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Dissemination of Small Desalination Plants Limiting Factors

Abstract - The potential market of new small desalination plant is limited by the actual contracting procedures that are selecting western technologies to be imported into growing countries, without any involvement of local capabilities. The lack of confidence in the desalination technology is caused by this foreign origin, and is combined with the large necessary expenditures to be planned for the procurement and the operation of the plants. Local expertize in design, maintenance and installation is necessary to disseminate confidence and provide social justification to the investments, as a chance for the technical growth of local engineers. The dissemination of desalinators for the production of fresh water is mainly affected by the combination of two limiting factors.
a) High cost of the product water;
b) Lack of confidence in the producing plants.

Before examining each of these factors and their combination, it is necessary to assess the situation of the potential marked and to compare it with the actual demand of new production plants.

1. Potential and present market overview

The growth of the world population and the expectation for a better quality of life, should be originating a continuos increase of fresh water demand. In the European countries the pro-capite water need exceeds 300 lt/day, whilst in East African poor countries it is still below 10 lt/day.

A 100 lt/day of additional consumption for 500 million people, means 50 million tons/day of additional water needs, mostly concentrated in the dry countries of Africa and Asia, where the sea water desalination is the main source of fresh water. Over 2 million tons/day of new installed capacity may be the expected request of plants for the next 10 to 20 years, against the 0,5-1 million tons/year recorded in the past 25 years (see fig. 1). The total installed capacity of desalination plants

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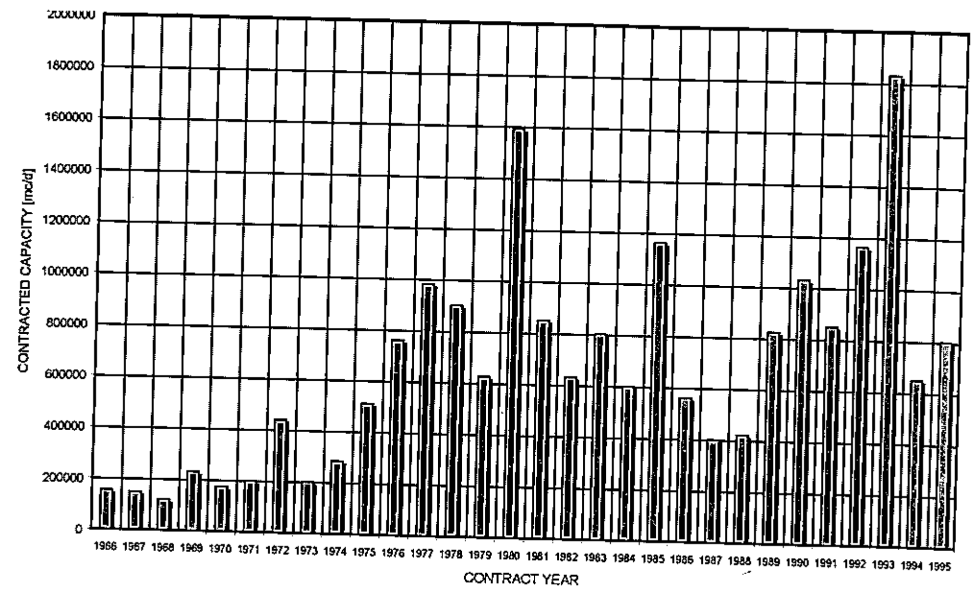

Fig. 1. Capacity of all land-based desalting plants capable of producing 100 m³/d/ UNIT or more fresh water vs. CONTRACT YEAR.

