



# Solar thermal desalination for decentralized production of pure drinking water - A technological overview

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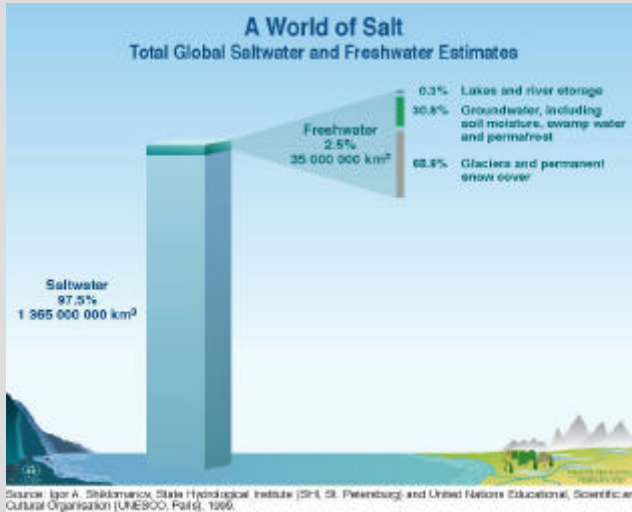
Intersolar US, 14th July 2010

ROOF & PREFABRICATED BUILDING TECHNOLOGY	SOLAR & WATER TECHNOLOGY	ALUMINIUM EXTRUSION, FACADE & SOLAR MOUNTS TECHNOLOGY	FASTENING TECHNOLOGY
<ul style="list-style-type: none"> <li>MAGE HILDBERG GmbH, Germany</li> <li>MAGE INC, Italy</li> <li>MAGE HILDBERG s.p.a., Poland</li> <li>MAGE sdn bhd, Malaysia</li> <li>TBA MAGE INC, USA</li> <li>REPRESENTATIVE OFFICE, Russia</li> </ul>	<ul style="list-style-type: none"> <li>ALMECO TiNOX GmbH, Germany</li> <li>MAGE SOLAR GmbH, Germany</li> <li>MAGE SOLAR INC, USA</li> <li>ECO4 ENERGY GmbH, Germany</li> <li>REPRESENTATIVE OFFICE, P.R. China</li> <li>MAGE AIRESHHANGMENT GmbH, Germany</li> </ul>	<ul style="list-style-type: none"> <li>MAGE SEIBERS GmbH, Austria</li> <li>MAGE ALL SYSTEMS GmbH, Austria</li> </ul>	<ul style="list-style-type: none"> <li>MAGE AG, Vertriebsfilialen</li> <li>MAGE FASTENERS LTD, Great Britain</li> <li>MAGE FAST, Germany</li> <li>MAGE FASTENERS INC, The Netherlands</li> <li>MAGE FASTENERS SA, Slovakia</li> <li>MAGE FASTENERS SA, Portugal</li> <li>MAGE CZ s.r.o., Czech Republic</li> </ul>

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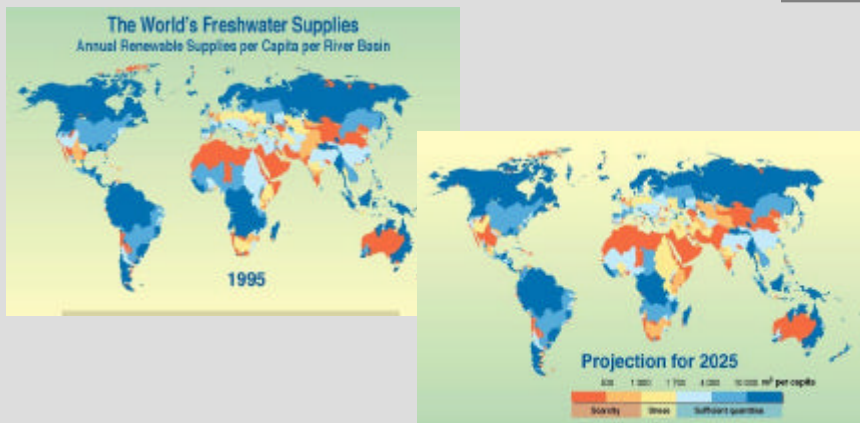
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# Fresh water distribution



