further support in this area has been requested by Member States.

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 encouraged the Technical Working Group on Nuclear Desalination (TWG-ND) to continue as a forum for advice and review on nuclear desalination activities, and encouraged support for the enhancement of the scope of the TWG-ND to address challenges related to integrated water resources management (IWRM) in the efficient use of water in nuclear facilities, which may involve the use of seawater desalination. The General Conference requested the Director General, subject to the availability of resources, to: (a) develop a report that provides generic guidance on cogeneration options and assesses the economics associated with such options; and (b) continue to hold regional training workshops and Technical Meetings and to use other available mechanisms for disseminating information on nuclear desalination and water management using small and medium sized reactors (SMRs); and (c) to undertake further activities aimed at better establishing how existing reactors may offer options for cogeneration. The General Conference requested that the Director General note the high priority given by interested Member States to the nuclear desalination of seawater in the process of preparing the Agency's Programme and Budget, and to report on progress to the Board of Governors and to the General Conference at its 58th regular session in September 2014. This report has been issued in response to that request.

B. Activities of the Agency

3. No meeting of the TWG-ND has been held since the 57th regular session of the General Conference in September 2013 as the Working Group is scheduled to convene every two years. However, in the meantime, the Agency has enhanced the scope of the TWG-ND to encompass IWRM activities specifically relating to the efficient use of water in nuclear facilities. The TWG-ND will next meet in early 2015.

4. In May 2014, a Technical Meeting bringing together representatives from the DEEP Users Group was held in Vienna, as a forum for the exchange of information on the utilization and robustness of the Agency-developed Desalination Economic Evaluation Program (DEEP). The meeting provided an

opportunity to disseminate the results of the latest research and development (R&D) activities relating to seawater desalination using nuclear energy, as well as to discuss the evolving use of the DEEP software and to evaluate new ideas for improving and updating DEEP in order to make the software more beneficial and user-friendly.

5. In September 2014, a consultants' meeting on cogeneration options and their economic assessment was held in Vienna. The aim of this meeting was to discuss the benefits of cogeneration using non-electric applications, steps for end users to implement non-electric applications, and to address frequently asked questions related to non-electric applications. The meeting concluded that existing reactors could only be used for low temperature applications such as district heating and desalination, whereas other types of reactors that provide high temperature process heat were still under development and required further investment of money and time to reach the deployment stage. It was recognized that the successful deployment of cogeneration technologies involves several stakeholders, including owners, vendors, stakeholders, end users and safety authorities. This meeting will be followed by another consultants' meeting late in December 2014 on the same topic.

6. Since September 2013, the Agency has launched a new coordinated research project (CRP) on the application of advanced low temperature desalination systems to support nuclear power plants (NPPs) and non-electric applications. The main objectives of the CRP are to enhance international collaboration among Member States on low temperature desalination systems, develop recommendations on the application of advanced low temperature desalination systems to supply NPPs with water of required quality and quantity, and provide detailed case studies on the economics of cogeneration using waste heat from NPPs for non-electric applications. The CRP will encompass the assessment of the economics of SMRs and large NPPs for single application use or cogeneration, including nuclear desalination.

7. In July 2014, a Training Course on Water Management in Nuclear Power Plants was held in Vienna as a forum for the exchange of information and good practices relating to strategies that help reduce water use and consumption in NPPs and to provide training on the estimation of water needs in NPPs based on the type of cooling systems employed. Participants were trained in the use of the newly developed Agency toolkit for efficient water management in NPPs, the Water Management Program in Nuclear Power Plants (WAMP).

8. Also in July 2014, a separate consultants' meeting was held in Vienna on water management programmes at NPPs. The aim of this meeting was to discuss a potential update of *Efficient Water Management in Water Cooled Reactors* (IAEA Nuclear Energy Series No. NP-T-2.6) and to prepare an annex containing details of the water management programme at the Palo Verde NPP, where reclaimed water is used as a main source for cooling the three reactor units in this plant. As the WAMP toolkit is still undergoing further development, the experts participating in the meeting also discussed how to update the software so as to incorporate feedback received, and how to make the toolkit more robust and less prone to malfunctioning.

9. In October 2014, a Technical Meeting on Advances in Non-Electric Applications of Nuclear Energy and Efficiency Improvement at Nuclear Power Plants will be held at the University of Ontario, Institute of Technology (UOIT), Canada. The purpose of the meeting is to exchange information on prospects and challenges relating to non-electric applications of nuclear power; to assess the technical and economic aspects of cogeneration and utilization of electricity and useful heat at NPPs; and to explore approaches and strategies for improving efficiency at existing NPPs.

