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## PLAN FOR PRODUCING POTABLE WATER ECONOMICALLY

1. Resolution GC(44)/RES/22 requests 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-fifth regular 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 2000 and July 2001. Further relevant information on nuclear desalination can be found in the Nuclear Technology Review 2001.

### NUCLEAR SEAWATER DESALINATION

2. The prospects of using nuclear energy for seawater desalination on an industrial scale are promising since desalination is an energy intensive process that can utilize the heat and/or the electricity from a nuclear reactor. The Agency's “Options Identification Programme for Demonstration of Nuclear Desalination” (completed in 1996) and the international symposium on “Nuclear Desalination of Seawater” in 1997 gave momentum to many Member States to consider evaluating, planning, or in some cases, initiating nuclear desalination projects.

#### *International Desalination Advisory Group*

3. The International Nuclear Desalination Advisory Group (INDAG) held the first meeting of its second term in July 2001. INDAG members exchanged information on the progress of national activities in the field of nuclear desalination and reviewed the progress of the Agency's work, including activities planned for 2002–2003. INDAG also discussed how the Agency could contribute to facilitate nuclear desalination programmes in Member States.

4. Among the national activities flagged at the INDAG meeting were the following. Argentina has deferred its construction plan of a CAREM reactor at Atucha. In Canada a test rig was built to obtain experimental data for verifying performance improvements of reverse

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osmosis (RO) membranes as operating temperature and pressure are increased. The data are expected to validate the proposed concept of “RO preheats” for seawater desalination. China initiated a pre-feasibility study of a nuclear seawater desalination plant in Yantai area using an NHR-200 coupled with the vertical tube-MED process. The production capacity of the plant will be 160 000 m<sup>3</sup>/d. Egypt is about to complete its feasibility study of a nuclear co-generation plant (electricity and water) at El-Dabaa site under the Agency technical cooperation project. France is taking an initiative in promoting a joint European study on reactor development for nuclear desalination (the EURODESAL project). Civil and engineering work required for setting up a 6300 m<sup>3</sup>/d nuclear desalination demonstration plant at the PHWR station at Kalpakkam in India is proceeding and commissioning is foreseen to start early 2002. Basic design of the SMART concept continued in the Republic of Korea with expected completion in 2003. Pakistan is continuing its efforts for setting up a nuclear desalination demonstration plant of up to 4500 m<sup>3</sup>/d, to be connected to KANUPP. In the Russian Federation the floating power unit project development is coming to the end, and construction of a pilot plant at the shipyard in Severodvinsk, Arkhangelsk Region, is planned for 2005–2006. Tunisia is planning a pre-feasibility study of a co-generating nuclear desalination plant under the Agency’s interregional technical co-operation project with specific site conditions in the southeast area of the country.

#### *Current activities*

5. In October/November 2000 and April/May 2001 final progress review meetings were conducted in the framework of the Agency’s technical co-operation project in Egypt concerning a “Feasibility Study on a Nuclear Co-generation Plant (production of electricity and water) at El-Dabaa”. A new two-year technical co-operation project in Egypt on “Simulation of Nuclear Desalination Plant” started in 2001.

6. In November 2000 an Advisory Group Meeting (AGM) was held to prepare a technical document (TECDOC) entitled “Design Concepts of Nuclear Desalination Plants”. The document contains an overview of various design concepts which are being proposed, planned, implemented or evaluated in Member States.

7. Based on the recommendations of INDAG, a co-ordinated research programme (CRP) on “Optimization of the Coupling of Nuclear Reactors and Desalination Systems” has been extended from its original three years to five years. A consultancy meeting on “Analytical Modelling of Coupling Configurations of Nuclear Desalination Plants” was held in December 2000 to review and identify the future work plan of an input compilation tool for computer simulation programs which analyse the carry-over behaviour of radioactive substances.

