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PLAN FOR PRODUCING POTABLE WATER ECONOMICALLY

1. In September of last year, in resolution GC(XXXIV)/RES/540, the General Conference requested the Director General: "to contact appropriate United Nations agencies and international and national organizations and institutions with a view to assessing all available information on the future need for potable water relevant to nuclear desalination;" "to assess in detail - within his competence and with the assistance of international and other organizations concerned and also making use of cost-free experts whenever possible - the costs of potable water production with various sizes of nuclear desalination plant at selected promising sites, with a comparison of the costs of desalination by nuclear and other means;" "to include nuclear desalination as one of the activities in future programmes of the Agency in the process of preparing the Agency's programme and budget;" and to present to the Conference at its thirty-fifth regular session "a report on progress in implementing the relevant recommendations contained in the Attachment to document GC(XXXIV)/928."

2. The Attachment to this document contains a report on progress made to date and on further actions planned.

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ATTACHMENT

PLAN FOR PRODUCING POTABLE WATER ECONOMICALLY

Progress report

Introduction

1. In response to resolution GC(XXXIV)/RES/540, the Secretariat contacted - inter alia - those United Nations agencies (FAO, UNEP, UNESCO and WMO) which have been engaged in a special programme of water resource assessment activities since the United Nations Water Conference held in Argentina in 1977; it suggested co-operation in the area of information exchange and received data about freshwater requirements and resources in different countries and regions. In addition, the World Bank was approached with a view to co-operation in the nuclear desalination area.

2. Subsequent to the adoption of resolution GC(XXXIV)/RES/540, Algeria, Egypt, the Libyan Arab Jamahiriya, Morocco and Tunisia submitted a request to the Agency for assistance in carrying out a feasiblity study on nuclear desalination for some selected sites in the North African region. The Secretariat decided to proceed simultaneously with the detailed cost assessment requested in the Conference resolution and the regional feasibility study requested by these five Member States (referred to in the remainder of this report as "the participating countries").

3. The work, which is being done in the Division of Nuclear Power, is being financed from the Regular Budget, from technical co-operation resources and from funds made available by the participating countries.[1/]

1/ One of the participating countries has made available US$ 100 000 and the services of a cost-free expert.

Activities

4. The initial activities undertaken as part of the detailed cost assessment consisted in reviewing and analysing the relevant information and data available within the Secretariat (mainly information and data resulting from earlier studies on nuclear desalination and on small and medium power reactors) and in obtaining (through questionnaires) complementary, up-to-date technical and economic data from potential suppliers of nuclear reactors suitable for coupling to desalination plants. Also, the Secretariat looked into the availability of desalination experts and of suitable nuclear reactors. These activities were followed by preliminary comparative economic evaluations carried out with the assistance of interested potential suppliers.

5. At the same time, an outline and a detailed action plan were developed for the regional feasibility study. In 1991, emphasis was placed on analysing the electricity and potable water demand and the available energy and water resources in the participating countries and on reviewing desalination processes and relevant experience. These activities were performed jointly with relevant institutions in the participating countries.

Available systems

6. Seawater desalination is an established technology, and various desalination processes are commercially available. Reverse osmosis (RO) and multi-effect distillation (MED) appear to be the most efficient processes, the RO process possibly having greater development potential. No new commercial desalination processes are expected to emerge during the next 10-20 years, and consequently these two processes (RO and MED) were chosen for further analysis.

7. The energy required for these processes can be supplied either by conventional sources or by nuclear reactors; there are no technical

impediments to the use of electricity or heat (or both electricity and heat) produced by a nuclear reactor.

8. The only reactor currently being used for seawater desalination is the BN-350 (a fast breeder) at Shevchenko, USSR, which has been in operation since 1973 . It is a dual-purpose plant (supplying electricity and heat) with an electrical output of up to 125 MW(e) and a thermal output feeding a desalination system capable of producing 100,000 m^3/day of potable water. All other desalination plants operating in the world are supplied by conventional energy sources.

9. It is considered that the power reactors commercially available today or likely to become commercially available in the short or medium term could accommodate practically any size of desalination plant in any of the typical situations that are encountered in practice: when an electric grid connection is available (grid concept), the power reactor could be integrated into the grid and optimized to satisfy the demand of the electricity supply system and of the desalination plant, thus benefiting from the size effect; when no electric grid connection is available (stand-alone concept), the reactor would be dedicated to the desalination plant. The reactor could be land-based or floating, and could be used primarily either for heat production (coupled with the MED process) or for electricity production (coupled with the RO process). When coupled with the MED process, the reactor would have to be located at the desalination site, where it would co-generate electricity and heat; when coupled with the RO process, it would not need to be near the desalination site.

10. With the grid concept, depending on the size of the electric grid and on the electricity demand of the desalination plant, medium or large nuclear reactors could be employed, either for the co-generation of electricity and heat or for electricity generation only; the optimum reactor size would be determined in the light of the combined demand of the electricity supply

system and the desalination plant. With the stand-alone concept (and/or when the electricity grid is very small), reactors in the lower power ranges would be suitable (information and data on such reactors were requested in particular).

11. A summary of the reactor systems on which information and data have been provided to the Secretariat is given in the Annex. According to the potential suppliers, some systems are available now and others would become available within the next decade.

