Desalination In Saudi Arabia
An Overview

N. Nada
General Manager Desalination Nomac
Historical Background

- In 1928 King Abdul Aziz established Kendasa (Condenser) in Jeddah (MED).

- 1965 Ministry of Agriculture established desalination department.

- 1969 Duba and Alwajh desalination MSF plants commissioned 198 m³/d (52000 gpd) each.

- 1974 Saline water Conversion Corporation (SWCC) established.
Jeddah Phase 1
## Daily Production In KSA

<table>
<thead>
<tr>
<th>Region</th>
<th>Production (M m³/d)</th>
</tr>
</thead>
<tbody>
<tr>
<td>East Coast</td>
<td>3.722</td>
</tr>
<tr>
<td>West Coast</td>
<td>3.892</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>7.614</strong></td>
</tr>
</tbody>
</table>

2.0 BGD
Desalinated Water Distribution According to Process

- RO: 14%
- Thermal: 86%
- MSF: 75%
- MED: 11%
## Basic Principal for Sea Water Intake

<table>
<thead>
<tr>
<th>Coast</th>
<th>Water Type</th>
<th>Depth</th>
</tr>
</thead>
<tbody>
<tr>
<td>East Coast</td>
<td>Shallow water</td>
<td>-5m depth</td>
</tr>
<tr>
<td>West Coast</td>
<td>Deep Water</td>
<td>-17 m depth</td>
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</tbody>
</table>
Sea Water Pretreatment

RO

MSF

MED
Coupling Desal Plants (Thermal or Membrane) with Power Plant reduces energy requirement for desalination by half.

Dual purpose plant or hybrid
Power + Thermal
Power + RO
Power + (Thermal + RO)
Dual Purpose Plant Configuration

(1) Back Pressure Turbine

MSF
MED
Dual Purpose Plant Configuration

(2) Extraction Condensing Turbine
FLOW DIAGRAM FOR DUAL PURPOSE PLANT WITH THERMAL DESALINATION PLANT

Fuel Gases (NO\textsubscript{x}, SO\textsubscript{x}, P, CO\textsubscript{2})

