PROJECT SUMMARY

Stingray Tidal Stream Energy Device – Phase 3

OBJECTIVES

- Demonstrate that electricity can be generated at a potentially commercially viable unit energy cost using Stingray technology.
- Reinstall, operate, recover and decommission the 150kW Stingray demonstrator.
- Produce a repeatable, optimised power cycle.
- Demonstrate the flow / machine interaction.
- Collect more and varied data points for full validation of the existing mathematical model.

SUMMARY

The Engineering Business Ltd (EB) has been developing a tidal stream generation system since 1997. This resulted in the installation, in 2002, of the 150kW Stingray demonstrator – the worlds first full-scale tidal stream generator. Stingray was reinstalled in 2003 to meet the objectives of this, the Phase 3 project. During the marine operations significant improvements in energy capture and power generation were made, compared to the Phase 2 operations. The mathematical performance model was validated by the test results, enabling a second-generation (500kW) Stingray concept to be developed and cost models to be produced.

These demonstrate that, with sufficient installed capacity, commercially viable unit energy costs can be achieved.

Figure 1. Stingray commissioning in Shetland

PROJECT DURATION

17 months – May 2003 to October 2004.

BACKGROUND

The Stingray project is the culmination of the tidal stream energy programme established by The Engineering Business Ltd (EB). The programme started in 1997 with the Active Water Column Generator, which subsequently developed into the Stingray concept. A technical and commercial feasibility study (Phase 1) in 2001 led to Phase 2 – the design, build, installation and operation of the 150kW Stingray demonstrator in Yell Sound in the Shetland Islands in 2002.

Stingray is a system designed to extract useable electricity from tidal currents. It differs from other proposed devices in that it uses an oscillating motion rather than rotation to capture the energy from

the tidal flow.

The key component of Stingray is the wing-like hydroplane (Figure 1). This is attached to a seabed mounted supporting frame by a moveable arm. As tidal currents pass over the hydroplane, lift and drag forces cause the hydroplane to lift. Hydraulically powered cylinders are used to alter the hydroplane angle such that the apparent angle of attack, relative to the oncoming current, is maintained at its optimum angle. As the current lifts the hydroplane, this causes the arm to lift, actuating hydraulic cylinders at the arm / frame pivot. The high-pressure oil developed by the cylinders turns a hydraulic motor that, in turn, drives an electric generator. When the hydroplane, and arm, reach their upper limit, the hydroplane angle is reversed such that the arm is driven down, and the cycle repeated.

The results of the test work carried out with the demonstrator machine during the summer of 2002 showed that the concept had considerable potential. However, there were a number of areas that required further development, test work and analysis in order to move the technology on from engineering concept to a commercially viable system. To this end, a programme of work was set in place to carry out further test work with a modified version of the demonstrator in the summer of 2003 (Phase 3).

THE WORK PROGRAMME

To achieve the project objectives, a number of activities were undertaken, with the broad aim of reinstalling the 150kW Stingray demonstrator and obtaining more operational data for analysis. These encompassed design, production (manufacture and assembly), marine operations (installation, operations, monitoring and removal), investigations and analysis, and project management and reporting.

Phase 3 activities started in May 2003. The support barge arrived in Shetland in June, with final assembly and commissioning leading to installation of Stingray in July (Figure 2). Stingray was finally recovered in September, with demobilisation complete in November. Analysis of the data, development studies relating to the tidal resource, grid connection and the second generation Stingray, and cost modelling continued through into 2004. As part of the consent requirements, a post-decommissioning seabed survey was undertaken in 2004.

Figure 2. Stingray prior to installation in Yell Sound

Design and Production

Various aspects of Phase 2 were reviewed to identify areas for improvements in the performance and operation of Stingray. An operations barge was selected and converted for use for installation, recovery and control of Stingray. The identified improvements and modifications were implemented, with work taking place on Tyneside,

mainland Scotland and in Shetland.

