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Atoms for Peace

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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(53)/RES/13 and GC(54)/RES/10, this document contains progress reports on the Programme of Action for Cancer Therapy (PACT) (Annex 1); support to the African Union's Pan African Tsetse and Trypanosomosis Eradication Campaign (AU-PATTEC) (Annex 2); use of isotope hydrology for water resources management (Annex 3); nuclear energy activities (Annex 4); producing potable water economically using small and medium-sized nuclear reactors (Annex 5); Agency activities in the development of innovative nuclear technology (Annex 6); small and medium-sized reactors (SMRs) – development and deployment (Annex 7); and approaches to supporting infrastructure development for nuclear power (Annex 8).
- Further information on the Agency's activities related to nuclear science, technology and applications can be found in the Nuclear Technology Review 2011 (document GC(55)/INF/5), the Agency's Annual Report 2010 (GC(55/2), in particular the Technology section, and the Technical Cooperation Report for 2010 (GC(55)/INF/2).


## Recommended Action

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

# Programme of Action for Cancer Therapy

1. At its fifty-third regular session in September 2009, the General Conference (GC), in resolution GC(53)/RES/13.A.2, requested the Director General to continue to advocate, build support and allocate and mobilize resources for the implementation of the Programme of Action for Cancer Therapy (PACT) as one of the priorities of the Agency; and to continue formalizing, where feasible and appropriate, PACT's collaboration with partners already identified for the benefit of more effective development and implementation of country-level PACT projects.

2. The GC recommended the continuous development, in consultation with Member States, of imPACT reviews (integrated missions of PACT); that the PACT Programme Office (PPO) continue to raise awareness about the global cancer burden in low and middle-income (LMI) countries, and that the PPO use all tools at its disposal, including partnerships with local, national and international media, to meet this objective; and that the PPO, in consultation with relevant Agency departments and the World Health Organization (WHO), as appropriate, continue working to assist developing Member States in establishing comprehensive national cancer control plans, involving full participation of other international organizations and agencies. The GC requested the Director General to report on the implementation of this resolution at its fifty-fifth (2011) regular session.

3. In September 2010, the GC, in its resolution GC(54)/RES/10.A.5, commended the Director General's efforts to place special focus on cancer control in developing countries. It requested the Secretariat to continue to undertake activities aimed at enhancing the capacities of developing countries in cancer control, encouraged Member States to provide extrabudgetary resources for the Agency's cancer-related activities; and the Director General to continue his efforts to strengthen the partnership between the Agency, WHO and other organizations in addressing the issue of cancer control in developing countries.

## A. Agency-wide Cancer Control Activities

4. The Director General assigned special priority to the Agency's work on cancer control in 2010. He addressed this issue in his meetings with Member States, encouraged enhanced attention to it by the United Nations in his meeting with the UN Secretary-General, spoke on this subject at the *World Economic Forum* in January 2010 in Davos and raised it in numerous bilateral meetings with potential donors for Agency activities in this field. The Director General's message conveyed that *"cancer is a serious problem in developing countries; it should be recognized as a vital part of the global health agenda; and the IAEA can play an important role in improving cancer control in developing countries, in cooperation with the WHO and other partners. The Agency's work, especially through the PACT programme, undoubtedly makes a difference, but there is much more that needs to be done. The Agency's goal must be to ensure that all developing countries have the personnel and equipment they need to provide a good quality of care to their people*[1]*"*. This message defined the way forward for all cancer-related activities delivered through the Agency's programmes.

5. True to the forecasts made by the International Agency for Research on Cancer (IARC)[2], cancer incidence continues to grow alarmingly, particularly in LMI countries. By 2030, it is estimated that cancer will cause one in six deaths, with seventy-five per cent of these deaths occurring in the developing world. This is a tremendous challenge requiring concerted and well-coordinated efforts by

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[1] Excerpt from Director General's statement to the IAEA Board of Governors on 1 March 2010.
[2] IARC's GLOBOCAN 2008 project provides contemporary estimates of the incidence of, and mortality from major types of cancers, at the national level, for all countries of the world. See http://globocan.iarc.fr/

all key players at the national, regional and global levels. The Agency has worked over the past decades to enable its developing Member States to initiate cancer therapy programmes and to develop a sound basis for the capacity and infrastructure required for cancer control. PACT's activities have confirmed the need for a unified strategy to maximize the Agency's contribution to the global fight against cancer and ensure the effectiveness and sustainability of its efforts.

6. PACT has been recognized by Member States as an Agency flagship programme. It endeavours to create a unifying vision and operational framework, including coordinated management and communication processes, for all Agency cancer-related activities, so that these can achieve maximum public health impact in LMI Member States, and to further facilitate donor interest in and commitment to supporting the Agency's activities and placing cancer on the global health agenda.

7. Since September 2009, following PACT's cancer control approach referred to above, the Agency has continued supporting its Member States through its Technical Cooperation (TC) and Human Health programmes. Agency funding for capacity building and infrastructure improvements in cancer control reached over US$25 million annually, or over 25% of total TC delivery. Supplemented by cancer-related scientific and technical activities, carried out under their regular programmes, by the Department of Nuclear Safety and Security and the Department of Nuclear Sciences and Applications, the assistance has enabled over 100 LMI Member States to establish safe and effective diagnostic imaging and radiation therapy capacity. The focus on cancer was particularly evident during 2010 through the implementation of 154 TC projects related to radiation medicine across the regions. For the 2012-2013 TC cycle, over 160 project concepts related to human health were received from 96 Member States; of these, 70% were cancer-related and for the first time they were reviewed by PPO.

8. The Agency has also undertaken extensive outreach and advocacy activities to draw attention to the problem of cancer in developing countries. One such event was the 2010 Scientific Forum entitled: "Cancer in Developing Countries: Facing the Challenge" held during the 54th Regular Session of the IAEA General Conference. The Forum hosted prominent scientists and public health leaders from national cancer societies, cancer control organizations and international bodies including WHO policy-makers, health care experts and dignitaries, who discussed the cancer epidemic's implications for public health policy in LMI countries. The conclusions of the Scientific Forum were sent with a message from the President of the General Conference to the President of the UN General Assembly (UNGA). In his message, the President, referring to UNGA Resolution 64/265 on "Prevention and control of non-communicable diseases" (NCDs), conveyed the IAEA's full support to the discussions of the UN-Millennium Development Goals (MDGs) High-Level Meeting regarding NCDs, and, in particular, to the actions proposed by WHO in preparing for the next High-Level Meeting planned for September 2011 at the UN Headquarters in New York. The Agency and WHO have worked together to contribute to the preparatory work leading to the High Level Meeting on NCDs in September 2011.

9. Also, in late 2009 and during 2010, PACT participated in and co-sponsored three major international events: the 3rd International Cancer Control Congress; the Union for International Cancer Control (UICC) World Cancer Congress; and the 7th Congress of the African Organization for Research and Training in Cancer (AORTIC). The contribution to the work of these major events is critical to ensure that the role of the Agency as a global partner in cancer control is recognized and maintained.

# B. WHO-IAEA Joint Programme on Cancer Control

10. With the development of PACT, the Agency has emphasized that expanding radiotherapy capacity alone is not enough to combat the cancer crisis. This has also been confirmed through a field

evaluation carried out by the Agency with respect to the African region[3]. The Agency's goal to reduce cancer mortality by improving cancer survival in LMI countries can only be achieved if a country's radiation medicine capacity is fully integrated into its National Cancer Control Programme (NCCP), which is crafted to suit its specific needs within the public health system.

11. With this understanding the WHO/IAEA Joint Programme on Cancer Control (the Joint Programme) was launched in 2009 to promote the integration of cancer prevention, early detection, diagnosis and treatment, and palliative care, as well as the related advocacy, public education and capacity building within the context of NCCPs. The complementarity of the mandates of both WHO and IAEA has contributed to the strength of the programme.

12. Communicating as a Joint Programme is a priority for both organizations. In February 2011, the Directors General of WHO and the Agency published a joint op-ed in *Project Syndicate*[4] urging that cancer be acknowledged as a vital part of the global development agenda and that effective cancer control be included as an integral part of national health-care systems throughout the developing world.

13. In addition to assisting the Agency's Member States in developing and improving their radiation medicine capacity and infrastructure, the Joint Programme also aims at strengthening public health approaches to prevention and other areas of cancer control. In November 2010, the Mongolian Ministry of Health hosted a Joint WHO–IAEA Cancer Workshop in Ulaanbaatar, Mongolia. This was the first WHO/IAEA event since the establishment of the Joint Programme, and it involved over 50 health professionals from Albania, Ghana, Mongolia, Sri Lanka, Vietnam and Yemen, as well as other international experts.

## C. Cancer Control Capacity Assessment, Evaluation and Support in Member States

14. One of the key services provided to Member States is the imPACT review[5], the purpose of which is to assess the Member State's readiness to develop and implement a long term radiation medicine capacity building plan, including the relevant safety, regulatory and quality assurance requirements, within the framework of a national cancer control programme. The imPACT review team *collects information* on the status of existing plans, strategies, policies, safety practices, regulations, capacities and infrastructure related to cancer control; *assesses* the Member State's radiation medicine capacity and human resource development; and *provides advice* on immediate actions and planning of the country's cancer-related IAEA TC projects for future cycles. To date, 84 Member States have requested this service. In the past two years, PPO coordinated 20 imPACT reviews in close collaboration with the concerned Departments of the Secretariat and WHO, including its regional and/or country offices. These missions were implemented with extrabudgetary contributions from France, Monaco, New Zealand, the Republic of Korea, Spain and the United States of America, as well as with additional funding allocated through the Peaceful Uses Initiative (PUI). As a baseline

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[3] GOV/2009/72, "Evaluation of Technical Cooperation Activities in 2009", Annex 4, Page 1: "Evaluation of the Agency's assistance to fight cancer in one selected region" (Africa).

[4] *Project Syndicate* is the world's pre-eminent source of original op-ed commentaries. As of May 2011, *Project Syndicate* membership included 462 leading newspapers in 150 countries.

[5] On 7 April 2011, the WHO-IAEA Joint Programme Steering Committee recommended implementation of Joint Cancer Control Assessment Missions as part of the Joint Programme's activities.

document, the Country Cancer Profile (CCP) was developed as a reference[6] for information on cancer-related activities and statistics for all Member States visited.

15. PPO continued to facilitate training for health professionals with emphasis on the eight PACT Model Demonstration Sites (PMDS). In-kind contributions from the US National Cancer Institute (NCI) allowed for the participation of 38 professionals from 23 Member States in summer training courses in 2010 and 2011. In addition, 13 doctors and nurses from six African countries participated in the third and final train-the-trainers workshop on palliative care organized in December 2009 by the Alliance Mondiale Contre le Cancer (AMCC), an affiliate of the International Network for Cancer Treatment and Research (INCTR), in Burkina Faso, using extrabudgetary funding received from a number of Member States.

16. Within the framework of the 2009-2011 TC programme, two regional TC projects (RAF/6/041 and RAS/6/060) supported the development of national cancer control programmes in Africa and in Asia and the Pacific.[7] Two regional events aimed at enhancing Member State capabilities to initiate the design and implementation of NCCPs were held with WHO in India and Senegal, with a total of 72 participants from over 30 Member States. These workshops were supported by experts from partner organizations, such as the WHO regional offices, the American Cancer Society (ACS), the International Agency for Research on Cancer (IARC), AORTIC, and the Tata Memorial Centre.

17. Responding to the inequity that persists in access to radiation therapy in the developing world, the Advisory Group on increasing access to Radiotherapy Technology in low and middle income countries (AGaRT) was launched by the IAEA in 2010 as a new PACT activity. Building upon the outcomes of a meeting with manufacturers of diagnostic and radiotherapy equipment during the International Conference on Advances in Radiation Oncology (ICARO, April 2009), AGaRT seeks to bring together users and suppliers of diagnostic and radiotherapy technologies and other stakeholders, with a view to encouraging the production of safe, affordable and reliable equipment for the specific requirements of radiotherapy centres in developing countries. The first meeting of AGaRT took place in June 2010 in Vienna with the participation of 25 experts from all geographic regions, as well as representatives of WHO, the International Electro-technical Commission (IEC), the International Organization for Medical Physics (IOMP), the European Society for Therapeutic Radiology and Oncology (ESTRO), the National Institute of Radiological Sciences, Japan (NIRS), and the Korean Institute for Radiological and Medical Sciences (KIRAMS). The participants concluded that concerted action needs to be taken in identifying priority areas, developing action plans and sustainable solutions to eventually increase access to radiotherapy in LMI countries and that regular meetings with industry are required to share further information on comprehensive solutions that meet international standards.

# D. PACT Model Demonstration Sites

18. The PACT Model Demonstration Sites (PMDS) are pilot projects in Member States aimed at demonstrating synergies between international partners, donors, cancer therapy experts, and national authorities for effective cancer control planning and implementation. In 2009 and 2010, upon request from their respective governments, and following discussions between the Agency and the WHO

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[6] In addition to open source information such as Globocan (WHO-IARC), WHO webs, the WHO Country Cooperation Strategy, and the World Bank, the Country Cancer Profile (CCP) includes information provided by the relevant TC Regional Division, NAHU and NSRW.

[7] For details of TC activities in the field of cancer control, refer to the Technical Cooperation Report for 2010 in GC(55)/INF/2.

within the scope of the Joint Programme, Ghana and Mongolia joined Albania, Nicaragua, Sri Lanka, Tanzania, Vietnam and Yemen as PMDSs.

19. During 2010 all PMDS Member States were encouraged to assess their action plans and to develop project proposals for funding in all areas of cancer control. In the past two years, 13 follow-up missions were undertaken in Albania, Ghana, Mongolia, Nicaragua, Sri Lanka, Tanzania and Vietnam, on the basis of which evaluation and monitoring tools are being specifically designed to assess the effectiveness of the PMDS concept.

