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Veolia Environnement

- World leader in Environmental Services
- 315,000 employees in more than 100 countries
- 4 business segments, 1 focus: Environment

1.1 

- ENVIRONMENTAL SERVICES
  - € 34.8 Billion

- WATER
  - € 12.1 Billion
  - World Leader

- ENERGY
  - € 7.5 Billion
  - European Leader

- TRANSPORT
  - € 8 Billion
  - European Leader

- WASTE MANAGEMENT
  - € 9.3 Billion
  - World Leader
Sidem within Veolia Water

Veolia: World Leader in Water Services through 2 Subdivisions

- **Veolia Water**
  - Operation of water and wastewater systems on behalf of public authorities and companies
  - Turnover: €12.6 billion – 90,000 employees
  - 9.8 bn m³ of water distributed – 7.3 bn m³ of wastewater collected

- **Veolia Water Solutions & Technologies**
  - Design of water solutions and technologies, engineering and construction of water and wastewater treatment plants
  - Turnover: €2.2 billion – 9,600 employees (incl. 60% engineers)
  - 57 countries / 135 businesses / over 250 proprietary technologies

- **Sidem**
  - Design, engineering and construction of thermal and hybrid seawater desalination plants for industrial and municipal needs
  - Turnover: €250 m – 290 employees – HQ’s in Paris with regional offices in Abu Dhabi, Saudi Arabia, Qatar, Libya and St Marteen Caribbean

Within Veolia, the expertise in thermal desalination is from Sidem and its subsidiary Entropie
1.3 Sidem 1900 – 1985
World’s Leader in MSF Technology

- 1970: Incorporation of SIDEM
- 1976: Umm Al Nar Abu Dhabi
- 1979: Al Khobar II Saudi Arabia
- 1982: Taweelah Abu Dhabi


- SCAM Development of MSF
- Nouakchott
- MSF – Umm Al Nar East Abu Dhabi 3 x 27,500 m³/d (1976)
- MSF – Al Khobar II Kingdom of Saudi Arabia 10 x 5.9 MIGD (1979)
- MSF – Misurata Libya 3 x 10,500 m³/d (1982)
- MSF – Al Taweelah Abu Dhabi 3 x 35,300 m³/d (1982)
Sidem 1960 – 2010:
From development to world’s leader of MED

1.4 Sidem 1960 – 2010: From development to world’s leader of MED

- **1965**: Incorporation of SIDEM
  - Arzew, Algeria: 3 x 200 m³/d
- **1970**: MED-TVC
  - Trapani, Sicily: 9,000 m³/d – GOR: 16.3
- **1971**: MED-TVC
  - Curaçao Island: 12,000 m³/d – GOR: 13.4
- **1971**: MED-TVC
  - Das Island, Abu Dhabi: 2 x 125 m³/d
- **1989**: MED-TVC
  - Trapani, Italy: 2 x 9,000 m³/d
  - MED-TVC
  - Curaçao Refinery, Netherlands Antilles: 1 x 12,000 m³/d – GOR: 16.3
- **1997**: MED-TVC
  - Layyah, Sharjah: 22,700 m³/d – GOR: 8.4
- **1998**: MED-TVC
  - Fujairah II, UAE: 12 x 38,700 m³/d
  - Veolia buys SIDEM
- **1999**: MED-TVC
  - Layyah, Sharjah: 36,370 m³/d – GOR: 8.4
- **2008**: MED-TVC
  - Fujairah II, UAE: 12 x 38,700 m³/d
  - Veolia buys SIDEM
  - SWRO/MED Hybrid Plant
Sidem Worldwide Capacity Booked

Cumulated contracted capacity in m³/day

More than 80% installed in the Gulf

Technology Switch from MSF to MED

1.5

Special

VEOLIA
WATER

Innovation & Technology

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1.6 Evolution of MED Units Capacity

- **Umm Al Nar, UAE**
  - Unit Cap.: 3.5 MIGD
  - GOR: 7.9
- **Layyah, Sharjah**
  - Unit Cap.: 5 MIGD
  - GOR: 8.4
- **Curaçao Island**
  - Unit Cap.: 2.6 MIGD
  - GOR: 13.4
- **Al Hidd, Bahrain**
  - Unit Cap.: 6.00 MIGD
  - GOR: 9.07
- **Marafiq Jubail, KSA**
  - Unit Cap.: 6.59 MIGD
  - GOR: 9.85
- **Ras Laffan C, Qatar**
  - Unit Cap.: 6.3 MIGD
  - GOR: 11.1
- **Fujairah II, UAE**
  - Unit Cap.: 8.5 MIGD
  - GOR: 10.3
- **Trapani, Sicily**
  - Unit Cap.: 2.0 MIGD
  - GOR: 16.3
- **Fujairah II, UAE**
  - Unit Cap.: 8.5 MIGD
  - GOR: 10.3
Main References in the Gulf Countries

1.7

MED - Marafiq Saudi Arabia
27 x 6.55 MIGD (2007-2010)

MED - Layyah Sharjah
2 x 5 MIGD (1999-2001)

MED - Layyah Sharjah
2 x 8 MIGD (2005-2006)

MED - Taweelah Abu Dhabi
14 x 3.8 MIGD (2007-2010)

MED - Al Hidd Bahrain
10 x 6 MIGD (2006-2008)

Hybrid MED / RO - Fujairah II
MED: 12 x 8.5 MIGD
SWRO: 30 MIGD (2007-2010)

MSF - Al Khobar II KSA
10 x 5.9 MIGD (1979-1982)

MED - Ras Laffan C Qatar
10 x 6.3 MIGD (2007-2010)
This Scheme represents a Multiple Effect Distillation unit consisting of 3 cells.

