

Wind and Tidal - Benefits and Opportunities in Australia

Presented by

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Outline

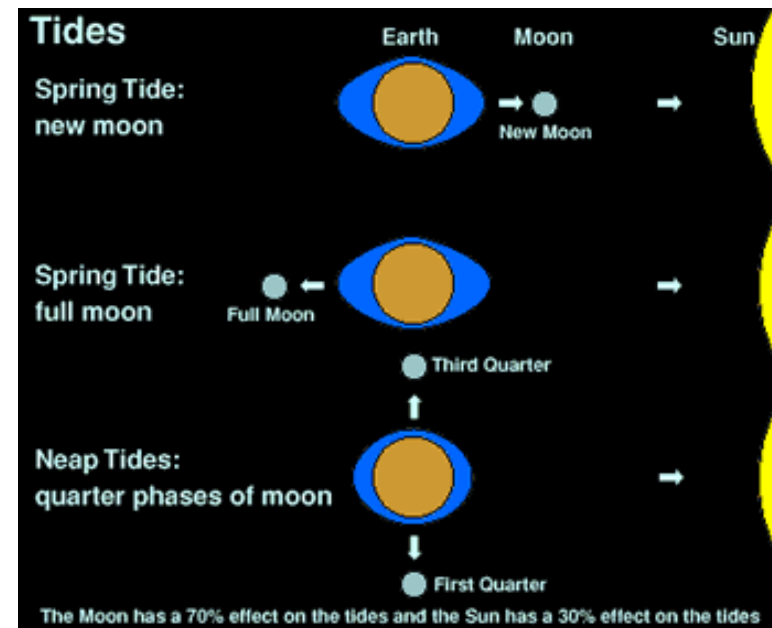
- Ocean Energy Introduction
- Tidal/Ocean Current Resource
- Wave Resource
- Types of Wave Energy Converters
- The CETO Project
- CETO in the South West
- Conclusion

Introduction- Waves

- Wave energy is a reliable and sustainable renewable energy resource that is plentiful in supply.
- Wave energy is constantly renewed by the sun according to the following sequence:
 - **Radiation from the sun warms the earth;**
 - **Earth's atmosphere warms unevenly;**
 - **The uneven warming patterns create pressure variations and general rotation of the atmosphere;**
 - **The rotation of the atmosphere in combination with gravity and the rotation of the globe cause winds;**
 - **As the winds drag across the surface of the ocean ripples, wavelets and ultimately waves are formed.**
- Ocean waves can travel great distances with minimal loss of energy until they break at a shore.

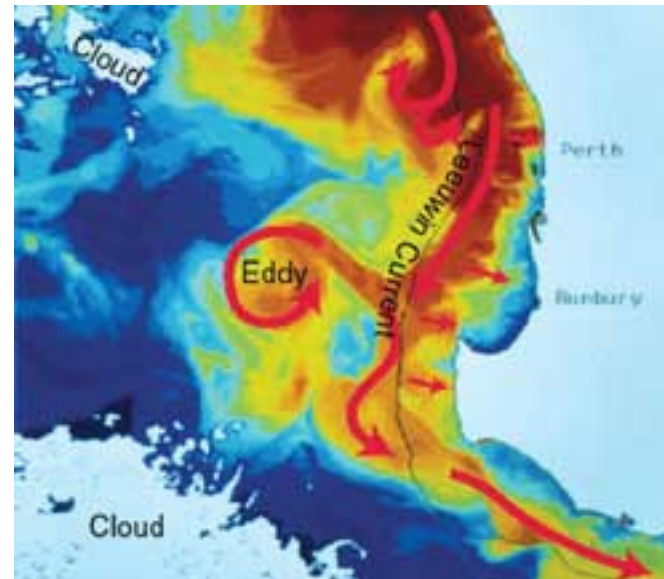
Introduction- Tides

- Caused by the gravitational effect of the moon, and to a lesser extent the sun, on the world's oceans in combination with the rotation of the earth.
- Tides are created twice a day as the earth rotates through the bulges in the ocean on either side of the earth.
- The tidal range at a location also depends on the nature of the coastline which can amplify the tidal effect.



Introduction- Ocean Currents

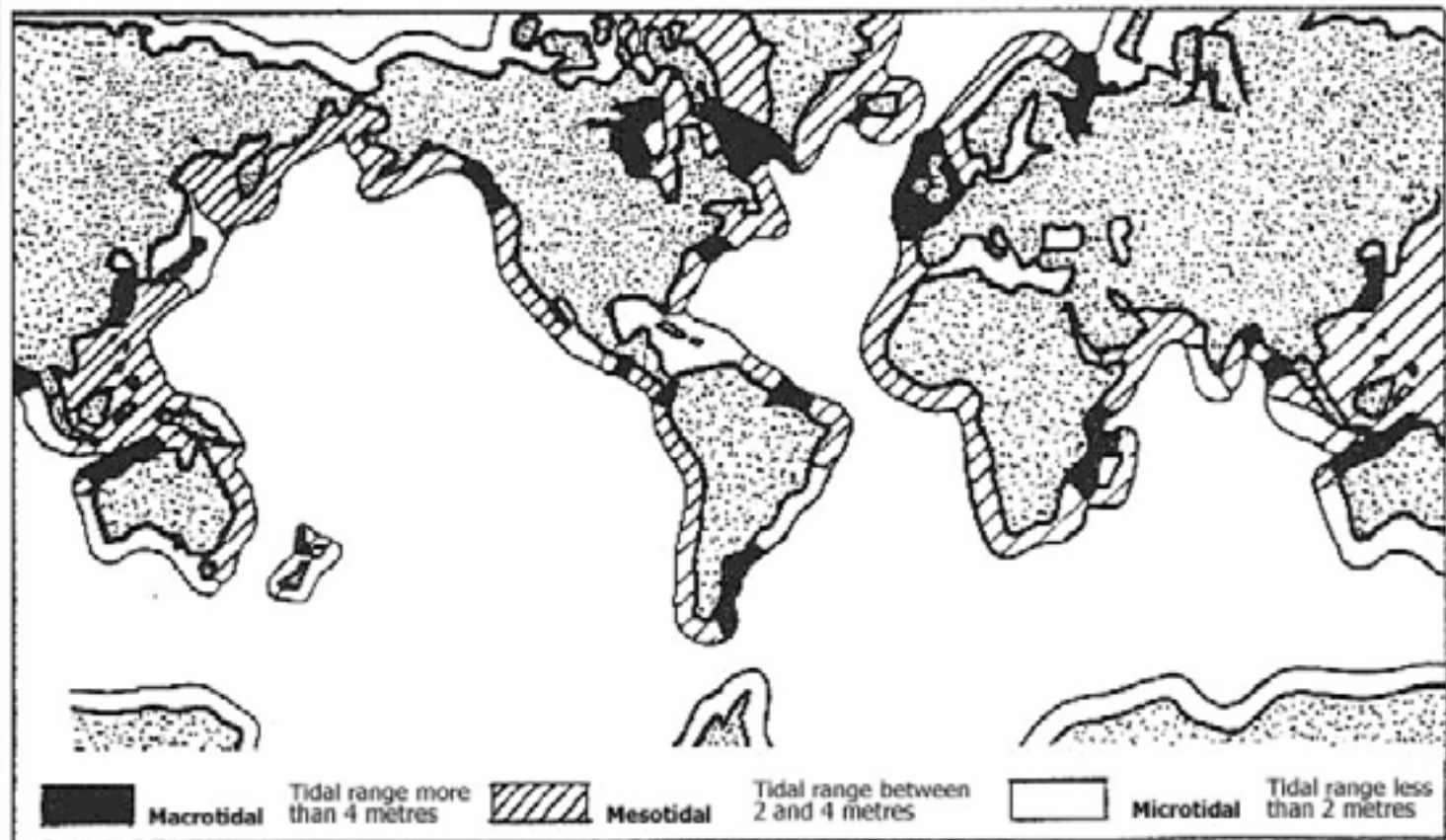
- Ocean currents are relatively constant and flow in one direction only in contrast to the tidal streams caused by the tides which are closer to shore.
- Ocean currents flow in patterns affected by the wind, water salinity and temperature, topography of the ocean floor, and the earth's rotation.
- Some examples of ocean currents are the Gulf Stream, Florida Straits Current, and California Current, and the Leeuwin current