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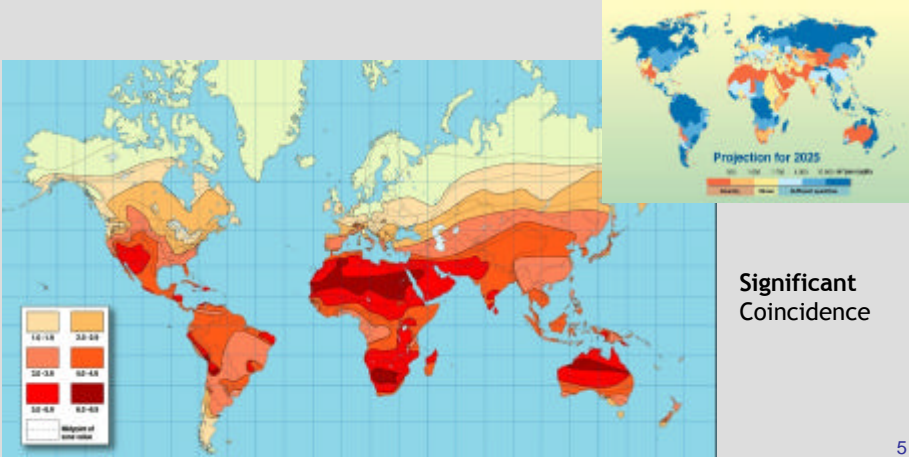
# Change of fresh water availability



Source: [http://maps.grida.no/go/graphic/renewable\\_freshwater\\_supplies\\_per\\_river\\_basin](http://maps.grida.no/go/graphic/renewable_freshwater_supplies_per_river_basin)  
Philippe Rekacewicz, UNEP/GRID-Arendal)

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# Solar Irradiation



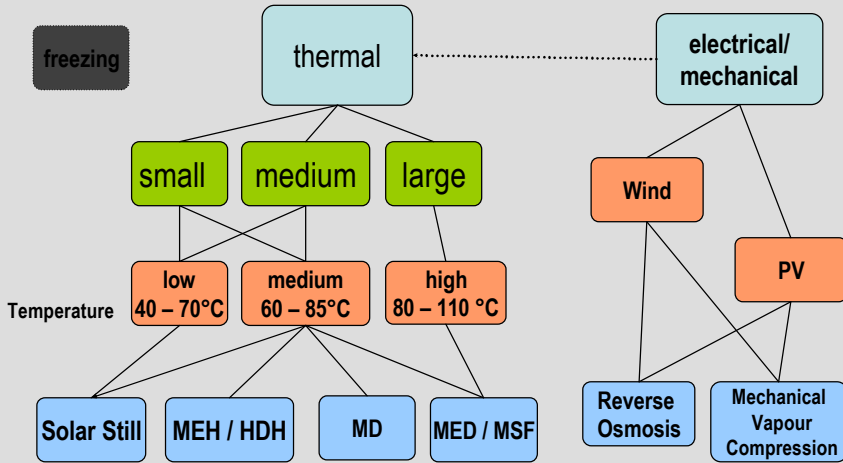
Significant  
Coincidence

Source: <http://blessedsun.wordpress.com>

# Technologies



# Desalination methods using Renewable Energies



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## Thermal Processes: Solar Still

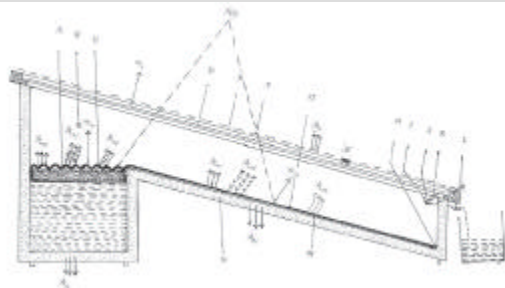
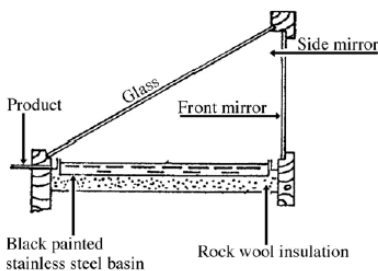


