International Atomic Energy Agency
GENERAL CONFERENCE

GC(39)/12
8 August 1995
GENERAL Distr.
Original: ENGLISH

Thirty-ninth regular session
Item 17 of the provisional agenda
(GC(39)/1)

PLAN FOR PRODUCING POTABLE WATER ECONOMICALLY

1. Last year the General Conference had before it document GC(XXXVIII)/8, which summarized the progress of various studies and other actions initiated by the Agency on the topic "Plan for producing potable water economically".

2. Following discussions based on information provided in document GC(XXXVIII)/8, the General Conference, in resolution GC(XXXVIII)/RES/7, noted the following two main conclusions of the studies initiated by the Agency: (i) "that the use of nuclear energy as an alternative option to the use of fossil fuelled plants for supplying energy for sea water desalination is technically feasible and in general economically competitive" and (ii) "that there is a need to establish a programme for identifying a practical set of options from which one or more demonstration facilities with well-defined objectives might be chosen".

3. Noting also the continuing interest of a number of Member States in activities relating to seawater desalination using nuclear energy and stressing the importance of adequate water supplies for mankind, the General Conference requested the Director General to continue consultations concerning those main conclusions and called upon Member States in a position to provide expert services and extrabudgetary resources in support of the activities relating to seawater desalination using nuclear energy to make such services and resources available.

4. Lastly, the General Conference decided to include in the agenda for its thirty-ninth regular session an item entitled "Plan for producing potable water economically" and requested the Director General to submit to the Conference at that session a report on progress made in response to resolution GC(XXXVIII)/RES/7. This document has been prepared in response to that request.

SEA WATER DESALINATION FEASIBILITY STUDIES

5. With regard to the main conclusion that nuclear desalination is technically feasible and in general economically competitive, the progress made is reported on in paragraphs 6-17 below.

North African feasibility study

6. The North African regional feasibility study has been completed. Publication of the report is awaiting final approval by the governments of the five participating countries.

7. For each of the five sites selected by the participating countries (one in each country), forecasts were made both of the future potable water demand and of the capacity of the electrical grid to which the site and the adjacent region would be connected. On the basis of the electrical grid capacity forecasts it was possible to determine the maximum allowable size of any electricity-only or dual-purpose (electricity plus heat) plant that could be considered for each site. The criterion usually applied in this connection is that, for grid stability, no single plant should have a capacity greater than 10-15% of the projected grid capacity. However, this criterion was not applied (except for setting upper limits) in the selection of suitable energy sources for the sites. Rather, the matrix of energy sources for each site was selected on the basis of more practical considerations such as the urgency of additional potable water supplies as compared to additional electricity supplies and ensuring that several energy source options were included in the study.

8. For each of the sites, the following three processes were compared: the reverse osmosis (RO) process, which is coupled electrically to the energy source; the multi-effect distillation (MED) process, which is coupled thermally to the energy source; and a hybrid RO/MED process. The selection of these processes permitted a reduction in the number of options to be compared and was consistent with the conclusions concerning the relative economics of desalination technologies drawn in the technical document IAEA-TECDOC-666, "Technical and economic evaluation of potable water production through desalination of seawater by using nuclear energy and other means", issued by the Agency in September 1992.

9. The economic evaluation, which, for this feasibility study, was based on costs provided by various vendors of nuclear energy sources rather than the generic costs quoted in IAEA-TECDOC-666, confirmed the conclusions regarding competitiveness drawn in that IAEA-TECDOC. For each of the five sites, ranging in potable water production requirements from 24 000 m^3/day to 720 000 m^3/day, a nuclear option can produce potable water at a cost similar to that of potable water produced by means of a fossil energy source. Although not all of the possible coupling options were considered for each site, the following results were obtained:

(i) The RO process coupled contiguously (i.e. on the same site) with the energy source - fossil or nuclear - yielded the lowest water cost. However, neither the possible risks associated with contiguous siting nor the additional expense associated with the transport of the water from the possibly more remote nuclear site were reflected in that cost.

(ii) The cost of water from MED plants was always higher than that of water from RO plants[1], and it became significantly higher if the energy source was a heat-only plant and not a dual-purpose one.