Tides –Worldwide Resource

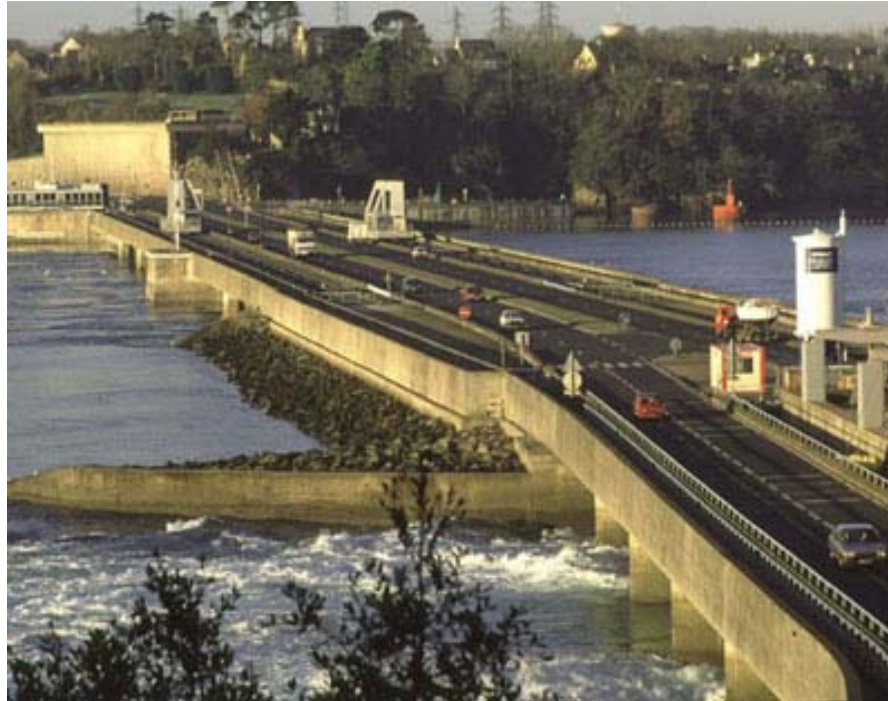
Global tidal ranges around the world (from Davies 1964)

© Western Power



Tides –Global Installations

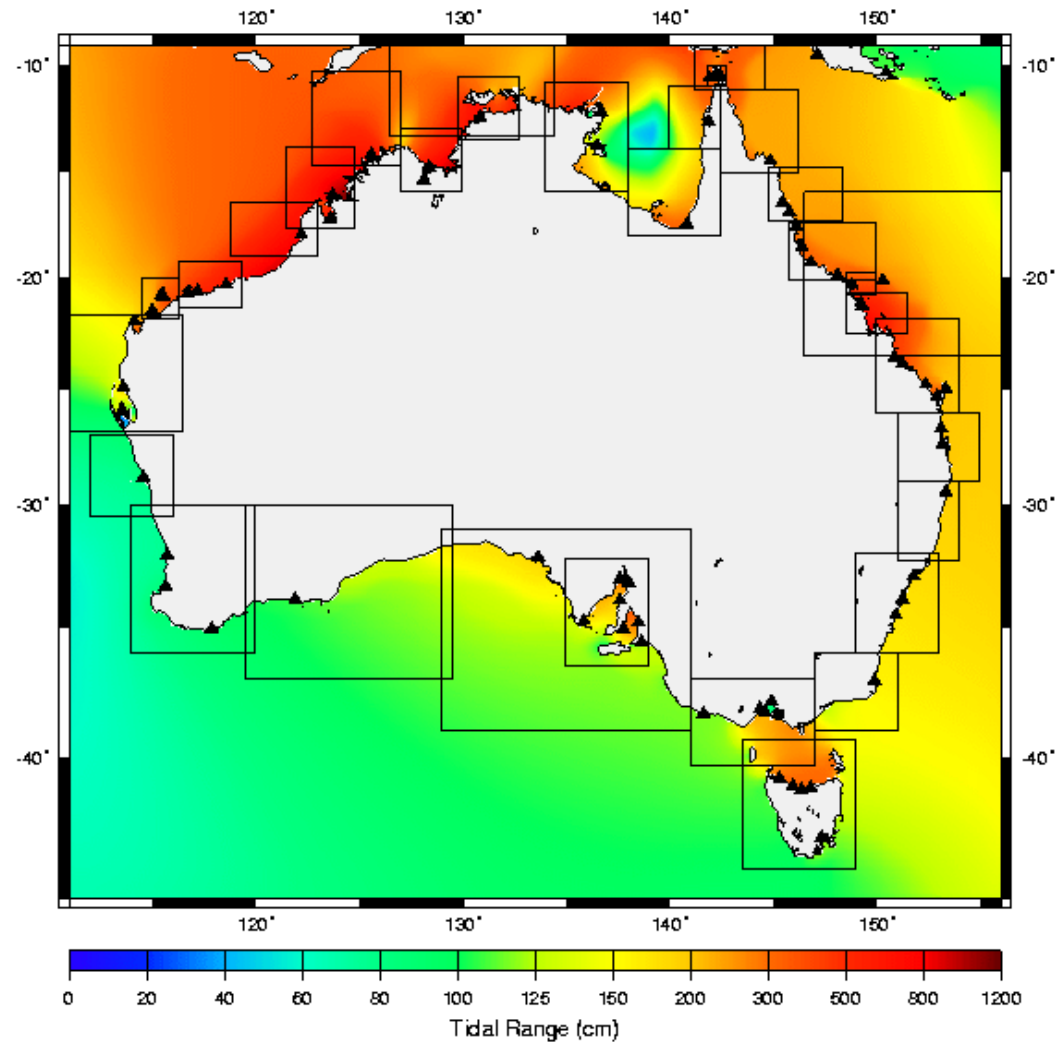
- Tidal Barrages – La Rance in Brittany, France (250MW capacity – 8m tidal range)



- Tidal Fences – Uldomuk Strait, Korea (~1MW capacity, water speeds 6.5 m/s)
- Tidal Turbines – Strangford Lough, Northern Ireland (1MW capacity, >3m/s)
- Tidal Lagoons – Swansea Bay, Wales (30MW capacity – 6-8m tidal range)