10. In support of the Agency's activities in the field of non-electric applications of nuclear energy, a new Professional staff post for an Associate Nuclear Engineer (P-2) has been established within the Department of Nuclear Energy.

C. Activities in Member States

11. In Argentina, for the purpose of the development of the non-electric applications of the CAREM reactor, the National Atomic Energy Commission (CNEA) has decided to set up a permanent group to carry out studies and R&D work in this area. The working group is based at the CNEA's Department for Chemistry and Processes in Nuclear Installations, which is participating in the CAREM project. The technical coupling of multi-effect distillation (MED) and reverse osmosis (RO) processes in hybrid MED–RO systems for the prototype CAREM-25 NPP has been analysed. In order to minimize the impact of coupling desalination technologies attached to the reactor's secondary coolant circuit, different configurations have been studied, taking into account thermodynamic aspects. The results obtained from these studies are being used in both the ongoing conceptual engineering of the coupling and the financial–economic assessments that are being carried out. In relation to the experimental facilities, the group is working on the design and specifications for a modular device for implementation of the MED concept in an integrated and compact heat exchanger. In this respect, the construction of an experimental loop is planned to validate the actual MED concept that is developed, as well as the coupling of RO systems to an NPP prototype, either as individual technologies or in a hybrid configuration. The first stage of the experimental loop construction will involve constructing and commissioning a heat supply system to provide steam to the MED and RO systems. The commissioning of the NHSS device is expected to take place in early 2015.

12. In Canada, studies have been carried out at the UOIT on the development of nuclear based integrated systems for seawater desalination. The desalination subsystems include both thermal technologies (multi-stage flash distillation and MED) and membrane technologies (e.g. RO). The proposed integrated systems produce multi-purpose heat (in the form of process and waste heat), power from the NPPs, hydrogen from electrolysis and/or copper–chloride cycles (a hybrid process with both thermochemical and electrolysis steps), and cooling through multi-effect cooling system pumps. These integrated systems are thermodynamically analysed through energy and exergy analysis methods, and their effectiveness is assessed in terms of both energy and exergy efficiencies. Parametric studies are conducted to investigate the effects of varying the operating conditions and thermodynamic properties on the overall system efficiencies, the amounts of fresh water and hydrogen produced, cooling effect, heat load, etc. The cost of the product water is estimated to be \$2.451/m^3 and \$54.2/MJ when source water with salinity of 35 000 ppm is fed into such integrated systems.

13. In China, several NPPs are under construction in coastal areas that will rely on seawater desalination to meet their water needs. The RO desalination process is the dominant one for all these new builds. At the site of the Haiyang NPP in Shandong province, a RO desalination plant is being constructed. Another RO plant was commissioned in 2013 for the Xudabao NPP in Liaoning province. An RO plant with a capacity of 11 000 m^3/day is being considered for the Ningde NPP in Fujian province. In addition, research is being carried out into nuclear desalination using an MED system coupled to a small modular reactor with a nominal thermal power capacity of 100-110 MW(th). A further nuclear desalination project involving the coupling of MED technology to a small modular reactor mounted on an ocean or offshore platform was launched in 2012 and is being supported by the Ministry of Science and Technology. The Chinese Government has also initiated discussions to establish cooperation with the Russian Federation on this latest project.

14. In India, there is a requirement for large, medium and small size desalination and water purification units to operate as part of an IWRM programme. The Nuclear Desalination Demonstration Plant in Kalpakkam, which uses hybrid multi-stage flash (MSF)–RO technology and has a combined production capacity of 6300 m^3/day, is coupled to Madras Atomic Power Station (MAPS). High quality distilled water produced by MSF distillation is supplied to MAPS for high-end applications. The remainder is supplied to a water reservoir along with potable water produced by RO. India has

experience with different types of coupling mechanisms and isolation loops for nuclear desalination plants. It is planned to integrate a multi-effect distillation–thermal vapour compression (MED–TVC) nuclear desalination plant (consisting of three units, each with a capacity of 800 m^3/day) with an advanced heavy water reactor. It is also planned to set up a hybrid seawater desalination plant based on indigenous RO–MED technology at one of the sites of the Department of Atomic Energy. In view of the successful demonstration of nuclear desalination in India, the opportunity now exists to provide technical training there on nuclear desalination to interested Member States through the Agency's technical cooperation programme. Research activities are being undertaken on the environmental aspects of nuclear desalination as well as on zero liquid discharge concepts. It is proposed to organize the 2015 Trombay Symposium on Desalination and Water Reuse in Mumbai in January 2015, and this will feature a technical session exclusively devoted to nuclear desalination and IWRM.

