History of Desalination Cost Estimations
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Abstract
The history of desalination’s cost estimations is some four decades old. Initially, at the beginning of the 1960s, the only process for seawater desalination was distillation. The only feasible and economical option to achieve large capacities was by dual-purpose, electric power/seawater desalination plants, using multi-stage flash (MSF) technology. About a decade later, two new technologies capable to desalt seawater have evolved, the low-pressure multi-effect distillation (MED), and improved reverse osmosis (RO).

Since the seventies, these three technologies are the main processes used for seawater desalination. MSF and MED are implemented in conjunction with power production while RO is the only viable option for an independent application.

The two practical options, since the 1960s, for brackish water desalination are electro dialysis (ED) and RO. ED is mainly applied for water of low salinity or for special purposes such as nitrate removal, while RO is used for a wide spectrum of raw water sources. This wide spectrum has recently been expanded to include also some “difficult” surface water sources, including wastewater, by applying improved Integrated Membrane Systems (IMS), integrating ultra-filtration (UF) or micro filtration (MF) with low fouling RO membranes.

Major feasibility studies and cost estimates were initiated by the US Office of Saline Water (OSW) and the International Atomic Energy Agency (IAEA). These studies evaluated dual-purpose plants for combined supply of power and desalinated seawater.

The aim of the present paper is to review significant cost estimations, and in some cases actual desalination costs in the last four decades. All the costs are normalized according to a common set of ground rules and macro-economic parameters.

1. First cost estimates

In the 1950s desalination water cost was some $1/1,000 gal (~ $0.5/m³). This cost was considered very high at that time. OSW was established in 1952 to tackle this challenge and by 1956, OSW sponsored the first study on the applicability of combining nuclear reactors with saline water desalination processes.

The 1960s had witnessed many national programs intended to study and evaluate long-range development of desalination, mainly in conjunction with nuclear power reactors, for combined supply of power and water. OSW initiated large number of studies and conceptual designs of desalination plants [1], while IAEA and Oak Ridge National Laboratory (ORNL) were active in evaluating nuclear dual-purpose plants [2-7].

Several national programs were reported at a symposium on nuclear desalination, organized in November 1968 by IAEA in Madrid:

- H. Kronberger reviewed the U.K. desalination RO program [5], activities in improving MSF and other desalination processes were discussed.
- M. N. Edwards reviewed fifteen years of the US desalination program [1], emphasizing the pursuing for low cost desalination technology.

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1 All $ symbols refer to US dollar
The Japanese presented evaluation of a nuclear dual-purpose plant to produce 1,000 MWe and 500,000 m³/d, using MSF technology \[6\]. The evaluation, assuming fixed charge rate of approximately 11% and a fuel cost of 0.18 cent/kWh, resulted in costs of $130/ m³ - d for construction, and 9.3 cent/m³ overall unit water cost for this very large capacity plant.

Israel, faced with a problem of diminishing water sources and in lack of indigenous energy sources, started, with the support of the US, a joint feasibility study of a 200 MW – 100 MGD (378,500 m³/year) nuclear dual-purpose plant that was published in 1966 \[4\]. The unit water cost was estimated to amount to 18 cent/m³, assuming a fixed charge rate of 10% and an electric power cost of 0.5 cent/kWh \[7\]. When in 1965, an 1 MGD (3,785 m³/year) MSF dual-purpose plant started operating in Eilat, the actual water cost amounted to about $0.3/m³ \[8\]. This relatively low cost was due to the very low fuel-oil prices of $10-15/ton prevailing at the time.

2. Cost estimates in the 70s

In the 70s, especially after the 1973 war, fuel oil cost increased very sharply, affecting strongly the desalination cost, especially in processes with high specific energy consumption. Strenuous efforts were made in Israel and in many other places to shift from desalination of seawater by distillation to desalination of brackish water, using ED and to a much larger extent - RO. By the second half of the 70s the RO process was considered in many regional developing programs as an option also for small and large seawater desalination plants, due to improvement in RO seawater (SWRO) technology.

