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Technology Feature: The WaveNET

WaveNET: light and easily installed

Image courtesy of Albatern

In the latest edition of our newsletter, LRI interviewed David Campbell, CFO of Albatern. Their wave energy converter, the WaveNET, is designed to capture wave energy with minimal material costs. The WaveNET has a unique advantage over other wave energy converters (WEC)'s and the sector's earlier technologies: the low cost of production makes projects much more feasible. A small-scale commercial project is due to be completed Q1 2014, which will demonstrate readiness for commercial deployment. At present Albatern are seeking between £2-3m of investment to commercialise their smaller scale arrays in off-grid projects, and to scale up the Squid units used in the WaveNET array for grid scale projects of up to 100MW.

Albatern

Albatern is a wave technology developer pioneering a unique approach to wave energy conversion. Their modular wave energy converter units, called Squids, can be connected together in arrays called WaveNETs. As more Squids are added to a WaveNET, the capacity factor of the WaveNET increases, as well its overall installed capacity. At present the company is focusing on the development of demonstration projects using small-scale fully commercial WaveNET arrays, and then scaling up the Squid units from the current 7.5kW each to 75kW and 750kW.

The Squid

Each individual Squid unit has 6 pumping modules which move in response to the circular pressure field within the wave. The pumps drive a hydraulic generator system which produces electricity. The hydraulic system of each Squid is interconnected with that of the other Squids in the WaveNET array through a hydraulic ring main system. The innovative design means that the device does not fit neatly into the previous categories prescribed by the industry.

The power take-off modules on individual Squid units work on fully articulated joints and could be thought of as acting like point absorbers, but this misses the fact that they are linked together in an array that converts wave energy by harnessing up to 5 of the main 6 degrees of freedom, and responding to surge. For these reasons, Albatern's Wavenet is different to any other device currently commercially available or in testing.

Timeline

Aug 2012: Albatern secures £617,000 of WATERS 2 funding for their first Wavenet array.

Oct 2012: Testing of 1:10 scale Squids in a Wavenet, to validate system design in the laboratory environment.

Apr – Nov 2012: Open water testing of a single small-scale commercial Squid unit rated at 7.5kW in a still water environment.

London Research International

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Competitive Edge

- A device the length of the wave is required to capture the energy in the wave effectively. Most other designs require a significant size of wave energy converter to do so. Albatern simply need to keep adding more Squids to the WaveNET array. Albatern has efficiently matched the impedance of large waves with an array of large span that has little weight.
- The close coupling of Squid units into the WaveNET array are showing improved yields in modelling and wave tank results. Accordingly, Squids are placed in close proximity, which allows WaveNET arrays to achieve very high energy density per km^2.
- The installation and operation of a Squid device has several advantages over other wave technologies. The devices are installed offshore, which is a relatively less challenging environment to install and maintain wave devices than the near shore environment. The near shore environment is characterised by more horizontal energy and breaking waves, which presents a challenge to performing work activities.
- The installation process of a Squid is relatively simple. The current 7.5kW unit can be towed out by vessels already operating in the site area, adjusted for buoyancy to sit in its operating position, and then moored in place. The installation process precludes the need for heavy engineering, such as piling and grouting, and does not require the assistance of specialist and expensive marine operations vessels.
- At present, the design limitations of some other offshore wave devices means they have to be towed into calmer waters during extreme storm events. The design of the Squid explicitly avoids a mechanical "end stop". Modelling and laboratory testing of the Wavnet during extreme events suggests the mechanism avoids large stresses improving its survivability. Accordingly, once the WaveNET has been installed, it can remain in situ without the need for re-location.

2013: Development of the medium-scale commercial Squid unit rated at 75kW commencing in Q4 2013. Technical development of large-scale commercial Squids, potentially rated up to 750kW, will follow in mid 2014.

2014: First small-scale commercial units expected to be deployed as a WaveNET and connected to an offshore off-grid system. The 45kW WaveNET will consist of up to 6 Squids, rated at 7.5kW.

System design

The currently available small-scale commercial Squid has a capacity of 7.5kW, a dry weight of 8.4 tonnes, and is installed at depth of 20-30m.

The Squid has a standard hydraulic generation system, which has been modified for marine conditions. The electricity produced by the generator is rectified from AC to DC on the device, before being brought onshore. All of the hydraulic pumps operate together and are connected by a network of pipes and hoses in a ring main system. The ring main approach has several advantages:

- An interconnected system means there is a smoothed pressure in the hydraulic system. Peaks and troughs in pressures, which could adversely effect or damage the system, are evened out.
- There are electrical connections throughout the array which aggregate the electricity produced from all of the units for take-off by a single cable.
- Multiple export cables can be used to increase the redundancy of the system in the case of cable failure.