Economic assessments

12. Economic assessments of medium and large power reactors (grid concept) can be performed with reasonable accuracy and confidence, as there is substantial information available - including information on such reactors operating in the co-generation mode. Although there are at present no medium or large power reactors providing energy (electricity or heat) to desalination plants, such reactors could readily do so without substantial design modifications.

13. For new designs of reactors, in particular in the lower power ranges, detailed comparative economic assessments are much more difficult to perform as there is less information available. Nevertheless, a preliminary evaluation of various cost studies indicates that nuclear desalination could be economically competitive. It is estimated that, for both the RO and the MED process, potable water costs (measured in US dollars per cubic meter) would be lower with larger desalination systems. With systems producing less than 50,000 m^3/day, the projected costs are in the range US$ 1.0-1.5/m^3; with systems producing 50,000-150,000 m^3/day, the projected costs are about US$ 1.0/m^3; with systems producing more than 150,000 m^3/day, the

projected costs are below US$ 1.0/m^3; and with very large systems, the projected costs may approach US$ 0.5/m^3. The costs, expressed in constant 1991 US dollars, include energy and electricity costs, capital charges and operating costs, but not distribution costs.

14. The economic competitiveness of nuclear desalination would depend to a large degree on the capacity of the nuclear reactor and the costs of fossil fuels. A preliminary assessment suggests that nuclear desalination would be competitive at many locations where the higher specific capital cost of nuclear power is more than offset by lower nuclear fuel cycle costs. Also, it is expected that nuclear fuel cycle costs will remain more stable than fossil fuel costs.

Regional feasibility study

15. Data on the demand for and supply of potable water and electricity have been collected in all the participating countries. A preliminary evaluation indicates: a current potable water deficit in North Africa of 3 million m^3/day, growing to about 9 million m^3/day around the turn of the century; and a need for additional electricity-generating capacity growing from 4.5 GW(e) in 1993 to about 16 GW(e) in the year 2000.

16. Data have also been collected on available resources, experience with seawater desalination and 11 possible desalination sites. Of the 11 desalination sites, five (one in each of the participating countries) are receiving particular attention; they represent a wide range of desalination capacities. Three sites representing roughly equal desalination capacities within that wide range are being studied for cross-checking purposes. In the case of the selected sites and plant sizes, evaluations will be made for different combinations of available nuclear reactors with desalination processes.

Further actions planned

17. It is expected that the activities being carried out in response to resolution GC(XXXIV)/RES/540 will be completed (and reported on) during 1992 and that the regional feasibility study will be completed in 1994 (a report on the first phase being prepared during 1992).

18. An advisory group meeting has been scheduled for 25-29 November 1991. The objective of the meeting is to review the progress made, to select a methodology for making economic and technical comparisons in the field of nuclear desalination, to define a programme for the final evaluation, to initiate further necessary studies and to bring together potential users (both the five participating countries and other interested Member States) and potential manufacturers.

NUCLEAR REACTOR SYSTEMS FOR DESALINATION
(Information provided to the IAEA Secretariat as of 15 August 1991)

COUNTRY	REACTOR	TYPE	POWER	MAIN APPLICATIONS
ARGENTINA	CAREM	PWR modular integrated	10–25 MW(e)	Electricity production
CANADA	CANDU-3	PHWR (pressure tube)	1439 MW(th) 450 MW(e)	Electricity/co-generation
CANADA	SES-10	LWR integrated pool type	10 MW(th)	Heat production
CHINA	HR-200	PWR integrated	200 MW(th)	Heat production
FRANCE	THERMOS	PWR integrated pool type	50-200 MW(th)	Heat production (possibility of small electricity production)
FRANCE	NP-300	PWR compact	950 MW(th) or 300 MW(e)	Electricity, co-generation or heat only
GERMANY	HTR	Modular HTR	8 x 200 MW(th) max.640 MW(e)	Electricity, co-generation or heat only
JAPAN	4 S-LMR	Modular sodium cooled	$\leq$125 MW(th) $\leq$50 MW(e)	Electricity production

Note: The designs are in different stages of development

COUNTRY	REACTOR	TYPE	POWER	MAIN APPLICATIONS
SWEDEN	BWR-90	BWR	2350 MW(th) 720 MW(e)	Electricity production
SWITZERLAND	TITLIS	PWR integrated pool type	50 MW(th)	Heat only (possibility of electricity production)
UK	SIR	PWR integrated pool type	1000 MW(th) 320 MW(e)	Electricity, co-generation or heat only
USA	AP-600	PWR	1933 MW(th) 600 MW(e)	Electricity production
USA	MHTGR	Modular HTR	4 x 450 MW(th) 692 MW(e)	Electricity, co-generation or heat only
USA	TRIGA TSP	PWR pool type	64 MW(th) and 10 MW(e)	Electricity, co-generation or heat only
USSR	AST-500	PWR integrated	500 MW(th)	Heat production (possibility of small electricity production)
USSR	APVS	PWR	80-170 MW(th)	Electricity, co-generation or heat only
USSR	ATEC-150	PWR	100 MW(th) and 169 MW(e)	Co-generation