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Webinar: Renewable Desalination

Jorge Salas Orta

November 2018

Think about it …

Energy transformation always implies energy losses.
Those losses are residual energy (i.e. waste heat).

Efficiency

Thermal to Mechanical
- Motor gas power plant: 42%
- Thermoelelectric power plant: 35%
- Combined cycle power plant: 55%

Mechanical to Electric
- 96-98%

Mechanical to Hydraulic
- 70-88%

Radiation to Electric
- 16-18%

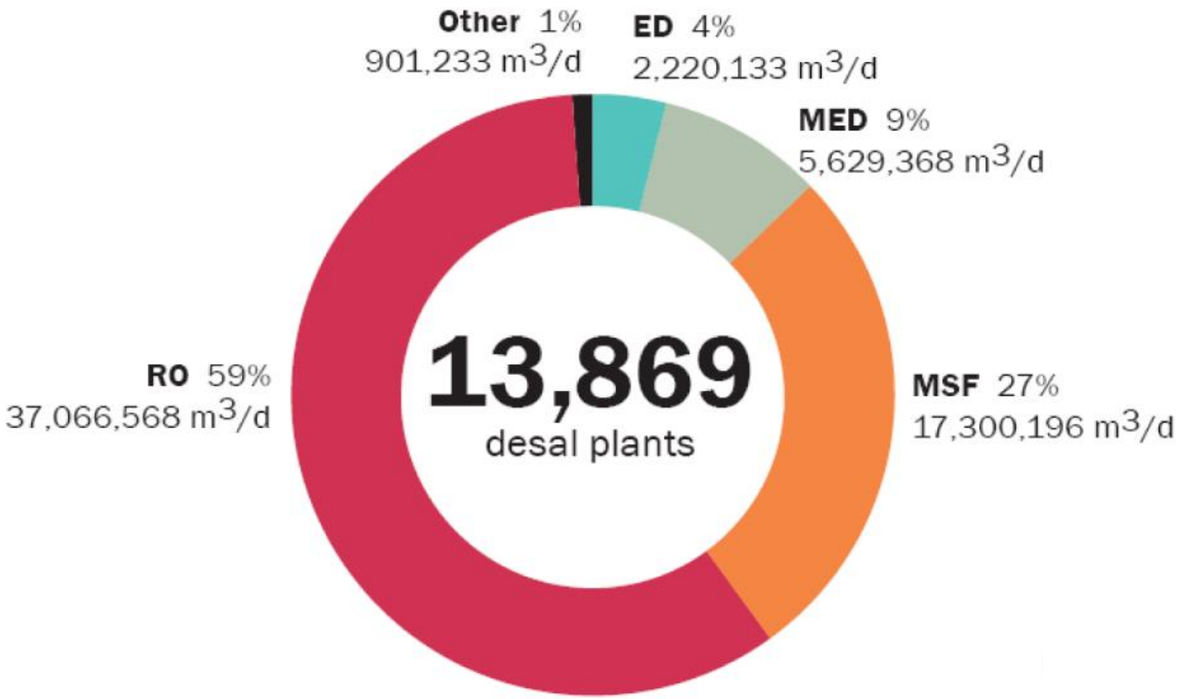
Future of desalination technologies + renewables:
=
use of energy losses from other processes
+
Avoid Energy transformation
=
Renewable Desalination

- Nowadays **131 desalination plants worldwide** (1% global desalination capacity) are powered by **renewable sources**
  - 43% solar photovoltaic
  - 27% solar thermal
  - 20% wind energy
  - 10% hybrid renewable energy sources

Source: Recent progress in the use of renewable energy sources to power water desalination plants Desalination 435 (2018) 97–113

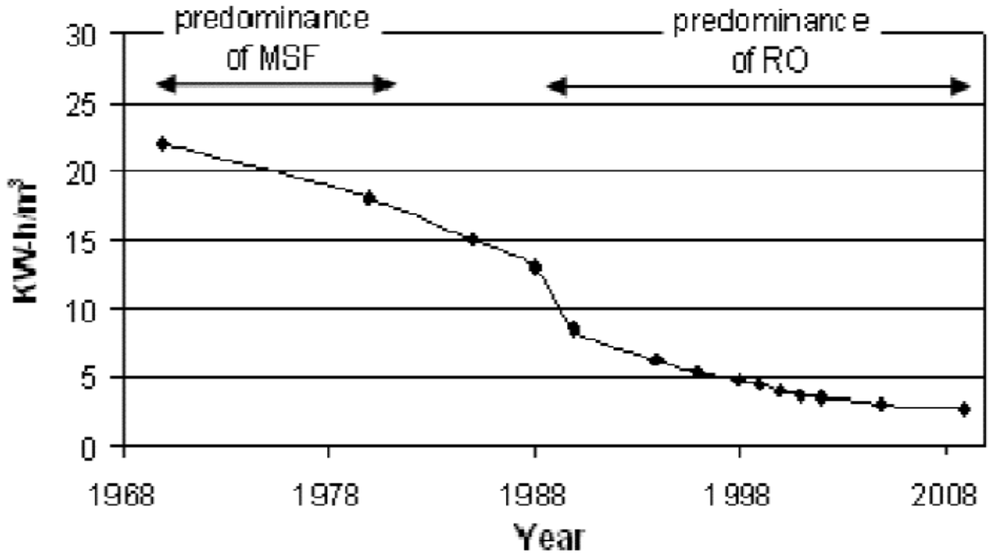
Desalination technologies

Available desalination technologies



Source: GWI DesalData/ IDA (2014)

Evolution of energy consumption of desalted seawater in Spain



Source: AEDyR (2009)

RO is the most used desalination technology worldwide

RO is the most energy efficient desalination technology in common use today

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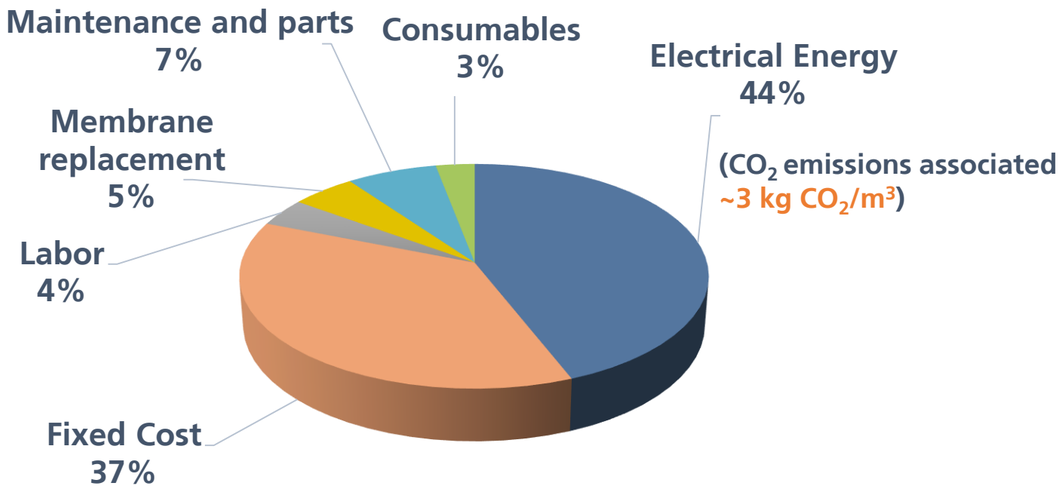
The cost of desalination

