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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(47)/RES/10 and GC(48)/RES/13, this document contains progress reports on the use of isotope hydrology for water resources management (Annex 1); plan for producing water economically using small and medium-sized nuclear reactors (Annex 2); support to the African Union's Pan African Tsetse and Trypanosomosis Eradication Campaign (AU-PATTEC) (Annex 3); and Agency activities in the development of innovative nuclear technology (Annex 4).
- Further information on the Agency's activities related to nuclear science, technology and applications can be found in the *Nuclear Technology Review — Update 2005* (GC(49)/INF/3), the Agency's *Annual Report 2004* (GC(49)/5), in particular the Technology section, and the *Technical Cooperation Report for 2004* (GC(49)/INF/2).

## **Recommended Action**

- It is recommended that the Board take note of Annexes 1 – 4 of this report and authorize the Director General to submit the report to the General Conference at its forty-ninth session.

# Use of Isotope Hydrology for Water Resources Management

## A. Background

1. At its forty-seventh session in September 2003, the General Conference, through resolution GC(47)/RES/10.D, requested the Director General to, inter alia, continue to further strengthen the efforts directed towards fuller utilization of isotope and nuclear techniques for water resources development and management, with particular emphasis on groundwater management; to strengthen activities which contribute to the implementation of the programmes adopted by the World Summit on Sustainable Development and the United Nations Millennium Summit, such as those related to an improved understanding of the water cycle; and to develop human resources in isotope hydrology through appropriate courses, at universities and institutes in Member States, through the use of advanced communications techniques. It further requested the Director General to report on achievements in implementing resolution GC(47)/RES/10.D to the Board of Governors and to the General Conference at its forty-ninth session.

## B. Developments since the General Conference's 2003 session

2. Water resources management continued to be a priority issue on the international agenda. Following the 2003 International Year of Freshwater, the United Nations proclaimed 2005–2015 as an International Decade for Action, “Water for Life”, to bring about a greater focus on the critical linkage between water and human development at all levels. The 4<sup>th</sup> World Water Forum and Ministerial Conference will be held in March 2006 in Mexico City, Mexico.

3. The Secretariat continued its efforts to bring isotope hydrology into the mainstream of national and international water resource related programmes. This has resulted in a wider use of isotope techniques for water resources and environmental management, investigations for development of geothermal resources as well as safety of dams, which are used for hydroelectric power in interested Member States. About \$7.6 million were disbursed for 74 technical cooperation projects operational in the 2003–2004 programme cycle. In 2005–2006 technical cooperation programme the number of operational projects increased to 87 for an adjusted budget of \$6.9 million.

### B.1. Groundwater Management

4. The Agency initiated a partnership with the World Bank, Global Environment Facility (GEF), the International Association of Hydrogeologists (IAH), and the United Nations Educational, Scientific and Cultural Organization (UNESCO) to develop a global strategic vision for groundwater

use and protection. A joint project to be funded by this partnership will be launched at the 4<sup>th</sup> World Water Forum in 2006. Isotope hydrology is a key component of these efforts as it provides crucial information on the residence time of groundwater and recharge or renewability of aquifers, particularly in arid and semi-arid areas.

5. Co-funding of \$1 000 000 has been provided by UNDP/GEF for an IAEA/UNDP/GEF project to improve the management of the Nubian aquifer system shared by Chad, Egypt, Libyan Arab Jamahiriya and Sudan. The project will be implemented in cooperation with other international partners such as UNESCO.

6. The IAEA/UNESCO Joint International Isotopes in Hydrology Programme (JIHP) expanded operational activities including a joint regional training course held in Egypt on the use of isotopic techniques for artificial groundwater recharge, helping to address the increasingly critical issue of how to manage the recharge of aquifers in arid areas for drinking water. The Agency also participated in a new initiative led by UNESCO and IAH, together with the United Nations Economic Commission for Europe, to develop guidelines for delineation of protection zones around public groundwater supplies and management policy.

7. A regional project on the sustainable management of groundwater resources was completed in Latin America. Improved understanding of aquifers resulting from this project is important for national water managers to support their efforts for improving water supply to rural and urban users. A cooperation agreement between Ecuador and Peru was facilitated through a TC project to coordinate a management plan for a transboundary aquifer, with a total contribution of \$1.5 million from the European Union, the Spanish Agency for International Cooperation and the Organization of American States.

8. Partnerships with other international agencies and programmes in the area of groundwater management were further strengthened. A strong link was established with UNEP's Global Environment Monitoring System Water Programme (GEMS/Water) through a joint project to undertake inter-laboratory comparison exercises for water chemistry aimed at improving the quality of chemical data worldwide. In collaboration with UNESCO, the Agency organized a meeting on groundwater resources sustainability indicators. The working group focused on identification and review of groundwater indicators and produced a draft document, which will contribute to the United Nations' World Water Development Report.