20. The approval of the Agency's *Policy on Partnerships and Resource Mobilization* in 2010 enabled the Agency to engage partners directly in the implementation of priority country projects in PMDS defined by respective governments. In 2010, the Bhabhatron telecobalt unit donated by the Government of India to Vietnam through the Agency was commissioned. A tripartite agreement was also signed for the donation of an additional Bhabhatron unit to Sri Lanka. Within the framework of a grant from the OPEC Fund for International Development (OFID), agreements were signed with the INCTR to implement a project on increasing access to palliative care services in Tanzania; with the Albanian Institute for Public Health for a project on raising breast cancer awareness; and with the Ministry of Health of Nicaragua on early detection and treatment of cervical and paediatric cancers in women and children. An agreement was also signed with the National Cancer Centre of Mongolia for the establishment of a playground for children with cancer, funded by the United Nations Women Guild (UNWG) in Vienna.

# E. Promoting Regional Cancer Training Networks through a Virtual University

21. In May 2010, the first African pilot project of the Virtual University for Cancer Control (VUCCnet Africa) was launched within the PACT framework, with Ghana, Tanzania, Uganda and Zambia as pilot sites, and Egypt and South Africa as mentor sites. This initiative, which relies on support from PACT partners and existing Agency experience, is expected to facilitate the education and training of cancer care professionals in their home countries, utilising the local e-learning infrastructure and a regional African training network as a complement to traditional teaching approaches. In addition to a donation from the USA in 2009, financial resources were mobilized from the private sector, formalized through an agreement with the Roche African Research Foundation in 2010.

22. The Annual Stakeholders Project Coordination Meeting held in Vienna in June 2011 was attended by over 50 representatives of Member States, WHO, IARC, INCTR, the African Radiation Oncology Group (AFROG) and other Agency partner organizations. The meeting concluded that, as a regional approach building upon existing training materials, African training networks and African infrastructure, and embedded in the existing African education and training institutions, VUCCnet shall be a vehicle and a facilitating mechanism to enhance cancer control education and training capacity in Africa. The meeting also concluded that tripartite cooperation arrangements between the participating Member States, the African Regional Cooperative Agreement (AFRA) and the Agency could facilitate the integration of VUCCnet Africa into existing health education and training systems.

# F. Funding, Resource Mobilization and Partnerships

23. PACT's support to Member States largely relies upon external financial resources. Between September 2009 and September 2011, a total of $21.6 million were mobilized in terms of new extrabudgetary funding from development banks, bilateral donors, Member States, partner

organizations, the PUI and the private sector. PACT's fundraising and resource mobilization strategy is implemented by PPO and focuses on the following categories:

a) **Development Banks:** Support is provided to Member States directly seeking funding from development banks such as, for example, the Arab Bank for Economic Development in Africa (BADEA), the Islamic Development Bank (IDB), and OFID[8].
b) **Bilateral funding:** PMDS projects are presented for direct bilateral funding to potential donor countries and/or group of countries. Examples include the Republic of Korea for Mongolia and Vietnam[9].
c) **Grants to PMDS or other cancer projects**: PMDS projects endorsed by the national health authorities or supported through TC cancer-related footnote a/ projects are presented to various donors or foundations for funding. The funds raised under this category are usually transferred through the Agency and then allotted to the respective projects, according to the provisions of the Agency's Partnerships and Resource Mobilization Policy. Examples include: OFID funding for Albania, Nicaragua and Tanzania ($500 000 for all three); Monaco funding for projects in Niger (€175 000); Spain funding for Nicaragua and North African Member States (€500 000); India for Vietnam & Sri Lanka; US NCI in-kind training support to an average of twenty fellows annually (~ $250 000/year); and a donation by the Roche African Research Foundation of $4 000 000 for the Virtual University for Cancer Control.
d) **Grants to the PACT general fund**: Funds are used for the overall implementation of PACT. Examples include donations from France, the Republic of Korea, Monaco, New Zealand, Spain and the USA.

24. Over the long term, fundraising and resource mobilization can benefit from effective partnerships. In addition to the WHO/IAEA Joint Programme and previously reported partnership agreements, the Agency has signed six new Practical Arrangements (PAs) with well-recognized organizations active in cancer control[10] during the reporting period.

# G. Achieving the Cancer Mandate: the Main Challenges Ahead

25. While progress has been achieved on a number of fronts such as: a strengthened Joint Programme with WHO, new partnerships with international organizations, increased requests from Member States to assess cancer control capacity and needs, and the launching of the VUCCnet Africa project, much remains to be done in all areas of PACT work. Of particular relevance here is the need to ensure that all Agency sectors involved in cancer-related activities strive to work together within the scope of a unified and well-coordinated cancer control policy, and other relevant strategies linked to existing programmes, under the umbrella of PACT.

26. Looking beyond 2011 and into the longer term prospects for PACT, a number of factors and challenges, which will be influencing the planning of future human health and cancer-related programmes within the Agency and in Member States, are highlighted below:

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[8] As an example, 13.7 million were mobilized for Ghana from two development banks as reported in September 2009.

[9] Other examples previously reported include Australia for Vietnam, Saudi Arabia for Yemen and Canada for Tanzania.

[10] The latest PAs have been signed with the American Society of Clinical Oncology (ASCO), KIRAMS, the Catalan Institute of Oncology (ICO), the Breast Global Health Initiative, the London School of Hygiene and Tropical Medicine and the International Cancer Centre Abuja (ICCA). Additional PAs are under preparation to formalize PACT's partnership with the French National Cancer Institute (INCa) and AORTIC.

a) **In many parts of the world, the absence of a specific reference to cancer in the Millennium Development Goals has led to cancer control being allocated a lower priority by national governments and global health funders:** There needs to be greater incentives developed for LMI countries to prioritize cancer and other non-communicable diseases. The High-Level Meeting on 19-20 September 2011 at the General Assembly in New York will deal with the issue and corresponding initiative.

b) **Developing the capacity to treat the large number of cancers that will be diagnosed in the coming years:** Surgery, chemotherapy, and radiotherapy are essential components in the treatment of cancer. By promoting a comprehensive cancer control approach, effective prevention could reduce the risk of cancer, and effective screening could allow many others to be diagnosed early enough for successful treatment. The Agency shall continue to advocate for a public health approach and maintain its focus on cancer control in order to secure the success and sustainability of its radiation medicine assistance.

c) **The need to expand radiotherapy both quantitatively and qualitatively:** It is estimated that over 2 500 radiotherapy machines are currently installed in developing countries. This figure is significantly below the estimated needs of almost 5 000 machines. More importantly, there is an enormous need for qualified professionals capable of operating new radiotherapy equipment, where the accuracy with which each step of the treatment process is carried out may have a significant impact on the patient. The development of the medical infrastructure for cancer diagnosis and treatment will thus be a major challenge and a substantial undertaking for Member States in all regions, in particular in Africa and Asia, over the forthcoming years. In this connection, PACT's continued work as an Agency umbrella programme on cancer and engaging with donors and partners that can provide the enormous resources needed for the development of the infrastructure for modern cancer diagnosis and treatment facilities is essential. Future cancer-related activities will need to continue to follow a comprehensive cancer control approach in order to be effective and sustainable. As the PACT Model Demonstration Sites are opening the way for such an approach, a vital issue for PACT during the next five years will be to ensure that the necessary coordination, tools and policies are in place to successfully demonstrate that international agencies can cooperate and extract synergies to maximize their individual and collective impact at the country and regional levels, resulting in new or additional resources for cancer control in developing countries. In this regard, it is essential to note that a continued strong programme in cancer will provide both the tools and the guidance for improving radiation medicine standards, and will offer an incentive for better practices in cancer centres supported by the Agency.

d) **The need to expand accreditation as well as the recognition of education and training by participating Member States through their respective authorities and/or professional societies**. Such national recognition could enhance the sustainability of capacity-building initiatives. For example, the Agency has the opportunity through initiatives like the VUCCnet project in Africa to greatly enhance human resources for cancer control. A challenge will be to foster this in a sustainable manner. Accreditation of education and training activities could raise the potential long-term impact.

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

## A. Background

1. In resolution GC(54)/RES/10 A.3. the General Conference expressed its appreciation of the importance of livestock development in rural communities affected by tsetse flies and trypanosomosis as a pathway out of poverty and hunger and a basis for food security and socio-economic development. It welcomed the signing of a Memorandum of Understanding between the African Union and the Agency, formalizing their collaboration, within their respective mandates, in support of the overall objectives of the AU-PATTEC Plan of Action; and the Agency's initiative to designate the Centre International de Recherche-Développement sur l'Elevage en Zone Sub-Humide (CIRDES) in Bobo-Dioulasso, Burkina Faso, as an IAEA Collaborating Centre in "The Use of the Sterile Insect Technique for Area-Wide Integrated Management of Tsetse Fly Populations". The General Conference further requested the Secretariat, in cooperation with Member States and international organizations, to maintain funding – through the Regular Budget, the Technical Cooperation Fund and other partnerships – and to strengthen its support for R&D in and technology transfer to African Member States to complement their efforts to create and subsequently expand tsetse-free zones. It urged the Secretariat to strengthen capacity building and to support the establishment of regional training centres in the affected Member States so as to promote the development of the human resources necessary for implementing the operational national and regional PATTEC projects. The General Conference stressed the need for continued harmonized, synergetic efforts by the Agency and other international partners, particularly FAO and WHO, with the aim of supporting the African Union Commission and Member States through the provision of guidance and quality assurance in planning and implementing national and subregional AU-PATTEC projects. It furthermore 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-fifth (2011) regular session.

## B. Work since the 54th General Conference

2. In consultation with its international partners, particularly FAO and WHO, the Agency maintained close interaction with AU-PATTEC and provided assistance to the six current national PATTEC projects in Burkina Faso, Ethiopia, Ghana, Kenya, Mali and Uganda. In early October 2010 one representative of each FAO and IAEA visited the African Union Commission in Addis Ababa, Ethiopia, in order to discuss with representatives of AU-PATTEC areas of cooperation in support of Member States' efforts to alleviate and, if possible, eliminate the tsetse and trypanosomosis (T&T) problem, and to explore specific areas of FAO and IAEA support to the overall objectives of the AU-PATTEC initiative. The AU-PATTEC representatives requested the IAEA to continue providing support in the sterile insect technique (SIT) for tsetse as part of an area-wide integrated pest management (AW-IPM) effort, and specifically in tsetse mass rearing, baseline data collection and relevant operational research. The FAO was requested to support efforts directed

at sustainable agriculture and rural development (SARD), as well as aspects relevant to land use and animal health. PATTEC re-confirmed the need for continued WHO support for interventions against human African trypanosomosis (HAT, i.e. sleeping sickness) as well as for the continued interaction with all three UN system organizations in the development of national legislation and relevant regulatory measures. It was agreed that an effort would be made to enhance joint planning, implementation and monitoring of T&T intervention projects at the national and sub-regional level and that there should be a major focus on joint training and capacity development in three main areas: a) project management; b) laboratory and field techniques; and c) baseline data collection and feasibility assessment subject to availability of funds.

3. FAO, IAEA and WHO continued to cooperate, together with other partners, in the Programme Against African Trypanosomosis (PAAT), as a means to synergise their support to Member States' efforts against the T&T problem. As recommended in a 2009 external review, some structural adjustments of PAAT and a revised strategic framework are being designed in order to streamline the results-based services of PAAT to PATTEC projects and other stakeholders. Funding available to the Joint FAO/IAEA Division and to the FAO Animal Production and Health Division in Rome was used through PAAT to recruit consultants, one based in Accra, Ghana, and one in Addis Ababa, Ethiopia, to support the PATTEC projects in West and East Africa, respectively.

4. The Agency contacted PATTEC, FAO, WHO and several national PATTEC coordinators for information on training needs and priorities in capacity development, based on which two regional FAO/IAEA training courses were prepared and will be carried out in early 2012.

5. The collaboration with CIRDES in Bobo-Dioulasso, Burkina Faso, as an IAEA Collaborating Centre focusing on the use of the SIT for the area-wide integrated management of tsetse fly populations, was enhanced in accordance with the agreed topics of cooperation, including capacity development, methods validation and support in planning and initiating tsetse AW-IPM campaigns with an SIT component.

6. The Insect Pest Control Laboratory (IPCL) of the Joint FAO/IAEA Division in Seibersdorf has worked on validating techniques and strategies for integrated management of the tsetse salivary gland (SG) virus that is particularly hampering the mass rearing of *Glossina pallidipes (G. pallidipes)*. Additional efforts were focussed on sex separation of tsetse flies in the late pupal stage and on the development of standardised methods for long-distance bulk shipment and aerial release of chilled sterile tsetse fly males. A new colony of *Glossina palpalis gambiensis (G. p. gambiensis)*, originating from the target area in Senegal, was established and mating compatibility studies between strains of *G. p. gambiensis* from Burkina Faso and Senegal were conducted in order to assess whether the mass reared Burkina Faso strain can be used for SIT operations in Senegal. The laboratory, furthermore, conducted studies on the mating behaviour of *G. pallidipes* and on the SG virus.

7. The Agency manages two coordinated research projects (CRPs) using research and methods that are relevant to the T&T problem: "Improving SIT for Tsetse Flies through Research on their Symbionts and Pathogens" and "Applying GIS and Population Genetics for Managing Livestock Insect Pests". A total of 35 scientists and tsetse control personnel from 21 Member States are participating in these CRPs.