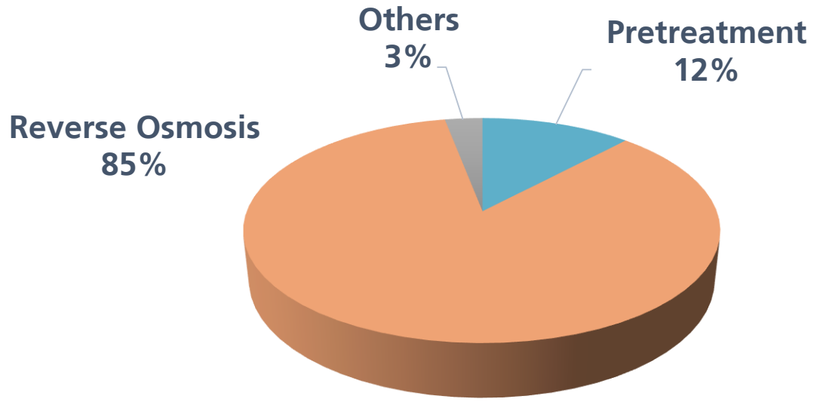
Energy is the largest segment of water production cost of desalination systems

Desalination plant costs breakdown per cubic meter of desalinated water (conventional energy)



*Considering 7 cUSD/kWh

Energy consumption breakdown in a desalination plant



Theorical minimun energy consumption RO is around 0.769 kWh/m^3 (TDS 35 g/l T: 25ºC)

Reducing the cost of the desalination. How is possible?

Scientific and technological community believes that there is a future

Combination of desalination technologies

The process combines Electrodialysis and Continuous Electrodeionization reduces desalting energy by over 50% compared to best available technology.

Case study: SIEMENS *Ingenuity for life*

TDS 35 g/l (NaCl)

T 25 ºC

Membrane resistance 2,8 ohm-cm^2

Current density 35 A/m^2

Osmotic permeability 4,5 ml/(m^2 h bar)

WR 40%

This process could use sea water desalination to produce potable water at an energy consumption of about 1.5 kWh/m^3

Use of renewable energy in desalination

New world record-breaking tariff achieved for the 300 MW PV Project of US Cents 2.3417/kWh

ACWA Power wins the first ever Utility Scale Renewable Energy project in Saudi Arabia

Tuesday, 6 February 2018

- Record-Breaking Tariff Achieved for the 300 MW PV Project
- A 25-year PPA contract was awarded to ACWA Power at a new world record tariff of 8.781 halalas/kWh (US Cents 2.3417/kWh)
- Located at a site at Al Jouf spanning over six square kilometers, Skaka plant of an investment value of c. SR 1,132 million (c. US $ 302 million) will generate 300 MW

ACWA Power, the Saudi, global leader in developing, constructing and operating power generation and desalination water plants in 11 countries, has won Skaka IPP PV solar project, the first utility scale Renewable Energy plant at the oil capital, the Kingdom of Saudi Arabia. This plant is the first of what will be a series of procurement within the visionary and ambitious Saudi national renewables program aiming to produce 9.5 GW of renewable energy by 2023 as a first phase. The 25-year Power Purchase contract was awarded for ACWA Power at a new world record tariff of US Cents 2.3417/kWh (8.781 halalas/kWh).

Located in Al Jouf at a site spanning over six square kilometers, Skaka plant of an investment value of c. US $ 302 million (c. SR 1,132 million) will generate 300 MW.

Using only solar power, we can get a 30% saving in the price of the desalinated water

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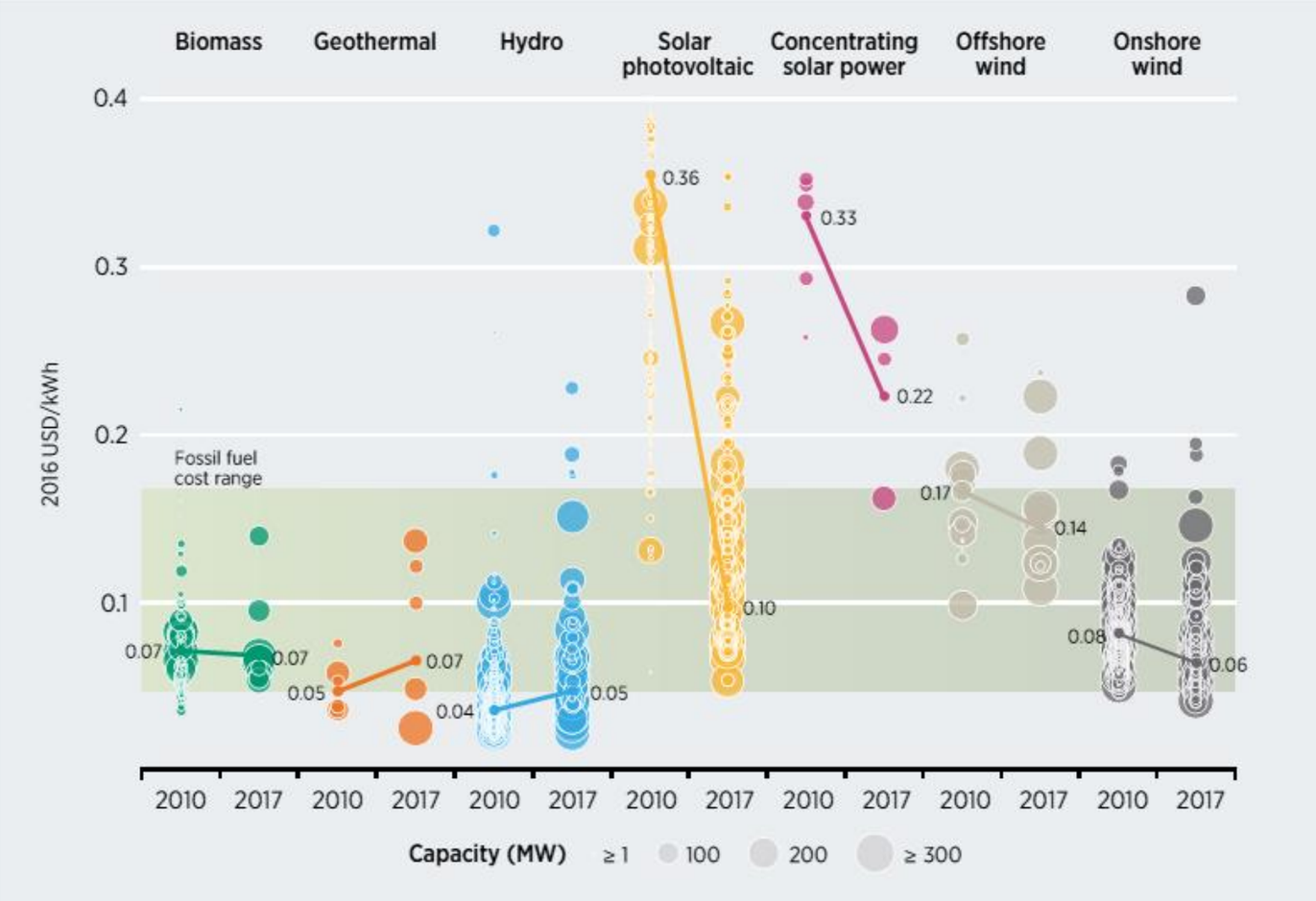
Reducing the cost of the desalination. How is possible?

