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Qatar Environment & Energy
Research Institute

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Unlocking human potential.

The Role of Science & Technology in Addressing the World's Challenges in Water, Energy and Food

Adel Sharif

asharif@qf.org.qa

Qatar Environment and Energy Research Institute
The Qatar Foundation

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The Millennium Development Goals

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Unlocking human potential.

1. Eradicate extreme poverty and hunger
2. Achieve universal primary education
3. Promote gender equality and empower women
4. Reduce child mortality
5. Improve maternal health
6. Combat HIV/AIDS, malaria and other diseases
7. Ensure environmental sustainability
8. Develop a Global Partnership for Development

Global Challenges F. E. W.

- Water, Food & Energy the most important commodities for our existence and the survival of our society and our civilization.

Energy + Water = Food

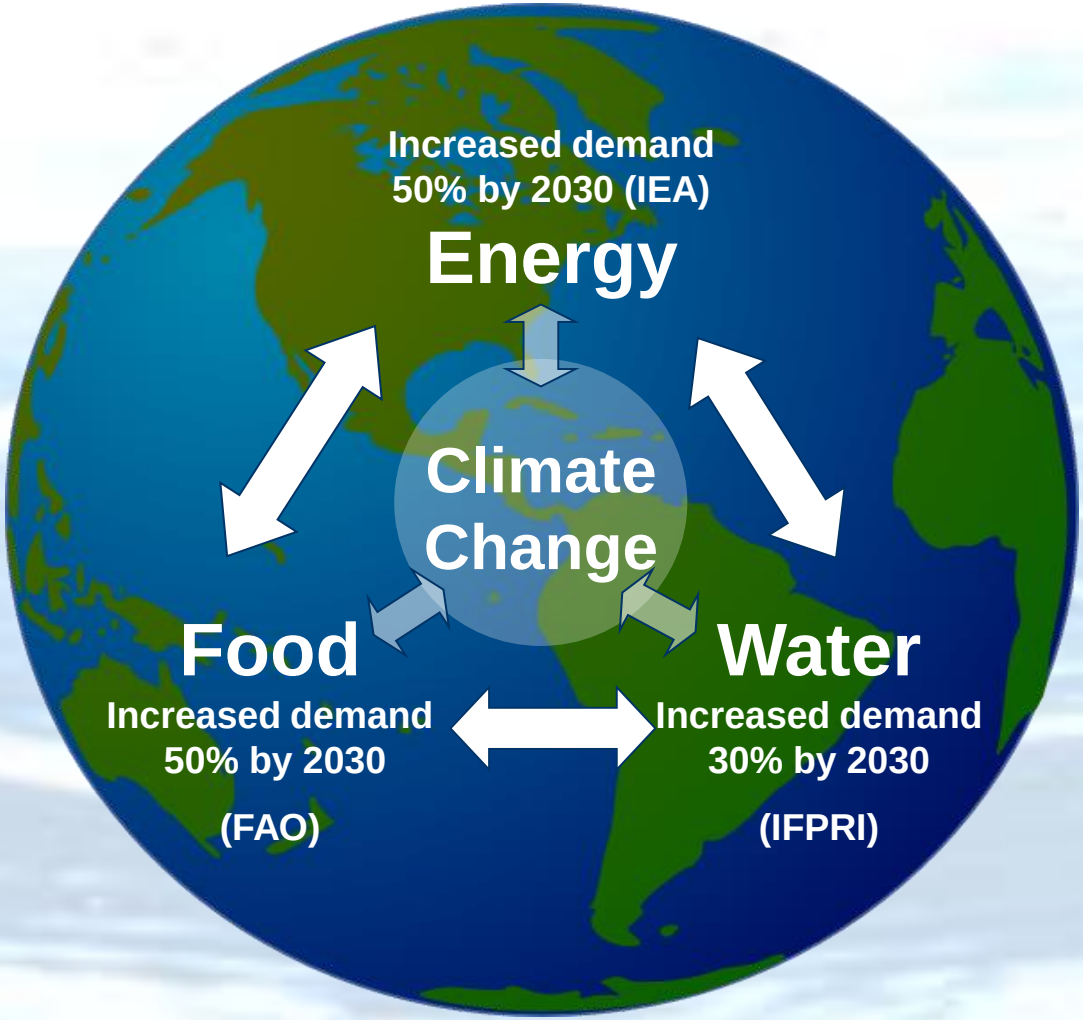
- ***Food Shortages – A Sleeping Tsunami***
- ***Food, Energy and Water 'Perfect Storm' by 2030***

CC = GW + GH

- Highest national priority -Ensuring an adequate, safe, sustainable and secure supply of

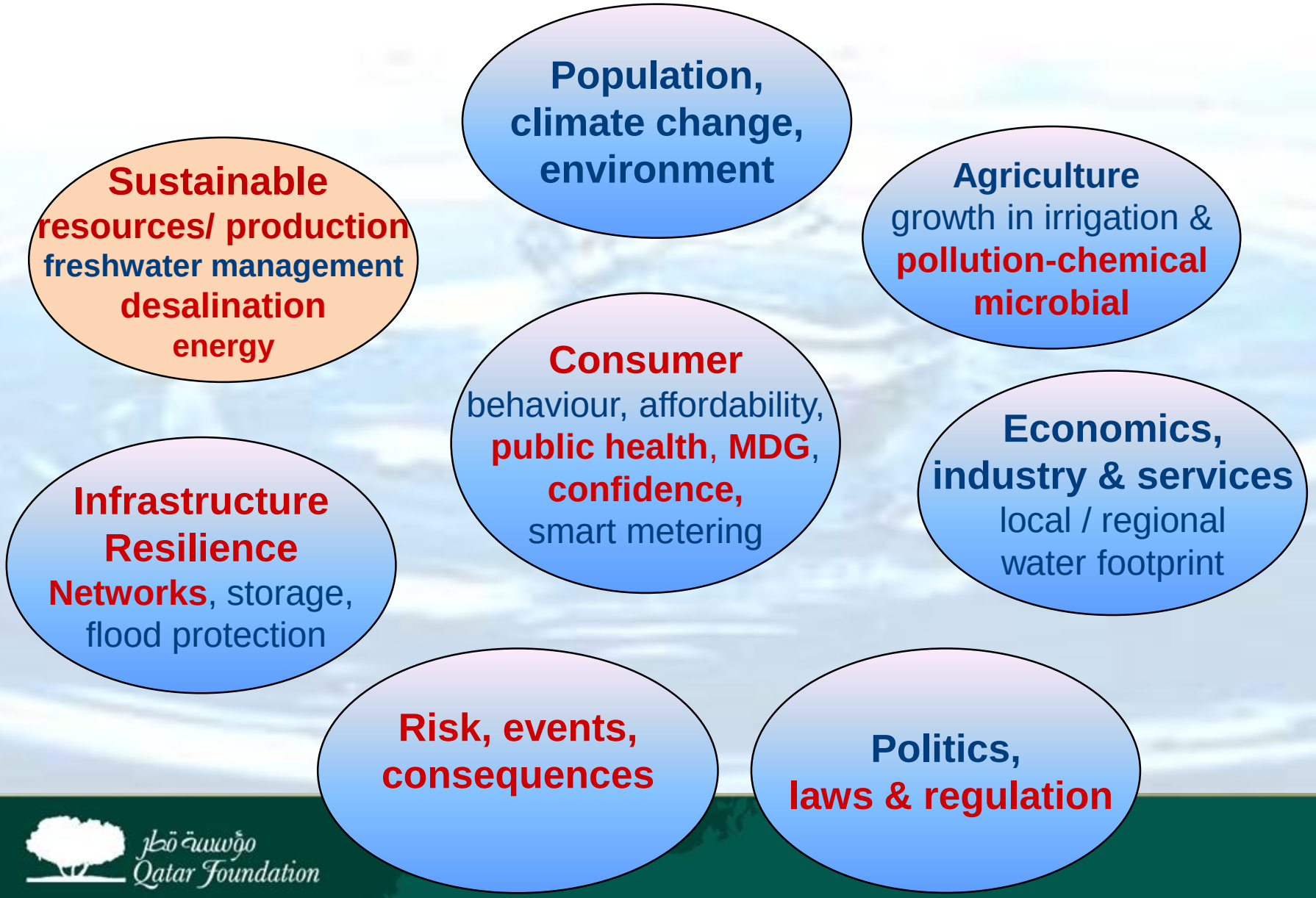
Water, Energy and Food.

The Perfect Storm?



