



National Centre of
Excellence in Desalination
AUSTRALIA

Reducing Carbon Footprint of Desalination

International Conference on Desalination,
Environment and Marine Outfall Systems
13 April 2014
Sultan Qaboos University, Muscat, Oman

Neil Palmer, CEO



Australian desalination in the 1890s using renewable energy – WA goldfields



Early Australian desalination



Coolgardie,

 Mammoth Water Condenser. 

Designed by Mr. St. Quinton, M.E. Murch.

Constructed by the Western Australian Government at Coolgardie. This Condenser can produce 88,000 gallons of fresh water per day, consuming 120,000 gallons of salt water and 100 tons of wood fuel.

This unit produced 0.5 ML/d and used 100 tonnes of firewood each day



The National Centre of Excellence in Desalination Australia



- Established in 2009
- \$20m funding over 5 years from Australian Government's Water for the Future Initiative
- \$3m funding from WA Government



Australian Government
Water for the Future



Research Partners



Administering Organisation



University of Wollongong



One of the NCEDA objectives for desalination:



“researching ways of efficiently and affordably reducing the carbon footprint of desalination facilities and technologies”.



Rockingham Desalination Research Facility





Australia's Millennium drought 1997 - 2009



*"I love a sunburnt country
A land of sweeping plains
Of ragged mountain ranges
Of drought and flooding rains"*

Dorothea Mackellar

**Wivenhoe Dam,
Brisbane
January 2011**





Major Australian desalination plants





Perth 1



Perth 2



Gold Coast



Sydney



Adelaide



Melbourne

The Big Six Australian Desalination Plants



Australia's current major desal plants



PLANT	MLD	MGD
• Perth SDP	145	38
• Gold Coast	125	33
• Sydney	250	66
• Adelaide	300	78
• Perth SSDP	300	78
• Cape Preston	140	47
• Melbourne	450	118
TOTAL	1710	458