The cost of the renewable energies has been reduced in the last ten years

Global levelized cost of electricity from utility-scale renewable power generation technologies, 2010-2017



Source: IRENA Renewable Cost Database (2018)

Latest tariff

PV: USD Cents 2.3 kWh

Thermosolar: USD Cents 7.3 kWh

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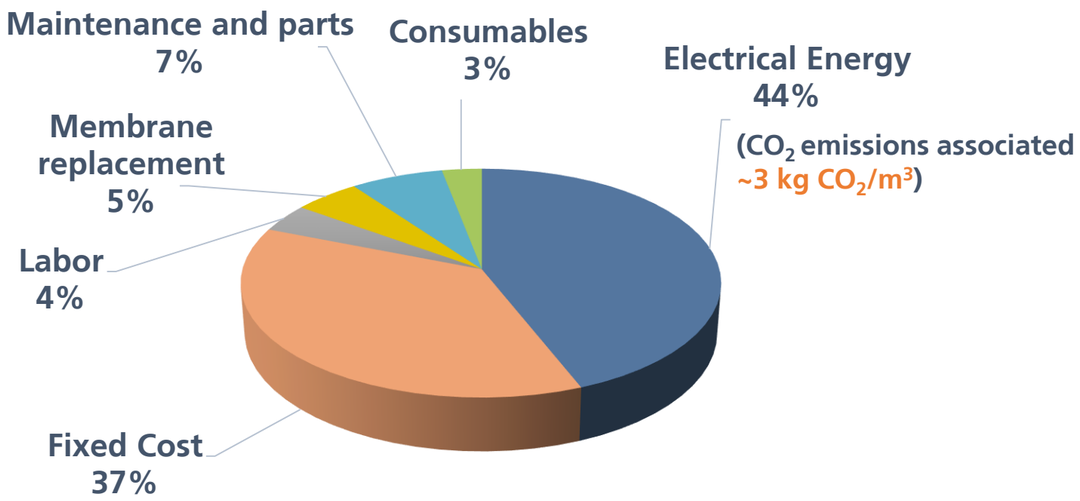
Reducing the cost of the desalination. How is possible?

Renewable energies, the sustainable solution. Desalination powered with solar energy

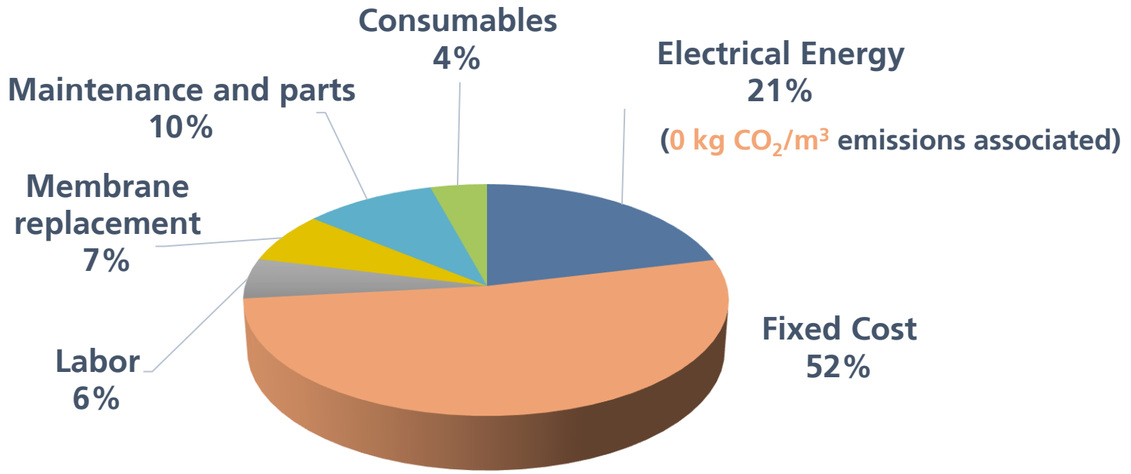
Desalination plant costs breakdown per cubic meter of desalinated water

Conventional energy



*Considering 7 cUSD/kWh

Only solar power



*Considering 2,4 cUSD/kWh

Using only solar power, we can get a 30% saving in the price of the desalinated water