2.1. Investment costs

Many comparative cost estimates for sea and brackish water desalination were published in this time period \[8-18\]. Cost data from References 16, 17 and 18 were chosen to represent typical cost estimates of the 70s. Table 1 summarizes the various desalination plants’ investment costs (MSF, VTE\(^2\), MED, SWRO for seawater and ED and RO for brackish water). Investment costs for 1-100 MGD (3.8K – 380K m³/d) plants by MSF and MED are estimated according to Reference 16, as well as 0.1-5 MGD (380-19K m³/d) SWRO plants and 1-25 MGD (3.8K – 95K m³/d) brackish water (BW) desalination plants by ED and RO. The cost estimates in References 17 and 18 covers the range of 4,000-100,000 m³/d MSF, MED, SWRO, BWED and BWRO plants.

Table 1: Investment cost of desalinations plants according to 70s cost estimates

<table>
<thead>
<tr>
<th>Reference</th>
<th>Capacity - MGD</th>
<th>Capacity - m³/day</th>
<th>Investment, $/m³·d</th>
</tr>
</thead>
<tbody>
<tr>
<td>MSF</td>
<td>2,260</td>
<td>3,785</td>
<td>1,650 - 2,200</td>
</tr>
<tr>
<td>VTE/MED</td>
<td>2,050</td>
<td>4,000</td>
<td>1,375</td>
</tr>
<tr>
<td>SWRO</td>
<td>1,290</td>
<td>18,925</td>
<td>1,130</td>
</tr>
<tr>
<td>BWRO</td>
<td>388</td>
<td>94,625</td>
<td>360(^{(1)}) - 410(^{(2)})</td>
</tr>
<tr>
<td>BWED</td>
<td>338(^{(3)}) - 447(^{(4)})</td>
<td>100,000</td>
<td>285(^{(3)}) - 390(^{(4)})</td>
</tr>
</tbody>
</table>

(1) 3,600 ppm TDS  (2) 600 ppm TDS  (3) 2 stage – “easy” water  (4) 4 stage – “difficult” water

\(^2\) Vertical Tube Evaporator [16]
It should be noted that the investment costs cited in Reference 16 are based on 1979 prices while prices cited in Reference 17 - on mid-1975 prices.

2.2. Unit water costs

The calculated water cost in Reference 17 assumes fixed charge rate of 16.5% while in Reference 18 - 12.5% fixed charge rate is employed. Other factors to be normalized are as follows:

<table>
<thead>
<tr>
<th></th>
<th>Reference 16</th>
<th>Reference 17</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Dual purpose &amp; SWRO</td>
<td>BWRO &amp; ED</td>
</tr>
<tr>
<td>Plant factor</td>
<td>85%</td>
<td>95%</td>
</tr>
<tr>
<td>Fuel price</td>
<td>2.2 $/106 BTU (88 $/TOE)</td>
<td>120 $/TOE</td>
</tr>
<tr>
<td>Electricity price</td>
<td>2.5-4.0 cent/kWh</td>
<td>3.0-5.0 cent/kWh</td>
</tr>
</tbody>
</table>

In order to present all the comparative costs on the same basis, the following economic parameters were applied:

- Fixed charge rate: Dual purpose 12.5%, SWRO 12.5%, RO & ED for BW 12.5%
- Plant factors: Dual purpose 85%, SWRO 85%, RO & ED for BW 90%
- Fuel Price: $100/TOE
- Electricity: 4.0 cent/kWh

The unit water costs by the various technologies according to References 16 and 17 are summarized in Table 2.

### Table 2: Unit water cost according to 70s cost estimate [cent/m³]

<table>
<thead>
<tr>
<th>Reference</th>
<th>[16]</th>
<th>[17]</th>
<th>[16]</th>
<th>[17]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capacity:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- MGD</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- m³/d</td>
<td>1,3785</td>
<td>4,000</td>
<td>94,625</td>
<td>100,000</td>
</tr>
<tr>
<td>Technology</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MSF</td>
<td>143</td>
<td>171</td>
<td>76</td>
<td>89</td>
</tr>
<tr>
<td>VTE</td>
<td>138</td>
<td>-</td>
<td>70</td>
<td>-</td>
</tr>
<tr>
<td>MED</td>
<td>-</td>
<td>151</td>
<td>-</td>
<td>74</td>
</tr>
<tr>
<td>SWRO</td>
<td>120</td>
<td>119</td>
<td>-</td>
<td>74</td>
</tr>
<tr>
<td>BWRO</td>
<td>38</td>
<td>41-51</td>
<td>28</td>
<td>24-37</td>
</tr>
<tr>
<td>BW - ED</td>
<td>26-35</td>
<td>-</td>
<td>20-26</td>
<td>-</td>
</tr>
</tbody>
</table>

Comparison between the two references shows that:
- Unit water cost by MSF technology is 20% higher if calculated according to Reference 17.
- Concerning VTE vs. MED – the difference in the results is less than 10%.
- All other costs are in reasonable agreement.