Cape Preston desalination plant - Citic Pacific magnetite mine Pilbara WA



Water security for Australia's mainland capital cities

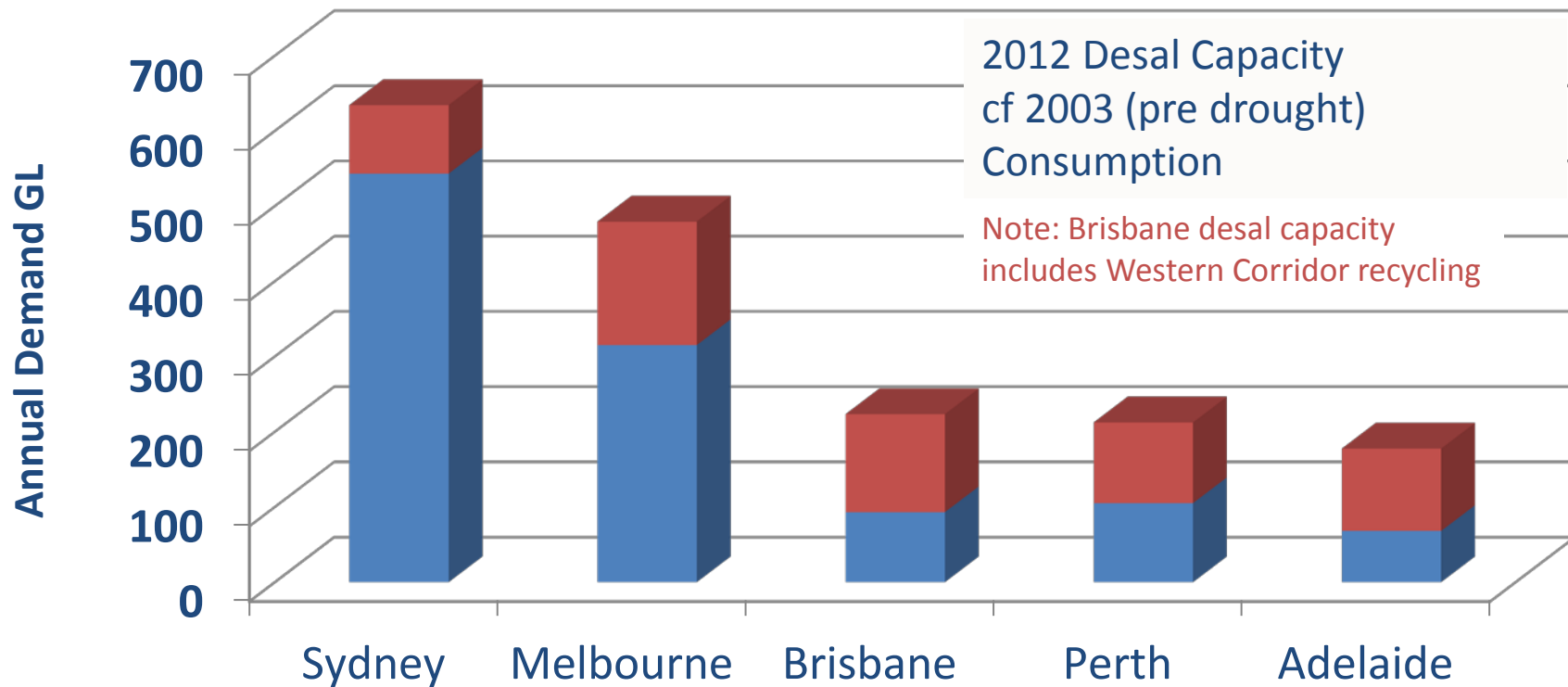


City	Water Consumption 02/03*, GL	Desal Capacity, ML/D	Desal Capacity GL/y	Percent Desal
Sydney	634	250	91	14%
Melbourne	479	450	164	34%
Brisbane SWRO	223	125	46	20%
Brisbane Reuse	223	232	85	38%
Brisbane Total	223	357	130	58%
Perth PDSP	212	144	53	25%
Perth SSDP	212	150	107	26%
Perth Total	212	294	110	51%
Adelaide	178	300	110	62%
TOTAL	1726	1651	603	35%

* WSAAfacts 03



■ Trad ■ Desal





Membrane and system improvement – some recent step changes



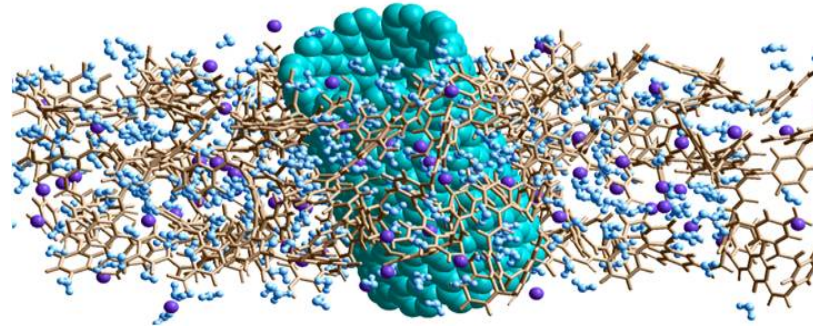


Reverse osmosis membranes

- 1980 – energy intensity 16 kWh/kL
- 2008 – 1.8 kWh/kL
- Theoretical minimum 1.06 kWh/kL
 - 35 g/l salinity
 - 25°C
 - 50% recovery
- Total plant including pre and post treatment around 3 kWh/kL
- 1.4 kg CO₂ generated per kL water produced



Nano H₂O



- Polyamide membrane with embedded, aligned carbon nanotubes
- Standard 100 and 200 mm spiral wound membrane elements
- Retrofit enables 10% overall energy reduction
- 110 ML/d Palmachim plant in Israel – conventional elements replaced by NanoH₂O elements

Kurth, CJ; R Burk; J Green (2011) *Utilizing Nanotechnology to Enhance RO Membrane Performance for Seawater Desalination* IDA World Congress, Perth, September 2011

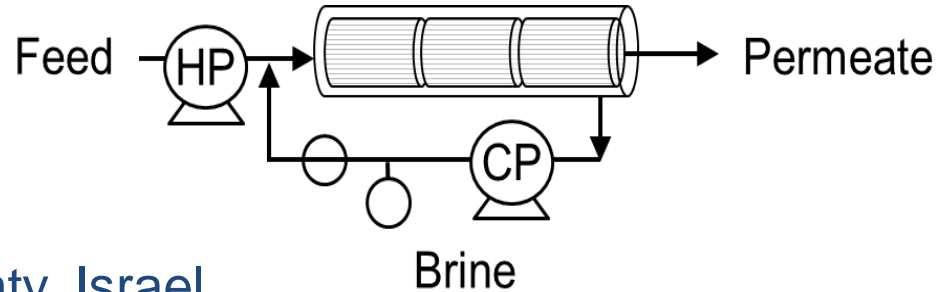




Palmachim
Desalination
Plant
Israel



Desalitech



- Inventor Prof Avi Efraty, Israel
- Batch RO process – “dead end” operation
- Recirculation pump provides cross flow
- When desired recovery reached, brine “swept” out and replaced by feed (no shut down)
- Membrane operation optimised
- Simple concept – no energy recovery
- Total energy intensity of 2 kWh/kL reported

