FRESH WATER WITH NUCLEAR POWER

The intensive nuclear desalination development programmes undertaken at heavy cost by some industrialized countries and the keen interest shown by developing states in their possible applications, lend special significance to the role of an international organisation. In order to keep its Member States abreast of the latest developments in this field the IAEA has participated in a series of studies and convened expert panels at regular intervals since March 1963.

In pursuing its task, the Agency faces a situation similar to that which prevailed in respect of nuclear power costs in the early 1950's - a climate of confidence in ultimate achievement and uncertainty on operational data. For there is as yet no nuclear desalination in operation, although there soon will be.

A plant is under construction in the Soviet Union near the Caspian Sea, and will generate 150 MW of electricity and produce 120 000 cubic metres of fresh water per day. This reactor is of the breeder type and will be completed by 1968/69.

A feasibility study has been carried out for a plant in California; the plant could be operating by 1970. It would have two light water reactors of 750 MW(e) net each and water production of 600 000 cubic metres per day.

Signing of the tripartite agreement between IAEA, Mexico and USA, for a joint nuclear desalination project. Dr. S. Eklund (Director General, IAEA), Mr. H. Margain (Mexican Ambassador to USA), Dr. G. Seaborg (Chairman, USAEC), President Johnson, and (signing), Mr. N.C. Flores (Mexican Nuclear Energy Commission). (Photo. United Press International)

Another detailed feasibility study has been completed for a joint USA-Israel project, and the plant could be in operation by 1971. The reactor would be of 1 500 MW(t) producing 200 MW(e) and 40 000 cubic metres per day of fresh water for domestic and agricultural purposes.

Tunisia has received preliminary bids for a dual-purpose plant to produce 50 MW(e) and 20 000 cubic metres per day of water for industrial and domestic use, in the region of Gabès.

The USA are considering a large prototype reactor of about 1 000 MW(t) capacity, which could prove economical if eventually coupled to a large-scale 200 000 m^3/day desalination plant. No desalination plants approaching this size have yet been operated, and they should result in important economies of scale.

In October 1965 an agreement was concluded between the IAEA, USA and Mexico, whereby a study group under Agency chairmanship is to make a preliminary assessment of a dual purpose plant to produce water and electricity, for the region of California, Lower California and Sonora in Mexico. The group will assess the economic advantages of various possible sizes for the plant, considering different reactor types and power-producing systems, as well as desalination methods.

The Agency has participated directly in several of the foregoing appraisals, and has produced several reports of its own.* In addition, in fulfilling its recognized role as a clearing-house for information of this kind, it is being assisted by Member States. For example, an agreement between USA and the USSR concluded in November 1964 for co-operation in the field of desalination stipulates that "the parties will give the IAEA copies of accounts, reports and other documents which they exchange, and also in appropriate cases, invite IAEA observers to symposia and scientific meetings."

ROLE OF IAEA

The expert panel which met in April 1965 recommended that the Agency should continue to serve as the focal point and to provide assistance, advice and co-ordination. It would reply heavily on the support of Member States, making as much use as possible of work done under national programmes. It should seek any additional information required through national organizations, or where necessary initiate studies on specific problems. The panel recommended that the Agency should prepare a report on different costing procedures, including various methods of assessing total capital and annual costs, and the effects of using different procedures for allocating costs between water and power, in dual-purpose plants. The

* *"Desalination of Water Using Conventional and Nuclear Energy"*, IAEA **Technical** Reports Series, No. 24, 1964;

"Study on the Potentialities of the Use of a Nuclear Reactor for the ***Industrialization*** *of Southern Tunisia"*. IAEA Technical Reports Series, No. 35, 1964.

panel also considered that the Agency should make a continuing study of nuclear reactor types and their application in various situations, paying special attention to distillation processes.

All this betokens a spirit of growing confidence, and promises an increasing flow of firm information. There is no substitute for full-scale operating experience, however, and economic assessments must be made with caution. In this field the first word belongs to the development engineers. Several processes for water purification, although promising, have only reached the pilot plant stage, and desalination plants capable of being coupled economically to power reactors would be many times larger than the biggest unit operating today. First estimates, therefore, must be made from the relatively firm ground of proven systems and of plants most likely to be developed in the near future on an industrial basis. In consequence, the considerations which follow are limited to the possible role of reactors as sources of heat for water desalination through distillation or evaporation. This in no way reflects doubt as to the future of other processes such as freezing, vapour compression, electrodyalisis, and reverse osmosis.**

A first attempt to determine roughly an area of competitiveness between nuclear and conventional plants as heat sources may be made by estimating the relative cost of steam from the two (under similar supply conditions). This is, of course, only a first approximation, since in practice there will be other equally important variables. Further, in dual purpose plants, steam production costs may no longer be equivalent to the cost of the heat for the water desalination plant, because of the complexities of allocating total costs between the water produced and the electricity generated. However, there do appear to be thresholds of competitiveness for light water reactors ranging from 300 MW(t) to 1 600 MW(t) by comparison with fossil fuel stations. The first figure assumes a cost of 35 cents per million BTU's for heat produced from fossil fuel, and 7 per cent fixed charges; the second assumes 25 cents per million BTU's and 14 per cent fixed charges. The comparison is restricted to light water reactors in order to extend the range of competitiveness to as small a size as possible.