15. In the Republic of Korea, a study on coupling the system-integrated modular advanced reactor (SMART), a 330 MW(th) integral-type pressurized water reactor, to a desalination plant (of the MED–TVC type) has been completed. This configuration is expected to achieve a total purified water production capacity of 40 000 m^3/day, as well as a power output of 90 MW(e). The study followed on from a similar one conducted several years ago. The findings of this latest study will be reflected in the final design of the SMART-based nuclear desalination plant.

16. In Pakistan, a nuclear desalination demonstration plant (NDDP) with a capacity of 1600 m^3/day has been coupled with the Karachi NPP (commissioned in January 2010) and is still operating. The safe operation of the NDDP has paved the way for a larger desalination plant coupled with an NPP. The remineralization of product water and the successful use of such remineralized water for drinking purposes have recently further strengthened the claim for the safe operation of nuclear desalination. In Pakistan, the annual per capita availability of potable water has been decreasing at a very alarming rate. Whilst it was 1672 m^3 in 1990, it is forecast to be only 837 m^3 in 2025. Below an annual per capita availability of 1000 m^3, chronic water stress is experienced. Large scale desalination plants are the only solution to meet this challenge. The high cost of product water is an impediment to the supply of desalinated water to large segments of the population in Pakistan.

17. In the Russian Federation, a floating NPP for desalination and/or district heating is under consideration. Other countries are also investigating or considering launching nuclear desalination programmes, either on a national or a multilateral basis, and the feasibility of integrated nuclear desalination plants is being analysed at various levels. These countries include Indonesia, Jordan, Kuwait, Oman, Qatar, Saudi Arabia and the United Arab Emirates.

Nuclear Knowledge Management

A. Background

1. In resolution GC(56)/RES/12.B.3, the General Conference, aware of continuing concerns about a shortage of personnel in nuclear fields and about a possible erosion of the nuclear knowledge base, recognizes that preserving and enhancing nuclear knowledge and ensuring the availability of qualified manpower are vital to all aspects of human activity related to the continued and expanded safe and secure utilization of all nuclear technologies for peaceful purposes. The General Conference also recognizes that nuclear knowledge management (NKM) involves education and training for succession planning and also the preservation or enhancement of existing knowledge in nuclear science and technology.

2. Recognizing that nuclear knowledge management is a cross-cutting issue that is important to all activities of the Agency and its Member States, the Secretariat was requested to continue to strengthen its current and planned efforts in this area. Doing so, in a holistic, interdepartmental manner, while consulting and engaging with Member States and other relevant international organizations, the Secretariat will seek to increase awareness regarding the creation, preservation and sharing of nuclear knowledge and experience

3. The General Conference requested the Director General to report on progress made to the Board of Governors and to the General Conference at its 58th session and every second year thereafter. This report responds to that request.

B. Strengthening Nuclear Knowledge Management

4. The Agency continues its nuclear knowledge management activities focused on formulating and providing guidance and services, facilitating knowledge sharing networks, developing pilot projects, and fostering and supporting nuclear education and training. Current activities are also driven by the IAEA Action Plan on Nuclear Safety related to capacity building, including human resources development, education and training, knowledge management and knowledge networks, which was prepared in response to a recommendation of the IAEA Ministerial Conference on Nuclear Safety held in 2011. The nuclear safety and security knowledge management process has been updated to preserve and capture the Secretariat's knowledge in nuclear safety and security, including enhancing internal knowledge transfer.

5. In response to requests arising from the 56th session of the General Conference to ensure sustainability of nuclear education and training, and the request to address needs of developing countries or those considering or launching a nuclear power programme, the meetings held by the Agency in 2013 and 2014 addressed new topics, such as: the development of a results-based methodology for a national nuclear education capability assessment and planning framework, being piloted with the AFRA Network for Education in Nuclear Science and Technology (AFRA-NEST); a new initiative to focus on NKM issues and approaches on new build projects in expanding and newcomer countries; and the facilitation of interregional university collaboration in the establishment of full master's level degree programmes in nuclear management education.