9. In Bangladesh, application of isotope hydrology has provided data and information for better understanding of groundwater systems, which is important for planning the best ways to address the arsenic contamination problem in the country. The technology is gaining the recognition of the concerned authorities, and has been incorporated as an important component in the World Bank supported Bangladesh Arsenic Mitigation Water Supply Project.

## **B.2. Improved Understanding of the Water Cycle**

10. Use of isotopes was successfully integrated in the World Meteorological Organization/World Climate Research Programme's Global Energy and Water Cycle Experiment (GEWEX) project. An IAEA/GEWEX workshop evaluated potential means of integrating precipitation isotope data in moisture source tracing models and, as a first step, initiated an international inter-comparison of the isotopic modules in different global circulation models.

11. The coordinated research project (CRP) "Isotopic Composition of Precipitation in the Mediterranean Basin in Relation to Air Circulation Patterns and Climate" was completed, providing a relationship between the origins and trajectories of respective air masses and the isotope contents in

precipitation and atmospheric water vapour. The results are significant for the investigation of the processes responsible for precipitation and the impact of climate change and its variability on water resources in the Mediterranean region.

12. A new CRP was initiated to develop new isotope applications for the study of water and carbon cycle dynamics. The objective of the project is to improve the ability to quantify moisture fluxes in the biosphere and atmosphere exchange for better simulation of the hydrological cycle under present and future climate conditions.

13. A second CRP aims to develop isotope methods for the assessment of groundwater sustainability by using the residence time and flowpaths of baseflow (groundwater discharge) in large river basins. This CRP will complement the research being conducted in an ongoing CRP on the isotopic monitoring of river discharge. In addition, the re-orientation and strengthening of the Global Network for Isotopes in Precipitation, through monthly or daily sampling at 170 stations in 53 countries, will increase the use of isotope data networks in climate and hydrological research.

### **B.3. Capacity Building in Member States**

14. Analytical services to the technical cooperation programme were coordinated through a network of Member State laboratories. Inter-laboratory comparisons for analysis of isotopes in water were conducted and results disseminated to participating laboratories for quality control and quality assurance of their analytical procedures. Laboratory facilities for isotope analyses were strengthened in China, Ethiopia, Jordan, Pakistan, Syria and Vietnam. These and other laboratories strengthened previously in Egypt, El Salvador, Morocco and South Africa were used to provide isotope analyses for national or regional technical cooperation projects.

15. The Agency provided support under the technical cooperation programme to Member States to consolidate the human resource base and maintain a core of qualified staff in isotope hydrology. This included initial training of newly recruited staff, advanced training in isotope hydrology techniques and strengthening the institutional capacity for the further integration of isotope hydrology in the water sector. In Africa, two regional training courses held in Ethiopia and Senegal were attended by 42 participants. In addition, 20 practicing hydrologists attended an advanced regional training course organized by the Agency at Argonne National Laboratory, USA, on the application of isotopic methodologies for groundwater age dating in support of national projects. The participants acquired interpretation skills for isotopic data as inputs to their hydrological models to determine areas and timescales of recharge in aquifers.

16. The International Symposium on Quality Assurance for Analytical Methods in Isotope Hydrology was held in Vienna 25–27 August 2004 with 74 participants from 34 countries and 4 international organizations. This was the first symposium to focus on state-of-the-art analytical techniques in isotope hydrology, and it concluded that a need existed to expand efforts to assure data quality by promoting the establishment of laboratory quality systems. The Agency's role in providing international standards for isotope measurements was considered central to the task and it was emphasized that dissemination of information on the state-of-the-art procedures and techniques should be increased.

17. The Agency organized nearly 40 group training activities, such as training courses, workshops and seminars for developing Member States worldwide. This responded to the continuing demand to build and develop human resources in the field of isotope hydrology. Under the JIIHP, a regional training course on isotope hydrogeology was held in Panama in October 2003.

18. A CD-ROM entitled “Isotope Hydrology — Learning, Teaching and Applying Isotope Techniques in Hydrology” was made available to institutions and universities in Member States. The Spanish version of a joint IAEA/UNESCO series of textbooks, *Environmental Isotopes in the Hydrological Cycle*, was published and a French version is in preparation, providing a wider range of hydrology professionals with access to information on isotope hydrology.

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

## **A. Background**

1. At its forty-seventh session in September 2003, the General Conference, through resolution GC(47)/RES/10.E underlined the urgent need for regional and international cooperation in helping to solve the serious problem of potable water shortages, particularly through desalination of seawater, and noted the interest of a number of Member States in activities related to seawater desalination using nuclear energy. It further requested the Director General to report on progress made in implementing this resolution to the Board of Governors and to the General Conference at its forty-ninth session. This document provides an overview of activities concerning nuclear seawater desalination and small and medium-sized reactors (SMRs) undertaken by the Secretariat between August 2003 and June 2005.

