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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(50)/RES/13 and GC(51)/RES/14, this document contains progress reports on: support to the African Union's Pan African Tsetse and Trypanosomosis Eradication Campaign (AU-PATTEC) (Annex 1); the development of the Sterile Insect Technique for the control of mosquitoes (Annex 2); nuclear energy activities (Annex 3); nuclear knowledge management (Annex 4); infrastructure development for nuclear power (Annex 5); innovative nuclear technology (Annex 6); and producing potable water using nuclear reactors (Annex 7). A new Agency report on *Financing New Nuclear Power Plants* (NG-T-4.2), which was also requested in the above referenced resolutions, is summarized briefly in Annex 3.

- Further information on the Agency's activities related to nuclear science, technology and applications can be found in the *Nuclear Technology Review 2008* (document GC(52)/INF/3), the Agency's *Annual Report 2007* (GC(52)/9), in particular the Technology section, and the *Technical Cooperation Report for 2007* (GC(52)/INF/5).

- Further to General Conference resolution GC(50)/RES/13, General Conference resolution GC(51)/RES/14 requested that the Secretariat provide, "a separate biennial comprehensive report on international status and prospects of nuclear power, beginning in 2008". For 2008, that report is provided as GOV/INF/2008/10-GC(52)/INF/6. The report, with updates as required, will also be provided as a separate annex in the *Nuclear Technology Review 2009*. Subsequent biennial reports on the international status and prospects of nuclear power will also take the form of annexes in the *Nuclear Technology Review*. In the years between these reports, the *Nuclear Technology Review* will include similar annexes on the status and prospects of selected nuclear applications in food and agriculture, water resources, human health and environmental protection. This reporting sequence is designed to facilitate discussions at the Board of Governors on these issues.

Recommended Action

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

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

A. Background

1. At its fifty-first session in September 2007, the General Conference, through resolution GC(51)/RES/14.A-3, appreciated the continuous support of the Agency to Member States in their efforts to build capacity and further develop the techniques for integrating the sterile insect technique (SIT) with other control techniques in creating tsetse-free zones in sub-Saharan Africa. The General Conference also appreciated the contributions provided by some Member States and United Nations specialized agencies in support of these efforts and welcomed the special donors' conference organized in February 2007 in Addis Ababa by the African Union and the African Development Bank to generate further loans and grants for additional countries embarking on subregional tsetse and trypanosomosis (T&T) control programmes. It called upon Member States to strengthen the provision of technical, financial and material support to African States in their efforts to create tsetse-free zones and requested the Secretariat, in cooperation with Member States and international organizations, to continue – through Regular Budget activities under the Joint FAO/IAEA Programme and the Technical Cooperation Fund – supporting R&D and technology transfer to African Member States in order to complement their efforts to create and subsequently expand tsetse-free zones. The General Conference stressed the need for continued cooperation with the Commission of the African Union and other regional and international partners, particularly FAO and WHO, with the aim of harmonizing efforts in line with the AU-PATTEC Plan of Action and providing guidance and quality assurance in planning and implementing national and subregional AU-PATTEC projects, and requested the Director General to report on the progress made in the implementation of this resolution to the Board of Governors and to the General Conference at its fifty-second (2008) regular session.

B. Developments since the General Conference's 2007 session

2. In light of soaring food prices, amid challenges of climate change, energy security and the need for urgent and decisive action to address food security issues, the Agency's contribution to agricultural development, particularly in African Member States, is of increasing importance. In this context, the transfer of SIT as part of area-wide integrated pest management (AW-IPM) to create, in selected areas, zones that are free of tsetse flies and the disease they transmit, addresses a key problem at the root of rural poverty.

3. In 2007-2008, the Agency continued to foster its partnership with AU-PATTEC and to contribute to the implementation of the AU-PATTEC Plan of Action through one regional, and ten national technical cooperation projects in Botswana, Burkina Faso, Ethiopia, Kenya, Mali, Senegal, South Africa, Uganda, the United Republic of Tanzania and Zimbabwe. Under these projects, the Agency continued to assist its Member States with feasibility assessment, capacity building and pre-

operational support on tsetse SIT, largely through the provision of training, expert services and equipment.

4. The six AU-PATTEC coordinated projects (Burkina Faso, Ethiopia, Ghana, Kenya, Mali and Uganda – referred to as the "AU-PATTEC List-I" countries), continue to face difficulties in achieving tangible progress. Within their respective mandates, FAO, WHO and the IAEA have provided advice to these countries on project planning and implementation. The technical assistance provided by the Agency during the reporting period to the AU-PATTEC List-I countries was acknowledged by the National PATTEC Coordinators at international meetings, in particular the development of several manuals and guidelines, which were deemed useful for the national AU-PATTEC projects. The 'FAO/IAEA Guidelines for Collection of Tsetse Baseline Data for Area-Wide Integrated Pest Management Programmes' is expected to be published under the FAO Animal Health Series in late 2008, and earlier drafts of these guidelines have already been used by the national AU-PATTEC coordinators and other counterparts for the planning and implementation of standardised baseline data collection in preparation of tsetse control / eradication projects.

5. In October 2007, the African Union International Scientific Council for Trypanosomosis Research and Control (AU-ISCTRC), recommended that projects use the FAO/IAEA document "Guidelines to Assessing the Feasibility of Creating Tsetse and Trypanosomosis-Free Zones" to clearly assess the feasibility of project implementation. The ISCTRC also recommended that prerequisites identified in the Guidelines for successful planning, preparation, and implementation of tsetse AW-IPM be in place before embarking on the operational phase of a tsetse eradication project.

6. In January 2008, the IAEA Secretariat's annual review to assess progress confirmed the relevance of the Agency's approach to providing appropriate technical support, as needed, to ongoing tsetse projects in Member States, with special focus on a relatively advanced project in Ethiopia, as well as projects in Senegal and South Africa/Mozambique. The review concluded that the Agency continues to adhere to the phased and conditional planning and implementation approach supported by FAO and WHO.

7. The Southern Rift Valley Tsetse Eradication Project (STEP) in Ethiopia is the largest tsetse control programme in sub-Saharan Africa with which the Agency is associated. The STEP's objective is to create a T&T-free zone in a 25 000 km² area, thereby generating an environment conducive to livestock development and improved agricultural production. The Agency continued to support STEP under TC project ETH/5/012 — Integrating Sterile Insect Technique for Tsetse Eradication. The Agency and the FAO continued implementing activities under the two-year Japanese-funded United Nations Trust Fund for Human Security (UNTFHS) project entitled "Establishing a Zone Free of the Tsetse and Trypanosomosis Problem in the Southern Rift Valley, Ethiopia, and Assisting Rural Communities in Agricultural and Livestock Development". Special emphasis was placed on increasing the mass-reared tsetse colonies at the STEP Kaliti Tsetse Rearing and Irradiation Centre in Addis Ababa, initiating intense tsetse suppression and identifying specific rural development opportunities for communities in the project area.

8. The STEP tsetse mass-rearing benefited from two new recently equipped fly rearing modules and the availability of two strains of the main target species (*Glossina pallidipes*), each serving as a back-up for the other. In addition, the colonisation of the second tsetse species (*Glossina fuscipes fuscipes*) that is present in a small part of the project area has been initiated. In the field, pre-SIT suppression measures have been maintained in important livestock areas and standardised routines for measuring and reporting progress are being introduced. Subsequent to the first trial release of sterile male flies in a 1 km² area south of Arba Minch, intensive tsetse suppression was initiated in a 100 km^2 test area north of Arba Minch. This suppression will be followed by weekly sterile male ground releases scheduled to begin in late August to assess the impact of the sterile males on the wild fly population.

Further progress under this large and complex Ethiopian project will largely depend on three points: (i) establishment of an autonomous and effective management structure with appropriate administrative and financial procedures and improved salary, allowances and incentive programme; (ii) intensive area-wide tsetse suppression in agricultural and tsetse-infested wildlife areas; and (iii) a drastic increase in the number of mass-reared sterile male tsetse flies to be able to initiate operational SIT phase. An evaluation of the STEP project will be made by the Agency to determine the readiness of the project to move into the operational phase, and subsequently, the extent of the Agency's future support for the project.

9. Using extrabudgetary funds from the United Nations Fund for International Partnerships (UNFIP) and the Government of the United States of America, geographical information system (GIS) based maps for planning and managing T&T intervention projects were purchased, entomological baseline data were collected in a standardised manner, insectary equipment was purchased for the Ethiopian STEP campaign and support to designing a tsetse mass rearing facility in Burkina Faso was provided.

10. In Burkina Faso, counterpart staff closely followed policy and technical advice provided by the Agency in close collaboration with FAO and WHO. A study initiated in 2005-2006, compiling available baseline data in the Mohoun basin, was complemented in 2007 with additional entomological data. With the assistance of experts from the Centre International de Recherche-développment sur l'Elevage en zone Subhumide CIRDES in Burkina Faso, training was provided in tsetse biology, ecology and in survey techniques, and sites for standardised entomological monitoring were selected. Operational field teams were established and actual field work started in December 2007. Agency support in the near future will include awarding a contract to a geographic information system (GIS) office in Burkina Faso to develop detailed vegetation classification maps. This, together with GIS hard and software and additional guidance provided by the Agency and other partners, will facilitate strategy development and the planning of tsetse intervention activities.

