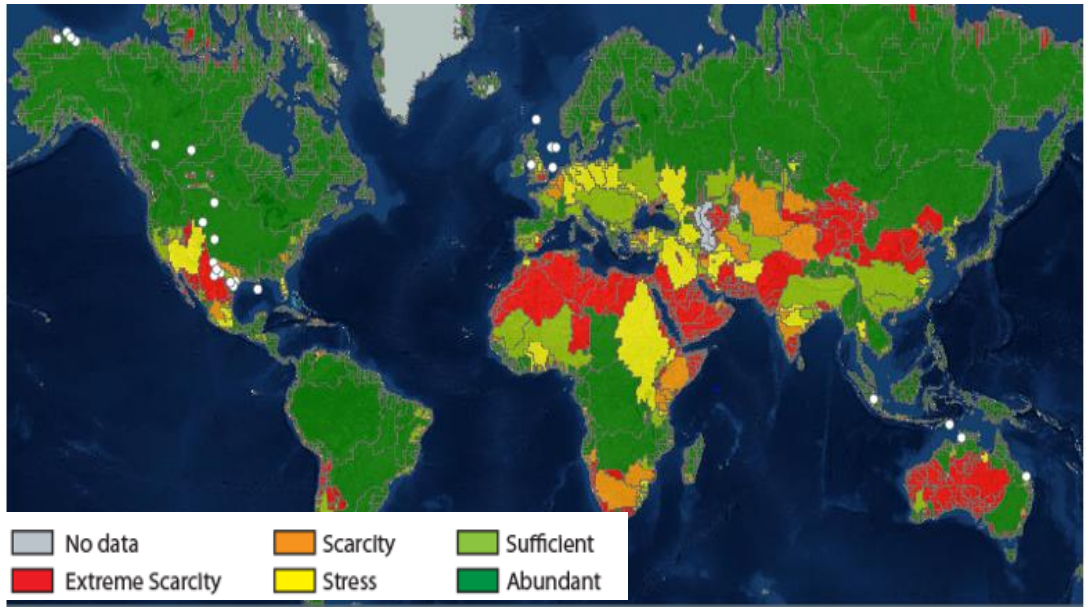
United Nation's Sustainable Development Goals

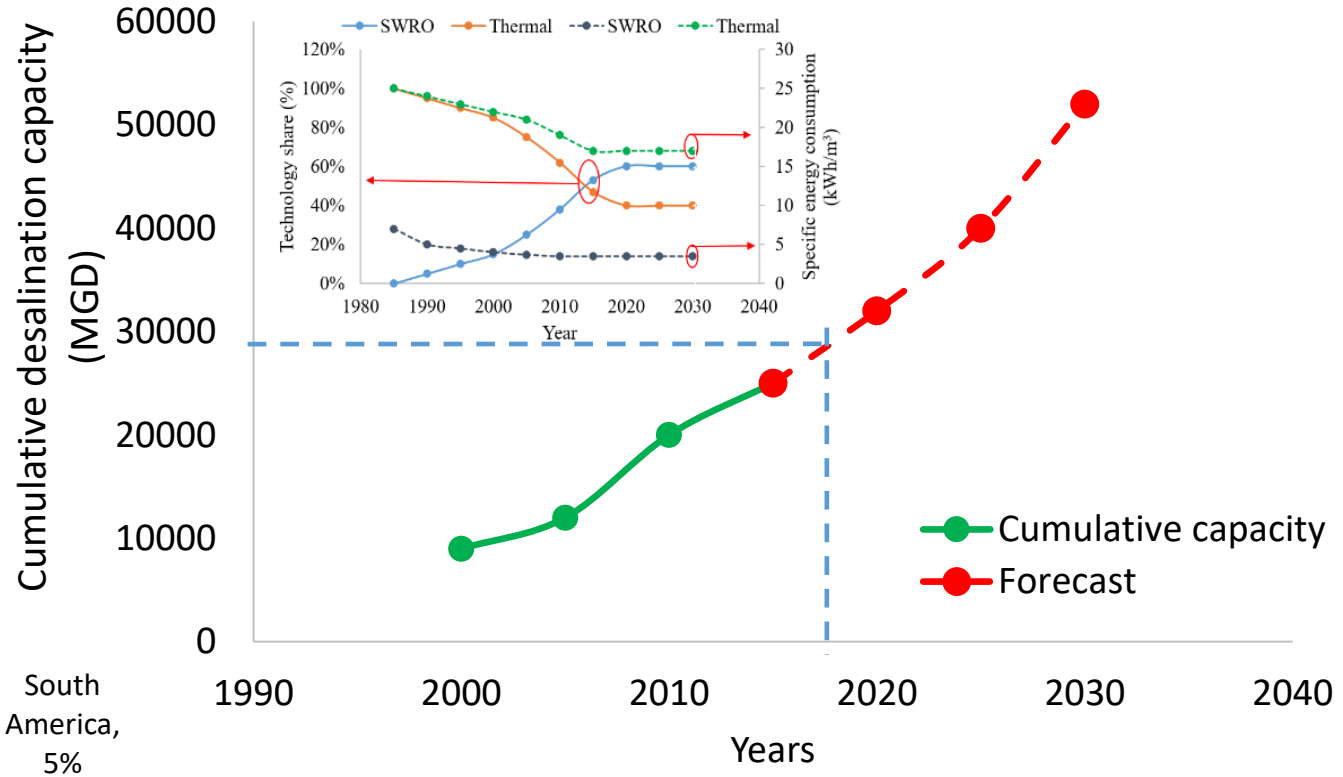
Transforming our World: the 2030 Agenda for ***Sustainable Development***

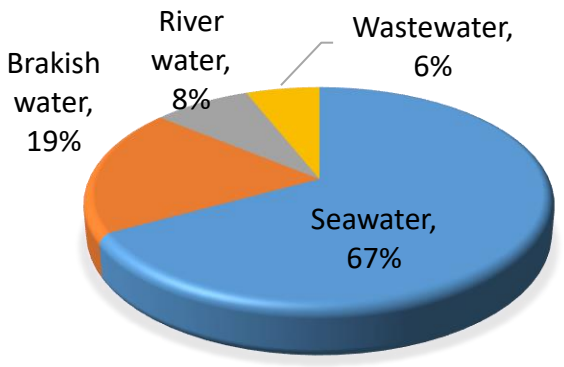
(17 goals and their 169 targets)