## **B. Nuclear Seawater Desalination**

2. Since the completion of the Agency's Options Identification Programme for Demonstration of Nuclear Desalination in 1996 and the international symposium on nuclear desalination of seawater in 1997, many Member States have taken steps to evaluate, plan, or in some cases, initiate nuclear desalination projects. In order to facilitate these activities, the focus of the Agency's programmes on nuclear desalination has gradually shifted from generic studies to specific needs-oriented programmes in the form of coordinated research projects (CRPs) and technical cooperation (TC) projects.

3. Agency activities in the field of nuclear desalination were reviewed by an External Evaluation Panel in May 2004. The Panel's report in June 2004 commended the nuclear desalination programme's various activities and publications, including CRPs and the development and application of the Desalination Economic Evaluation Program (DEEP). It recommended that the Agency disseminate the outputs of the nuclear desalination programme more proactively and increase the attention given to collateral issues relevant to public concerns about its practical implementation. A follow-up action plan on the recommendations of the Panel has been submitted to the Agency's Office of Internal Oversight Services (OIOS).

### **B.1. International Nuclear Desalination Advisory Group**

4. The International Nuclear Desalination Advisory Group (INDAG) held its seventh meeting in July 2004. INDAG members exchanged information on the progress of national and interregional

activities in nuclear desalination and reviewed the progress of the Agency's work, as well as activities planned for 2006–2007. INDAG also discussed how the Agency could contribute to facilitating nuclear desalination activities in Member States. The third and fourth issues of INDAG's newsletter were published in September 2003 and September 2004, respectively. [www.iaea.org/nucleardesalination].

## **B.2. Activities of Member States**

5. Among the national activities reported at the INDAG meeting are the following: Argentina continues its active participation in the Agency's two ongoing CRPs related to nuclear desalination. A related initiative on safety aspects of nuclear desalination addresses practical improvements and implementation, and shares advances around the world through technical exchanges. Canada is evaluating the extension of its advanced reverse osmosis (RO) seawater desalination technology to the clean-up of salt-contaminated wastewater produced as a result of environmental remediation activities. In China, a test system is being set up in the Institute of Nuclear and New Energy Technology for validating the thermal-hydraulic parameters of a multi-effect distillation process. In Egypt, construction of the pre-heat RO test facility has been slowed by delays in selecting the contractor. Construction is now scheduled to be completed this year. France is coordinating the preparation of a follow-up project to the EURODESAL project for work under the International Cooperation with Mediterranean countries (INCO/MED) of the 6<sup>th</sup> Framework Programme of the European Commission. India is proceeding with the full commissioning of the nuclear desalination demonstration plant at Kalpakkam, which is now due to be completed in early 2006. In 2004 India commissioned a low temperature evaporation plant at the CIRUS heavy water research reactor at Trombay utilizing its moderator waste heat for producing high quality water from seawater. Israel continues to regularly provide technical and economic information on low cost desalination technologies and their application to large-scale desalination plants. Japan continues with its operation of nuclear desalination facilities co-located inside many nuclear power plants. The Republic of Korea is in the verification phase, including separate effect tests and comprehensive integral tests, of constructing a pilot System-Integrated Modular Advanced Reactor (SMART). The pilot plant is scheduled to go into operation by 2008. Libya is continuing its consideration of nuclear desalination, and is currently focusing on capacity building activities and a cost optimization study of nuclear desalination. Morocco continues the process of establishing an adequate legal and institutional legislative and regulatory nuclear framework, while staying abreast of technical developments in general and nuclear desalination. Pakistan has completed the design and begun construction on coupling a desalination plant with the existing pressurized heavy water reactor (PHWR) at Karachi nuclear power plant (KANUPP) for demonstration purposes. The Russian Federation continues its R&D activities in the use of small reactors for nuclear desalination, and has invited partners to participate in an international nuclear desalination project based on a nuclear floating power unit equipped with two KLT-40S 150 MW(th) pressurized water reactors (PWRs). The United States of America continues its assessments of advanced desalination and power plant combinations for sustainable development, and is launching a new project to examine the technical economic and socio-economic feasibility of a nuclear energy/water cogeneration plant along the Texas coast for supplying energy, water and hydrogen.

## **B.3. Activities of the Agency**

6. The CRP entitled "Optimization of the Coupling of Nuclear Reactors and Desalination Systems" ended in December 2003. It analysed the details of optimizing the safe and economic coupling of various reactors and desalination systems based on thermal, membrane and hybrid processes. The results of the CRP were published as an IAEA Technical Document (IAEA-TECDOC-1444).