11. Senegal is making good progress along the phased conditional approach. A total of 12 technical staff have been trained, a detailed action plan for the collection of entomological baseline data has been developed, flies have been sampled for population genetic studies in and outside the target area, a veterinary survey has been conducted and the entomological baseline data collection was completed in most of the tsetse infested target area. In the first half of 2009 the project may enter the pre-operational phase, with the possible implementation of an operational tsetse SIT component in late 2009 and 2010. The Agency is also strengthening its collaboration with the Centre de Coopération Internationale en Recherche Agronomique pour le Développement (CIRAD) and the Institut de Recherche pour le Développement (IRD) of France in support of this project.

12. Based on the conclusions of the feasibility study, supported by the IAEA in South Africa and completed in 2006, the development of a business plan/bankable project document is currently underway for a sub-regional project that targets the T&T problem in the province of KwaZulu-Natal of South Africa and southern Mozambique. This approach has the merit of translating into concrete action the commitment of both Member States to jointly address the problem. Based on information received from WHO indicating the presence of tsetse flies in the border zone between Mozambique and Swaziland, the project will also need to include a small area in Swaziland (currently not an IAEA Member State) in the planning of a sub-regional campaign, for which extrabudgetary resources will be necessary.

13. In 2007, scientists were trained in Mali in general tsetse ecology and biology, as well as in parasitological and serological techniques through an Agency TC project. However, before the project is eligible to receive additional international support, counterpart staff need to address some of the suggestions made by Agency staff for completing entomological base line data collection and for

assessing the feasibility of creating and subsequently sustaining a tsetse free zone, possibly involving a SIT component.

14. In Botswana the Agency gave policy advice on the area-wide concept of integrated pest management and technical assistance, including guidance on standardised entomological monitoring, advice on probability calculations on tsetse absence, and the establishment of a field insectary with the target species *Glossina morsitans centralis*. Probability models suggest that the sequential aerosol technique (SAT) has freed the Okavango delta from tsetse flies and the disease they transmit, and that a final phase of SIT will not be necessary. Nevertheless, the tsetse SIT-package remains part of a phased national intervention strategy, and is available in case it will be needed in Botswana or as part of the initiated trans-boundary operations in the sub-region that includes northern Botswana, northeastern Namibia, southeastern Angola and southwestern Zambia.

15. Agency assistance provided to the United Republic of Tanzania in 2006 led to the conclusion that the very low disease prevalence recorded among livestock on Mafia Island may not justify the investment of substantial funds to eradicate *Glossina brevipalpis* there. In 2007 and 2008 the Agency focused on introducing mechanisms for improved national planning, initiating standardised baseline data collection and assessing the feasibility of creating zones that are free of tsetse flies and the disease they transmit in a sustainable manner. In this context the 'FAO/IAEA National Planning Workshop on Entomological Baseline Data Collection in Preparation of Integrated Area-wide Management of *Glossina swynnertoni* in Tanzania' was held at Mondoli, Tanzania from 19 May – 6 June 2008.

16. A regional AU-PATTEC/FAO/IAEA training course on 'Standardized Collection and Processing of Tsetse Flies for Molecular Tsetse Population Genetic and Morphometric Analyses' was held in Tororo, Uganda, 29 November – 7 December 2007. Also, an AU-PATTEC/FAO/IAEA regional training course on 'Principles of Baseline Data Collection for Integrated Area-Wide Tsetse and Trypanosomosis Intervention Projects with a Sterile Insect Technique Component' was held in Dakar, Senegal, 18 February – 13 March 2008.

17. In an effort to harmonise the Agency's tsetse activities with relevant efforts by other partners, especially AU-PATTEC, FAO and WHO, Agency staff interact frequently with the AU-PATTEC Coordinator. The Agency participated in the 13th meeting of the Programme Against African Trypanosomosis (PAAT) Advisory Group Coordinators and the 12th meeting of the PAAT Programme Committee, which were held in Luanda, Angola, and in Antwerp, Belgium, in September 2007 and May 2008, respectively.

18. Three university lecturers with experience in training in tsetse and trypanosomosis met in Vienna 15-19 October 2007 to develop criteria according to which African Member States could assess and nominate candidate institutes as Regional Designated Centres for training in various aspects relevant to T&T. The experts developed a detailed questionnaire, which was shared with and technically complemented by counterparts at FAO and WHO, and was subsequently distributed to African Member States for completion and return to the IAEA. The questionnaires will be screened by an independent group of experts and it is anticipated that an existing AFRA mechanism will be used for evaluating, identifying and possibly supporting regional designated training centres.

19. A meeting of entomologists and GIS specialists was organised on 12-14 March 2008, to develop a detailed training course prospectus and a course programme for a regional training course on the use of GIS and related techniques, tailored to the special needs of tsetse control personnel in the field. It is anticipated that the first regional training course on the subject will be organised in early 2009.

20. The first Research Coordination Meeting (RCM) of the Coordinated Research Project (CRP) entitled 'Improving SIT for Tsetse Flies through Research on their Symbionts and Pathogens'

(D4.20.12) was held in Vienna, 3-7 September 2007. A key topic addressed under this CRP and through additional research at the FAO/IAEA Agriculture and Biotechnology Laboratory is the development of techniques to manage the salivary gland hypertrophy virus, a pathogen affecting the performance of the tsetse fly species *Glossina pallidipes* under mass-rearing conditions. In November 2007, a new CRP was approved entitled 'Applying GIS and Population Genetics for Managing Livestock Insect Pests'. This CRP aims at developing techniques to bring together GIS and population genetic and simulation modelling techniques for a better understanding of pest risk scenarios, and to enable a better management (i.e. planning, monitoring and decision making) of livestock insect pests with particular reference to tsetse and screwworm flies. The first RCM under this CRP was held 18-22 August 2008 in Vienna.

21. The FAO/IAEA Agriculture and Biotechnology Laboratory, Seibersdorf and some collaborating partners tested, with encouraging results, the use of UV irradiation and X-ray irradiation as alternative options to radioactive sources for reproductive sterilisation of tsetse fly males and for decontamination of locally collected blood for feeding mass reared tsetse fly colonies. This was necessary in response to the increasing difficulties and restrictions experienced with the purchase and international transport of radioactive sources.

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

A. Background

1. Malaria is the most damaging insect-transmitted disease. The causative agents are parasites of the genus *Plasmodium* that are transmitted by female mosquitoes of the genus *Anopheles*. It causes approximately 2 million deaths a year and there are about 300-500 million cases of clinical malaria annually. Over 90% of the world's malaria cases occur in Africa, and in many countries it consumes a major portion of the national health budget. The disease constitutes a major obstacle to poverty reduction in Africa; according to some estimates, it has slowed down economic growth in African countries by 1.3% per year.

2. Treatment of malaria requires affordable and effective drugs but the growing problem of drug resistance will necessitate a switch to more expensive alternatives. Malaria vaccines have not currently proved sufficiently protective to warrant use in malaria control. These limitations of current interventions have led to renewed interest by Member States in the potential of the Sterile Insect Technique (SIT) for the suppression of malaria-transmitting mosquitoes in suitable areas.

3. In light of this renewed interest in the potential of the SIT, at its fiftieth session in September 2006, the General Conference, through resolution GC(50)/RES/13, requested the Agency to continue and strengthen the research, both in the laboratory and in pilot projects in the field, required to use the SIT for the control of mosquitoes; and to increasingly involve African and other developing Member States' scientific and research institutes in the research programme in order to ensure their participation, leading to ownership by affected countries. It further requested the Agency to increase its efforts to raise funds for the research programme, and invited donors to continue with their financial support, and other Member States to make financial contributions to the research programme. It requested the Director General to report on the progress made in implementing this resolution to the General Conference at its fifty-second session.

B. Developments since the General Conference's 2006 Session

B.1. Research and Development in the Agency's Laboratories at Seibersdorf

4. In the FAO/IAEA Agriculture and Biotechnology Laboratory in Seibersdorf, research and development on mass rearing, sterilization, and genetic sexing made progress during 2006-2007. A screen for an *Anopheles arabiensis* genetic sex-separation strain based on dieldrin resistance was successful. A potential strain was isolated and has been established in several collaborating laboratories. The strain has already been transferred to Sudan for testing and possible release in 2009-

10. The Entomology Unit insectary continues to support the culture of several strains of *Anopheles arabiensis* from Sudan and Zimbabwe, and various strains created as part of the project activities for sex separation. These are also distributed to Member States as requested for educational purposes and seed stocks. In addition, using modern biotechnology, several strains have been isolated in which the male mosquitoes express a fluorescent protein which might be used for sex separation.

5. The mating competitiveness of irradiated *Anopheles arabiensis* has been compared with that of non-irradiated males in the Agency's laboratory. These experiments determined the relationship of irradiation to male sterility and competitiveness, and enabled a radiation protocol for effective sterilization to be determined. The results have been published in scientific papers. In addition, a research contract was awarded to the University of Georgia, USA, to measure the flight performance of irradiated males. The results, which will soon be submitted for publication, showed that radiation had relatively little effect on flight ability in males.