6. Recognizing the increasing importance of managing design knowledge over the nuclear facility life cycle, maintaining it through different phases in an effective manner for the safe and efficient utilization of nuclear technology, in both newcomer countries and countries with existing nuclear power programmes, the Secretariat is currently developing related documentation and services. The main objective of the initiative is to raise awareness among managers in nuclear organizations of the need to develop a strategic approach to proactively manage the risks of knowledge loss, as well as to enable nuclear organizations to retain, transfer and utilize this knowledge to maintain and develop the competences of new and existing workforce personnel. Meetings on this topic and on modern plant information models are scheduled for late 2014.

C. Building Capacity and Implementing Nuclear Knowledge Management

7. The Nuclear Energy Management School (NEMS) at the International Centre for Theoretical Physics (ICTP), Trieste, Italy, is an annual event to introduce young professionals from developing countries to the principles of effective nuclear energy programme management. This event has witnessed growing interest since it was first held in 2010. To date, 178 participants from 61 countries have graduated from the NEMS. The Agency has also received over 300 applications for the November 2014 NEMS. Japan has also hosted a NEMS on an annual basis since 2011, specifically for the Asia region. The host institute is the University of Tokyo and the organization of the NEMS is supported by the Japanese Government. NEMSs were also held for the South and North American regions, hosted by the Texas A&M University, USA, in 2013. Several more countries have approached the Agency and expressed interest to host NEMSs for their regions in the future, including the Russian Federation, South Africa and the United Arab Emirates.

8. The Agency conducted the International Conference on Human Resource Development for Nuclear Power Programmes: Building and Sustaining Capacity from 12 to 16 May 2014 at the Agency's Headquarters in Vienna. The conference provided a forum for exchanging experience and information on all aspects of capacity building, including human resources development, knowledge management, education and training and knowledge networks. The meeting attracted over 300 participants from 65 countries and five international organizations. Participation was very broad, including a good balance of participants from newcomer countries, countries with expanding nuclear power programmes, and countries with 'mature' nuclear energy programmes that are facing new NKM challenges related to decommissioning, waste management and environmental remediation. The conference also attracted participation from various types of nuclear institutions, ranging from facility operators to regulators to academia.

9. An increased number of Member States included knowledge management components in national and regional technical cooperation (TC) projects and are providing extrabudgetary funds to the Agency for this purpose, such as Japan, the Republic of Korea, the Russian Federation and the USA. Such contributions in the form of funding and cost-free experts have led to many successes, such as the production of some of the interactive e-learning modules explaining the Milestones approach to introducing a nuclear programme. These are available on the Agency's website and the Cyber Learning Platform for Nuclear Education and Training (CLP4NET).

10. In the area of human health, several initiatives were developed to preserve and enhance knowledge: e-learning modules in nuclear medicine were created, new training material on medical

physics was published, and regular training programmes in the area of nuclear instrumentation were provided.

11. The annual School of Nuclear Knowledge Management is celebrating 10 years of successful cooperation between the Agency and the ICTP. The School is enjoying growing popularity, receiving over 160 applications annually. Between 30 and 40 young professionals from developing countries are trained each year, depending on funds available. The School uses blended teaching techniques and provides a basic understanding of NKM tools and challenges, as well as opportunities for sharing experiences and good practices with peers and experts. In the past 10 years, more than 300 young professionals have attended the School. Responding to Member State requests, the first regional School of Nuclear Knowledge Management will be held in 2014 at the Korea Atomic Energy Research Institute, Republic of Korea, with the support of the Korean Government and TC project RAS/0/064.

12. The Agency's knowledge management assist visits focus on activities aimed at helping interested Member States to assess their knowledge management, nuclear education and human resource development needs and identify ways to address those needs by formulating country-specific policies, based on the application of best practice NKM techniques. These assist visits have been undertaken in Armenia, Belarus, Bulgaria, China, Estonia, the Islamic Republic of Iran, Kazakhstan, Lithuania, Malaysia, the Russian Federation, Slovakia, Thailand, Ukraine and the United Republic of Tanzania, and have been funded by both the Regular Budget and the Technical Cooperation Fund.

D. Applying Nuclear Knowledge Management to Development

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

14. In Africa, TC project RAF/0/041, focuses on sharing best practices in preventive maintenance of nuclear equipment among the participating countries including a maintenance programme, technical documentation and quality control procedures that can be shared among the professionals in the Member States. TC project GHA/0/012, 'Establishing the Postgraduate School of Nuclear and Allied Sciences for the Preservation, Maintenance and Enhancement of Nuclear Knowledge, Phase II', focuses on ensuring the safe and successful use of nuclear techniques. Six regional and six national training courses provided support for sharing and transferring of knowledge.