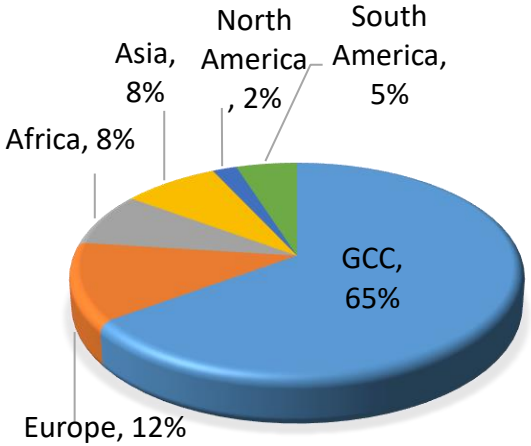
SUSTAINABLE DEVELOPMENT GOALS

Global Water Scarcity and an Alternate Solution



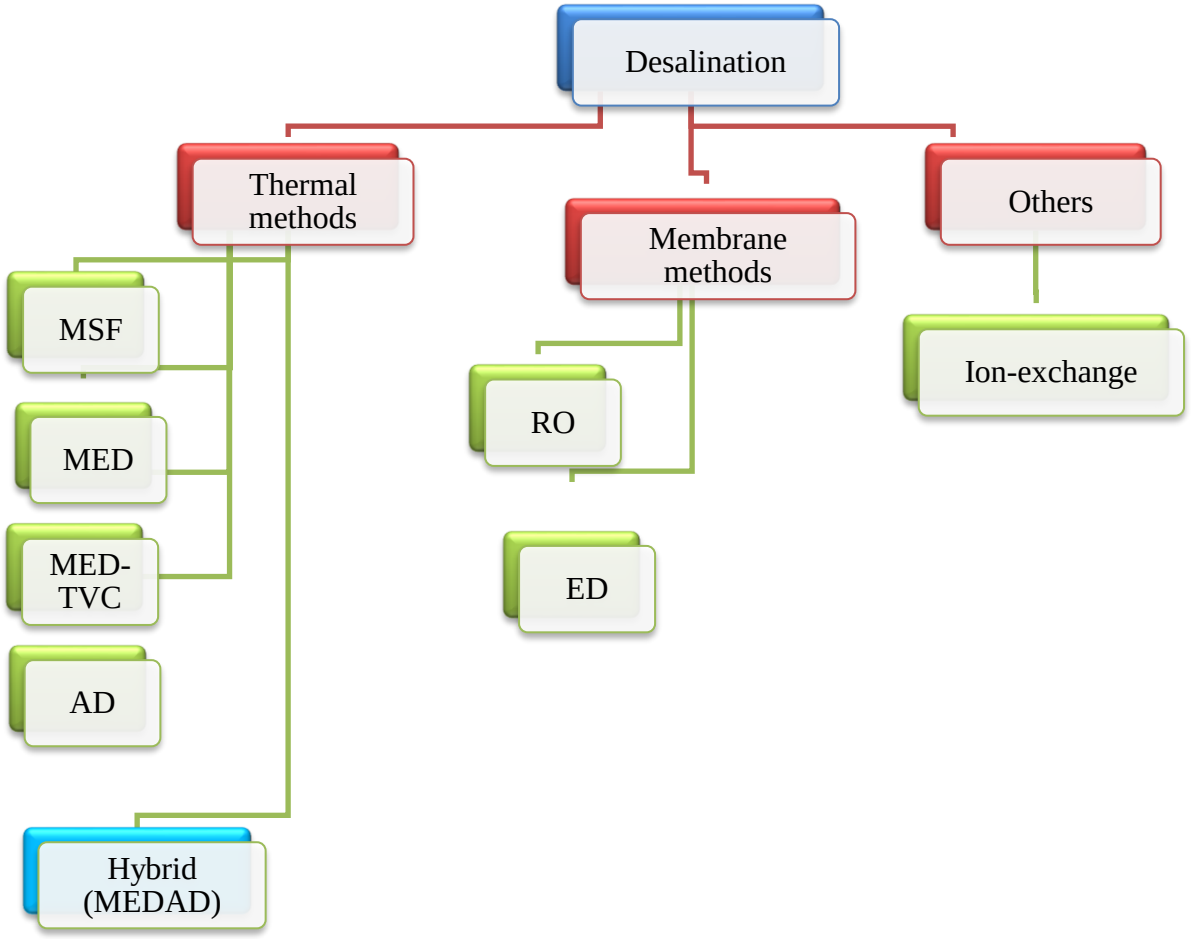


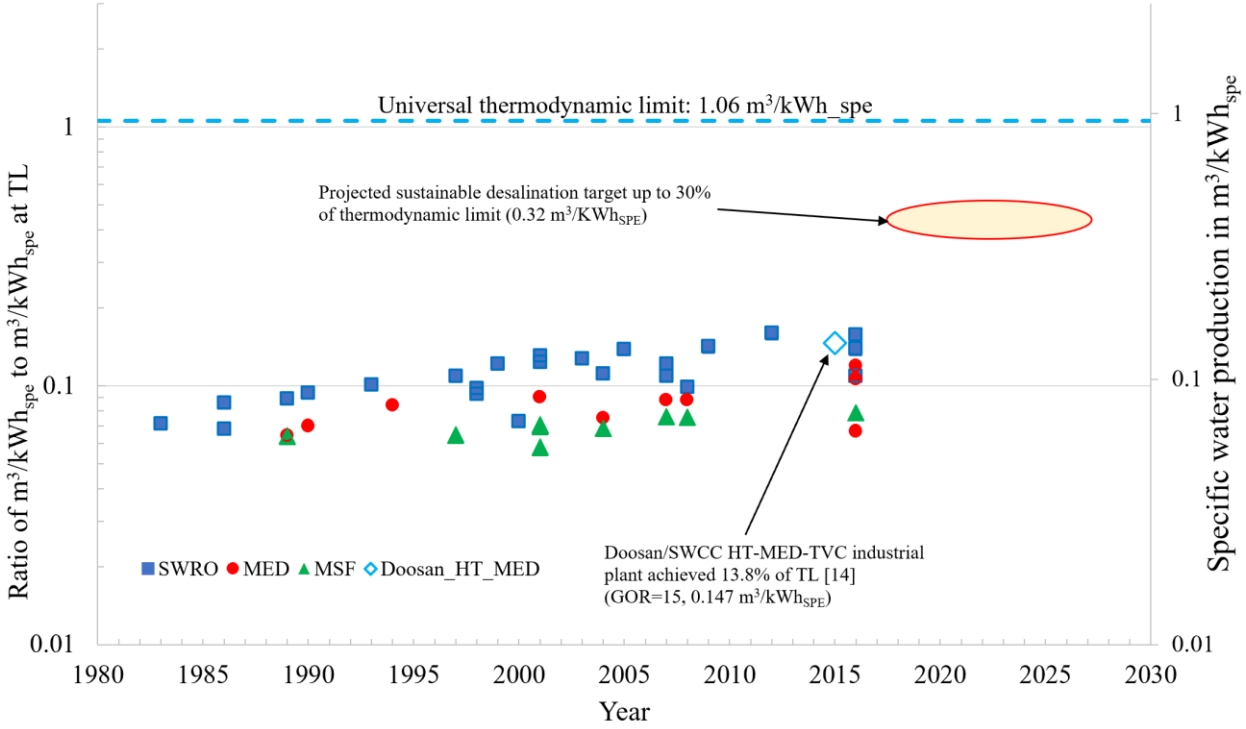




Today installed desalination capacity is 28000 million gallon per day

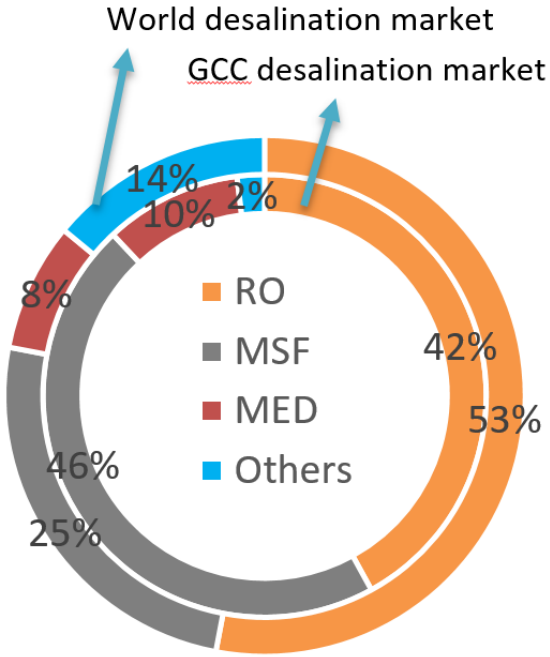
Water Treatment Processes Energy Efficiency