6. Stable isotopes of nitrogen and carbon were used in several novel applications in support of SIT application. They were applied to determine the feeding preference of adult mosquitoes and to detect insemination and the multiple mating rate of males in cage situations. The use of stable isotopes will enable the mating success of sterile males to be monitored in the field as well as providing a marker to differentiate them from wild males. Articles based on the results of these experiments have been published in peer reviewed journals.

7. A prototype mass-rearing cage was developed and distributed to Ghana, Italy, and French Polynesia for further refinement and testing with *Anopheles arabiensis* and *Aedes albopictus.* Recipient laboratories are expected to make recommendations to the Agency regarding refinements.

8. The insect green house that is located in Seibersdorf, and simulates semi-field conditions, has been partially completed and is expected to be available for use under ambient conditions in the fall of 2008.

B.2. Coordinated Research, Capacity Building, and Planning

9. The Coordinated Research Project (CRP) on "Mass Rearing of Mosquitoes" conducted its second Research Coordination Meeting (RCM) in Belgium in March 2008. At the meeting, which was attended by representatives of 8 Member States, significant progress was reported particularly in mass-rearing of larvae and determining male characteristics that can be controlled during production related to mating effectiveness.

10. A second CRP on "Male Biology of Mosquitoes in Relation to Genetic Control" was initiated in 2008. The first RCM was conducted in Vienna in July 2008 with the participation of scientists and observers from 14 Member States.

11. From 2006 to the present, six fellows from Ghana, Indonesia, Kenya and Sudan have received a total of 28 months of training in Seibersdorf on mosquito culture and related activities under the IAEA technical cooperation (TC) programme. An additional four fellows from Sudan and Tanzania were trained for a total of 17 months. Topics included mass-rearing of mosquitoes, adult energetics, geographic information systems (GIS), mating studies and population genetics. Twelve single/team expert missions were fielded to Sudan. In addition to TC funds, a related regional TC project in Africa (RAF/5/052) received an extrabudgetary contribution from France.

B.3. Preparatory Activities for Field Pilot in Sudan

12. The Agency continued to focus its field pilot support on Sudan, where the first trial releases of sterile males for research purposes were initiated in November 2007 to refine shipment logistics from

Khartoum to the project site in the Northern State of Sudan, assess male survival and measure dispersal distances. These releases were attended by representatives of the Tropical Medicine Research Institute of Sudan, consultants and members of the Northern State Ministry of Health and the Malaria Administration. Initial results of these trials indicated that the sterile males survived well in the field and dispersed some distance from the release area. Insecticide resistance surveys conducted in the Northern State of Sudan found only very low levels of resistance to insecticides useful for control of the SIT target species, *Anopheles arabiensis*. These studies, conducted by the Malaria Administration, provide useful baseline information that confirms that conventional insecticide could be used for pre-SIT-release population suppression.

13. Studies by the counterpart's team in the semi-field cages constructed in Dongola, Sudan, and by Agency staff demonstrated that irradiated males compete reasonably well with wild-type males for wild-type females. In conjunction with these studies, efforts were made to identify sites that might be useful for monitoring of males.

14. Data from the extensive larval surveys conducted in 2006 in two study sites in the Northern State were analyzed using GIS. The results show very clear spatial and temporal variation in the abundance of larval breeding sites. The random design of the experiments allows good estimation of the region-wide number of breeding sites according to land use type.

15. The Sudanese government and counterparts have taken ownership of the project and have successfully raised private funds to begin the design and construction of a mass-rearing facility to be located in Khartoum. As a result, more than US$ 1 million have been committed in cash and in kind. Mosquitoes produced in this facility will be released in the Northern State sites in which detailed baseline data has been collected. In view of this, the Agency has intensified its efforts to develop design requirements for a facility to produce 1 million sterile males per day. Meetings to determine facility requirements have been held in Panama, which has three mass rearing facilities, and Vienna. The design will be finalized at an experts meeting in Khartoum with local engineers and counterparts supported under regional project RAF5052. The design is expected to be completed in 2008.

16. The Sudanese counterparts have also completed a two-year intensive survey of mosquito larval breeding sites in the project area. This is an essential component of base-line data collection as the data can be used to establish the size of the adult mosquito population and hence the number of sterile male mosquitoes that will be needed for the release phase.

B.4. Preparatory Activities for Field Pilot on Réunion Island

17. Agency representatives attended high level meetings in Paris, France, to discuss the possibility of developing closer ties with the Institut de Recherche pour le Développement (IRD) of France, including collaborative activities in Réunion Island on mosquito SIT and closer IRD/IAEA cooperation on the development of the SIT for mosquitoes. During follow-up meetings in Vienna in March 2008, it was agreed to consider developing a Practical Arrangement between IRD and the Agency to formalize the roles of both organizations for collaborative work on mosquito SIT.

18. A further follow-up technical meeting was held in Vienna in 2007 to discuss the possibility of developing SIT against *Aedes* mosquitoes. Species of this mosquito genus are responsible for transmitting numerous viral diseases including Chikungunya, which has spread from countries in Africa to various locations including Italy, Réunion Island and several other islands in the Indian Ocean. The meeting was attended by representatives of the Agency and of both Italy and Réunion Island.

19. In February 2008, Agency staff, local and regional representatives and consultants attended a meeting on Réunion Island sponsored by IRD to finalize the research needs for the Réunion Island vector control project. The meeting concluded that a control approach that includes an SIT component against *Anopheles arabiensis* would be the initial focus with research toward the feasibility of *Aedes albopictus* suppression as a possible second target for control.

Nuclear Energy Activities

1. This annex summarizes highlights of Agency activities not covered in Annexes 4, 5, 6 and 7, which address nuclear knowledge management, infrastructure development for nuclear power, innovative nuclear technology, and producing potable water using nuclear reactors.

2. The utility and financial markets have changed since nuclear power's last period of rapid growth. In view of these changes and the current expectations about the growth of nuclear power, the IAEA General Conference in 2007 requested "a report on the financing of nuclear power as an option in meeting energy needs".

3. *Financing New Nuclear Power Plants* (NG-T-4.2), published in late summer 2008, responds to that request. It starts with a brief exposition of basic financing requirements, and then explores the roles, responsibilities and options for both government and industry with regard to nuclear power plant financing, as well as financial risk mitigation (for government) and financial risk management (for industry). The report stresses that finance for new nuclear build can be secured in a number of ways, but that efficient risk allocation and proper assurances of loan repayment as well as returns on capital must be integral parts of any financing scheme. Good project management and careful contracting are the key elements in commercial risk allocation, ideally to the parties that can best manage or control the given risk.

4. The Agency's 2008 updates of its own projections for global growth in nuclear power revised both the low and high projections upwards. In the updated low projection, global nuclear power capacity reaches 473 GW(e) in 2030, compared to 372 GW(e) at the end of 2007. In the updated high projection it reaches 748 GW(e).

5. Consistent with rising expectations for nuclear power, requests to the Agency for national energy studies continued to rise. The Agency provides training in the use of energy planning tools to assist Member States in determining whether nuclear power is appropriate in its energy mix. Those trained in the Agency's methods for analyzing energy systems and options rose more than 50% from 2006 to 2007, from 274 to 429. To respond to demand, a pilot project was successfully completed in 2007 for a new distance learning service. Based on this experience, distance learning is being expanded in 2008 to reach more energy analysts and professionals in Member States.

6. The Agency attended the 13th session of the Conference of the Parties to the United Nations Framework Convention on Climate Change (COP-13), the 3rd meeting of the Parties to the Kyoto Protocol (CMP-3), and the 16th session of the Commission on Sustainable Development (CSD-16) and contributed, as a member of several working groups, to the completion of the 4th Assessment Report (AR4) of the Intergovernmental Panel on Climate Change (IPCC), which was released in November 2007.

7. Given significant developments in nuclear power around the world since the ministerial conference on the future of nuclear power in Paris in 2005, arrangements are being made for a 'Ministerial Conference on Nuclear Energy in the 21st Century' in Beijing, China, 20-21 April 2009. The announcement for this conference can be found on the Agency's website at http://www-pub.iaea.org/MTCD/Meetings/Announcements.asp?ConfID=35252.

8. The Secretariat, through its Nuclear Power Support Group (NPSG) continues to ensure coordination for the Agency's support to Member States considering the introduction of nuclear power. The internal coordination provided by the NPSG ensures that the Agency gives holistic advice when Member States ask for assistance on nuclear power infrastructure development programmes.

9. The Agency works with other international organizations on plant life management (PLiM) for long term operation and held its second international symposium on Nuclear Plant Life Management in Shanghai, China in October 2007. Participants emphasized that the effects of extended operations and power upratings on power plant systems, structures and components must be continually reanalysed for safety and for system optimization. Other issues highlighted were the importance of easy access for inspections, the need for designs that facilitate easy inspections and component replacement, and early implementation of knowledge management tools in operational practice.

10. Recognizing the essential role of the Agency as the principal international forum for the exchange of information and experience, the Agency maintains effective liaison with organizations such as the OECD-NEA, WANO, FORATOM, Generation IV International Forum (Gen IV GIF), and the EC-JRC (Joint Research Centre). Meetings are held regularly to discuss developments in safety and operational aspects of existing nuclear facilities, including operational experience feedback, development of new nuclear energy technologies for power and non-power applications, technology assessment in an energy systems context with special focus on energy security and investment requirements. The Agency organized international conferences and workshops in cooperation with other international organizations such as EC-JRC, OECD-NEA, FORATOM and WANO. In addition, the Agency participates in the OECD-NEA programme for multi-design evaluation and the EC programme NULIFE (Nuclear Plant Life Prediction).