15. In Asia and the Pacific, at least four regional projects are making significant contributions to building capacities, including RAS/2/016, "Supporting Decision Making for Nuclear Power Planning and Development — Phase II", and RAS/9/064, "Strengthening the Transfer of Experience Related to Occupational Radiation Protection in the Nuclear Industry and Other Applications Involving Ionizing Radiation". TC project RAS/0/060, "Enhancing Capacity for Effective Use and Maintenance of Nuclear Instrumentation", supports the region through the transfer of knowledge and the provision of effective practical experience in order to carry out training, maintenance, repair, calibration and quality control of nuclear instrumentation. TC project RAS/0/064 promotes the use of CLP4NET in the region, facilitating access to the educational resource and teaching experience.

16. In the Latin America region, under TC project RLA/0/048, "Networking for Nuclear Education, Training, Outreach and Knowledge Sharing", which provides support to the projects of the Latin American Network for Education in Nuclear Technology (LANENT), six professionals were trained at the Nuclear Knowledge Management School. A LANENT web page was developed, providing information on all aspects of preserving and promoting nuclear knowledge within this network, as well as an integrated database on nuclear education, to be hosted in the region and used for information exchange by the main nuclear education networks acting worldwide.

17. In the Europe region, the capability of national experts was enhanced through four expert missions, two fellowships and three scientific visits to enhance the capacity of qualified experts in the nuclear field under project CZR/0/007.

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

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

19. Safety services such as the Integrated Regulatory Review Service, Operational Safety Review Team, Design and Safety Assessment Review Service, Safety Evaluation of Fuel Cycle Facilities During Operation are based on the Agency's safety standards, which further enhance knowledge management, information sharing and feedback. Most activities in the area of nuclear safety and security have contributed to fostering networking and the exchange of information and the sharing of knowledge among Member States.

20. The integrated concept of capacity building includes four essential elements: education and training; human resource development; knowledge management; and knowledge networks. Progress was made by developing guidance for conducting self-assessments for capacity building, in particular self-assessments of knowledge management within the organizations. The Agency has also developed a Fukushima Daiichi accident knowledge base to ensure that lessons learned are captured, retained and disseminated in a structured and consistent manner.

21. The Education and Training Review Service, which includes guidelines for self-assessment, has been developed and is being used by Member States, including most recently, the Pakistan Nuclear Regulatory Authority in September 2013.

22. The Postgraduate Educational Course in Radiation Protection and the Safety of Radiation Sources has continued to provide a pool of future experts in radiation protection. Short term training events cover a wide range of topics. The full list of training events for 2013 and 2014 is available on the Agency's website.

23. State systems of accounting for and control of nuclear material (SSACs) are fundamental for efficient and effective safeguards implementation. To help Member States establish and strengthen their SSACs, the Agency conducted IAEA SSAC Advisory Service (ISSAS) missions in the Republic of Moldova and Tajikistan in 2013, and Kyrgyzstan and the United Arab Emirates in 2014, at the request of the States concerned.

24. 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 22) was published in April 2013 to enhance their understanding of relevant safeguards obligations. To provide States with a mechanism for sharing experience and good practices in fulfilling various aspects of their obligations under their respective safeguards agreement, four 'Safeguards Implementation Practices Guides' will be published in 2014 and 2015.

F. Strengthening Nuclear Knowledge Sharing Networks

25. National, regional and interregional networks support NKM by facilitating the exchange of information, education and training and promoting human resources development. The Asian Network for Education in Nuclear Technology (ANENT), LANENT and AFRA-NEST, established in collaboration with the Agency in 2004, 2011 and 2013 respectively, cooperate in education, capacity building and knowledge management, supported by the Agency through seminars, workshops and training courses organized, either under the Regular Budget or with TC support, in the regions or at Agency Headquarters. There is also growing interest in forming a new regional nuclear education network with universities in the region of the Commonwealth of Independent States. A consultancy meeting was held in early 2014 and steps are being taken in collaboration with the Agency to facilitate the establishment of this new nuclear education network.