(iii) Hybrid RO/MED plants yielded water costs between those for RO and those for MED plants.

10. In line with the generic studies described in IAEA-TECDOC-666, specific water costs (expressed in 1994 US dollars per m^3 of water produced) increased as the water output requirements decreased, primarily because specific energy costs became higher. No attempt was made to seek an optimum coupling arrangement at each site in order to obtain the lowest water cost. Nevertheless, the following results were obtained:

(i) Water costs for RO plants coupled contiguously to nuclear energy sources ranged from about US \$0.7/m^3 for the largest plant (720 000 m^3/day) to about US \$0.9 /m^3 for the smallest (24 000 m^3/day).

(ii) Water costs were some US \$0.1-0.2 /m^3 higher for MED plants coupled to dual-purpose energy sources than for the RO plants, depending on the size of the plant and on the size of the dual-purpose energy source.

(iii) Both the nuclear and the fossil energy options for providing heat only for the lowest-output MED plant (24 000 m^3/day) yielded water costs of about US \$2.0 /m^3.

(iv) The stand-alone option for RO plants (i.e. separate siting of the energy source and the desalination process) yielded water costs US \$0.02-0.04/m^3 higher than those for contiguous siting. Hence, although contiguously sited RO plants yield lower water costs, the margin may not cover the additional risks and water transportation costs already identified.

11. Two sites were considered as possible sites for a large desalination plant which could serve the needs of adjacent regions in two different countries - a new site and one of the reference sites. Besides the economic benefit accruing from a large plant, the choice of either site would help to foster regional co-operation in the peaceful uses of nuclear energy - an important goal being pursued by the countries of North Africa. Common approaches, activities such as the development of joint regulatory infrastructures, the application of common safety criteria, rules, regulations and procedures, and joint local participation and manpower development would represent a major step in achieving this goal.

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[1] This is consistent with IAEA-TECDOC-666. It was specified for this study that the water quality should meet WHO standards. If European (EC) standards for water quality were required, however, for the RO process the specific energy consumption would be at least 10% higher - i.e. the EC water quality standards imply higher water costs. Since thermally processed desalinated water meets the EC standards, the relative ranking might be reversed if those standards were specified for the study.

Other studies and related activities

12. With regard to the feasibility study for Saudi Arabia, preparations are being made for the collection of the up-to-date data necessary for provision of the requested technical assistance and for planning the initial technical assistance phases.

13. The development of a computer code which enables site-specific technical optimization and economic evaluation has been completed, and the code is now available for use in the Saudi Arabian study and other possible studies. A training course on the operation of the code has been held for a group of North African experts. Work is under way on a more detailed computer code for allocating the costs of dual-purpose plants and determining their optimum coupling.

14. A small and medium reactor (SMR) status report containing up-to-date technical information on most of the SMRs being developed or designed or already commercially available has been completed and is undergoing final editing prior to publication. The North African feasibility study and previous studies have led to the conclusion that SMRs are of the most suitable size for the majority of nuclear desalination applications.

15. For small nuclear plants to be economically competitive with fossil plants in applications involving low outputs of electricity, district heat or - of specific interest here - desalted water, efforts must be made to reduce the capital and operating costs and thereby the specific costs per unit of output. Accordingly, a Technical Committee on "Small reactors with minimized staffing and/or remote monitoring" has discussed issues such as safety and reliability and ways of reducing capital and operating costs.

16. Given the desire for regional participation in the manufacture, construction and operation of nuclear desalination plants, an Advisory Group meeting on "Technical and economic development in seawater desalination by using nuclear energy: Emphasis on local participation" has been held, with the focus on nuclear desalination in North Africa and the Middle East. The meeting provided a forum for the participants (34 persons from 14 countries, representing both vendors and potential users) to discuss the prerequisites for local participation and the opportunities that might exist at different project phases.