11. Interest in uranium exploration, mining and production has risen, driven partly by uranium price increases. The latest update of the biennial 'Red Book' — *Uranium 2007: Resources, Production and Demand* — was published jointly by the Agency and the OECD/NEA in June 2008. Reported uranium resources have increased since the last edition of the Red Book, due mainly to reported increases by Australia, Russian Federation, South Africa and Ukraine. Identified conventional uranium resources, recoverable at a cost of less than $130/kgU, are now estimated at 5.5 million tonnes (MtU), 15% higher than in the last Red Book. (For reference, the spot market uranium price reached almost $360/kg in June 2007, but had dropped back to $150/kg by June 2008). Expanded uranium exploration and mining will involve new countries and will require new manpower. The Agency has increased its training activities and organized a meeting in Namibia and plans two meetings in Vienna, Austria, and Amman, Jordan, in October and November 2008, respectively.

12. The global volume of stored spent fuel continues to increase, and expected storage periods continue to lengthen. Agency activities cover technology for spent fuel storage and the long term behaviour of spent fuel and storage components. Since September 2007, the Agency has published several documents, including the *Proceedings of the 2006 International Conference on Management of Spent Fuel from Nuclear Power Reactors* (IAEA-STI/PUB/1295), *Advances in Applications of Burnup Credit to Enhance Spent Fuel Transportation, Storage, Reprocessing, and Disposition* (IAEA-TECDOC-1547), and *Spent Fuel and High Level Waste: Chemical Durability and Performance under Simulated Repository Conditions* (IAEA-TECDOC-1563).

13. In September 2007, the Agency launched the International Decommissioning Network (IDN) to improve the flow of knowledge and experience among those engaged in decommissioning and to encourage organizations in developed Member States to contribute to the activities of Member States requiring decommissioning assistance. The IDN held its inaugural planning meeting in December. In 2008 it will hold one workshop with ENRESA in Spain on waste management and clearance and another in Belgium on size reduction for decommissioning nuclear facilities. A 3-year programme of workshops and other technical activities has been developed and will be implemented through an expanded regional technical cooperation project in Europe on decommissioning.

14. In November 2007, the Agency held a conference on management and use of research reactors in Sydney, Australia. Its focus was not only on sharing the latest scientific, technical and safety

information related to research reactors but also on stimulating alliances among operators to improve utilization and broaden the scope of services they provide. The conference recommended expanding Agency efforts to reduce proliferation risk, including the minimization of highly enriched uranium, and developing international coalitions and peer-group networks, high capability shared regional facilities, and feasibility studies for future reactors.

15. At the request of Member States, and in cooperation with the Global Threat Reduction Initiative (GTRI), the Reduced Enrichment for Research and Test Reactors (RERTR) programme, and the Russian Research Reactor Fuel Return (RRRFR) programme, the Agency assists Member States in converting research reactors from the use of high enriched uranium (HEU) to low enriched uranium (LEU) fuel and in shipping HEU fuel back to its country of origin. More information on specific projects is available in the Annual Report 2007. A workshop on Technical and Administrative Preparations for Shipment of Russian-Origin Research Reactor Spent Fuel to Russia was held in May 2008 in the Czech Republic. The meeting focused on lessons learned from the latest shipments of spent HEU fuel elements from research reactors in the Czech Republic and Latvia.

Nuclear Knowledge Management

1. In resolutions GC(48)/RES/13.E (2004) and GC(50)/RES/13.C (2006), the General Conference recognized "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."

2. The General Conference urged "the Secretariat to continue to strengthen, subject to the availability of resources, its current and planned efforts in this area, recognizing the need for a focused and consolidated approach…" and requested the Director General to report on progress to the Board of Governors and to the General Conference at its 52nd session and every second year thereafter.

3. The Agency has adopted an Agency-wide approach and strategy for nuclear knowledge management (NKM), which identifies the following key areas: providing guidance for policy formulation and implementation of nuclear knowledge management; strengthening the contribution of nuclear knowledge in solving development problems, based on needs and priorities of Member States; pooling, analysing and sharing nuclear information to facilitate knowledge creation and its utilization; implementing effective knowledge management systems; preserving and maintaining nuclear knowledge; securing sustainable human resources for the nuclear sector; and enhancing nuclear education and training.

A. Consolidating nuclear knowledge management

4. In 2007 and 2008 the Agency convened two major meetings that considered trends and experience in NKM activities worldwide and the tailoring of the Agency's programme to these developments.

5. The 2007 International Conference on Knowledge Management in Nuclear Facilities was held in Vienna. It assembled 230 decision makers and professionals from governments, the nuclear industry and academia. They reviewed recent NKM developments, discussed how NKM improves the operation and safety of nuclear facilities, promoted the use of NKM in the nuclear industry and developed recommendations. The conference confirmed that the Agency's NKM programme had been effective and efficient in supporting Member States' efforts to introduce NKM and that NKM has become an important management approach used by an increasing number of regulators, utilities, R&D institutions and government agencies. The conference recommended that the Agency contribute to establishing a global nuclear knowledge culture and that it should remain the global forum for advancing the application of NKM. The focus of the Agency's NKM programme should continue to be on providing methodology and guidance, strengthening networks for nuclear education and implementing pilot knowledge preservation projects in key areas. The conference also recommended that the Agency's NKM services should be extended to the nuclear industry and that the customer base be expanded by targeting regulators and issuing regular status reports on NKM.

6. The 2008 meeting of senior officials on NKM cooperation for development was also held in Vienna. Officials from all four technical cooperation (TC) regions were invited to share their knowledge and experience and to help identify needs and priorities for expanding cooperation among Member States with respect to NKM. Participants recommended that the Agency should have a strong role in harmonizing curricula in nuclear education and training programmes, exchanging experiences

and best practices on NKM, helping Member States assess their own knowledge management performance, and expanding Internet-based learning platforms.

B. Managing nuclear information

7. The Agency has developed its principal nuclear knowledge portal, NUCLEUS, as a 'single sign-on' gateway to the Agency's databases and other technical, scientific and regulatory information resources. NUCLEUS currently provides access to more than 100 Agency databases, the Agency's safety standards, scientific and technical publications, reports and other documents in the nuclear field.

8. The Nuclear Energy Knowledge Portal continues to develop as a key nuclear energy information resource accessible via the Internet, featuring nuclear power technology databases, such as the Power Reactor Information System (PRIS), the Net Enabled Waste Management Database (NEWMDB), the Waste Management Research Abstracts (WMRA), the Fast Reactor Database, and a new database called NuArch, for 'nuclear archive', which is designed to preserve all useful nuclear related information from the Internet.

9. The International Nuclear Information System (INIS) plays an important role in the Agency's preservation of nuclear knowledge and in making that knowledge easily and readily available. In 2007, INIS membership grew to 141 members (118 countries and 23 international organizations).

10. The Agency's support through its technical cooperation programme increased in 2007 through the establishment or reactivation of several national INIS centres. New national centres were launched in Burkina Faso, Kenya, Niger and Uzbekistan. Assistance was provided to Qatar to reactivate its national INIS Centre, and a national training course on INIS was conducted in Ghana. The Agency continued its efforts to expand free access to the INIS database for universities. In 2007, a total of 354 universities from 63 Member States had free access to INIS bibliographic and full text information through the Internet. Also, a multilingual thesaurus was completed in 2007 and distributed among Member States in seven languages — the six official Agency languages plus German.

11. The IAEA Library has recently started tailoring its services and products to Member State needs and has strengthened its collections to expand the nuclear information available. The International Nuclear Library Network (INLN), which is coordinated by the Agency, brings nuclear libraries together to share knowledge, best practices and lessons learned, and continues to attract new members. One new participating library joined in 2006, four in 2007 and two more so far in 2008. Thus, the INLN now has 12 participating libraries in 11 countries.

12. In the period since September 2006 eight publications related to key pilot NKM projects have been issued by the Agency.[1]

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[1] Fast Reactor Database 2006 Update; Knowledge Management for Nuclear Industry Operating Organizations; Web Harvesting for Nuclear Knowledge Preservation; The World Nuclear University: New Partnership in Nuclear Education; The Asian Network for Education in Nuclear Technology (ANENT) — IAEA Activities and International Coordination; Managing Nuclear Knowledge: Proceedings of a 2005 Workshop, Trieste, Italy; Planning and Execution of Knowledge Management Assist Visits; Fast Reactor Knowledge Preservation System: Taxonomy and Basic Requirements

C. Building capacity for nuclear knowledge management

13. In 2007, the fourth School of Nuclear Knowledge Management was held at the International Centre for Theoretical Physics (ICTP) in Trieste, Italy. The school provides participants with a basic understanding of the tools, mechanisms and challenges of NKM. In a special session to compare curricula in non-power nuclear applications and to develop recommendations for improvement, lecturers and students shared experiences in developing educational curricula, identified the basic trends and knowledge management needs to support non-power nuclear activities, and developed recommendations for further Agency activities to improve nuclear education and training. The fifth School of Nuclear Knowledge Management will be held in September 2008 with additional financial support from the European Commission (EC).