### Advantages

- Simple Design
- Affordable Investment
- Proven technology

### Obstacles

- Specifically high maintenance
- Low efficiency
- High ground area demand
- Limited system capacity (100 l/d)



## Chances for solar stills



### Facts

- Investment  
10 000 to 20 000 €/m<sup>3</sup>/d
- Daily production rate  
3 to 5 l/m<sup>2</sup>



Watercone®

### Chances for solar stills

- Cost reduction
- Material simplification
- Mass production



### Limitation

- Capacity
- Area

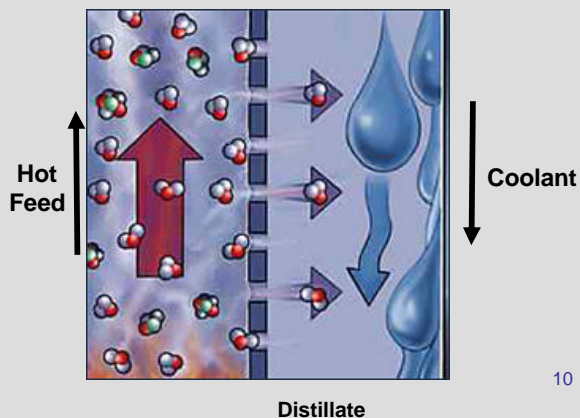
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## Membrane Distillation(Thermal process)



Micro porous PTFE membrane  
(average pore size 0,2 µm)

Distillation driven by partial pressure difference on the two sides of a hydrophobic membrane which permit the flow of vapour but not of liquid water



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## Solar Driven Membrane Distillation (Fraunhofer ISE)



**Typical daily distillate production:**  
15 to 20 l/m<sup>2</sup>

**Modular Capacities:**  
100 L/day (1 membrane, 6 m<sup>2</sup> of solar collectors and

1000 L/day (4 membranes, 72 m<sup>2</sup> of solar collectors)

1400 L/day (5 membranes, 90 m<sup>2</sup> of solar collectors)

**Specific Investment (System):**  
20'000 to 50'000 €/ m<sup>3</sup>/d

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## Solar membrane distillation (Namibia 2010)



- Capacity: 5 m<sup>3</sup> per day
- Solar Collector Array: 220 m<sup>2</sup>
- Autonomous Operation

**Manufacturer:**  
Fraunhofer ISE, Germany

Source: [www.solarspring.de](http://www.solarspring.de)

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## MED Desalination (CIEMAT, PSA)



- AQUASOL production 60 L/m<sup>2</sup>d (PSA winter day)
- Cost of AQUASOL produced water: 8.12 €/m<sup>3</sup> (PSA plant / 3 m<sup>3</sup>/h)
- Land cost not considered

- 14 effects MED plant (3 m<sup>3</sup>/h distillate prod.)
- Stationary CPC solar collector field (500 m<sup>2</sup>)
- Thermal storage system (water, 24 m<sup>3</sup>)
- Double-effect (LiBr-H<sub>2</sub>O) absorption heat pump



<http://www.ciemat.es>

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## Reverse Osmosis - (Photovoltaic Electricity)



- Proven large scale technology
- High demand for pretreatment and technical supervision is obstructive for small scale application
- Pressure exchanger for efficient operation available from 20 m<sup>3</sup>/day



At the Canary Islands Institute of Technology, solar panels feed energy to a stand-alone reverse-osmosis desalination system in operation since 1998. The domes cover desalination prototypes, including workshops and labs.

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## ProAqua PV/R.O. Solution



- "pilot plant", 1..5 m<sup>3</sup>/h,  
energy consumption app.  
4 kWh/m<sup>3</sup>
- solar powered by photovoltaics
- new developed "turbo charger"  
pumps: energy recovery for  
efficiency
- uses electrolytical proaqua  
ScaleRemover
- ready to operate within 48 hours
- telemetry and remote control by  
satellite: optimal user support