Source: UK Government Office for Science. Prof. Sir. John Peddington

Water security – Global issues

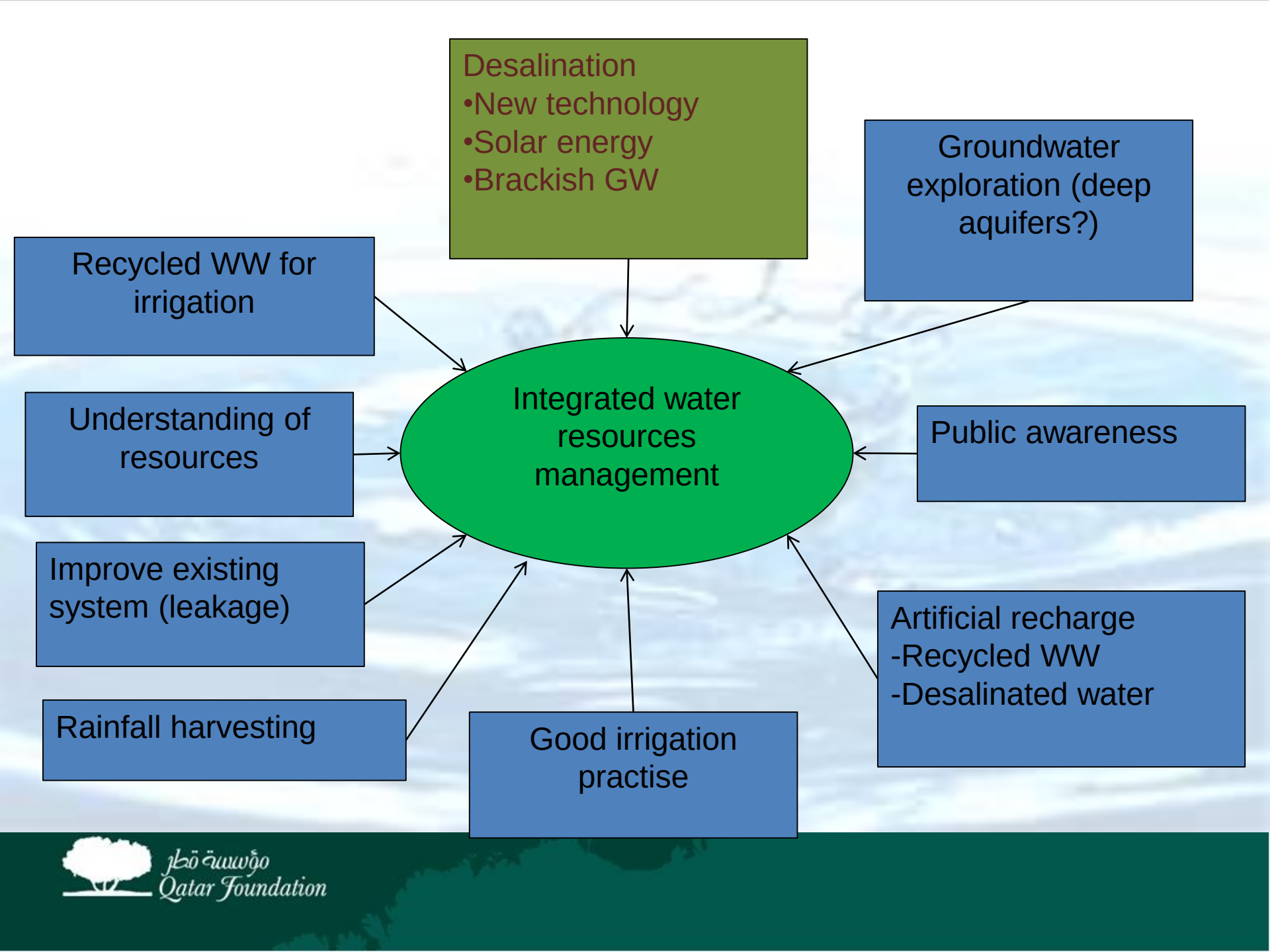


Water Situation in Qatar

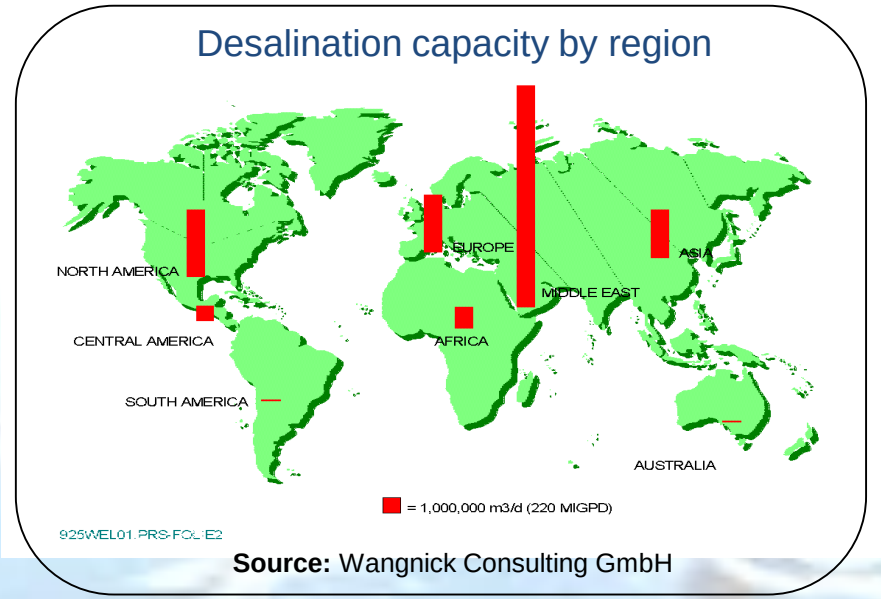
- Population: 2.2 million (October 2013)
- Average water consumption: 500 L per capita per day
- Desalination (1.49 MCM/d) meets 99% of domestic needs
- Average annual GW recharge: 56 MCM/yr
- Average GW extraction: 220 MCM/yr
- Average annual GW recharge through KSA: 2.2 MCM/yr
- Annual domestic WW production: 110 MCM/yr
- Treated domestic wastewater (tertiary treatment): 98% (108 MCM/year)
- Average water consumption per sector (2012) :

  59% agriculture, 39% domestic and 2% for industry

Source: Darwish and Shomar (2013)


Desalination
•New technology
•Solar energy
•Brackish GW
Groundwater exploration (deep aquifers?)
Recycled WW for irrigation
Integrated water resources management
Understanding of resources
Public awareness
Improve existing system (leakage)
Artificial recharge
-Recycled WW
-Desalinated water
Rainfall harvesting
Good irrigation practise

Desalination: A Solution for Water Security?



Source: Wangnick Consulting GmbH

"If we could ever competitively, at a cheap rate, get fresh water from salt water this would be in the long-range interests of humanity and would dwarf any other scientific accomplishments."
--John F. Kennedy, 1962

- Desalinated water meets 99% of domestic needs in Qatar
- 40% of the world desal capacity is in the ME.
- Sea is a sustainable source with 70% of world population live within 50km.
- Current desalination significantly more expensive than conventional water treatment due to high energy costs
- Step change in technology required

QEERI's Vision to Qatar Water Security

- ***Innovation*** is solving tomorrow's problem today!

- Research Drivers
  - Energy Efficiency, quality, cost, environmental impacts and sustainability

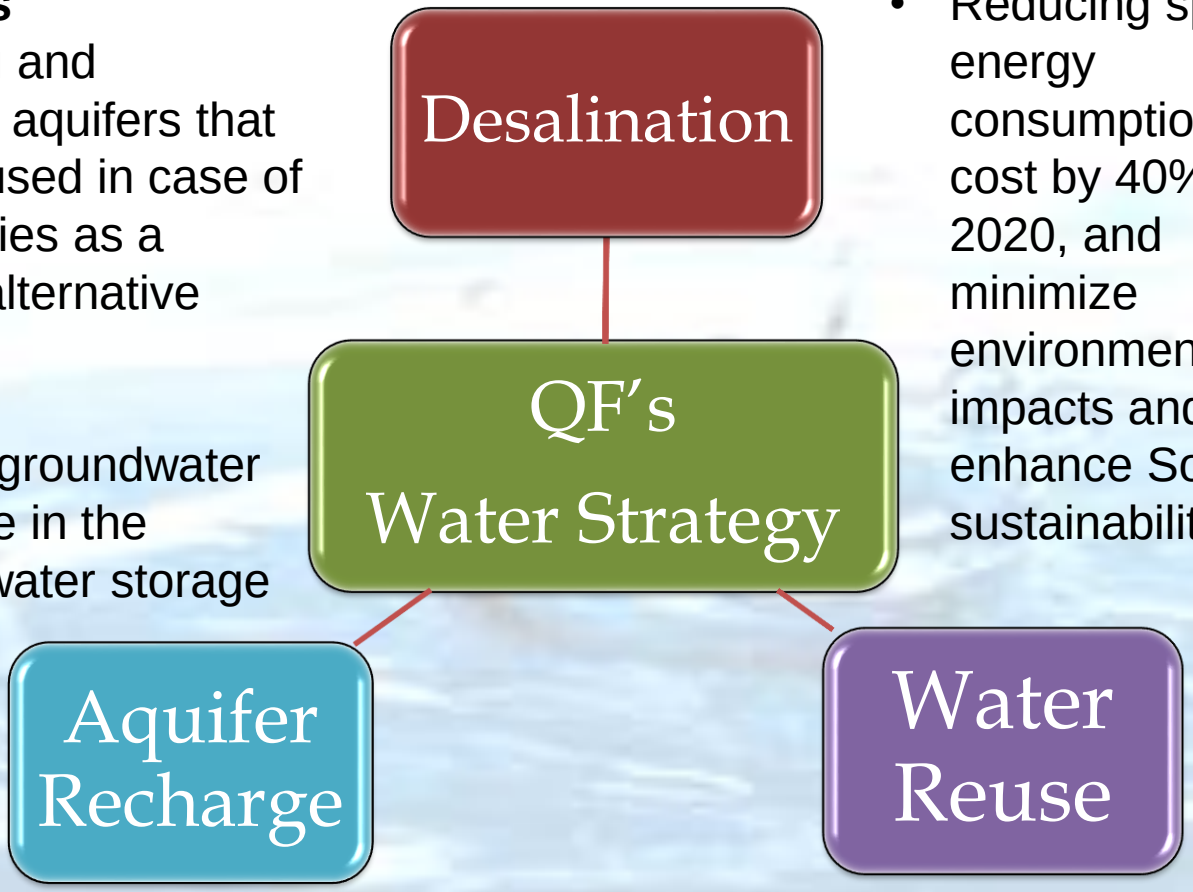
- Research Approaches
  - Incremental development (Evolutionary)

  - Step change (Innovation, think out of the box)
    - New Processes (novel technologies)
    - New Materials for membranes & electrodes