8. In December 2000 the Board of Governors approved an interregional technical co-operation project on “Integrated Nuclear Power and Desalination System Design” for the 2001–2002 cycle. Following a mission in July 2000 to Indonesia under the Agency’s interregional technical co-operation project, the Protocol of the joint study on “Preliminary economic feasibility of nuclear desalination in Madura Island, Indonesia” has been prepared and will soon be exchanged between Indonesia and the Republic of Korea. Upon signature of the Protocol, assistance is due to start as part of the Agency’s technical co-operation programme. A mission was sent to Tunisia in April 2001 to identify needs for the pre-

feasibility study of a nuclear power and desalination plant development. Technical assistance from France is being arranged. Other requests for technical assistance have been received from the Islamic Republic of Iran and Pakistan and potential technology providers are being contacted.

9. In April and May 2001 two training workshops on nuclear desalination were held at the International Centre for Theoretical Physics, Trieste, Italy. The first workshop covered technologies that could be used for nuclear desalination, while the second dealt with economic aspects and comparative assessments. The purpose of the workshops was to train about 30 participants mainly from developing countries, in the use of the Agency's software, the Desalination Economic Evaluation Program (DEEP).

10. A TECDOC entitled "Market Potential for Non-electric Applications of Nuclear Energy" has been prepared. It focuses on the market potential and the economics of the nuclear option in district heating, supply of process heat, seawater desalination, ship propulsion, outer space applications, and on innovative areas such as fuel synthesis (including hydrogen production) and oil extraction. For seawater desalination, the document concludes that the growing number of facilities needed to meet global fresh water requirements will increase the attractiveness of nuclear desalination.

11. Work has progressed on safety related aspects in connection with seawater desalination using nuclear energy. A draft TECDOC on the safety aspects of nuclear desalination has been prepared and approved for publication.

12. It is expected that a large variety of proposed SMRs using different design approaches, technologies and safety features will be used, apart from electricity generation, for non-electrical applications such as desalination and district heating. This requires the siting of the reactors in the vicinity of populated zones, with additional implications on safety, licensing and acceptability. A general approach for the preparation of the design safety requirements for applications such as desalination using the Agency safety objectives and the strategy of defence in depth has been developed. A TECDOC on the implementation of the methodology to a modular high temperature gas cooled reactor will be issued by the end of 2001.

13. An Internet homepage for nuclear desalination is also in preparation. It comprises information on the technology of nuclear seawater desalination, past and current activities of the Agency and sample calculations with the Agency's software DEEP. In addition, announcements for planned meetings and activities will be included and updated regularly.

#### *Future activities*

14. The Secretariat received operating performance data in 1999 and/or 2000 of heat application systems from about 50 co-generating plants in Member States. These data will be integrated into the Agency's Power Reactor Information System (PRIS) database and will be released for test use in 2001 to selected PRIS users.

15. A new CRP on "Economic Research on, and Assessment of, Selected Nuclear Desalination Projects and Case Studies" will be initiated in late 2001. The objective is to contribute to enhancing the prospects for the demonstration of nuclear desalination and its

successful implementation in Member States. The CRP will: evaluate the economic aspects and investigate the competitiveness of nuclear desalination under specific conditions in case studies; identify innovative techniques leading to further cost reduction; and refine economic assessment methods and tools.

16. A symposium on “Nuclear Desalination: Challenges and Options” is being planned jointly with the World Council of Nuclear Workers (WONUC). The symposium is to be held in Marrakech, Morocco, in October 2002 and will highlight technology advances in nuclear desalination, economic and financing issues as well as the issue of water needs for sustainable development.