Tides –Resource in Australia

Australian Tidal Ranges, From Australian Government Bureau of statistics, web site, 2007, http://www.bom.gov.au/oceanography/tides/index_range.shtml



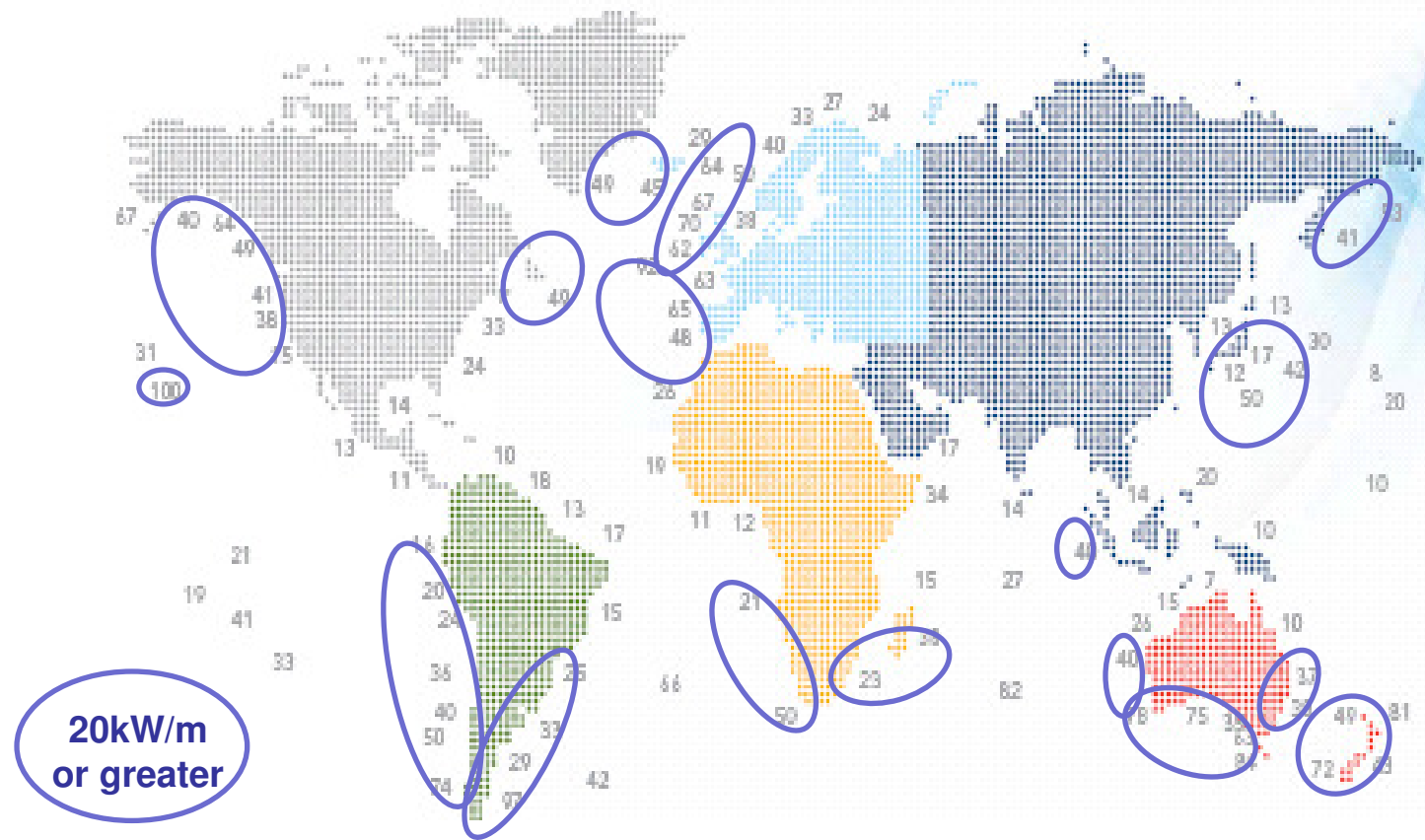
Tidal, Ocean and Estuarine Current Power Opportunities in the South West

- Analysis by Carnegie finds there are no viable sources of renewable energy obtainable from the ocean, estuaries, or rivers as tidal or current energy in the south west from Bunbury around to Esperance.
- Advice from Centre for Water Resources (CWR) indicates there are none anywhere south of Broome.
- The tidal range in the South West is only around 1 meter and the magnitude of currents is relatively small.

Wave Energy as a Global Energy Resource

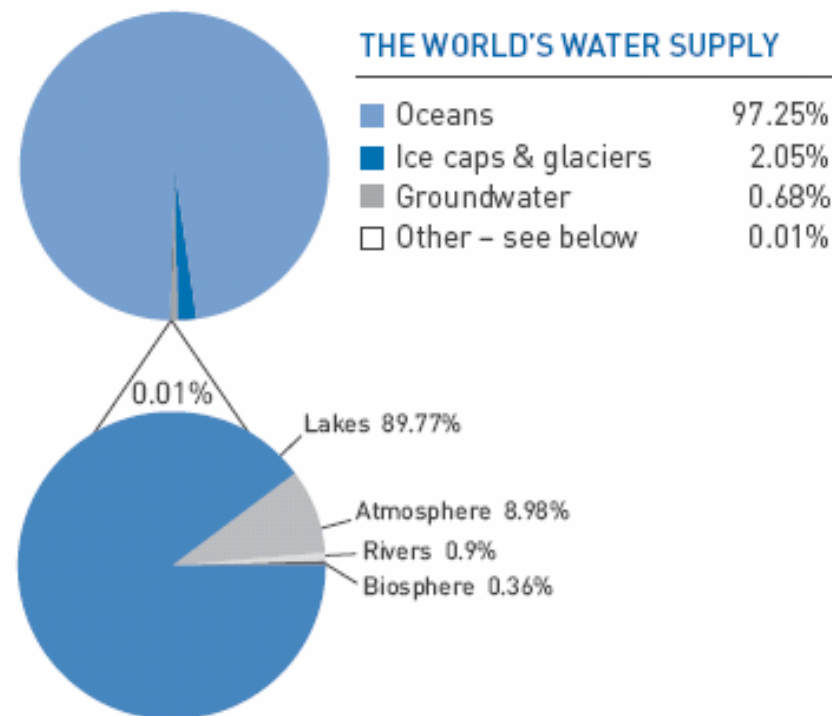
- Its estimated that the energy from the world's waves is equal to twice the amount of electricity that the world currently consumes.
- There is potential for the majority of world base load power requirements to be sourced from wave energy.
- Wave energy locations are dictated by global wind patterns making waves more prevalent in the mid-latitudes (40-60(N/S)).
- Western Europe, the west coast of USA and South America, and the coasts of Australia, New Zealand and Japan are particularly suitable.

