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(GC(44)/1)

## PLAN FOR PRODUCING POTABLE WATER ECONOMICALLY

### The Nuclear Desalination of Seawater and Small and Medium Sized Reactor Development

#### A. INTRODUCTION

1. Resolution GC(43)/RES/15 requests the Director General to report on the progress made in the implementation of the resolution to the Board of Governors and the General Conference at its forty-fourth session. This document provides an overview of actions concerning nuclear seawater desalination and Small and Medium Sized Reactors (SMRs) implemented by the Secretariat since the last General Conference in September 1999.

#### B. NUCLEAR DESALINATION OF SEAWATER

##### 2. International Nuclear Desalination Advisory Group (INDAG)

INDAG was established in 1997 as an advisory body to the Director General in the field of nuclear desalination. Its fourth meeting, the last in the current term, was held in April 2000. The highlights of the meeting of INDAG in respect of: (1) information exchange of national activities on nuclear desalination, in particular, demonstration project plans; (2) review of and advice on the Agency's programme status and future plans; and (3) assessment of INDAG fulfilment of its missions are, as follows:

##### 2.1. National activities on nuclear desalination related to demonstration project plans

Argentina identified the construction site for its CAREM project. Egypt continues its feasibility study of a nuclear co-generation plant (electricity and water) at El-Dabaa site (EGY/4/040). The study is scheduled to be completed by late 2000. France started nuclear desalination feasibility and economic studies as part of CEA's own innovation programme and as part of a proposed joint-European study (the EURODESAL PROJECT). India is setting up a 6,300 m<sup>3</sup>/d nuclear desalination demonstration plant at the PHWR station at Kalpakkam. The civil and electrical work has started. The commissioning is foreseen for early 2002. The Republic of Korea proceeded with its basic design phase of the SMART (System-integrated Modular Advanced Reactor) concept with expected completion in 2003. Morocco

is examining the plan for the follow-on step of its demonstration project at Tan-Tan after the completion of the pre-project study<sup>1</sup>. In Russia the design and licensing activities for a floating co-generation plant based on Nuclear Floating Power Unit (NFPU) with KLT-40C reactors are in progress. Decision to start construction is expected later this year. In Tunisia several studies were done to select the suitable desalination process including those using nuclear energy. Two sites in the southeast area of the country were identified for specific studies.

Activities on nuclear desalination in other countries are described in the INDAG report, which is available from the Secretariat.

## 2.2. Review of and advice on the Agency's programme status and future plans

INDAG supported all ongoing tasks for 2000 and proposed tasks for 2001 (GC(44)/6) to be approved by the General Conference. Recommendations on additional tasks for 2002 onward were made for consideration, which include: (1) Case study on applying the clean development mechanism (CDM) to nuclear desalination plants; (2) Preparation of an international symposium in 2002 on "Advances in Nuclear Desalination" (provisional title); and (3) Compilation of a status report on nuclear desalination activities in Member States.

## 2.3. Assessment of INDAG fulfilment of its missions

INDAG made its self-assessment through the evaluation of its activities, using a methodology very similar to the one applied for the Programme Performance Assessment System evaluations. The results are: (1) INDAG has demonstrated success in meeting its initial purpose. It has provided a forum for international exchange of information among experts from Member States and supplied advice, guidance and technical recommendations for the Agency's planned programme of work; (2) A number of Member States have active programmes in nuclear desalination and have approached the Agency for assistance and guidance in this technology that is still not yet commercially well-experienced. This interest remains high as indicated by the repeated General Conference resolutions as well as by the extent of extra-budgetary contributions from Member States; and (3) Due to the continual advances both in reactor technology and in the development of desalination systems, it is desirable that INDAG continue its function to provide a forum for advice and review on nuclear desalination activities. The complete Mission Report of the first term of INDAG is available from the Secretariat.

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<sup>1</sup> In June 2000 Morocco informed the Agency that the demonstration project had been stopped.