7. The second and the third Research Coordination Meetings (RCM) of the CRP entitled “Economic Research on, and Assessment of, Selected Nuclear Desalination Projects and Case Studies” were held in October 2003 and May 2005, respectively. The objectives of the CRP are to evaluate economic aspects and to investigate the competitiveness of nuclear desalination under specific conditions, identify innovative techniques leading to further cost reductions, and refine economic assessment methods and tools.
8. The aforementioned RCMs recommended specific upgrades to the DEEP software. In this connection the Agency solicited expert recommendations on improvements to DEEP version 2.1. These improvements are being implemented in version 3.0, which is scheduled for release in September 2005.
9. The TC interregional project entitled “Integrated Nuclear Power and Desalination System Design”, which had begun in 1999, was completed in 2004 with the successful finalization of projects in Indonesia, Pakistan and Tunisia. The Indonesian project was reviewed in the third and final project review meeting in February 2004. An interregional workshop on the techno-economic aspects of nuclear desalination was held in September 2004 at the National Nuclear Energy Agency (BATAN), Jakarta, Indonesia. National counterparts in Indonesia and the Republic of Korea completed the report *Preliminary economic feasibility of nuclear desalination in Madura Island* and a *User requirement document*. These reports were reviewed and are now ready for submission to the Government of Indonesia.
10. In response to a request by the Pakistan Atomic Energy Commission in 2001, three Agency missions have been carried out in 2002, 2003 and 2005 to facilitate project planning of the nuclear desalination demonstration plant under an interregional TC project. The conceptual design has been put in place, and construction of the plant is expected to be completed by the end of 2006.
11. The final draft of the pre-feasibility report entitled *Nuclear power and desalination plant at La Skhira, Tunisia*, prepared jointly by the National Centre for Nuclear Science and Technology (CNSTN), Tunisia, and the Atomic Energy Commission (CEA), France, was reviewed and approved under the Tunisian TC project TUNDESAL.
12. A review meeting for the Egyptian TC project “Simulation of Nuclear Desalination Plant” was held in September 2004 to discuss progress. The software being developed by the project is expected to be ready in September 2005.
13. A technical meeting on integrated nuclear desalination systems was convened in Chennai, India, in December 2004, and a visit was arranged to the Indian nuclear desalination demonstration project at Madras Atomic Power Station (MAPS), Kalpakkam, to share experiences on existing and planned seawater desalination demonstration projects.
14. Integration of a database for non-electrical application systems, including desalination, into PRIS was completed in 2003, and subsequent data collection has been done through the new web-based PRIS data acquisition system. A technical meeting on the PRIS database and its products was held in October 2004. The Technical Reports Series publication TRS-428 entitled *The Power Reactor Information System (PRIS) and its Extension to Non-Electrical Applications, Decommissioning and Delayed Project Information* was published in May 2005.
15. In terms of outreach, the Agency website ([www.iaea.org/nucleardesalination](http://www.iaea.org/nucleardesalination)) for nuclear desalination continues to provide access to up-to-date information on the status of nuclear seawater desalination technology and the Agency’s ongoing and future activities, and to the latest TECDOCs. The Agency will hold a session on “New Energy — Nuclear” at the International Desalination Association (IDA) World Congress on Desalination and Water Reuse to be held in Singapore from 11



to 16 September 2005. The Agency is also cooperating with the Water Sciences and Technology Association (WSTA) to organize the 7<sup>th</sup> Gulf Water Conference being held in Kuwait from 19 to 23 November 2005. An international symposium on non-electrical applications of nuclear power: seawater desalination, hydrogen production and other industrial applications is planned for 2007.

#### **B.4. Interaction with other Organizations**

16. Interactions between the Agency and other international organizations active in nuclear seawater desalination include the following.

- The Agency provided inputs to the World Health Organization (WHO) initiative to issue guidelines for drinking water quality from desalination plants. The *Guidelines for Drinking-water Quality: Third Edition Vol. 1 — Recommendations*, were published by the World Health Organization in 2004.
- The Agency regularly provides information and updates on nuclear desalination activities to the OECD Nuclear Energy Agency (OECD/NEA). OECD/NEA most recently participated in the INDAG meeting in July 2004.
- Agency participants presented papers at the European Desalination Society (EDS) Conference Euromed-2004, Marrakech, Morocco, May–June 2004, and at the Middle East Desalination Research Centre (MEDRC) Conference at Limassol, Cyprus, December 2004.

### **C. Small and Medium-Sized Reactors**

17. Small and medium-sized reactors (SMRs) are of interest for desalination in many developing Member States, where they are better suited to smaller electrical demands and transmission system capacities, as well as to limited investment opportunities. More than 50 concepts and designs of innovative SMRs are under development in more than 15 Member States representing both industrialized and developing countries. SMRs are under development for all principle reactor lines, and many of them provide for a co-generation option with flexible or multiple non-electrical applications, including nuclear desalination. Reflecting on these developments, the Agency conducts a number of dedicated activities for SMRs, which are described in more detail in the report on innovative nuclear technology development (see Annex 4, paragraphs 19-22).

18. Many concepts and designs of small reactors have been developed worldwide, of which several may be commercially deployed within the next 5–7 years. A floating NPP with KLT-40S small pressurized water reactors is licensed in the Russian Federation; the South African gas-cooled pebble bed modular reactor (PBMR) is not licensed but preparatory works at the site have been started, and the detailed design of the Korean SMART is near completion. All projects mentioned above provide for a nuclear desalination option.