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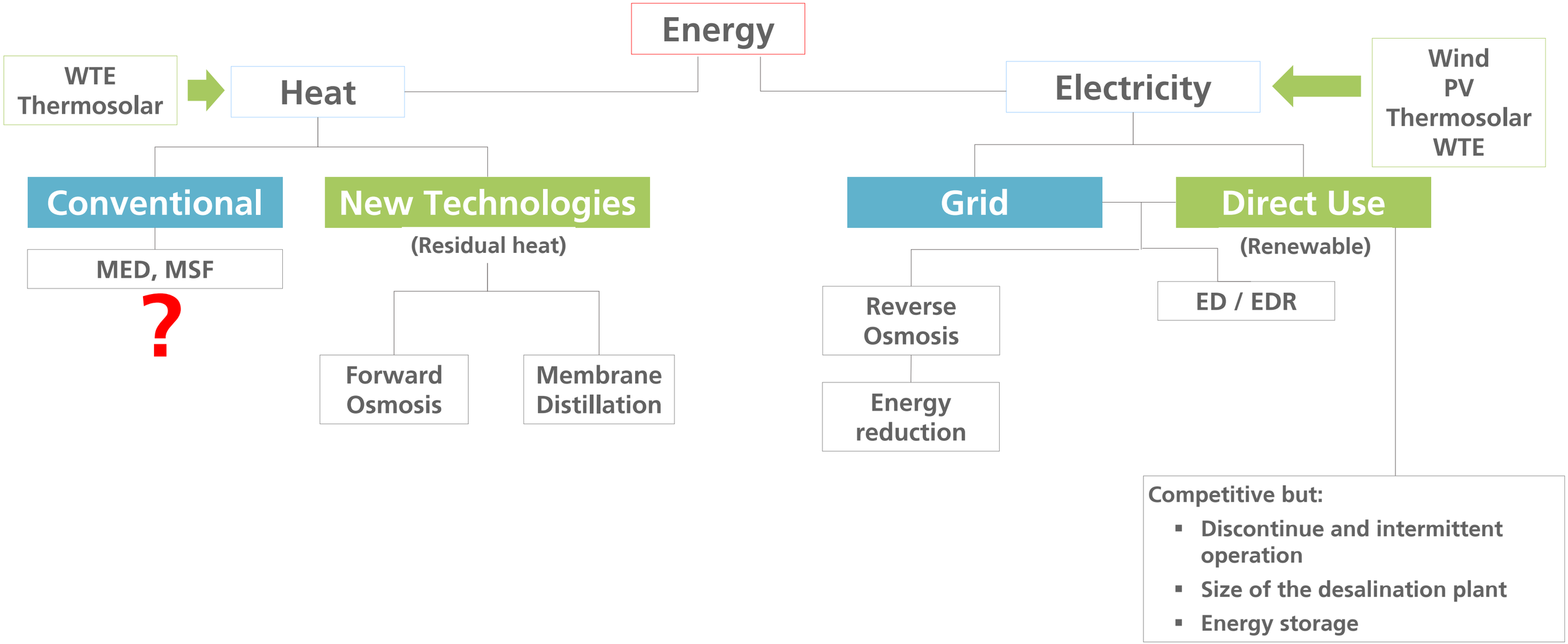
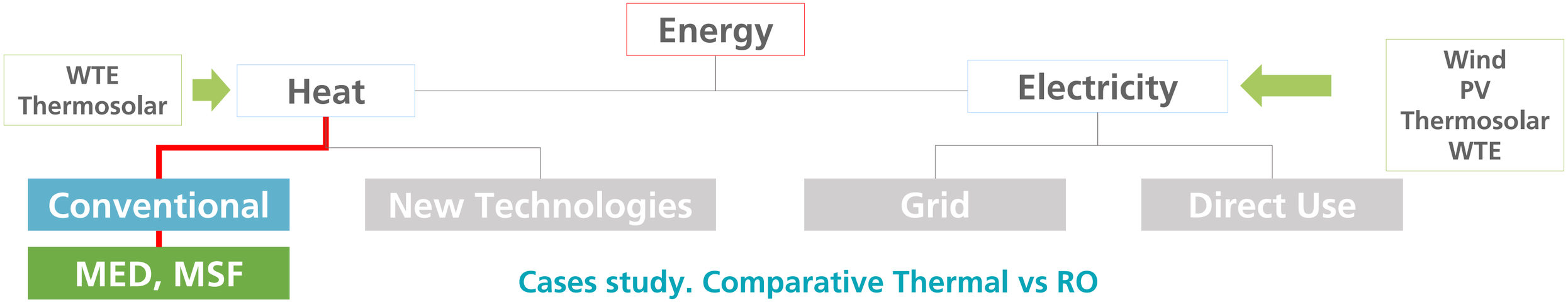
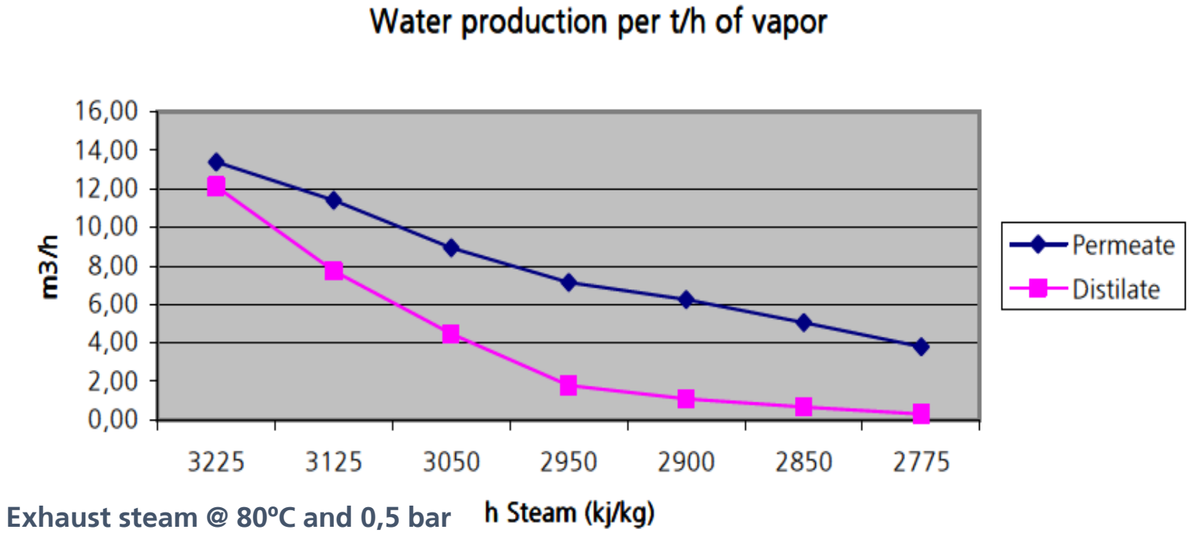
Desalination conventional technologies vs renewable energies



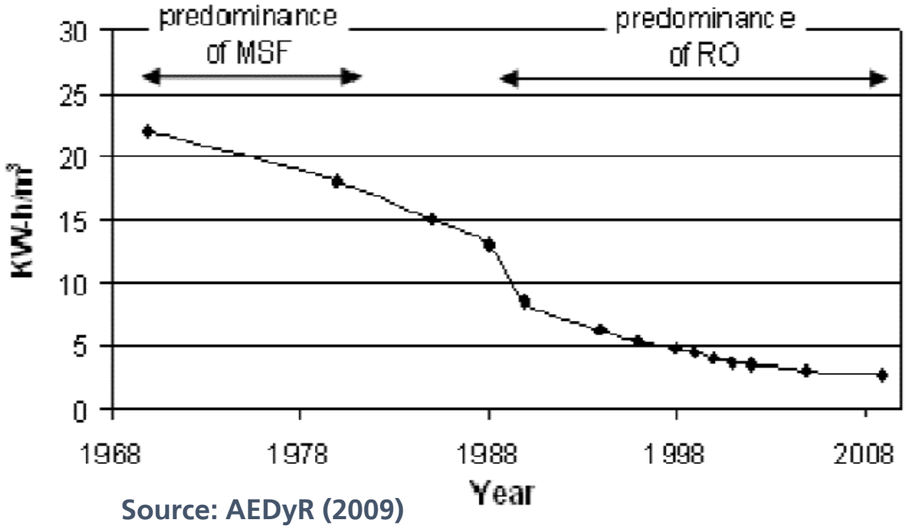
Desalination conventional technologies vs renewable energies



Cases study. Comparative Thermal vs RO



Exhaust steam @ 80ºC and 0,5 bar



Source: AEDyR (2009)

Increase efficiency: By using steam to generate electricity, we can produce more desalinated water.