8. In the past year, the Agency supported the AU-PATTEC Plan of Action through two regional technical cooperation (TC) projects (RAF/5/059, RAD/5/060) and five national TC projects (CHD/5/002, SEN/5/029, SEN/5/031, UGA/5/031). Assistance, in the form of training, expert services and equipment, was provided to 12 Member States affected by the T&T problem. The focus

was on baseline data collection, feasibility assessment studies, capacity building and pre-operational support for the use of the SIT. For the 2012-2013 TC cycle six new national TC projects and one regional project have been designed and submitted to the Agency for consideration. In addition, one of the two on-going regional projects (RAF/0/060) will be extended into the next TC cycle.

9. The IAEA has been providing support for the last 13 years to the Southern Tsetse Eradication Project (STEP) to control T&T in the Southern Rift Valley, Ethiopia, suppressing vector populations and bringing significant benefits to farming communities in this valley. Since the last IAEA General Conference the IAEA has continued to provide support through a TC project on "Creating a Tsetse-Free Zone in the Southern Rift Valley", that was initiated in 2009. Under this project, the Agency, together with FAO and other partners, completed the implementation of laboratory and field activities funded through Japanese contributions to the United Nations Trust Fund for Human Security (UNTFHS).

10. Some progress was made in addressing project shortcomings that had been identified in an OIOS study in 2009. The fulfilment of these shortcomings serves as a prerequisite for STEP to enter, and for the Agency to provide support to the operational (tsetse elimination) phase of the project. The progress made includes the introduction of an appropriate mechanism for project oversight, the revision of the managerial set-up and the implementation of recommended actions in several technical areas related to the mass production of sterile male tsetse flies and to the field operations. The efforts concerning the mass production of sterile male tsetse flies have resulted in an encouraging increase in the tsetse colony production at the Kaliti insectary. The *Glossina fuscipes fuscipes* (*G. f. fuscipes*) colony at its current level is already adequate for pilot operational releases to be conducted in the Deme basin by late 2011. Regarding the *G. pallidipes* (Tororo), pilot operational releases of the sterile male flies would be initiated in the third quarter of 2012, provided the growth of the colony can be kept at the same levels attained in the past 15 months.

11. In recognition of the STEP-coordinated T&T suppression in the Southern Rift Valley and the resulting benefits for rural communities in the area, other infested regions in Western Ethiopia have demanded similar support for their regions, coordinated at the national level. In response to this, participants in an international workshop organized by the Government of Ethiopia in Addis Ababa, held on 14–15 July 2011, requested the establishment of a national institution for the coordination of T&T control and elimination activities in all affected regions in Ethiopia, similar to the integrated intervention measures currently implemented by the STEP in the Southern Rift Valley. STEP and regional agricultural bureaus have requested funding from the new three-year Ethiopian Growth and Transformation Plan (GTP), the implementation of which began in July 2011, to gradually expand its activities to 190 000 km² of tsetse infested area under a national T&T control programme.

12. A meeting between representatives of STEP and the Ugandan PATTEC project was held in Vienna in May 2011. Uganda has repeatedly faced difficulties in past years with creating a mass-reared colony of the tsetse species *G. f. fuscipes*, which is the key vector for transmitting animal and human trypanosomosis (sleeping sickness) along the northern shoreline of Lake Victoria. Since the STEP mass-rearing facility in Ethiopia (the Kaliti insectary) can produce substantially more sterile male flies of this species than the SIT operations in the STEP project area require, Ethiopia and Uganda have agreed upon elaborated detailed plans for the procurement of sterile males for an SIT feasibility demonstration in Uganda, starting in the TC biennium 2012-2013.

13. As part of the Peaceful Uses Initiative (PUI), the United States Government agreed in November 2010 to provide $350 000 to support a project entitled "Contributing to Agricultural Development in West Africa Through the Control of Tsetse Flies and the Trypanosomosis Problem". The funding is being used to validate in the field, at a sufficiently large scale, methods developed by

the FAO/IAEA Insect Pest Control Laboratory, Seibersdorf, in the framework of IAEA CRPs in support of a tsetse SIT project in Senegal-Burkina Faso. The validation efforts include refinement of tsetse mass rearing techniques, long distance transport of tsetse pupae, ground and aerial release systems for sterile male tsetse flies and the provision of other support and services to tsetse SIT operations in West Africa. The results are expected to benefit several AU-PATTEC tsetse control and elimination programmes in East, West and Southern Africa, and eventually to contribute to fostering agricultural development and food security.

14. The Agency continued to provide technical assistance and guidance to Senegal under a national TC project (SEN/0/031) on "Implementing the Pre-Operational Phase to Create a Zone Free of *Glossina palpalis gambiensis* using the SIT". The good collaboration between the various partners in the project, i.e. the Government of Senegal, the Centre de Coopération Internationale en Recherche Agronomique pour le Développement (CIRAD), the Institut de Recherche pour le Développement (IRD) of France and the Agency has continued. Relevant entomological, environmental, parasitological and socio-economic data were collected and analysed. It could also be confirmed that the Burkina Faso *G. p. gambiensis* male flies from the CIRDES have the same mating behaviour as those of the target area. Long-distance transport tests of sterile male material from the CIRDES in Burkina Faso to Dakar, Senegal, were used to refine shipping and handling protocols, and test releases were used to develop standard procedures to enable the initiation of the SIT phase (i.e. release of sterile male flies) in Senegal. In addition, the project initiated suppression of the target fly population using traps impregnated with insecticides in advance of operational sterile male releases.

15. A Mexican company, Servicios Aéreos Mubarqui, which is a major partner in the sterile fruit fly release programmes in Central America and the developer of both release and rearing equipment, has designed a system to release chilled adult male flies for tsetse SIT projects. In late 2011 the Agency will receive, through an in-kind contribution from Servicios Aéreos Mubarqui, a complete chill fly release system with navigation and monitoring electronics and a web-based monitoring and management tool for testing operational sterile male releases in the project in Senegal.

16. The Agency continued supporting a regional TC project (RAF/5/059) on T&T in the north-eastern part of South Africa and southern Mozambique. In adjacent tsetse infested areas in Mozambique and Swaziland further baseline data were collected. This cooperative effort aims at generating the basis for detailed planning of T&T control measures and enabling the identification of the level of funding required for implementing project activities in the sub region.

17. IAEA support contributed to Kenyan efforts to develop national capacity for tsetse SIT. The Agency's fruitful collaboration with the Institute of Zoology, Slovak Academy of Sciences (IZ-SAS), Bratislava, was instrumental in 2010 in engaging SlovakAid to provide €184 000 worth of bilateral assistance to the Trypanosomosis Research Centre (KARI-TRC) in Muguga, Nairobi, Kenya. The SlovakAid support is being used to further increase the colony of the tsetse species *G. pallidipes* at the KARI-TRC and to contribute towards the initiation of pilot SIT releases in the Lambwe Valley, Kenya.

# C. Conclusion

18. Tsetse and trypanosomosis remain a major obstacle to rural development in significant parts of Africa. The fly is spreading, no new control methods have emerged and the Sterile Insect Technique

(SIT), as part of area-wide pest control, maintains its appeal as a unique and environmentally friendly nuclear application to eradicate tsetse. Yet there remain challenges, including developing the SIT for different species with different biologies, and adapting each project to unique ecological and socio-economic conditions and requirements needed for success.

19. The scarcity of sterile male tsetse production facilities in Africa remains the most critical bottleneck for the expanded application of SIT against tsetse. Besides just five institutes worldwide holding seed- or back-up tsetse fly colonies, there are only two African tsetse mass-rearing centres, in Addis Ababa, Ethiopia, and in Bobo-Dioulasso, Burkina Faso, with the latter still in the process of being established. This lack of tsetse SIT capacity needs to be addressed by the IAEA together with its partner organizations.

# Use of Isotope Hydrology for Water Resources Management

## A. Background

1. At its fifty-third session in September 2009, the General Conference, through resolution GC(53)/RES/13.A.5, requested the Director General to continue to further strengthen the efforts directed towards fuller utilization of isotope and nuclear techniques for water resources development and management in interested countries through appropriate programmes, by increased collaboration with national and other international organizations dealing with water resources management; to continue to help Member States obtain easy access to isotopic analysis; to continue work on groundwater management; to strengthen activities which contribute to the understanding of the climate and its impact on the water cycle; and to continue to develop human resources in isotope hydrology. It further requested the Director General to report on achievements in implementing resolution GC(53)/RES/13.A.5 to the Board of Governors and to the General Conference at its fifty-fifth session.

## B. Work since the 53rd General Conference

2. Ten years after adopting the Millennium Development Goal (MDG) of "reducing in half the number of people without access to safe drinking water", both the United Nations' 2010 Millennium Development Goals Report and the Dushanbe Declaration, which emanated from the UN *Water for Life* conference held in Dushanbe, Tajikistan, in June 2010, noted that significant progress has been made and that 86% of the population in developing regions are expected to have access to safe drinking water by 2015. Progress, however, has been uneven, and in some large regions, less than 60% of the population currently have access to safe drinking water. In addition, there is an increasing concern that improvements in water quality have not kept up with improved water access. The Dushanbe Declaration describes some of the critical areas that must receive additional attention to address current problems in achieving the safe drinking water target: (1) more coordinated efforts at the national and international levels to improve integrated water resources management; (2) the need for improved hydrological data collection, assessment and information dissemination; and (3) the need to prevent the closure of national and regional hydrological and meteorological monitoring stations and networks which are critical data resources for addressing water management and climate change issues.

### B.1. Raising Awareness of the Agency's Work and the Role of Isotope Hydrology in Water Resource Management

3. A number of activities were implemented to raise awareness of the Agency's role in promoting the use of isotopes for water resources management and related areas. The Agency participated in the COP-15 climate change meeting in Copenhagen, Denmark, in December 2009. In 2010, the Agency co-sponsored the International Association of Hydrogeologists Congress in Krakow, Poland, the 2nd International Conference on Integrated Water Resources Management and Challenges for Sustainable Development in collaboration with UNESCO and several Moroccan organizations in Agadir,

Morocco, and the Stable Isotope Network Austria (SINA) meeting in Seibersdorf in collaboration with the Austrian Institute of Technology. In 2011, the Agency co-sponsored the XXVth General Assembly of the International Association of Hydrological Sciences meeting in Melbourne, Australia, and the HydroEco 2011 conference in Vienna in collaboration with the University for Bodenkultur (BOKU) and other international sponsors. A new series of Agency isotope hydrology fact sheets was also developed to promote better understanding of how isotope methods can help Member States address their water resources problems.

4. To raise awareness among the technical community, information booths were established at the European Geophysical Union (EGU) annual meetings in Vienna in 2010 and 2011. Agency staff also coordinated a stable isotope hydrology short course at the 2010 EGU meeting and contributed lectures at an EGU short course on laser absorption based isotope analysers in 2011.

5. The Agency hosted the International Symposium on Isotopes in Hydrology, Marine Ecosystems, and Climate Change Studies from 27 March to 1 April 2011 in Monaco. This event was the 13th in the series of quadrennial isotope hydrology symposia that started in 1963. The symposium was held in collaboration with the Agency's Marine Laboratory in Monaco, at which over 275 participants and observers from 76 Member States attended. The symposium brought together isotope experts in the fields of climate change, carbon cycling, groundwater age dating, water quality, marine and terrestrial environments, and others, offering a great opportunity to learn about the latest advances and applications of isotopes. The results of the Agency's technical cooperation projects in several Member States were also presented. The outcomes of the symposium will be used to help the Agency define its future programmatic activities for water resources management.

## B.2. Expanding Access to Isotope Techniques and Information

6. The Agency has substantially built upon the progress related to easier access to isotope analyses and information that was reported since the 53rd General Conference. The increase in the use of laser-based stable isotope analysers in Member States has been significant. These instruments are powerful tools for rapid and accurate analyses of stable isotopes in groundwater, surface water and precipitation. There are now twenty-three Member State laboratories using these instruments as a result of Agency assistance and more have requested instruments through the upcoming 2012-2013 Technical Cooperation project cycle. In addition, the Agency has played a major role in expanding the use of these instruments in other Member States where many laboratories have utilized the Agency's operation and maintenance procedures and training materials. Since the last review in 2009, the Agency conducted two training courses in Vienna in February and June 2010, and developed a fact sheet on laser absorption based analysis of stable isotopes in liquid water samples which is also available through the Agency's webpage (www.iaea.org). The fact sheet contains supplementary information for users of laser-based systems to improve analysis quality, maintain their instruments and troubleshoot various problems. In addition, the Agency published a 45-minute video entitled "Overview of Laboratory Isotope Analysis Methods for Water Resources Studies" (IAEA-IWSA) to increase Member State capacity to perform their own stable isotope and radioactive isotope analyses. The video describes many of the key analysis methods used for isotope hydrology studies. The Agency also published a guide to field sampling for isotope hydrology so that investigators have a handy reference for proper sampling protocols and preservation methods.

7. The Agency published a TECDOC on assessing pollutant behaviour in the unsaturated zone in late 2009 (IAEA-TECDOC-1618). The unsaturated zone is the region below the ground surface and above water table and can contain large inventories of pollutants. The TECDOC is the output of a coordinated research project (CRP) that addressed the combined use of conventional hydrological and nuclear techniques to study transport and other processes in the unsaturated zone. The study has led to an improvement in identifying the means of pollutant transport to aquifers and in characterizing

complex physicochemical processes in the unsaturated zone that act to modify pollutant concentrations.