19. For 2006–2007, a dedicated project on common technologies and issues for SMRs is being proposed, including a new CRP on identification of competitive technological options for SMRs. These activities will be performed in close cooperation with the Agency's subprogramme A.5 on non-electric applications of nuclear power.

## **D. Extrabudgetary Contribution**

20. Activities relating to nuclear desalination and the development of SMRs are to a large extent financed from the Regular Budget. Since the forty-seventh session of the General Conference in 2003, the Agency has received extrabudgetary resources from the Pakistan Atomic Energy Commission, totalling \$5000.

## **E. Publications**

21. Publications issued by the Agency since the report to the General Conference in 2003 include:

- Considerations in the development of safety requirements for innovative reactors: Application to modular high temperature gas cooled reactors, IAEA-TECDOC-1366, Vienna (2003);
- Optimization of the coupling of nuclear reactors and desalination systems, IAEA-TECDOC-1444, Vienna (2005);
- The IAEA Power reactor information system- PRIS and its extension to non-electrical applications, decommissioning and delayed projects information, IAEA-TRS-428, Vienna (2005);
- Innovative small and medium sized reactors: Design features, safety approaches and R&D trends, IAEA TECDOC-1451, Vienna (2005).

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

## **A. Background**

1. At its forty-eighth session in September 2004, the General Conference, through resolution GC(48)/RES/13.B, appreciated the continued support of the Agency to Member States in their efforts to build capacity for applying the sterile insect technique (SIT) in creating tsetse-free zones in Africa, and called upon Member States to continue to provide technical, financial and material support to African States in their efforts to create tsetse-free zones. It requested the Secretariat, in cooperation with Member States and international organizations, to continue to support research and development and technology transfer to African Member States in order to complement their efforts to create and subsequently expand tsetse-free zones within available resources, and stressed the need for continued cooperation with the Commission of the African Union and other regional and international partners with the aim of harmonizing efforts in line with the AU-PATTEC Plan of Action. It further requested the Director General to report on the progress made in the implementation of resolution GC(48)/RES/13.B to the Board of Governors and to the General Conference at its forty-ninth (2005) session.

## **B. Developments since the General Conference's 2004 session**

2. As a result of the impetus created by the African Union's Pan African Tsetse and Trypanosomosis Eradication Campaign (AU-PATTEC), Member States in Africa and their international partners have renewed their efforts to address the problem of the tsetse fly and trypanosomosis. Aware of the special significance of tsetse control and eradication and its potential to improve the quality of life for people in areas infested by the fly, the Agency continued its support of this goal through its Regular Budget and the technical cooperation programme.

3. In 2004, the Agency has re-assessed its role with the assistance of internal and external audits in supporting national and regional goals to create tsetse free zones by contributing, where feasible, the SIT component to area-wide campaigns against the tsetse fly. One major finding was that the creation of tsetse-free zones by implementing SIT in an area-wide integrated pest management (IPM) strategy (AW-IPM) is a long-term undertaking, requiring major financial investment and concerted action by Member States and partners over many years, including the policy, institutional and technological interventions, as well as substantial necessary human resources. The conclusions and management

guidance for future tsetse interventions that resulted from this review were presented to Member States in a briefing session “The Way Forward” in Vienna in March 2004.

4. The Agency contributes directly to the PATTEC Plan of Action through the implementation of one regional, and nine national technical cooperation (TC) projects in Botswana, Burkina Faso, Ethiopia, Kenya, Mali, Senegal, South Africa, Uganda and the United Republic of Tanzania. The support was largely through provision of training to Member State personnel, expert services and equipment. Assistance has been provided to supply semi-automated feeding units for validation under operational conditions; to construct and improve tsetse-rearing facilities in Burkina Faso, Ethiopia and the United Republic of Tanzania; to assess the efficiency of the watersheds between adjacent river basins as barriers in Mali using release-recapture studies; to develop and validate standardized recording, reporting and management system for field operations; to collect entomological and veterinary baseline data in target areas; to carry out genetic studies of tsetse fly populations; to establish a DNA extraction laboratory in West Africa; and to develop tsetse prediction and land-use / land-cover maps. Through the above support and in the context objectives of the PATTEC initiative, the capacity of Member States in SIT-relevant aspects of tsetse rearing and field activities has been enhanced in several countries.

5. The Agency continued fostering partnerships for PATTEC through its representation to the PATTEC Policy and Mobilization Committee alongside other mandated United Nations organizations (FAO and WHO) and stakeholders such as the Programme Against African Trypanosomosis (PAAT).

6. The Agency continued to assist Ethiopia under the Southern Rift Valley Tsetse Eradication Project (STEP), which is being supported under project ETH/5/012, “Integrating Sterile Insect Technique for Tsetse Eradication”. Significant efforts have been made by the national counterparts to complete the first two rearing modules of the Kaliti mass rearing and irradiation facility. The Agency procured automated tsetse production equipment. Field suppression activities using insecticides in anticipation of SIT operations cover at present an estimated 80% of the initial 10 500 km<sup>2</sup> target area in the Southern Rift Valley. The positive impact of the tsetse suppression effort on farmers has become apparent in terms of enhanced milk and meat production. STEP received a major boost when the African Development Bank approved a loan amounting to about \$15 million to address the tsetse and trypanosomosis issue in the context of agriculture and rural development.

