RECENT TREND OF SEAWATER DESALINATION TECHNOLOGY AND ROLES FOR JAPAN

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Trend of Seawater Desalination in the World

1. The world's capacity : 39.9 million m^3/day in 2006, 64.3 million m^3/day in 2010 and 97.5 million m^3/day in 2015
2. The Persian Gulf countries occupied about 50% in1995, but did 40% in 2005.
3. The growth rate in the rest of the world is a little larger than that of the Gulf countries.
4. However, the Gulf countries still remain the biggest market in the world.

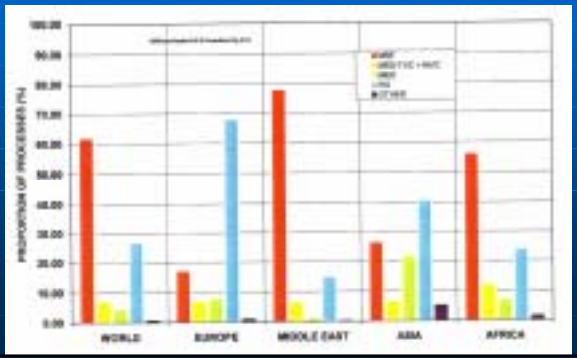
Contents

Present and Future Desalination Market by Country

(unit: m^3/day)

Country	2006	2010	2015
Saudi Arabia	7,246,000	11,496,000	16,436,000
UAE	5,456,000	8,356,000	11,556,000
USA	6,616,000	7,866,000	10,566,000
China	622,000	1,972,000	5,322,000
Spain	2,379,000	3,824,000	4,954,000
Algeria	721,000	2,561,000	4,461,000
Kuwait	2,081,000	3,191,000	4,341,000
Australia	362,000	1,222,000	3,472,000

Desalination Processes by Region



Trend in the Middle East

1. The main stream is still MSF, but some changes are observed recently.
2. SWRO of CTA (Cellulose Tri-Acetate) membrane was established in Red Sea region in Saudi in 1980s, and is extending to the Persian Gulf. Ex.: Bahrain and Al Jubail.
3. Hybrid system of MSF-RO at Fujairah in 2001 (ADWEA). And some others of in Sharjah
4. MED is gaining power and eating the MSF market; Marafiq selected recently MED of 800,000m^3/day at Al Jubail desalination. The current share of 24% will be 37% in 2015.

Desalination Processes by Region

1. The largest portion in the world is MSF followed by RO (2nd) and MED (3rd).
2. The Middle East favors more MSF than the world does, but the trend is the same.
3. Europe prefers RO instead of MSF.
4. Africa is similar to the world average.
5. Asia goes between the Middle East and Europe.
6. The RO is recently growing its share.

Advantages and Disadvantages for MSF

1. Advantages

(1) Wide selection of feed water (seawater)

(2) High quality of product water

(3) High reliability in long operations

(4) Suitable for constant and large water production

2. Disadvantages

(1) Much energy consumption of power and steam

(2) Higher environmental load

(3) Slow response to water demand fluctuations

Advantages and Disadvantages for RO

1. Advantages
(1) Lower water cost, less energy consumption
(2) Lower environmental load
(3) Flexible for water demand fluctuations
(4) Expected much technical advancement in future
2. Disadvantages
(1) Sensitive to feed quality (unfavorable to polluted feed)
(2) Product water contains some salinity (TDS).
(3) Not enough reliability for polluted area; the membrane fouling is still unsolved completely.

Plant Construction Cost Comparison

Process	Feed Water	Construction (US$/m^3/day)
MSF	Seawater	1,800 – 2,500
MED	Seawater	1,500 – 2,000
RO	Seawater	1,000 – 1,500
RO	Surface water	600 - 800
RO	Ground water	500 – 700

Advantages and Disadvantages for MED

1. Advantages
(1) Wide selection of feed water
(2) High quality of product water with high reliability
(3) Less water cost and energy consumption than MSF because of no need of recirculation pump
2. Disadvantages
(1) Higher environmental load than RO, but not so much as MSF
(2) Slow response to water demand fluctuations, but not so slow as MSF
(3) Less unit capacity than MSF, but increasing

Operation Cost for SWRO

Investment	US$1,200/m^3/day
Power consumption	3.5 kWh/m^3
Membrane exchange	20%/year (5 year life time)
Chemicals	US$0.03/m^3
Maintenance	2%/year of investment
Labor	US$0.03/m^3

Operation Cost for MSF

Investment	US$2,000/$m^3$/day
Power Consumption	4kWh/m^3
Steam Consumption	125kg/m^3 (4.0 – 10bar A)
Chemicals	US$0.02/$m^3$
Maintenance	1% /year of Investment
Labor	US$0.02/$m^3$

Recent Development of SWRO-1
Less Power Consumption-1

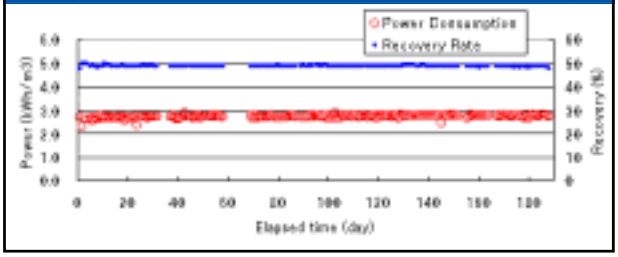
1. The normal energy consumption has been 3 - 5 kWh/m^3 in the past years.
2. Water Re-use Promotion Center (WRPC) achieved 2.6 – 2.8 kWh/m^3 for 40,000mg/L salinity at Muscat, Oman in 2003.
3. Affordable Desalination Collaboration (ADC) reported less than 2kWh/m^3 for salinity of 31,900mg/L seawater in California, USA, in 2007.