14. A number of regional workshops on NKM, hosted by the Karlsruhe Research Center, Germany, by the Obninsk Center for Science and Technology, Russian Federation, and by the Tokyo Institute of Technology, Japan, provided specialized training in NKM to more than 150 specialists from Member States.

D. Applying nuclear knowledge management to development

15. The Agency has implemented a total of 16 TC projects supporting Member States in the establishment of policies and strategies to preserve and further enhance knowledge, competence and expertise, and in the provision of practical guidance for NKM in governmental organizations, industry and academia. These projects focus on building capabilities and developing national infrastructure by elaborating common approaches in nuclear technology and nuclear education, and by implementing practical activities (such as management systems for quality assurance in diagnostic and testing laboratories) to ensure the sustainable development of nuclear power and non-power nuclear applications.

16. In Africa, the Agency played a major role in the first Conference on Information and Communication Technology in Training and Learning in Nuclear Science and Technology, held in Niamey, Niger, 26–30 November 2007. The African Regional Co-operative Agreement for Research, Development and Training Related to Nuclear Science and Technology (AFRA) Member States are currently implementing, with the Agency's support, their regional strategy for human resource development and NKM through the AFRA Network for Education in Nuclear Science and Technology (AFRA-NEST).

17. In the Asia and the Pacific region, a project web site was created to allow Member States in the region to access all information related to a TC project aimed at achieving self-reliance and sustainability of national nuclear institutions, and to benefit from accumulated experience.

18. In Europe, the Agency is helping Member States to establish policies and strategies to preserve and further enhance knowledge, competence and expertise and to provide practical guidance for the application of NKM in governmental organizations, industry and academia. A regional TC project aimed at strengthening capabilities for nuclear knowledge preservation supported an expert meeting on developing a knowledge portal for nuclear power plants and the preparation of a document on conducting knowledge management assist visits.

19. A number of efforts address quality assurance in relation to knowledge management. Both at the Agency's Headquarters and at its Laboratories at Seibersdorf development of a formal quality assurance system has begun. The IAEA Dosimetry Laboratory (DOL) at Seibersdorf operates a quality system according to the ISO/IEC 17025 standard. The Safeguards Analytical Laboratory (SAL) operates according to the ISO 9001 standard and serves as a knowledge base for a large number of analytical laboratories worldwide. Quality manuals for both SAL and DOL have been prepared using the process based approach. Distance-learning modules and associated training materials are being developed and will be made available on CD and the Internet. The 'animal genetic and serum bank', which will contain phenotypic and genotypic data about animal breeds as well as reference sera and their associated characterization details, is in the process of being established.

20. In Argentina, Botswana, Brazil, Cameroon, Cuba, El Salvador, Indonesia, Nigeria, Pakistan, Thailand, Uruguay and Vietnam, the Agency supported ISO/IEC 17025 based quality assurance management programmes to improve quality assurance management in food and agriculture.

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

21. Major NKM activities in nuclear safety and security are linked to the preparation and application of the Agency's safety standards and security recommendations and guides. These processes have been comprehensively mapped, and the knowledge domains underpinning them have been identified. The Agency's review services, which are based on the Agency's safety standards, have been re-designed, in particular the Integrated Regulatory Review Service (IRRS), which has been successfully provided to several countries. The Agency security services are based on international instruments and Agency security recommendations. Feedback for both the development and application of safety standards and security recommendations and guides is continuously collected and used to improve knowledge management for safety and security.

22. In 2007, the Agency launched an information and communication technology (ICT) multimedia project to capture expert knowledge and experience from countries implementing the Agency's safety principles. The project includes a film of a training course on operational experience and a CD containing presentations on Member States' experiences in implementing management systems. In addition, multimedia training material was produced in 2007 for a five-hour training course on management systems based on the Agency safety standards. The Agency also organized a series of various security training courses and workshops to cover prevention, detection and response. These were delivered in many Members States to a total of more than 1000 participants in 2007.

23. The NKM portal that is focused on nuclear safety and security is a solution designed to capture, analyse and share nuclear safety knowledge and to improve programme planning, coordination and transparency. New approaches, such as wikis[2], are being tested. The management system previously developed for the nuclear security programme has been extended to support other extrabudgetary programmes related to safety. The system includes technical knowledge and administrative data and assists in the analysis and reporting of programme outputs.

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[2] A wiki is a collection of web pages designed to enable anyone who accesses it to contribute or modify content using a simplified markup language.

24. In 2007, the Agency started a broad review to identify possible synergies among nuclear safety networks. The term "Global Nuclear Safety Network (GNSN)" is used to describe the set of existing networks and information resources, i.e. internationally accessible information. The review identified several ways to improve the GNSN. In particular, work has begun to establish a common GNSN platform for enhancing outreach based on the wiki approach. This should make it easier to share knowledge globally, while still maintaining the decentralized nature of the networks and resources. An important principle is that the ultimate responsibility for content and quality remains with information providers and network operators.

25. Work also progressed on specific safety networks. The Asian Nuclear Safety Network (ANSN), which pools nuclear safety knowledge, is now mature. Given the rapid expansion of existing Asian nuclear power programmes, and the interest of other Asian countries in beginning such programmes, the ANSN is expected to be an increasingly important regional forum for senior decision makers to share strategies and experience to strengthen nuclear safety. Topical groups have been created for specific thematic areas as forums to share experience and create new knowledge. The topical groups are composed of specialists in the groups' respective technical areas. The groups are being used increasingly for managing regional activities and reviewing self-assessments on nuclear safety performed annually by each country in the programme. The ANSN Education and Training Topical Group will lead a study on regional capacity building for nuclear safety infrastructure, particularly safety regulation, and will develop a strategy to harmonize the ANSN countries' evaluations of training needs and implementation. The Agency's ANSN website expanded considerably in 2007 with the addition of all material on past Asian extrabudgetary activities, a total of about 150 workshops and training courses corresponding to about 2000 presentations. These additions greatly increase the accessibility of extensive and valuable information on nuclear safety.

26. The Ibero-American Radiation Safety Network is now operational, having been established through an extrabudgetary programme on nuclear and radiation safety under the auspices of the Ibero-American Forum of Radiological and Nuclear Regulatory Agencies. In 2007, a project on probabilistic safety assessment applied to radiotherapy treatment with linear accelerators was finalized. The project was successful in identifying potential accident sequences and grading them in terms of risks and provided recommendations to prioritize the use of resources to avoid accidental exposure.

27. Another knowledge sharing network, the Radiation Safety Regulators Network (RaSaReN), founded to facilitate worldwide exchange of knowledge and experience essential to establishing and maintaining an effective and sustainable regulatory infrastructure for radiation safety and security of radioactive sources, grew substantially between 2006 and 2008 and now has 171 members from 71 Member States.

28. Following implementation of a quality management system in the Agency's Radiation Protection Monitoring Service, the Austrian Accreditation Authority issued ISO/IEC 17025 accreditation to the Nuclear Safety Testing Laboratory for Radiation Measurement, Monitoring and Protection — it became the first such accreditation for an Agency service. The Agency used the knowledge gained during the accreditation process to create a training course for Member States to help their laboratories implement a quality management system and achieve officially recognized proficiency.

29. The training of personnel from Member States in the application of safeguards remains an important Agency NKM activity. Since September 2006, more than 20 national, regional and international training courses and workshops have been conducted to assist States in fulfilling their obligations under their safeguards agreements. These courses and workshops not only deliver knowledge, but also gather and share experience. Furthermore, to help States establish and strengthen their State systems of accounting for and control of nuclear material (SSACs), which are fundamental for efficient and effective safeguards implementation, the Agency conducted IAEA SSAC Advisory

Service (ISSAS) missions in Armenia, Serbia, Singapore, Switzerland and Ukraine in 2006 and 2007. An ISSAS mission was completed in Niger in February 2008, and missions to Georgia, Kazakhstan and Romania are anticipated before the end of 2008.

30. The nature and purpose of nuclear verification is such that many of the Department of Safeguards' knowledge management activities are geared to internal needs and continue to be implemented as an integral part of the Department's quality management system. Cooperation with Member States is important in this regard, particularly in terms of access to laboratories and nuclear facilities in order to develop new safeguards approaches and training. Experience gained will be passed on to Member States through training on relevant safeguards topics, thereby contributing towards capacity building for the future.

F. Strengthening nuclear educational networks

31. The Agency supports a number of networks for education and training. These include the African Network for Education in Nuclear Science and Technology (AFRA-NEST), the Asian Network for Education in Nuclear Technology (ANENT), the European Nuclear Engineering Network (ENEN) and the Russian Association of Nuclear Science and Education (RANSE). Technical meetings and workshops have been held to share knowledge and experience in enhancing nuclear education in different parts of the world. A technical meeting hosted by the University of Pavia, Italy, in June 2008 provided the basis for an Agency technical document on status and trends in nuclear education that is expected to be published in 2009. The Agency supported the 2007 World Nuclear University (WNU) Summer Institute by funding the participation of 24 qualified candidates from developing countries through its technical cooperation programme, by the participation of a number of Agency staff as faculty members and by helping to plan the programme. The Summer Institute is a six-week course for some 100 young nuclear professionals and academics to help build a global network of future nuclear leaders.