<http://desalitech.com/technology/>





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Desal and Green Energy Research Projects



Solar vacuum assisted
membrane distillation at
Tjuntjuntjara, a remote site in
Western Australia





Tjuntjuntjara



Tjuntjuntjara

Rockingham



1300 km

Canberra



Pryor T (2013) *Tjuntjuntjara Remote Inland Indigenous Community Solar/Waste Energy Groundwater Desalination Project* NCEDA International Desalination Workshop 6, Melbourne 28-29 Nov

Murdoch University
University of Technology Sydney
WA Dept of Housing
Parsons Brinckerhoff
memSYS Clearwater (Singapore)
Institute of Filtration and Techniques of Separation (France)
Membrane Technology Centre

- Solar heating (and possibly waste heat from diesel powered generators)
- Hypersaline groundwater feed
- Blending of distillate with existing limited water supply from brackish groundwater
- Potential for many more applications in deserts





Tjuntjuntjara solar
membrane
distillation pilot
plant





memSYS membrane
distillation pilot plant
at Tjuntjuntjara



The four stage vacuum assisted memSYS membrane distillation process

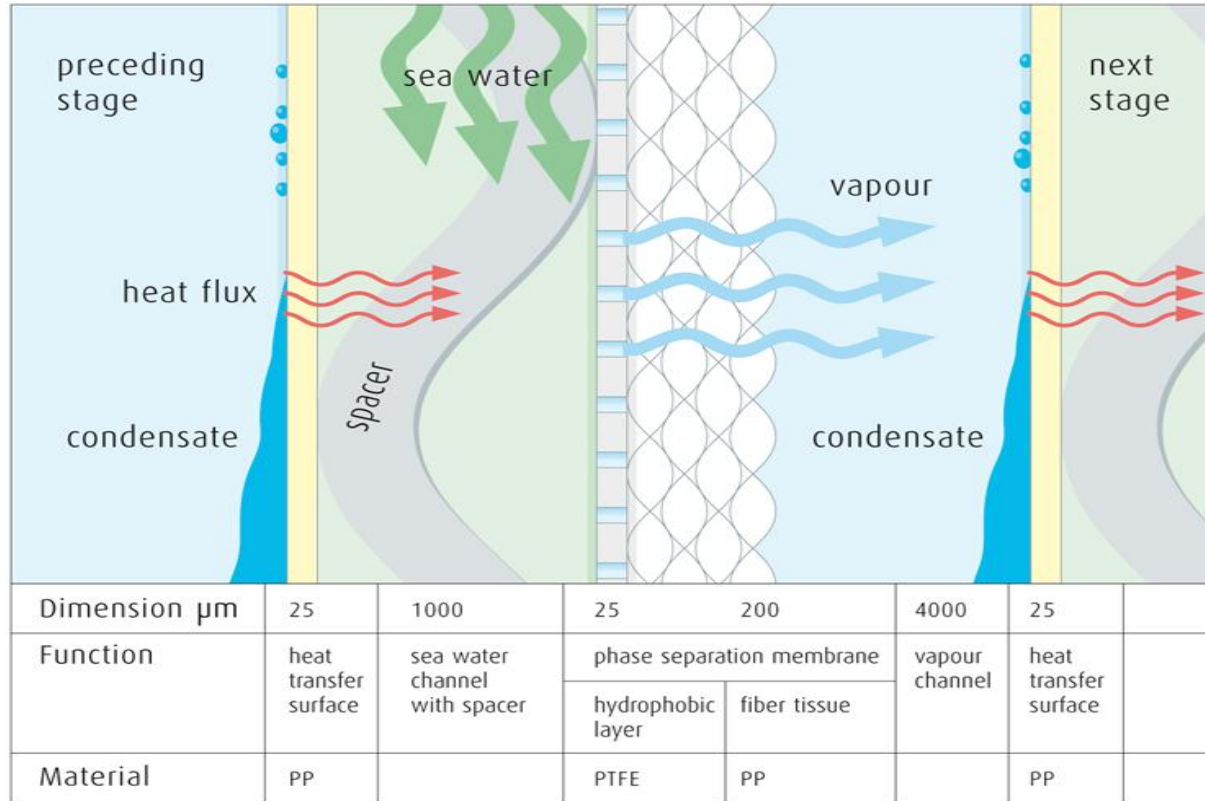
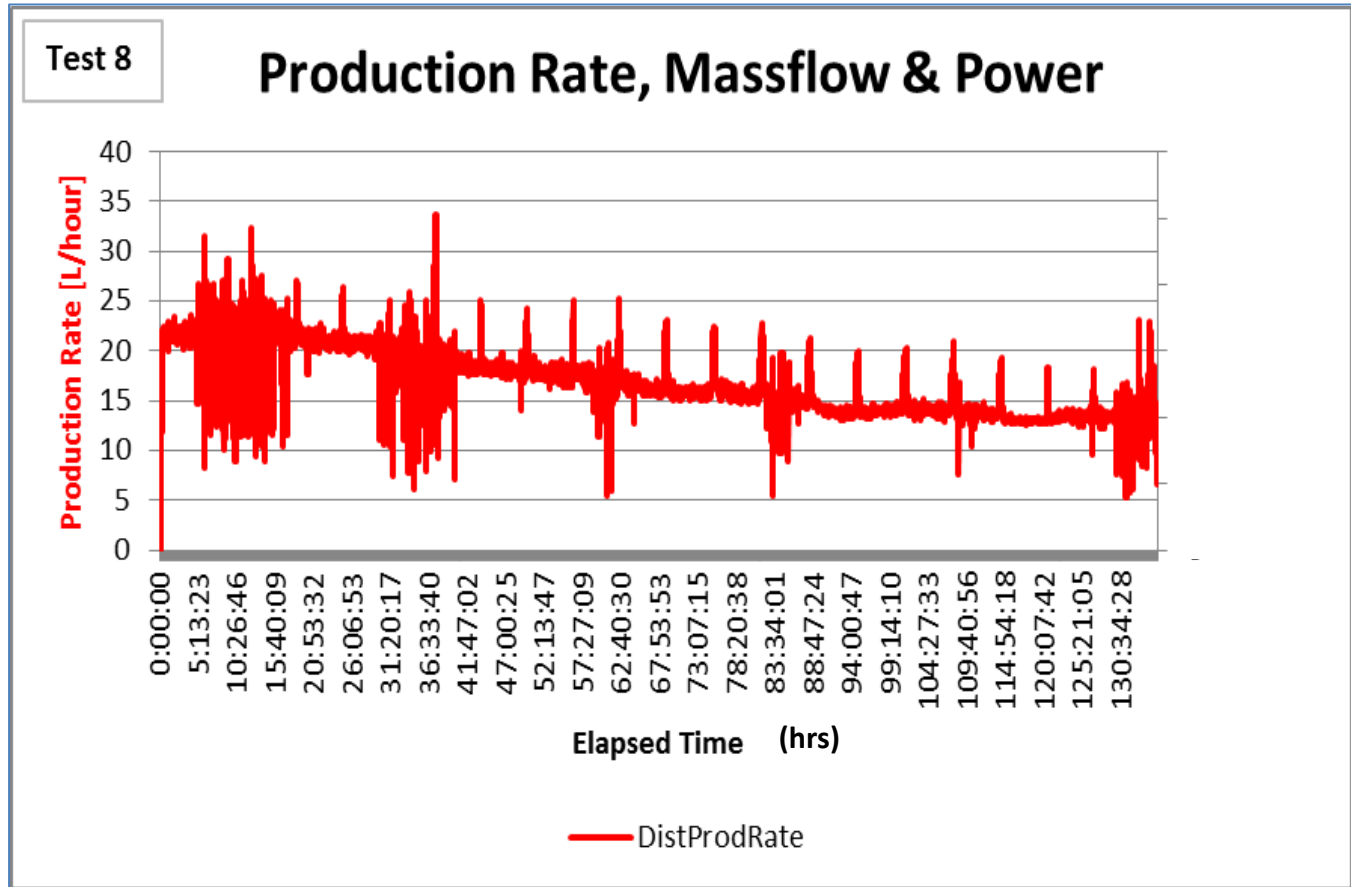


Image courtesy
memSYS



memSYS unit
performance
February 2014

Calcium and
magnesium sulphates,
soluble iron and heat
contribute to scaling.
HCl cleaning effective