### 3. Current and Future Activities

3.1 The Interregional Technical Co-operation Project (INT/4/134) on "Integrated Nuclear Power and Desalination System Design" has continued to deepen specifications of needs by "Technology Seekers" and opportunities of "Technology Providers." Based on the recommendations of INDAG in June 1999, a questionnaire was sent in July 1999 to interested Member States in order to specify their needs and requirements for participating in and benefiting from the project. Evaluation of responses to the questionnaire has led the Secretariat to the conclusion of the necessity to consult bilaterally with Member States to specify needs by individual "Technology Seekers" with concrete Government endorsement. The Secretariat started consultations with several selected Member States in January 2000 requesting further identification of the needs of "Technology Seekers" and the opportunities which could be provided by "Technology Providers". In the process of specifying needs/opportunities, the Secretariat sent a mission to Tunisia in June 2000 and another mission to Indonesia in July 2000 for preparing specifications of the collaborative framework with prospective technical partner(s).

3.2 The second Research Co-ordination Meeting (RCM) of the Co-ordinated Research Project (CRP) on "Optimization of the Coupling of Nuclear Reactors and Desalination Systems" was held in February 2000 in Mumbai, India. Progress since the first RCM in 1998 was reported by Chief Scientific Investigators (CSIs) and next steps were defined with focus on strong interaction and co-operation among participating institutes. In order to enhance synergy, interactions in providing better feedback among participants were coordinated in the revised workplan. Extension of the CRP to five years was strongly recommended by all CSIs. Strong interest in this CRP was expressed by the participants of the International Working Group on Gas-Cooled Reactors (IWGGCR) in September 1999, especially those from France, the Netherlands, South Africa and USA.

3.3 The software "Desalination Economic Evaluation Programme" (DEEP), Version 2, was released on CD-ROM and distributed to 87 experts in 28 Member States. A user's Manual was compiled and approved for publication in the Agency's Computer Manual Series.

3.4 A detailed and comprehensive economic assessment of nuclear seawater desalination in comparison with fossil options was performed with DEEP and a technical document on "Examining the Economics of Seawater Desalination Using the DEEP Code" was compiled and submitted for publication.

3.5 Two workshops on desalination technology and for training on DEEP were held under the IAEA Technical Cooperation programme: one on desalination technologies in Indonesia in August 1999 and the second on DEEP in Tunisia - for the North African region - in October 1999. In total, 21 experts from 7 Member States were trained at these workshops.

3.6 Work has progressed on safety aspects of desalination using nuclear energy. A draft technical document on the safety aspects of nuclear desalination has been prepared and it will be submitted for publication after final editing. The report addresses the major aspects that could have an impact on safety, such as: coupling of the nuclear reactor with the desalination unit, transients, water quality and monitoring, siting and licensing. In addition, the report addresses the applicability of the IAEA Safety Standards to nuclear desalination plants and provides input for their interpretation and application. A consultants meeting held in Vienna

in December 1999 concluded that the draft technical document represents the completion of the work requested to the Agency with respect to the safety related aspects of nuclear desalination. The consultants recommended that the Agency carry out further work on safety related aspects when more detailed site and project specific information becomes available from Member States.

3.7. As regards security aspects of future nuclear reactors, including their application to nuclear desalination, consideration will be given to determining whether there are any unique security aspects for these future facilities, e.g. reactor features susceptible to sabotage or special threats that these facilities pose. If appropriate, additional guidance may need to be considered to supplement the relevant international conventions and agreements in effect for these nuclear facilities, as well as the Agency recommendations for physical protection of nuclear material and nuclear facilities, INFCIRC/225/Rev.4.

3.8 Under an ongoing Technical Co-operation project with Egypt on a feasibility study on a nuclear co-generation plant (electricity and water) at El-Dabaa (EGY/4/040), two comprehensive progress review meetings (in August 1999 and in May 2000) and one mission for safety review (in March 2000) were conducted.

3.9. Extension of the existing PRIS (Power Reactor Information System) database and associated software was successfully tested in its phase 1 at a consultancy meeting in November 1999. The extended version accommodates design characteristic data of heat application systems connected to some 60 nuclear power units. The database will be released to selected users, who provided data to the extended database, for on-line test use in 2000. The first dissemination of collected data will be planned in the form of an Agency technical document in 2000.