Wave Energy – a global resource



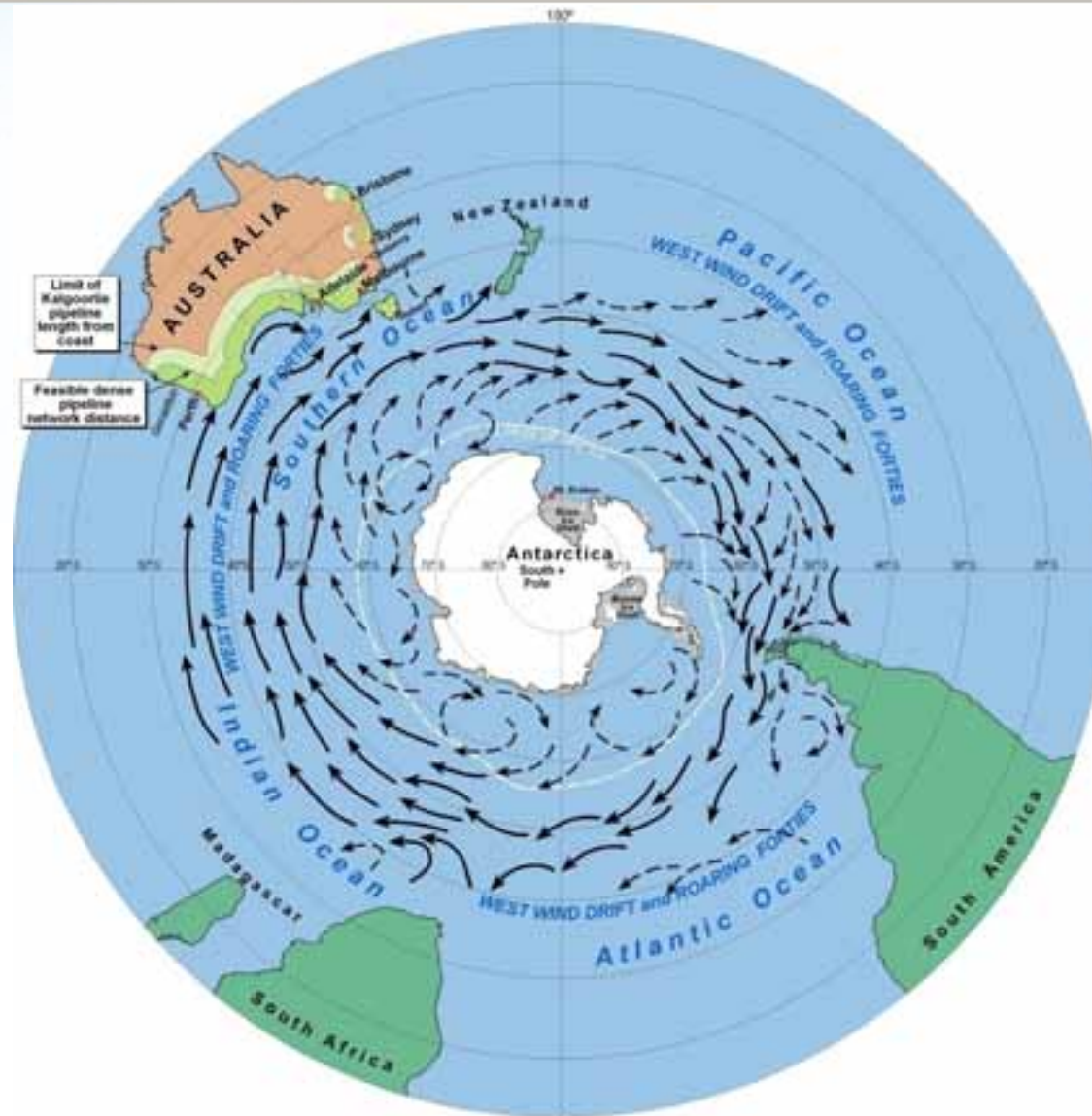
What water shortage?

Only 0.01% of the world's water supply is accessible without seawater desalination.



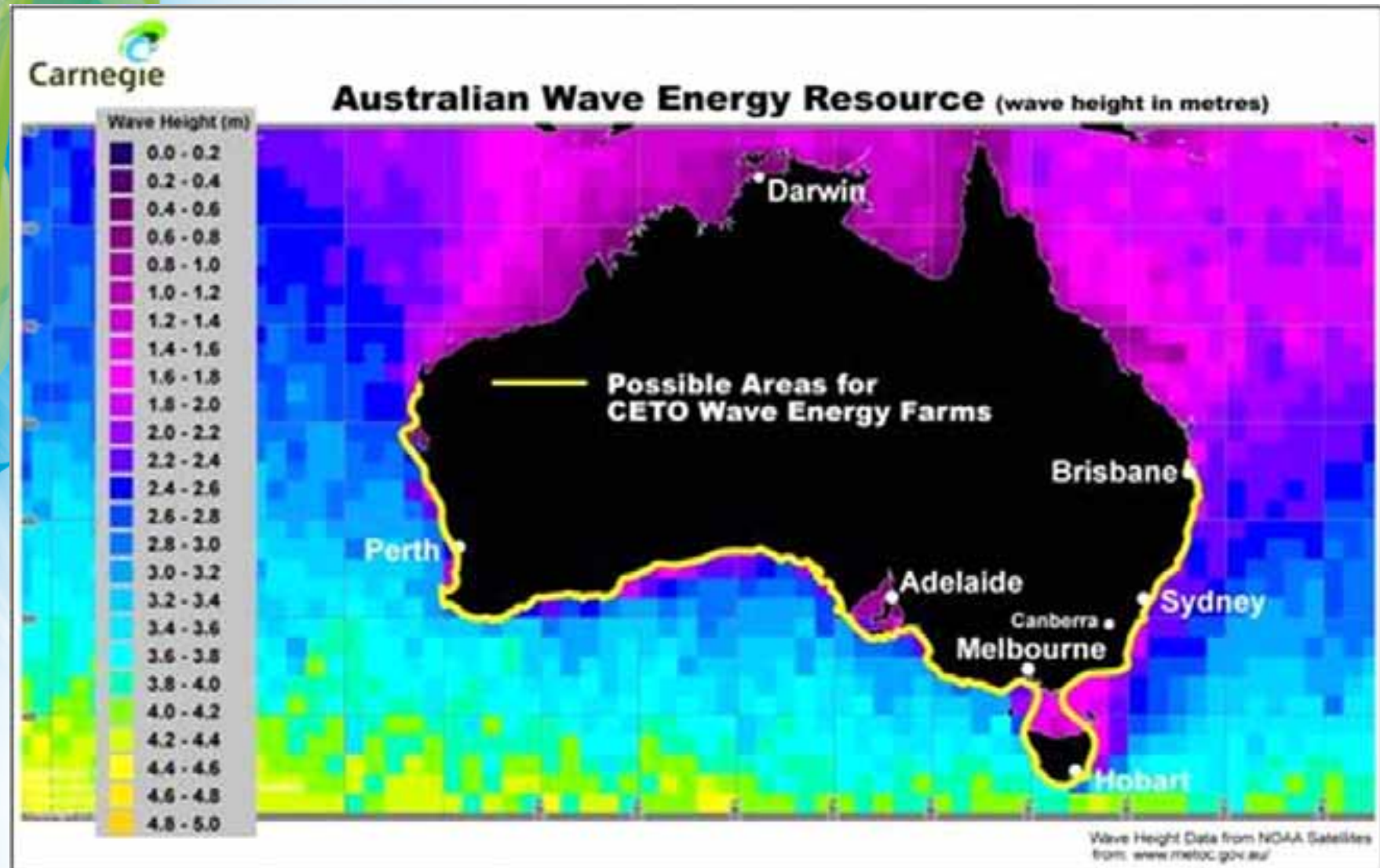
Source: Pinet, P. (2003) 'Invitation to Oceanography'

