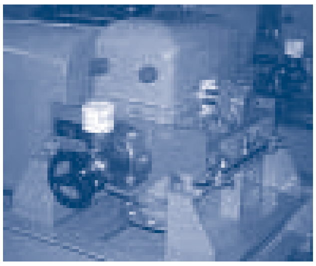

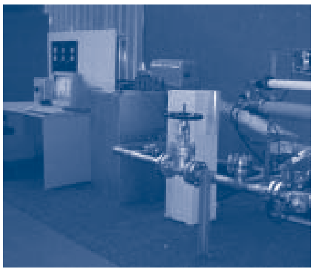

RENEWABLE ENERGY HOLDINGS PLC

EXECUTIVE SUMMARY: TECHNICAL APPRAISAL OF THE "CETO" WAVE POWER GENERATION DEVICES

Amber Court
William Armstrong Drive
Newcastle Business Park
Newcastle upon Tyne
NE4 7YQ
t: +44 191 226 2198
f: +44 191 226 2104

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EXECUTIVE SUMMARY

PB Power was commissioned by Renewable Energy Holdings PLC (REH) to provide a “competent person’s report” on the present CETO I wave power device prototype tests and future design of a further step in the development of a commercial system, CETO II. The CETO devices have been developed by Seapower Pacific PTY Ltd (SPPL), with recent involvement of REH in Western Australia. This report presents the findings from the review of the project, and forms a preliminary view on the robustness of the concept.

The information for this review has been provided by SPPL based upon initial questioning aimed at understanding both the performance of CETO I and the nature of CETO II. PB Power carried out a visit to the CETO testing site near Fremantle in order to meet the SPPL team and review the on-shore facilities and equipment. After further review, a meeting in Newcastle, UK with the device’s inventor Alan Burns and Mike Proffitt of REH was held to clarify the operating principles. This was followed up by a telephone conference between PB Power staff in the UK and SPPL staff in Australia.

PB Power understand that lessons learned in the development and testing of CETO I have been used to inform the design of CETO II, which is a smaller scale version of the commercially envisaged CETO III. It is intended as a next step to deploy CETO II at the same test site in Fremantle where CETO I was deployed.

As useful background for the reader a short description of the company and biographies of the key team members for the production of this report are presented below.

PB POWER

PB Power is part of the Parsons Brinckerhoff group of companies, one of the world’s largest engineering consultancies. We consolidate the power industry skills and experience of over 1000 professionals, placing it among the worlds leading power engineering consultancy firms. The company possesses some of the best power related technical and management skills to be found anywhere in the world.

PB Power has extensive experience in providing independent specialist advice to the Power Industry. We have provided advice to clients on the technical and commercial issues relating to a range of renewable generation technologies including the development, design, and financing of energy efficiency projects and subsequent installation and maintenance. Furthermore, we advise on best practice in the measurement, monitoring and verification of a project's energy savings, together with review and advice on associated political, legal and commercial issues.

Mark Denny MEng, MBA, CEng, FIMechE

Mark is the project manager for this assignment and as well as managing PB Power’s wind power and renewable group in Newcastle has relevant previous hydropower experience. Mark brings his qualifications as a mechanical engineer and business administrator to add technical input, business knowledge and direction to the work of the team.

Chris Lomax BSc, MSc CGeol FGS

Chris is a marine renewables specialist and brings extensive experience to this assignment from his previous involvement as the project manager of the 'Stingray' tidal stream project at the Engineering Business based in Northumberland. Prior to this he was a Director of a marine geotechnical consultancy specialising in marine foundations and the routing, installation and protection of subsea pipelines and cables.

This experience allows him an excellent insight into bringing a marine energy device from inventor's concept through the process of development to deployment for a full scale test. This includes the technical and environmental aspects as well as commercial issues related to funding and grants.