QEERI Water Strategy –Goals

GW Aquifers

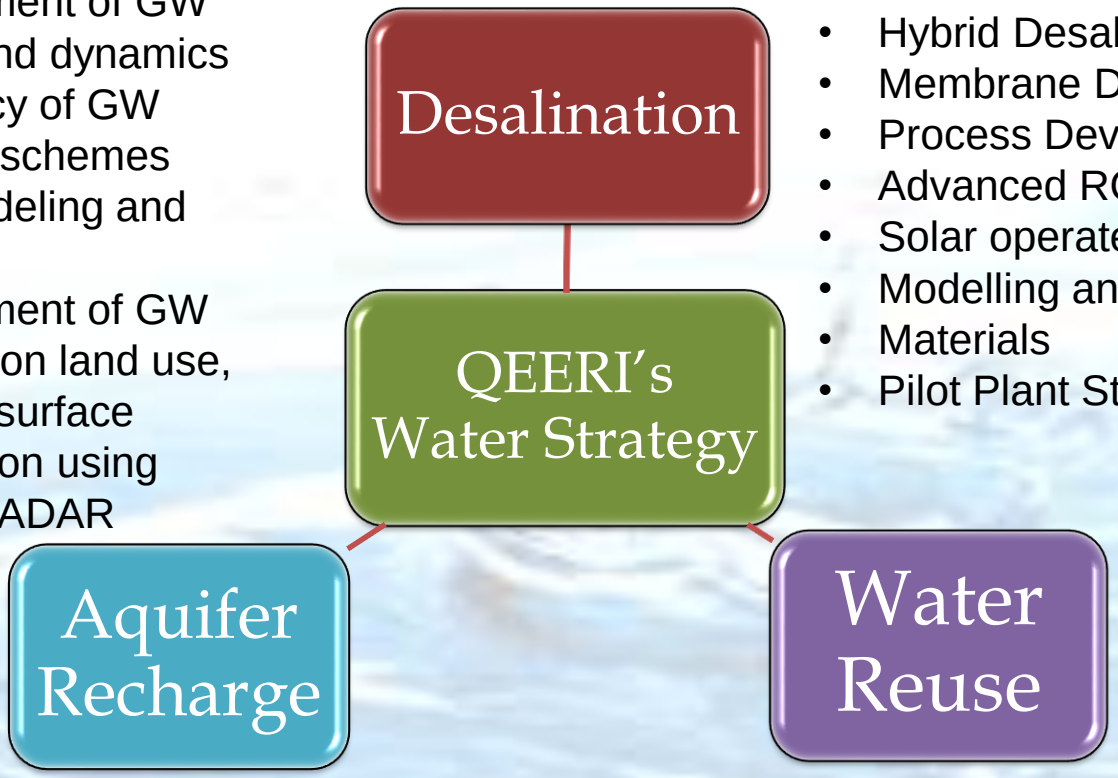
- Identifying and assessing aquifers that could be used in case of emergencies as a strategic alternative reserve.
- Elevating groundwater (GW) table in the strategic water storage aquifers



- Reducing specific energy consumption and cost by 40% by 2020, and minimize environmental impacts and enhance Social sustainability.
- Increasing water reuse by 30% by 2020; minimizing health risks, reducing environmental impacts and enhancing social responsibility.

QEERI Water Strategy –Objectives

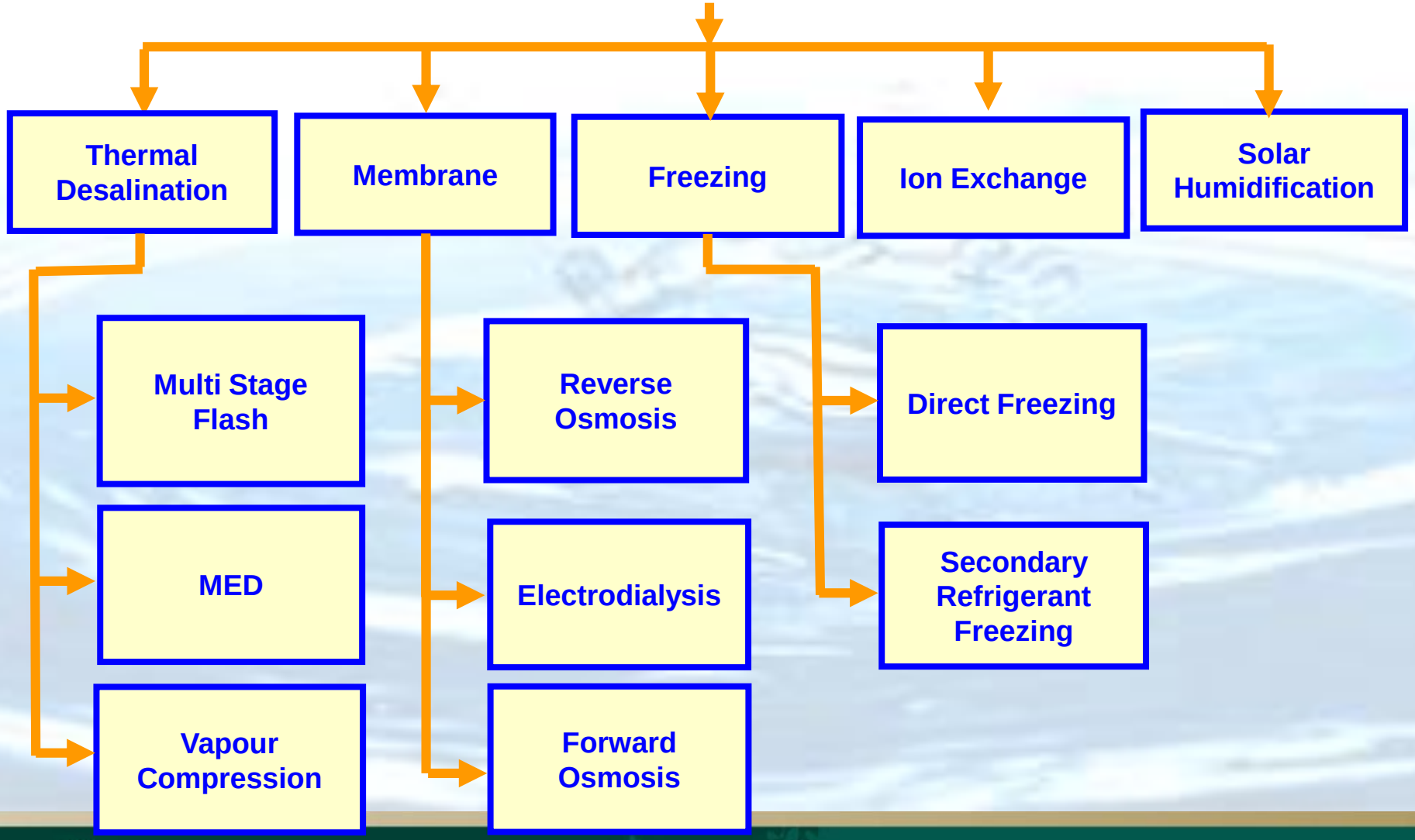
- - Assessment of GW system and dynamics
- - Efficiency of GW recharge schemes
- - GW modeling and mapping
- - Assessment of GW recharge on land use, and land surface deformation using InSAR RADAR



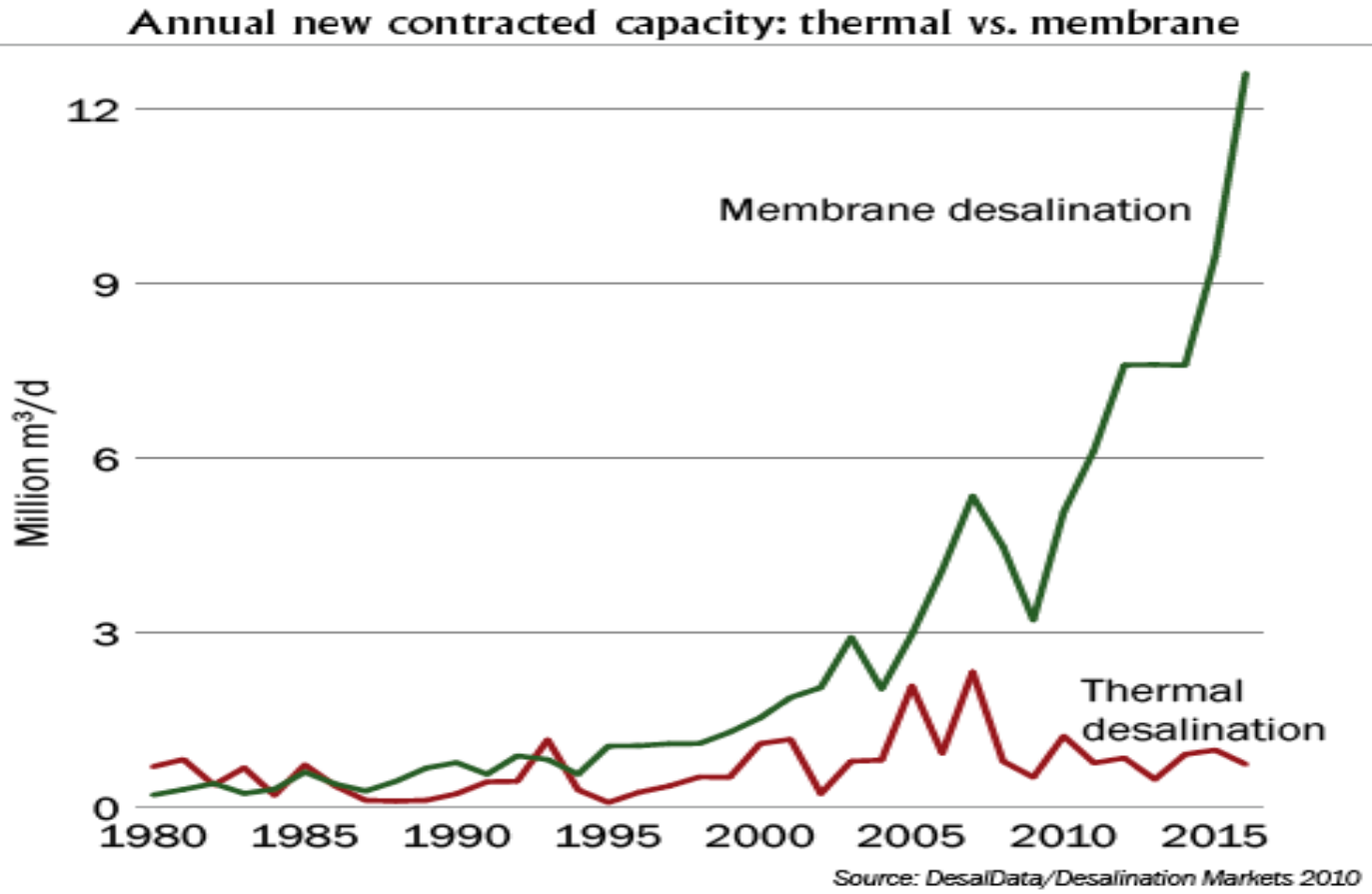
- Hybrid Desalination
- Membrane Development.
- Process Development.
- Advanced RO pre-treatment
- Solar operated desalting systems
- Modelling and Simulation
- Materials
- Pilot Plant Studies & Scale-up