8. A CRP on geostatistical analysis of spatial isotope variability to map the sources of water for hydrological studies was completed in 2010. Participants developed improved isotope maps and statistical analyses contributing to more sound and useful interpretations of isotope results. One statistical routine has been posted on the Agency's webpage (www.iaea.org) because of its broad application for water resources studies in many Member States. A CRP on the use of environmental isotopes in assessing water resources in snow, glacier and permafrost dominated areas under changing climatic conditions was also initiated in 2010 with the participation of 13 Member States. The main objective of the CRP is to develop and test isotope techniques for a quantitative assessment of interactions between water in snowpack, glaciers and permafrost, groundwater and surface water, using environmental isotopes. Ice and snow supplies and melting patterns are expected to be particularly sensitive to climate change and shifts can have large effects on surface water and groundwater supplies.

9. Isotope mapping was also a strong focus during the period under review. The third in the series of regional isotope hydrology atlases was published late in 2009 and presents isotope and related hydrological information for 23 Member States in the Americas. Based on approximately 19000 records, the atlas presents data obtained from 150 Agency projects implemented between 1968 and 2008. The atlas series is a valuable reference for scientists and practitioners in the field of hydrology and water resources. The atlas concept was expanded to the national level with the publication of the Atlas of Isotope Hydrology -- Morocco in 2010. Developed in collaboration with the Agency's Moroccan counterparts, the atlas describes the results of ten different isotope hydrology projects across Morocco. It is both a national and regional resource and serves as an example of how isotope hydrology can be integrated into national water resources assessments. One important new aspect of the Morocco atlas is the inclusion of isotope interpolation maps for the various study basins. These maps reveal important characteristics of the groundwater systems including recharge areas and locations of modern and fossil groundwater. The interpolation approach was developed at the Agency and the resultant maps are helping to demonstrate the value of isotopes to water managers and policy makers.

10. The year 2010 marked the 50$^{th}$ anniversary of the Agency's global isotope monitoring networks for precipitation (GNIP). Responding to a growing user demand for global raw and gridded isotope data, the Agency significantly expanded operations for its GNIP and its similar network for rivers (GNIR) through the establishment of new monitoring stations. The importance of GNIP (and also GNIR) data continues to grow because of the increasing demand for globally distributed isotope data to support hydrological studies and for understanding the effects of land use and climate change. Through the Agency's monitoring networks new isotope datasets of the water cycle were compiled from different continents and made available to Member States through a dedicated webpage (www.iaea.org/water, click on the monitoring programmes box).

11. The Agency continued its efforts towards providing Member States with access to powerful noble gas groundwater age dating tools. In 2010, analyses of groundwater resources in Tanzania and Brazil were conducted to demonstrate how tritium/helium-3 dating and other noble gases can be used as a reconnaissance characterization method. Results from Tanzania revealed important characteristics about a recently discovered groundwater system that had not previously been detected and results are being used by Tanzania to further assess the potential of this groundwater resource. To expand the use of noble gas data even further, a new CRP on tritium/helium-3 dating was initiated in 2010 with the participation of 10 Member States. The CRP will examine the application of noble gases to groundwater dating in a variety of hydrogeological settings and quantification of baseflow in rivers.

The CRP will also evaluate different sampling techniques to provide guidelines for optimal use of the method.

## B.3. Capacity Building and Human Resource Development through Technical Cooperation

12. During the period under review, activities related to the IAEA/Global Environmental Facility (GEF)/UNDP-funded *Nubian Sandstone Aquifer* project, initiated in 2006, were focused on modelling and developing a framework for transboundary aquifer characterization. A numerical model of groundwater flow in the Nubian Aquifer system, shared by Chad, Egypt, the Libyan Arab Jamahiriya and Sudan, was jointly developed in cooperation with the relevant organizations in these four Member States and the US Geological Survey. The isotopic age of groundwater (as old as one million years) was used to verify the model, which was then used to analyse transboundary issues related to the current and planned use of the aquifer. Based on the current results, the Nubian countries have agreed to adopt the model to help address future groundwater management issues.

13. Activities related to the IAEA/GEF/UNDP-funded *Nile Basin* project, initiated in2007, involving nine basin countries included large data mining efforts to support water balance modelling at the basin scale and field collection campaigns for isotopes. In addition, a coordination and steering committee meeting was held in Addis Ababa with 24 participants. The meeting evaluated technical progress and established plans for future field and modelling investigations. Two regional training workshops for 20 participants were also held in 2010. The first course was on Basic Isotope Hydrology in Addis Ababa, Ethiopia and the second on Integration of Isotope Data in River Basin Water-Balance Models held in Cairo, Egypt. Except for the newest three project members (Burundi, Democratic Republic of the Congo, Rwanda), all countries have completed their initial isotope sampling campaigns. In addition, water balance models are being developed and the participants should be able to implement these models for their own use by the end of 2011.

14. An African Regional Cooperative Agreement (AFRA) project on *Building Capacity in Support of Regional and Sub-regional Water Resources Planning, Development and Management (RAF/8/048)* made progress toward the goal of developing Africa's capacity and self-reliance to integrate isotope techniques in the planning, development and sustained management of water resources. A basic isotope hydrology training course was held in Addis Ababa, Ethiopia in 2009, and laboratory and field methods courses were held in Rabat, Morocco in 2010 with over 15 Member States participating. At the 2$^{nd}$ coordination meeting, which is planned to be held in Rabat, Morocco in 2011, participants are expected to report on national activities in isotope hydrology and discuss future training and human resource development needs. In addition, the establishment of regional designated centres will be discussed. It is anticipated that these centres will play a leading role in promoting isotope hydrology in Africa.

15. A Regional Co-operative Agreement for Research, Development and Training Related to Nuclear Science and Technology for Asia and the Pacific(RCA) regional project on *Assessing Trends in Freshwater Quality Using Environmental Isotopes and Chemical Techniques for Improved Resource Management (RAS/7/021)*, in which fifteen Member States participated, will be finalized in 2011. The isotope results obtained through the project have helped national counterparts address important issues related to groundwater and surface water pollution, sources of groundwater recharge, and establish monitoring networks and water resources protection areas. For example, the isotope results from the Philippines were used as a basis for providing recommendations for groundwater areas requiring closer monitoring and protection from surface water contamination. A training course on Advanced Techniques for Isotope and Related Applications in Water Resources Management was held in 2010 in Mumbai, India, and isotope laboratory equipment was procured for several of the participants. The final meeting of the project is scheduled to take place in November 2011.

16. A regional project in the European region, *Using Environmental Isotopes for Evaluation of Streamwater/Groundwater Interactions in Selected Aquifers in the Danube Basin (RER/8/016)* is being finalized in 2011. Bank filtered groundwater is an important resource for the mid- and lower-Danube countries and isotopes are being used to understand important surface water/groundwater interactions. Capacity building has been enhanced through a regional training course on isotope hydrology field methods held in Sofia, Bulgaria, in 2010 with the participation of six Member States. A second training course on groundwater flow modelling and isotopes was held in June, 2011 with fifteen participants from five Member States.

17. A Regional Cooperative Agreement for the Promotion of Nuclear Science and Technology in Latin America and the Caribbean (ARCAL) regional project *Application of Isotopic Tools for Integrated Management of Coastal Aquifers (RLA/8/041)* was completed in 2010. The goal was to improve the capability of six Latin American Member States to assess the dynamics of coastal groundwater systems and water quality deterioration by means of isotope and geochemical techniques. Using isotopes, the project was able to address important questions such as the impacts of seawater intrusion, the origins of groundwater recharge and the importance of mixing between local groundwater bodies and river water. The information collected is being used by local authorities to understand water resource vulnerabilities and develop plans for future management.

18. Training highlights over the period under review included: an advanced regional training course on Isotope Techniques for Assessment of Shallow Groundwater and their Interactions with Surface Waters organized in collaboration with the Argonne National Laboratory in the United States of America; regional training courses on isotope hydrology in India, Mexico and Morocco; and national training courses in the Democratic Republic of the Congo, Ethiopia, Ghana, Thailand and Uganda.

## B.4. Developing Partnerships and Increasing Collaboration with Other International Organizations

19. To build new opportunities for cooperation in the area of river basin management, the IAEA co-hosted a two-day workshop in 2010 with the International Commission on the Protection of the Danube River (ICPDR). The workshop focused on the problem of nitrogen and nitrate in the Danube basin. Twenty-five participants representing most of the Danube basin countries worked to identify knowledge gaps and possible activities that will help to address nutrient pollution issues related to the European Union Water Framework Directive.

20. The Agency has initiated the IAEA Water Availability Enhancement (WAVE) project, which focuses on building national capacity for conducting comprehensive assessments of water resources in order to accelerate progress toward achieving the water MDG. Accomplishments to date include the development of an integrative water-use science framework; the development of training modules; and the completion of preparatory studies and fact-finding missions in Costa Rica, Oman, the Philippines and Slovenia. Pilot studies have been initiated in Costa Rica, Oman and the Philippines. In addition, consultancy meetings and scientific visits were held in Vienna to discuss the overall approach and coordination with potential international partners such as the German Federal Institute for Geosciences and Natural Resources, the U.S. Geological Survey, the University of Avignon, the University of Tokyo, the World Bank Groundwater Management Advisory Team and the World Meteorological Organisation. Discussions have also been held with other UN organizations such as UNESCO to broaden WAVE collaborations as the project progresses.

21. The Agency participated as one of the 28 members of UN Water in meetings held in Bonn, Germany and Stockholm, Sweden in 2010, and in the 19$^{th}$ Intergovernmental Council meeting of the UNESCO International Hydrological Programme held in Paris, France in 2010. Through these

meetings, the Agency collaborates with other UN Water members in areas such as the impact of climate change on water resources and integrated water resources management.

22. The Agency has also collaborated with the UNESCO-IHE (Institute for Water Education) in the Netherlands to help teach isotope hydrology to international graduate students and has supported two Master's students from Africa since 2009.

# Nuclear Energy Activities

1. This annex summarizes highlights of Agency activities not covered in Annexes, 5, 6, 7 and 8, which address potable water production using nuclear reactors, innovative nuclear technology, small and medium sized reactors, and infrastructure development for nuclear power, respectively.

2. The Agency annually updates its low and high projections for global growth in nuclear power. The new projections made in Spring 2011 were lower than the projections made in 2010, largely because of the Fukushima-Daiichi accident. Specifically, the 2011 low projection for the world's total installed nuclear power capacity in 2030 was 501 GW(e), down from the 2010 low projection of 546 GW(e). The 2011 high projection for installed nuclear power capacity in 2030 was 746 GW(e), down from the 2010 high projection of 803 GW(e).

3. The Agency's presence at the 16th Session of the Conference of the Parties (COP-16) to the United Nations Framework Convention on Climate Change (UNFCCC) in Cancún, Mexico, in December 2010 provided an excellent opportunity to present its work on the linkages between climate change and nuclear power, to disseminate pertinent publications and to discuss the nuclear power option and its climate change mitigation benefits with government and non-government delegates.

4. As part of an on-going project, the Agency prepared a book entitled *Geological Disposal of Carbon Dioxide and Radioactive Waste: A Comparative Assessment*, which was published in March 2011. This is the first systematic comparative assessment of $CO_2$ and radioactive waste disposal, and it reveals many similarities, including the transformation of the geological environment, safety and monitoring concerns, and regulatory, liability and public acceptance issues. It helps policymakers to consider, as part of developing national energy strategies, the broad range of issues involved in the disposal of wastes from nuclear energy and from fossil based power generation with $CO_2$ capture.

5. The Agency's Power Reactor Information System (PRIS) supports the exchange of operating experience around the world and is a comprehensive data source, for both experts and the public, of information on reactors that are under construction, in operation or being decommissioned. Immediately after the Fukushima-Daiichi accident, daily visits to the PRIS website rose to more than 5000 per day as people sought information about the Fukushima-Daiichi reactors, other similar reactors, and broader information on operating and planned reactors.

6. The number of new reactors under construction is at its highest level since 1992. Sixty-five reactors are under construction in fifteen countries.[11] To support planned and active construction projects, the Agency prepared *Project Management in Nuclear Power Plant Construction: Guidelines and Experience* (IAEA NE Series No.NP-T-2.7), which provides advice and guidance on project management from the preparatory phase through commissioning. Publication is scheduled for later in 2011. Nuclear power is also expanding through the uprating of existing reactors. To support planned and active uprating projects, the Agency published *Power Uprate in Nuclear Power Plants: Guidelines and Experience* (IAEA NE Series No. NP-T-3.9) in March 2011.

7. The Agency conducted its second Independent Engineering Review of Instrumentation and Control (I&C) Systems (IERICS) mission in Ukraine in December 2010. It evaluated the digital I&C systems, based on field programmable gate arrays, used for reactor protection, control and monitoring in Ukrainian nuclear power plants.

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[11] As of 20 June 2011.

8. The Agency conducts training courses on nuclear knowledge management to reach broader audiences and supports networks that disseminate information in this field. In November 2010, it conducted a Nuclear Knowledge Management School at the International Centre for Theoretical Physics (ICTP) in cooperation with ICTP and the Kuwait National Foundation of Science. For the first time, in November 2010 the Agency also conducted the Nuclear Energy Management School at ICTP. This training course provided an opportunity for young managers from developing countries to be involved in a nuclear programme management course and to learn from world experts and the Agency's specialists about global nuclear energy development.

9. In the area of fuel performance, the Agency published *Advanced Fuel Pellet Materials and Fuel Rod Design for Water Cooled Reactors* (IAEA-TECDOC-1654) and *Delayed Hydride Cracking of Zirconium Alloy Fuel Cladding* (IAEA-TECDOC-1649), which reports the results of a Coordinated Research Project (CRP) that transferred testing technology to nine Member States and investigated the cracking behaviour of six commercial cladding alloys.