Dominic Cook, BEng, MSc, BTec, CEng, MIET, ACMI

Dominic is a specialist on the costs of generation. Dominic brings an overview of the commercial situation for renewables within the context of different markets. Dominic is presently a Principal Consultant within the Energy and Utilities Consulting Division of PB Power with 14 years energy industry experience and 5 years involvement in international energy consulting. He has had direct involvement in business and consulting activities in the UK, European, CIS, African and Middle Eastern energy markets encompassing power generation development, energy supply contracts, distribution and transmission and regulatory matters.

With a solid understanding of both bilateral and pool based electricity market structures having been involved in the development of power projects, electricity trading systems and business processes within both environments, he has provided professional advice to major lending institutions on the structure and risk associated with long-term electricity sales and gas off-take agreements and third party trading arrangements and routes to market for electricity supply.

Thomas McKay, BEng (Hons), MIET, AMIMechE

Tom is an Energy Economist who is predominantly responsible for technical, economic and financial appraisals of low and zero carbon energy developments. His engineering experience extends to the design, review and analysis of various renewable power projects. Tom has a broad knowledge and understanding of differing types of generation technology, project and client. Tom has worked as an Energy Planner on numerous sustainable energy developments both in the UK and overseas and has participated and led on a wide range of power projects, including: feasibility studies, due diligence, market studies, technical advisory services and economic and financial appraisals.

Other staff within PB Power globally have contributed to specific issues, such as environmental and computational fluid dynamics etc.

PRINCIPLE OF OPERATION

It is understood that the original idea behind CETO was to harvest a proportion of the high density of energy from waves with a low cost mass produced device, while also simplifying the associated infrastructure by pumping pressurised sea water ashore, rather than electricity. This has the additional benefit of allowing onshore based desalination depending on the deployment area. It is therefore apparent that, considering differing geographic availability of wave energy resource and demands for electrical energy or potable water, the system may be tailored for best use of the resource considering local needs.

It is understood that CETO III will be the commercial sized device (approximately 6 times the size of CETO II devices). The intention of SPPL/REH to fabricate the commercial sized units in commercially competitive regions such as China is a logical step to minimise the capital costs of projects.

CETO OBJECTIVES AND TARGETS

SPPL's stated objective for CETO I was to achieve sustained high pressure and flow of sea water ashore. Although PB Power is not aware of specific targets relative to the energy recovery devices included in the test rig (reverse osmosis plant and Pelton water turbine) it is apparent that the tests were successful in proving this objective and therefore the operation of the desalination. The principle of a commercial CETO device would require a number of pump units (CETO I only comprised 2 pump units operated by a single actuation mechanism) to derive electrical power and/or water. Therefore this test proved that the CETO system can derive energy from the waves using pumped high pressure sea water.

CETO device deployment is suitable for those regions where a high energy wave environment coincides with a need for electricity and / or potable water. Such areas where there is a scarcity of water and a promising wave energy resource include the West coast of the Americas, Southern Africa and Western Australia. Other countries with high wave energy potential and reasonable water supplies would lend themselves simply to generation of electricity eg Northern Europe.

In terms of testing a full scale CETO II there are established marine energy test centres such as WaveHub, EMEC etc which should be included in the future review of possible sites pending a successful outcome from CETO II tests. SPPL consider that a good commercial project test site may be in Northern Ireland, where there is economic support available for renewable energy projects in terms of the NIROC, combined with a good wave energy resource.

FINANCIAL MODELLING

A cash flow operational model has been prepared to enable the analysis of the CETO wave energy plant and is based on discounted cash flow techniques that are widely used and accepted within the investment community for the assessment of power generation and desalination projects globally.

The assumptions used in this assessment are based on those provided by SPPL for the scaled up CETO III commercial design. The basis of these assumptions is that the targeted manufacturing cost reductions and scalability is achievable and that the overall nature of the device operation, efficiency and reliability is proven over an extended period by the CETO II pre-production device.

Sensitivities were calculated to understand the range of likely outcomes from the project assuming a +/-30 % tolerance on the capital and operation and maintenance cost estimates provided by SPPL. These are summarised below.