7. Within the framework of regional project RAF/5/051, “Sterile Insect Technique for Area-Wide Tsetse and Trypanosomosis Management”, and under the auspices the African Union, a regional meeting on integrating the sterile insect technique in efforts to create tsetse free zones in Africa was organized by the Agency in Addis Ababa in November 2004 in cooperation with the Ethiopian and the US Governments. The outcomes of the meeting will contribute to improving further the management of Agency related activities in Member States. They will also provide a good basis for follow up actions by the countries embarking on creating tsetse free zones, supported by the AU-PATTEC, in their efforts to plan and implement area-wide IPM programmes and to strengthen ties with their development partners (multilateral organizations and donors).

8. A proposal to the United Nations Fund for International Partnerships (UNFIP), entitled "Coordinated, Phased Programme for the Creation of Tsetse-Free Zones in Africa: A Prerequisite to Enhance Agricultural Development and to Control Human African Trypanosomosis", co-financed by the US Department of State was revised based on close interactions of the Agency with AU-PATTEC, Member States, FAO and WHO. Extrabudgetary funding of \$300 000 was secured from UNFIP to support mainly actions preparing for and holding donor meetings, with special emphasis on Ethiopia.

9. The Agency is organizing a workshop with AU-PATTEC and FAO to be held in eastern Africa in late 2005 or early 2006 on tsetse sampling for population genetic assessments, which is relevant for developing sub-regional and area-wide integrated intervention strategies. It is also organizing a training course in the same region in early 2006 on area-wide integrated intervention against the tsetse and trypanosomosis problem with emphasis on the SIT component and the principles of baseline data collection.

10. The Agency continued its research and development efforts through a coordinated research project and also through research at the FAO/IAEA Agriculture and Biotechnology Laboratory at Seibersdorf, Austria. An automated holding and feeding system for mass-reared tsetse flies was completed, and transferred to the field through a TC project, and automated sexing of tsetse pupae through near-infrared scanning was achieved.

11. The Agency developed two technical papers: Generic Design, Technical Guidelines and Optimal Location of Tsetse Fly Mass-Rearing Facilities and Procedures for Declaring Areas Free of Tsetse Flies and Tsetse-Transmitted Trypanosomosis. Also, draft manuals and guidelines on tsetse rearing, dosimetry and the collection of entomological baseline data, and a standardized database for the management of colony and field monitoring data were developed.

# Development of Innovative Nuclear Technology

## **A. Background**

1. In September 2004, in resolution GC(48)/RES/13.F, the General Conference, conscious of the need for sustainable development and of the potential contribution of nuclear energy to meeting the growing energy needs in the 21<sup>st</sup> century, invited all interested Member States to combine their efforts under the aegis of the Agency in considering the issues of nuclear reactors and fuel cycles, in particular by examining innovative, safe, proliferation-resistant and economically competitive nuclear technology.
2. The General Conference requested the Director General to report on the progress made in the implementation of this resolution to the Board of Governors and to the General Conference at its forty-ninth session.

## **B. Developments since the General Conference's 2004 Session**

### **B.1. International Project on Innovative Nuclear Reactors and Fuel Cycles (INPRO)**

3. The International Project on Innovative Nuclear Reactors and Fuel Cycles (INPRO) is an Agency-wide project, coordinated by the Department of Nuclear Energy with contributions from all relevant Agency Departments and Divisions. INPRO is implemented using mostly extrabudgetary resources offered by INPRO members. Since 2004, the project has been partly implemented with Regular Budget funds to support one Professional and two General Service posts.
4. Phase-1B of INPRO was started in July 2003 and, as it was decided by the seventh meeting of the INPRO Steering Committee on 2-3 December 2004, will now last until the middle of 2006. It includes the validation and improvement of the INPRO methodology through case studies performed by Member States and selected individual experts, preparation of a user manual on the INPRO methodology to assist users in assessing innovative nuclear energy systems (INSSs); assessments of INSSs by INPRO members through application of the updated methodology; analyses of the role and structure of INSSs to meet national, regional and global energy demands in a sustainable manner; and selection of the most suitable areas for collaborative research and development (R&D).
5. The INPRO methodology was validated on the basis of results from the case studies. The updated methodology was presented to the seventh meeting of the INPRO Steering Committee and was published in December 2004 as an IAEA Technical Document (IAEA-TECDOC-1434),

*Methodology for the assessment of innovative nuclear reactors and fuel cycles.* Preparatory work for the user manual has started and a first draft will be available by the end of 2006.