BPG Turbine

Fuel
HFO

TBT = 85c – 112c

FGD
ESP

B

Reject to sea

Anti foam

Vent

D/A

Cl\textsubscript{2}

CW

SWP

PW

BRPP
BDPP

antifoam
antiscalant
Dual Purpose Plant Configuration

(3) Condensing Turbine
Dual Purpose Plant Configuration

(4) Back Pressure Turbine + Hybridization (Thermal + RO)
Shuaibah IWPP

**Project cost**
SR 9,188 million ~ $ 2,450 million

**Power capacity**
900MW (ACWA Net 270 MW)

**Water capacity**
880,000 M$^3$/day
(ACWA Net 264,000 M$^3$/d)

**Contract type**
20 year PWPA based on BOO

**PCOD**
14 January 2010

**ACWA Ownership**
30%
Shuaibah Expansion IWPP

**Project cost**
SAR 875 million ~ $233 million

**Water capacity**
150,000 M³/day
ACWA Net 45,000 M³/day

**Contract type**
20 year WPA based on BOO

**PCOD**
November 2009

**ACWA Ownership**
30%
FLOW DIAGRAM FOR DUAL PURPOSE PLANT WITH SWRO
Shuqaiq IWPP

**Project cost**
SR 6,866 million ~ $ 1,831 million

**Power capacity**
850 MW
ACWA Net 289MW

**Water capacity**
212,000 M³/day
ACWA Net 72,080 M³/d

**Contract type**
20 year PWPA based on BOO

**Scheduled PCOD**
December 2010

**ACWA Ownership**
34%
flow diagram for SWRO
<table>
<thead>
<tr>
<th>Plant</th>
<th>Conf.</th>
<th>Power (MW)</th>
<th>Water (MGD)</th>
<th>P/W</th>
<th>Chem. Treat</th>
<th>TBT</th>
<th>Com m.</th>
<th>PR</th>
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<tr>
<td>J 1</td>
<td>LT</td>
<td>50</td>
<td>ECT</td>
<td>5</td>
<td>10:1</td>
<td>Acid</td>
<td>120</td>
<td>1970 1980 10</td>
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<tr>
<td>Ak 1</td>
<td>LT</td>
<td>GT</td>
<td>5</td>
<td>5</td>
<td>Acid</td>
<td>120</td>
<td>1974 1982 10</td>
<td></td>
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<tr>
<td>J 2</td>
<td>LT</td>
<td>25</td>
<td>ECT</td>
<td>5</td>
<td>5:1</td>
<td>Acid</td>
<td>120</td>
<td>1978 2007 10</td>
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<td>J 3</td>
<td>CT</td>
<td>62</td>
<td>ECT</td>
<td>5.8</td>
<td>10:1</td>
<td>Ad</td>
<td>107</td>
<td>1979 7</td>
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<tr>
<td>J 4</td>
<td>LT</td>
<td>120</td>
<td>ECT</td>
<td>11.6</td>
<td>10.3:1</td>
<td>Ac/Ad</td>
<td>110</td>
<td>1982 2005 7</td>
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<tr>
<td>M&amp;Y1</td>
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<td>75</td>
<td>ECT</td>
<td>6</td>
<td>12.5:1</td>
<td>Ac/Ad</td>
<td>120</td>
<td>1982 10</td>
</tr>
<tr>
<td>Job 1</td>
<td>CT</td>
<td>60</td>
<td>ECT</td>
<td>6</td>
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<td>Ad</td>
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<td>1982 8.5</td>
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<td>Job 2</td>
<td>CT</td>
<td>130</td>
<td>BPT</td>
<td>27.6</td>
<td>4.7:1</td>
<td>Ad</td>
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<td>1983 8.5</td>
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# 2nd Generation

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<th>Conf.</th>
<th>Power (MW)</th>
<th>Water (MGD)</th>
<th>P/W</th>
<th>Chem.</th>
<th>TBT</th>
<th>Comm</th>
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<tr>
<td>Sho 1</td>
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<td>60</td>
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<td>12</td>
<td>5:1</td>
<td>Ad</td>
<td>102</td>
<td>1988</td>
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<td>Shuq 1</td>
<td>CT</td>
<td>80</td>
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<td>15.2</td>
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<td>Ad</td>
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<td>Sho 2</td>
<td>CT</td>
<td>100</td>
<td>BPT</td>
<td>24</td>
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<td>Ad</td>
<td>110</td>
<td>1999</td>
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<tr>
<td>M&amp;Y2</td>
<td>CT</td>
<td>80</td>
<td>BPT</td>
<td>18</td>
<td>4.4:1</td>
<td>Ad</td>
<td>110</td>
<td>2000</td>
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# 3rd Generation

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<td>Shoaiba 3</td>
<td>CT + RO</td>
<td>1200</td>
<td>232.5</td>
<td>5.2:1</td>
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<td>110</td>
<td>2009</td>
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<td>Shuqaiq 2</td>
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<td>1020</td>
<td>57</td>
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<td>Acid</td>
<td>-</td>
<td>2010</td>
<td>-</td>
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<tr>
<td>Marafiq</td>
<td>CC + CT</td>
<td>2743</td>
<td>211</td>
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<td>63</td>
<td>2010</td>
<td>9.5</td>
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<tr>
<td>Ras Al-Khair</td>
<td>CC + CT</td>
<td>2500</td>
<td>264</td>
<td>9.5:1</td>
<td>Add.</td>
<td>112</td>
<td>2013</td>
<td>9.5</td>
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</table>
Rabigh IWSPP