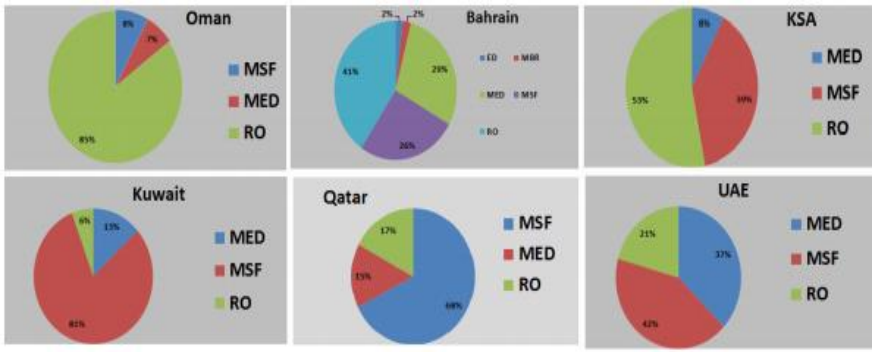




All conventional processes are operation only at 10-13% of thermodynamic limit…

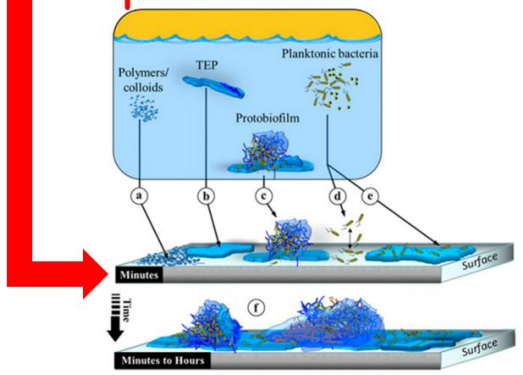
Desalination Processes



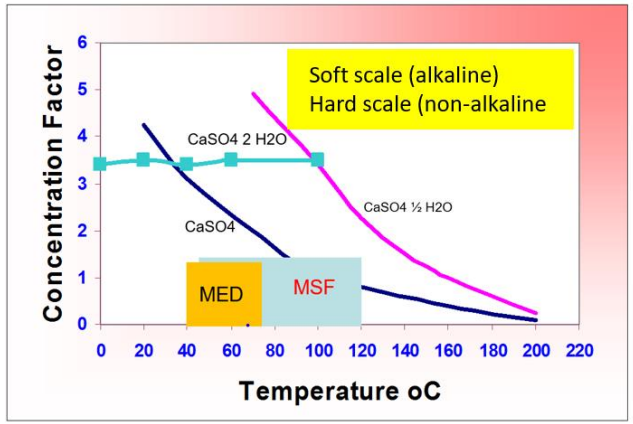


SWRO

HABs accelerate biofilm on SWRO membranes

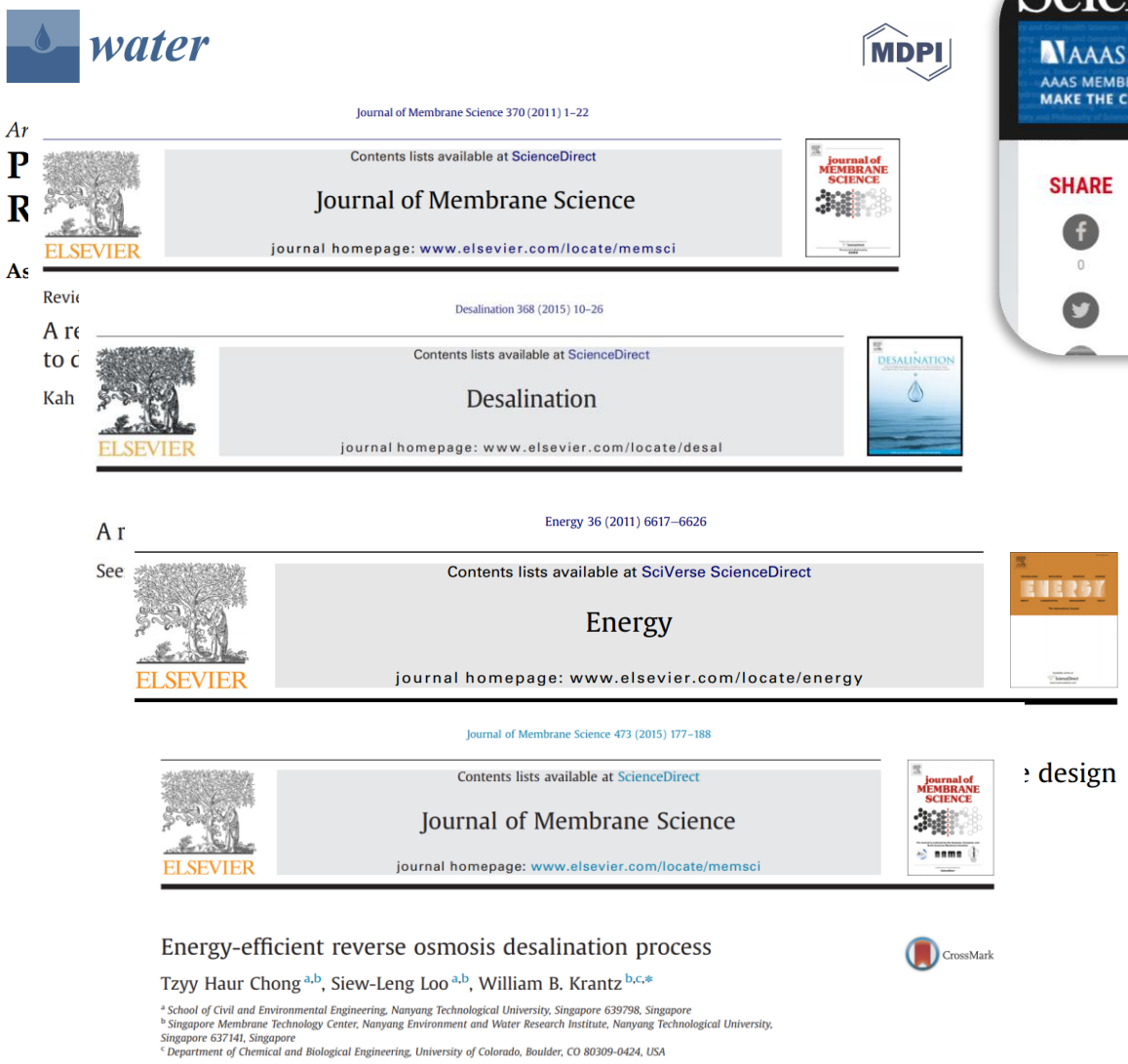


MED/MSF



Reduction in heat transfer and hence performance

SeaWater Reverse Osmosis…..An Efficient Process?



water

MDPI

Journal of Membrane Science 370 (2011) 1–22

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Journal of Membrane Science 473 (2015) 177–188

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Energy-efficient reverse osmosis desalination process

CrossMark

Tzyy Haur Chong [a,b], Siew-Leng Loo [a,b], William B. Krantz [b,c,*]

[a] School of Civil and Environmental Engineering, Nanyang Technological University, Singapore 639798, Singapore
[b] Singapore Membrane Technology Center, Nanyang Environment and Water Research Institute, Nanyang Technological University, Singapore 637141, Singapore
[c] Department of Chemical and Biological Engineering, University of Colorado, Boulder, CO 80309-0424, USA

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The Future of Seawater Desalination: Energy, Technology, and the Environment

Menachem Elimelech*, William A. Phillip†

+ See all authors and affiliations

Imperial College London

Department of Chemical Engineering

Barrer Centre

Improved recovery and energy efficient reverse osmosis process