6. At its seventh meeting in December 2004 the INPRO Steering Committee approved the terms of reference for the second part of Phase-IB, which started in January 2005, and for Phase-2 with the understanding that changes may be needed depending on findings within the second part of Phase-1B. Major elements of the second part of Phase-IB include the finalization of the user manual, defining and modelling of INS deployment scenarios; and the facilitation of INS assessments by Member States. The identification of possible frameworks and implementation options for collaborative R&D for INS development is also part of this phase. The terms of reference for Phase-2 foresee that INPRO will continue in three directions: R&D, institutional/infrastructure, and methodology oriented activities.

7. Several INPRO members have started assessments of INSs on a national or international basis. These studies are also expected to identify INSs for further development, and will provide important feedback on the INPRO methodology.

8. As of July 2005, the following 23 Member States and international organizations were INPRO members: Argentina, Armenia, Brazil, Bulgaria, Canada, Chile, China, Czech Republic, France, Germany, India, Indonesia, Republic of Korea, Morocco, Netherlands, Pakistan, Russian Federation, South Africa, Spain, Switzerland, Turkey, Ukraine and the European Commission. Japan participates in INPRO as an observer. In total, 28 cost-free experts have been nominated by INPRO members and have worked at the Agency as members of the INPRO International Coordinating Group. A periodically updated homepage for INPRO has been established at <http://www.iaea.org/OurWork/ST/NE/NENP/NPTDS/Projects/INPRO/index.html>.

9. The Agency pursues increased cooperation with other international efforts targeted at innovative technology development, such as the Generation IV International Forum (GIF). In September 2004, a meeting took place between the INPRO and GIF secretariats, during which topics of joint interest were identified. Options for cooperation will be discussed during a follow-up meeting in September 2005.

## **B.2. Nuclear Power, Fuel Cycle and Nuclear Science**

10. Through Major Programme 1, Nuclear Power, Fuel Cycle and Nuclear Science, the Agency is assisting the innovative nuclear technology research and development efforts of interested Member States through scientific and technical information exchange and collaborative R&D. New generations of nuclear power plants are being developed, building on the background of nuclear power's success and applying lessons learned from the experience of operating plants. Advanced designs comprise evolutionary and innovative approaches, and evolutionary designs may include innovative features, such as enhanced safety (e.g. passive features) and means to achieve improved economics. Advanced nuclear reactor designs presently under development include water cooled reactors (both light water reactors (LWRs), and heavy water reactors (HWRs)), gas cooled reactors, fast reactors, and various transmutation and actinide utilization reactors, both critical and subcritical. An important new approach incorporated into several advanced LWR and HWR designs involves the utilization of simplified systems. This approach promises to provide improved economics and a very high level of safety through reduced design complexity and reduced demand of human interventions.

11. A CRP on natural circulation phenomena was started in 2004. The scope includes natural circulation to remove core power under normal operation (startup, nominal and shutdown) and accident conditions, and to provide cooling of the containment. Building on the shared expertise of the participants of the CRP, a TECDOC is in publication describing the present state of knowledge on natural circulation in water cooled NPPs and passive system reliability. It will serve to guide the

planning and conduct of the CRP thereby focusing activities on advancing the state of knowledge. Based on the results of the CRP, this document will be updated to produce a document on the state-of-the-art of natural circulation in water cooled NPPs.

12. Expertise from the CRP and material in the TECDOC which is in publication have been used in an intensive Agency educational course for scientists and engineers involved in the design, testing and analysis of natural circulation systems, held at the International Centre for Theoretical Physics (ICTP) in Trieste, Italy, in June 2004.

13. Another activity involves the preparation of an Internet database of thermo-physical properties of LWR and HWR materials, resulting from collaboration in a CRP on thermo-physical properties of LWR and HWR materials. A TECDOC is being prepared to present new measurements of thermo-physical properties as well as the data assessments conducted during the CRP. Use of accurate data for thermo-physical properties of materials in reactor design can remove the need to incorporate excessively large margins into new reactor designs simply for the purpose of allowing for uncertainties in data.

14. A new activity on innovative water cooled reactors, to be conducted on the advice from the previous meetings of the Technical Working Group on Advanced Technologies for Light Water Reactors and the Technical Working Group on Advanced Technologies for Heavy Water Reactors, is the CRP on heat transfer behaviour and thermal hydraulics code testing for supercritical water cooled reactors. Planning of this CRP is being coordinated with the OECD/NEA and the GIF supercritical water cooled reactor steering committee.

15. In the area of advanced fast reactors, a review of the current research and technology development status was performed at the annual meeting of the Technical Working Group on Fast Reactors (TWG-FR). A technical meeting, hosted by the Japan Nuclear Cycle Development Institute (JNC) in Tsuruga, Japan, provided a global forum for information exchange on the status of the MONJU reactor and its potential for international collaboration in fast reactor R&D. A number of concrete proposals for coordinated research projects were made (e.g. for natural circulation experiments), and the JNC agreed to promote such activities under the Agency's aegis to facilitate international fast reactor R&D collaboration. Within the framework of the Agency's fast reactor data retrieval and knowledge preservation initiative, document IAEA-TECDOC-1405 was published summarizing operational and decommissioning experience with fast reactors.