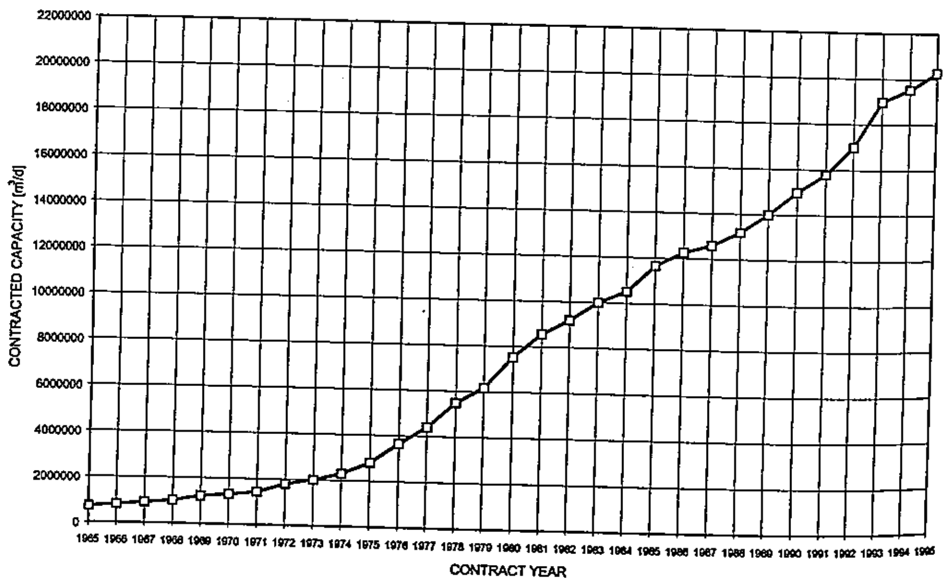

Fig. 2. Cumulative capacity of all land-based desalting plants capable of producing 100 m³/d/ UNIT or more fresh water vs. CONTRACT YEAR.

totals about 20 million tons/day capacity, 50% of them concentrated in the Middle East (see fig. 2). The yearly installed capacity has been very stable around average 800,000 tons/day since about 25 years with two peaks of 1.6-1.8 million tons/year in 1980 and 1993.

The working life of the desalination plants is expected to be very long and exceed 30 years. Therefore no significant replacement market is recorded up to now, and all the new installed capacity means an increase in the overall production. Since 2010, the replacement demand of plants installed in the years 70ies is envisaged to side the demand of new plants and push up the market accordingly.

The total yearly market of desalination plants may be therefore expected to increase from average 800,000 tons/day up to over 2,500,000 tons/day in the next 10-15 years.

The desalination technologysts and the plant producers are now investing money and resources in order to afford the future market adequately, and are now implementing their design and production process, towards larger plants, new materials and lower construction costs.

ECC Center for economical studies published a report in Aug. 96 focused on the R&D efforts underway in the Desalination Technology and completed this report with a forecast of the achievements expected from these efforts, outlining the technical features of the desalination plants in the year 2015.

In fig. 3/4 and 5 these features are summarised by the author, and presented in the Desalination Seminar ACCADUEO at Ferrara in May 1998. The entirety of the R&D efforts are devoted to reduce the cost of the desalination plants through an increase of the production capacity (saving by scale effect), selection of more sophisticated materials (very thin titanium tubes in evaporative plants, and new generation membranes in filtration plants) and in the assurance of a longer life of the investment.

It seems that a limited number of very large installations targeted for a small number of users are attracting the consideration of the R&D engineers, much more that the possibility of dissemination of a large number of small installations.

Producers of desalination plants are preparing to afford the competition between themselves much more than disseminating the technology and searching for confidentiality in order to develop the market into new categories of prospective users. The number of producers of plants is rather small and quite concentrated in a few developed areas of the world. 90% of the plant production is covered by:

a) Membranes: main producers, all from USA and Japan;
b) Evaporation plants: main producers, all from Europe, USA and Japan.