In the last cell the produced steam is condensed on a conventional shell and tubes heat exchanger (distillate condenser) cooled by sea water.

At the outlet of the condenser, part of the warmed sea water is used as make-up of the unit, and part rejected to the sea. Brine and distillate are collected from cell to cell till the last one from where they are extracted by centrifugal pumps.

The thermal efficiency of a unit is quantified by the Gain Output Ratio (GOR) defined as the quantity of distillate produced per unit of heating steam used.
Single Cell Principle

Sea water
Spraying system

Sea water

Heating steam

Distillate

Produced vapour

Brine

Heat exchanger
(Heating tubes bundle)
2.3 Enhanced Process with Thermal Vapour Compressor (MED – TVC)

- GOR can be enhanced by addition of a thermocompressor (TVC) between one of the cells and the hot one.
- Using LP or MP steam this static compressor will take part of the vapour raised in one cell and recycle it into higher pressure vapour to be used as heating medium for the first one.
- In this example of 3 cells, the GOR is doubled in comparison with standard MED.

GOR = 6

MED-TVC Process Scheme
2.4 Desalination without available steam (MED –MVC)

- **When no steam is available**, it is still possible to use the MED process by adding a Mechanical Vapour compressor (MED-MVC).
- In such case the vapour is recycled from the cold cell to the hot one by means of a **centrifugal compressor** driven by an electric engine.
- A maximum capacity of 5,000 m3/day can be obtained with current compressor technology.
Within MSF-BR, huge quantities of water are circulated through large recycling pumps of very high electrical consumption.
### Comparison between MED & MSF

<table>
<thead>
<tr>
<th>MAIN ATTRIBUTES</th>
<th>MSF</th>
<th>MED</th>
<th>CONSEQUENCE</th>
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</thead>
<tbody>
<tr>
<td><strong>Evaporator Design</strong></td>
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<td>the seawater circulates inside</td>
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<td>the pressure difference</td>
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<td>between inside and outside tube</td>
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<td>is very high (ΔP up to 6 bar)</td>
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<td>seawater in the higher pressure</td>
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<td>side</td>
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<td>the steam circulates in the</td>
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<td>tubes and SW is sprayed on the</td>
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<td>outside</td>
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<td>Little pressure difference</td>
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<td>between inside and outside tube</td>
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<td>is &lt; 0.1 bar</td>
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<td>distillate in the higher</td>
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<td>pressure side</td>
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<tr>
<td>Failure of MSF tubes more likely</td>
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<tr>
<td>to occur, with high flowrate</td>
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<td>Leak of MSF tubes is SW that</td>
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<td>will contaminate the distillate</td>
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<td>Leak of MED tubes is steam at</td>
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<td>low flowrate, without effect on</td>
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<td>product quality</td>
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<td><strong>Heating medium</strong></td>
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<td>Uses steam at pressure between</td>
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<td>2 &amp; 3 bars</td>
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<td>Can make use and be optimised</td>
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<td>for steam between 0.35 and 40 bars</td>
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<td>MED process can make use of</td>
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<td>less valuable (lower pressure)</td>
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<td>steam</td>
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<td>MED can be sized for 2+ steam</td>
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<td>pressure conditions</td>
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<td><strong>Enhanced process</strong></td>
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<td>Based on large brine</td>
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<td>recirculation pump</td>
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<td>7+ volumes of brine will</td>
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<td>recirculate to produce 1</td>
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<td>volume of distillate</td>
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<td>Large, thick water boxes</td>
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<td>required; expensive material</td>
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<td>Based on vapour recirculation</td>
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<td>Vapour recirculated by Thermal</td>
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<td>Vapour Compression (MED-TVC)</td>
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<td>MED: no sophisticated, expensive</td>
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<td>and critical rotating pump in</td>
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<td>place</td>
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<td>less maintenance downtime during</td>
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<td>pump maintenance</td>
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<td>MSF: electrical consumption is</td>
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<td>higher by up to 3 kWh/m³</td>
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<tr>
<td><strong>Scaling &amp; Corrosion</strong></td>
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<td>Operation up to 120°C</td>
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<td>Permanent sponge balls</td>
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<td>cleaning system (taprogge)</td>
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<td>Permanent injection of 2 – 3 ppm</td>
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<tr>
<td>antiscalant &amp; 0.1 ppm antifoam</td>
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<tr>
<td>Periodic acid cleaning of tubes</td>
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<td>&amp; demisters</td>
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<tr>
<td>Operation at temperatures below</td>
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<td>65°C at low concentration (&lt;1.5)</td>
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<td>to reduce scaling</td>
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<td>Permanent injection of 2 – 3 ppm</td>
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<td>antiscalant &amp; 0.1 ppm antifoam</td>
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<td>Periodic acid cleaning of tubes</td>
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<td>MED &amp; MSF: same period of</td>
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<td>operation between acid cleanings</td>
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<td>MSF: demisters fouling at top</td>
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<td>stages causes more maintenance</td>
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<td>and stops</td>
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<td><strong>Operability &amp; Availability</strong></td>
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<td>Important quantity of water and</td>
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<td>wide range of temperature</td>
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<td>within evaporator (110°C – 40°C)</td>
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<td>Minimized quantity of water and</td>
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<td>reduced range of temperature</td>
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<tr>
<td>within evaporator (80°C – 40°C)</td>
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<tr>
<td>MSF: less flexible, start-up</td>
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<td>and shutdown longer</td>
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<td>MED: easier to operate, better</td>
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<td>availability and easy load</td>
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<td>variation</td>
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</table>
### Economic Advantages of MED vs. MSF