- Investigate the suitability of treatment techniques for reuse and safe disposal
- Develop new processes for treatment and reuse purposes
- Process modeling and simulation
- Application schemes (wetlands and greenhouses)

Desalination Processes

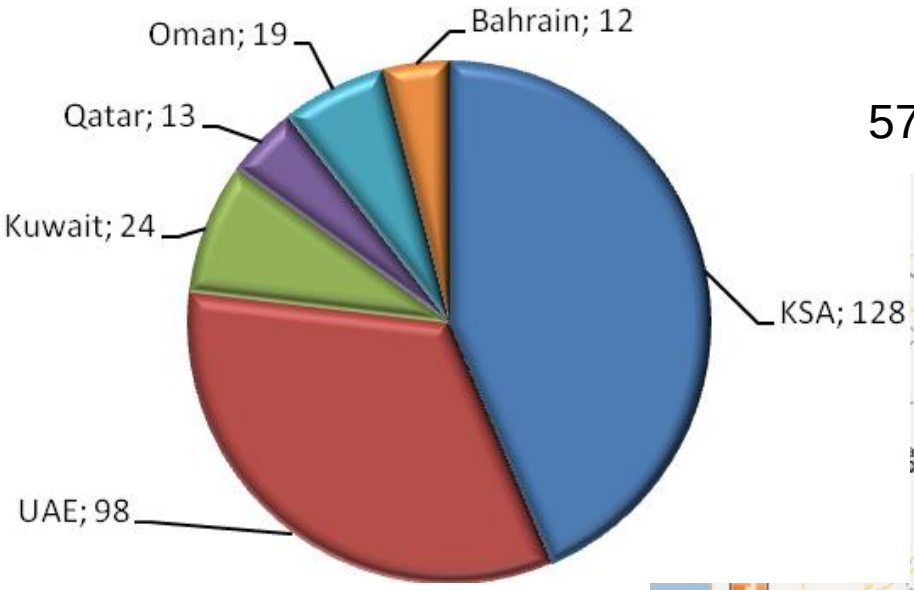


Thermal Vs. Membrane Desalination

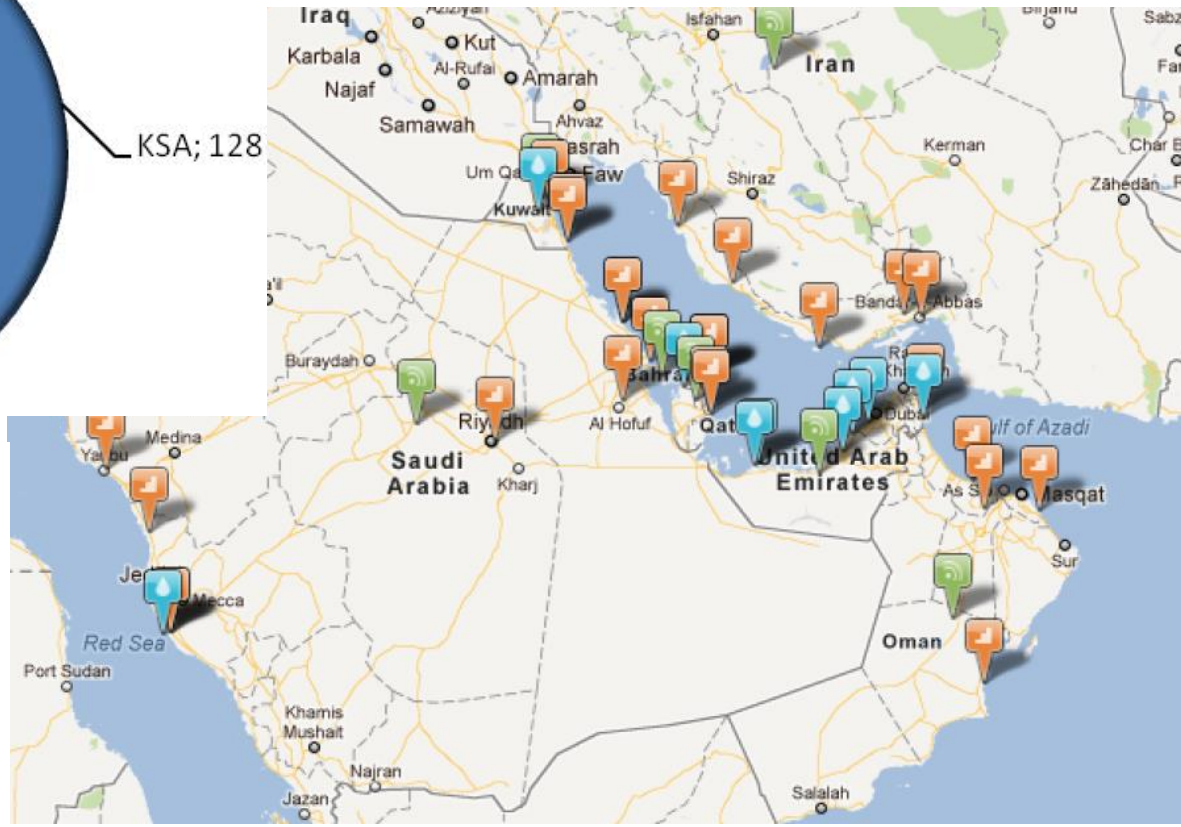


Current seawater RO plants operate at about 5 kWh/m^3.
MSF plants at about 48 kWh/m^3 (Thermal) & 4.5 kWh/m^3 (Electrical)

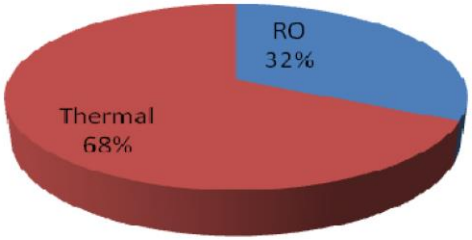
Desalination Plants in the GCC in 2012



57% of the World's Desal. Capacity



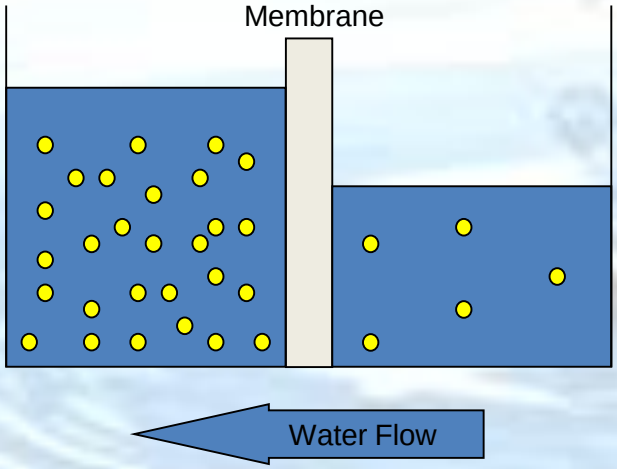
GCC



Source: DesalData (2012)

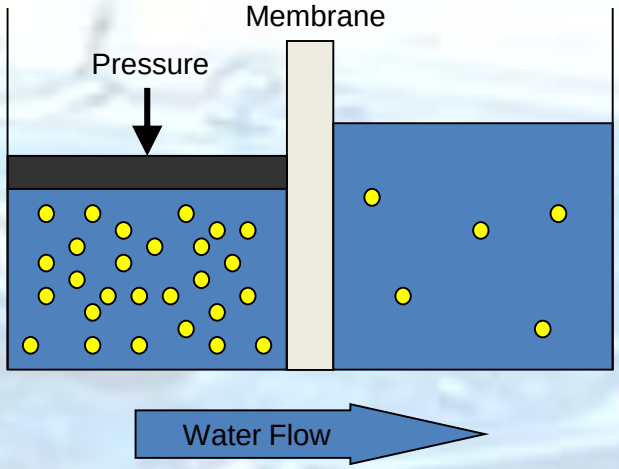
Forward and Reverse Osmosis

Forward Osmosis



Water diffuses naturally through membrane from low concentration side to high concentration side