32. With respect to training, ANENT has developed, with assistance from the Agency a 'cyber platform' that integrates electronic resources from the Agency (e.g. publications and training material) with shared curricula and courses from other organizations (e.g. the European Nuclear Engineering Network and the Dalton Nuclear Institute). The cyber platform is operated jointly by ANENT and the Agency. The first e-training course to use it took place in 2007 as a pilot project to provide training on the Agency's energy system analysis and planning tools. Students learned about the tools and how to apply them to case studies that examined, *inter alia*, the environmental impacts of different energy options at the country level. The pilot project was a success and will be built on, both to increase the number of people the Agency trains in energy systems analysis in future years and to expand ANENT's distance learning programme.

33. Two postgraduate programmes in radiation protection have been established in each of the four geographical regions of Africa, Asia and the Pacific, Europe and Latin America, with the objective of developing a core group of safety professionals to ensure the maintenance of competence and the preservation and transfer of knowledge and skills.

34. Additional examples of activities to expand innovative training opportunities include the development of distance learning modules and training materials based on ICT. For example, in April 2008 the Agency launched a distance learning course in radiation oncology for cancer treatment. The

ISO training course contains 71 training modules under eight topics and is designed to improve the training of radiation oncologists especially in low and middle income countries.

G. Expanding nuclear knowledge management services

35. In 2007 and 2008 the Agency conducted NKM assist visits to the Darlington and Bruce nuclear power plants in Canada, the Ignalina nuclear power plant in Lithuania and the Zaporozhe nuclear power plant in Ukraine. An assist visit to Atomic Energy of Canada Limited is planned later in 2008. The visits, which are guided by a team of Agency experts, focus on self-assessments of the risk of knowledge loss as well as introducing efficient knowledge management practices in nuclear organizations.

36. Kazakhstan received assistance with the development of a national concept on NKM. A meeting of national coordinators under a regional project, held in Goa, India, in 2007 on supporting web-based nuclear education and training through regional networking, helped develop the concept and select training and educational materials for the ANENT cyber education platform. In addition, a coordinated research project on comparative analysis of methods and tools for nuclear knowledge preservation helps Member States select and implement appropriate cost-effective technological solutions for nuclear knowledge preservation.

Supporting Infrastructure Development for Nuclear Power

A. Background

1. As it had done the year before in resolution GC(50)/RES/13, the General Conference, in resolution GC(51)/RES/14, recognized that the development and implementation of an appropriate infrastructure is of central importance for the successful introduction of nuclear power, as well as for its safe and efficient use, taking into account relevant Agency standards, especially for countries that are considering and planning for the introduction of nuclear power.

2. With that in mind, the General Conference encouraged the Secretariat to continue to undertake generic and country-specific assessments of ways to address infrastructure requirements so as to provide related guidance for Member States that are interested in or planning for the introduction of nuclear power. The General Conference recommended that the Secretariat report to the Board of Governors and to the General Conference at its 52nd Session on developments relevant to that resolution. This document responds to that recommendation.

B. Work since the 50th session of the General Conference

3. In the last two years 43 Member States have shown their interest in considering the introduction of nuclear power by requesting IAEA assistance through the technical cooperation programme. In addition some 10 countries have also indicated an interest without requesting technical cooperation assistance. In the IAEA's high projection for nuclear power growth, approximately 10 new countries would operate nuclear power plants by 2020, with an additional 15 countries by 2030. Additional information is available in *International Status and Prospects of Nuclear Power* (GOV/INF/2008/10-GC(52)/INF/6).

4. Many of these countries face the challenge of building the necessary nuclear infrastructure and are interested in Agency assistance. The Agency is responding to this increased demand through increased technical assistance, missions and workshops and with new and updated documents.

B.1. Technical assistance and missions

5. In the Agency's current technical cooperation programme, there are 10 national and 2 regional projects supporting the introduction of nuclear power. It is anticipated that the number of national and regional TC projects related to infrastructure development will more than double in the 2009–2011 technical cooperation cycle.

6. The Agency sends integrated missions consisting of experts with multidisciplinary knowledge to facilitate a holistic approach to national infrastructure development. Their objectives are to find out the facts, explain the Agency's guidance publications and available services, and discuss future actions. Integrated missions were conducted in Egypt (March 2007), Belarus (March 2007), Jordan (May

2007), Vietnam (June 2007), Thailand (September 2007), at the request of States Members of the Gulf Cooperation Council (May 2007 and October 2007), and in the Philippines (January 2008). In addition, regional workshops were conducted in the Republic of Korea and Lithuania.

B.2. Publications and workshops

7. The Agency provides Member States with practical guidance on infrastructure issues through technical documents. An overall description of infrastructure issues was published in the brochure *Considerations to Launch a Nuclear Power Programme* (GOV/INF/2007/2), which was targeted mainly at policy makers. A publication, Nuclear Energy Series No. NG-G-3.1, *Milestones in the Development of a National Infrastructure for Nuclear Power*, issued in September 2007, provides more detailed guidance on the three phases of development outlined in the above brochure. It describes the sequential development through the three phases for each of 19 issues ranging from the government's national position on nuclear power to procurement.

8. The Agency held technical workshops related to these documents in December 2006 and November 2007, with co-sponsorship by the Governments of Canada, China, France, India, Japan, Republic of Korea, Russian Federation and United States of America. Each of these workshops was attended by more than 40 Member States. They offered a forum for an exchange of views on important infrastructure issues. The 2007 workshop also included special sessions on improving prospects for financing NPPs. The results of the workshops have provided further information for the development of the Agency's documents and assistance.

9. The burden of infrastructure development can be reduced significantly if a country forms a sharing partnership with other countries. *Potential for Sharing Nuclear Power Infrastructure between Countries* (IAEA-TECDOC-1522), issued in October 2006, describes areas where countries may be able to achieve the required level of infrastructure by sharing resources and facilities.

10. For countries introducing nuclear power, managing an NPP project is a major new challenge for governmental, utility, regulatory, supplier and other support organizations. *Managing the First Nuclear Power Plant Project* (IAEA-TECDOC-1555), issued in May 2007, presents an overall description of the main project management activities and provides references to related detailed guidance on appropriate engineering and quality requirements, safety standards and security guides.

11. Restarting NPP projects that have been delayed for several years presents particular management issues beyond the normal management tasks needed for projects implemented within planned schedules. *Restarting Delayed Nuclear Power Plant Projects* (Nuclear Energy Series No. NP-T-3.4), issued in March 2008, addresses specific management issues collected from practical experience in restarting delayed projects.

12. A bibliography of Agency infrastructure-related publications dating back to the 1980s was developed by the Nuclear Power Support Group. The bibliography is available at http://www-pub.iaea.org/MTCD/publications/ninfrastructure.asp.

B.3. Documents in preparation

13. One outcome of recent workshops related to *Milestones in the Development of a National Infrastructure for Nuclear Power* has been the identification of Member States' needs for further information on concrete implementation steps to be taken to introduce nuclear power. A new report is being prepared on the responsibilities and competencies of a nuclear power programme implementing organization, i.e. the organization created by a government to study the introduction of nuclear power and create an implementation strategy. A related report is also being prepared on the competencies of the owner–operator. Both of these reports will be completed in 2008.

14. A new report is also being prepared on workforce planning for new nuclear power programmes. This report responds to Member States' requests for additional assistance on how to implement the guidance in *Milestones in the Development of a National Infrastructure for Nuclear Power*. The new report is scheduled for publication in 2009. Its focus will be on the competencies and human resource requirements needed during each of the three phases of infrastructure development. It will provide a framework, in the form of a matrix, which addresses each of the 19 infrastructure issues. The framework will identify:

- the main activities to be undertaken to address each issue, together with an indication of the responsibilities of key organizations in completing these activities;
- an indication of the competencies required to successfully complete these activities;
- education and training programmes needed to achieve these competencies; and
- workforce planning needed to deliver these competencies within the project.

15. Additional guidance is also being prepared on how to determine the level of preparedness of a given country in developing its nuclear power programme. The new report focuses on the evaluation of the national nuclear infrastructure development status and is based on *Milestones in the Development of a National Infrastructure for Nuclear Power*. The report, scheduled for completion by the end 2008, will provide guidance for both self-evaluations and external reviews.

16. The Agency is also preparing a new report on infrastructural issues associated with improving prospects for financing nuclear power projects. It will describe practical ways in which future infrastructure developments in areas such as the assurance of fuel services, financing arrangements, international design approval and evaluation, and the harmonization of codes and standards can reduce investment risks and improve prospects for financing nuclear power projects. The report will be completed in 2008.

17. The Agency will also issue an updated report on invitation and evaluation of bids for nuclear power plants. The report will provide integrated and practical guidance on the preconditions and infrastructure issues which need to be addressed in the bidding process as well as the bid invitation specifications and technical and economic evaluation of bids. The final report is planned to be completed in 2009.