Barrer Centre Seminar with Prof Chong Tzyy Haur (Nanyang Technological University)

Date: 24 Nov 2017
Time: 11:00 - 12:00
Venue: Lecture Theatre 3, Department of Chemical Engineering
Campus: South Kensington Campus

Related Faculty: Engineering

Event type: Seminar
Audience: Open to all

Environmental Science Water Research & Technology

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Saving energy with an optimized two-stage reverse osmosis system

Quantum J. Wei, Ronan K. McGovern and John H. Lienhard V*

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SEAWATER REVERSE OSMOSIS SOLUTION ACHIEVES OPTIMUM ENERGY EFFICIENCY

Thermal Desalination.....An Efficient Process?

Renewable and Sustainable Energy Reviews 24 (2013) 343–356

Contents lists available at SciVerse ScienceDirect

Renewable and Sustainable Energy Reviews

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Letter to the Editor

Energy consumption and water production cost of conventional and renewable-energy-powered desalination processes

Environmental Science
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PAPER

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Future sustainable desalination using waste heat: kudos to thermodynamic synergy†

Muhammad Wakil Shahzad,[a] Kim Choon Ng*[a] and Kyaw Thu

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Renewable and sustainable approaches for desalination

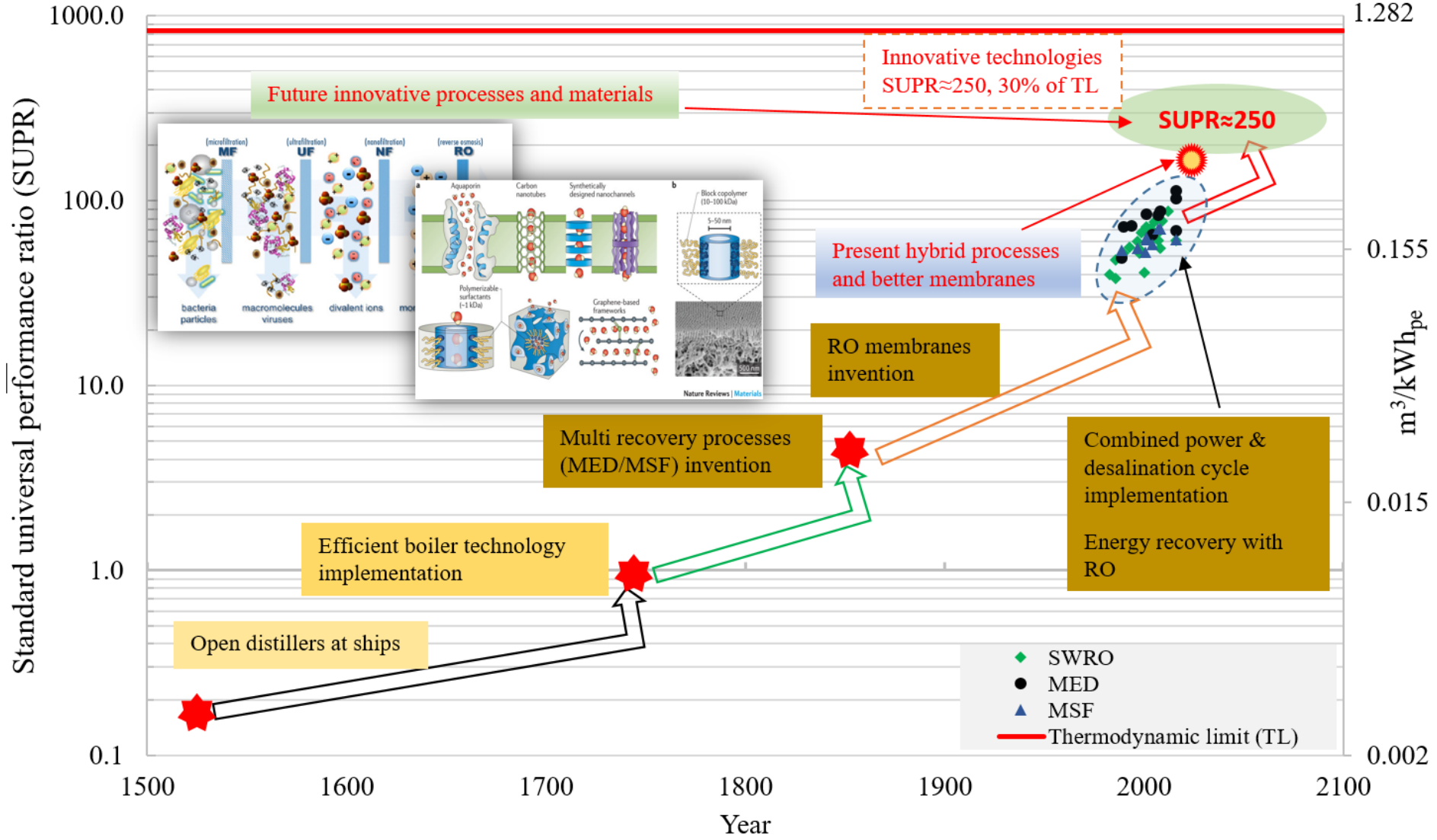
Veera Gnaneswar Gude[a], Nagamany Nirmalakhandan[b], Shuguang Deng[a,*]