Fig. 5 and 6 provides a graphical representation of the above concentration. The competition among the plant producers became harder and harder in the last years, with a remarkable reduction in the selling prices and in the industrial margins. Some company restructuring is underway through merging of companies,

Process	Technical Bottleneck	R&D needs Efforts	R&D needs Budget
MSF/MED	Corrosion and improvement of materials	medium	medium
MSF	Scaling	medium	medium
MSF	Energy consumption (optimisation on the electrical side and of heat exchange)	medium	high
VC	Compressor problems (reliability/costs)	medium	high
VC	Small unit capacity	low	low
RO	Pre-treatment (Scaling & Fouling)	medium	low
RO	Fouling	medium	low
RO	Membranes (higher throughput, lower pressure loss)	high	medium

Fig. 3. Most relevant technical bottlenecks of desalination processes that shall be solved by 2015.

Process	Operational Availability %		Plant Life-Time (years)		Largest Unit Capacities (mc/day)	
	1996	**2015**	1996	**2015**	1996	**2015**
Seawater						
MSF	75-98	**85-99**	15-35	**15-40**	60,000	**120,000**
MED	68-95	**70-97**	10-30	**15-40**	10,000	**60,000**
VC	65-96	**75-98**	10-30	**10-40**	3,000	**20,000**
SWRO	70-96	**85-97**	8-30	**15-35**	8,000	**20,000**
MED/SWRO	90	**96**	20	**25**		**100,000**
Brackish						
BWRO	70-96	**85-97**	8-30	**15-35**	10,000	**20,000**
ED	80-96	**90-96**	15-30	**15-30**	5,000	**5,000**

Fig. 4. Summary of some technical parameters and their development [IPTSinq, 1996].

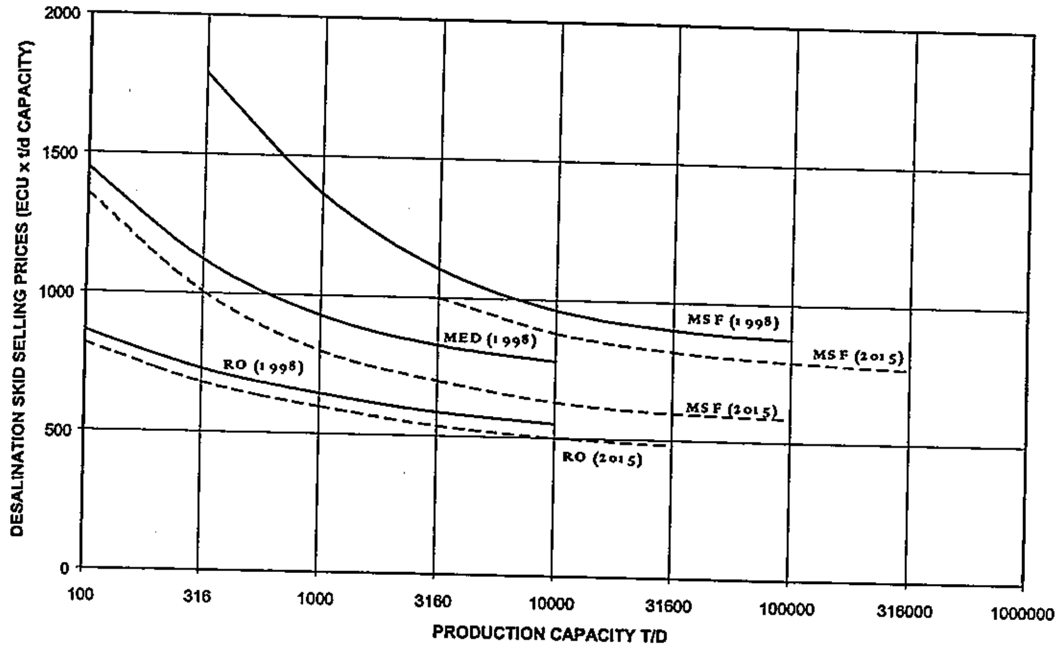

Fig. 5. Present prices and forecast (average) sea water desalination plants.