10. In the area of waste pre-disposal, work began on five handbooks, out of a planned series of eight, to restructure, consolidate and update the information in a large number of Agency publications on predisposal. The consolidated set of handbooks will include operating experience and lessons learned and help Member States to align design and operation with safety requirements and guides and to develop training material. The five handbooks on which work has begun cover (i) characterization, categorization and monitoring, (ii) treatment of low and intermediate level liquid waste, (iii) management of gaseous waste, (iv) processing of high level waste and spent nuclear fuel declared as waste and (v) storage of radioactive waste and conditioned waste packages. The other three handbooks will be on (vi) pre-treatment of waste, (vii) treatment of low and intermediate level solid waste and (viii) conditioning of low and intermediate level waste.

11. Since the fifty-fourth session of the General Conference, the International Decommissioning Network (IDN) has organized workshops and training courses, supported by the Technical Cooperation Programme, on Clearance of Buildings and Structures (Germany), Decommissioning Safety Assessment (Denmark), Use of Dose-planning Software (Belgium), Large Component Management (France), Nuclear Facility Decommissioning and Environmental Remediation Skills (USA), Decommissioning of Radioactively Contaminated Facilities (South Africa), Advanced Cutting Technologies (Germany), and Application of State-of-the-Art Characterization and Visualization Technologies in Decommissioning (France).

12. The International Network for Disposal of Low Level Waste (DISPONET), as part of its systematic training programme for developing disposal facilities for very low, low and intermediate level radioactive waste, held a regional training course on waste disposal for Africa in May 2011 and workshops on Waste Acceptance Criteria for Disposal of Very Low, Low and Intermediate Level Waste (Germany, September 2010) and Siting and Modelling Regarding LLW Disposal (Argentina, October 2010).

13. The Underground Research Facilities Network (URF) organized workshops on Strengthening National Competencies in the Area of Stakeholder Dialogue for Radioactive Waste Disposal (USA), Site Characterization and Underground Experiments (France) and Fundamentals of Geological Disposal (Czech Republic). The International Network on Environmental Remediation (ENVIRONET) held workshops and training courses on Remediation of Legacy Facilities and Sites (Russian Federation), Communication and Stakeholder Involvement on Environmental Remediation Projects (Kazakhstan), Fundamentals of Environmental Remediation (USA) and Support System for Assessment of Remediation Performance in Uranium Mining Sites (Sweden).

14. In Ghana studies are underway at a site that has been selected for borehole disposal. It is envisaged that disused sealed radioactive sources will be disposed at this site when sufficient funding is available and the facility is fully licensed.

15. Collaboration among Member States in the use and planning of research reactors was enhanced, with Agency support, through the creation of the Mediterranean Research Reactor Network (MRRN) in September 2010. The Agency continued to support activities of the Asia-Oceania Neutron Scattering Association (AONSA) that helped to promote research reactor networking in the Asia-Pacific region, such as research reactor training. In addition, the Australian Nuclear Science and Technology Organisation (ANSTO), with its state-of-the-art neutron-beam facilities at the OPAL research reactor in Australia, was re-designated as an IAEA Collaborating Centre for Neutron Scattering Applications.

16. The technical cooperation project to repatriate spent fuel from the Vinča Institute in Serbia to the Russian Federation was successfully completed in December 2010 through the return of 2.5 tonnes of spent fuel, including 13.2 kg of HEU, to the Russian Federation.

17. The International Nuclear Information System (INIS) membership increased to 150 (126 countries and 24 international organizations) with the addition of Benin, Chad and the Islamic Republic of Mauritania. In April 2011 INIS launched a new web search interface for its collection of over 3.3 million bibliographic records and more than 280 000 full-text non-conventional documents. This increases the speed of searching and downloading, supports multilingual queries and the standard search interface. INIS receives more than 70 000 searches per month.

# Producing Potable Water Economically Using Small and Medium-sized Nuclear Reactors

## A. Background

1. In resolution GC(53)/RES/13.A.4, the General Conference (GC) noted that seawater desalination using nuclear energy is technically feasible and generally cost-effective, and that it has been successfully demonstrated through various projects in some States. It also noted that a number of Member States have expressed interest in seawater desalination using nuclear energy. The GC requested the Director General to continue consultations with interested Member States and relevant governmental organizations on activities relating to seawater desalination using nuclear energy; and, subject to the availability of resources, to (a) develop a report on nuclear energy both for seawater desalination, as well as for cogeneration options (e.g. electricity, seawater desalination, hydrogen production), and (b) hold a workshop to discuss nuclear desalination and water management in nuclear power plants. The GC requested that the Director General report on progress to the Board of Governors and to the General Conference at its fifty-fifth session. This report responds to that request.

## B. Activities of the Agency

2. The Agency's activities on seawater desalination using nuclear energy are conducted largely within the framework of the Technical Working Group on Nuclear Desalination (TWG-ND). As part of the harmonization of the terms of reference of all TWGs, the TWD-ND was created in 2009 as the successor to the International Nuclear Desalination Advisory Group (INDAG). The TWG-ND met for the second time in April 2011. Recommendations addressed integrated water resources management for efficient water use in nuclear facilities, nuclear desalination as a possible additional freshwater source for accident response at nuclear power plants, public communication on seawater desalination using nuclear energy, extraction of valuable compounds from brine discharged from desalination plants, and improvements to Agency tools, summarized below, such as its Desalination Economic Evaluation Program (DEEP) and DEsalination Thermodynamic Optimization Program (DE-TOP).

3. The Coordinated Research Project (CRP) on New Technologies for Seawater Desalination Using Nuclear Energy held its second Research Coordination Meeting in October 2010 and began to assemble results from participating Member States for the CRP's final report.

4. The CRP on Advances in Nuclear Power Process Heat Applications was completed in 2009. With respect to nuclear desalination, the CRP concluded, first, that further detailed design and economic analysis of hybrid nuclear desalination technologies using waste heat from high temperature gas reactors (HTGRs) should be carried out to reflect developments in HTGR technology. It also concluded that the safety of a desalination plant coupled to a HTGR must be thoroughly analyzed based on requirements for reactor safety, with a view to ensuring that there is no radioactive contamination of the water produced. A final report will be published later in 2011.

5. In 2009, the Agency released a 'toolkit' in the form of a webpage on nuclear desalination. The toolkit, intended for Member States considering nuclear power for seawater desalination, provides access to information on the Agency's Desalination Economic Evaluation Program (DEEP), Agency publications on nuclear desalination, Agency activities in the field, the work of the TWG-ND, options for seawater desalination and launching a nuclear desalination programme. The toolkit was improved in 2010 with updated and expanded information. In September 2010, the Agency published the second issue of the Nuclear Desalination newsletter, the successor to the previous INDAG Newsletter.

6. A new version of DEEP (DEEP 4.0) was released in February 2011 with new and user-friendly features. The Agency also released a new tool named DEsalination Thermodynamic Optimization Program (DE-TOP), which complements DEEP and is used to analyze the thermodynamics of cogeneration systems with emphasis on water desalination.

7. In February 2010, *Environmental Impact Assessment of Nuclear Desalination* (IAEA-TECDOC-1642) was published, which assembles operating experience from existing nuclear desalination demonstration projects to estimate the environmental impacts of commercial scale nuclear powered desalination and compares them with those of desalination powered by fossil fuels.

8. In March 2011, a Technical Meeting on Technology and Economic Assessment of Nuclear Desalination was held in Vienna as a forum for information exchange among Member States, particularly about feasibility studies to assess technical, economic and coupling aspects of different desalination processes. The meeting provided information on DEEP 4.0 and DE-TOP, technical and economic assessments of current and future seawater desalination systems using nuclear energy, best practices in assessing such systems, common criteria for assessment methods, and strengthening national and regional infrastructures for nuclear desalination in interested Member States.

9. The Agency's Power Reactor Information System (PRIS) was expanded to include non-electrical applications. PRIS is a comprehensive data source on nuclear power reactors in the world, with all operating nuclear power plants providing data regularly. Starting in 2011, the data in PRIS on monthly production and power losses are now complemented by data on energy for non-electrical applications like district heating, process heat supply and seawater desalination.

# C. Activities in Member States

10. The following paragraphs summarize the activities in Member States based largely on reports presented at the TWG-ND.

11. Algeria continues to pursue a nuclear desalination programme with the overall goal of installing 2.26 million $m^3$/day total freshwater capacity. A technical and economic prefeasibility study of nuclear desalination, conducted in 2007 in collaboration with the IAEA, concluded that nuclear desalination would be competitive with desalination powered by fossil fuels.

12. Argentina is investigating the coupling of its CAREM reactor to desalination processes. CAREM is a small (100 MWth) integral light water reactor. A working group dedicated to desalination has been revived, and there are plans for an experimental desalination facility.

13. In China, the Liaoning Hongyanhe Nuclear Power Company announced in June 2010 that the first nuclear seawater desalination system in China was ready for operation at Hongyanhe although the four reactors at Hongyanhe are still under construction. The first is expected to be connected to the

grid in 2012. The desalination system uses the seawater reverse osmosis (SWRO) desalination process and has a capacity of 10 000 $m^3$/day. The freshwater will be for industrial uses by the Hongyanhe reactors and for general consumption as potable water on the site.

14. In Egypt, the Nuclear Power Plants Authority (NPPA) has constructed an experimental reverse osmosis (RO) facility in El-Dabaa to validate the concept of feed water preheating. Feed water preheating takes advantage of the higher temperature of water discharged from nuclear power plants compared to fossil fuelled plants. The facility began operation in 2008. Its results show that the performance of RO desalination, in terms of product water rates and conductivity, increases as the temperature and pressure of the feed water are increased.

15. In France, nuclear desalination is being investigated by the Commission of Atomic Energy (CEA), which is developing engineering support systems for nuclear desalination studies. Work is focused on developing models of coupling multi-effect distillation (MED) and RO with nuclear power plants, validating models and recovering valuable materials from discharged brine, where they are more concentrated and easier to extract than from normal seawater. CEA is collaborating in particular with the Bhabha Atomic Research Centre (BARC) in India.

16. In India, two nuclear desalination plants are in operation: a first-of-a-kind low temperature evaporation (LTE) desalination plant coupled with the CIRUS research reactor at BARC and a 6 300 $m^3$/day nuclear desalination demonstration plant in Kalpakkam that uses the hybrid multi-stage flash – reverse osmosis (MSF-RO) technology coupled with an Advanced Heavy Water Reactor (AHWR). The demonstration plant is designed for higher maximum brine temperatures and requires low pumping power. Its capacity of 6 300 $m^3$/day can meet the freshwater needs of around 45 000 people.

17. In Pakistan, a 1 600 $m^3$/day MED nuclear desalination demonstration plant was commissioned in 2010 at the Karachi Nuclear Power Complex (KNPC). It is Pakistan's first desalination plant to be coupled with a nuclear power plant. It is supplied with thermal energy from the Karachi nuclear power plant (KANUPP). One of the feed heaters in the secondary steam cycle of KANUPP has been isolated from the cycle, and the bleed steam from the turbine transfers thermal energy to the re-circulating heater of an intermediate coupling loop where steam is produced in a re-boiler and then acts as motive steam for the MED unit.

18. Saudi Arabia has the largest desalination programme in the world driven by its rapid population growth, high per-capita consumption of water, scarce natural water sources and rapid industrialization. Since 2008 nine desalination plants have been constructed with a total capacity of 1.8 million $m^3$/d. None of this desalination capacity is nuclear powered, but Saudi Arabia indicated its interest at the TWG-ND to develop a nuclear energy programme for electrical power generation and seawater desalination.

19. In the USA, many view small and medium sized reactors (SMRs) as technologically and economically promising for future deployment, both in the USA and elsewhere (see Annex 7). Although the coupling of desalination and SMRs could be economically advantageous where water resources are limited, most work on SMRs in the USA focuses on electricity generation.

20. Other countries that are investigating or considering launching nuclear desalination programmes, either on a national or a multilateral basis, include Bahrain, Indonesia, Jordan, Kuwait, Oman, Qatar, Syria and the United Arab Emirates.

# Agency Activities in the Development of Innovative Nuclear Technology

## A. Background

1. In resolution GC(54)/RES/10/B.3, the General Conference (GC) noted progress in a number of Member States in developing innovative nuclear energy systems technology and the high potential for international collaboration to further such development. It noted that the Agency's International Project on Innovative Nuclear Reactors and Fuel Cycles (INPRO) provides a forum for technical experts to discuss global scenarios, visions and perspectives and explore the development and deployment of innovative nuclear energy systems. The GC emphasized the important role that the Agency can play in assisting interested Member States with the planning and development of their nuclear power programmes with innovative nuclear energy systems, by using Agency tools and methods for energy system planning and nuclear energy system assessments (NESAs). It further called upon the Secretariat to investigate the availability of new, more proliferation-resistant reactor and fuel cycle technologies and recommended that it continue to explore synergies between the Agency's activities, including INPRO, and those pursued under other related international initiatives. The GC 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-fifth (2011) regular session.

2. This report responds to that request and summarizes Agency activities related to innovative nuclear technology, in particular those carried out under INPRO.

## B. INPRO Activities

### B.1. Overall project status

3. As of May 2011, INPRO had increased its membership by two countries (Jordan and Poland) and had 33 members, representing 75 per cent of the world's gross domestic product and 65 per cent of the world population: Algeria, Argentina, Armenia, Belarus, Belgium, Brazil, Bulgaria, Canada, Chile, China, Czech Republic, France, Germany, India, Indonesia, Italy, Japan, Jordan, Kazakhstan, Republic of Korea, Morocco, Netherlands, Pakistan, Poland, Russian Federation, Slovakia, South Africa, Spain, Switzerland, Turkey, Ukraine, USA and the European Commission (EC).