Comparative unit water cost breakdown as estimated in Reference 18 for a 100,000 m³/d plant, using projected advanced technology, is shown in Figure 1.
3. Cost estimates in the 80s

A work by Leitner [19] was aimed to evaluate implementation of the three tentative technologies: SWRO, MSF and MED for 23,000 m$^3$/d desalination plants in the Arabian Gulf [19] (high design temperature of feed water - 32°C). Capital and operating costs for the three competing processes were made according to the format proposed in the cost study made by ORNL for the US Office of Water Research and Technology (OWRT) in 1981[19].

The estimates were based on 1989, 2nd quarter, $ US costs, using the following parameters:

- Fixed charge rate: 11.7% (10% interest, 20 years depreciation)
- Plant load factor: 90% (330 operating days/year)
- Energy cost: Electricity: $0.05/kWh
  Fuel price: $18/bbl (5.8 M BTU) ~ $124/TOE
- Indirect capital costs: Interest during construction: 10%
  Provisional sums: 10%
  Contingency +A&E charges: 16%
  Working capital: 5%

The investment costs evaluated in this study are shown in Figure 2 and the unit water cost is shown in Figure 3.

A similar capacity plant costs (SWRO 20,000 m$^3$/d) for a Mediterranean site (design temperature: 23°C), evaluated by Mekorot Water Co. [20] are also shown in Figure 2 and Figure 3. The comparison shows 15% lower unit water cost in the SWRO at the Mediterranean site compared with the cost of water in the plant desalting higher salinity seawater in the Arabian Gulf (Figure 3)
Figure 2: Comparative investment costs of MSF, MED and SWRO (1980 – 1990)

Figure 3: Breakdown of comparative unit water cost (1980 - 1990)
4. Cost estimates in the 90s and early 2000s

Three major developments characterize this era:

- Indication of preference of MED and RO over MSF
- Remarkable technological performance improvements accompanied by cost reduction in SWRO (especially in the later years of the 90s)
- Dramatic cost reduction in large international tenders, mainly using the BOOT project approach

The cost estimates published in the first part of the decade were still based on late 80s technology and/or performance data. Leitner [29], presented a cost comparison of three SWRO plants in the range of 10,000-57,000 m$^3$/d put on operation in 1988-1989, in Malta, Las Palmas and Jeddah. Normalizing the reported cost on 11.58% fixed charge rate, 0.05$/kWh$ and five year membrane replacement rate resulted in total water cost between 0.95 and 1.19 $/m$^3$. This cost range was reported at 1991 Malta International Conference on Destination and Water Reuse.

Another study in the same cost format, presented by Mekorot at the above conference [30], evaluated costs for 20,000 and 200,000 m$^3$/d SWRO plants. This study resulted in an estimated cost range of $0.88$-$1.10$/m$^3$ was for the 20,000 m$^3$/d plant. Normalized (see normalized costs in 5.1) costs breakdown of the above estimates is shown in Figure 4. Three references [31, 32, 33] were chosen out of the many other projects’ cost estimates [31-42] to represent on a normalized basis, cost estimates in the mid - 90s. The evaluated projects are as follows:

![Figure 4: Breakdown of SWRO unit water cost - actual operating [29] and estimated [30] (early 90s – based on late 80s technology)](image)

4.1. Projects of brackish and seawater desalination by IPTS [31]

Comparative normalized cost estimate based on the 10,000-20,000 m$^3$/d MSF, MED, SWRO and BWRO plants in the referred evaluation, results in the following unit water costs:
Technology: MSF MED SWRO BWRO
Unit water cost, cent/m³  101-150  76-120  69-117  21-53

Obviously, the low end of the range refers to the lowest investment and operating cost estimates. The high end refers to average values of investment and operating cost. Breakdown of unit water costs are shown in Figure 5.