The Squid is a floating structure secured to the seabed within a purpose designed mooring system.

Images courtesy of Albatern

A WaveNET array would have a number of anchoring points for Squids placed within the array. Albatern are assessing the feasibility of using a taught line mooring system (as opposed to a catenary system), which could reduce the incidence of peak loads on attached units. The use of a taught mooring system for future WaveNETs could also improve the capacity factor of the array as well as improve its structural.

Installation

The 7.5kW Squid can be transported to dock on a flatbed lorry and lifted with standard crane equipment. Local vessels, already operating in an area, can be used to tow the Squid out to site. The Squid is horizontal when towed to the site, whereupon its ballasting is altered to bring it into its operating position. To secure the Squid in position, it is attached into its mooring system which will have been laid prior to deployment.

Maintenance

All of the components with the greatest risk of failure have been brought together and housed in a power take-off module in a surface piercing location which increases accessibility for repairs and maintenance. This means that divers and expensive interventions are minimised which keeps O&M costs low. In the instance of a failure that cannot be rectified at sea, each Squid can be removed and taken back to sheltered water or ashore. This can be done without affecting the other Squids in the WaveNET and the ailing squid could be replaced at the same time.

In addition, the interconnected hydraulic system of a WaveNET is able to maintain pressure (and thus continue to generate electricity) in the case of an individual Squid or hose failure. When combined, these features reduce the down time

Image courtesy of Albatern

experienced by the Squid relative to other wave technology designs with inaccessible components and systems that suffer from entire system downtime due to individual component failures.

Survivability

The Squid is designed with 20 year survivability in mind. The wave tank testing of 1:10 scale WaveNET system showed that it could operate comfortably in wave energies in the top 10% of that experienced on the EMEC full scale site. The current 7.5kW system is also designed to cope with 6m significant waves, with account taken of the highest wave statistically likely to occur over a 100 year period on this basis.

The design of individual Squids and WaveNET arrays means that they have no end stops (the point at which excessive force causes the pieces of a mechanism to collide). The lack of end stops reduces the stresses placed on the system, which reduces the risk of catastrophic system failure. The WaveNET structure does not react against the mooring system as it moves with a wave. As a result, the WaveNET avoids the rapid slackening and tightening of rope (known as snatch loading) associated with moored objects responding to wave motion in heavy seas. This reduces risk to the mooring equipment, O&M costs and increases longevity.

Applications and Markets

The current 7.5kW Squid will be deployed in WaveNET arrays from 25kW to in excess of 250kW. David Campbell suggests that the target market for installations of this size is the offshore aquaculture industry, off-grid island communities and offshore platforms. These groups typically source electricity from diesel generators. David Campbell suggests that WaveNET arrays are a viable alternative because they can become cost competitive with off-grid diesel generators relatively quickly.

Mr Campbell considers global markets to present a significant opportunity for Albatern. There are many areas with a developing off-shore aquaculture industry and viable wave resource. In terms of the commercial market for larger capacity supplies, the development of the 75kW Squid unit will give Albatern access to project developers seeking to develop larger 10MW installations for export to the grid.

There is still uncertainty over when the full-scale 750kW Squid unit will become fully developed. Once it is proven to be technically viable, the 750kW Squid will give Albatern access to project developers seeking to develop utility scale wave installations of up to 100MW, where Albatern have modelled arrays of 1.2km x 300m consisting of up to 134 Squid units.

Business model

So far, Albatern have been funded through a mixture of grant money, investment by the senior management, and significant investment from a high net worth individual. The 2012 WATERS 2 funding has provided good support to developing the current generation of 7.5kW Squids and the first array demonstrator.

The 7.5kW Squid only cost approximately £200,000 to design, develop and build, a testament to the concept of capturing wave energy with low material cost. Going forward, Albatern are seeking funding for two aspects to the company's development:

1) The commercialisation of the Squid for applications in the aquaculture industry and other off-grid contexts;

2) The scaling up of the 7.5kW device to 75kW, and subsequently to 750kW.

Albatern are seeking between £2-3m over the next 18months to fund these development plans. Funding is likely to come from a combination of sources. Albatern will continue to seek out grants and other means of supporting the high risk taken by the company's investors. The company are working on securing technical and funding partnerships with companies who have grid-scale project experience in the offshore environment.

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Summary

Improved Yield
The Squid units are fully articulated so they can capture energy from 5 of the 6 main components of wave energy. The interaction of Squid units coupled into a WaveNET array further improves yield.

Lower Costs
The WaveNET array is made up of many standard Squid units. In turn these use multiple standard modules and components. The repeatability of components and space frame design concept offer a rapid cost reduction opportunity.

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