**Project cost**
SR 4,279 million ~ $1,141 million

**Power capacity**
360 MW
ACWA Net 86MW

**Water capacity**
134,000 M³/day
ACWA Net 32,026 M³/day

**Steam capacity**
1,230 t/hr
ACWA Net 294 tons/hr

**Contract type**
25 year WECA based on BOOT

**PCOD**
June 2008

**ACWA Ownership**
23.9%
International Barges Company for Water Desalination Ltd.  BOWAREGE

**Project cost**
SR 370 million ~ USD 100 million

**Water capacity**
52,000 M³/day
ACWA Net 33,720 M³/d)

**PCOD**
First quarter 2008

**ACWA Ownership**
64.85%
Marafiq / Jubail IWPP

**Project cost**
SR 12,588 million ~ $ 3,360 mil

**Power capacity**
2,743 MW
ACWA Net 549 MW

**Water capacity**
800,000 M³/day
ACWA Net 160,000 M³/d

**Contract type**
20 year PWPA based on BOOT

**Scheduled PCOD**
March 2010

**ACWA Ownership**
20%
Cogeneration Power & Water Block

- GT
  - 151 MW
  - HRSG

- GT
  - 151 MW
  - HRSG

- GT
  - 151 MW
  - HRSG

- BPT
- G
  - 256 MW

- 9 MED Evaporators
Cogeneration Power Block

GT

151 MW

HRSG

GT

151 MW

HRSG

GT

151 MW

HRSG

ST

G

T/C
Rabigh IPP

**Project cost**
SR 9,397 million ~ $ 2,506 million

**Power capacity**
1,204 MW
ACWA Net 482MW

**Contract type**
20 year PPA based on BOO

**Scheduled PCOD**
April 2013

**ACWA Ownership**
40.0%
Present Desalination Practice in KSA

1. High Power Demand
2. High Water Demand
3. No Preferable Desalination Process
   MSF, MED, RO
   24MGD, 7.5MGD, Unlimited

<table>
<thead>
<tr>
<th></th>
<th>MSF</th>
<th>MED</th>
<th>RO</th>
</tr>
</thead>
<tbody>
<tr>
<td>PR</td>
<td>9.5</td>
<td>9.5</td>
<td>4.6 KWhr/m³</td>
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<tr>
<td>TBT</td>
<td>112</td>
<td>63</td>
<td></td>
</tr>
<tr>
<td>Conf.</td>
<td>CT</td>
<td>TVC</td>
<td>Single &amp; Double Pass</td>
</tr>
<tr>
<td>Size</td>
<td>24MGD</td>
<td>7.5 MGD</td>
<td>Unlimited</td>
</tr>
</tbody>
</table>
What is next?
Thermal Desalination Process

1- Implementation of solar energy.
2- Improve the performance ratio PR.
3- Develop high temperature antiscalant.
4- Reduce design fouling factor.
5- Improve the heat transfer coefficient.
Proposed improvement for Membrane Desalination

1- Improve the existing commercially viable membrane flux.
2- Improve salt rejection.
3- Resist organic fouling.
• In 1977 an agreement between US Department of energy and KSA (KACST) was signed for the corporation in the field of solar energy to build freezing desalination plant using solar energy to produce 180 m3/d.

• The plant was built in 1985 and run for two years.
Solar Energy Water Desalination Engineering Test Facility
Solar Panels
Freezing plant consist of:

1-Energy collection system, 18 solar panel with total surface area 1285 m2. The design was based on local solar radiation 8.3 kwhr/m2. With Solar collector efficiency 65-68% steam temperature reached 389 C. Peak solar energy during operation 5400 kwhr/day.

2- Energy storage system.
3- Energy delivery system.

4- Supplementary diesel firing system.

5- Desalination Plant design parameters:
   - Daily production  180 m3/ d.
   - Sea water TDS  45000 ppm
   - Sea water temperature  35 C.
   - Product water TDS < 500 ppm.
Forgotten Desalination Process

• **Freezing**
  • Advantages:
  • 1- Low latent heat, energy consumption is \( \frac{1}{7} \) of the MSF or MED.
  • 2- No corrosion.
  • 3- No antiscalant i.e. no pretreatment.
  • 4- Near atmospheric pressure.
  • 5- Direct heat transfer.
  • 6- High thermodynamic efficiency of refrigerant cycle.
  • 7- Consistent product water quality.
Thank you