Capacity of all land based desalting plants capable of producing 100 m³/d/UNIT or more fresh water vs home office Region of:	Capacity in million mc/d						
	North America	Cen./S. America	Europe	Africa	Middle East	Far East	Total
Plant manufacturers	6	–	7	–	1	6	20
(Membranes manufacturers only)	(5,4)		(0,1)	(0,1)	(0,2)	(1,5)	(7,3)
Plant utilizers	3,5	0,2	2,2	1	11	2,1	20
Balance (+ exporter – importer)	+2,5	–0,2	+4,8	–1	–10	+3,9	=

Fig. 6. Desalination plants, (All process MSF + MED + MVC + RO + EDR).

acquisitions and sometimes withdraw from the market. A number of small aggressive companies are on the other hand starting their activity in Europe and in Asia. From these new companies, more attention is expected for the actual requirements of the users' market and for the dissemination of the technology through a larger extent of confidentiality and easier after sale assistance. The market is therefore expected to share into the two more differentiated sectors relevant to large infrastructures and to small plants, easy to be operated, maintained and assisted.

It has to be noticed as last that in the specific market of the desalination plant, there is a peculiar situation by which the European Technologysts have no domestic market and all their activity is devoted to export towards the growing countries. On the other hand, no significant activity is performed within the growing countries. The comparisons of figure 6 proves that nearly all the plant design capacity in Europe and most of it in USA are devoted to supplies in the Middle East and Africa. No other examples are there in the world of activities undertaken and developed in Europe without any domestic market, and entirely focused to export.

2. Cost of fresh water product

The cost of the desalination water is to be very high, because of the chemical properties of dissolved salt. Separation cannot be achieved by an easy process in any case, and consumption of energy is to be quite elevated accordingly. In other words, it is a thermodynamical limit and not a technological problem. The actual cost of desalinated water is affected by a number of factors.

a) Cost of the investment, including land and allied infrastructures.
b) Mortage ratio and relevant financial cost.
c) Nature of energy (electrical/thermal) and relevant cost.
d) Cost of manpower for operation/maintenance.
e) Cost of storage/distribution.

In the case of sea water the order of magnitude is nowadays about 3.5 U.S.$/m^3, being 50% of it due to the investment and 50% to operation costs. (When water to be desalinated is brackish, costs may be remarkably lower). The figure proves that only particular utilizers may effectively pay the cost of desalinated water, if other sources are available. Agriculture and extensive drinking water distribution are usually excluded from desalinated, unless in particular conditions of very low energy cost and easy land availability. Industrial water (process or feed to boilers) or strategic drinking water (army, tourists resort, isles) are considered the usual destination of the desalinated water. The very high quality of the distillated water produced by the evaporative processes, is quite suitable for critical industrial users, such as feed to boilers or to chemical process plants.

An investment plan concerning desalination has therefore to be studied with

the target of reducing the cost of the water. Adequate solutions may affect the overall cost remarkably (from –50% to over +100%). The following factor are to be explored carefully:

— Availability of energy. Thermal energy recovery is always convenient, even if at rather low temperature. The combination of a desalination plant with other industrial installations (Power Plant, Refinery, Chemical plant etc.) provides remarkable advantages.

— Availability of sea water. A sea water intake may be very expensive if only devoted to a desalination plant. Wherever a sea water intake is already available for other purposes, the desalination plant can be fed very conveniently.

The conclusion of this analysis is that a desalination plant has to be installed near the sources of energy/water instead of near the site of fresh water utilization. It is more convenient to transport the fresh water products instead of the sea water and the energy or (even worse) to generate them locally.

It is therefore necessary an adequate planning and business coordination between prospective producers of fresh water and prospective utilizers.

The impact on the cost of an adequate planning is much more effective than any R&D achievement in the design of the production unit. In other word, the R&D achievements may well impact on the competition among the plant manufacturers, but only an adequate planning of the plants may impact on the convenience of desalinated water among other solutions of water procurement.

3. Confidence in the desalination technology

The main reason of the lack of proper planning is due to the lack of knowledge and confidence in the desalination technology. The main reason of the lack of knowledge and confidence, is due to the absence of specialists, designers and maintenance engineers in the countries of destination of the plants. All specialists are located in Europe, USA and Japan, too far from the places where planning are studied and approved. The technologists and the plant manufacturers are often inquired only when the investments for desalination are approved.

