Attenuator Cost of Energy Reduction (ACER)

WES Novel Wave Energy Converter
Stage 1 Project
Public Report

4c Engineering

This project has been supported by Wave Energy Scotland

1 Project Report

1.1 *Project Introduction*

The Sea Power Platform is a two-body Wave Energy Converter (WEC) that has been under development since 2008. The WEC is classed as a floating attenuator device with energy extracted via the relative motion of two bodies connected by a hinged joint. A PTO system interfaces the two bodies at the hinge and extracts power by damping the motions of the device in wave climates.

The project consortium consisted of the following parties:

- **4c Engineering** – Project lead, project management, design & engineering activities, running of tank tests;
- **Sea Power Ltd** – Device developer and steering group member, input to project design, engineering and tank testing throughout;
- **DNV GL** – Numerical / hydrodynamic modelling of WEC, 3rd party verification of tank tests and validation of numerical model;
- **ARUP** – Study on concrete construction for pontoons.

The aim of the project was to identify a route to achieving the target LCOE cost of £150/MWh. Activities involved in delivering this included:

- Physical testing & numerical modelling to produce a prediction of performance at full scale;
- Development of the concept design of the full scale WEC;
- Investigation of structural options for floating pontoons;
- Development of a scalable, interactive cost model.

1.2 *Description of Project Technology*

The key features of the project technology, and its anticipated advantages are summarised as follows:

- Large stable platform floating on surface:
    - Straightforward access;
    - Minimal subsea work;
- Simple technology for converting wave motion to WEC motion – low risk, predictable;
- Range of PTO options are applicable – use best PTO proposed by developer;
- Rotary PTO under development as part of WES PTO programme:
    - Reuse of existing (windpower) technology;
    - No endstop problems;
- Range of control options – can enhance power extraction and/or limit loading.

1.3 *Scope of Work*

The ACER project contained the following key activities:

- Overhaul of existing 1:25 scale model of the Sea Power Platform (SPP), adapting to allow various pontoon shapes to be tested, hinge loads to be measured, and active control strategies to be trialled. The best-performing geometry from previous testing was taken as a baseline;

- Exploratory tank testing at Kelvin Hydrodynamics Laboratory, testing a range of pontoon shapes and selecting a leading design;
- Performance of most promising design characterised across a full range of sea states (mono- and polychromatic), including WES standardised tests with power production independently verified by DNV GL;
- Numerical model of WEC built in WaveDyn, and validated against tank test results (DNV GL);
- Concept design/engineering of a full scale SPP with concrete pontoons, including investigation of feasibility and costs of concrete pontoons, carried out by ARUP;
- LCOE model comprehensively updated to include verified performance results, fully scalable properties of the concept design, and updated costings from suppliers.

1.4 Project Achievements

Key achievements of the project include the following:

- Successful standardised tank testing produced a robust characterisation of the chosen device configuration;
- Peak observed capture width of device improved by around 30% compared to previous tank testing;
- Validated numerical model giving good agreement with physical tests – provides a powerful tool for future design investigation and performance prediction;
- Detailed LCOE model completed allowing straightforward comparison between deployment locations, device scales, lengths and control types. Allows identification of key drivers for reduction of LCOE.

With hindsight, the project would have been even better if:

- A better signal-to-noise ratio had been achieved during the tank tests. (Unanticipated levels of noise on certain sensor signals had an effect on the active damping control system, resulting in a less comprehensive study of this aspect than desired.)
- More data could have been collected, across a wider range of sea states, and allowing further optimisation of damping settings. (This would have required more tank time.)

1.5 Summary of Performance against Target Outcome Metrics

Progress was made against the WES Target Outcomes in the following areas:

Affordability

- A detailed, scalable LCOE model was produced, providing a powerful tool to assess cost sensitivities and identify the most promising routes to reduced LCOE;
- Coulomb damping shown to reduce maximum PTO loads significantly with only a modest reduction in average power (compared to linear damping) resulting in a more cost-effective PTO (lower generator capacity for a given average power → lower cost).

Performance

- Successfully built performance data and mean annual energy production into LCOE model;
- Exceeded performance improvement target; increased capture width of WEC compared to previous physical testing (peak up by almost 30%).

Availability

- As part of concept engineering activities, a detailed FMEA was produced to assess effects of failures in systems and sub-systems. This will be used to steer the design of subsystems and their interfaces so as to minimise risks of failure.

Survivability

- Detailed FMEA produced to assess effects of failures in systems and sub-systems;
- Promising results around potential of reinforced concrete pontoons to survive expected loads at reasonable cost. (Further optimisation required in future.)

1.6 Communications and Publicity Activity

The following public promotion activities have been (or will be) carried out by 4c Engineering:

- Poster presentations at WES events & conference;
- Website blog;
- Website case study (coming soon).

Sea Power Ltd carries out its own additional activities relating both to WES projects and others such as their SEAI-funded large-scale demonstrator deployment at SmartBay.

1.7 Recommendations for Further Work

Key areas of activity required to further develop this technology towards commercial deployment are summarised as follows:

- Further investigation of active damping strategies and their effects on loading & power production;
- Numerical modelling followed by wave tank testing for verification of device geometry/scaling assumptions (used for optimisation of device geometry for specific deployment locations and wave resources);
- Pontoon capex is identified as a major driver of cost – investigation into methods for further reduction would be hugely beneficial, including:
    - In-depth investigation of slam loads;
    - Optimisation of pontoon structures for load shedding;
- Materials:
    - Continue investigations in reinforced concrete pontoons;
    - Consider alternative materials (polymer/pre-stressed concrete);
    - Monitor WES Materials projects (in particular the CREATE and ACE-WEC projects further investigating concrete as a structural material);
- Commence FEED of a large prototype (quarter scale or similar) to allow specific structural design solutions and components to be identified;
- Incorporation of Rotary PTO design from Romax Technology Ltd (WES PTO Stage 2);
- Update FMEA & Risk Register as design is developed and specific components and solutions are identified;
- Engage with an electrical engineering partner for design of electrical systems.