Αυτόνομα συστήματα αφαλάτωσης με ΑΠΕ – Δραστηριότητες του ΓΠΑ

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Presentation Structure

1. Introduction and Desalination in the world
2. Desalination technologies
3. Renewable energies and desalination
4. Wind, solar PV, solar thermal
5. Conclusions

Introduction

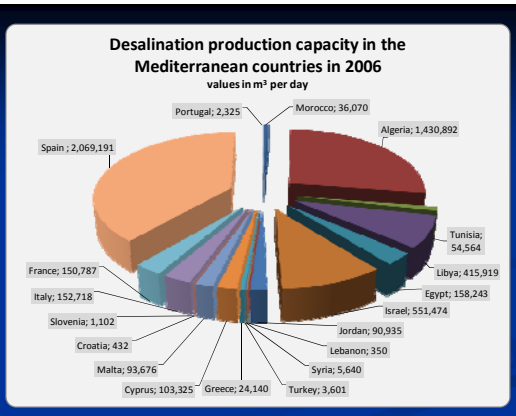
- Water is an essential component of the life support system
- Why go for desalination?
  - Lack of water resources
  - Deteriorating quality of fresh water sources
  - Reduced cost of water produced by desalination
  - Security of supply
- Source of water for desalination
  - Brackish water
  - Seawater

Desalination should be the ultimate solution

- Water saving, especially in agriculture, e.g.
  - New water irrigation methods
  - Water distribution networks – maintenance
- Surface water collection at regional and local level (houses)
- Motivation of renewable energy driven desalination

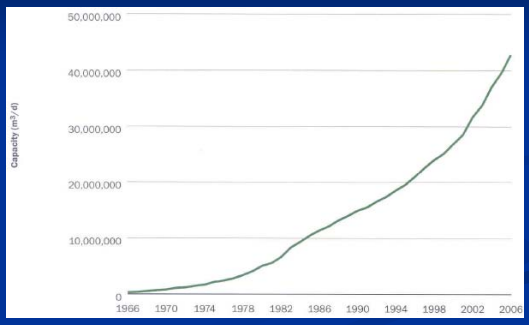
Desalination production capacity in the Mediterranean countries in 2006

values in m³ per day



Source: MEDRC, Koussai 2008, ADIRA workshop Athens

Global installed capacity since 1966



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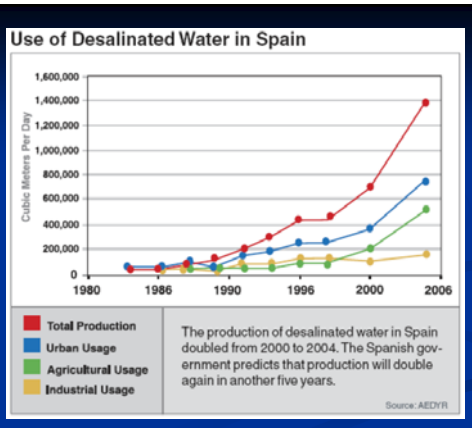


Desalination processes

- Desalination Processes
  - Thermal – needs thermal and electrical energy
  - Membranes – needs electrical energy only
- *Both are energy intensive, accounting for 40-75% of the operating cost*

Energy requirements

- It is the energy needed to get fresh water from saline water
- Depends on the technology (specific energy consumption kWh/m^3)
- Increases as salinity increases

Thermal desalination

- Normally, source of energy is fossil fuel
- Energy required to heat pure water from 25 °C to boiling at 100 °C and then evaporate to produce 1 m^3 of pure water is over 700 kWh
- Ways to affect this requirement
  - Use multi-stage concept to recover energy from condensing steam and hot brine leaving plant
  - Use low quality energy. Low grade steam from power plants (dual purpose plants)

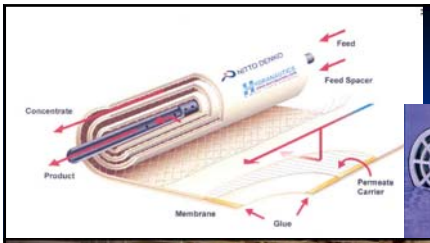
Thermal desalination

- Processes with multi stage concept to reduce energy consumption
  - Multi Stage Flash (MSF)
  - Multi Effect Distillation (MED)
  - Vapor Compression (VC)

