The Pelamis Wave Energy Converter

A phased array of heave + surge point absorbers

Max Carcas, Business Development Director
Pelamis WEC technology - CONCEPT

- Articulated cylinder
- Swings head-on to incident waves
- 4 x main segments, 3 x joints
- Wave induced joint motion resisted to absorb power

140m long, 3.5m diameter
750kW rated power
Capacity factor 0.25-0.4
Pelamis WEC technology – POWER TRAIN

- 3 x 2-axis, 250kW rated ‘POWER CONVERSION MODULES’
- Hydraulic rams pump fluid into smoothing accumulators
- Hydraulic motors drive induction generators to generate STEADY OUTPUT
- PROVEN, AVAILABLE & EFFICIENT TECHNOLOGY & COMPONENTS
Pelamis WEC technology - Features

PELAMIS Features

- Offshore deployment
- Inherent survivability
- Highest power capture/unit weight
- Available technology
- INDEPENDENTLY VERIFIED

- Forecastable output
- Negligible visual intrusion
- Minimal environmental impact
- Minimum on-site construction work
- Off-site maintenance
Experimental and numerical modelling

Time = 31.1
Pelamis WEC technology – SURVIVABILITY

- Small cross-section, finite length, streamlined form, compliant moorings
- Self-limiting ‘hydrostatic loading’ => limits absorbed power in large waves
- Almost invisible to ‘hydrodynamic loading’ in large seas
- Too short to react against extreme storm waves
Extreme ‘100 year’ wave – 28m wave height
Full-scale production prototype - Development

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<th>1999</th>
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<td>Concept development</td>
<td>Primary R&amp;D &amp; modelling</td>
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Rigorous, staged & efficient R&D

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www.oceandelivery.com
Full-scale operation
Production prototype – Specifics

- 750kW production prototype
- Outsourced fabrication with assembly and operation undertaken by OPD
- Proven company processes – have successfully ‘prototyped OPD’

- Launched and tested April 2004
- 4 sets of sea trials
- Installed at EMEC August 2004
- 1,000 hours operation recorded

- Concept, handling, operation and control confirmed
- Initial teething problems resolved
- Power capture and conversion in line with prediction
PROJECTS
Enersis – Project #1

Enersis
- Portugal’s largest developer of renewable projects
- Subsidiary of Semapa
- Aim to be Portugal’s leading wave developer

Project phase 1:
- Three Pelamis P1A machines
- 2.25 MW
- 5km off Aguçadoura
- 50m water depth
- Cable + substation in place
Enersis – Project expansion

Phase 1
- Three Pelamis P1A 750KW machines
- Production underway
- Permitting and consents secured

Phase 2
- Letter of intent
- Expand project to 24MW
- Grid connection rights secured

Phase 3
- Multi-site deployment
Production for Portugal

Order – 3 x P-1A 750kW machines
Main tube fabricator: Camcal
Main tube castings: Goodwins
Power module fabricator: RDI
Hydraulic rams: Hystat
Accumulators: FCH
Generator Pack: Hytec
Assembly/commissioning: OPD

Production of 3 machines progressing to cost and schedule
Ross Deeptech - Stonehaven
Fife energy park - Methil
Major international utility
UK’s largest wind developer

Developer of UK’s first offshore and
Europe’s largest wind-farm (700MW)
in Western Isles

- Consortium development
- Plan: phased 22.5MW wave farm
- Grid connection applied for
- Target: first stage 2005/6
- Key DTI/Scottish Executive market
  enablement mechanisms
South West England

Wave Hub
- Cornwall
- £1.5m Consenting and permitting
- 20MW (30MW ultimately)
- Initially allocated in 5MW tranches
- Anticipated 2007

Ocean Prospect
- Expression of interest for 5MW at Wave Hub
- In discussion about larger UK project
- Overseas opportunities
United States

- Public/private project part funded by DOE, NREL and individual states
- Project: five state wave energy sites in Maine, Oregon, Washington, Hawaii, Massachusetts + city of San Francisco
- Pelamis selected by EPRI as system currently recommended for deployment.
- Target installation 2007
- Funding for ocean energy approved in recent Energy bill
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MARKET POTENTIAL
Global market

- WORLD > 2000 TWh/yr, £500bn CAPEX (c.f. existing hydro & nuclear)
- eg UK > 80 TWh/yr (~20%), >£20bn CAPEX
- eg Portugal > 12 TWh/yr (~25%), >£5bn CAPEX
Cost barriers

Cost reduction drivers:
- Technological advances
- Cost of capital
- Economies of scale

Source: European Commission ATLAS
Cost reduction – Driving down the costs

- Rapid but controlled innovation
- Freeze design for production
- Define and optimize production process
- Develop, execute and assess procurement/production plan
- Deliver high quality, on time, minimum cost
- Efficient feedback of experience

Cost Reduction Process

- Time
- Innovation
- Standardization
- Continuous Improvement

Graph:
- Ordered capacity per year (MW)
- Cost of energy (p/kWh)
- Years: 2004 to 2014
- Key stages:
  - Pilot Projects
  - Rapid Learning
  - Economies of Scale
  - Volume Production
  - Mature Learning

Graph highlights:
- Ordered capacity increases from 2004 to 2014
- Cost of energy decreases from 2004 to 2014

Graph data points:
- 2004: Ordered capacity per year (MW) and Cost of energy (p/kWh)
- 2005: Ordered capacity per year (MW) and Cost of energy (p/kWh)
- 2006: Ordered capacity per year (MW) and Cost of energy (p/kWh)
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- 2012: Ordered capacity per year (MW) and Cost of energy (p/kWh)
- 2013: Ordered capacity per year (MW) and Cost of energy (p/kWh)
- 2014: Ordered capacity per year (MW) and Cost of energy (p/kWh)
Other potential market opportunities

- Off grid
- Oil and gas – generation
- Oil and gas – pumping
- Desalination