Marine Operations

The barge EMS6, assisted by the tug Forth Drummer, provided the working platform for the marine operations. At slack water and on the flood tide Stingray would be operated to develop its control strategy, test its performance and generate electricity.

Stakeholders and the Environment

The Phase 2 consents were extended to cover Phase 3 operations. Shoreline monitoring continued, in addition to investigations on marine growth, acoustic emissions and cetacean activity. On completion, a decommissioning seabed survey was undertaken, followed by an independent review of the monitoring results and survey.

Test Results

The marine operations confirmed that electricity could be generated through the oscillation of hydroplanes in a moving fluid. Developments to the power cycle resulted in significant improvements on the Phase 2 levels (Figure 3), with further gains clearly available. Full cycle times of 24 seconds in a 2m/s current provided an average hydraulic power output of 117.5kW.

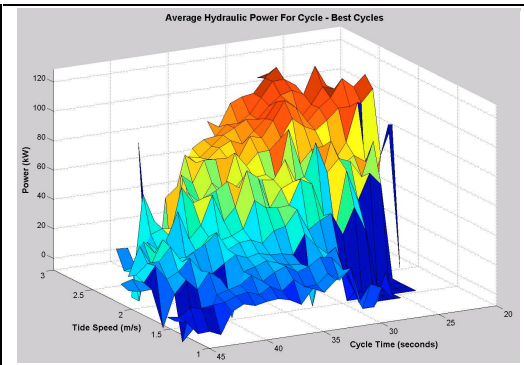

Figure 3. Effect of cycle time and tidal velocity on power generation

Cumulative energy production through the course of repeated tides was demonstrated on several occasions.

Cost Modelling

To enable the development of a robust cost model, the mathematical model that predicts Stingray performance was validated against the test results. In addition, a concept design for a second generation, 500kW, Stingray was developed and costed (Figure 4).

A series of cost models were generated, demonstrating that the unit energy cost would reduce to competitive levels with increased installed capacity.

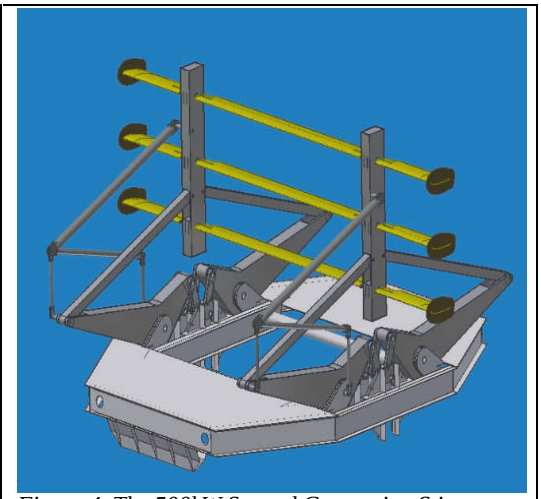

Figure 4. The 500kW Second Generation Stingray Concept

It is estimated that a unit energy cost of 6.7p/kWh can be achieved once 100MW of Stingray capacity is in place. This does not allow for the potential step-change improvements in power generation that could result from harnessing the unsteady hydrodynamic effects that were been demonstrated during operations.

CONCLUSIONS

- Stingray technology is technically viable for the generation of electricity at a potentially commercially viable unit energy cost.
- Many viable sites exist for this technology, and the variable geometric configuration of Stingray ensures as wide as possible a range of sites can be considered viable.
- The system does not generate any significant environmental impacts.

POTENTIAL FOR FUTURE DEVELOPMENT

The Stingray project has demonstrated that the concept is technically and commercially viable. As it stands, the second generation (500kW) Stingray concept is anticipated to be commercially viable once 100MW of capacity has been installed. If an optimistic view is taken of potential developments in harnessing the unsteady hydrodynamics, step-change improvements in energy capture beyond those already considered viable for the commercial systems are possible.

However, although EB understands that further investment is available to continue with Stingray development, there is no clear route to profitability in the next stage of the programme. This makes further development commercially unattractive to EB in the current climate.