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Development of Innovative Nuclear Technology

Report by the Director General

Background

- In September 2003, in resolution GC(47)/RES/10.C, the General Conference noted the progress achieved in a number of Member States in the development of innovative nuclear technology, stressed the need for international collaboration in the development of innovative nuclear technology and the high potential and added value achieved through collaboration efforts, conscious of the potential contributions of nuclear energy to meeting the growing energy needs of the 21st century, and recognized the unique role that the Agency can play in international collaboration in the nuclear field.
- 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-eighth (2004) session.

Recommended Action

- It is recommended that the Board take note of this report and authorize the Director General to submit it to the General Conference at its forty-eighth regular session.

A. Developments since the General Conference's 2003 Session

A.1. International Project on Innovative Nuclear Reactors and Fuel Cycles (INPRO)

1. INPRO is an Agency-wide project, being coordinated by the Department of Nuclear Energy with contributions from all relevant Agency Departments and Divisions. INPRO is implemented using mostly extra-budgetary resources offered by INPRO Members. From 2004 INPRO is partly funded through the Regular Budget supporting one professional and one general service post.
2. Phase-IB of INPRO was started in July 2003 and is projected to last until the end of 2005. It includes the validation of the INPRO methodology for the assessment of innovative nuclear energy systems (INSs) through reviews by representatives from the nuclear industry and regulators and Case Studies performed by INPRO Members and selected individual experts. Phase IB also includes the preparation of a User's Manual on the INPRO methodology to assist in the assessment of INSs performance by INPRO Members through applying the validated methodology, identification of most suitable areas for joint R&D, and further development of analytical tools for the assessment of the potential of INSs for global, regional and national sustainable energy supply.
3. In the first part of INPRO Phase-IB, 14 Case Studies have been performed to validate the INPRO methodology by applying it to trial assessments of specific INSs. In June 2004 reports of all Case Studies were submitted to the Agency. Further activities will include incorporation of modifications into the INPRO methodology through a series of meetings with experts from INPRO Members as required, preparation of a draft Phase-IB report on the updated INPRO methodology, and submission of this report to the 7th meeting of the INPRO Steering Committee in December 2004.
4. The IAEA-TECDOC on "Innovative Fuel Cycle Technologies: Status and Trends" is under preparation. This document will summarize the status of innovative nuclear fuel cycles and associated nuclear reactor developments and will provide information for Member States on INSs for their assessment within the second part of INPRO Phase-IB. The IAEA-TECDOC will be submitted for publication by the end of 2004.
5. At its sixth meeting in January 2004 the Steering Committee of INPRO appreciated the amount of work done within national and individual Case Studies and recommended to form an ad-hoc group to amend the INPRO Terms of Reference and to draft the scope and schedule for INPRO Phase II. In line with this recommendation, the IAEA/INPRO Secretariat is preparing proposals for the Terms of Reference and Vision Statement for INPRO Phase-II, which will be submitted for consideration to the ad-hoc group and to the members of the INPRO Steering Committee.
6. As of July 2004, the following 20 Member States and International Organizations have become INPRO Members: Argentina, Brazil, Bulgaria, Canada, Chile, China, Czech Republic, France, Germany, India, Indonesia, the Republic of Korea, Pakistan, Russian Federation, South Africa, Spain, Switzerland, the Netherlands, Turkey and the European Commission. In total, 23 Cost Free Experts have been nominated by INPRO Members and have worked at the Agency as members of the INPRO International Co-ordinating Group.
7. Provisions have been made for increased future coordination between INPRO and the Agency's activities for developing a consensus safety approach for innovative reactors and exploring a safety-compliance check system for reactor designs. The expected outcome is a technology neutral approach to safety and licensing, which would be of benefit to many designs of innovative nuclear energy systems.

8. INPRO pursues increased cooperation with other international efforts targeted at innovative technology development, such as Generation-IV International Forum (GIF). INPRO Secretariat participates as observer in GIF Policy Group meetings and the GIF Secretariat participated as an observer in the last INPRO Steering Committee meeting. GIF performed a peer review of the INPRO assessment methodology and also participated in a meeting on proliferation resistance. Another area for planned cooperation is the establishment of indicators for sustainable development.

A.2. Nuclear Power, Fuel Cycle and Nuclear Science (MP 1)

9. The Agency's Major Programme 1 (MP 1), Nuclear Power, Fuel Cycle and Nuclear Science, is assisting the innovative nuclear technology research and development efforts of interested Member States through scientific and technical information exchange, collaborative assessments and collaborative R&D. New generations of nuclear power plants are being developed, building upon the background of nuclear power's success and applying lessons learned from the experience of operating plants. Advanced designs comprise evolutionary and innovative approaches. It is emphasised that the evolutionary designs may include innovative features, such as enhanced safety (e.g., passive systems) and means to achieve improved economics. Advanced nuclear reactor designs presently under development comprise 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 sub-critical.