RANGE OF REQUIRED ELECTRICITY PRICES (PRE-TAX VIABILITY)

Pre tax	Base	O&M +30%	O&M -30%
Base	£53/MWh	£63/MWh	£44/MWh
Capital +30%	£57/MWh	£67/MWh	£48/MWh
Capital -30%	£50/MWh	£60/MWh	£41/MWh

RANGE OF REQUIRED ELECTRICITY PRICES (POST-TAX VIABILITY)

Pre tax	Base	O&M +30%	O&M -30%
Base	£60/MWh	£70/MWh	£51/MWh
Capital +30%	£64/MWh	£74/MWh	£63/MWh
Capital -30%	£57/MWh	£67/MWh	£48/MWh

The highlighted cells represent PB Power's best estimate of the likely outcome of price for the CETO III project at this stage in the development process. The CETO II unit is yet to start its trial and, until this is complete, PB Power would expect the maintenance costs to bias towards the upper bound with the capital costs remaining around the base case.

OBSERVATIONS ON FINANCIAL MODEL OUTPUTS

Recent studies into the evolution of the wave power generation sector indicated that the lower expectation for wave energy capture devices at present is 12 p/kWh. The main drivers for the differential between the CETO III expectations of 7 p/kWh and this range is the marginally lower discount factor used in the assessment and the lower specific capital cost of the CETO device (£1500/kW versus £4000/kW). Even with this price advantage, the CETO device will require financial support either through capital grants at the front end or through ongoing support as is available through the Renewable Obligation arrangements in the UK.

There are still uncertainties relating to the plant capital costs and the ongoing costs associated with maintenance and operation of the plant. These should be better understood following the completion of the CETO II development.

The CETO device has an implicit capacity factor of around 43 % on the basis of the data provided by SPPL. This is within the expectations for wave energy capture devices, albeit towards the upper end of expectation (45 %). This will vary from site to site with the wave conditions; however, one of the most significant factors in this will be the unit's reliability. This will be clearer once the CETO II project has been completed.

CONCLUSIONS AND RECOMMENDATIONS

Generally it appears that the development of the CETO devices is following a logical progression and that experienced, competent and qualified staff are working on the project. Whilst no guarantee can be provided at this stage in the technology's development cycle, on the basis of the information made available to date, PB Power believes there to be a reasonable chance of commercial success.

Clearly, the best way of managing the project and its risks is to test the project in a series of discrete steps to help ensure success at the next stage. SPPL has been following this principle with CETO I, design and testing of CETO II, CETO II prototype tests and subsequent plans for CETO III.

PB Power's primary recommendations are made below. PB Power considers that the mitigation of risks is possible, through the project lifecycle, by management of these key items and any other issues that may arise. The presence of a particular recommendation is not to say that SPPL is not already aware of and/or actively managing many of the issues, rather to provide an aide memoir.

It is recommended that:

1. When CETO II is tested it is fully instrumented (eg with upstream and down stream Waverider buoys, stroke detection, pressure sensors etc) to allow a detailed comparison with the predicted results from CFD modelling. Observations on the equipment must also focus on reliability, to understand any potential failure mechanisms (eg fatigue) to inform the design of the commercial CETO III device. Comprehensive environmental surveys and monitoring should also be undertaken.

2. A short period at the end of design stage is included in the project timeline to allow for checking quality issues (eg cross referencing of part drawings, tolerances, materials etc).

3. Variables such as coastline profile, water depth at device, bathymetry, incident wave spectra and directional spreading are considered by SPPL in order that subsequent design of CETO III commercial devices may be successfully deployed in a range of global sites.

4. Consideration is given to the safety of divers and how the need for diver intervention may be minimised through design.

5. A detailed document defining the objectives, success factors and the measurement methodology for the CETO II testing is produced by SPPL in advance of its manufacture and deployment. This will help ensure the maximum benefit is achieved from the tests and help provide confidence in the evolution of the design. The key outputs must focus on reliability, energy conversion and installation and maintenance processes as well as review of costs.