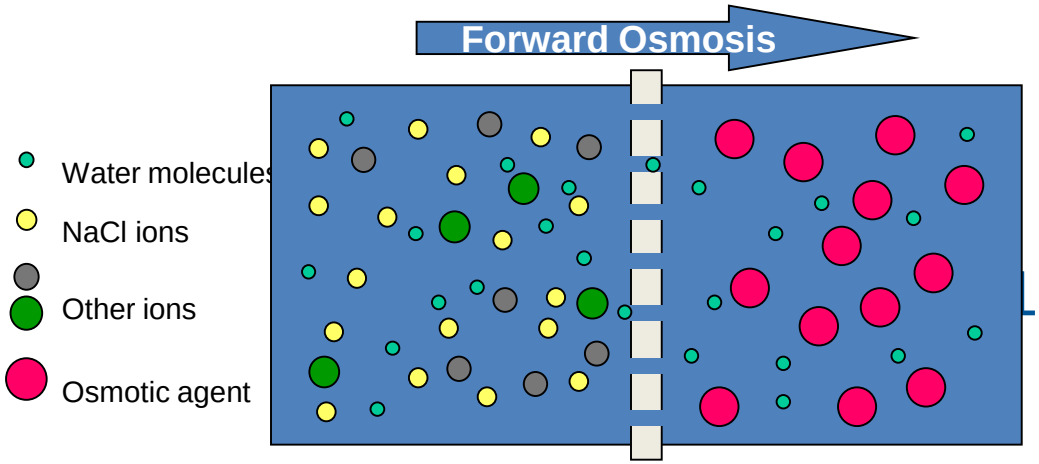
Reverse Osmosis



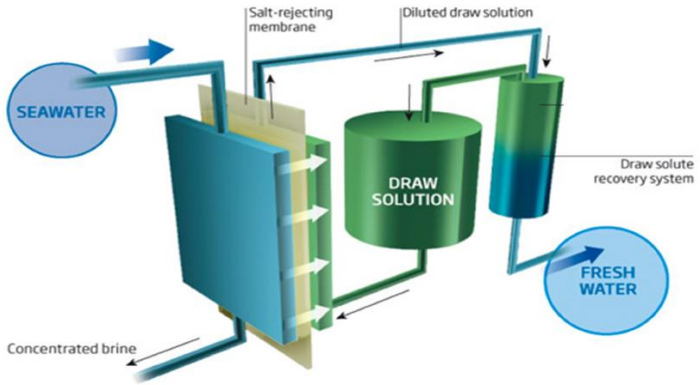
Pressure is applied to concentrated solution to overcome osmotic pressure and force water through the membrane from the high concentration side to the low concentration side

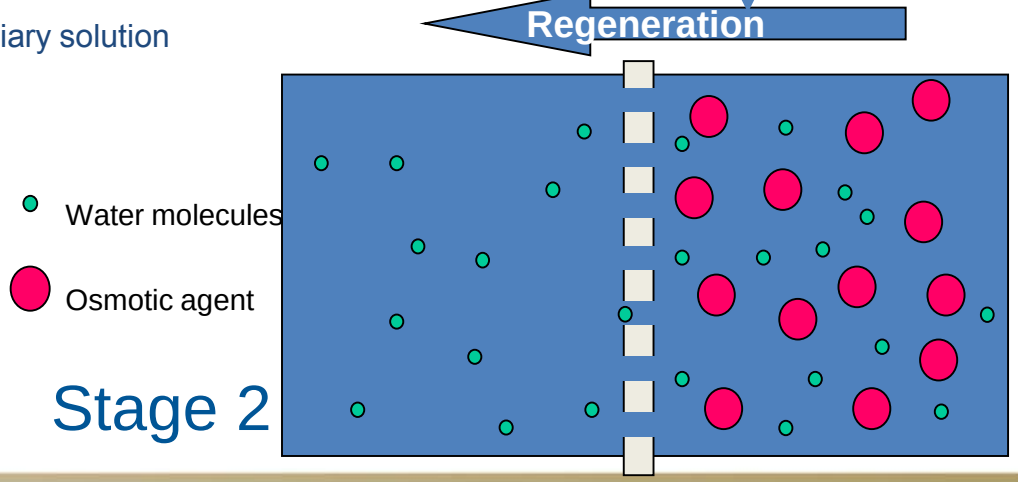
Forward Osmosis Desalination

Two stage process



Stage 1: create a ‘clean’ intermediary solution





Stage 2: extract water and recover agent for reuse

Forward Osmosis

FO has the potential to provide:

- a reliable and cost effective technology for producing fresh water with low energy consumption;
- high performance and less negative environmental impacts if existing limitations are addressed and the technology is developed further.

FO R&D Challenges

FO Desalination from Lab to Market

- Research developed at the University of Surrey with eight key inventions & patents
- The Royal Society Brian Mercer Award for Innovation, 2005

- IPO raised GBP 30m (US$ 60m)
- Listed on UK AIM in June 2007
- First pan-European Academic Enterprise Award, 2008
- Sustainability Award 2009
- Institute of Chemical Engineers Water Award, 2011
- The Queen's Anniversary Prize for Water Research, 2011
- Development and commercialisation of technologies
- Plant sales
  - 1st desal proving plant, Gibraltar, 2008
  - 2nd desal and first commercial plant, Oman, 2009
  - 3rd evaporative cooling proving plant Oman, 2010
  - 1st world's FO commercial plants (Oman 2011)

THE ROYAL SOCIETY

MODERNWATER

THE QUEEN'S ANNIVERSARY PRIZES
FOR HIGHER AND FURTHER EDUCATION

Desalination Technologies Coefficient of Desalination Reality' scores

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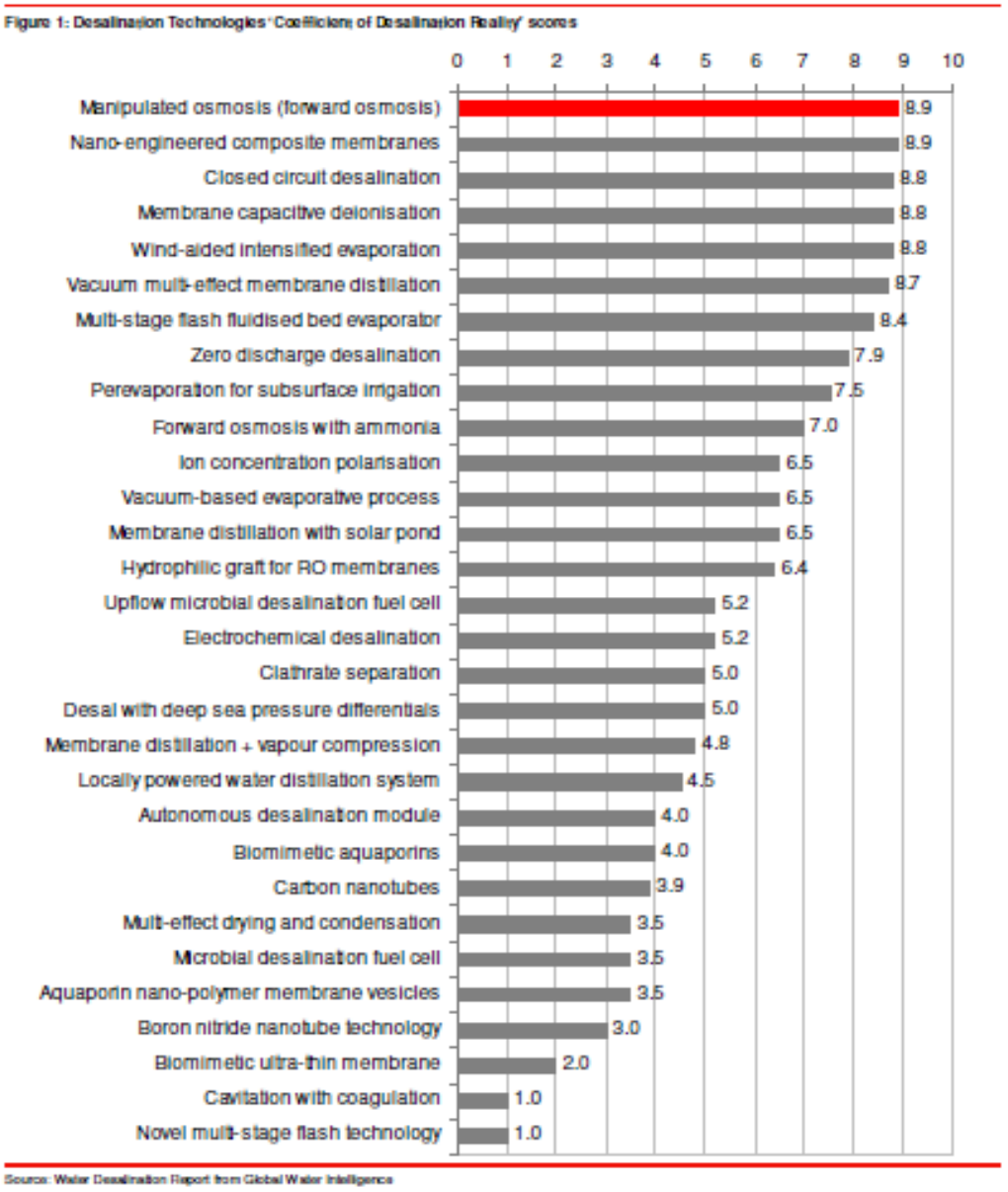
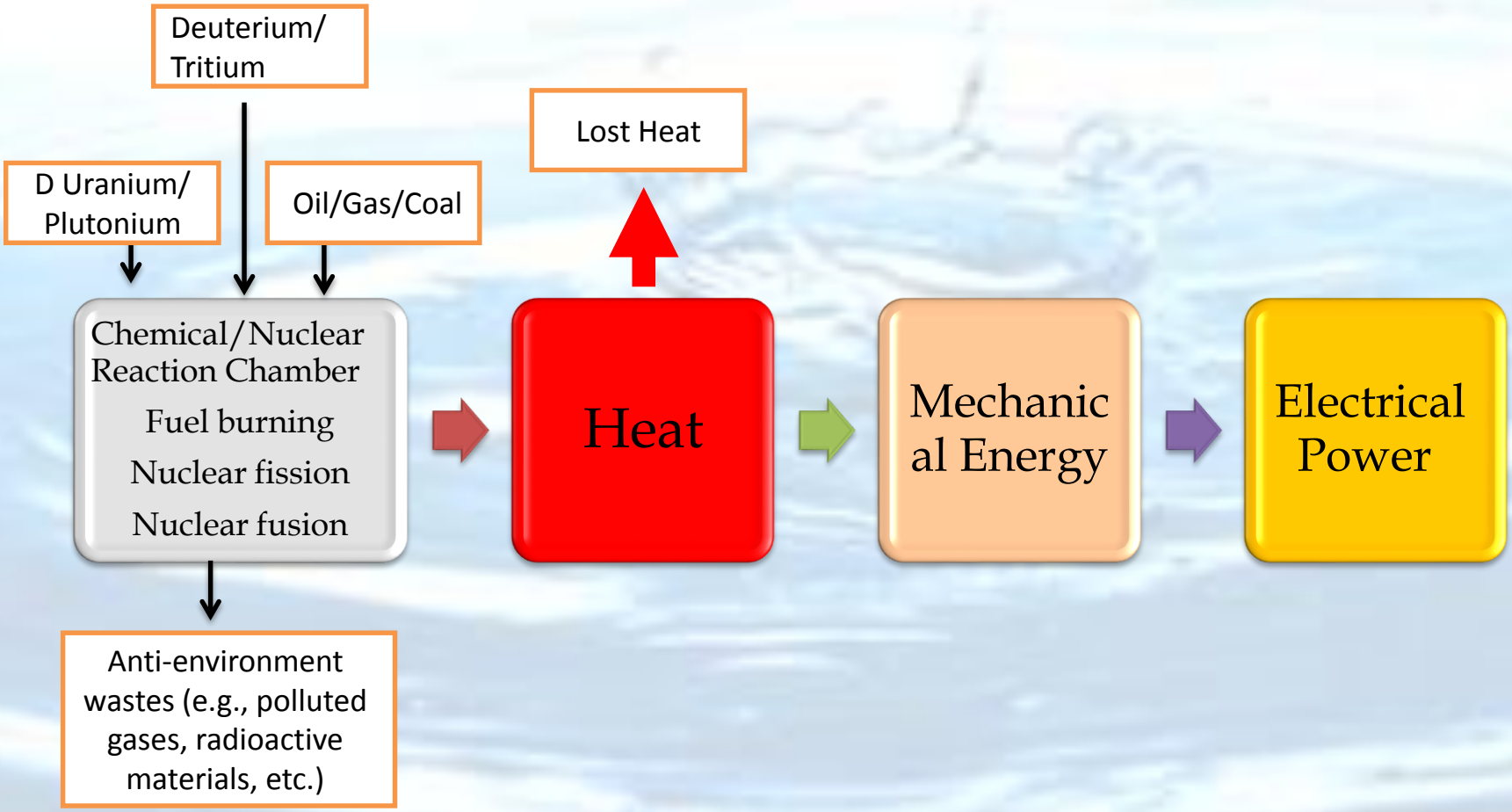