Figure 5: Comparative unit water of medium size (10,000 - 20,000 m³/d) according to low and average cost estimates in 1996 [31]

4.2. Nuclear desalination for water supply in North Africa by IAEA [32]

Two dual-purpose electric power – seawater desalination plants of about 130,000 m³/d for a Moroccan site are analyzed on the normalized basis. Resulting unit water costs are:

Technology: MED SWRO
Unit water cost, cent/m³  105  95

The cost components: capital, energy and O&M are shown in Figure 6.

4.3. SWRO plants for various water types [33]

Desalination of five seawater types of different salinity and temperature has been evaluated in this work:

A. Oceanic sea water (35 Kmg/l, 18⁰C)
B. Caribbean (36 Kmg/l 26⁰C)
C. Mediterranean (38 Kmg/l 26⁰C)
D. Red sea (41 Kmg/l, 24-32⁰C)
E. Arabian Gulf (45 Kmg/l 16-35⁰C).
Six plant capacities were evaluated: the smallest is 1 MGD (3,785 m$^3$/d) for water source A, and the largest - 24 MGD (90,840 m$^3$/d) for water source E. Capital cost of the SWRO plants ranges between 722-1085 $/m^3$-d (excluding indirect capital cost), 25% indirect capital cost was assumed and a 10% fixed charge rate was used. Unit water costs were evaluated for the sites prevailing power costs, varying from a low cost of 4.0 cent/kWh at the Arabian Gulf to a high of 10 cent/kWh at the Caribbean. The normalized costs for these plants are summarized in Table 3.

Table 3: Capital cost and unit water cost for various seawater types

<table>
<thead>
<tr>
<th>Seawater type</th>
<th>Oceanic</th>
<th>Caribbean</th>
<th>Medit.</th>
<th>Red</th>
<th>Arabian Gulf</th>
</tr>
</thead>
<tbody>
<tr>
<td>Case</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Capacity MGD</td>
<td>A</td>
<td>B</td>
<td>C</td>
<td>D</td>
<td>E1</td>
</tr>
<tr>
<td>m$^3$/d</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Direct capital cost $/m$^3$/d</td>
<td>859</td>
<td>722</td>
<td>865</td>
<td>907</td>
<td>1,085</td>
</tr>
<tr>
<td>Sp. energy consumption kWh/m$^3$</td>
<td>4.47</td>
<td>4.32</td>
<td>5.01</td>
<td>6.16</td>
<td>7.39</td>
</tr>
</tbody>
</table>

| Unit water cost         |         |           |        |     |              |
| Fixed charges cent/m$^3$ | 37.7    | 31.7      | 38     | 35.5 | 47.7         |
| Energy                 | 22.4    | 21.6      | 25     | 30.8 | 37.5         |
| O&M                    | 20.5    | 13.8      | 17.6   | 16.6 | 21.7         |
| TOTAL                  | 80.6    | 67.1      | 80.6   | 82.9 | 106.9        |

(1) Based on reference [32] (1996), normalized as follows:
- Indirect capital cost = 45%
- Fixed charge rate = 10%
- Power cost = 5.0 cents/kWh
4.4. End of Century estimations

4.4.1. SWRO in Spain and Israel

In the latter part of the 90s, lower actual unit water costs were reported in Israel [35] and Spain [36]. The unit water cost of Lanzarote III in the Canary Islands, operating since 1994, amounted to 81 cent/m$^3$ on a normalized basis. The unit water cost in 10,000 m$^3$/d Sabha C plant in Eilat, Israel, operating since 1997 amounted to some 80 cent/m$^3$. The expected estimated cost in the same plant after expanding its capacity to 20,000 m$^3$/d will be some 72 cent/m$^3$. The breakdown of these SWRO plants costs is shown in Figure 7.

![Figure 7: Unit water costs of two operating SWRO plants –90s](image)

4.4.2. International BOO&BOOT tenders in the turn of the Century

In the latter part of 90s and the beginning of the new third Millennium, construction of large desalination plants in the US, Cyprus, Israel and other places by BOO (Build, Own, Operate) and BOOT (Build, Own, Operate, Transfer) project management and financing were initiated, following an international bidding procedure.