Industrial waste
heat driven
multi-effect
distillation



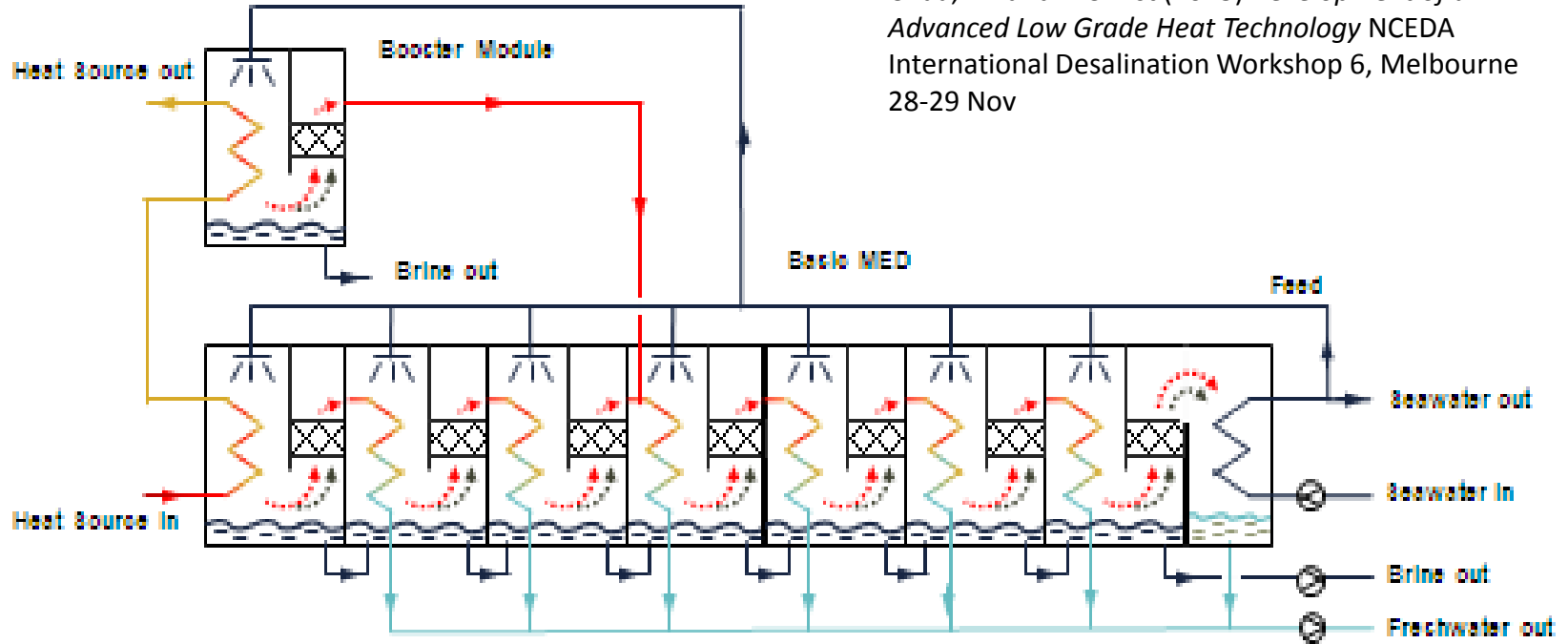
University of Western Australia
WA Geothermal Centre of Excellence
Industry Partner BHP Billiton

- Novel MED technology
- Improves MED efficiency by 30%
- Uses waste heat from the refining process
- Full scale plant will:
 - provide recycled water for the refinery
 - reduce fresh water demand
 - reduce tailings water balance