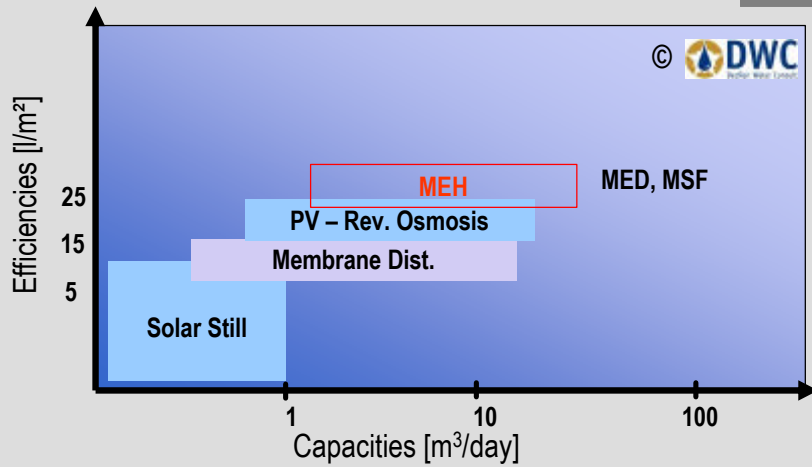
<http://www.pro-aqua.net> 15

## Photovoltaic Reverse Osmosis (Brackish Water)





## Overview: Capacities and efficiencies



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## MAGE Water Management GmbH: SAL-MEH Systems for decentralized use



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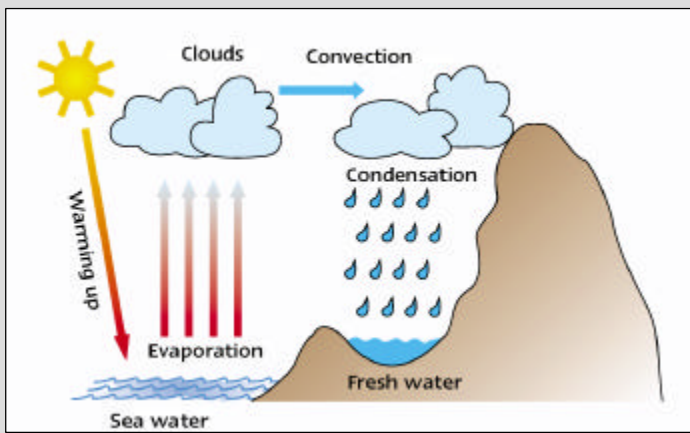
## Solar Thermal Desalination applying the MEH method



- Water Desalination by multiple evaporation of salty waters and consecutive condensation of the generated humidity
- Energy recovery by sophisticated arrangement of condensation - evaporation unit
- Required process energy is low temperature heat at 80 °C (175 °F)

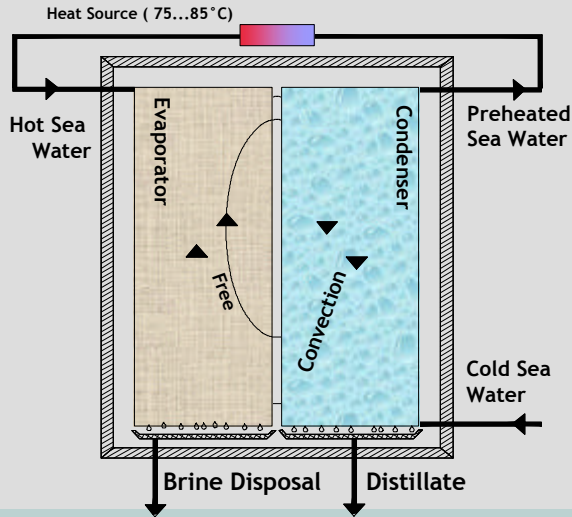
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## The MEH-Process... ... rebuilds the natural water cycle



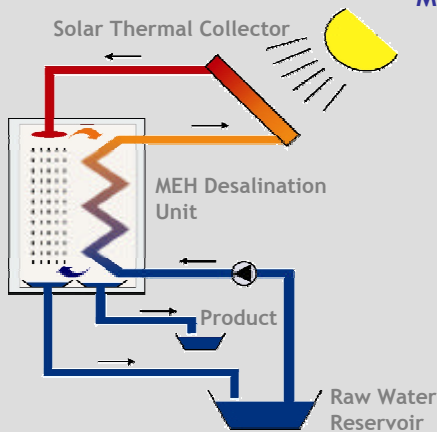
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## Evaporation and Condensation