A new thermal technology is needed for heat direct use.

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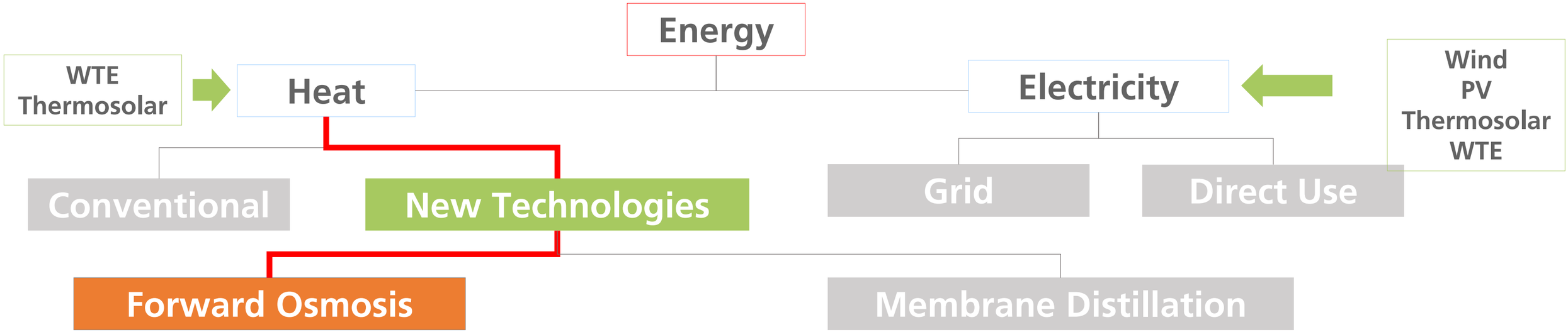
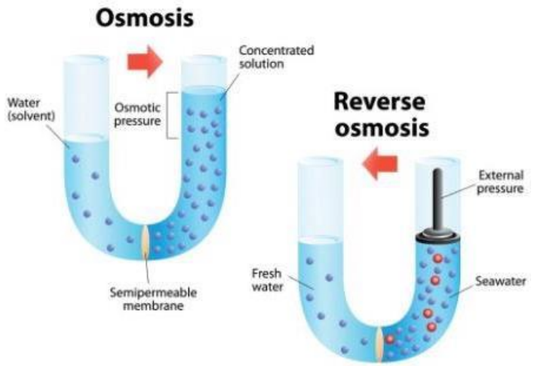
Desalination conventional technologies vs renewable energies



➢ Draw solution that could be recovered by residual heat



Desirable properties of ideal osmotic agent:

- Non-toxic, inert, not fouling in nature, inexpensive
- High solubility
- High osmotic pressure on a mass or molar basis
- Easy to recover

Osmotic agents considered

- Carbon dioxide/ ammonia- recovered through use of low grade heat
- Sodium chloride
- Organic molecules (precipitate at higher temperatures)
- Mixtures (sugars ad inorganic salts)
- Nanoparticles, magnetized particles

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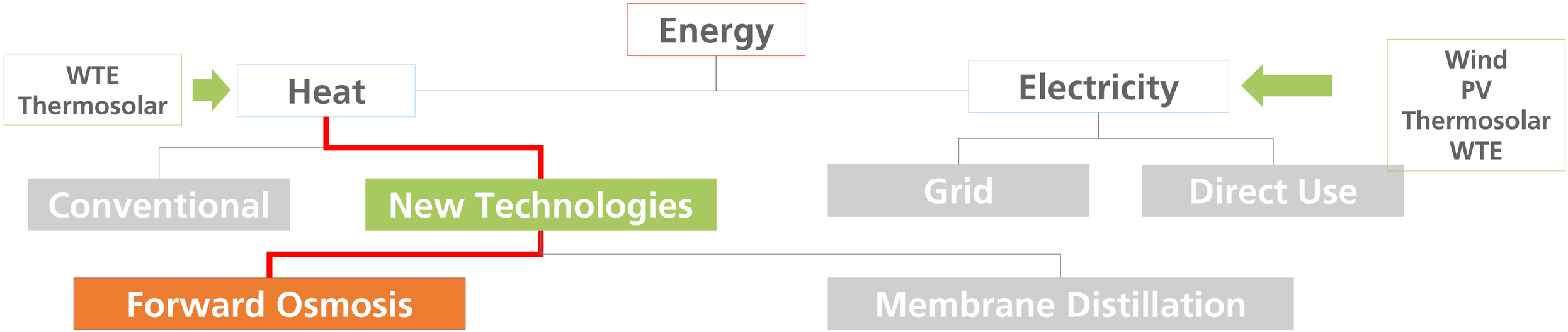
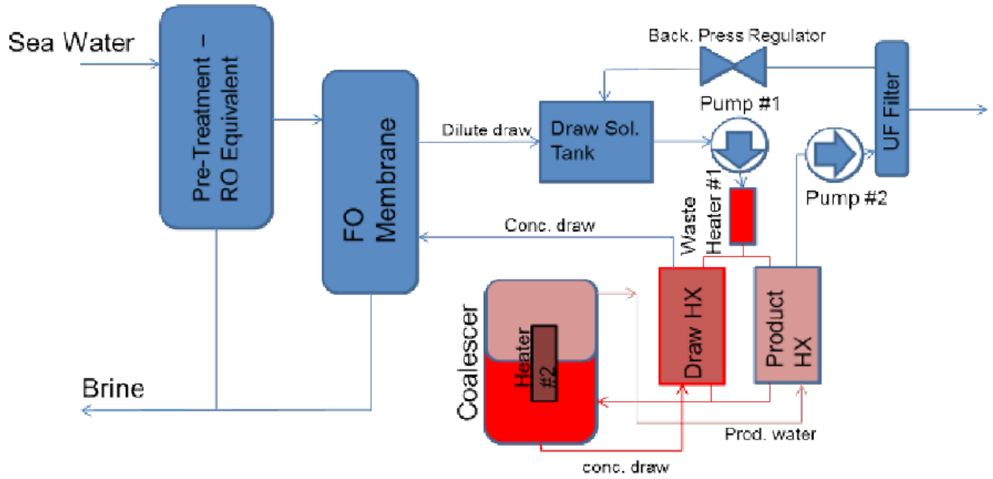
Desalination conventional technologies vs renewable energies



TREVI SYSTEMS



- The technology is based on the use of waste heat or low grade thermal heat at 75ºC to separate the draw solution from the water.
- Heat requirements are approximately 50 Mj/m^3 (13.8 kWh/m^3)

The process desalinates seawater at 1/8th the electrical energy of current RO systems (0.5 kWh/m^3)