#### *Interaction with other organizations*

17. Interaction between the Agency and other international organizations in the field of nuclear seawater desalination included the following:

- The Agency provided input to the WHO initiative to issue Guidelines for Drinking Water Quality from desalination plants. Input was given regarding energy options for desalination, status of nuclear desalination worldwide, and the need for the new water quality guidelines to be applicable to nuclear desalination. It was agreed that the new guidelines should include explicit references to desalination with nuclear energy. Safe drinking water from nuclear desalination would then be covered by two sources of guidance: WHO on water quality and the Agency on technical installation safety.
- The Agency participated, upon invitation of the Middle East Desalination Research Centre (MERDC), in the Research Advisory Council meeting of the MEDRC in February 2001 and provided input and advice to the research projects to be funded by MEDRC.
- The Agency co-ordinated its activities with the newly established EURODESAL research project of the European Commission, led by the Commissariat à l'Énergie Atomique (CEA), France, and provided technical input and expertise to the kick-off meeting in February 2001 in France.
- The Agency's activities on nuclear desalination were reported in June 2001 to OECD/NEA at meetings of its two standing committees: the Nuclear Development Committee and the Nuclear Science Committee.

#### **SMALL AND MEDIUM SIZED REACTORS (SMRS)**

18. Small and medium sized reactors (SMRs) are of interest for desalination in many developing Member States because the thermal energy required to produce the fresh water is considerably less than the amount of heat produced by large reactors. Innovation is needed for small size reactors in particular to be economically competitive. The projected demand for desalination is mainly in developing countries where SMRs are better suited to smaller electrical demands and transmission system capacities.

#### *Current and future activities*

19. In November 2000 a TCM on “Gas Turbine Power Conversion Systems for Modular High Temperature Gas Cooled Reactors (HTGRs)” was held in Palo Alto, California, the results of which are reported in a TECDOC of the same name. The gas turbine modular HTGRs under development have favourable characteristics for supporting desalination in a co-generation mode.

20. In May 2001 an Agency seminar on “Status and Prospects for Small and Medium Sized Reactors (SMRs)” was held in Cairo, Egypt, in co-operation with OECD/NEA and World Nuclear Association. It was hosted by Nuclear Power Plants Authority of Egypt. The seminar was attended by designers, users and policy makers. The major topics discussed were: new and innovative SMR designs, challenges of SMR deployment, and incentives for introduction of these reactors, in particular in developing countries. Other issues included: economics and financing, fuel cycle, safeguards and safety, and different technologies including water cooled, gas cooled and liquid-metal cooled designs. Around thirty different innovative SMR conceptual designs were presented. Emphasis was given to design simplification and standardization, reduction of construction period, safety and reliability enhancement and proliferation resistance. Co-generation applications of SMRs such as nuclear seawater desalination and the necessary infrastructure development were considered.

21. In May 2001, a national training course on “Nuclear Fuel Cycle” was organized in Casablanca, Morocco, following the recommendations by an Agency expert mission in November 1999 to Morocco, and at the request of Moroccan National Electric Utility (ONE). The course was implemented under the technical co-operation project “Feasibility of Small and Medium Reactors for Electricity Production”. Lectures were provided on the subjects in the areas of nuclear fuel cycles and of spent fuel storage. A new technical co-operation project “Pre-Contract Activities for the First Nuclear Power Plant” was initiated in 2001. It is designed to increase the capabilities of ONE staff in implementing activities related to the acquisition of the first NPP in Morocco, covering topics such as preparing bid invitation specifications, evaluating bid documents, preparing evaluation reports and contracting. A national training course on the NPP acquisition process is planned for the second half of 2001.

22. A TECDOC has been prepared summarizing the conclusions and recommendations of a Technical Committee Meeting (TCM) on “Natural Circulation Data and Methods for Innovative Nuclear Power Plant Design” held in Vienna in July 2000. Natural circulation is an important phenomenon in innovative water cooled reactors that could support seawater desalination in a co-generation mode.