In looking forward over an extended period, the future of nuclear fuel costs must be considered. There appear no grounds to expect a shortage of uranium ore in years to come, but only a gradual shift to higher cost deposits. On the opposite side, the fabrication and re-processing of fuel elements are only beginning to reap the benefits of standardization, mass production and automation. The speed-up in the development of plutonium-

** *In electrodialysis, dissolved salts under the influence of an electric current are separated out by means of semi-permeable membranes. Osmosis is the process of a dilute or lighter solution flowing through a semi-permeable membrane into a more concentrated and heavier solution. By applying pressure in excess of the heavier solution's own osmotic pressure to one side of the membrane, the direction of the osmotic flow is reversed. Fresh water then flows out of the salt water.*

fuelled fast breeder reactors is likely to guarantee a substantial value to this element. At the same time, the radically improved utilization of nuclear fuels in the next generation of reactors - whether converters or breeders - will relieve whatever pressure may arise on present proven supplies. Nuclear reactors of the current established type are not likely to be penalized over their lives by higher fuel cost than those estimated today for their first years of operation.

ECONOMIES OF SCALE

Forecasts based on reactors of the present-day technology proceed along two lines, which are sometimes combined together: size increase, and development of low- temperature reactors specially suitable for desalination.

There is no doubt that for nuclear plants, unit capital costs continue to diminish as size increases, far beyond the point where unit costs of conventional plant become practically constant. There appears to be no insuperable technical obstacle to develop reactors of 10000 MW(t) and more for certain types of reactor at least. As for the suggestion that low-pressure steam producing reactors could offer an attractive solution as heat sources, major cost items for the current proven reactor types would be little affected by lowering temperature, on the other hand serious problems would arise in the heat exchangers. In fact it seems that nuclear reactors which will supply heat for desalination will be based on the progress achieved and expected for electricity-producing nuclear power plants. The inherent advantages of dual-purpose installations can only reinforce this point.

In comparing economic results of nuclear and conventional dual-purpose plants, a few general considerations only are possible, because such plants are usually designed and operated with either water or electricity production as the chief objective, and may have widely different ratios of water to electricity. However, it remains true that the savings of scale will favour nuclear plants in dual purpose installations. Another advantage of nuclear stations arises from the wide range of water-to-power ratios which they offer, whereas large dual purpose plants using fossil fuel are likely to be economically restricted to relatively low water-to-power ratios.

Estimates of the cost of water produced can only relate to all the detailed circumstances of a particular plant. However, in assessing the possible role of nuclear desalination in the future, some idea of the order of magnitude of the costs of water produced is necessary. The water costs quoted by studies involving nuclear power reactors of proven types and sizes, combined with water plants extrapolated in size, extend over a range of 7 to 14 cents per cubic metre (25 to 50 cents per 1000 gallons). The advent of breeder reactors is likely to bring down this cost range substantially.

A FORECAST

Meanwhile, however, a forecast on the role of nuclear desalination must distinguish between the time periods involved.

Over a short term, nuclear desalination involves the coupling of two rapidly progressing technologies which have up to now been developed for quite separate objectives. In this initial phase, economic desalination is likely to occur only in special situations of acute water shortage, with nuclear heat being competitive only in the sub-category of cases where relatively large dual purpose plants can be considered.

Over the medium term, the development effort undertaken in the first phase is likely to lead to the construction of a series of large dual purpose installations, where the combination of economies of scale with the cost characteristics of advanced reactors will ensure a major role to nuclear energy.

Finally, over the long term, the technology of flash evaporation and distillation is likely to be supplemented by other means of water desalination. Indeed, it will have to be, if desalination is expected to make a major contribution to the world water supply without exerting a serious pressure on fossil and even nuclear fuel resources. A short calculation would show that with the performance ratios available today, which yield 12 pounds of water for every 1000 BTU's of heat, and with the expected growth in water demand in the world until the turn of the century, an attempt to meet a large fraction of the additional requirements by distillation or evaporation processes would involve quantities of fuel substantially exceeding those predicated for electricity production.

Although it would be idle to speculate on which of the promising desalination processes, at present in the research and development stages, will be economically successful, all of them are bound to be energy consumers to varying extents. Hence all depend on the existence of a low cost energy supply base, which only nuclear fuels can ensure.