10. With regard to technology advances to improve the economics and safety of water-cooled reactors, the Agency has established a Coordinated Research Project (CRP) on "Natural Circulation Phenomena, Modelling and Reliability of Passive Systems that Utilize Natural Circulation". This CRP will produce a TECDOC that summarizes the state-of-the-art in natural circulation computation and experimentation. A training course on natural circulation in water-cooled reactors was held in June 2004. Another activity involves the preparation of an Internet database of thermo-physical properties of materials of LWRs and HWRs. The TECDOC 1391 "Status of Advanced LWR Designs: 2004" was published in May 2004. This report presents design descriptions of 35 advanced LWR designs.

11. 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 frame of a CRP, aiming at the comparative assessment of the dynamic characteristics of transmutation systems. A review of the current status of accelerator-driven systems (ADS) for energy production and transmutation of long-lived nuclides was performed during various consultancy and technical meeting within the frame of the Technical Working Group for Fast Reactors (TWG-FR). Two IAEA-TECDOCs, 1356 "Emerging Nuclear Energy and Transmutation Systems: Core Physics and Engineering Aspects" and 1365 "Review of National Accelerator Driven Systems Programmes for Partitioning and Transmutation", were published in August 2003. Two topical technical meetings covering generic R&D issues in the field of ADS were organized, specifically on heavy liquid metal (HLM) thermal hydraulics and on fuel designs. The Agency prepared a Technical Report Series document on "Implications of Partitioning and Transmutation on Radioactive Waste Management". Partitioning and transmutation of waste may permit the considerable reduction of its toxicity and its impact on the environment. The Agency initiated a CRP with nine participating Member States on the research of process-efficiency associated with the partitioning and transmutation systems. Basic studies will compare the pyro-chemical dry partitioning process with the aqueous partitioning process. Among others, proliferation resistance, economics and minimization of environmental impact will be considered in this CRP. The Agency is collaborating with NEA/OECD in the field of partitioning and transmutation to complement each other's work. In that respect, for instance, both Organizations are sponsoring the Information Exchange Meeting on Partitioning and

Transmutation in November 2004. The Agency has also held a teaching and training Workshop on “ADS Technology and Applications” in October 2003.

12. In the area of innovative gas-cooled reactors, the IAEA-TECDOC 1382 was published in November 2003, documenting the first part of the results of the ongoing CRP on “Performance Evaluation of High-Temperature Gas-Cooled Reactors (HTGRs)” (CRP-5), which aims at reducing HTGR design calculation uncertainties. The report documents a first batch of code-to-code and code-to-experiment comparisons of results in the area of HTGR core physics and thermal hydraulics. A Technical Meeting on “Current Status and Future Prospects of Gas Cooled Reactor Fuels” (June 2004) discussed the role of coated particle fuel in fissile material disposition including plutonium incineration. Preparations for the workshop on “Safety Demonstration and Market Potential of High Temperature Gas-Cooled Reactors”, due to be held in September 2004 in Beijing, China, continued. The workshop is organized within the framework of the TC inter-regional project INT/4/141. The Agency is cooperating with the European High-Temperature Reactor Network on their HTR-2004 international conference, also to be held in China in September 2004 in sequence with the Agency’s Workshop.

13. Many developing countries have expressed an interest in Small and Medium Sized Reactors (SMRs) having electric power less than 700 MW. In June 2004, the Agency convened the technical meeting on “Innovative Small and Medium Sized Reactors: Design Features, Safety Approaches and R&D Trends”. The meeting addressed the state-of-the-art in technology development and design of innovative SMRs, their application potential and strategies for their deployment.

14. The Agency is reviewing alternative fuel cycles for advanced reactor systems and the thorium fuel cycle through a series of expert meetings. Alternative fuel types, such as metallic, dispersion and non-oxide fuel materials continue to be under development and attract interest. The Agency acts as an information exchange platform in this matter to ensure that results and experience from previous work remains available and that advanced fuels are explored for their potential use in new reactor systems. IAEA-TECDOC-1374 “Development Status of Metallic, Dispersion and Non-oxide Advanced and Alternative Fuels for Power and Research Reactors” published at the end of 2003, presents innovative Fast Reactor and LWR fuel design concepts.

15. Due to the current surge of interest in a future hydrogen economy and based on a recommendation from the Senior Advisory Group for Nuclear Energy (SAGNE), a new project on nuclear hydrogen has been defined and will be merged with nuclear desalination under one sub-programme on non-electric applications, starting in 2006.