6. In advance of the design for CETO II SPPL incorporates implicit reliability into the design. There are a number of options available to achieve this: redundancy, streamlined design (by reducing connection points and areas that are known to have frequent maintenance requirements), design for robustness, low utilisation of mechanical strength (a higher resulting reserve or safety factor), environmental simulation testing of components subject to various environmental loads, use of well-proven components, Failure Mode and Effects Analysis study, control of manufacturing, fabrication and commissioning in such a way to reduce the incidence of failures induced by poor workmanship or human induced problems, etc.

7. For the CETO device consideration should be made of fatigue of components and piston rod; buckling of the piston rod; wear properties of the seals, pins and bearing surfaces involved; accumulation of debris, bacterial growth, and resulting increase in viscosity of the fluid; filter arrangements and filter quality mesh size and cleaning arrangements; heat generation and dissipation,

8. Fatigue life of the hydraulic piping will need to be considered. BS EN 13480 is a comprehensive standard for the design of industrial piping. Alternatively, ASME codes are also used in the hydraulic industry.

9. Avoidance of piston type accumulators with air as the compressible medium, as the increase in oxygen partial pressure with compression combined with potential catalytic action from debris accumulating over time can lead to auto-ignition and explosion of the accumulator.

10. The design of any handling equipment and vessels for deployment should be considered to ensure safety and economy.

11. Due consideration must be made of the effects of seawater on the water turbine unit.

12. The control and monitoring requirements for the device should be summarised describing the objectives and attributes of the control system

13. Special attention be given to effects on monitoring and control systems from the following - vibration (wave slamming, sloshing of tank contents, local structural vibration, impact, excitation from hydraulic, pneumatic and mechanical systems

etc); temperature, humidity, salinity, electromagnetic interference, atmospheric pressure (may fluctuate in sealed compartments), and assumptions on quality and variability of, hydraulic, pneumatic, fibre optic devices and power supplies.

14. An additional Waverider buoy is installed during CETO II, ensuring that there are buoys located both in front of, and behind, the array.

15. SPPL, as an organisation, should consider the operational management requirements for a commercialisation.

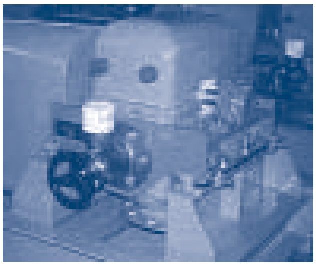
16. Further consideration should be given to production engineering of CETO III when appropriate.

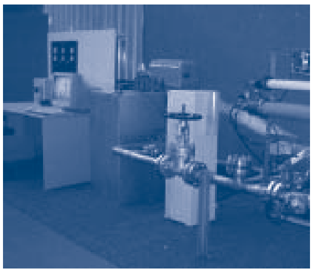
17. A systematic approach to documentation throughout the operation of the device's life be ensured as the level of documentation is an important step in order to obtain the recognition from financiers and underwriters that the risks (including those affecting performance and production) have been identified and were controlled to the defined risk levels and have been appropriately mitigated through design or operational constraints.

18. Procedures for maintenance, inspection and repair should be developed at an early design stage. Consideration should be given to access to areas to be inspected and the extent, frequency and choice of inspection methods.

19. In developing future project costs a detailed maintenance strategy is developed. This should incorporate planned and unplanned maintenance, spares to be stocked, and maintenance staff and equipment requirements. SPPL suggest that, for larger array installations a trained dive team and workboat would form the core maintenance team. Although the majority of subsea components are bespoke, consideration could be given to undertaking a reliability assessment to estimate the failure rate of specific components when developing the maintenance strategy.

20. A spare parts philosophy be defined taking into account the time from ordering to the availability of replacement parts, criticality of part (regarding survivability and functional requirements), maintenance requirements and costs of stock, preservation and storage of spare parts. A list of spare parts should be produced and included in the maintenance plan.





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