Seawater Desalination with Solar Energy Technologies and Potential

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MENA Water Supply Scenario

- Decreasing renewable water resources
- Increasing gap between demand and sustainable supply
Conventional Desalination Plant

- Tunel Intake
- Screening, Filtration
- Desalination Plant
- Power Plant
- Fuel
- Heat / Power
- Direct Discharge
- Anti-Scaling
- Anti-Foaming
- Anti-Corrosion
- Desinfection
Impacts of Conventional Seawater Desalination

- Seawater intake for desalination and for the cooling system may cause impingement and entrainment of organisms.

- Airborne emissions of pollutants and carbon dioxide are caused by the generation of electricity and heat required to power the desalination plants.

- Chemical additives and biocides used to avoid fouling, foaming, corrosion and scaling of the desalination plants may finally appear in the brine.

- Discharge of hot brine with high salt concentration to the sea may affect local species.
Advanced CSP-Desalination Plant

Concentrating Solar Collector & Storage → Power Plant

Nano-Filtration → Desalination Plant

Heat / Power

Horizontal Drain Intake or Micro- & Ultrafiltration

Multiport Diffuser Discharge

Source: catalanadeperforacions.com; cormix.info
Global Water Scarcity

- Little or no water scarcity
- Approaching physical water scarcity
- Physical water scarcity
- Economic water scarcity
- Not estimated
Global Potential for Concentrating Solar Power

DNI annual sum [kWh/m²a]

- < 2000 or excluded
- 2000 - 2100
- 2100 - 2200
- 2200 - 2300
- 2300 - 2400
- 2400 - 2500
- 2500 - 2600
- 2600 - 2700
- 2700 - 2800+

DNI data based on NASA SSE 6.0
http://eosweb.larc.nasa.gov/sse/

Data provided by DLR (2008) for EU-project REACCESS

REACCESS 2009
Fossil fuels cost 2002 - 2012

- Coal (Australia)  
  x 4.2

- Crude Oil  
  x 5.6

- Natural Gas  
  x 1.2

- Natural Gas (Russia)  
  x 4.4
Learning Curves for Renewable Energies

![Graph showing learning curves for renewable energy sources](image_url)
Renewable Energies for Desalination: why CSP?

Desalination plants require continuous operation
→ Conflict with the intermittent nature of renewable energies
→ CSP offers the option of thermal energy storage
→ Hybrid operation is possible in the same power block (no “shadow power plant” required)

A fair technology comparison has to be carried out by definition of a load profile!
→ To Wind and PV cost, storage (if available) and back-up cost have to be considered
→ Grid import is not for free
CSP Technology Overview
CSP Scheme

- Solar Field: 395°C
- Fossil Back-up: 385°C
- Re-heater: 377°C, 100 bar
- Steam Turbine: G
- Thermal Storage: 295°C

Temperature depends on the configuration.
Reverse Osmosis (RO)

Heat $0 \text{ kWh}_{\text{th}}/\text{m}^3$
Power $3 - 6 \text{ kWh}_{\text{el}}/\text{m}^3$

Membrane stacks and high pressure pumps

Source: DME
Multi Stage Flash (MSF)

Al Khobar, Saudi Arabia ➔ 267,000 m³/day

- Stages: 20 - 40
- Heat: 70 - 125 kWh\(_{th}/m^3\)
- Power: 3 - 5 kWh\(_{el}/m^3\)

www.dlr.de/tt/aqua-csp
Multi Effect Distillation (MED)

Abutaraba – Libya → 40,000 m³/day

Stages 8 - 12
Heat 70 - 125 kWhₚₑₜ/m³
Power 1.5 kWhₑ𝑙/m³

Possible CSP-DES Configurations

- CSP: Parabolic Trough
- 2 desalination technologies:
  - MED: Multiple-Effect-Distillation
  - RO: Reverse Osmosis
- Desalination: 100,000 m³/d
- Power: ca. 100 MW\textsubscript{el}
- Storage: 7.5 h (design)
- Plant operation: 8,000 h/y including fossil fuel back-up
- Levelized cost of electricity: 20 – 24 US$\textperthousand/kWh
- Levelized water cost: 1.5 – 1.9 US$/m³
Conclusions

- High uncertainty on future water availability! Unmet water demand of MENA in 2050 between 85 km$^3$ and 283 km$^3$ (average scenario 199 km$^3$)

- A set of countermeasures is urgently required: increased efficiency of water production, distribution, end-use and management, re-use of waste water, sustainable desalination

- Yearly adaptation cost US$ 103 Billion €$^{2010}$. Yemen (11.8%), Iraq (7.5%), Morocco (4.7%), Jordan (4.0%) and Egypt (2.4%) will face the highest cost in relation to the GDP

- Almost all countries have enough potential to develop CSP also on coastal areas

- Start to act now in order to build-up the required industrial capacities. Political support is required!
Thank you for your attention!

For more Info:
www.dlr.de/tt/menawater
www.med-csd-ec.eu
www.dlr.de/tt/aqua-csp

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