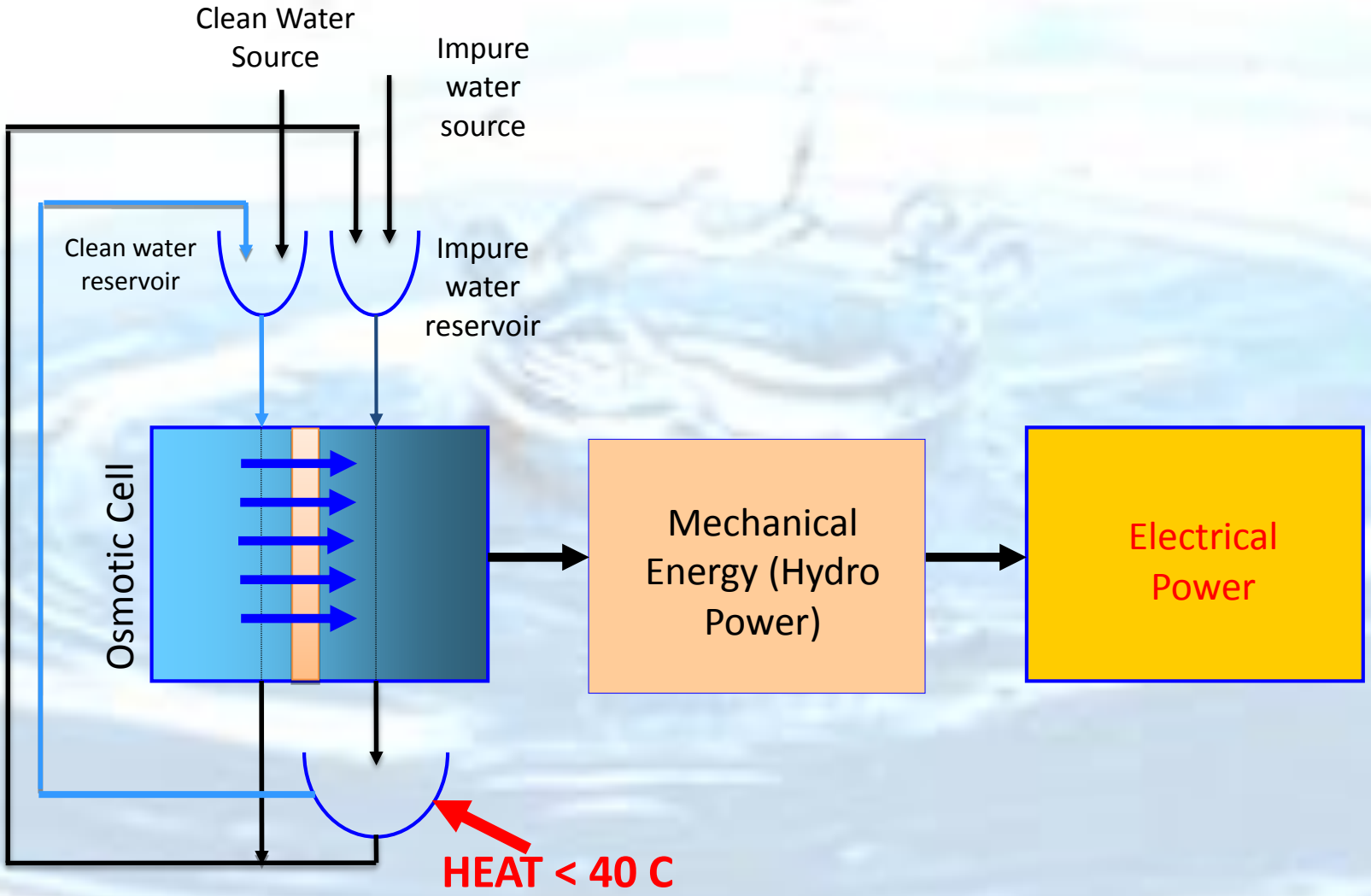
Source: Water Desalination Report, 44 (2010)

Importance of Energy

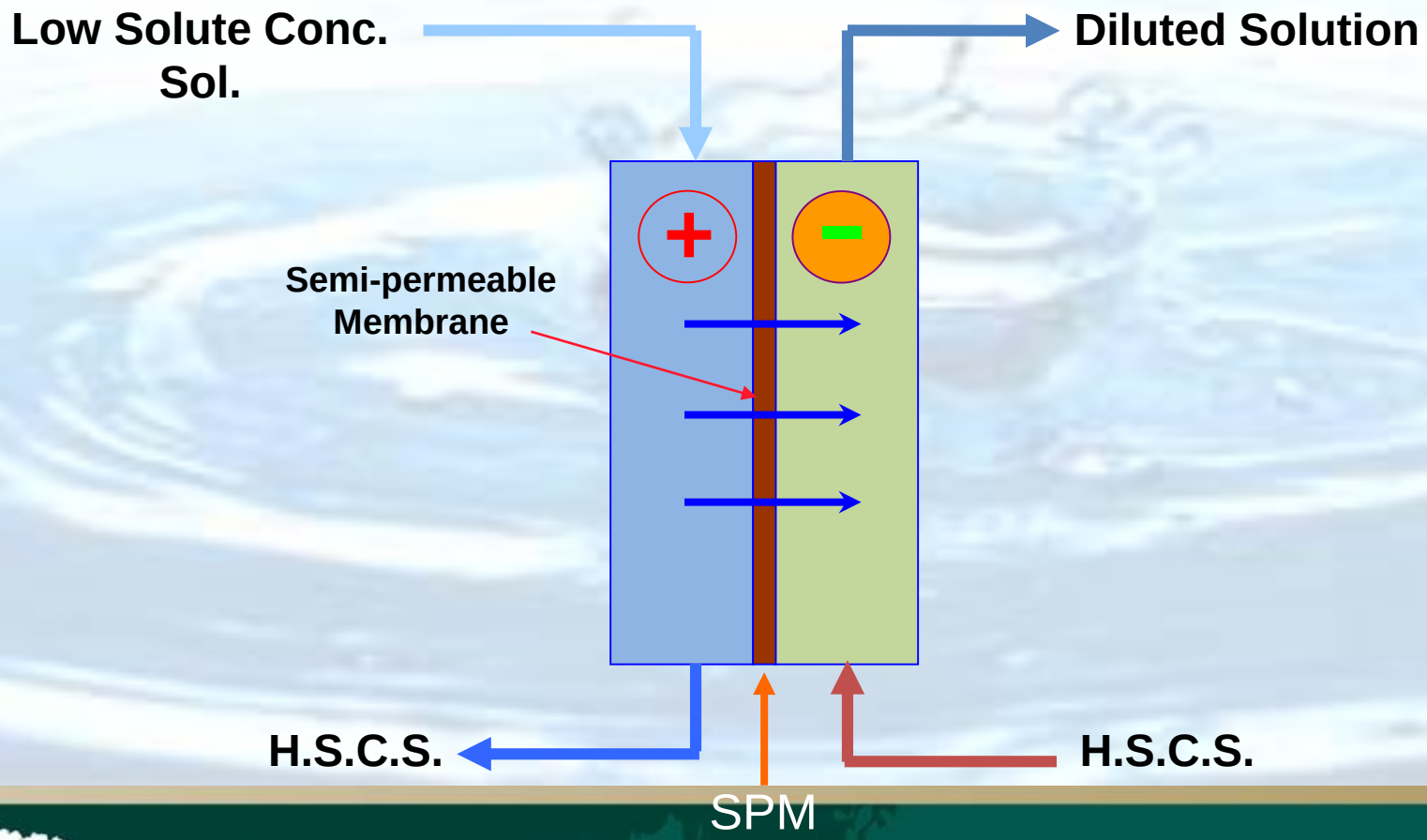
Conventional Fuel-Based Power Generation Cycle