*International Project on Innovative Nuclear Reactors and Fuel Cycles (INPRO)*

23. Resolution GC(44)/RES/22 notes “the initiative of the Director General in establishing in 2001 a task force on innovative nuclear reactors and fuel cycles” and invites “Member States to consider contributing to its activities.” At a meeting of senior officials from 25 Member States and international organizations in November 2000, the objectives and conditions of an “International Project on Innovative Nuclear Reactors and Fuel Cycles (INPRO)” were discussed and the Terms of Reference for INPRO were finalized. A Steering

Committee was established to provide overall guidance, advise on planning and methods of work and review the results achieved.

24. In May 2001, the Steering Committee defined the organizational chart for INPRO and approved the structure and preparation of the report on “innovative nuclear reactors and fuel cycles” proposed by the International Co-ordinating Group (ICG), comprising cost free experts from participating Member States. ICG co-ordinates and implements the project on the basis of experts’ work in Member States. The project will be implemented in two phases. In the first phase, work will proceed in five subject areas recognised as important for the future development of nuclear energy technology. Upon successful completion of the first phase, taking into account advice from the Steering Committee, and with the approval of participating Member States, a second phase of INPRO may be initiated. Drawing on the results from the first phase, it will be directed to: examining the context of available technologies and the feasibility of commencing an international project; and identifying technologies which might be appropriate for implementation by Member States of such an international project.

25. In July 2001 a Topical Workshop on “Proliferation-Resistance in Innovative Reactors and Fuel Cycles” in connection with INPRO project was convened in Como, Italy, in co-operation with the Landau Network — Centro Volta. The meeting considered the proliferation resistance characteristics and technological features of innovative reactors and fuel cycles, including export control mechanisms and verification arrangements, that would provide credible assurance that such innovative reactors and fuels cycles and the associated nuclear materials remain committed to peaceful use. Findings and conclusions of the Como meeting provide a basis for the development of non-proliferation requirements for innovative reactors and fuel cycles within INPRO activities.

26. The study of “Innovative Nuclear Reactor Developments — Opportunities for International Co-operation”, which has been jointly conducted by OECD/IEA, OECD/NEA and the IAEA during the past three years, has been almost completed and the Study report will be published in late 2001 by IEA on behalf of the three participating agencies. This report is a first step in examining the scope for enhanced international co-operation in developing new nuclear fission reactor technologies. Its objectives are to highlight the ways in which new technologies are attempting to address the challenges facing nuclear power today, and to begin identifying potential areas for co-operation among technology developers. The report reviews specific reactor design proposals so as to identify how they are addressing the challenges facing nuclear power and to examine the underlying “enabling” technologies that might constitute fruitful areas for collaboration on research and development (R&D). The report will form an important input to the INPRO project.

## **FINANCIAL ASPECTS**

27. Since the General Conference in 2000, extrabudgetary funds have been received from the Arab Atomic Energy Agency (\$4000) for nuclear desalination and from Turkey (\$4000) for SMR activities. The USA has provided a cost free expert in the field of desalination technology. As of August 2001 funds have been received from the Russian Federation (\$670 000) and ten cost free experts have been made available from seven Member States and one international organization to support implementation of the INPRO project in 2001.

## **PUBLICATIONS**

28. Publications issued by the Agency since the report to the General Conference in 2000 include:

- Status of non-electric nuclear heat applications: technology and safety, IAEA-TECDOC-1184
- Desalination Economic Evaluation Program (DEEP) Version 2.0. A User's Manual: Computer Manual Series-No.14
- Examining the economics of seawater desalination using the DEEP code, IAEA-TECDOC-1186
- Introduction of nuclear desalination: a Guidebook, IAEA-Technical Report Series No.400
- Guidance for preparing user requirements documents for small and medium reactors and their application, IAEA-TECDOC-1167
- Small power and heat generation systems on the basis of propulsion and innovative reactor technologies, IAEA-TECDOC-1172
- Staffing requirements for future small & medium reactors (SMRs) based on the projections and experience of operation, IAEA-TECDOC-1193

## **RECOMMENDED ACTION BY THE BOARD**

29. 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-fifth regular session.