Southern Wave Energy Engine

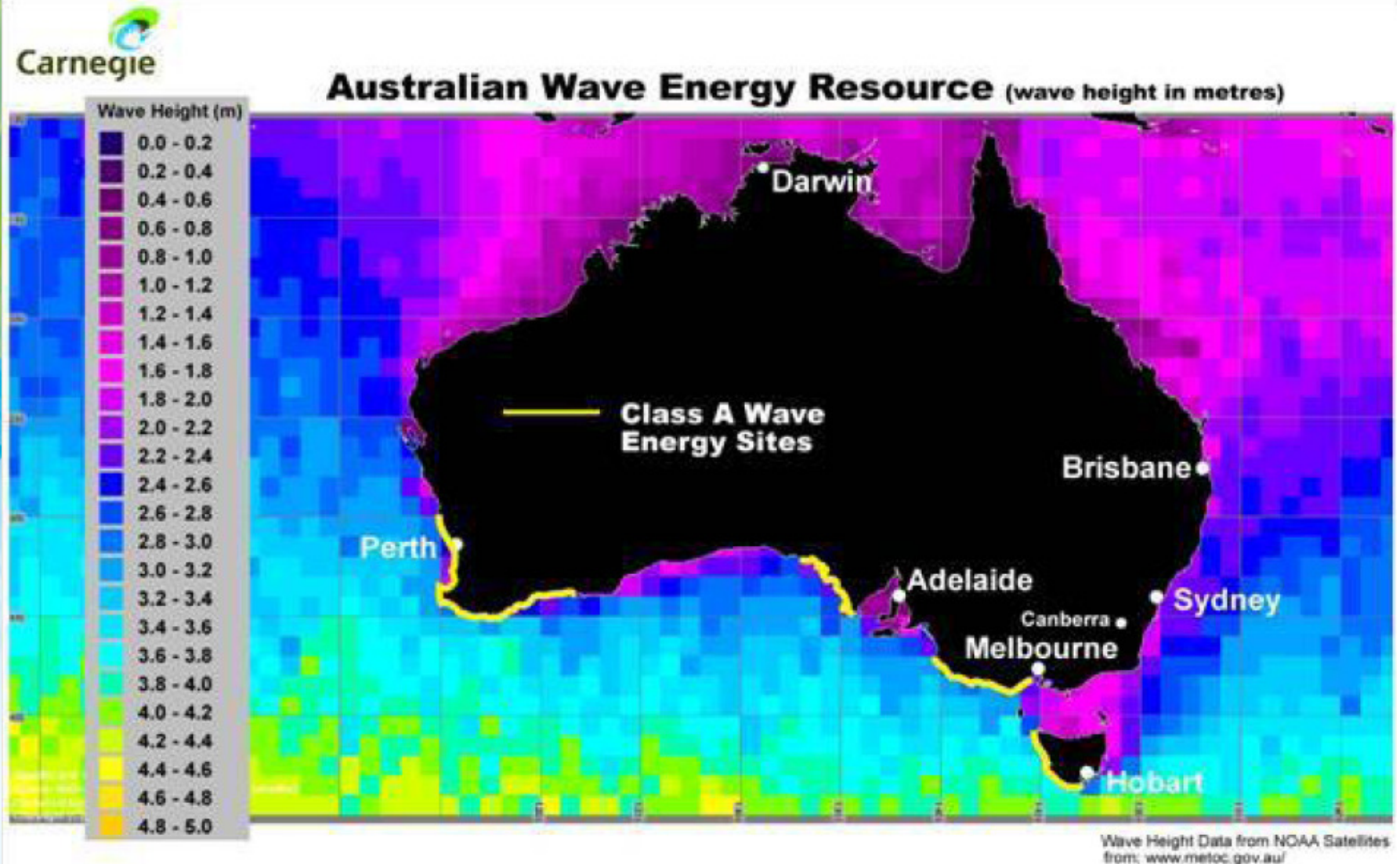


CIRCUMPOLAR WAVE ENERGY ENGINE

Australian Wave Resource



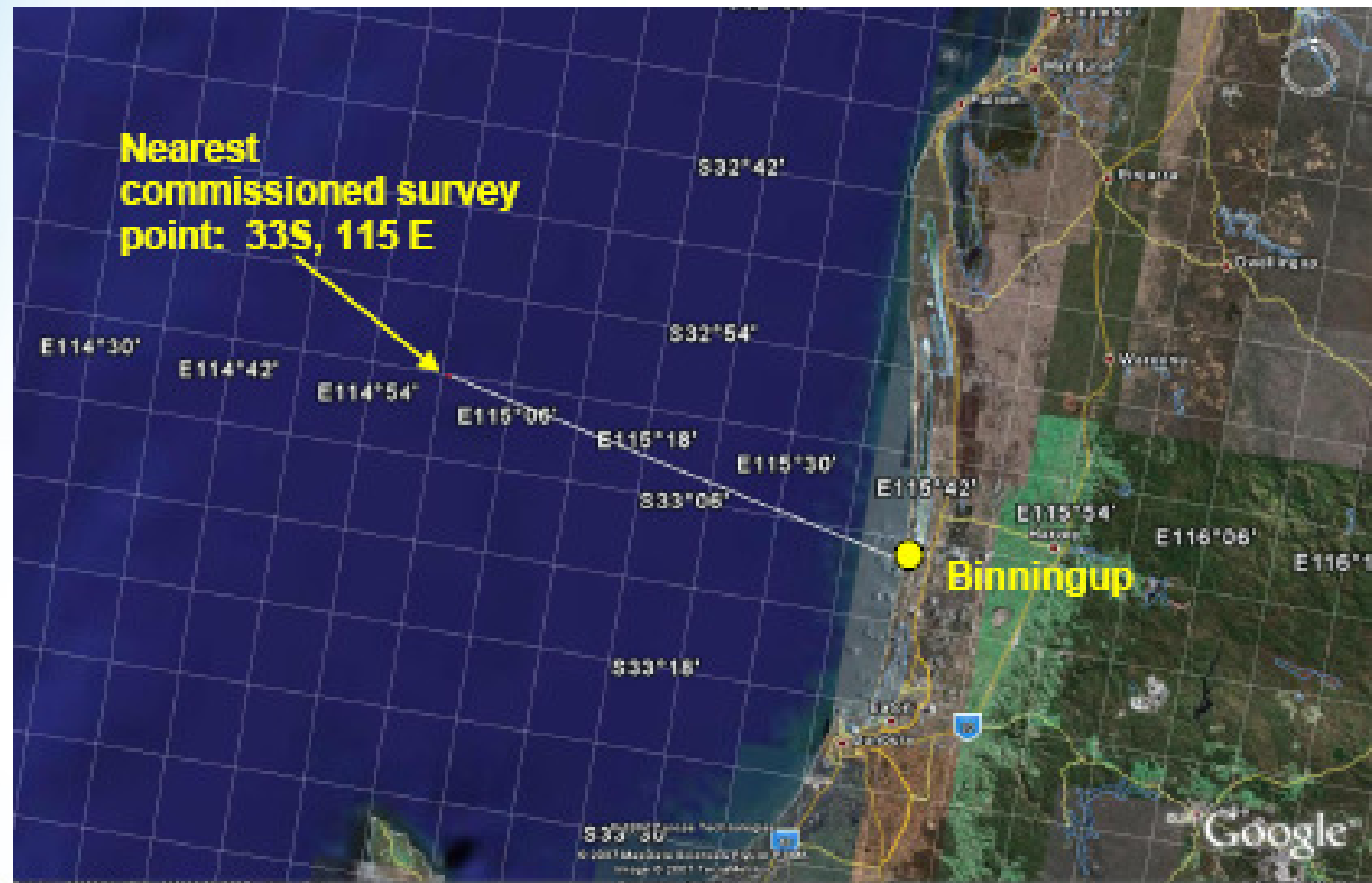
Australian Class A Wave Sites



Australian Class A Wave Sites in WA

- Encompasses the South West coastline
- Estimate of available wave energy from Perth around to Esperance is 117-137 GW
- Harnessing 40% of this would yield 47-55 GW
- Many sites within this region are suitable for the provision of base load power
 - High availability of swell waves in 2-3 m range