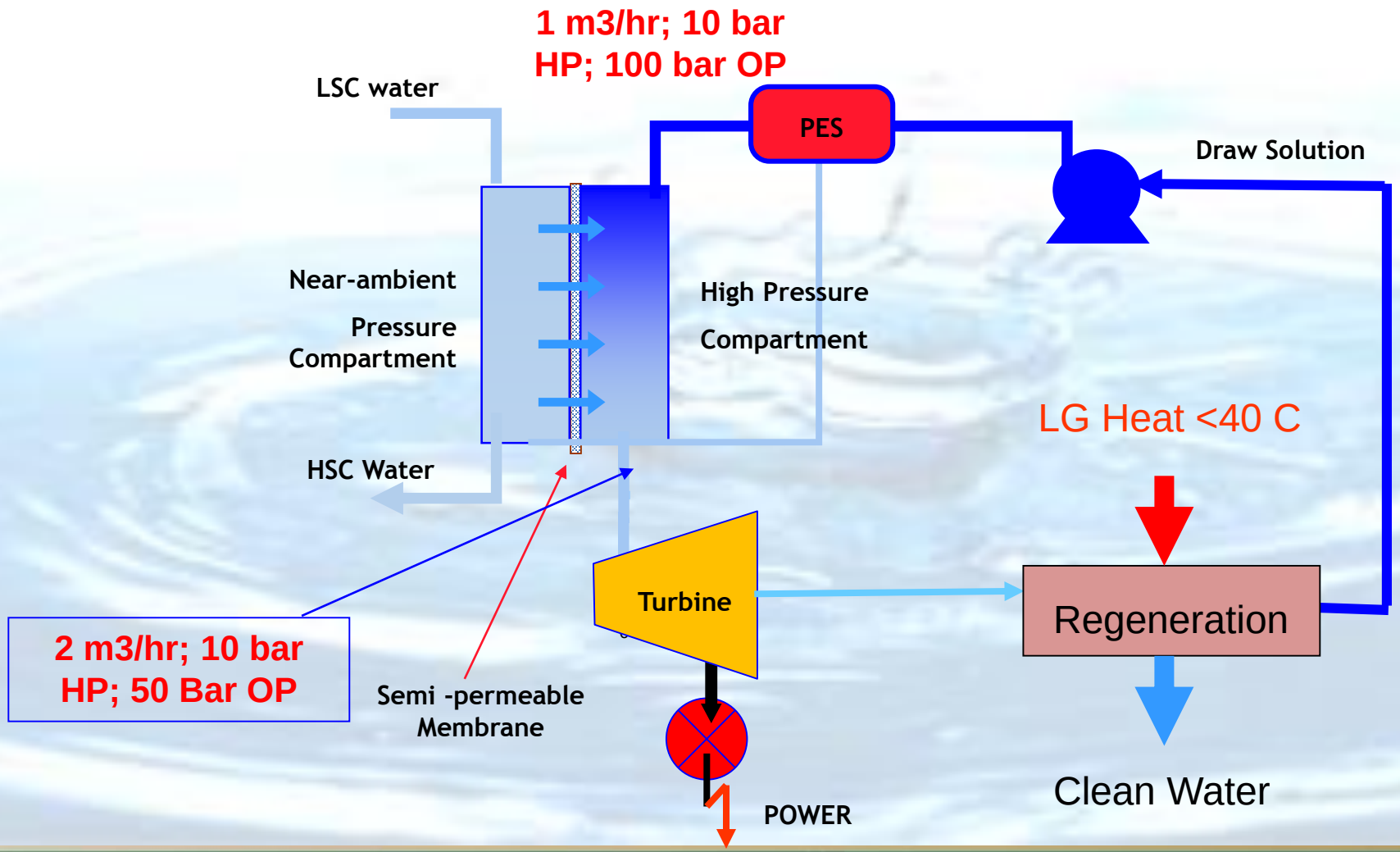
Osmotic Power Generation Cycle



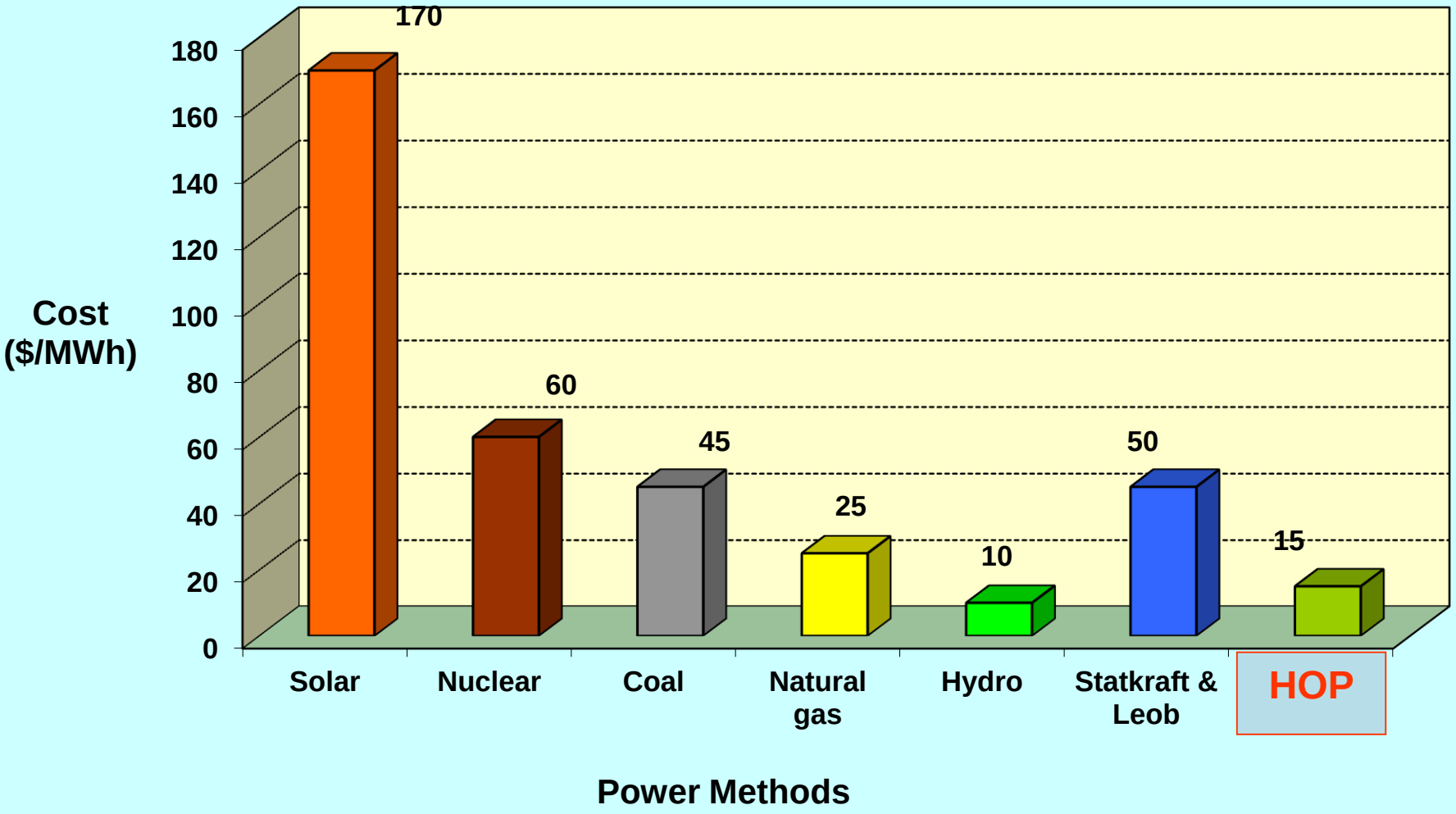
OSMOTIC BATTERY



Co-Production of Water and Power



Projected cost of the Hydro-Osmotic Power Plant



Stages of food Security

- Food security exists when all people,

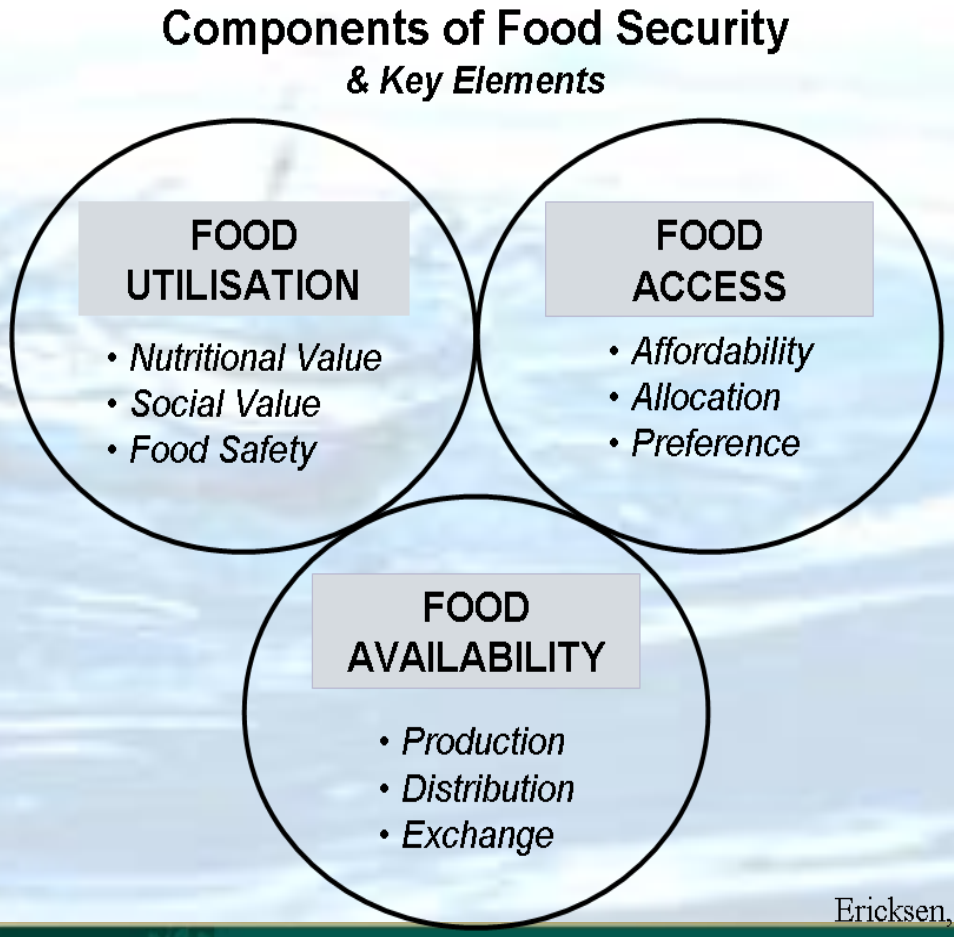
at all times, have access to sufficient,

safe and nutritious food to meet their

dietary needs and food preferences

for an active healthy life (FAO)