Critical Review

Energy Issues in Desalination Processes

RAPHAEL SEMIAT*
Rabin Desalination Laboratory, Grand Water Research Institute, Wolfson Faculty of Chemical Engineering, Technion—Israel Institute of Technology, Technion City, Haifa 32000, Israel

SUPR Trend since 1500: Lesson Learned from History



Significant jump in performance can only be achieved by technology **CHANGE!**

Conventional Desalination Processes Limitations

Thermal Desalination Systems Limitations

Fouling of tubes

Heat source
(65°C)

Heat rejection to sea
(30°C)

Ambient limit

Thermal processes are **more favorable** at sever water conditions

Thermal processes are **more robust** then membrane processes

Thermal processes are **more efficient** then membrane processes

Reverse Osmosis Systems Limitations

Red tides

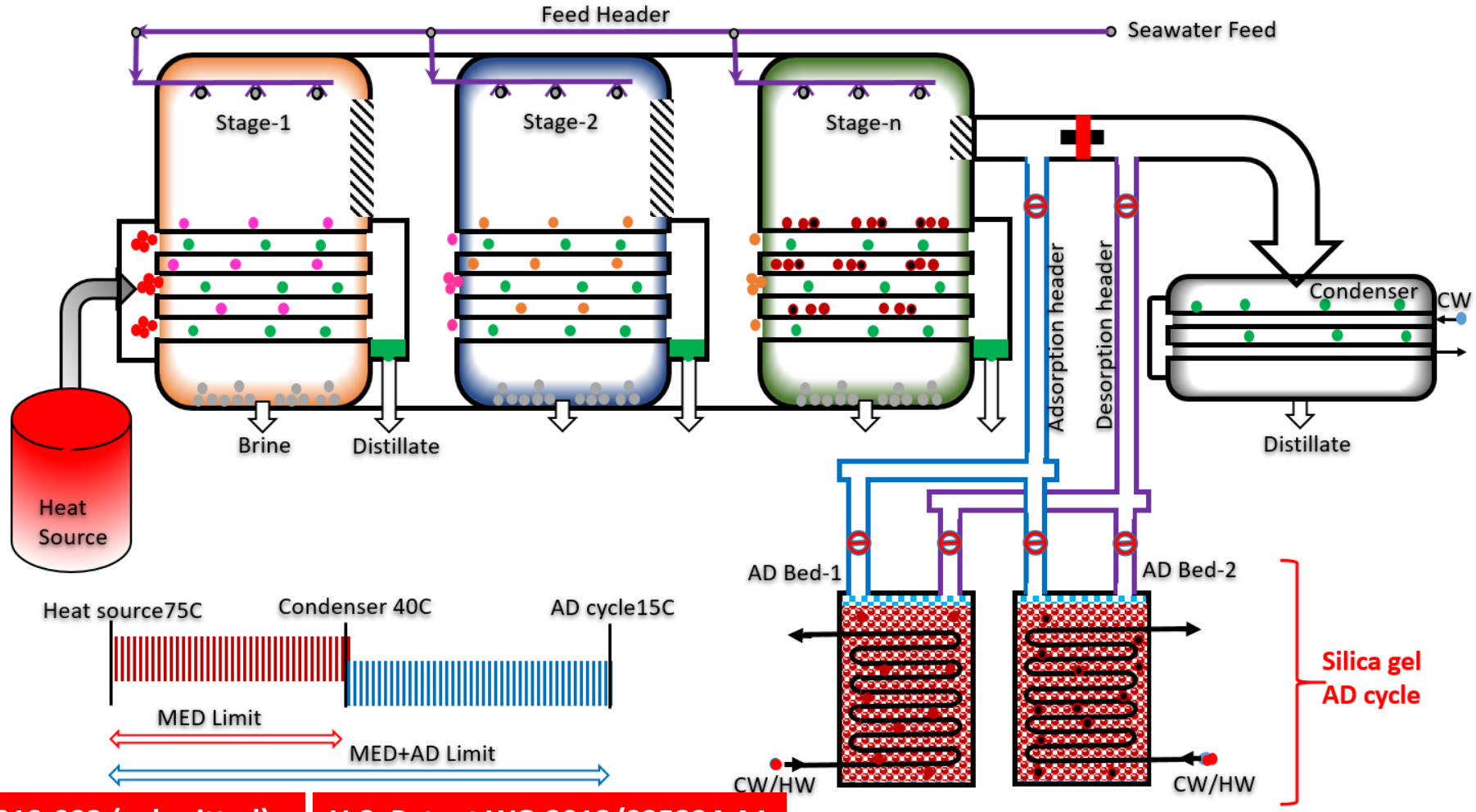
Algae blooms

Seafoam

Membranes fouling/clogging

Hybridization of Desalination Processes to Overcome Limitations

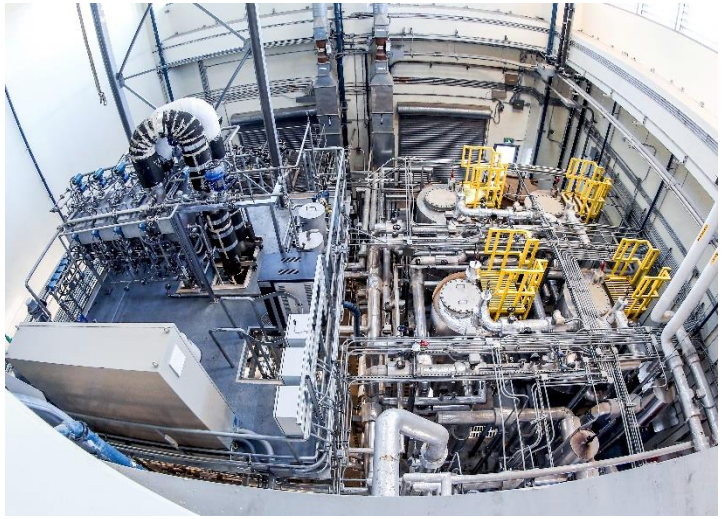
Multi Effect Desalination Integration with Adsorption Cycle (MED+AD)