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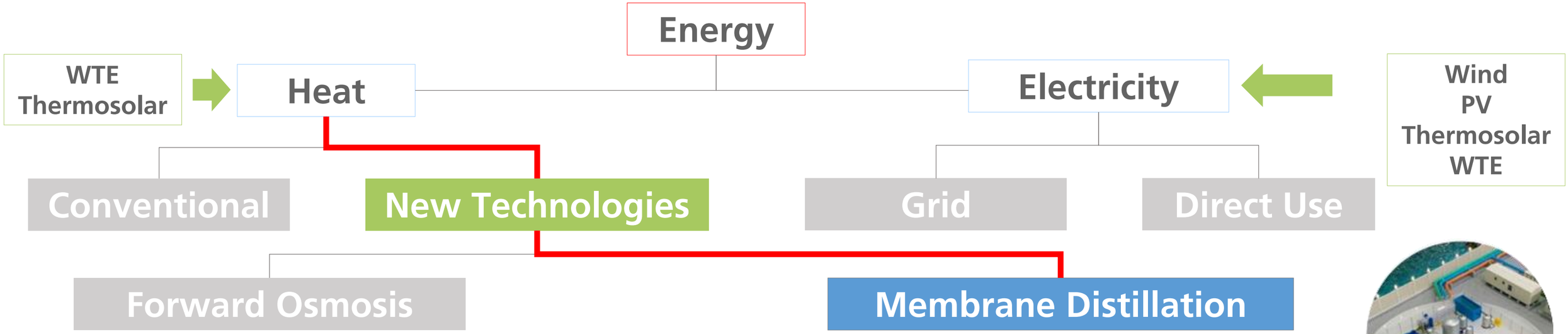
Desalination conventional technologies vs renewable energies

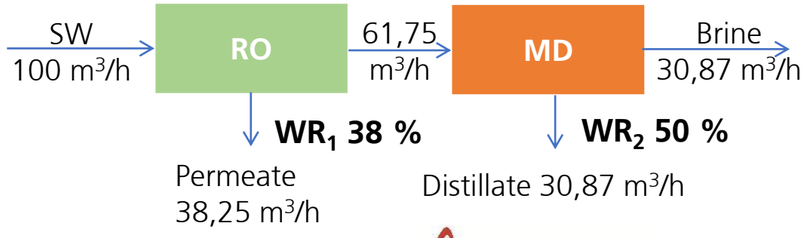


- Powered by **waste heat** (Memstill® technology):
  - Energy savings around 30% vs RO
- Higher recovery values than RO because these systems are not limited by the osmotic pressure
- **PV collectors** could supply electricity MD requires to drive pumps and other electric devices, with direct current battery cells and electric current inverters

Masdar Project:

- Location: Ghantoot, UAE
- Capacity: 1.060 m^3/d
- Thermal energy consumption: 80 kWh/m^3.
- But very low temperature heat required (40ºC).
- Technology: Micro-ultrafiltration, reverse osmosis & membrane distillation

Total Water Recovery 69 % using residual heat



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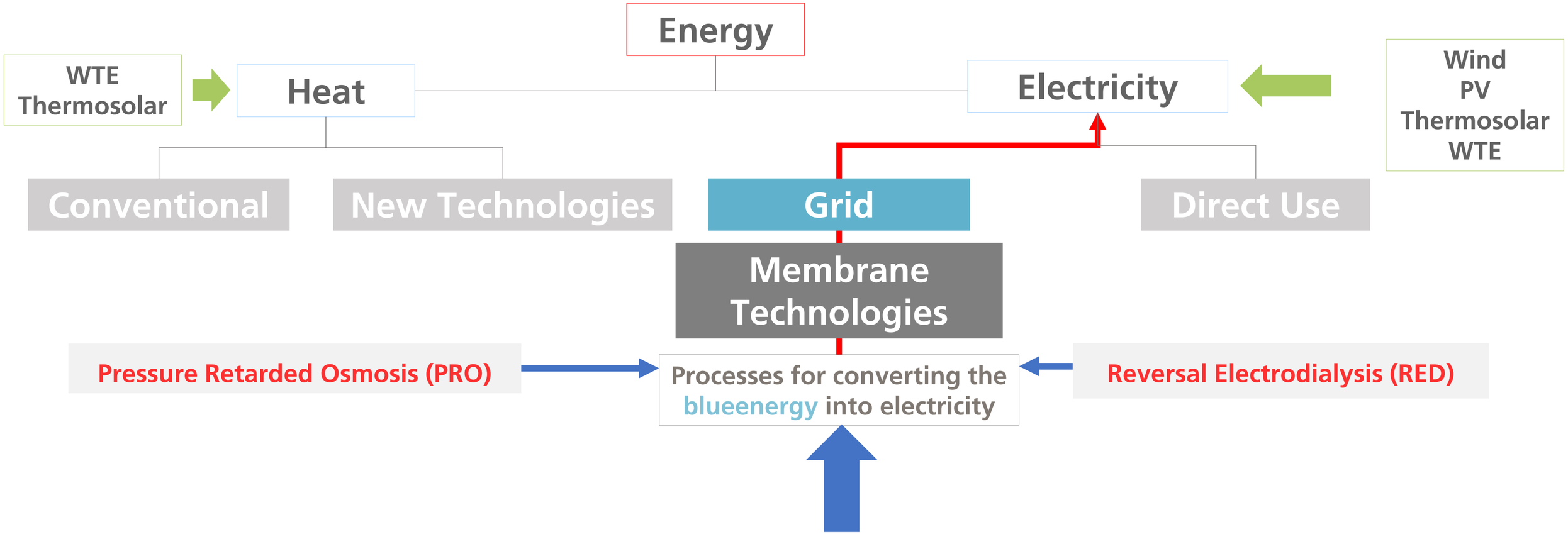


- **Production of osmotic energy**
- **Dilution of seawater**
- **Energy reduction around 30%**