Membrane processes

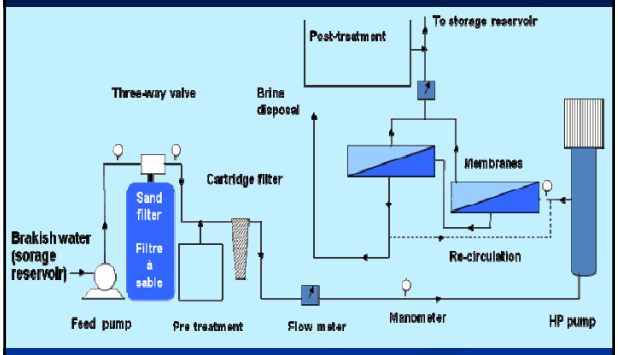
- Thermal processes involve phase change (evaporation) high energy requirements
- Need to produce water without involving phase change to reduce energy consumption
- Two processes emerged: Reverse Osmosis and Electrodialysis. RO is predominant

Reverse osmosis



Source: Zaara 2008, ADIRA workshop Athens

Typical RO design



Source: Mokhlisse 2008, ADIRA workshop Athens

Reverse osmosis

- **Energy consumption initially high, → 12 kWh/m^3**
- How to reduce energy consumption ?
- Major method→ Recover energy from reject brine with energy recovery devices

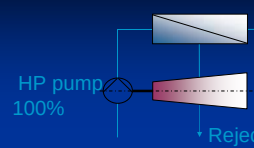
Energy recovery

- Recuperation of energy from brine with the maximum efficiency:
  - 55 – 75% of pressurized feed water leaves the system with about 60 bar pressure in the concentrate stream
  - High pressure concentrate is fed into recovery devices where it produces a rotating powerful output. Energy recovery systems lead to energy savings up to 40%

Energy recovery

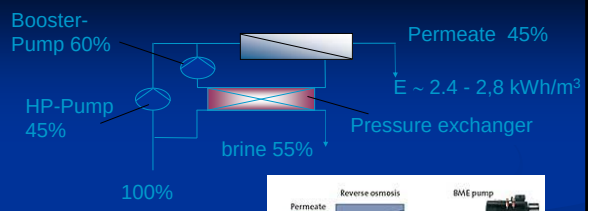
- **Turbo-machine systems, e.g.**
  - Reversible Pumps
  - Pelton Turbines
- **Volumetric Systems, e.g.**
  - ERI (Pressure Exchanger)
  - Axial Piston Pressure Exchanger Pump (LATEST)

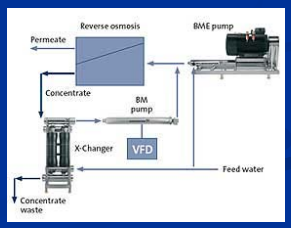
Energy recovery - turbine



Source: Zaara 2008, ADIRA workshop Athens

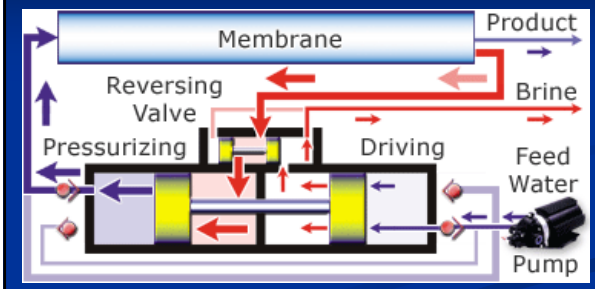
Energy recovery – pressure exchange





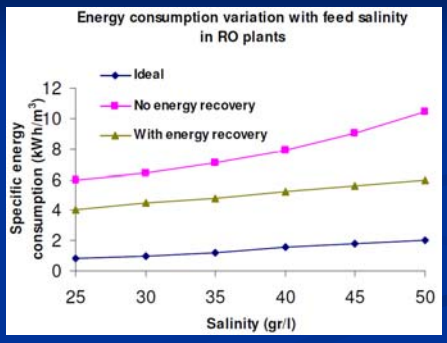
Source: Zaara 2008,
ADIRA workshop Athens