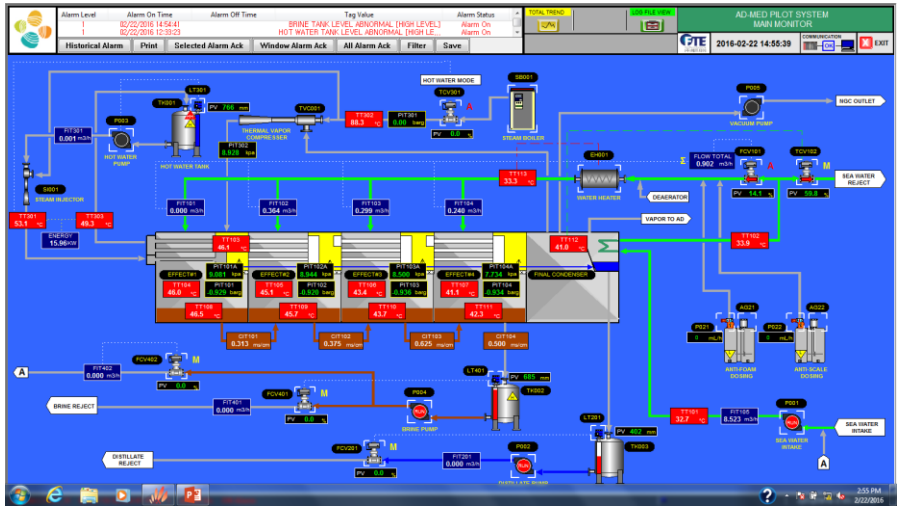
Application # 2019-092 (submitted) **U.S. Patent WO 2018/025224 A1**

Muhammad Wakil Shahzad, M Burhan, N Ghaffour, KC Ng, A multi evaporator desalination system operated with thermocline energy for future sustainability, Desalination 435 (2018) 268-277.

Hybridization MED+AD Pilot at KAUST



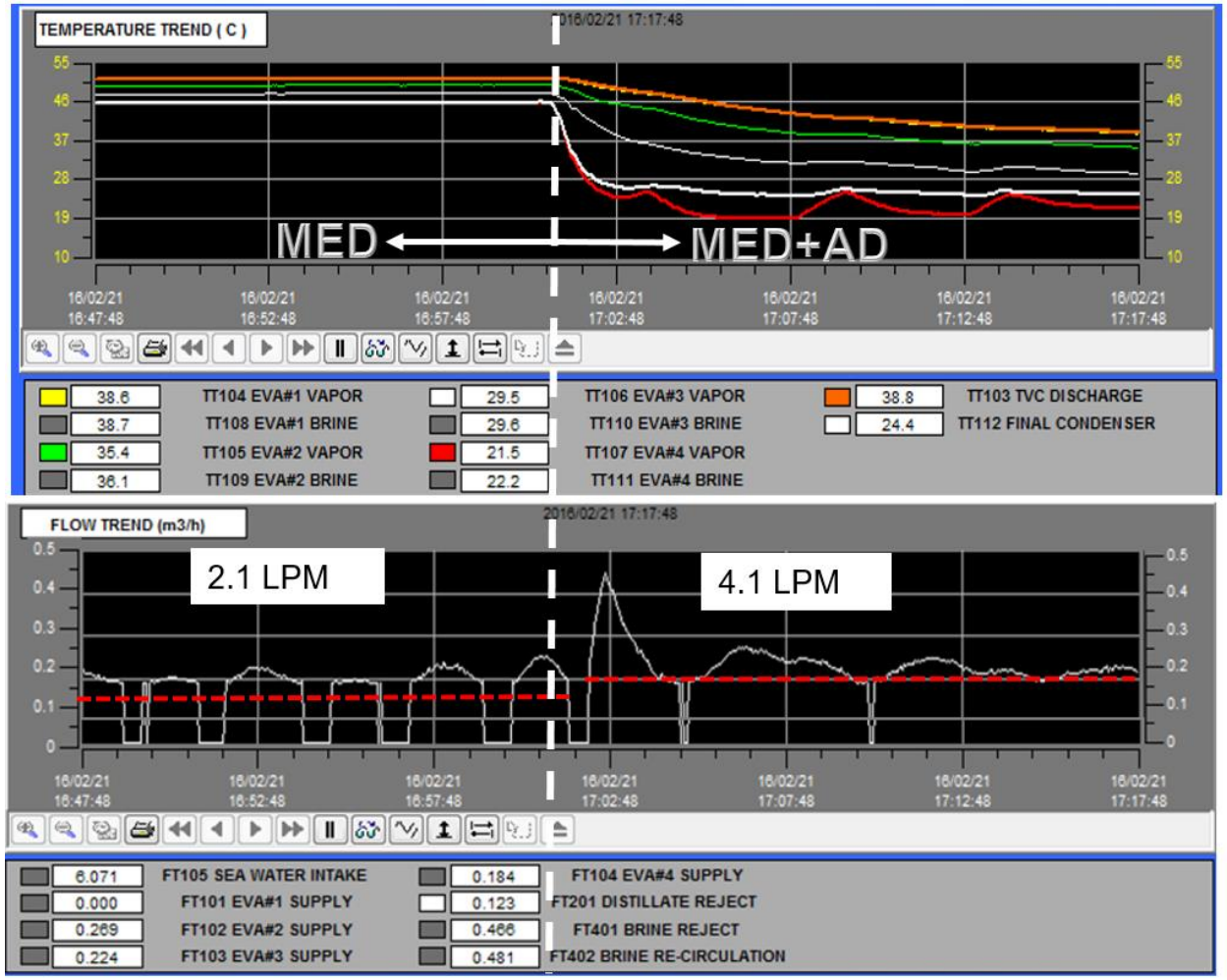
- 10,000 liter per day pilot is installed at KAUST
- Operated with 352 m^2 area of evacuated tube solar collectors