South West Wave Survey Example- Binningup, WA



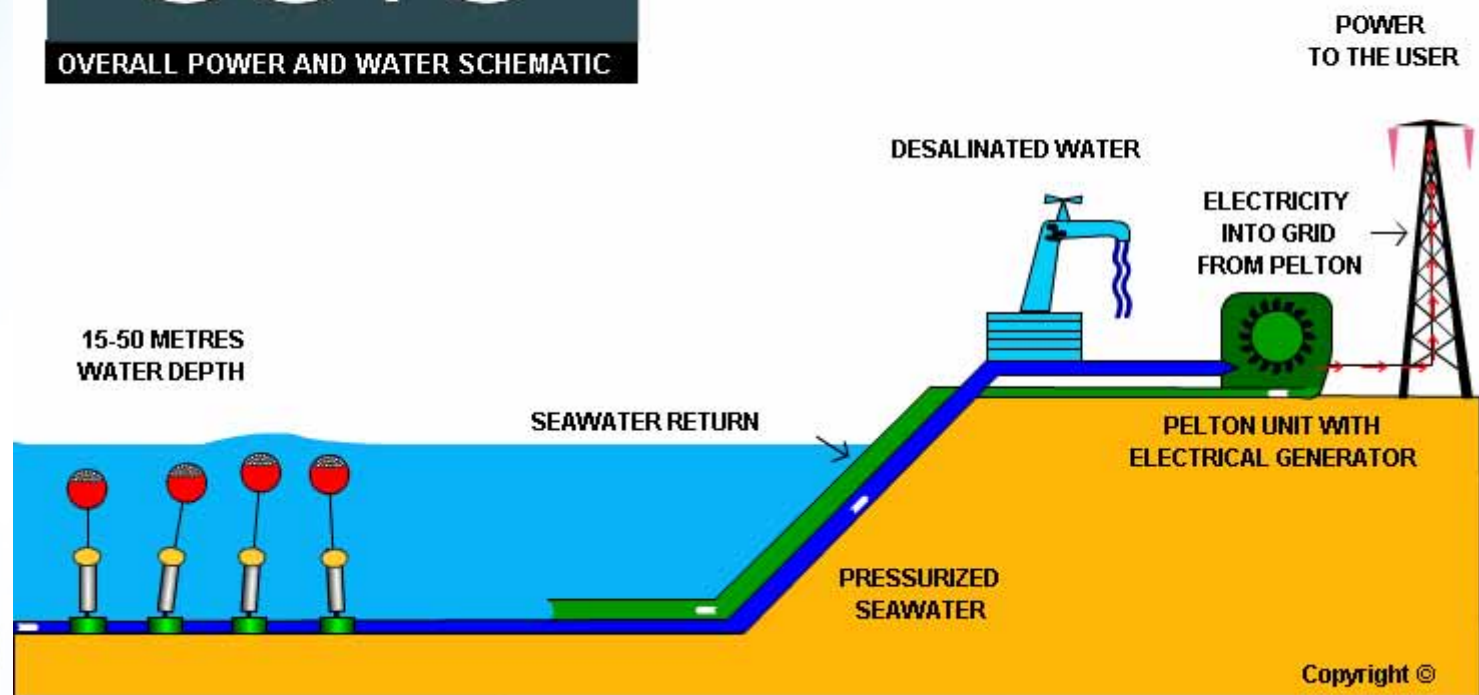
Binningup, WA Wave Survey- Data

33s115e	HsTotal				Exceedence Percentile for HsTotal							Main Direction(s)
	Min	Max	Mean	Std. Dev	90	80	50	20	10	5	1	
January 1997 - 2003	1.15	5.13	2.48	0.66	1.72	1.90	2.39	3.02	3.35	3.72	4.34	SW
February 1997 - 2003	0.86	4.92	2.53	0.72	1.61	1.88	2.51	3.16	3.43	3.74	4.36	SSW SW
March 1997 - 2003	0.94	6.10	2.60	0.77	1.69	1.99	2.50	3.22	3.62	4.04	4.51	SW
April 1997 - 2003	1.04	7.24	2.76	0.98	1.73	1.98	2.59	3.44	3.96	4.58	6.24	SW
May 1997 - 2003	1.00	8.25	3.37	1.17	2.08	2.37	3.18	4.37	4.97	5.48	6.93	SW WSW
June 1997 - 2003	1.45	9.36	3.91	1.32	2.39	2.72	3.70	4.89	5.63	6.44	7.86	SW WSW
July 1997 - 2003	1.50	9.59	4.10	1.29	2.60	2.97	3.89	5.21	5.90	6.45	7.39	SW WSW
August 1997 - 2003	1.74	8.16	3.94	1.15	2.57	2.96	3.77	4.83	5.54	6.10	6.92	SW WSW
September 1997 - 2003	1.77	8.58	3.95	1.21	2.51	2.88	3.77	4.94	5.59	6.19	7.45	SW WSW
October 1997 - 2003	1.06	8.41	3.22	1.03	2.16	2.45	3.01	3.84	4.50	5.21	6.87	SW WSW
November 1997 - 2003	1.03	5.01	2.57	0.76	1.71	1.93	2.42	3.22	3.58	4.04	4.72	SW
December 1997 - 2003	0.77	5.14	2.39	0.69	1.58	1.81	2.34	2.93	3.27	3.62	4.21	SW
Summer 1997 - 2003	0.77	5.14	2.47	0.70	1.66	1.86	2.41	3.04	3.36	3.70	4.29	SW
Autumn 1997 - 2003	0.94	8.25	2.91	1.04	1.79	2.08	2.70	3.66	4.30	4.89	6.29	SW
Winter 1997 - 2003	1.45	9.59	3.99	1.26	2.51	2.88	3.79	4.97	5.75	6.34	7.38	SW WSW
Spring 1997 - 2003	1.03	8.58	3.25	1.16	1.99	2.29	3.03	4.06	4.84	5.47	6.90	SW WSW
1997 - 2003	0.77	9.59	3.17	1.20	1.87	2.18	2.93	4.05	4.82	5.51	6.90	SW WSW

Wave Energy – about to go mainstream...