Subsequent to large technological improvements, mainly in SWRO technology, favorable financial conditions, such as low interest rates and in some cases use of tax-exempt private activity bonds or other taxable financing (Tampa, [40]) and strong competition, extremely low cost figures were reported: 45 cent/m$^3$ for the 25 MGD (94,625 m$^3$/d) Florida West Coast (Tampa) SWRO seawater desalting plant [40] and 52 cent/m$^3$ for the 50 million m$^3$/year SWRO plant in Ashkelon, Israel [45].

The original offers of total capitalization for the Tampa plant ranged between $98 million to $129 million, and the power requirements ranged between 3.7 to 4.88 kWh/m$^3$ [40]. Detailed cost breakdown was not published. However, by using the lower investment cost of $98 million for 94,625 m$^3$/d capacity (1,036$/m^3$-d), the 3.7 kWh/m$^3$ power requirement and O&M derived from tables presented in [40], normalized unit water cost (cent/m$^3$) breakdown could be calculated:

- Fixed charges: 31.4 (330 operating days/year)
- Energy: 18.5
- O&M: 10.1 (from [40], Table 3)

**Total, cent/m$^3$: 60.0**
The unit water cost breakdown of the 50 million m$^3$/year SWRO Ashkelon plant is not available, but from a cost evaluation made by Mekorot for a plant of the same capacity [43], the following cost breakdown (cent/m$^3$), based on normalized basis, can be derived:

- Specific investment cost: 800 $/m^3$-d
- Capital cost (10% fixed charge rate): 24.2
- Energy (3.7 kWh/m$^3$ @ 5 cent kWh): 18.5
- O&M: 12.9
- Boron reduction$^3$ + re-mineralization: 8.0
- **Total, (cent/m$^3$):** 63.6

The reduced quoted price of 52 cent/m$^3$ is most probably due to a lower power cost via power supply from an incorporated natural gas power-station and to favorable project financing.

5. **Evolution of desalination cost in the last four decades**

5.1. **Normalized costs**

The unit water cost evolution for medium and large capacities is shown in Figure 8 and Figure 9 respectively. In order to enable presentation of the evolution in the last four decades due to technological improvement, all cost estimates in the previous decades were recalculated at the same fixed charge rate on the investment (10%) and the same power cost (5 cent/kWh).

Three inflation indexes of each one of the referred years are indicated: the Building Cost Index (BCI), the Chemical Plant Cost Index (CE) and the US Consumer Price Index (CPI). The CPI permits evaluation of the unit water cost in real terms.

5.2. **Analysis of the normalized costs**

The 60s are characterized by very low energy prices and by euphoria regarding the future of low nuclear energy. The only satisfactorily demonstrated seawater desalination technology was MSF. The investment cost for small 3,000 – 4,000 m$^3$/d capacities was in the range of 250 – 350 $/m^3$-d. At the prevailing low fuel-oil prices of 10 – 20 $/ton, the unit water costs were 0.5 $/m^3$ or somewhat less. This cost was considered too high for large-scale water supply. However, considerable cost reductions were foreseen due to large capacities and implementation of some projected technological improvements.

In the 70s, prior to the improvements in SWRO technology, the two competing seawater desalination technologies were MSF and MED. At sites with prevailing low energy prices (Arabian Gulf), the MED with its lower energy requirements had little advantage. It was preferred mainly in locations with high-energy prices.

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$^3$ Recently, the Israeli Water Commission has dictated 0.4 mg/l - maximum content of boron in desalinated water. Therefore, for seawater using RO technology, boron has to be reduced either by using a second RO pass or by ion exchange system using boron selective resins [44].
Figure 8: Evolution of seawater desalination unit water costs in medium size plants (10 - 40 K m$^3$/d) 1979 - 1997

Figure 9: Evolution of seawater desalination unit water costs in large capacity (90 – 150 K m$^3$/d) plants, 1975 - 2002
Figure 10: Membrane replacement cost Vs. specific membrane capacity cost and membrane life time
In the 90s, the continuous improvement and cost reduction in RO technology increased, in most cases, the economic benefits of SWRO over the distillation process. The largest cost reduction was related to the much lower membrane replacement cost (see Figure 10) and to the reduced specific energy consumption (see Figure 11). A very significant cost reduction is observed in current prices of the SWRO, regardless the large inflation rate. For medium size...
capacities (Figure 9) the cost reduction from about more than 1 $/m$^3$ at the end of the 70s to about 0.8 $/m$^3$ in 1996 is more than 20% in current prices and more than 60% in real terms (inflation of 216% in CPI). A much lower cost reduction, in current prices, has occurred in the other technologies, but in real terms, the technological improvements in MSF and MED have also resulted in cost reduction.