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## Solar heat collection and evaporative desalination

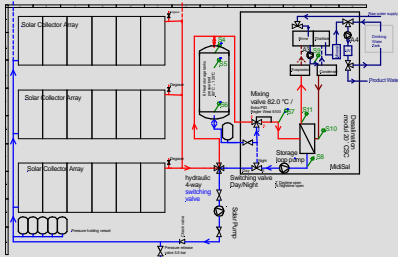


### MEH System properties:

- Thermal energy demand  $100 \text{ kWh}_{\text{thermal}}/\text{m}^3$
- Specific water production:  $25\text{-}35 \text{ l}/\text{m}^2_{\text{Collectorarea}}$
- No chemical raw water pre-treatment needed
- Produced water is complying with EU drinking water directive (COUNCIL DIRECTIVE 98/83/EC of 1998 on the quality of water intended for human consumption) and WHO standards
- Low maintenance demand

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## Our expertise:



- Individual system design according to your demand
- Outstanding expertise and experience in solar system design
- Turn key solution according to your demand
- Any system size between 1 and 100 m<sup>3</sup> per day can be realized
- Installation and commissioning by our skilled technicians

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## Modular concept, available sizes are



- MiniSal™1000, capacity 1 m<sup>3</sup>/d (Box on 3 Euro-Pallettes)
- MidiSal™5000, capacity 5 m<sup>3</sup>/d (20' Standard container)
- MegaSal™10000, capacity 10 m<sup>3</sup>/d (40' Standard container)
- MaxiSal™50000, capacity 50 m<sup>3</sup>/d (5 MegaSal)



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## Integral Container Casing Concept



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## High local acceptance



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## Advantage of MEH desalination units



*Comparing the alternatives for small scale (1..50 m<sup>3</sup>/d) desalination using renewable energies , the MEH system has*

- Low specific investment cost  
- 15 €/l/d for the central unit
- low total water costs for any solar driven configuration after 15 years  
5.35 €/m<sup>3</sup> (app. 2.5 \$Cent per Gallon)
- minimal maintenance demand, no chemical pre-treatment needed
- high water recovery (70%), compared with R.O. (30% - 40%) and MD (45%-60%)
- best product water quality



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## Examples of realized systems- Reference Systems



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## Tunisia, Sfax. 1999



Supply of water for irrigation agricultural cooperative

Average Production: 800 l/d



## Oman, Al-Hail close to Muscat



### MiniSAL system

- Installation 2001
- 40 m<sup>2</sup> flat plate solar collectors
- 2,4 m<sup>3</sup> heat storage tank
- 24 hours per day operation
- Average production (2001-2003) 930 l/d



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## Solar Farm Kingdom Saudi Arabia



### MidiSAL™5000 System

- Commissioned 2006
- Water Production from salty ground water



- Wind for pumping of ground water
- 140 m<sup>2</sup> (1500 ft<sup>2</sup>) Solar thermal collectors
- 10 m<sup>3</sup> thermal storage tank for 24 hours operation per day

Intelligent Energy Europe

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[www.mage-watermanagement.com](http://www.mage-watermanagement.com)

## Supply of Office Building Sami Al-Bakri, Jeddah, KSA



### MidiSAL™5000 System

- Production 5 m<sup>3</sup> /d (1300 gpd)
- 140 m<sup>2</sup> (1720 ft<sup>2</sup>) thermal collectors
- Use of water is for human consumption, replacing daily truck delivery



Utilization of solar collector field  
as shading for car parking

Intelligent Energy Europe

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## MiniSal™1000 Desalination System Cyprus



- Autonomous Operation since December 2007
- Implementation in water heating system by solar thermal collectors (total 85 m<sup>2</sup> absorber area)
- Designed capacity 1000 l/d (260 gpd)

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## Dubai, VIP Event Arena in the desert (start of operation July 2008)



- MidiSal™5000 System
- 160 m<sup>2</sup> ( 1720 ft<sup>2</sup>) Solar Thermal collectors Heat Supply
- 5 kW<sub>peak</sub> PV for autonomous electricity supply
- Raw water is high saline and high alkaline ground water