4. The INPRO Action Plan for 2010–2011, approved at the 15th meeting of the INPRO Steering Committee in November 2009, was implemented during 2010 and continues to be implemented through 2011. The plan comprises activities in six areas:

(a) Nuclear energy system assessments (NESAs) using the INPRO methodology;

(b) Global visions, scenarios and pathways to sustainable nuclear development;

(c) Innovations in nuclear technology;

(d) Innovations in institutional arrangements;

(e) INPRO Dialogue Forum on Nuclear Energy Innovations; and

(f) Policy Coordination, Communication and INPRO Management (cross-cutting).

5. Coordination with related activities throughout the Agency is effected through the Action Plan, which defines interfaces for coordination for all INPRO activities and programme areas. The Action Plan reflects the interests and priorities of its members and is implemented in cooperation with the Agency's regular programme. It continues to rely mainly on in-kind and extrabudgetary contributions from its members. Results obtained under INPRO are in turn available to all Agency Member States. As of May 2011, eleven cost-free experts worked in the INPRO group at the Agency, bringing the total since INPRO's establishment to 43.

6. INPRO's communication activities continued to support cooperation with its stakeholders in Member States and provide them with current information on the project's activities and results. In 2010, the Agency marked the 10th anniversary of INPRO's founding during a technical session held in the margins of the 54th session of the IAEA's General Conference in September. The session was attended by more than 50 Member States and highlighted achievements in understanding nuclear energy sustainability, long range nuclear energy planning, and promoting technical and institutional innovations. A video film was produced which summarized INPRO's development during its first decade from the point of view of participating Member States. In May 2011, the *2010 INPRO Progress Report* was published. It summarizes the results of cooperative studies with Member States and INPRO's achievements.

7. Coordination and cooperation with other international initiatives continued, including with the Generation IV International Forum (GIF). The 5th IAEA/INPRO/GIF coordination meeting took place in March 2011 in Vienna. GIF presented an update on the status of its six selected reactor systems. The meeting discussed progress made in implementing the existing Memorandum of Understanding in connection with proliferation resistance, safety, economics, human resources, education and training, social acceptance, modelling and simulation, non-electrical applications, small and medium-sized reactors, and the activities of the Agency's International Nuclear Infrastructure Group (INIG). The joint action plan on coordination and cooperation with GIF was updated. Follow-up activities were agreed upon, including a future workshop on sodium cooled fast reactors (SFRs) which could address harmonization in SFR safety approaches and reliability of SFR technology.

## B.2. Nuclear energy system assessments (NESA) and long-range planning

8. In November 2010, the Agency published *Introduction to the Use of the INPRO Methodology in a NESA* (NE Series No. NP-T-1.12). It contains practical guidance to Member States on how to use the INPRO methodology effectively to carry out NESAs, addressing three types of assessors: nuclear technology developers, experienced users of nuclear technology and newcomers. The guidance also clarifies the synergy between the INPRO methodology and the Agency's 'milestones approach'[12] when used by newcomers. It concludes that while the INPRO methodology is a tool for long term considerations related to the sustainability of a nuclear energy system, the milestones approach involves near term activities which are required to implement a first nuclear power plant and provides a systematic method for assessing how well prepared a country is to introduce nuclear power. *Introduction to the Use of the INPRO Methodology in a NESA* is being translated into Russian and Arabic.

9. Following feedback from Member States, INPRO further developed its NESA support package. The expanded package includes training material in the form of PowerPoint presentations to be used for familiarizing a country with the INPRO methodology and *Introduction to the Use of the INPRO*

[12] *Milestones in the Development of a National Infrastructure for Nuclear Power*, (NE Series No. NG-G-3.1), 2007.

*Methodology in a NESA*. The support package further contains algorithmic input tables that explain the input data needed for a NESA and provides examples of such data. For economic assessment, a tool was developed that enables the user to calculate all necessary input data in accordance with the INPRO methodology, e.g. levelized unit energy costs of nuclear power and alternative energy sources. In 2011, work started on preparing an e-learning course and a training course for students and young nuclear specialists on using the INPRO methodology for NESAs.

10. Belarus's NESA, which was initiated in 2009, reported good progress. The final report is to be completed and translated into English during the second half of 2011. Because of its full scope, Belarus's NESA can also serve as a reference model for Member States initiating or implementing NESAs.

11. At a kick-off meeting in Kazakhstan to discuss a NESA, held in October 2010 at the Institute of Atomic Energy in Kurchatov, Kazakhstan proposed to perform a full-scope NESA and assess all seven areas of the INPRO methodology to investigate the various options for the country's nuclear energy system, nuclear power plants and fuel cycles. The aim is to confirm that Kazakhstan's strategic plans to develop nuclear power will ensure adequate energy for the sustainable development of the country. In June 2011, a follow-up workshop to monitor progress was held in Astana, Kazakhstan.

12. Poland and Indonesia have expressed interest in conducting NESAs, and Jordan announced a national NESA "to assist in strategic planning and decision making on long-term nuclear energy deployment and to compare different nuclear energy systems to find the optimal one consistent with sustainable development objectives of Jordan, and requested assistance from the IAEA for this NESA".

13. An in-depth nuclear energy system planning study and a limited-scope NESA were initiated in Ukraine at the beginning of 2011, supported by the Agency. The Ukrainian NESA focuses on three areas of the INPRO methodology: economics, infrastructure and waste management. Ukrainian scientists are being trained in the application of all necessary Agency tools and approaches to perform such studies. In April 2011, a two-week training session on energy system planning was held in Kiev, Ukraine, with support from INPRO in cooperation with Programme 1.3, Capacity Building and Nuclear Knowledge Maintenance for Sustainable Energy Development. A training workshop on the INPRO methodology will be held later in 2011. The full study is planned to be finalized by the end of 2013.

14. In August 2011, a training course on developing national long range nuclear energy strategies will be organized in collaboration with the Government of the USA through the Argonne National Laboratory. This follows a workshop on long range nuclear energy programme planning and strategy development held in June 2010, in cooperation with Programme 1.3, at which representatives from 35 Member States learned about the Agency's tools, methods and case studies for long term planning of nuclear energy systems.

15. Projects on which two or more INPRO members collaborate as part of their contributions to INPRO are called "collaborative projects". INPRO's collaborative project "Proliferation Resistance: Acquisition/Diversion Pathway Analysis" (PRADA) was completed in 2010. It developed a method for identifying plausible pathways for the acquisition of weapons-useable material. The project also evaluated barriers against proliferation for the identified pathways. It concluded that an evaluation must be performed at three separate levels, i.e. the State level, the nuclear energy system level and the facility level. A second conclusion was that overall robustness of the barrier system in meeting the safeguards goals effectively and efficiently is not a simple function of the number of barriers and their individual characteristics, but must take into account their interactions. In addition, PRADA considered the feasibility of merging the method developed by GIF (to identify and analyse acquisition/diversion pathways for nuclear material) with the INPRO method. The conclusion was that

merging would benefit both. As a follow-up to PRADA, a new GIF/INPRO collaborative project on proliferation resistance and safeguardability was proposed to develop a coordinated set of GIF/INPRO proliferation assessment tools. This new project would include performing a prototype application on a country with an open fuel cycle.

16. The collaborative project "Environmental Impact Benchmarking Applicable for Nuclear Energy System under Normal Operation" (ENV) harmonizes the methods used in different countries to assess the impact of radiological stressors on the environment. The focus is on releases from a nuclear power plant under normal operation to the atmosphere, seas and surface water and on the impact on humans. Three case studies have been undertaken: one with all parameters — such as meteorological data, transfer coefficients, exposure pathways and consumption rates — predefined; a second with site specific meteorology; and a third which includes a diversity of natural and cultural living conditions, such as country specific food chains. At the final meeting, to be held in October 2011, the results concerning the ranking of radionuclides according to their impact on human health will be summarized for publication in a final report.

## B.3. Global and regional scenarios for sustainable nuclear energy in the 21st century

17. In this area, INPRO investigates opportunities and challenges for nuclear energy in the 21st century. *Global Scenarios and Regional Trends of Nuclear Energy Development in the 21st Century* was published in December 2010, which showcases a limited set of technical scenarios of regionally equitable nuclear deployment based on nuclear energy systems composed of several reactor and fuel cycle types available today. Also, it describes some fast reactors that may be developed in the near future to illustrate the potential role of interregional transfers of nuclear fuel resources in supporting the growth of the global nuclear energy system based on a closed fuel cycle with fast reactors. Its scenarios are one input for formulating an INPRO vision on global nuclear energy sustainability in the 21st century, together with the results of several other studies, including GAINS (see paragraph 18), ThFC (paragraph 19), FINITE (paragraph 20), and RMI (paragraph 20).

18. Work continued on the collaborative project "Global Architecture of Innovative Nuclear Systems based on Thermal and Fast Reactors including Closed Fuel Cycles" (GAINS). Two consultancy meetings, held in 2010, discussed the project's main achievements and the way forward. The reference database for GAINS scenario studies was completed and ten 'GAINS key indicators' were identified which depict nuclear power production, material resources, discharged fuel, radioactive waste and minor actinides, fuel cycle services, system safety, and the costs of and investment in nuclear energy systems. In 2010, the focus of analysis was on the interaction between technical and institutional innovations as a mechanism for enhancing the sustainability of the global nuclear energy system. Simulation scenarios using national and Agency codes showed that innovative nuclear technologies were driving forces for enhancing system sustainability while a multilateral nuclear architecture increased the positive effect of their introduction and provided a global response to global challenges. The final report of GAINS is scheduled for publication later in 2011.

19. The collaborative project on "Investigations of the $^{233}$U/Th Fuel Cycle" (ThFC) was concluded in 2011 and its final report was completed. It summarizes R&D activities in six Member States on introducing thorium (Th) into nuclear fuel cycles, provides the results of a number of scenarios of Th introduction into different nuclear energy systems and takes into account economic aspects and proliferation resistance issues in both once-through and closed fuel cycles. It concluded that under certain conditions heavy water reactors could efficiently exploit Th-based fuel cycles for breeding and burning $^{233}$U in a once-through mode without recycling. The introduction of Th fuel in an open fuel cycle using light water reactors would require significant modification of the fuel management strategy, e.g. transition to very high burnups and the introduction of new material for fuel claddings.

The report also estimated conditions for the possible competitiveness of Th reactors operating in a closed fuel cycle compared to uranium/plutonium reactors and highlighted differences in their proliferation resistance. The final report is to be published by the end of 2011.

20. The collaborative project on "Fuel Cycles for Innovative Nuclear Energy Systems based on Integrated Technologies" (FINITE) is developing guidance for assessing advanced options for closed fuel cycles (CFC) taking into account different technologies and modalities of deployment. National scenarios through 2050 of nuclear energy supply have been developed using the Agency's analytical tools, such as the Model for Energy Supply Strategy Alternatives and their General Environmental Impacts (MESSAGE) and Dynamic Energy System — Atomic Energy (DESAE). At a meeting in China in December 2010, the main features of national strategies were reviewed, including the number, type, capacity and characteristics of nuclear installations, together with the current status and development plans for technologies necessary to implement these strategies. The collaborative project on "Meeting Energy Needs in the Period of Raw Materials Insufficiency during the 21st Century" (RMI) continued to be implemented during 2010–2011.

## B.4. Innovations in nuclear technology and institutional arrangements

21. Four collaborative projects on innovations in nuclear technology are nearing completion. The collaborative project on "Investigation of Technological Challenges Related to the Removal of Heat by Liquid Metal and Molten Salt Coolants from Reactor Cores Operating at High Temperatures" (COOL) focuses on experimental and analytical investigations of thermal-hydraulics of coolants that are capable of operating at high temperatures, and on issues related to the handling of these coolants. "Decay Heat Removal System for Liquid Metal Cooled Reactors" (DHR) investigates improved passive safety of fast reactors by performing independent analyses of a proposed passive decay heat removal system design. "Advanced Water Cooled Reactors" (AWCR) considers case studies related to phenomena that are important for advanced water cooled reactor designs that incorporate improved passive safety systems. Phenomena studied in this project include natural circulation and thermal stratification. "Performance Assessment of Passive Gaseous Provisions" (PGAP) contributes to the formulation of a consistent method for assessing the reliability of passive safety systems that involve natural circulation. The projects' participating States reviewed the results of R&D activities and took stock of progress made. All are scheduled for completion in 2011.

22. In the collaborative project "Implementation Issues for the Use of Nuclear Power in Small Grid Countries" (SMALL) participating countries investigate the deployment of nuclear power in countries with small grids and the technical and economic options for managing spent fuel and radioactive waste applicable to the conditions of such countries. The final report is to be published later in 2011.

## B.5. INPRO Dialogue Forum on nuclear energy innovations

23. The second workshop of the Dialogue Forum was held in October 2010, following the model established by the first workshop in January 2010, which brought together nuclear technology holders, nuclear technology users and subject matter specialists. The workshop was organized by INPRO and addressed multilateral approaches to nuclear energy deployment with a focus on institutional challenges and explored five key areas where non-technical multilateral cooperation could be valuable: multilateral approaches to the nuclear fuel cycle (front- and back-end); multilateral approaches in infrastructure for new nuclear power programmes; multilateral approaches in safety, licensing and regulation; financing issues in multilateral approaches to nuclear energy development; and multilateral approaches in prototypes and in the demonstration of innovative technologies.

# C. Other Agency Activities related to Innovative Nuclear Technology

24. The Agency provides an international forum for the review and discussion of technology development and the design of selected innovative reactors and their fuel cycles in the framework of Technical Working Groups on advanced water reactors, fast-spectrum systems (both critical and subcritical), gas cooled reactors, fuel cycle options and non-electrical applications of nuclear energy. Activities are planned and implemented in close cooperation with other relevant international initiatives and organizations, such as the OECD/NEA, GIF, EC and the International Centre for Theoretical Physics to avoid duplication across programmes.