Operation Cost for MED

Investment	US$1,600/$m^3$/day
Power Consumption	2.5kWh/m^3
Steam Consumption	125kg/m^3 (4.0 – 10bar A)
Chemicals	US$0.02/$m^3$
Maintenance	1% /year of Investment
Labor	US$0.02/$m^3$

Recent Development of SWRO
Less power consumption-2

Total Power Consumption and Recovery Ratio for ca 40,000mg/L Salinity at Muscat, Oman



Recent Development of SWRO-2
Boron Removal-1

1. The WHO Guidelines require 0.5mg/L boron in drinking water, while 4 - 5mg/L boron exists in the standard seawater of 35,000mg/L salinity.
2. To comply with WHO, 88.9% boron rejection is needed for the normal seawater. However, seawater with more salinity exists in the Persian Gulf, which means more boron rejection rate is demanded in the Gulf.
3. The next slide shows how much rejection is needed to comply with the WHO guidelines.

Recent Development of SWRO-2
Boron Removal – 3

The table shows the boron rejection rates achieved by RO membrane manufacturers in the world.

Year	Before 2000	2000 – 2003	2000 – 2007
Rejection Rate (%)	80 – 90	Ca 90	92 - 93

Recent Development of SWRO-2
Boron Removal-2

The following table shows how much more boron rejection rate the RO membranes is needed to comply with the WHO guidelines of less than 0.5mg/L in the product water.

Salinity (mg/L)	35,000	40,000	45,000	50,000	55,000
Boron rejection required (%)	88.89	90.27	91.36	92.22	92.92

Recent Development of SWRO-3
Pretreatment with MF or UF Membrane

1. Pretreatment with MF or UF membrane for feed water made much advancement. Thanks to PVDF-made membranes, we need little to mind chemical cleaning.
2. Low fouling membrane was developed by both smooth membrane surface as much as possible and pore size control on membrane surface; fouling particles are rejected by these controlled pores.

Japan's Roles in SWRO – 1

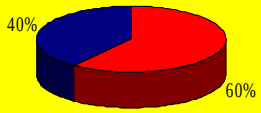
1. The market share of all membranes for the Japanese manufacturers is the largest (60%) in the world (the next slide).
2. The share of membrane for SWRO only occupies 70% (the next slide).
3. On the other hand, membrane technologies are expected to play an essential role in water treatment including desalination in future.
4. Therefore, Japan is leading to providing the world with membranes of good performance.

Japan's Roles in SWRO – 2

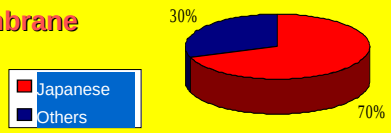
5. Japan has experience to operate SWRO plant at Okinawa since 1995 and at Fukuoka since 2005. The former is using polyamide RO and the latter is adopting CTA (Cellulose Tri-Acetate) RO.
6. The two plants are open to you.
7. Water Re-use Promotion Center (WRPC) had and have technology transfer projects with Saudi Arabia, UAE, Oman and Qatar.

Shares of Japanese Membrane Manufacturers

All membranes (SWRO, NF, BWRO, LP, MF and UF)



SWRO membrane only



Japan's Roles in SWRO – 3

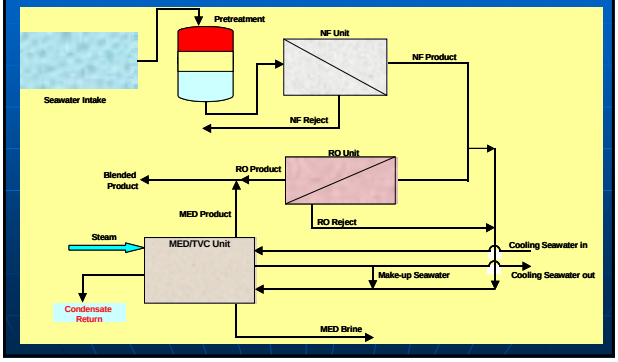
1. WRPC had a project to protect SWRO against an oil spill accident for Oman.
2. The protection method was to treat 4-8 mg/L oil-containing seawater feed to an SWRO plant with polypropylene-made oil absorbent.
3. The optimum conditions for absorption was found and the 200m^3/day SWRO test plant could be continued to operate for 20 days, during which an oil spill accident is solved in most cases.

Japan's Roles in SWRO – 4

1. A joint team of Qatari and Japanese staff is operating an SWRO plant at Dukhan, Qatar where seawater has 58,000mg/L salinity with turbidities fluctuating violently in winter and temperature varies between 17 and 38 Celsius.
2. The recovery ratio reached 32.5% with high recovery RO membrane.
3. A newly developed boron removal process could reduce boron to less than 0.5mg/L.

The process called "PCP" was adopted to a practical SWRO plant in Saudi Arabia recently.

Flow Diagram of NF-RO-MED



Japan's Roles in SWRO – 5

1. A joint team of Saudi Arabia and Japanese staff is developing a tri-hybrid desalination system of NF-RO-MED.
2. Calcium sulfate scale in feed seawater is prevented by NF membrane removal. Then, treated seawater is desalinated by RO.
3. The reject from the RO is distilled by MED at over 100C, say, 125 C. The increase in TBT increases GOR drastically (around 15).
4. A pilot plants of NF-RO and MED was built and experiment has started.
5. The system is expected to decrease greatly desalination cost.

THANK YOU FOR YOUR ATTENTION!

I earnestly hope this speech will promote friendship between Egypt and Japan.