B.4. Holistic infrastructure support

18. *Considerations to Launch a Nuclear Power Programme* and *Milestones in the Development of a National Infrastructure for Nuclear Power* describe a holistic view of nuclear power infrastructure development. Reflecting this view, the Agency has infrastructure programmes in nuclear power, legal affairs, nuclear safety and security, and safeguards. The Nuclear Power Support Group (NPSG)

coordinates assistance across the Agency's Departments. This section summarizes these efforts to the extent that they have not been covered above.

19. The Agency provides training in the use of energy planning tools to assist Member States in determining whether nuclear power is appropriate in its energy mix.

20. The Agency provides legislative assistance through national and regional workshops and seminars, bilateral assistance in drafting and reviewing national laws, and the training of individuals. The legislative assistance programme aims at assisting Member States in establishing a sound national legal framework governing the safe and peaceful uses of nuclear energy, as well as an independent regulatory body, in compliance with the relevant international legal instruments. The programme covers all branches of nuclear law, namely nuclear safety, nuclear security, safeguards and liability for nuclear damage.

21. Nuclear safety is a critical element of almost all aspects of nuclear power infrastructure development. The Agency supports newcomers, *inter alia*, through the technical cooperation programme, through Integrated Regulatory Review Service (IRRS) missions designed for this purpose. It is developing a new safety guide which will describe how all of the existing safety guidance and standards can be appropriately used by newcomers in preparing their infrastructure for safety. A workshop was organized on vendor responsibilities for safety, which addressed cooperation and support between vendors and government agencies, as well as contractual arrangements for the NPP itself. An international conference is being organized in November 2008 in Mumbai, India, on ensuring safety for sustainable nuclear development, which will include a special session on issues for countries considering the introduction of nuclear power.

22. The Agency's International Project on Innovative Nuclear Reactors and Fuel Cycles (INPRO) has completed a study on *Common User Considerations by Developing Countries for Future Nuclear Energy Systems*. The study assembles views from some interested developing country Member States. It includes their expectations for assistance from vendors in infrastructure areas such as the assurance of fuel services and support for their national regulators. The study will be published in 2008.

C. Future issues

23. There are additional aspects of nuclear infrastructure — beyond those covered in the documents described above — where existing Agency publications will need updating to reflect new developments in nuclear power and additional knowledge and experience that has been gained. The Agency is therefore restructuring, updating and further developing its guidance on infrastructure in order to address the current needs of Member States and reflect the changing social and commercial environment for nuclear energy. The new or revised publications planned to be issued in 2008 and 2009, beyond those described above, will cover the following:

- siting of nuclear power plants,
- industrial capacity and availability in light of the expected growth in nuclear energy,
- infrastructure issues related to transportable or non-stationary reactors, and
- infrastructure issues related to alternative contracting and ownership policies.

24. Taking into consideration that some Member States may plan to order their first nuclear power plants in the near future, special focus will also be given to increasing advice on infrastructure preparation needs during the phase following the agreement of a contract for the first NPP. Specific guidance based upon recent international experience will be developed to help effective management and implementation of the phase of NPP construction and commissioning.

Agency Activities in the Development of Innovative Nuclear Technology

A. Background

1. In resolution GC(51)/RES/14.B.3, the General Conference addressed Agency activities in the development of innovative nuclear technology, invited all interested Member States to combine their efforts under the aegis of the Agency in the activities of the International Project on Innovative Nuclear Reactors and Fuel Cycles (INPRO), and requested the Director General to report on the progress made in the implementation of that resolution to the Board of Governors and to the General Conference at its fifty-second (2008) regular session. This report, which summarizes Agency activities concerning innovative nuclear technologies with an emphasis on activities under INPRO, has been prepared in response to that request.

2. INPRO is an Agency-wide project, which was established in 2001 following General Conference resolution GC(44)/RES/21 in 2000. In the first phase, a methodology was developed for the assessment of innovative nuclear energy systems. INPRO's second phase has three main directions: methodology oriented activities, institutional/infrastructure oriented activities and collaborative projects.

3. INPRO remains largely funded through extrabudgetary contributions; since 2004 it has also been partly funded from the regular budget for staff costs. As of May 2008, INPRO has 28 members: Argentina, Armenia, Belarus, Belgium, Brazil, Bulgaria, Canada, Chile, China, Czech Republic, France, Germany, India, Indonesia, Japan, Republic of Korea, Morocco, Netherlands, Pakistan, Russian Federation, Slovakia, South Africa, Spain, Switzerland, Turkey, Ukraine, USA and the European Commission (EC).

4. As of June 2008, ten cost-free experts are working for INPRO in the Agency's Secretariat (eight full-time and two part-time). Since INPRO began in 2001, a total of 33 cost-free experts have been provided from 16 INPRO member countries.

B. Developments since the General Conference's 2007 session

5. A nine-volume user manual for the application of the INPRO assessment methodology was prepared in 2007. This *INPRO Methodology Manual* includes an overview volume and topical volumes on economics, reactor safety, fuel cycle safety, environment, waste management, proliferation resistance, physical protection and infrastructure.

6. Phase 2 of INPRO started in July 2006 with the endorsement of the Phase 2 terms of reference by the INPRO Steering Committee. Subsequently, the action plan for 2008–2009 was endorsed by the Committee (December 2007). Key elements in the action plan for 2008–2009 are an update of the INPRO methodology based on national and joint assessments, an analysis of nuclear energy in the context of sustainable development, institutional and infrastructural analyses, the development of

'common user considerations' for developing countries looking into nuclear power; and collaborative projects covering a broad range of additional topics.

7. The INPRO methodology has been applied in national assessment studies performed by Argentina, Armenia, Brazil, China, India and Ukraine, as well as the Republic of Korea. It has also been used in a joint assessment study of closed fuel cycles with fast reactors by Canada, China, France, India, Japan, Republic of Korea, Russian Federation and Ukraine. Summary reports on the results are under preparation for publication in 2008. These will cover assessments of the innovative nuclear systems that were studied, recommendations for future R&D to further develop these innovative nuclear systems, and insights into the usability of the INPRO methodology itself.

8. Stage 1 of the activity on common user considerations (CUC) was completed in early 2008. A report was prepared for publication in 2008 that summarizes considerations regarding future nuclear energy systems that developing countries might deploy. The process followed in assembling these common user considerations is described below. A limited number of developing countries were selected to represent the key characteristics of technology-user countries. Detailed discussions were conducted with stakeholders and experts, including government officials in charge of energy policy and nuclear programmes, nuclear regulators, and researchers from national laboratories and universities, utilities and financial institutions. The draft considerations were subsequently reviewed in two workshops held in November 2007 and in May 2008 with participation from both technology-users and technology-holders. Through these activities, INPRO reached out to an additional twenty-six countries that are not members of INPRO[3]. In Stage 2 of the CUC activity, which started in spring 2008, the common user considerations established in Stage 1 are being further refined jointly by technology holders and users.

9. Technologies for spent fuel recycling and long-term disposition of remaining waste have been investigated in Agency activities under INPRO and in Subprogramme 1.2.4 on Topical Issues of Nuclear Fuels and Fuel Cycles for Advanced and Innovative Reactors in the Agency's programme for 2008–2009. The subprogramme also covers fuels and fuel cycle options for fast reactors, high temperature gas cooled reactors and small and medium sized reactors (SMRs) with long core life.

10. Out of a total of twelve INPRO Collaborative Projects that had been endorsed by the INPRO Steering Committee, four projects have started since September 2007 and are operational with committed contributions from Member States. These are: Investigations of the 233Uranium/Thorium Fuel Cycle (ThFC), Proliferation Resistance: Acquisition/Diversion Pathway Analysis (PRADA), Decay Heat Removal for Liquid Metal Cooled Reactors (DHR), and Global Architecture of Innovative Nuclear Energy Systems based on Thermal and Fast Reactors including closed Fuel Cycles (GAINS).

11. An additional eight INPRO Collaborative Projects have been prepared and are open for Member States to join. These deal with various topics, such as removal of heat by liquid metal and molten salt coolants, fuel cycles for innovative systems, passive systems and components, environmental impact benchmarking, use of nuclear power in smaller countries, safety aspects of nuclear hydrogen production, availability assessment of raw materials and advanced water cooled reactors.

12. Collaboration on innovative nuclear technologies is also being supported through the Department of Nuclear Energy's standing Technical Working Groups (TWGs), which address and cover the different reactor technology lines and fuel cycle issues. As examples of the extensive cooperation

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[3] Bangladesh, Cameroon, Croatia, Dominican Republic, Egypt, Estonia, Ethiopia, Georgia, Ghana, Jordan, Kenya, Lithuania, Malaysia, Mexico, Republic of Moldova, Mongolia, Namibia, Nigeria, Poland, Romania, Sudan, Syrian Arab Republic, Tunisia, Uruguay, Venezuela and Vietnam.

conducted within the framework of these TWGs, a number of coordinated research projects (CRPs) were started in 2007–2008, including one on Heat Transfer Behaviour and Thermo-hydraulic Codes Testing for Super-Critical Water Cooled Reactors. Other newly started CRPs address passive safety systems of advanced reactors, natural sodium convection, hydrogen production and seawater desalination and other innovative topics.

13. In addition, TWGs provide advice relevant also for the implementation of INPRO Collaborative Projects. Through this mechanism, synergies between INPRO activities and regular programme activities under TWGs are being fostered.