CETO – zero-emission power & freshwater



CETO – Overview

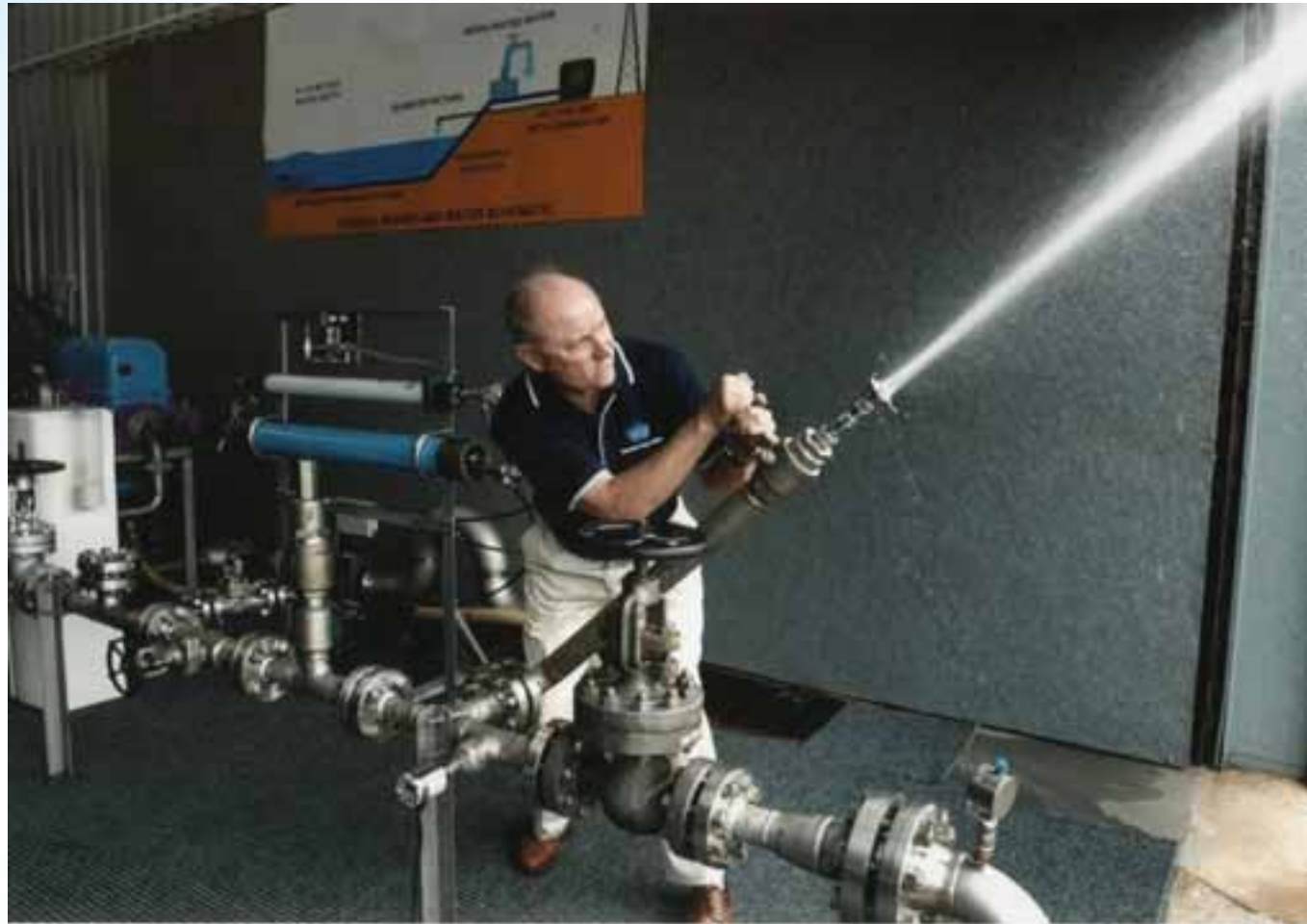
- Wave energy activates a pump which delivers high pressure water to the shore
- Electricity generated onshore (well-proven hydro-power technology)
- Additional benefit: allows onshore, zero-emission desalination
- Advantages include:
 - ✓ Fully submerged
 - ✓ No offshore electrical generation or transmission
 - ✓ Low cost mass produced device
 - ✓ Mass producible design

CETO Development Stages

- 1999 - 2003 – *Pre-CETO*
 - Scale models
 - Wave tank and flume testing
- 2003 - 2006 CETO I – *Proof of Concept*
 - Technology Demonstrator at Fremantle test site
 - Demonstrated concept of pressurising seawater
 - Freshwater & power production
- 2006 - 2008 CETO II – *Commercial Design Development*
 - Computational design development
 - In sea trials validating commercial design
 - Prototype array in operation
- 2009 - 2011 *Commercial Demonstration*
 - World first demonstration
 - Power & Water production