26. Over the past two years, special attention has been given to initiating collaboration at the interregional level with other established nuclear education networks such as the European Nuclear Education Network (ENEN) Association. In this connection, a common action plan for educational networks from ANENT, LANENT, AFRA-NEST and the ENEN Association was signed during a side event on networks for collaboration in nuclear education at the 57th session of the General Conference, prioritizing interregional activities on, *inter alia*, human resource development, the use of ICT, and outreach to support high quality nuclear education.

27. In the area of nuclear safety, the Global Nuclear Safety and Security Network continued to strengthen the global nuclear safety and security framework. In addition, regional networks and forums are valuable in improving safety and security at the regional and international levels. These regional networks and forums are the Asian Nuclear Safety Network (ANSN), the Arab Network of Nuclear Regulators, the European Nuclear Safety Regulators Group, the European Technical Safety Organisations Network, the Forum for Nuclear Regulatory Bodies in Africa and the Ibero-American Forum of Radiological and Nuclear Regulatory Agencies (FORO), and other thematic networks, such as the International Regulatory Network (RegNet), the Regulatory Cooperation Forum (RCF) and the Technical and Scientific Support Organization Forum. The RCF connects embarking countries with countries with mature nuclear power programmes to provide the necessary assistance in capacity building efforts. An example of activities implemented within the regional networks is the workshop on knowledge management which was held in China (September 2013) within the scope of the ANSN's and the FORO's project on strengthening regulatory competence.

28. The Agency's waste management networks comprise the International Decommissioning Network, the International Low-Level Waste Disposal Network, the Underground Research Facilities Network, the Network on Environmental Management and Remediation, and the International Network of Laboratories for Nuclear Waste Characterization.

29. The waste management networks mentioned above are linked together under the Agency's web-based platform Connecting the Network of Networks for Enhanced Communication and Training

(CONNECT). The platform has been launched in stages to limited network participants on a select number of topics to gain feedback and to correct problems before general release. CONNECT will allow all network participants to communicate directly with one another via workspaces for 'communities of practice' and to share learning materials and information. Benefits to participants will include the efficient sharing of technical solutions to waste management challenges, the accelerated adoption of best practices and enhanced peer-to-peer contacts, especially between those with developed and less developed programmes.

30. In response to a General Conference request in 2012 to "further develop and utilize e-learning technologies and methods to make nuclear knowledge more broadly available in a modern, effective and efficient manner", CLP4NET was further enhanced. The homepage of CLP4NET now includes an open learning management system for public access and self-study, a password-protected learning management system for tutor driven courses, and an integrated database on education and training, as well as links to the regional and local installations of CLP4NET.

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

32. The International Nuclear Information System, in collaboration with 129 Member States and 24 international organizations, provides the public with 3.6 million records, and has increased membership of the International Nuclear Library Network to 50 research institutes, libraries and nuclear regulatory authorities from 31 countries, and improved information services offered by the IAEA Library.

33. Research reactors (RRs) can be effectively utilized as tools to support nuclear capacity building in Member States that are interested in educating human capital for future nuclear science and technology programmes, including nuclear power. In this regard, the Agency's Internet Reactor Laboratory (IRL) project creates a virtual reactor in a remote location by linking an available and well-suited host reactor with university classrooms in neighbouring States via the Internet. The IRL project will be fully implemented in the Latin America region (with Argentina providing the host reactor) by the end of 2014 and is expected to be implemented in the Europe and Africa regions (with France providing the host reactor) by the end of 2015 and in the Asia region by the end of 2016.

34. The Agency is developing a compendium on research reactor utilization for higher education programmes, which will include detailed information on the experimental laboratory protocols, required facilities and practical implementation to be shared with the RR community. The compendium should be useful to guide Member States embarking on a new RR project to better identify the capabilities of each type of reactor for educational purposes; improve and enhance utilization of existing underutilized RRs; guide university professors in identifying RR experiments that could be included in the academic curricula; and help RR operators to identify potential stakeholders and users in academia and to set up experiments at their RR facility. A Technical Meeting for the development of the compendium was held in June 2014 and the document is expected to be finalized by the end of 2015.

35. The World Nuclear University (WNU) is a global partnership committed to enhancing international education and leadership in the peaceful applications of nuclear science and technology. Among WNU activities is the Summer Institute (SI), an intensive six-week programme for future leaders in nuclear science and technology. Since the SI's inception in 2005, a total of 800 fellows from

more than 70 countries have completed the WNU SI programme. The Agency supports the WNU by providing some lecturers for its courses and financial support for fellows.