#### 4. Publications

Publications prepared by the Agency on nuclear desalination since the report to the General Conference in 1999 include the following:

- Status of Non-electric Nuclear Heat Applications: Technology and Safety, IAEA-TECDOC-(submitted to the publications committee)
- Desalination Economic Evaluation Program (DEEP) Version 2.0. A User's Manual : Computer Manual Series- (in printing)
- Examining the Economics of Seawater Desalination Using the DEEP Code, IAEA-TECDOC-(in preparation)
- Safety Aspects of Nuclear Plants Coupled with Seawater Desalination and/or Other Heat Utilization Units, IAEA-TECDOC-(in preparation)
- Introduction of Nuclear Desalination: a Guidebook, IAEA-Technical Report Series No.400 (in printing)

#### 5. Interaction with other Organizations

5.1. The Agency contributed to the 20<sup>th</sup> session of the Administrative Committee on Co-ordination (ACC) Sub-Committee on Water Resources in October 1999. As an outcome, collaboration with WHO and with the UN Water Supply and Sanitation Collaborative Council

(UN WSSCC) is now being explored. In March 2000 the Agency attended the World Water Forum and Ministerial Conference in the Hague and publicized the Agency activities on nuclear desalination.

5.2. The Agency submitted in December 1999 a research proposal to the Middle East Desalination Research Centre (MEDRC) in Oman that covers activities on nuclear desalination in those Member States of the Agency which are located in the Middle East and North African region.

5.3. Co-operation also continued with the Arab Atomic Energy Agency (AAEA). The Agency participated, upon invitation, in its technical group meetings in June 2000 for providing advice and expertise to discuss their plans for a demonstration programme in the region.

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

#### **6. Current and Future Activities**

6.1. Member States have continued to express a strong interest in the development of innovative reactors, in particular in the SMR size range, for electricity generation, heat-only applications, and cogeneration of electricity and heat. Much of the interest from developing Member States has been directed toward SMRs for use in nuclear seawater desalination. Several activities on SMRs and desalination are being undertaken together, including development of a technical document providing guidance to developing Member States on the preparation of "User Requirement Documents" for SMRs and nuclear desalination which was submitted to the publications committee. The document includes guidance on establishing design requirements for both SMRs and nuclear desalination. The final version has been submitted for publication and is expected to be published in late 2000.

6.2. Addressing the Member States needs for guidance in planning for the possible introduction of nuclear power plants in their electricity generating systems, work started on the development of a technical document on "Nuclear Power Programme Planning: An Integrated Approach", with a focus on SMRs. The document deals with all nuclear power programme planning activities that need to be carried out up to the decision to proceed with a project feasibility study. It is intended to serve as guidance for executives and managers in developing Member States, to assist top-level decision-makers. The document is being prepared for publication as a technical document.

6.3. In recent years the Agency has obtained educational simulators from organisations in Canada and the US. These simulators operate on a personal computer and simulate responses of a number of reactor types in the SMR size range during operating and accident conditions. Two workshops were held on simulation of advanced water-cooled reactors: namely a Workshop on Nuclear Data and Nuclear Reactors - Physics, Design and Safety, ICTP, Trieste, Italy, in April 2000 and another workshop, on the development and use of such simulators, in November 1999 in Vienna. Training has been given, and simulators have been distributed to more than 155 participants from 40 countries.

6.4. The Integral Reactor Evaluation Programme (IREP), which optimises the economics of small integrated PWRs, taking into account reactor physics, thermal/hydraulics and

engineering design, was recently developed by an IAEA contractor in Argentina. A Technical Co-operation supported North Africa Regional Technical Workshop on IREP was hosted by the Nuclear Power Plants Authority of Egypt (NPPA) in Cairo, 15-28 October 1999.

6.5. Operating experience from reactors used for propulsion of icebreakers and freight carriers was initially reviewed during an Advisory Group Meeting in 1998, with additional discussion at a consultancy held in October 1999. With some design modifications these small sized reactors would be available either for electricity supply or for non-electrical applications such as district heating and desalination, particularly for remote areas. The results of the AGM and consultancy have been documented in a TECDOC, which has been approved for publication.

6.6. The Agency was requested in 1999 by the South African Government to provide within its Technical Co-operation Programme an independent review of the technical and economic feasibility of the Pebble Bed Modular High Temperature Reactor (PBMR), including safety aspects. The first phase of this study was successfully completed and the report was sent to the South African Government in December 1999. It was followed by a safety review of the reactor project conducted in the first quarter of 2000 by the Department of Nuclear Safety, with the final report on the review expected to be issued later this year. The results of the first phase of the Agency study were factored in to a recent positive decision by the South African Government to proceed with development of the design.