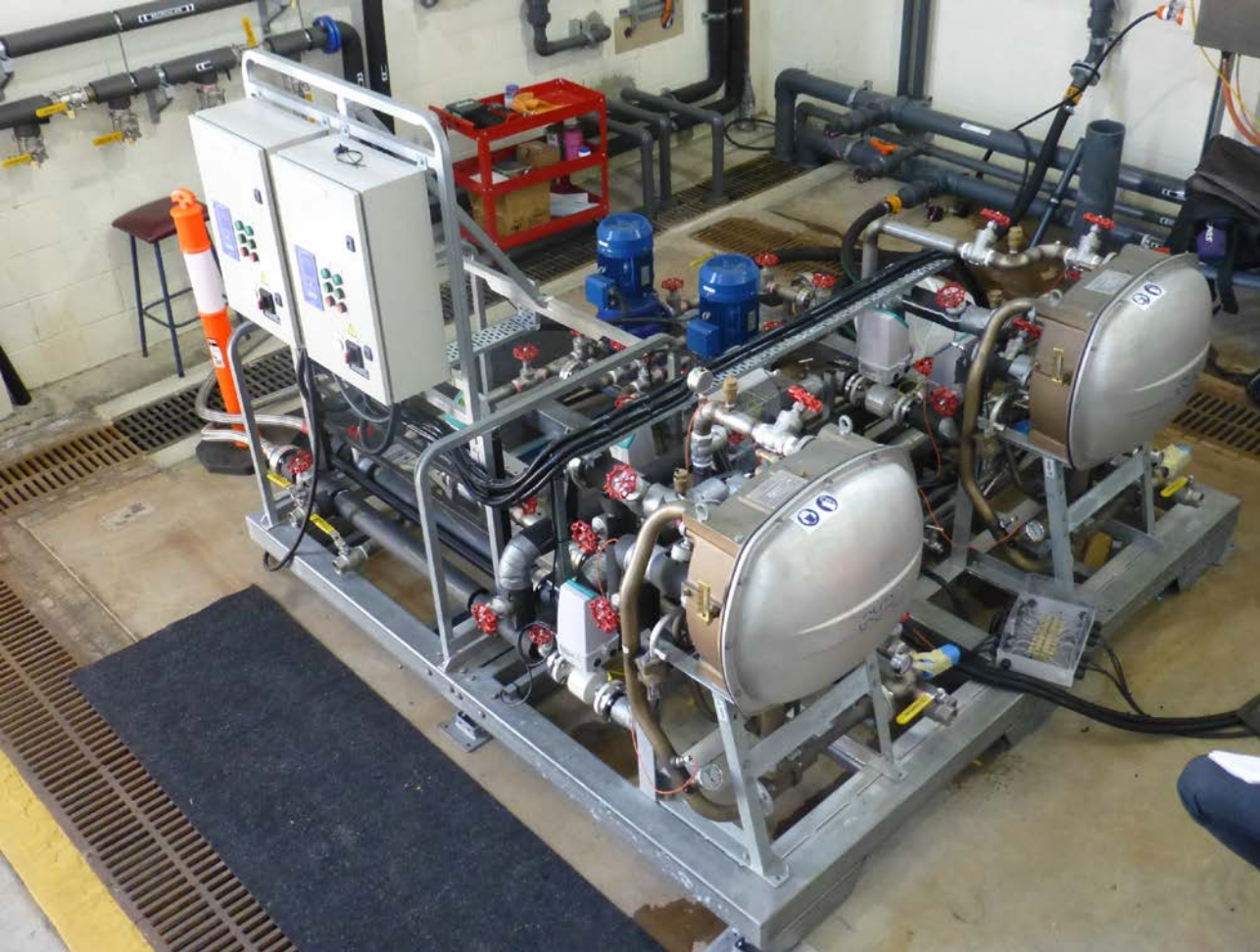


Chua, HT and A Christ (2013) *Development of an Advanced Low Grade Heat Technology* NCEDA International Desalination Workshop 6, Melbourne 28-29 Nov





1.5 kL/d pilot plant
has been built and
tested at
Rockingham Pilot
Test Facility
before being
relocated to mine
site south of Perth





Geothermal Energy



University of Western Australia
CSIRO
Pilbara Cities Office

Hot brackish groundwater in WA at depth

- Currently used for pool heating in Perth
- Large reserves:
 - beneath Perth (3 km)
 - the Pilbara – mining area of WA
- Potential for commercial desalination

Barron, O (2013) *Opportunities for desalination in Australian Agriculture* NCEDA International Desalination Workshop 6, Melbourne 28-29 Nov





Capacitive De-ionisation

UniSA Mobile Solar Powered CDI Unit





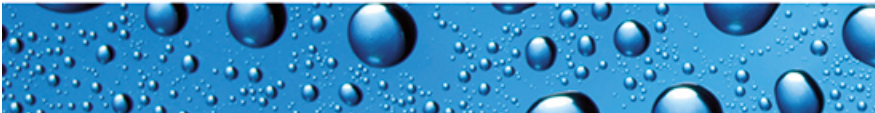
University of South Australia
SA Water
LT Green Energy

Zhang, W; M Mossad and L Zou (2013) *A study of the long-term operation of capacitive deionisation in inland brackish water desalination* Desalination Vol 320 (2013) pp 80-85