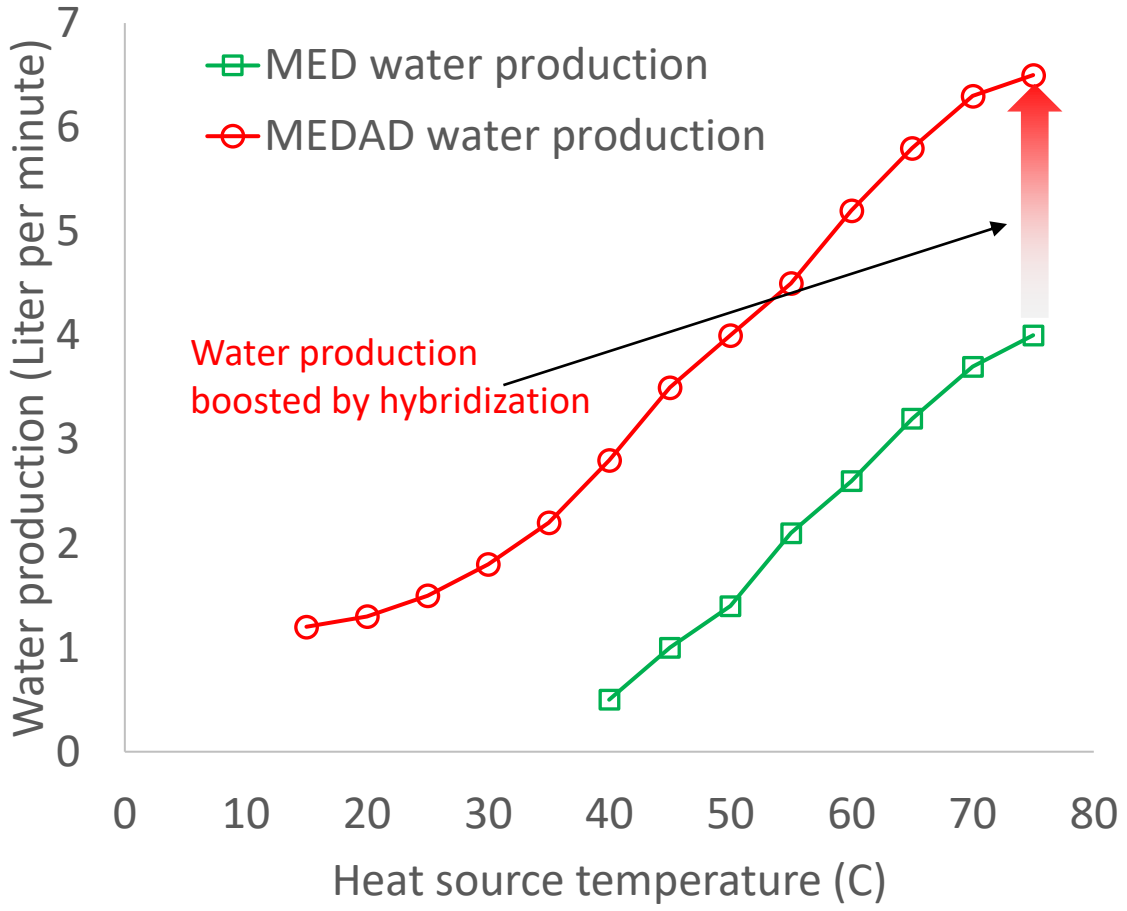


U.S. Patent WO 2018/025224 A1

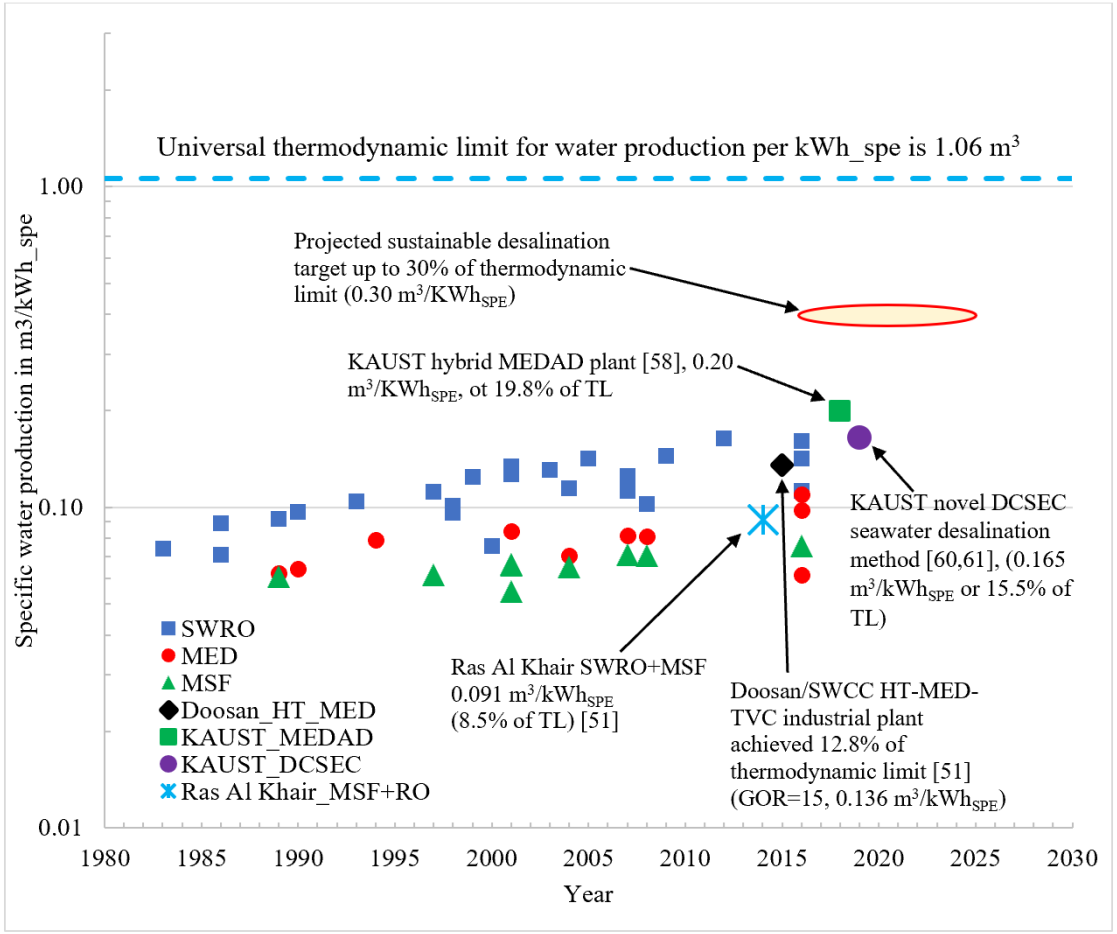
Application # 2019-092 (submitted)