2005 – High Pressure Seawater Production from CETO I

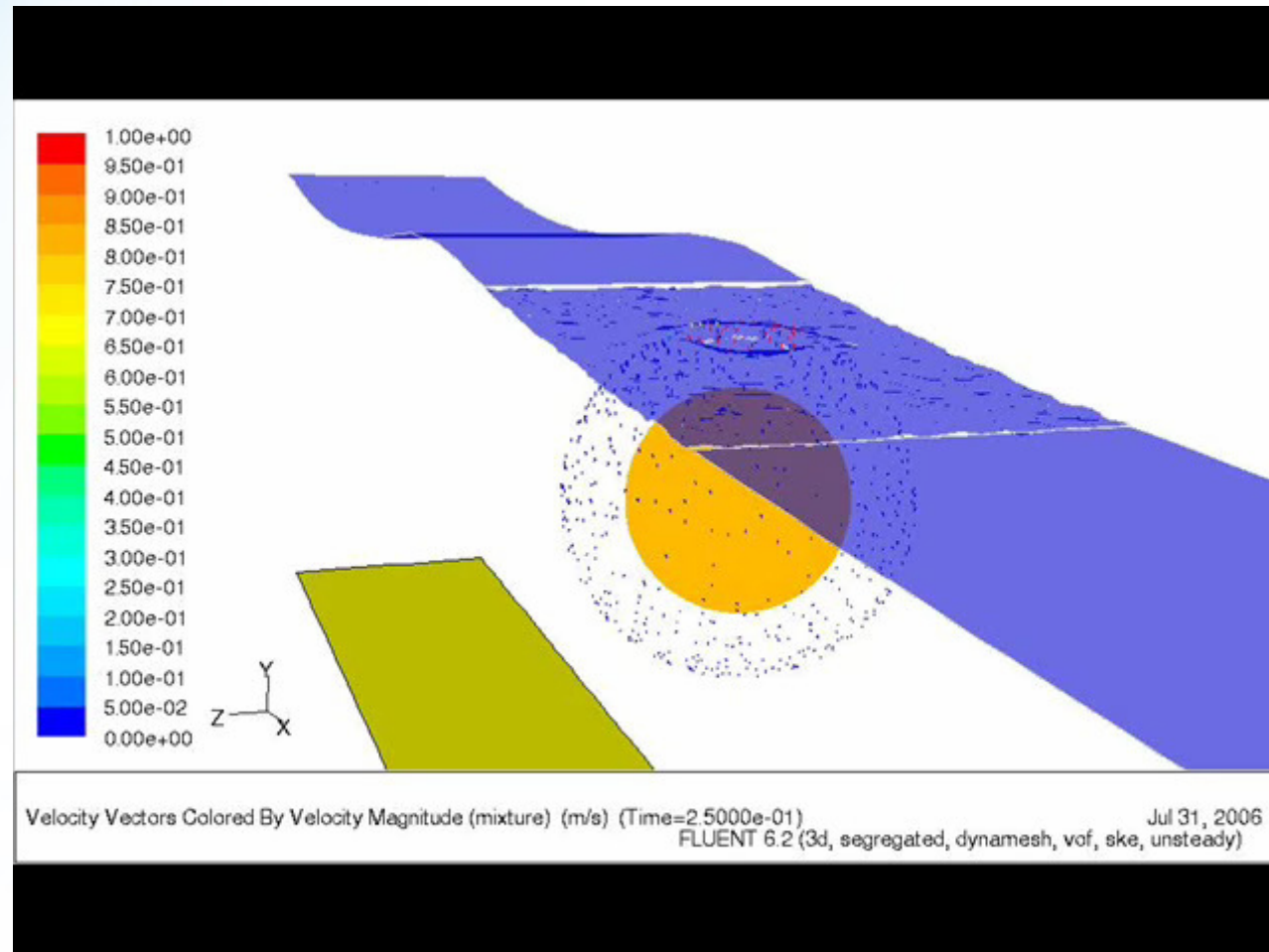


2006 – Power Production from CETO I

2006 – Fresh Water Production



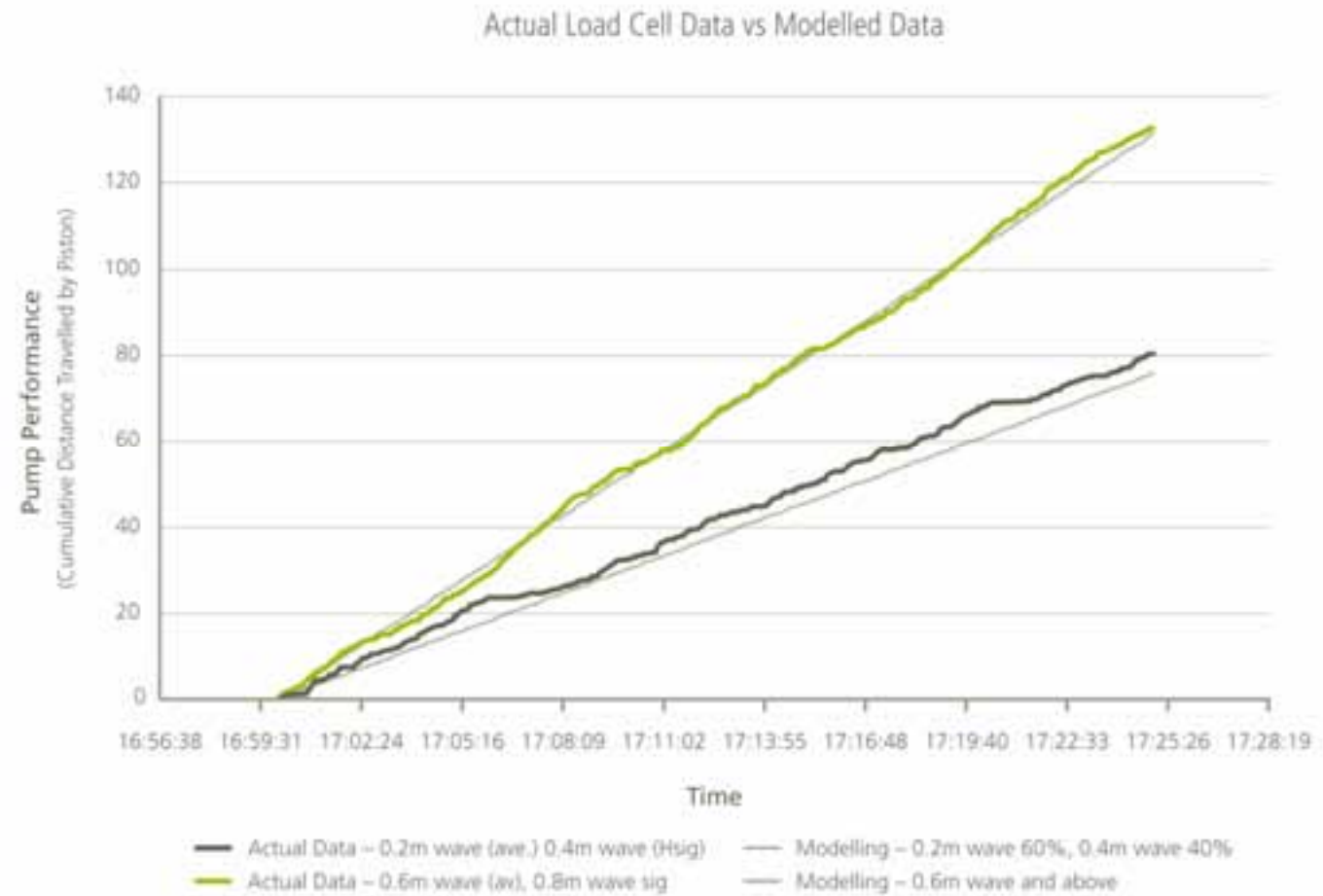
2006 & 2007 – Virtual Ocean and CETO II design



2007 – CETO II Initial In-sea Trials



2007 – CFD Model Validation



CETO – 2008 development milestones

- Deployment of a array of 5 – 10 CETO II units off Fremantle
- Recommence power and water production at Fremantle
- Finalisation of CETO II design options
- Deepwater CETO III tests
- Additional storm survivability mechanisms
- Pretreatment for R/O water production



CETO in the South West

Wave Farm Animation

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CETO in the South West- Potential Projects

Part power-supply to Southern Seawater Desalination Plant

- Made application to pre-qualify to submit a proposal for the supply of renewable energy to the Southern Seawater Desalination Plant (SSDP).
- Binningup has a very good wave resource, appropriate for a CETO wave farm.
- CETO could be co-located providing up to the maximum 40 GWh per annum to SSDP
- CETO could also provide a direct feed of pressurised water to the SSDP bypassing the electricity generating but still providing considerable energy offsetting to the plant.

CETO in the South West- Potential Projects

Stand alone CETO power and water plants.

- Wave energy is abundant with many possible sites that are able to provide base load power for export to the SWIS
- Opportunity for world-first demonstration plant to happen in South West of WA
- A commercial-scale demonstration plant, for example, located at any number of favourable sites could provide both power and water for example:
 - 50MW of power (25,000 households)
 - 15GL of water (100,000 households)

Carnegie Corporation Ltd

- Carnegie Corporation is a Western Australian, ASX-listed clean energy technology developer
- Focused on developing, commercializing and operating clean energy technologies
- 'CETO' Wave Energy developer and Southern Hemisphere licensee
- 'Cleaner Coal Power' technology developer
- Chairman: Alan Burns, CEO: Dr Michael Ottaviano

Conclusions

- Tidal and ocean current opportunities are not viable in the South West
- Wave energy is abundant with many possible sites that are able to provide base load power for export to the SWIS and off-grid applications.
- CETO technology can provide a mix of power and potable water and has the potential to ultimately be able to supply all of the South West's power and water needs.