16. In the area of innovative fast neutron spectrum systems for actinide utilization and long-lived nuclide transmutation, studies of advanced technology options for effective incineration of radioactive waste continued in the framework of a CRP aimed at the comparative assessment of the dynamics of transmutation systems. A review of the current status of accelerator-driven systems (ADSs) for energy production and transmutation of long-lived nuclides was performed as part of the TWG-FR's annual meeting. The Agency is preparing an accelerator-driven systems application cross section library for which the specifications were defined at a technical meeting convened in Vienna on 17-17 December 2004. The Agency also prepared a Technical Reports Series document entitled *Implications of Partitioning and Transmutation in Radioactive Waste Management*. Partitioning and transmutation with multiple recycling of actinides and long lived fission products could reduce the radiotoxic inventory of waste by over two orders of magnitude. This would allow the confinement of the residual waste to reach levels equivalent to natural uranium within a few hundred years. The CRP on the research of process-losses associated with the partitioning and transmutation systems continued with the participation of nine Member States. Basic studies will compare the pyro-chemical dry partitioning process with the aqueous partitioning process. This CRP considers, among others, proliferation resistance, economics and minimization of environmental impact. The Agency continues collaborating with OECD/NEA in the field of partitioning and transmutation to complement each other's work. In



that respect, both organizations sponsor the Information Exchange Meeting on Partitioning and Transmutation, the eighth session of which was hosted by the University of Nevada, Las Vegas, USA, in November 2004.

17. In the innovative high temperature gas cooled reactor (HTGR) fuel area, work on the CRP on advances in HTGR fuel technology continued, resulting in the drafting of the outlines of the proposed TECDOCs. A workshop on safety demonstration and market potential of HTGRs was held in Beijing, China, in September 2004, and advanced design options were discussed. A safety demonstration test, involving an anticipated transient without scram, was also successfully conducted at the HTR-10 reactor, at the end of the workshop. In 2005, a consultancy meeting was held in Manchester, UK, which addressed qualification of graphite materials to be used in HTGR designs. Also planned for 2005 are two research coordination meetings (RCMs) on HTGR core analysis code benchmarks and advanced fuel technology.

18. In the area of nuclear desalination, the results from the CRP on optimization of the coupling of nuclear reactors and desalination systems were published as document IAEA-TECDOC-1444 in July 2005. Economic evaluations of site-specific cases involving various types of nuclear reactors and desalination systems utilizing many innovative features are being investigated within the framework of the Agency's CRP on economic research on, and assessment of, selected nuclear desalination projects and case studies. The third RCM was held in May 2005. The Agency's Desalination Economic Evaluation Program (DEEP) software has been upgraded following inputs received from users and a new version DEEP 3.0 is due for release in September 2005. A technical meeting on integrated nuclear desalination systems was held at Chennai, India, from 13 to 16 December 2004, dealing with several innovative features related to new designs of seawater intake, pre-treatment systems, use of reject heat and cost reduction strategies (see also Annex 2, paragraph 13).

19. In the area of common technologies and issues for small and medium sized reactors (SMRs) a report entitled *Innovative small and medium sized reactors: Design features, safety approaches and R&D trends* was published as document IAEA-TECDOC-1451 in May 2005. This TECDOC presents a variety of innovative water cooled, gas cooled, liquid metal cooled and non-conventional SMR designs developed worldwide and examines the technology and infrastructure development needs that are common to many concepts of such reactors.

20. One trend of design and technology development for SMRs includes small reactors without on-site refuelling, which are the reactors that can operate without reloading and shuffling of fuel for a reasonably long period, from 5 to 30 years and beyond. A CRP on small reactors without on-site refuelling has been started with 17 participants from 11 Member States. The objective of this CRP is to increase the capabilities in Member States to achieve progress in the development and deployment of such reactors by formulating major requirements and increasing international cooperation for the development of key enabling technologies, including long-life cores, inherent and passive safety features and systems, and design and regulatory provisions to reduce or eliminate off-site emergency planning.

21. A technical meeting on the definition of plant safety design options to cope with external events for advanced NPP projects was convened at the Agency from 15 to 19 November 2004 with the participation of 14 experts from 10 Member States. The objective of the meeting was to assist the designers of evolutionary and innovative NPPs in the definition of a consistent strategy regarding plant protection from extreme external events, and to support the preparation of a relevant report that will be published in 2005.

22. A technical meeting to review passive safety design options for SMRs was held from 13 to 17 June 2005 in Vienna. The objective of the meeting was to provide a forum for information exchange

on the state-of-the-art in the development and application of inherent and passive safety features and passive systems in SMRs.

23. Due to increasing interest in a future hydrogen economy and based on recommendations from the Standing Advisory Group on Nuclear Energy (SAGNE), a new project on nuclear hydrogen production has been defined and will be included, together with a project in support of demonstration of nuclear seawater desalination, in a subprogramme on support of non-electric applications of nuclear power, starting in 2006.