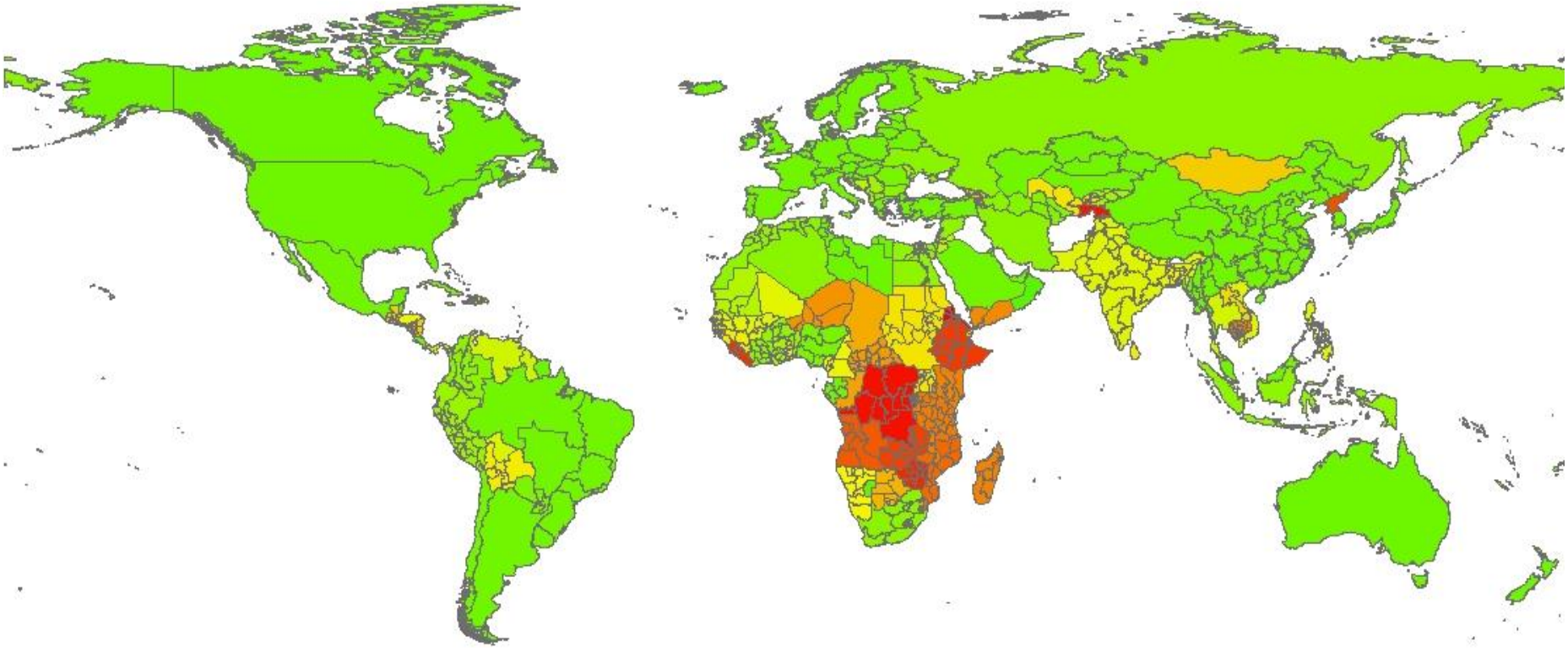
- What affects food security
  - Food supply (weather/natural factors)
  - Poverty and inequality
  - Politics/institutions



Ericksen, 2008

Food security hotspots =

hunger + food aid + dependence on agric GDP



Lowest *concern* — *Highest concern*

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derived from FAOStat + WRI; 2001-03

70 litres for one apple

15500 litres per kg

40 litres per slice

5000 litres per kg

Seawater Irrigation Techniques

- Innovative techniques using seawater have been invented and developed at Surrey University and Qatar Foundation for:

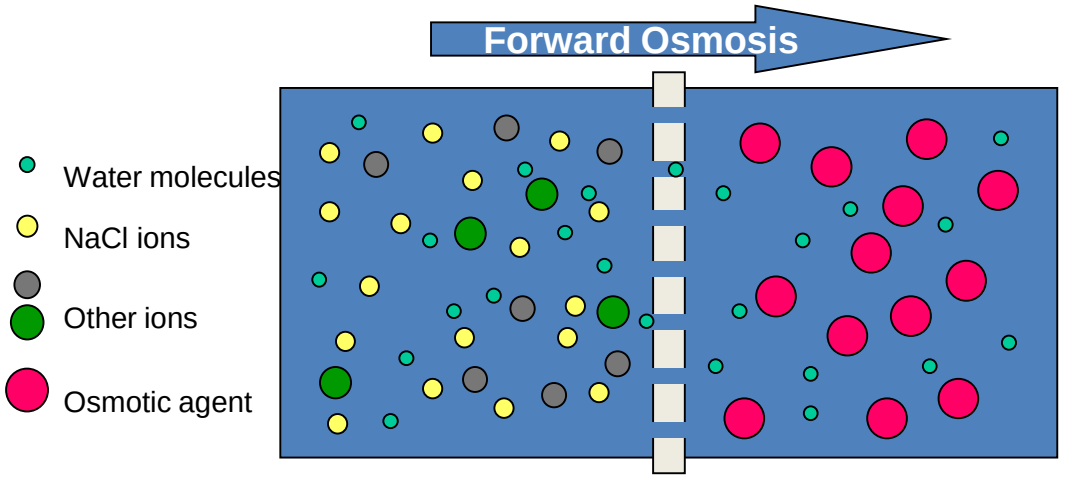
- High value crops (e.g. vegetables)
- Wheat and barley
- Trees and date palms

Low Grade Heat FO Desalination Process

- Low Grade Heat FO desalination and WT process has been invented (UK patent Apl. GB 1403883.0) using low boiling point draw solutions with heat regeneration at a temperature <40 C)

- Using specifically designed carbon based FO membrane.

- Using direct contact Heat Transfer technique for smaller footprint and higher energy recovery efficiency.



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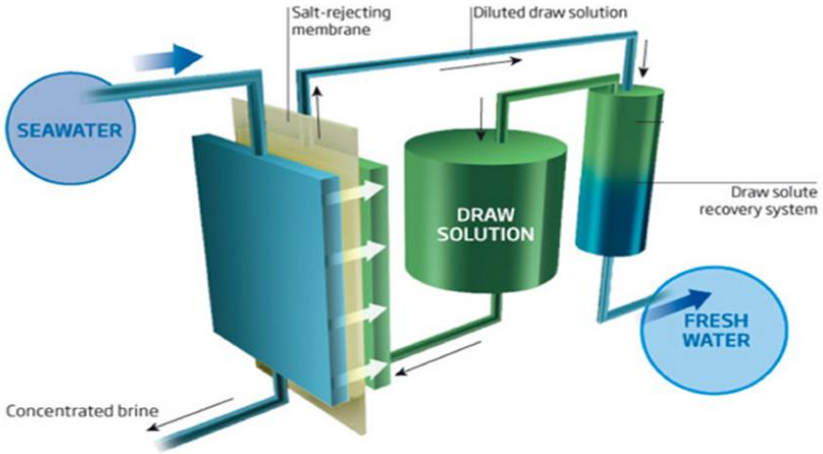


Concluding Words

Science, innovation and technology have the potential to address the world's challenges of Water, Energy and Food.

- Desalination has the undeniable potential to create much-needed secure water supplies for many water-stressed areas around the world.

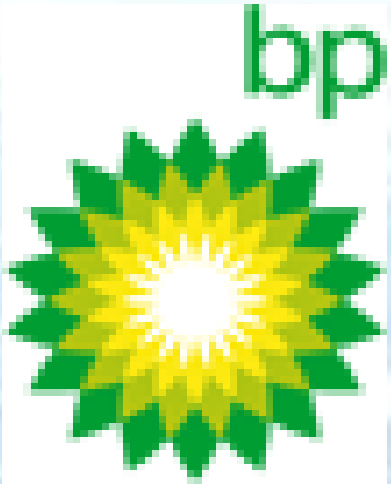
- Forward Osmosis offers novel processes for water and power production with a significant reduction in capital and operating costs, and also has a positive impact on the environment. Water and Energy are the base for Food production

By 2020, desalination and water purification technologies will contribute significantly to ensuring a safe, sustainable, affordable, and adequate water supply for Qatar and the region.

- *On the humanitarian side, if just a small proportion of the 3 million lives lost each year because of water related diseases can be prevented, then something special will have been achieved*

Acknowledgments

MODERNWATER



Thank You

Q&A