Perth Wave Energy Project
Design and Construction Update
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Global wave resource > current global power use

- Market is global, large and co-located with demand centers
- Resource is more predictable, consistent and available than wind or solar
- Total resource potential = >200TW (200 million MW)
Carnegie Introduction

- Owner and developer of “CETO” wave energy technology
- 32 engineering, commercial, administration staff
- ASX listed, based in Fremantle, Western Australia
- Subsidiaries in UK, Ireland and Chile
- 120 Patents or patents pending globally
- $70m spent to date on CETO
- EDF (French) is a CETO licensee
- IP is important – 120 patents and patents pending, $1m/yr
CETO Basics

- Buoyant Actuator (BA) travels in orbital fashion due to orbital wave forces
- BA is fully submerged and buoyant
- Waves and low pressure circuit work together to drive BA down
- Waves and BA buoyancy work together to drive BA up
- Controlling pressures allows damping control and can be optimised for each sea state
CETO Features

- Fully submerged, point absorber
- Near-shore location or deepwater location
- Onshore or offshore power generation
- Power & water production with onshore production
- Modular design largely using proven subsea components
Carnegie’s Technology Development

- Proof of concept prototype @ Fremantle, WA
- Wave tank testing @ Fremantle, WA
- 3 x 1kW prototypes @ Fremantle, WA
- 80kW prototype @ Garden Island, WA
- 3 x 240kW units @ Garden Island, WA. Power & water production
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- 25MW commercial project (25 x 1MW units)
- 3MW demo (3 x 1MW units)

Timeline:
- <2004
- 2005
- 2008
- 2011
- 2014
- 2016
- 2018
Ocean testing – 80kW prototype, Garden Island
Value of Modelling

- Modelling is the most important tool for development and cost reduction of new technology
- CETO models provide the figures for power, loads and motions
- Accurate load cases allow lower safety factors which results in lighter, cheaper components
- Pressures and flows allow accumulator volumes, valve and pipe sizes to be optimised
- Values for speeds and distance travelled allow sizing of bearings and material selection for seals
- Accurate motions allow reduction in component cost through reducing angular range requirements and simplifying installation procedures
Modelling Process

- Frequency Domain
- Time Domain – Unit Only
- Time Domain – Full System
- Time Domain – CFD Coupled
CWE Modelling and Engineering Capability

• Advanced System Modelling
  • Frequency domain, time domain and CFD codes
  • Wave surface elevation input
  • Non-linear PTO system response
  • Parallel computing with 8, 12 and 16 core HPCs
  • Use of iVEC supercomputer

• Mechanical Design
  • 3D design & drafting (Inventor, SolidWorks, ProE)
  • Finite element analysis (FEA) capability
  • Pile design software - LPile
Instrumentation

- Instrumentation is crucial for numerical model validation
- BA instruments provide data for:
  - 3D motions
  - Loads
  - Hull pressures
  - Buoy submergence
  - Overload Damper pressure and displacement
  - Tank leakage
- Other Unit instruments include load, inclination, pressure, temperature, etc.
- Plant instruments include pressure, temperature, flow, rotational speed, voltage, current, etc.
- Sampling up to 100 Hz
- >500 sensors on the PWEP system
Perth Wave Energy Project, Garden Island

- World first multiple wave energy converter array
- 3 x 240kW CETO 5 units
- 100NB, 210 bar flexible pipeline 3.2km
- Onshore power plant and grid connection
- Onshore reverse osmosis desalination pilot plant
PWEP System Architecture
System Architecture
CETO 5 Unit Design

**Buoyant Actuator**
- Captures wave energy and, by pulling on a flexible tether, drives the sealed mounted pumps.
- The top of the Buoyant Actuator sits 1-2m below the ocean's surface, fully submerged with no visual impact.
- Symmetrical design allows CETO to operate equally well irrespective of wave direction.
- Proprietary energy relief systems allow continued operation and survivability in high wave energy conditions.

**Tether**
- Transfers energy from the Buoyant Actuator to the Pump.
- Adapted from offshore oil and gas moorings.
- The flexibility of the Tether minimises unwanted loads on the system.

**Connectors**
- BA Connector connects the tether to the Buoyant Actuator.
- Pump Connector connects the tether to the pump.
- Made of steel.

**Pump**
- High pressure rated subsea hydraulic cylinder.
- Converts wave energy into useful and transportable hydraulic energy.
Perth Wave Energy Project - Status

- Design, approvals, off-take, funding complete
- Offshore foundations installed
- Pipeline installed
- Buoyant actuators delivered
Perth Wave Energy Project – Status

- CETO Unit Pumps manufactured
- Tether completed Factory Acceptance Testing
- Foundation Connector completed Factory Acceptance Testing
- Onshore construction activities commenced
- Commissioning target of Q2 2014
Perth Wave Energy Project – Support

- $13.1m Australian Government grant funding for power generation
- $7.3m Western Australian State Government funding
- $1.25m Australian Government grant funding for desalinated water production
- Cooperation agreement with the WA Government water utility, Water Corporation
- Offtake with the Australian Department of Defence (HMAS Stirling)
Perth Wave Energy Project – 2014

• Q1, 2014 activities:
  - Offshore foundation installation
  - Pipe installation
  - Delivery of CETO unit components

• Q2, 2014 activities:
  - Assembly & pre-install testing
  - Onshore power plant construction
  - Onshore desalination plant construction
  - Project commissioning

• Q3, 2014 onwards
  - Power generation & revenue
  - Water generation & revenue
  - Data collection and analysis
CETO 6 – Next Generation Design

- 1MW (1000kW) capacity Unit
- ~50% increase in diameter over CETO 5 => 4 x increase in rated capacity
- Electrical generation in BA
- First commercial production unit
- Cost competitive in large projects
Australian CETO 6: Expansion of Perth Project off Garden Is.
UK CETO 6 – Wave Hub, Cornwall