14. INPRO continues to seek good coordination with other international initiatives. The Agency continues to participate in the Generation IV International Forum (GIF) as a participant in working groups and as an observer in the policy group. In February 2008, INPRO and GIF agreed on a 14-point joint action plan. It includes the use of GIF's economic evaluation model ECONS by the Agency to estimate the costs of gas cooled reactors and the use by GIF of the Agency's economic evaluation model for nuclear generated hydrogen, HEEP.

Producing Potable Water Using Nuclear Reactors

A. Background

1. In resolution GC(51)/RES/14, the General Conference underlined "the urgent need for regional and international cooperation in helping to solve the serious problem of potable water shortages, particularly through desalination of seawater" and noted the interest expressed by a number of Member States in activities related to seawater desalination using nuclear energy. In that resolution, the General Conference requested the Director General to continue working in this area with interested Member States and other organizations, to assist interested Members States in preparing demonstration projects, to seek additional funds, and to report on progress to the Board of Governors and to the General Conference at its 52nd session. The General Conference also invited the International Nuclear Desalination Advisory Group (INDAG) to continue as a forum for advice and review on nuclear desalination activities.

2. Resolution GC(51)/RES/14 contains several specific references to desalination using small and medium size nuclear reactors (SMRs). As previous resolutions contained comparable references, the reports in response to those resolutions have also summarized Agency activities on SMRs. Unlike previous resolutions, however, resolution GC(51)/RES/14 requests a separate new report, to be submitted in 2009, specifically on the development and deployment of SMRs. Therefore, while this report includes some relevant summary information on SMRs, it focuses more exclusively on nuclear desalination than have past similar reports and does not elaborate on SMR activities which will be covered in next year's SMR report.

B. International Nuclear Desalination Advisory Group (INDAG)

3. INDAG held its ninth meeting in January 2008 at which INDAG members exchanged information on the progress of national, international and interregional activities in nuclear desalination. They reviewed the progress of the Agency's work and activities planned for 2008, discussed a proposed road map, and recommended that the IAEA create a 'nuclear desalination toolkit' to provide guidelines and information on launching nuclear desalination programmes in Member States. The seventh issue of INDAG's newsletter was published in September 2007.

C. Activities of the Member States

4. Highlights reported at the INDAG meeting include the following.

5. India has successfully demonstrated nuclear desalination through several projects, including the first nuclear desalination plant based on low temperature evaporation coupled to a research reactor, CIRUS. Other elements of India's Nuclear Desalination Demonstration Programme are a larger reverse osmosis desalination facility that is already in operation and a multi-stage flash desalination facility on which construction is nearing completion. This is expected to be commissioned before the end of 2008. India is also investigating coupling a nuclear desalination plant to the nuclear research reactor Dhruva at Trombay and integrating a large desalination plant with India's Advanced Heavy Water Reactor (AHWR).

6. Japan continues to operate desalination plants at ten nuclear power reactors for the production of make-up water.

7. The Republic of Korea is concentrating on the design and development of an integrated desalination plant with the small reactor SMART (System-integrated Modular Advanced Reactor). SMART will be used for seawater desalination and electricity generation.

8. Pakistan continues work to demonstrate nuclear desalination through a multi-effect desalination facility at the Karachi Nuclear Power Plant (KANUPP). The project is scheduled for completion and commissioning by the end of 2008.

9. The Russian Federation is constructing a floating barge-mounted heat and power co-generation nuclear plant. The facility is based on the small PWR-type reactor KLT-40S, which could also be used for desalination.

10. Several other countries are considering launching nuclear desalination demonstration programmes or desalination plants and are studying the technical and economic viability of different processes, on both a national and a multilateral basis. These include China, France, Libya and the countries of the Gulf Cooperation Council — Bahrain, Kuwait, Oman, Qatar, Saudi Arabia and UAE. Interest in nuclear desalination has also been expressed by Algeria, Brazil, Indonesia, Iran, Iraq, Italy, Jordan, Lebanon, Philippines, Syrian Arab Republic and the United Arab Emirates. Nuclear desalination is also a possible focus of a proposed working group on grid appropriate reactors which the Global Nuclear Energy Partnership's (GNEP's) Executive Committee will likely consider at its next meeting.

D. Activities of the Agency

11. In line with the INDAG recommendations summarized above, the Agency is consulting with Member States to develop the recommended roadmap on nuclear desalination activities and to create the recommended 'nuclear desalination toolkit'. The Agency is also working with Member States to establish a work plan to revise the Desalination Economic Evaluation Programme (DEEP) software and perform benchmark case studies for validation purposes. Several Member States are supporting these efforts with cost-free experts.

12. *Considerations to Launch a Nuclear Power Programme* (GOV/INF/2007/2) and *Milestones in the Development of a National Infrastructure for Nuclear Power* (Nuclear Energy Series No. NG-G-3.1) were published in 2007 and are applicable whether a country's focus is on nuclear desalination or electricity generation. The former document gives an overall description of important infrastructure issues and outlines three phases of development. The latter provides more detailed guidance on each of the three phases. Based on these documents, the Agency's support to Member States focuses on infrastructure development, capacity building, nuclear desalination simulation, training, and targeted technical meetings and conferences.

13. Specific, bilateral projects between Indonesia and the Republic of Korea; India and Pakistan; and France and Libya are also underway which will promote international cooperation in the planning and implementation of nuclear desalination activities.

14. The Agency has also launched an evaluation of major environmental impacts of nuclear desalination. The evaluation will cover both adverse impacts, such as brine pollution, and beneficial impacts, such as the preservation of existing natural water resources.

E. Extrabudgetary Contribution

15. As requested in resolution GC(51)/RES/14, the Director General has sought additional funds for nuclear desalination. In particular, the Secretariat has approached Member States to request their financial support and circulated letters soliciting funds for nuclear desalination and nuclear hydrogen production. Thus far, $20 000 has been received from the Republic of Korea, and a pledge for €10 000 has been received from Kuwait.

F. Information Exchange

16. The Agency continues to provide an international forum for exchanging information on nuclear desalination, including design, operation, coupling, safety, experience surveys, and monitoring of product water from desalination plants.

17. In cooperation with the Japan Atomic Energy Agency and OECD/NEA, the Agency organized an international conference on 'Non-electric Applications of Nuclear Power: Seawater Desalination, Hydrogen Production, District Heating and Other Industrial Applications', which was held in April 2007 in Oarai, Japan. The conference reviewed case studies on applications of nuclear heat for desalination, hydrogen production and enhanced use of fossil fuel resources (e.g. coal liquefaction or enhanced oil recovery from tar sands). More than 130 participants from 30 countries and 5 international organizations participated in the conference.

18. The first Research Coordination Meeting (RCM) of the coordinated research project (CRP) entitled 'Advances in Nuclear Power Process Heat Applications' was held in September 2007. The objectives of the CRP include evaluating low as well as high temperature applications of high temperature reactors. The main focus is nuclear hydrogen production and the use of waste heat from high temperature reactors for seawater desalination.

19. A technical meeting on DEEP validation was held in Vienna in October 2007. The meeting established a work plan to revise benchmarks and validate the DEEP software. It reviewed alternative methods for benchmarking DEEP and recommended that a new CRP be undertaken to extend the scope of benchmarking and that reference cases and relevant data for multi-stage flash (MSF), multiple effect desalination (MED), reverse osmosis (RO) and hybrid MED/RO and MSF/RO be defined.

20. A technical meeting on integrated nuclear desalination systems was held in Cadarache, France in December 2007. It highlighted the continuing need in many Member States for more public information about nuclear power in general and nuclear desalination in particular. While appropriate infrastructure and human resources development are prerequisites for nuclear energy deployment, participants agreed that the existence of a nuclear power programme in a country should considerably facilitate the deployment of nuclear desalination.

21. The Agency's website for nuclear desalination (www.iaea.org/nucleardesalination) continues to provide access to all relevant Agency publications as well as to up-to-date information on the status of nuclear seawater desalination technology and the Agency's current and planned activities.

G. Small and Medium Size Reactors and Seawater Desalination

22. Some Member States prefer small and medium size reactors (SMRs) for electricity generation and desalination for several reasons, including the SMRs' suitability to smaller electricity grids and lower investment costs. A new report entitled *Status of Small Reactor Designs without On-site Refuelling: 2007* (IAEA-TECDOC-1536) summarizes the common design objectives and considerations for reactors that have very long lifetime cores. The report provides information on important development trends and objectives for small reactors, on the state of the art concerning their design and technology development, on their design status, and on possible applications. As noted in paragraph 2 above, a detailed report on SMRs will be provided to the 53rd session of the General Conference.

H. Publications

23. Since the report to the 51st session of the General Conference, the Agency has issued two technical documents on desalination using nuclear reactors and is preparing to publish the proceedings of one conference as follows:

- *Status of Nuclear Desalination in IAEA Member States*, IAEA-TECDOC-1524 (2007).
- *Economics of Nuclear Desalination: New Developments and Site Specific Studies*, IAEA-TECDOC-1561 (2007).
- Proceedings of the international conference on 'Non-electric Applications of Nuclear Power: Seawater Desalination, Hydrogen Production, District Heating and other Industrial Applications' held in April 2007 in Oarai, Japan.