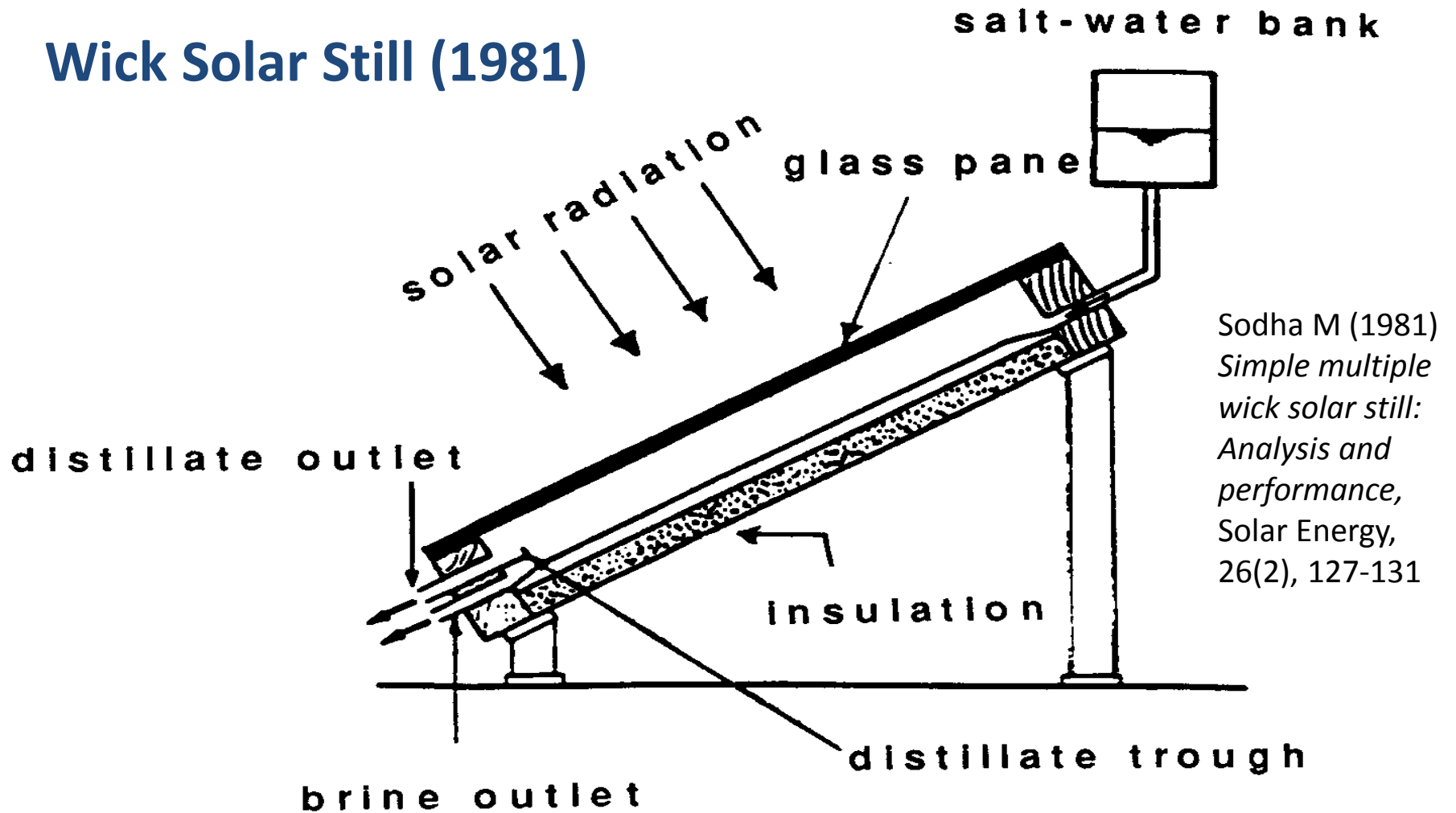
- Mobile solar photovoltaic desalination plant
- Mesoporous carbon electrodes
- 4 kL/d from brackish water over a 10 hour day
- 500 mg/L TDS fresh water produced



Australian solar wick distillation panels



Wick Solar Still (1981)



Carocell Solar Desalination Panels Made in Australia by F Cubed, Melbourne

- Solar energy
- Seawater used as feed at RDRF
- Photovoltaic powered feed pump
- 50% recovery
- 17 L/d maximum distillate produced in summer