#### CAPEX – Capital Expenditures
- Similar – depending on client specification

#### OPEX
- **Thermal Energy consumption**: identical
- **Electrical Consumption**: 4.5 kWh/m³, 1.5 kWh/m³
- **Antiscalant**: 2 to 3 ppm, 0.1 ppm
- **Antifoam**: 0.1 ppm
- **Operability**: less flexible, flexible, easy
- **Availability**: lower, higher

Based on same steam and same produced water characteristics and quantity.

For a 100 MIGD plant, annual savings on electrical consumption represent approx.
1 x 454,000 m³/day x 365 days x 3 kWh/m³ x 0.031 $/kWh = \(15,000,000\) $ savings per year + 50 MW worth of Power CAPEX

**In comparison with MSF, MED OPEX savings represent 2.75% of the Plant CAPEX per year (*)**

(*) And much more if converted to savings of unsubsidised fuel at power plant inlet
2.8 MED / RO Hybrid Plants

- **Purpose**: decrease overall fuel consumption of the Power Plant / Desalination Plant:
  - Priority for thermal desalination by recovery of the available exhaust steam (MED-TVC)
  - Balance of water production by RO or MED-MVC

- **Concrete Example**: Combined thermal and membrane technology of Fujairah-2 Project signed in 2007:
  - 100 MIGD MED-TVC + 30 MIGD RO

Veolia through Sidem & OTV is the only company able to provide inhouse large capacity hybrid plants based on MED & RO technologies.
Sustainability of Sidem’s Leadership in the desalination business is based on:

- Permanent effort to **improve the technology**
  - Optimisation of Bundles Wetting
  - Optimisation of Thermocompressor design
  - Selection of Materials
- **Controlled** increase of proposed MED units capacity
- Development and implementation of **tailor made solutions** *(all our projects are unique)*
- Optimisation of the thermodynamic process and **reduction of energy consumption**
- Permanent **feedback analysis** from existing plants
3.1 Ras Laffan C IWPP – Qatar 2008
MED – 286,000 m³/d (63 MIGD)

- Contract Award: 2008
- End User: KAHRAMAA
- Owner: Ras Girtas Power Co.
- 10 units x 6.3 MIGD – MED
- 8 effects
- GOR: 10.9
3.2 Fujairah 2 IWPP – Fujairah 2007
MED – 463,000 m³/d (102 MIGD)

- Contract Award: 2007
- End User: Abu Dhabi Water and Electricity Authority
- Owner: Fujairah Asia Power Co.

- 12 units x 8.5 MIGD – MED
- 8 effects
- GOR: 9.39
Jubail IWPP – Saudi Arabia 2007
MED – 800,000 m³/d (177 MIGD)

- Contract Award: 2007
- End User: Marafiq
- Owner: Jubail Water & Power Co.

- 27 units x 6.56 MIGD – MED
- 8 effects
- GOR: 9.84
3.4 Al Hidd IWPP – Bahrain 2006
MED – 272,000 m³/d (60 MIGD)

- Contract Award: 2006
- End User: Electricity and Water Authority
- Owner: Hidd Power Co.

- 10 units x 6 MIGD – MED
- 7 effects
- GOR: 9.03
Al Taweelah A1 IWPP – Abu Dhabi 2006
MED – 240,000 m³/d (53 MIGD)

- Contract Award: 2000
- End User: Abu Dhabi Water & Electricity Authority
- Owner: Gulf Total Tractebel Power Co.

- 14 units x 3.77 MIGD – MED
- 6 effects
- GOR: 8.04
Al Khobar Phase II – Saudi Arabia 1979
MSF – 267,000 m³/d (59 MIGD)
3.7 Umm Al Nar East – Abu Dhabi 1976
MSF – 82,500 m³/d (18 MIGD)