6. **Summary and conclusions**

6.1. **Scope**

The review of desalination cost estimates presents and analyzes data from three sources:

- Selection of published cost estimates made by various organizations by use of costing models and/or specific feasibility studies.
- Normalized cost data from operating desalination plants.
- Recently published quoted desalination prices in large international BOT or BOO tenders.

Three major seawater desalination processes were analyzed for this review. It should be noted that vapor compression (VC) process, that has not been analyzed here, is one of the oldest distillation process and energetically the most efficient. Despite of large improvements in the technology and reduction in its cost, this process cannot compete with SWRO in large capacities plants.

6.2. **Present-day status**

6.2.1. RO preferred technology for seawater desalination

In the 90s after very significant improvements in SWRO technology, SWRO became, in most cases, the preferred seawater desalination process, with continuously decreasing costs, from about one dollar or more for one cubic meter, to a figure around $0.5/m$^3$ for large capacities. A part of the cost reduction is due to change in macro-economic parameters, such as lower electric power prices and lower interest rates. Changes in the approach to project management, by publishing international tenders for Built Operate Transfer (BOT) projects or by similar procedures, triggering strong competition also served as an important tool for cost reduction.

The technology improvements were expressed in all three cost categories: capital cost, energy cost and O&M cost as follows:

- **Capital costs**: larger train capacities, improved membranes at a lower cost and reduced cost of control equipment.
- **Energy cost**: improved efficiencies in large size high-pressure pumps and energy recovery turbines, along with higher RO membrane permeability expressed in reduced specific energy requirement (kWh/m$^3$) – see Figure 11.
- **O&M cost**: reduced membrane replacement cost, lower cost of pretreatment chemicals, lower labor and maintenance cost in large capacities systems and use of better construction materials. A real dramatic cost reduction was achieved in the membrane replacement cost (Figure 10): from 200-250$/m$^3$-d of hollow fiber SWRO membranes in 1990 to 50-60$/m$^3$-d of spiral-wound SWRO membrane in 1998. The lower price along with increased guaranteed life span, reduced the membrane replacement cost from about 10-16 cent/m$^3$ to about 2.5-3.5 cent/m$^3$. 


6.2.2. Brackish water desalination is advantageous when brine rejection is not problematic

It is well known that brackish water desalination is a lot cheaper than seawater desalination. The prevailing cost of brackish water desalination in medium size plants (10,000-20,000 m$^3$/d), excluding feed water supply and brine disposal, is about 20-40 cent/m$^3$. Problematic water supply and brine reject can raise the cost to a higher than seawater desalination’s. Brackish water, as well as wastewater desalination, are however very important issues, especially for inland locations, and must therefore be investigated specifically for each case.

6.3. All means & sources of data for desalination cost estimation have drawbacks

It should be emphasized that each source for desalination cost data: costing models, cost analysis of existing desalination plants, and published tenders bids prices, have significant drawbacks:

- General cost estimates based on pre-design data may have according the American Association of Cost Engineers (AACE) accuracy limits of $\pm 30\%$ to -15\%. Therefore these cost estimates are mainly useful for comparing design alternatives.

- Analyses of operating plants’ costs are very site specific and are therefore most suitable to assess the cost of an additional plant using the same technology, at the same site.

- Bid prices are generally believed to represent market prices of high reliability. This may be correct for the customer receiving the product at a defined price. These prices may also indicate some trends in desalination costs. However, in some cases, the project cannot be realized because of a variety of reasons and the published price has no meaning. In some other cases the low price stems from a damping price by contractors eager to enter the market or by some special, and not generally objective, financing conditions. This should not disturb the customer, but the published price cannot indicate a real cost of an objective market.

6.4. Conclusion

It may be concluded, that any published cost estimate cannot and should not replace a specific feasibility study including pilot testing for each new or not fully recognized water type.

7. References


33. C.P. Shields, I. Moch, Jr., “Evaluation of global seawater reverse osmosis capital and operating costs”, ADA Conference, Monterey, California, August 1996.