Desalination conventional technologies vs renewable energies

Energy

WTE
Thermosolar

Heat

Electricity

Wind
PV
Thermosolar
WTE

Conventional

New Technologies

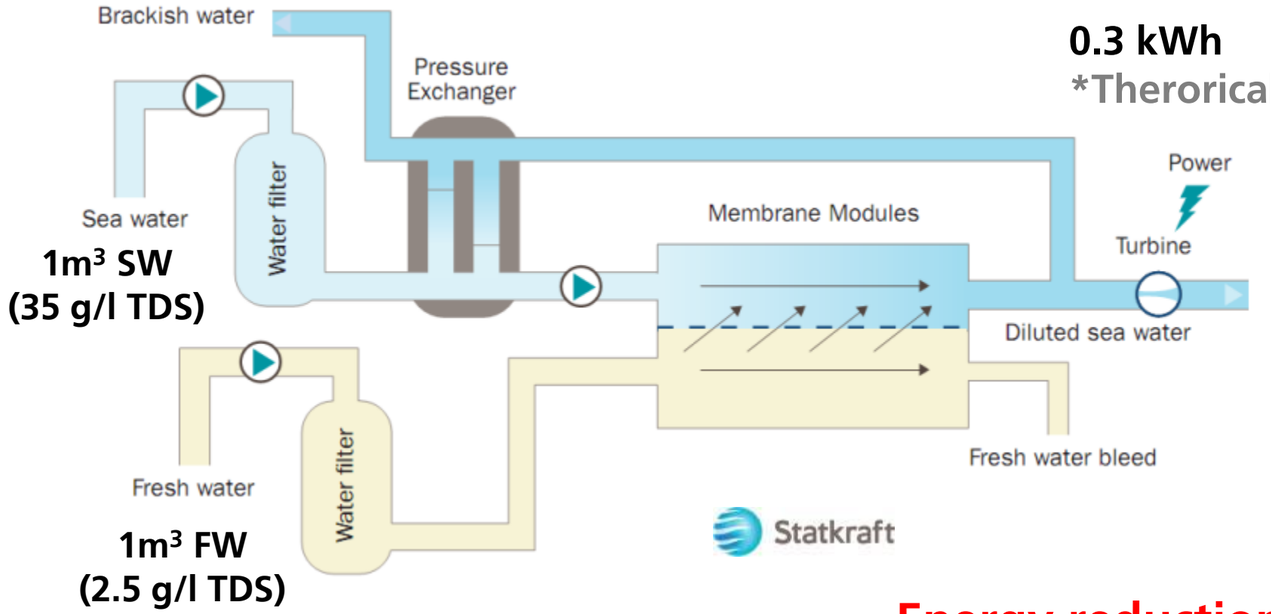
Grid

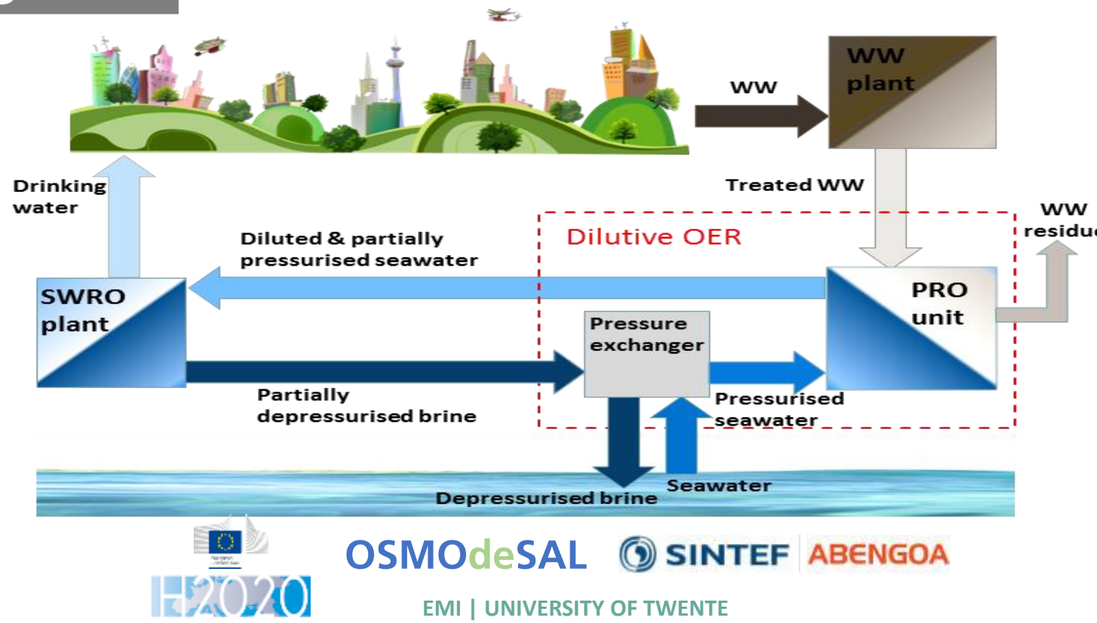
Direct Use

Membrane Technologies

Pressure Retarded Osmosis (PRO)

0.3 kWh
*Therorical value





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Energy reduction around 30%

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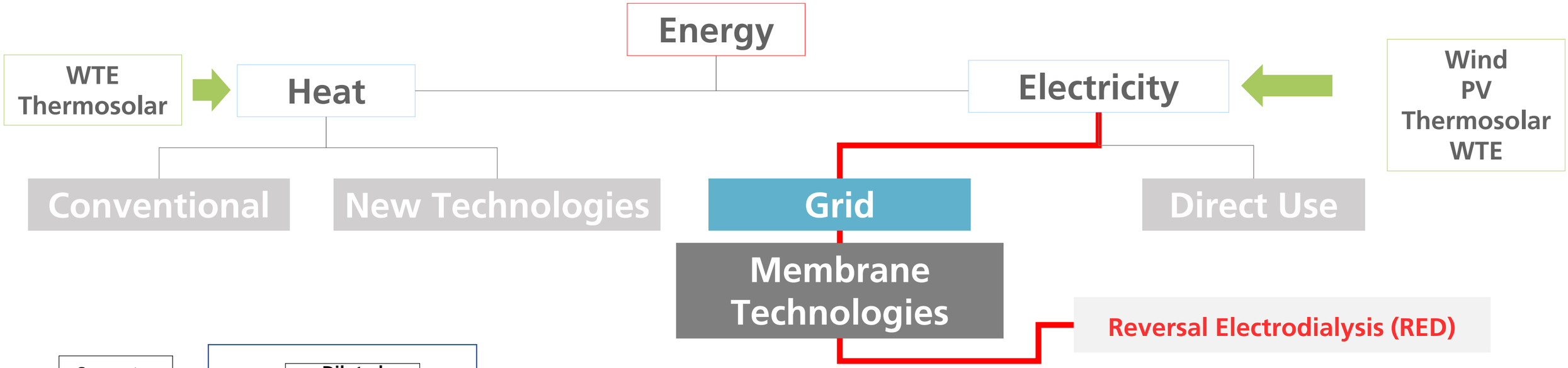

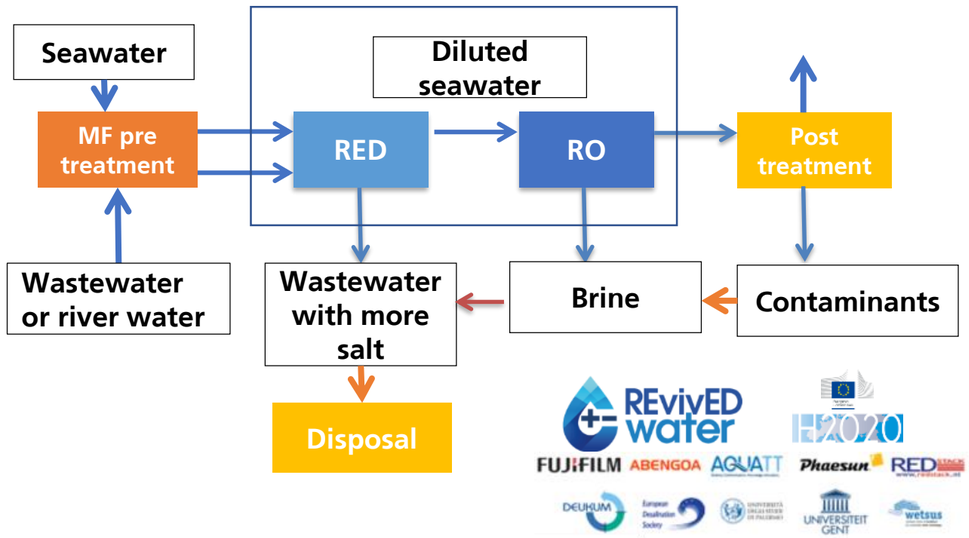

- **High efficiency:** Significant reduction of the energy consumption. The new revival of ED system requires Less than half the energy used by today's state-of-the-art Reverse Osmosis.
- **Versatility:** Innovative system for brackish water desalination, seawater desalination and tap water softening
- **Osmotic Energy:** The system allows the production of electricity by mixing effluents with different salinity gradient