17. It is widely considered that there is large potential worldwide for medium-capacity (50 000-100 000 m^3/day) fixed or transportable desalination plants and that such plants might be coupled to floating nuclear plants. In the light of this, a Technical Committee met recently to examine the question of "Floating nuclear plants for seawater desalination". Among the papers presented were a number by participants from the Russian Federation describing the experience gained with small desalination plants installed on nuclear-powered icebreakers and other surface vessels.

OPTIONS IDENTIFICATION PROGRAMME

18. With regard to the main conclusion that there is a need to establish a programme for identifying a practical set of options, the progress made is reported on in paragraphs 19-24 below.

19. A two-phase Options Identification Programme has been initiated with the help of Advisory Groups and consultants. The aim of the first phase - scheduled to be completed this year - is to evaluate data relevant to a demonstration programme. By the end of this phase the candidate combinations will have been narrowed down to those which have the greatest potential for yielding technical and economic data of general applicability. The second phase will be devoted to a detailed analysis of the most practical options for demonstration, and if sufficient funding is provided this phase will be completed in 1996, with a final report presented to the General Conference that year.

20. A world list of reactors has been reviewed and screened for potential availability in the short term (within the next five years) and the medium term (within the next 10-15 years), depending on the design and licensing status of each reactor concept. Also, the list has been screened for applicability to seawater desalination after analyses of the market demand for desalted water.

21. Consultants have studied the present and estimated the future market demand for desalted water, and their report points to the feasibility of large desalination plants with a capacity of 200 000-500 000 m^3/day and to the Islamic Republic of Iran, Saudi Arabia, the United Arab Emirates and water-short regions of the United States as the principal markets for such large facilities. They forecast that an annual average seawater desalination capacity of about 1.9 Mm^3/day will be installed during the five-year period 2011-2015, making a total of 9.5 Mm^3/day or more of new capacity for that period. They expect that during that period the four countries just mentioned will install new capacity of 6.3 Mm^3/day, representing about two thirds of the total new capacity installed. Also, they identified several countries which, in the same time period, will require plants capable of producing 80 000-100 000 m^3/day of desalted water. They expect that by the year 2015 the world's total installed desalination capacity will be greater than 35 Mm^3/day, which will still cover only about 70% of the projected demand for municipal desalted water at that time.

22. The market study revealed that the manufacturers of equipment for the various desalination technologies have developed their equipment on a modular basis, the maximum size of water production module for each technology being limited by considerations such as available pump capacities and transportability. Although some sizes may increase in the future, the design framework for typical modular desalination plants and typical nuclear power plants - with their coupling requirements - can be foreseen.

23. An examination of the reactor types which might be used in the near term for nuclear desalination projects indicates that any project involving a nuclear reactor and a contiguous desalination plant would be a candidate for further evaluation regarding practicability as a demonstration project.

24. During an Advisory Group meeting held in July 1995, several participants stated that demonstration projects were either under way or about to be initiated in their countries. It is envisaged that during the second phase of the Options Identification Programme the options identified in the first phase and also the projects described during the Advisory Group meeting will be the subject of more detailed evaluation.

CONSULTATIONS WITH MEMBER STATES ON FUTURE ACTIONS

25. The Secretariat has continued consultations concerning the main conclusions and called upon Member States in a position to provide expert services and extrabudgetary resources to make such services and resources available.

26. Pursuant to resolution GC(XXXVIII)/RES/7, the 21 Member States which had, during earlier contacts, displayed some interest in the Agency activities connected with nuclear desalination, including those Member States which had previously provided resources and/or expert services, were again contacted by the Secretariat. Two other Member States were also contacted, bringing the total to 23. Four responses had been received by 1 August 1995, with two countries offering the services of three experts.

27. As of 1 August 1995, the Agency has two cost-free experts, one partly cost-free expert and one junior Professional working in-house on the Options Identification Programme and the Saudi Arabian feasibility study.

28. Since last year, a contribution of CDN $20 000 has been received from Canada and one of US $150 000 (US $100 000 in respect of 1995 US $50 000 in respect of 1996) has been received from the Republic of Korea.[2] With these contributions, the extrabudgetary resources made available for the Agency's nuclear desalination activities now total about US $735 000.

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[2] The US $150 000 from the Republic of Korea has been designated specifically for the Options Identification Programme.