6.7. A new Technical Co-operation project (MOR/4/013) on Feasibility of Small/Medium Reactors for Electricity Production in Morocco was initiated in 1998. The project is focused on updating the earlier Feasibility Study for the first nuclear power plant to be built in Morocco, conducted by the National Electricity Utility (ONE), with the assistance of the French company SOFRATOME and IAEA. The Expert Mission in November 1999 identified the necessary platform to be established prior to updating the Feasibility Study (FS) and recommended an outline of a five-year work plan and an approach to be followed by ONE in order to prepare updating of the existing FS. Following this approach, IAEA will review and comment on the reports to be produced by ONE when updating the FS. In addition it was suggested a training program under the supervision of IAEA for the ONE staff, other concerned institutions and industry.

6.8. The successful development and deployment of SMRs to address the range of Member States' needs will require application of innovative technologies to provide cost competitive options. An Advisory Group Meeting on Development of a Strategic Plan for an International R&D Project on Innovative Nuclear Fuel Cycles and Power Plants, held in October 1999 in Vienna, produced recommendations regarding Agency organisation and support, and identified nine candidate projects for consideration by the Agency and Member States. One of the recommendations was partially addressed by a Technical Committee Meeting on Natural Circulation Data and Methods for Innovative Nuclear Power Plant Design held in Vienna 18-21 July 2000. Additional extrabudgetary funding is being requested to begin to address two more of the recommended projects.

6.9. An International Seminar on SMRs is planned for May 2001 in Egypt in order to provide a forum for information exchange and discussion regarding challenges and solutions for deployment of SMRs. Advisory Group meetings were held in November 1999 and March

2000 to develop a draft program, venue and date along with a plan and schedule for preparatory activities.

## 7. Publications

Publications prepared by the Agency on SMRs since the report to the General Conference in 1999 include the following:

- User Requirements Document for Small and Medium Reactors and its Applications in Developing Countries: A Guide for their Preparation, IAEA-TECDOC- 1167 (in printing)
- Staffing Requirements for Future Small & Medium Reactors (SMRs) Based on the Projections and Experience of Operation, IAEA-TECDOC- (in preparation)
- Nuclear Power Programme Planning: An Integral Approach, IAEA-TECDOC- (in preparation)
- Small Power and Heat Generation Systems on the Basis of Propulsion and Innovative Reactor Technologies, IAEA-TECDOC- (in preparation)

## 8. Interaction with Other Organizations

The OECD/IEA, the OECD/NEA and the IAEA initiated a joint study on innovative nuclear reactor R&D in 1998. The objectives of the study are to describe characteristics/features of innovative nuclear fission reactor designs that will, or appear likely to, contribute to addressing issues facing nuclear energy, based upon information provided by research teams/designers; to describe ongoing R&D programmes on innovative nuclear reactor designs; and to identify the potential role of enhanced international co-operation in accomplishing the needed R&D. Future nuclear technology R&D needs will be identified and discussed in the context of decreasing public and private energy technology R&D budgets. Phase 1 of the study, covering some 10 innovative designs, is foreseen to be completed by the end of 2000; a final report will be published by IEA on behalf of all three Agencies.

OECD/NEA and the Uranium Institute have agreed to co-sponsor the SMR Seminar described in item 6.9 above.

## **D. FINANCIAL REQUIREMENTS**

9. In 1999-2000, the main activities on nuclear desalination are performed in Project A.2.06 and SMR activities in Project A.2.01. Supporting activities for nuclear desalination are planned in Sub-Programmes H2 and C1, and for SMRs in A1, C1, C3 and H2. In the Agency's Budget for 2000 (GC(43)/6), the funding for A2.01 and A2.06 has been increased compared with the approved 1999 budget by US\$34000 and US\$8000, respectively. However, for full implementation of all activities in projects A.2.06 and A.2.01, extra-budgetary resources are required and the Secretariat has sent letters to potential donor States asking for financial and technical support.

**E. RECOMMENDED ACTION BY THE BOARD**

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 forthcoming forty-fourth regular session.