Hydraulic energy recovery



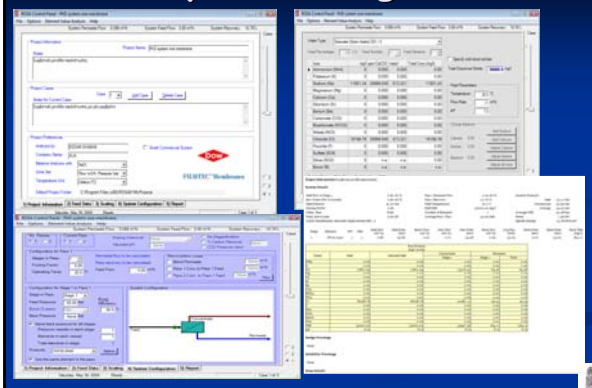
Source: Spectrawater

Reverse osmosis



Source: Mohamed 2009

RO system design tools



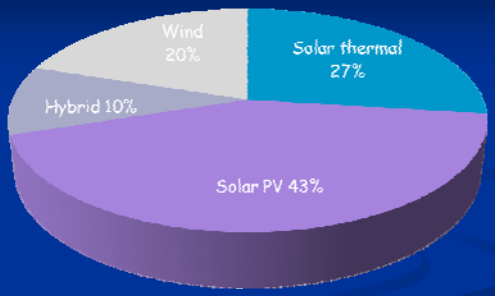
Desalination and renewables

- Attractive to reduce dependence on fossil fuels and CO_2 emissions
- Capital costs still high
- Operating costs very low
  - Solar thermal systems, photovoltaic, wind, wave, and geothermal can provide thermal, electrical or mechanical energy
  - Can be used in remote and rural areas for small scale applications
  - Can be used for medium scale plants
  - True but commercialization is forthcoming

Desalination and renewables

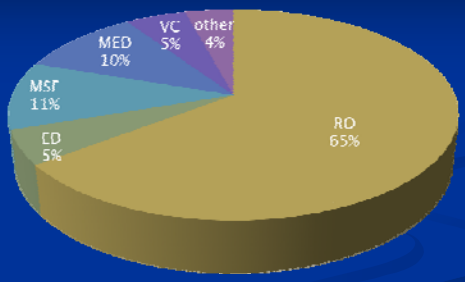
- Most attractive renewable energy sources
  - Wind energy
  - Solar energy (photovoltaics and solar thermal collectors)
  - Geothermal energy

Desalination and renewables



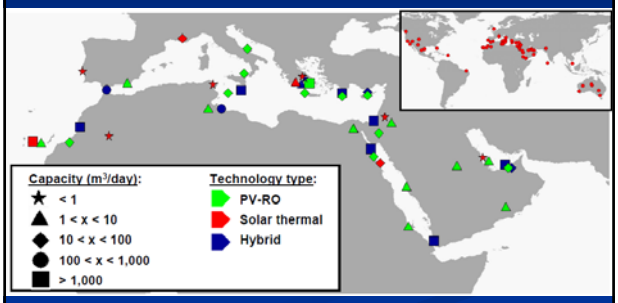
Source: Mathioulakis et al. 2007

Desalination and renewables



Source: Mathioulakis et al. 2007

Solar-driven RO desalination systems: geographical distribution and type in Mediterranean and MENA countries, and worldwide



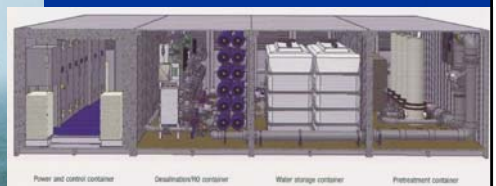
Source: Ghermandi & Messalem, DWT 2009

Desalination and renewables

- Wind energy
  - Electricity production to power reverse osmosis
  - Problems with the variation of the wind power production – need for storage and power regulation