## C.1. Innovations in Reactor Technology and Applications

25. A publication on *Construction Technologies for New Nuclear Power Plants* will be published later in 2011. The publication assimilates global experience from a variety of recent large construction projects and includes comprehensive descriptions of all construction methods including their advantages and disadvantages, and a discussion of best practices and lessons learned. Two follow-up workshops are planned to be held later in 2011.

26. Efficient water use is very important, in particular for countries with current or expected water supply shortages. All thermal power plants need water for different purposes, e.g. cooling and consumption. When countries consider introducing or expanding nuclear power, a detailed assessment of water needs is required. Reducing water use by nuclear power plants is likely to help countries to introduce nuclear power into their energy supply mix. The Agency completed a document on *Management for Efficient Water Use in Nuclear Power Plants*, to be published later in 2011.

27. Agency activities to foster collaboration among Member States on the development and deployment of water cooled, liquid metal cooled and gas cooled small and medium-sized reactors (SMRs) are summarized in Annex 7.

28. In the area of light and heavy water reactors, a technical meeting on the Application of Computational Fluid Dynamics (CFD) Codes for the Design of Advanced Water Cooled Reactors was held in December 2010 to foster international information exchange and cooperation in the development, verification and validation of CFD codes for the modeling and design of advanced water cooled reactors. Workshops were held on Integral PWR Design Natural Circulation Flow Stability and Thermo-hydraulic Coupling of Containment and Primary Systems during Accidents (March 2011) and on Good Practices in Heavy Water Reactor Operation (April 2011). Two training courses were organized on the Science and Technology of Supercritical Water Cooled Reactors (June 2011), in cooperation with the ICTP, and on Natural Circulation Phenomena and Passive Safety Systems in Advanced Water Cooled Reactors (July 2011), in cooperation with Harbin Engineering University, China. The Agency published *Advanced Fuel Pellet Materials and Fuel Rod Designs for Water Cooled Reactors* (IAEA-TECDOC-1654) in November 2010. More details are given in paragraph 33.

29. The Agency's activities in the field of advanced fast neutron systems research and technology development are implemented within the framework of the Technical Working Group on Fast Reactors (TWG-FR), which also deals with accelerator-driven systems. Two Coordinated Research Projects (CRPs) on sodium natural circulation in MONJU (Japan) and PHENIX (France) are nearly complete, and a new CRP on safety tests conducted in EBR-II (USA) will begin shortly. At its 44$^{th}$ annual meeting in May 2011 the TWG-FR members discussed possible Agency activities in 2011 and 2012, with special emphasis on technical meetings and CRPs devoted to analyzing safety features of current and future (i.e. Generation IV) fast reactor designs and the anticipated response of fast reactors

in loss of heat sink (LOHS) accidents and station black-out. Status Reports on *Fast Reactor Research and Technology Development* as well as on *Liquid Metal Coolants for Fast Reactors* will be published by the end of 2011.

30. The Technical Working Group on Gas Cooled Reactors (TWG-GCR) met in March 2011. It discussed the status of gas cooled reactor activities in Member States and provided advice on the Agency's planned activities for the next Programme and Budget cycle. The TWG-GCR reiterated the importance of collaboration among Member States on the successful demonstration of high temperature gas reactor (HTGR) technology. The TWG-GCR also considered the design features of current HTGR projects against the backdrop of the Fukushima-Daiichi accident. A technical meeting on Licensing Experiences for past HTGRs and Challenges for Future NPPs was held in November 2010 to initiate the exchange of information and experiences related to licensing HTGRs in order to better understand the licensing challenges faced by HTGR designers and facilitate a dialogue between designers and regulators to better understand each other's needs, requirements and capabilities.

31. Non-electric applications of nuclear reactors include seawater desalination, hydrogen production, district heating and the production of process heat for industrial uses. The Agency is finalizing technical reports on the *Status of Hydrogen Production Using Nuclear Energy* and *Advances in Nuclear Power for Process Heat Applications*. Agency activities on seawater desalination using nuclear energy are summarized in Annex 5.

## C.2. Innovations in Fuels and Fuel Cycles

32. In the area of innovation in thermal reactor fuels and fuel cycles, the Agency published *Advanced Fuel Pellet Materials and Fuel Rod Design for Water Cooled Reactors* (IAEA-TECDOC-1654), as noted in paragraph 29. It covers fabrication and design, advanced fuels and innovative fuels, and is based on the proceedings of a technical meeting that examined both evolutionary improvements of existing fuels and the development of innovative fuels. It summarizes the current status of developments as well as future perspectives and recommendations for further enhancements of fuel efficiency and reliability.

33. A meeting on High Temperature Gas Cooled Reactor Fuel and Fuel Cycles was held in September 2010. The meeting concluded that more technological developments are needed for the manufacture of multi-layer coated particle fuel, advanced techniques for the characterization of coated particles by destructive as well as non-destructive methods, and irradiation testing.

34. A CRP is underway to support the development of new radiation resistant materials for advanced and innovative nuclear power systems, such as fast reactors and future fusion reactors. Intermediate results of another CRP, on Accelerator Simulation and Theoretical Modelling of Radiation Effects, were reported at the Tenth International Topical Meeting on Nuclear Applications of Accelerators (AccApp'11) and the International Workshop on Dispersion Strengthened Steels for Advanced Nuclear Applications (DIANA I). The final report of the CRP will be prepared at the third research coordination meeting in December 2011 and published in 2012. A new CRP entitled Benchmarking of Structural Materials Pre-selected for Advanced Nuclear Reactors started in May 2011 and is focused on different oxide dispersion strengthened materials provided by project members for round-robin examinations. Upon finalization of the joint studies, a cross-verified database of properties and micro-structural characterization of these materials will be available for interested Member States.

35. A report on *Status and Trends of Nuclear Fuel Technology for Sodium Cooled Fast Reactors* (NE-Series No. NF-T-4.1) was published in May 2011. It covers the status and trends of fuel technology for sodium fast reactors, highlighting the manufacturing processes, out-of-pile properties

and irradiation behaviour of mixed uranium plutonium oxide (MOX), monocarbide, mononitride and metallic U-Zr and U-Pu-Zr fuels. It also covers, to the extent possible, minor actinide bearing fuels[13]. The report is intended as a resource for materials scientists and engineers involved in fuel development for fast reactors in general and sodium cooled fast reactors in particular.

36. In May 2011, the Agency also published *Status of Developments in the Back End of the Fast Reactor Fuel Cycle* (NE-Series No. NF-T-4.2). This report highlights emerging innovations and R&D needs for the back end of the fast reactor fuel cycle with emphasis on reprocessing of plutonium-based ceramic and metallic fuels. This publication will serve as a useful resource for nuclear scientists and engineers involved in fast reactor fuel development as well as reprocessing of spent nuclear fuel from fast reactors.

37. A meeting on Advanced Partitioning Processes was held in June 2011. The meeting concluded that the sustainable development of nuclear energy calls for the development of innovative technologies for recycling fissile and fertile nuclear materials and the destruction of long-lived radioactive wastes. Truly sustainable closed fuel cycles will require new, advanced separation technologies to optimize the selection of materials to be recycled. New R&D programmes based on innovative technologies are underway in many Member States to demonstrate the techno-commercial feasibility of advanced separation and partitioning processes to, first, separate highly radioactive minor actinides along with plutonium from spent nuclear fuel for possible recycling as advanced nuclear fuel and, second, prepare final waste forms with enhanced durability.

[13] Minor actinides include neptunium, americium and curium.

# Small and Medium-sized Reactors (SMRs) – Development and Deployment

## A. Background

1. In resolution GC(53)/RES/13.B.3 the General Conference encouraged the Secretariat to continue to assist Member States in the development of safe, secure, economically viable and proliferation-resistant SMRs, including for nuclear desalination and hydrogen production. The General Conference requested the Director General to report to the Board of Governors and to the General Conference on (i) the status of the programme initiated to assist developing countries interested in SMRs; (ii) progress made in the research, development, demonstration and deployment of SMRs in interested Member States intending to introduce them; and (iii) progress made in the implementation of this resolution. This report responds to that request.

## B. Activities of the Agency

2. The IAEA continues to encourage the development and deployment of SMRs through the activities of a project on "Common Technologies and Issues for SMRs", initiated in 2004 and implemented within the context of the regular budget. Reactors with power ratings less than 300 MW(e) are labelled "small", and those with ratings between 300 MW(e) and 700 MW(e) are labelled "medium-sized". SMRs are of interest to developed and developing countries that wish to add to their electricity generating capacity in increments smaller than 700 MW(e). Such additions can be attractive where electrical grid capacities are limited, where electricity generation is needed in remote areas, and where the relative ease of financing a smaller reactor offsets the economies of scale of building a larger reactor. SMRs may also be more suitable for process heat production for desalination, hydrogen generation and other applications. The IAEA has organized international meetings to bring together technology users and technology holders; it has facilitated networking among SMR users planning near-term deployment, coordinated research to address innovative SMR technological challenges and provided education and training on various aspects of SMR technology development, assessment and SMR applications.

3. A Coordinated Research Project (CRP) on Small Reactors without On-site Refuelling was started in 2004 and finalized at the end of 2009. The project created a network of 18 research institutions from 10 Member States. The overall objective of the project was to increase capability in Member States to develop and deploy small reactors without on-site refuelling. The final report, *Small Reactors without On-site Refuelling: Neutronic Characteristics, Emergency Planning and Development Scenarios* (IAEA-TECDOC-1652), identifies the advantages of these reactors, such as the absence of refuelling equipment, stored fresh fuel or stored spent fuel at the sites of such reactors. It also developed a conceptual method to relate emergency planning zones to the safety performance of such reactors and identified experiments to reduce discrepancies in the results of neutron depletion codes used for fuel design.

4. A CRP on the Development of Methodologies for the Assessment of Passive Safety System Performance in Advanced Reactors started in 2008 to determine a common method to analyse and test the reliability of passive safety systems. Natural circulation tests to obtain experimental data for computer code benchmarking are being carried out using the natural circulation loop L2 at the University of Genoa in Italy in coordination with the University of Pisa. The CRP is being conducted

jointly by the Department of Nuclear Energy and the Department of Nuclear Safety and Security. The CRP is progressing well and is expected to finish by mid-2012.

5. Technical Meetings were held in November 2009 and June 2010 to prepare a Nuclear Energy Series Report on *Options to Incorporate Intrinsic Proliferation Resistance Features into NPPs with Innovative SMRs and their Associated Fuel Cycle*. The objective is to harmonize the methods developed by the International Project on Innovative Nuclear Reactors and Fuel Cycles (INPRO) and the Generation IV International Forum (GIF) on proliferation resistance and physical protection. The meetings presented examples of previously performed proliferation resistance assessments for energy systems and reviewed the progress achieved in the development of a template for collecting designers' data on proliferation resistance.

6. Also under preparation is a publication on *Approaches to Assess Economic Competitiveness of SMRs*, which will present a consolidated description of software tools for the assessment of competitiveness of SMRs for different applications. Publication is expected later in 2011.

# C. Activities of the Member States

7. SMRs are under development for all principal reactor lines, i.e. water cooled reactors, liquid metal cooled reactors and gas cooled reactors. About 45 innovative SMR concepts are being investigated for electricity generation and for process heat production for desalination, hydrogen generation and other applications. Most concepts incorporate innovative safety features, such as passive safety systems. Technology development and conceptual design are progressing in a number of countries, including Brazil, China and Indonesia. Several Member States have SMR designs ready for deployment. These include several pressurized heavy water reactor (PHWR) designs, including CANDU 6 from Canada and the PHWR-220, PHWR-540, and PHWR-700 from India, as well as pressurized light water reactor designs, e.g. the VVER-440 from the Russian Federation and the CNP-600 from China. Altogether 11 SMRs are under construction in 5 countries, Argentina, China, India, the Russian Federation and Slovakia. Worldwide 132 SMR units are in operation in 25 Member States with a capacity of 59 GW(e). The following paragraphs summarize some examples of SMR concepts and designs.

8. Small and medium-sized light water reactors are being developed in Argentina, China, France, Republic of Korea, the Russian Federation and the USA. In Argentina, the CAREM reactor (a small, integral type pressurized light water reactor design of 150-300 MW(e)) is being developed with all primary components located inside the reactor vessel. Construction of a CAREM prototype plant of 27 MW(e) is planned for 2012. China has also developed pressurized light water cooled designs of 300 MW(e) and 600 MW(e). Three CNP-600 units are under construction in China. France is developing the Flexblue design, which is a small subsea nuclear power plant with an output rating of 50 to 250 MW(e). In the Republic of Korea, the SMART design has almost reached final design approval. SMART has a thermal capacity of 330 MW(th) and is, in particular, planned for seawater desalination. Two CNP-300 units are operating in Pakistan. The Russian Federation has deployed many VVER-440 units and is developing several VVER designs in the SMR category. In addition, the Russian Federation is building two smaller units of the KLT-40S series to be mounted on a barge and used for cogeneration of process heat and electricity. The KLT-40S was developed based on experience with reactors used to power icebreakers. In the USA, several SMRs are under development. These include the NuScale, which envisages one nuclear power plant made up of twelve 45 MW(e) modules; the mPower, which consists of four 125 MW(e) modules; and the Westinghouse

SMR, a 200 MW(e) pressurized water reactor (PWR) that uses passive safety systems and components with proven performance from the AP1000. The first two are scheduled to be submitted to the US Nuclear Regulatory Commission (NRC) for design review in 2012. All three US reactors are integral PWRs.

9. Heavy water reactors in the SMR category have been developed and designed in Canada and India. Canada has developed and deployed the CANDU series, which offers various power ratings. The 700 MW(e) CANDU 6 is in the SMR category, and 11 CANDU 6 units are operating in 5 countries. Several heavy water reactors are under construction or in operation in India. These include PHWRs of 220 MW(e), 540 MW(e) and 700 MW(e). An advanced heavy water reactor (AHWR) is being designed that incorporates a vertical calandria[14], thorium fuel and passive safety features.