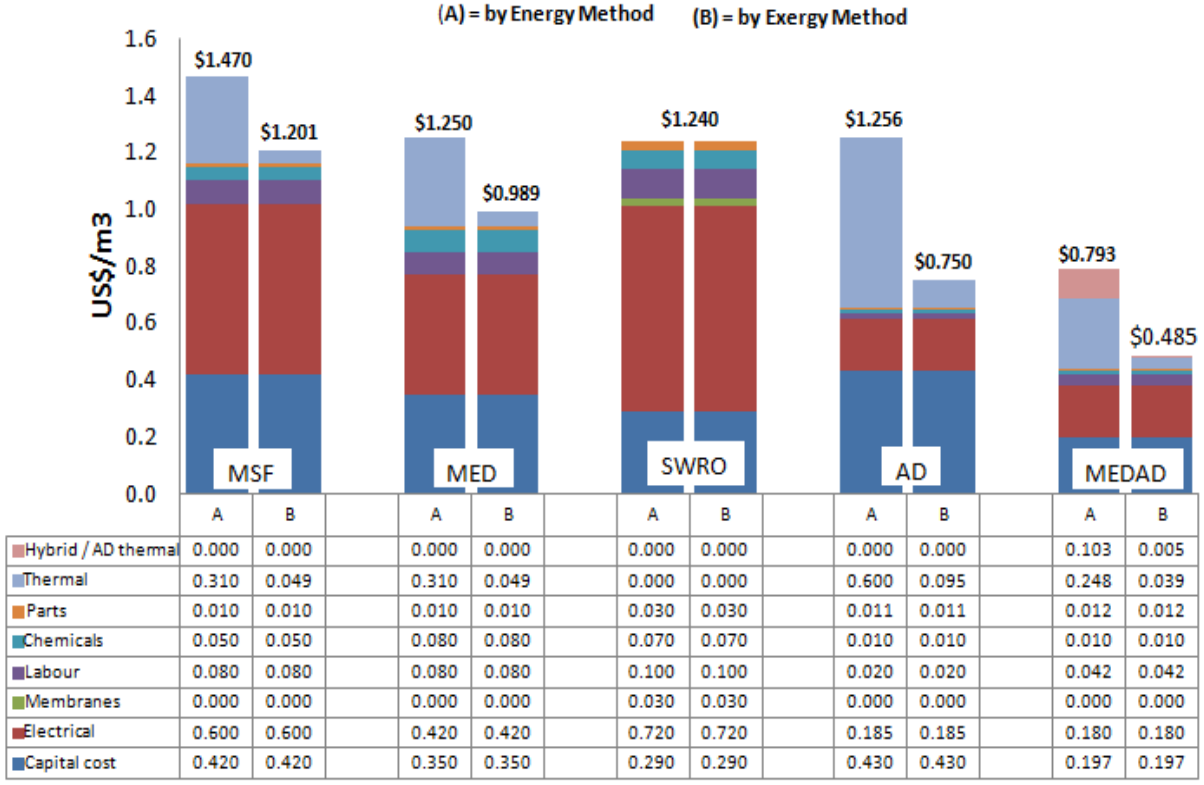
Hybridization MED+AD Pilot Experimental Results





Proposed Cycle Performance





	MSF A	MSF B	MED A	MED B	SWRO A	SWRO B	AD A	AD B	MEDAD A	MEDAD B
Hybrid / AD thermal	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.103	0.005
Thermal	0.310	0.049	0.310	0.049	0.000	0.000	0.600	0.095	0.248	0.039
Parts	0.010	0.010	0.010	0.010	0.030	0.030	0.011	0.011	0.012	0.012
Chemicals	0.050	0.050	0.080	0.080	0.070	0.070	0.010	0.010	0.010	0.010
Labour	0.080	0.080	0.080	0.080	0.100	0.100	0.020	0.020	0.042	0.042
Membranes	0.000	0.000	0.000	0.000	0.030	0.030	0.000	0.000	0.000	0.000
Electrical	0.600	0.600	0.420	0.420	0.720	0.720	0.185	0.185	0.180	0.180
Capital cost	0.420	0.420	0.350	0.350	0.290	0.290	0.430	0.430	0.197	0.197

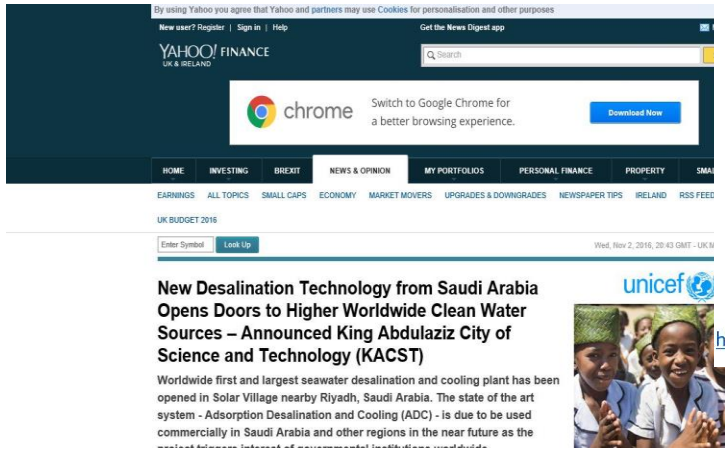
20% of TL

One of the highest performance reported up-till now!

$0.48 per cubic meter

One of the lowest cost reported up-till now!

Technology Highlights



https://www.nytimes.com/2019/10/22/climate/desalination-water-climate-change.htm

https://www.arabnews.com/node/1550811/saudi-arabia

processes has future implications for the economy and levels of environmental and marine pollution," Muhammad Wakil Shahzad, a research scientist at the Water Desalination Research Center (WDRC) at King Abdullah University of Science and Technology (KAUST), told Arab News.

"All conventional desalination processes are operating at only 10 to 13 percent of the thermodynamic limit. Sustainable desalination can only be achieved by 'out of box' solutions such as hybrid processes and highly efficient membranes applications."

Ward points out that "research into renewable desalination is under way, with the largest solar-based experiment located in Saudi Arabia." He says the transforma-

Muhammad.w.Shahzad@Northumbria.ac.uk

Awards..

MEED Sustainability Medal 2020

Awards..

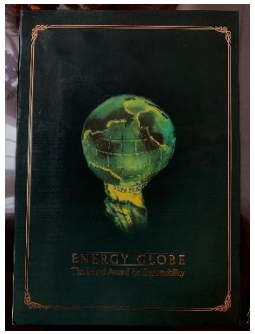
Global Innovation Award in Water-2020

International Desalination Association (IDA) Environment and Sustainability Award (Oct 2019)

Awards..

GE-ARAMCO Global Water Challenge Team Award

Energy Globe National Award 2019, Saudi Arabia



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SHOWER TOGETHER