F Cubed Australian factory
in Melbourne

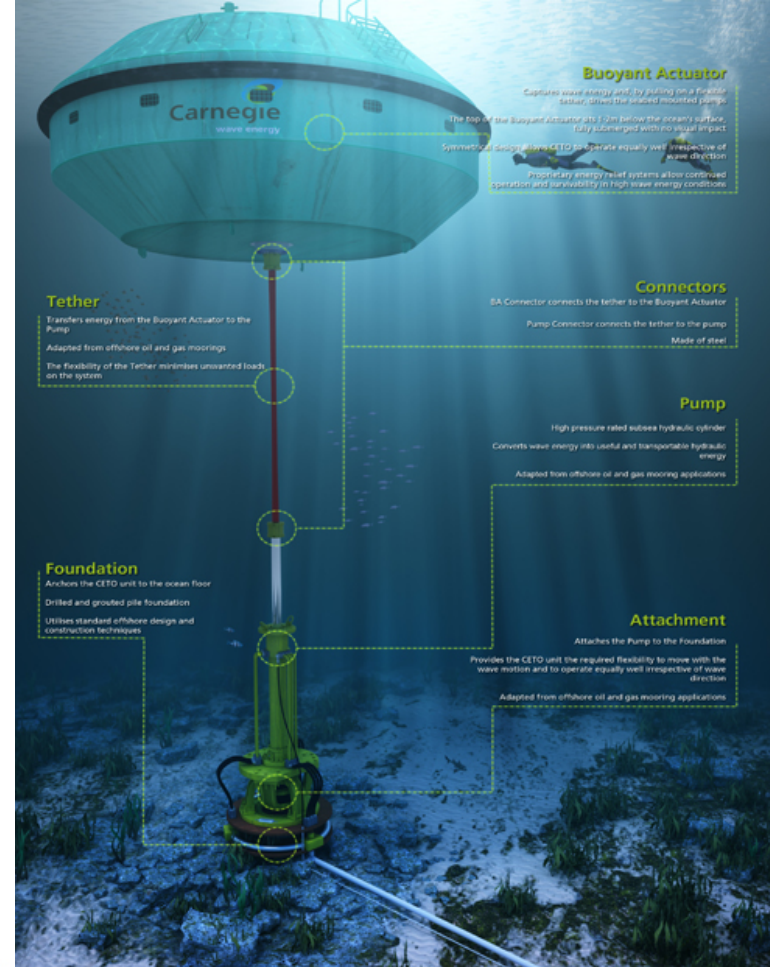


30 unit F Cubed installation at Kendenup
Farm near Albany WA – produces 0.5 kL/d



Carnegie Wave Energy

- Full scale demonstration plant
- Off Garden Island WA
- Electricity and water for HMAS Stirling
- High pressure fluid for
 - electricity generation or
 - seawater desalination
- NCEDA to validate results



Sundrop Farms – Growing Tomatoes from Seawater and Sunshine



Charlie Paton - environmental greenhouse in Oman 2012



Sundrop Farms, Port Augusta, South Australia



Hypersaline ground water used as feed

- Source: Spencer Gulf
- Approx 57 ppt (normal seawater 37 ppt)
- Parabolic solar collector
- Steam for power and desalination
- Multi effect distillation for water (hydroponic)
- Tomatoes, capsicums and cucumbers grown
- Sold in Adelaide markets
- \$A190m expansion approved
- 200 new jobs will be created



(NOTE THIS IS NOT AN NCEDA PROJECT).



Solar tower
proposed for
Port Augusta -
the first in the
Southern
Hemisphere



Torresol thermosolar
plant, Spain







David Pratt
Head Grower
Sundrop Farms
Pt Augusta SA





Green Energy for the Big Six Desalination Plants





Emu Downs

Wind Energy
for Perth
Seawater
Desalination
Plant





Perth Seawater Desalination Plant Kwinana

Wind Energy

Emu Downs, 300 km north of Perth

Stanwell/Griffin Joint Venture

40 turbines, 80 MW

66 percent of the energy output purchased

Equates to total energy load of the desalination plant

185 GW hrs/annum - equivalent to 24 MW continuous

Opened on 12 November 2006





Greenough River Solar Farm



Renewable
Energy for
Southern
Seawater
Desalination Plant
Binningup



Farm

Southern Seawater Desalination Plant Binningup



Wind Energy

Mumbida Wind Farm near Geraldton 400km north of Perth

Verve Energy – Macquarie Capital

22 turbines, 55 MW

2.5 MW GE turbines

Solar Energy

Greenough River 10 MW Solar Farm

Verve Energy – GE Financial Services JV

Expandable to 40 MW

80 hectares: 150,000 PV panels

Largest photovoltaic array in Australia





Sydney Desalination Plant

Capital Wind Farm for Infigen Energy Bungendore near Canberra
67 turbines, 141 MW Suzlon 2.1 MW ea

Melbourne Desalination Plant

Oaklands Hill Wind Farm, Glenthompson, near Hamilton for AGL
32 turbines, 63 MW Suzlon 2.1 MW ea

Adelaide Desalination Plant

Hallett Wind Farms 1,2, 4,5 for AGL
167 turbines, 361 MW Suzlon 2.1 MW ea

Gold Coast Desalination Plant

Operator purchases renewable energy credits





**Australian major urban
desalination plants
have no operating
carbon footprint**





Summary

- New reverse osmosis technology reducing energy intensity
- Heat from solar, industry, geothermal and energy from waves targetted for desalination in Australia
- Major urban Australian desalination plants purchase renewable energy. Increases operating cost but there is **no operating carbon footprint**
- Solar energy used for commercial greenhouse development
- New investors keen on sustainable projects





THANK YOU

Oasis of Biladsayt, Oman



National Centre of Excellence in Desalination

AUSTRALIA