The dissemination of desalination plant can occur and provide benefits to the population accordingly, only after the design ability is transferred from the manufacturing countries to the countries of destination, or at least after that this ability is shared or permanently represented.

The local enterpreneuring capability has to be involved in managing the desalination technology through cooperation, licence or joint venture agreements.

This involvement seems to be rather difficult at the moment because of two main reasons, that have to be overcome:

a) The plant designers and manufacturers are very jealous of their ability. This jealousy is now even increasing because of the increased competitiveness of the market.

b) The technological developments and achievements in the plant design are increasing the degree of sophisticacy of the plants and of its construction accordingly.

It has to be noticed that the degree of sophisticacy (that is the basis of both the issues above) is anyway in most cases useless for the pourpose of producing fresh water conveniently. Different materials may be conveniently selected among less sophisticated items and designed for the involvement of the local capabilities. Cement bodied evaporators shall certainly be less expensive and easier to be constructed by local contractors, compared to the reinforced solid stainless steel prefabricated for preassembled shipment to the countries of destination. Or alternatively, glass reinforced plastic cylinders may be easily machined locally and produce standard evaporation modules to be coupled under different sequences into a large number of different multiple effect desalination plants.

When local capabilities shall be involved, and easier maintenance shall be ensured accordingly, the degree of confidence by the customers will undoubthy increase and require for a more intensive utilization of this technology. Until a customer has to decide for a large expenditure and buy a turnkey plant from abroad, without any actual long term guarantee for fair assistance, we shall record a limited number of projects implemented by a limited number of main investors. When the local demand for investments shaped to back the growth of the local technical capabilities shall push the investors adequately, the attitude of the governmental institutions and the municipalities shall turn into favour for desalination plants.

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Nuclear and Fossil Seawater Desalination. Economic Evaluation Methodology and Results

Abstract - The International Atomic Energy Agency (IAEA) has addressed the issue of seawater desalination with renewed intensity after its Member States expressed increasing interest during the General Conference in 1989. The IAEA has published several "Technical Documents", assessing technical options for nuclear seawater desalination, practical implementation, economic viability and regional aspects. This paper reviews in detail experiences and activities of the IAEA.

Projects and experiences in several of the IAEA Member States in the field are described and an outlook on future developments is given. Prominent current nuclear desalination installations are located in Aktau, Kazakstan, and in Japan. Important projects include a feasibility study in Morocco using a Chinese heating reactor and an assessment of nuclear desalination in Egypt. Several other activities are mentioned, e.g. in Korea, Argentina, Indonesia, India and Russia.

A description of technologies and reactors suitable for nuclear desalination is given. Both heat and/or electricity from nuclear reactors can be used. Consequently, nuclear reactors can be coupled both to distillation processes (multi-effect distillation, multi-stage flash) and to membrane processes (reverse osmosis); hybrid plants are an option as well. The role of nuclear energy in the next century is discussed in the light of global climate change. While the use of nuclear energy stagnates in much of Europe and in North America, it continues to be a strong option in a number of Asian countries. Economics, security of supply and the overall goal of a sound energy mix in national energy plans have been considerations in the choice of nuclear power along with an awareness of its environmental benefits.

The IAEA has developed a computer software package "Desalination Economic Evaluation Programme" (DEEP), used for the economic comparison of different seawater desalination options. It's economic evaluation methodology is described. A nuclear reactor (PWR type) and a fossil plant (oil or gas), both of $600MW_{el}$ have been chosen for the comparison. Calculations have been performed for desalination plant sizes of 50.000 and 100.000 m^3/d and for interest/discount rates of 5%, 8% and 10%, both for plants using multi-effect distillation and reverse osmosis technology. Results of the economic comparisons using the software package DEEP are presented in detail. Without considering all input data in detail,

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