Desalination and wind energy

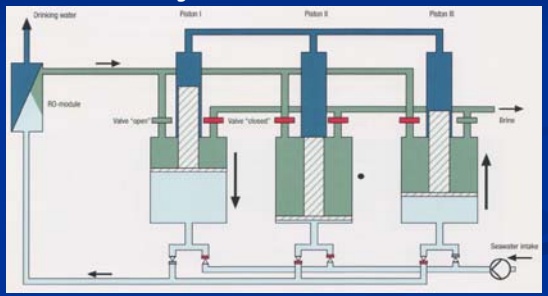
Example of a commercial technology



Source: ENERCON

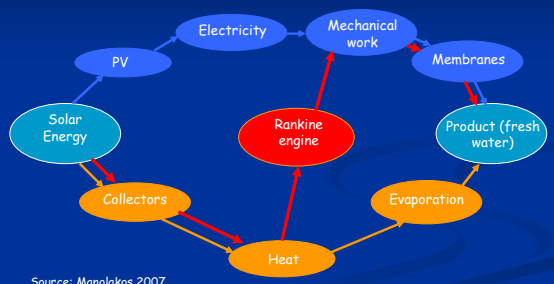
Desalination and wind energy

Pressure exchanger



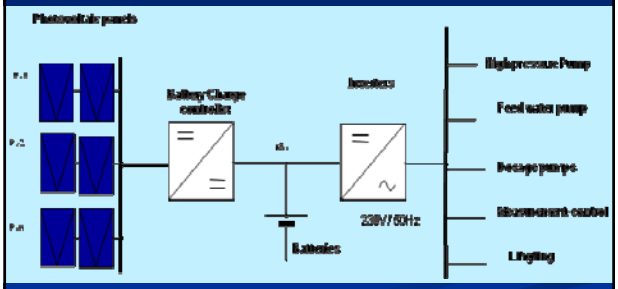
Source: ENERCON

Solar Energy and RO



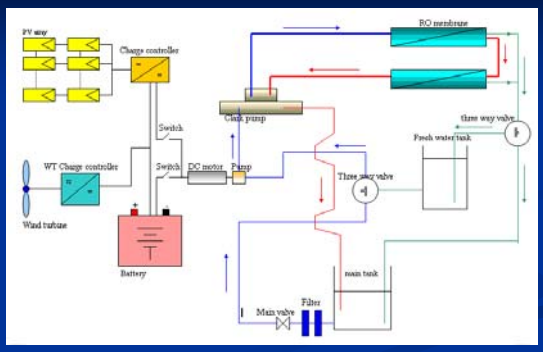
Source: Manolakos 2007

PV and RO



Source: Mokhlisse 2008, ADIRA workshop Athens

PV & wind driven RO



Source: Mohamed 2009

AUDESSY Decision Support Tool

- AUDESSY is a comprehensive DST for sizing and cost analysis of ADS
- On line data base & handbook for operators & installers

AUDESSY was developed by AUA and it can be freely downloaded at: www.adira.gr

The ADIRA HANDBOOK

- The ADIRA HANDBOOK: A guide to Autonomous Desalination Concepts
- A guide to decision makers, project developers and interested end users for the implementation of renewable energy driven desalination systems
- Designed for the non-specialist / non-engineer
- Provides instructions for planning, installing and maintaining of ADS and ready made material for training local users

Autonomous PV-RO (Msaim Morocco)

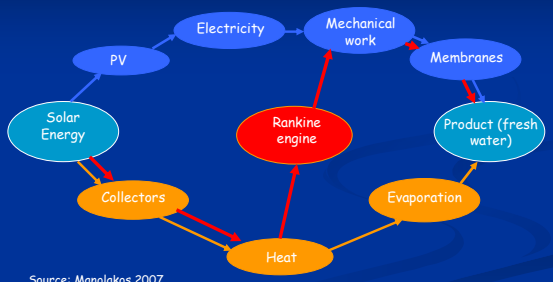
- System type: BWRO
- PV power: 3 kW_p
- Water production Capacity: 1 m^3/d

Source: ADIRA project

ADIRA project (MEDA)

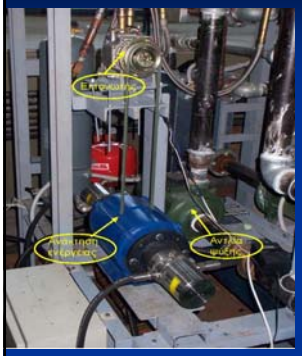
Country	System type	Use
Cyprus	Humidification/Dehumidification	Eco-tourism
Turkey	PV-RO	School
Turkey	PV-RO	Tourism
Jordan	PV-RO	School
Morocco	6 PV-RO systems	Rural villages

Solar Energy and RO



Source: Manolakos 2007

Solar organic Rankine RO



Source: Manolakos 2007

Desalinated water as energy storage in mini-grids

- RO desalination is an attractive technology of storing energy in the form of water
- It offers possibilities of increasing renewable power penetration in weak autonomous grids (mini-grids) such as those of the Greek islands
- Excess electricity produced from renewables can be used to desalinate water

Hybrid system (PV+wind+FC) and microgrid with RO

Source: Mohamed 2009

A microgrid system in Egypt

Source: HYRESS project 2009

Storage: Batteries and water

Source: HYRESS project 2009

What about the costs ?

- Wind powered RO desalination can be competitive at good wind potential
- Even PV driven RO desalination is competitive to transported water in the Greek islands
- Geothermal energy fits well to thermal desalination methods

Are there any environmental effects ?

- Yes
  - Energy use
  - Brine disposal

Conclusions

- Desalination increases at dramatic rates due to fresh water demand and decreasing production cost
- Carbon foot print of desalination will increase. Need for measures to be introduced for RE application
- Commercialisation of renewable energy driven desalination has just started
- Environmental problems can become significant especially in closed seas – research is necessary
- Research should continue for developing further the combination of renewable energy technologies with desalination technologies and reduce costs

Thank you for your interest

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