Reduction of energy consumption below 1.5 kWh/m³
(theoretical minimum is 1.06 kWh/m3 50% WR and 35 g/l TDS)

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Desalination conventional technologies vs renewable energies

Energy

WTE
Thermosolar

Heat

Electricity

Wind
PV
Thermosolar
WTE

Conventional

New Technologies

Grid

Direct Use

PV, Wind,…

Competitive but:

- **Discontinue and intermittent operation**
- **Size of the desalination plant**
- **Energy storage**

Dessalement et éolienne à Dakhla: Stimuler l'agriculture

Par **Perspectives Med** - Avr 19, 2018

Facebook Twitter Google+ Pinterest

Le ministère de l'Agriculture, de la pêche maritime, du développement rural et des eaux et forêts vient de Dakhla. aura une ca qui devrait conception, pour une pé investissen MDH pour l' tonnes de r MDH par an d'offres pou intéressés s dans le cad

The Sydney Desalination Plant is powered by 100% renewable energy.

Background

In mid 2008, the previous owner of the plant, Sydney Water Corporation, signed 20 year contracts for electricity, Renewable Energy Certificates and the construction of the Capital Hill Wind Farm. The Sydney Desalination Plant's power needs are fully offset by renewable energy produced at the purpose built Capital Hill Wind Farm. The Wind Farm is owned and operated by Infigen and it is one of Australia's largest renewable energy contracts.

How much energy does the plant use?

The Sydney Desalination Plant requires roughly 46 Megawatts at full production. The consumes is equivalent to the energy consumed by a domestic fridge if all of the wa the household was supplied from our desalination plant.

The Capital Hill Wind Farm

The Capital Hill Wind Farm generates around 140 Megawatts from 67 turbines. This is about the amount of energy used by 60,000 homes, and is three times the power needed for the desalination plant. Each turbine is 80 metres tall and its rotors span a diameter of 88 metres.

LATEST NEWS

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Tuesday, 6 February 2018

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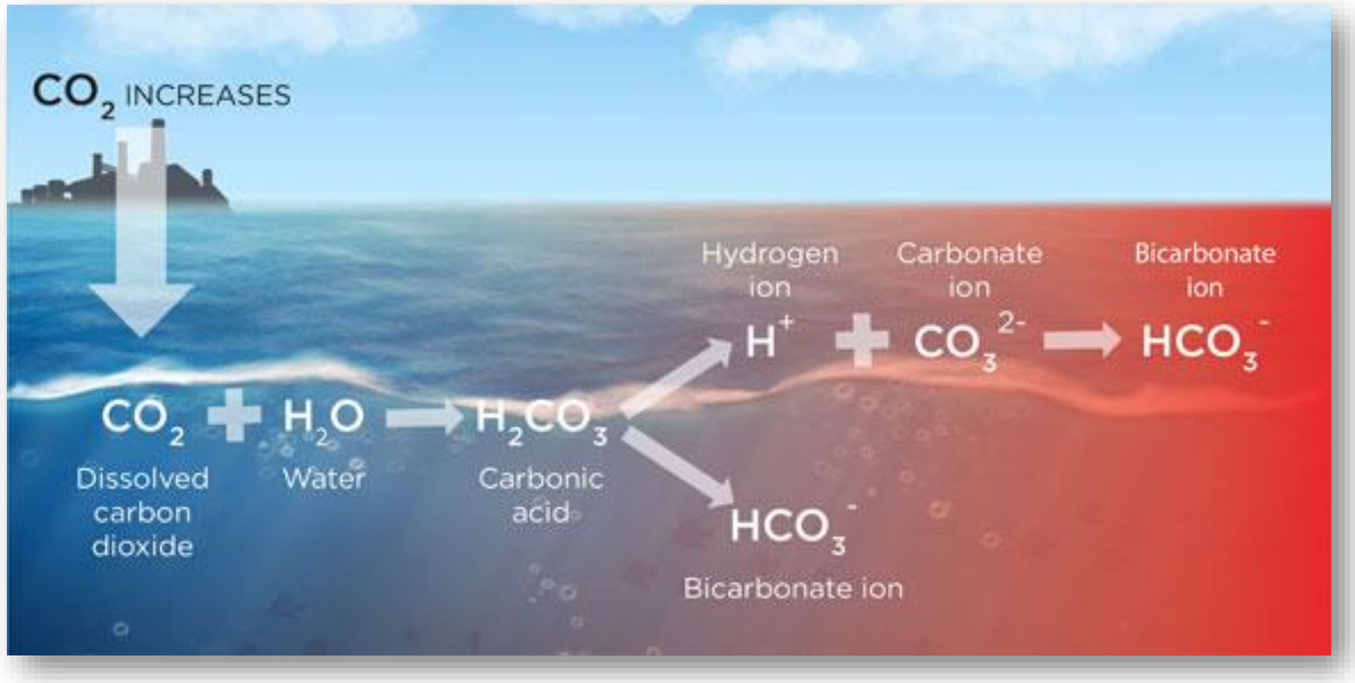
Advanced technologies: CO_2 Capture

Considering the physicochemical properties of brines, it can be used to capture CO_2

SWRO Brine could capture up to 135 g/m^3 CO_2

SW
TDS 34 g/l
Mg 1,198 mg/l
Ca 591 mg/l
SO_4 2,662 mg/l

SWRO Brine
TDS 68 g/l
Mg 2,394 mg/l
Ca 1,181 mg/l
SO_4 5,319 mg/l



USGS
science for a changing world

2014 Minerals Yearbook

MAGNESIUM COMPOUNDS [ADVANCE RELEASE]

Carbon sequestration is gaining world attention as a method to reduce greenhouse gas emissions. Magnesium-based minerals, particularly brucite and olivine, are being investigated as minerals that are naturally capable of sequestering carbon dioxide emitted by burning fossil fuels and other human activities and transforming the gas into a geologically stable carbonate. If this technology were to be developed commercially, it could represent a significant new market for these minerals.

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Thank you

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