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Dubai, VIP Event Arena in the desert (start of operation July 2008)



Best Fresh Water quality



## Upcoming projects



- MiniSAL unit for Hawaii together with company Sopogy
- Two MiniSAL Systems to India as demo
- Upcoming projects in India, Middle East, Sri Lanka

## Smallest solar desalination system: The Watercone®



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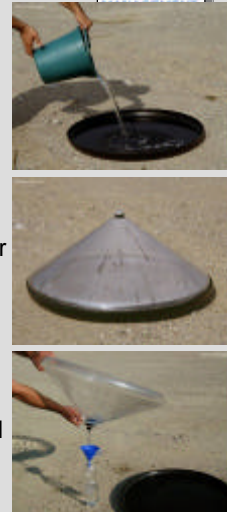
## Smallest solar desalination system: The Watercone®



Pour salty / brackish Water into pan.  
Then float the Watercone on top. The black pan absorbs the sunlight and heats up the water to support evaporation.

The evaporated Water condensates in the form of droplets on the inner wall of the cone. These droplets trickle down the inner wall into a circular trough at the inner base of the cone.

By unscrewing the cap at the tip of the cone and turning the cone upside down, one can empty the potable Water gathered in the trough directly into a drinking device.



more information...



- [www.solar-desalination.com](http://www.solar-desalination.com)
- [www.mage-watermanagement.com](http://www.mage-watermanagement.com)
- [www.watercone.com](http://www.watercone.com)

... or contact us!

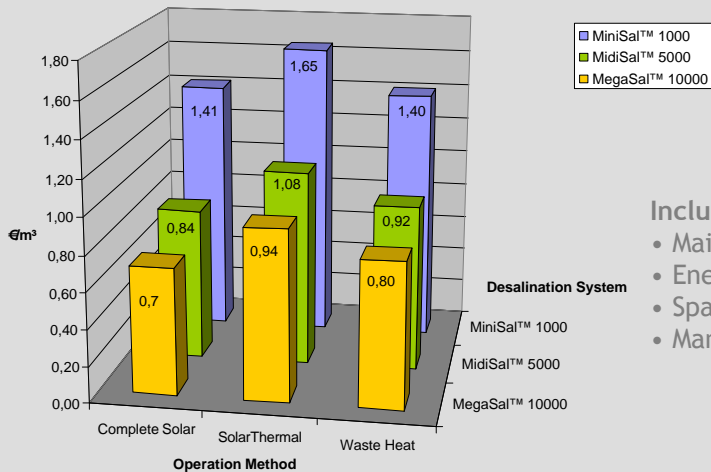
Thank you for your attention !

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## Total Operation Costs



Total Operation Costs per m<sup>3</sup> Produced Distillate



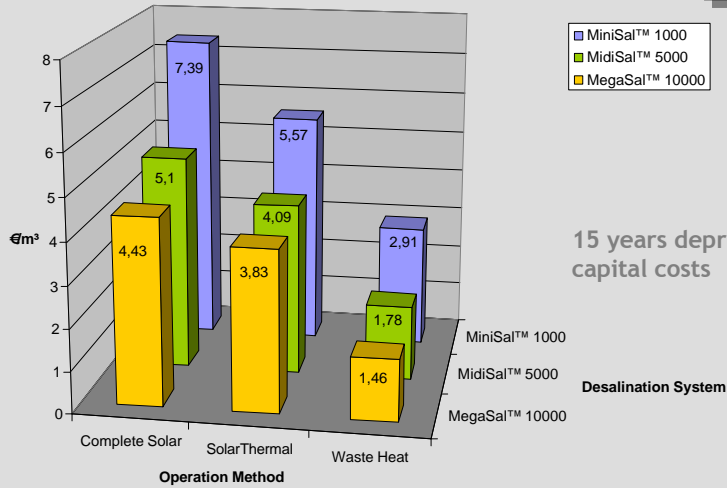
Including:

- Maintenance
- Energy costs
- Spare parts
- Man power

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# Investment costs

## Investment Costs per m³ Produced Distillate



15 years depreciation capital costs

Desalination System