10. There are several high temperature gas cooled reactors under development with power ratings below 700 MW(e). China has developed, constructed and operated the HTR-10, an experimental pebble-bed helium cooled high temperature reactor, and in April 2011 it started construction of a modular HTR-PM consisting of two 250 MW(th) modules. The USA has developed the gas turbine modular helium cooled reactor (GT-MHR), a high temperature reactor with block type fuel elements and a gas turbine cycle.

11. Liquid metal cooled fast reactors in the SMR category are being investigated in several countries. India is building the 500 MW(e) prototype fast breeder reactor (PFBR), which is planned for commissioning in 2012. Japan has developed a reactor (4S), which is designed to provide 10-50 MW(e) and to be located in a sealed, cylindrical vault about 30 m underground while the building would be above ground. The Russian Federation has also developed and plans to construct several SVBR-100 units, a small fast reactor with lead-bismuth eutectic alloy as the coolant and a power output of 100 MW(e). Its modular and integral design makes it suitable for large scale factory production, with high quality control, in order to reduce unit costs. In China, the Chinese experimental fast reactor (CEFR) has reached criticality and has been in the process of being commissioned since July 2010. Finally, in the USA, the power reactor innovative small module (PRISM) has been developed, and an application to the NRC for design certification is being prepared.

[14] A calandria in a CANDU reactor contains the core of the nuclear steam supply system. It is a large cylindrical vessel, filled with several hundred tonnes of heavy water. Hundreds of fuel channels run through the calandria, parallel to the cylindrical axis.

# Supporting Infrastructure Development for Nuclear Power

## A. Background

1. In resolution GC(54)/RES/10.B.2 the General Conference welcomed the Secretariat's internal coordination and holistic approach to nuclear infrastructure development, in particular the establishment of the Integrated Nuclear Power Infrastructure Group (INIG), and recommended that the Secretariat and the new Technical Working Group on Nuclear Power Infrastructure (TWG-NPI) consider ways and means to enhance nuclear infrastructure development assistance options for Member States. The General Conference requested that the Director General report on the progress made in the implementation of this resolution to the Board of Governors and to the General Conference at its fifty-fifth (2011) session. This report responds to that request.

## B. Work since the 54th session of the General Conference

### B.1. General

2. Notwithstanding the accident at the Fukushima Daiichi Nuclear Power Plant, interest in nuclear power remains high. Of the countries without nuclear power that, before the accident, had strongly indicated their intentions to proceed with nuclear power programmes, a few have cancelled or revised their plans, others have taken a 'wait-and-see' approach, but most have continued in their pursuit of introducing nuclear into their energy mixes. The factors that had contributed to increasing interest in nuclear power before the Fukushima accident, such as persistent energy demand growth due to population growth and economic development, largely remain the same. As countries make progress in their national programmes, they continue to make use of the Agency's support in this regard. The number of TC concepts submitted on the introduction of nuclear power for the 2012-2013 TC cycle increased slightly over the current number of TC projects and extrabudgetary contributions for this purpose have also continued to increase. The latter included the first contributions towards Agency activities supporting nuclear power infrastructure development under the Peaceful Uses Initiative.

3. Since the 54th regular session of the GC, the Agency has continued with the implementation of its activities in this area, which cover a wide range of technical topics, such as workforce planning, human resource development and support for the development of competent regulatory systems, and also include the development of guidance and other documents, the establishment of forums to share lessons learned and best practices, and the provision of technical assistance in the form of capacity building and review services.

4. The Agency takes a holistic approach to infrastructure development. The Nuclear Power Support Group (NPSG) helps coordinate overall guidance while the implementation of technical activities across all relevant areas of the Agency's programme is coordinated through INIG, established in 2010.

5. The Secretariat's principal activities include the further development and implementation of Integrated Nuclear Infrastructure Review (INIR) missions, integration of information from various databases for more effective planning and delivery of support activities under TC projects, training in

the use of energy planning tools, legislative assistance, guidance on ensuring safety for sustainable nuclear development, preparation and implementation of education and training materials, and forums for sharing information among Member States on lessons learned, experience and bilateral assistance.

## B.2. Technical Working Group on Nuclear Power Infrastructure

6. The TWG-NPI was established in 2010 as a group of international experts to share experience and information on national programmes and to provide advice to the Agency to support Member States considering or introducing nuclear power. The first meeting of the TWG-NPI was held in November 2010 and the second in May 2011. The TWG offered advice on the Agency's role and future plans, assistance to newcomers, the role of research in nuclear power infrastructure development, and 'soft coordination'. 'Soft coordination' refers to the Agency's efforts to promote the productive interaction among the Agency's infrastructure assistance and similar bilateral assistance between newcomers and vendor countries — all while respecting the independence of different assistance initiatives.

## B.3. Technical Cooperation

7. To facilitate the implementation of nearly 40 TC projects in the 2009-2011 cycle, involving the participation of 65 Member States, the Agency developed a catalogue of the services it provides in each of the 19 areas identified in *Milestones in the Development of a National Infrastructure for Nuclear Power* (NE Series No. NG-G-3.1). The catalogue was first distributed during the 54$^{th}$ session of the GC and used in planning the TC programme. It consolidates in one document the range of Agency support available and is useful not only to Member States seeking assistance but also to Agency staff in developing coherent responses that make efficient use of all Agency services. It is updated as needed.

8. Special emphasis has been placed on developing training courses for managers and leaders in new nuclear power programmes, drawing on the experience of countries with operating nuclear power plants. A good example is the Interregional Training Course on Leadership and Management of Nuclear Power Infrastructure in Emerging Nuclear Power States that was held at the Argonne National Laboratory (ANL), USA, in October 2010, following a successful similar meeting in 2009. The course attracted decision-makers from 25 Member States from Africa, Asia, Europe and Latin America. Its main objective was to increase awareness of specific processes and organization and management systems related to nuclear power. Based on the success of the 2009 and 2010 courses and the continued high demand for such training, two such courses are scheduled for 2011 — in July in France and in November at the ANL in the USA.

## B.4. Assessment of nuclear infrastructure

9. The Agency conducted Integrated Nuclear Infrastructure Review (INIR) missions in Thailand in December 2010 and in the United Arab Emirates in January 2011. These missions were greatly facilitated by the preparation of self-evaluations and were conducted under national TC projects. As with previous missions, the Member States who participated found them to be useful and supportive of national efforts. The Agency has received a formal request from Bangladesh for an INIR review mission and preparations are underway.

10. The UAE INIR mission was the first to be conducted in a country that has contracted its first NPP. It therefore provided an opportunity to fully implement and test the Phase 2 evaluation methodology described in *Evaluation of the Status of National Nuclear Infrastructure Development* (NE Series No. NG-T-3.2). A consultancy was conducted in May 2011, with national counterparts and

international experts who took part in the Thailand and UAE INIR missions, to review the evaluation methodology with a view to identifying areas where it needs to be strengthened or updated. A supplement to *Evaluation of the Status of National Nuclear Infrastructure Development* will be prepared in 2011. In an effort to continuously improve INIR missions, additional emphasis was placed on mission preparations, including training for INIR mission team members in interviewing techniques.

11. Based on the lessons learned and on the experience from the first five INIR missions, the first revision of the brochure, *Guidance on Preparing and Conducting INIR Missions*, was published in June 2011. The revision also takes into account the role of INIG, which was established in July 2010. The Thailand and UAE INIR missions were the first to follow the guidance contained in the revised brochure.

## B.5. Support for Human Resource Development

12. At the International Conference on Human Resource Development for Introducing and Expanding Nuclear Power Programmes held in March 2010 in Abu Dhabi, UAE[15], the Agency and the organizations sponsoring the conference announced an initiative to conduct a number of surveys of human resource development needs for operating organizations, regulatory bodies and new nuclear power programmes. Work on the surveys has begun and the results are expected in early 2012.

13. In October 2010, the Korea Hydro & Nuclear Power Company (KHNP) hosted a meeting to mentor future leaders of new nuclear power programmes. This was the second such meeting, following an initial meeting in June 2009[16]. This two-week programme offered primarily Asian decision makers an opportunity to experience several aspects of the Korean nuclear industry, including operations, design and construction. During the programme, the participants were mentored by recently retired senior managers from KHNP. This programme included visits to the corporate office of the nuclear power plant operating organization, an engineering company, an education institute and training centre, research organizations, an operating nuclear power plant, a nuclear power plant under construction, a heavy component manufacturing company, government ministries, and the nuclear safety regulatory body. This programme will be offered again in the fall of 2011.

14. Building on this effort, in April 2011 a technical meeting was conducted in the Republic of Korea on “Hands on Experience in Developing and Managing Nuclear Power Programmes”, which offered practical examples from the Korean nuclear power programme of some of the challenges faced by countries starting such programmes.

15. The International Framework for Nuclear Energy Cooperation (IFNEC) is cooperating with the Agency on the development of a workforce planning modelling tool for countries launching nuclear programmes. This tool is based on the Agency’s workforce planning approach. Discussions are underway to further develop the model and to offer it as a part of Agency assistance.

## B.6. Conferences and Workshops

16. The Agency uses international workshops as a mechanism for strengthening networking among Member States. One such workshop on “Topical Issues on Infrastructure Development: Managing the Development of a National Infrastructure for Nuclear Power” was held in February 2011 in Vienna. The meeting was attended by more than 80 representatives from 40 Member States, from the European

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[15] Please refer to document GOV/2010/43-GC(54)/10.

[16] Please refer to document GOV/2010/43-GC(54)/10.

Commission (EC) and the World Association of Nuclear Operators (WANO). This was the fifth annual workshop conducted by the Agency since 2006 to provide a platform for sharing experience and lessons learned aimed at facilitating the development and implementation of national infrastructures for nuclear power. The main outcome of the workshop was a recognition that the level of understanding of the commitments and responsibilities of a nuclear power programme has increased among the participants over the years. Breakout sessions during the workshop offered participants an opportunity to share solutions to common challenges related to developing a national position, self-evaluation, and becoming a knowledgeable customer.

17. A technical meeting on "Alternative Contracting and Ownership Practices for Nuclear Power Plants" was held in Vienna in March 2011 to review a draft report on the same subject. The meeting provided an opportunity to exchange information about the current contracting and ownership models being employed, such as those in recent projects between Turkey and Russia and between the UAE and the Republic of Korea. The meeting's results will be incorporated into the final report to be published later in 2011.

18. The Agency organized a workshop on "Sharing Experiences among Countries Embarking on Nuclear Power in Southeast Asia" in October 2010 in Jakarta, Indonesia. The main purpose of the workshop was to provide an opportunity for exchanging specific information and to facilitate the development and implementation of each country's national infrastructure for nuclear power, especially in planning the overall strategy and coordinating activities for the introduction of the first nuclear power plant.

19. The Agency organized a technical meeting on "Industrial Involvement and Technology Transfer on Nuclear Power Projects" in September 2010. The meeting discussed (i) development of a policy for national participation in a nuclear power programme, (ii) actions needed at the initial stages of such a programme to ensure the participation of industry, including a survey of national industry and (iii) integrated and updated practical guidance for a sustainable industrial capacity and technology transfer mechanisms in countries introducing nuclear power.

## B.7. Databases and Publications

20. The Country Nuclear Power Profiles (CNPP) compile background information on the status and development of nuclear power programmes in Member States. The format was revised in 2009 to allow Member States introducing nuclear power to contribute. Nine of the 10 countries invited to submit information for the 2010 edition provided information using the new format.

## B.8. Documents in preparation

21. *Managing Siting Activities for Nuclear Power Plants* (NE Series No. NG-T-3.7) has been submitted for publication and awaits printing. The integrated site selection and evaluation approach recommended in this document is based on the Agency's 'milestones approach' and takes into consideration the draft safety guide *Safety Aspects in Siting for Nuclear Installations* (DS433).

22. An initial draft of *Industrial Infrastructure to Support a National Nuclear Power Programme* has been prepared. Publication is planned for 2012.

23. A report entitled *Invitation and Evaluation of Bids for Nuclear Power Plants* has been finalized and will be submitted for publication by the end of 2011. The report will provide practical guidance on the establishment of the nuclear power plant bidding process including the preparation of bid invitation specifications, the technical and economic evaluation of bids, and the contract negotiation.

24. Two other NE Series reports have been submitted for publication, *Nuclear Power General Objectives* and *Stakeholder Involvement in the Lifecycle of Nuclear Facilities*. A third NE Series report, entitled *Alternative Contracting and Ownership Practices for Nuclear Power Plants* will be submitted for publication by the end of 2011.

# C. Future events

25. INIG has initiated a team approach to implementing Agency activities in nuclear power infrastructure with participation of technical staff from several departments. This approach seeks to foster effective coordination and integrated implementation of the Agency's activities related to the introduction of nuclear power. Regular coordination meetings, a common schedule of events and a cross-organizational workspace were introduced by INIG to encourage information sharing, reduce duplication and integrate services, as appropriate. Future plans include development of information resources such as generic terms of reference for workshops, case studies and other materials for Member States. While the NPSG provides a means for developing guidance, INIG will formalize the process for coordination at the working level.

26. A workshop on national infrastructure to support the introduction of nuclear power will be organized by the Agency in January 2012. This follows the series of workshops conducted since 2006 on the same topic including the one described in Paragraph 15. These workshops have promoted dialogue and cooperation and helped the Agency understand the needs of Member States embarking on nuclear power.

27. Additional regional workshops and training events are planned on developing a national position on nuclear power, performing critical self-assessments and creating learning organizations, performing feasibility studies, and assessing nuclear power technology options.