Albatern WaveNet Device
Isle of Muck Deployment

Introduction

Albatern was founded in 2007 by David Finlay, supported by his father and brother. From 2007 until 2010 the development of the technology was very much on a self-funded basis, to come up with the concept and develop early models. It was validated in test environments, going from the bath to open waters.

Isle of Muck is the smallest of four main islands in the Small Isles, part of the Inner Hebrides of Scotland. It is situated on the west coast of Scotland.

The project was a collaboration between Albatern and Marine Harvest Scotland. Albatern owns the technology, while the site is provided by Marine Harvest Scotland. The project in itself is a demonstrator project aiming to corroborate the supply of supplementary power to working fish farms by testing the 6-Series WaveNET arrays.

Motivation behind the project lays in the fact that aquaculture is one of Albatern's targeted markets. They believe that their device – WaveNET, is perfectly apt to deliver power to isolated off-shore fish farm sites, which currently rely on diesel generators.

Case Study Approach

The data on the market access of renewable energy technologies were collected both from the case studies in different renewable energy technology projects and from the secondary sources. To collect specific project data, a template was established with following subsections:

- **Technology description and a project summary**
  - Innovative characteristics
  - Technology readiness level
  - Available product / service supports from the manufacturer
  - Any standard procedures / requirements for integrating the technology into existing electricity networks, buildings and/or mainstream energy appliances / systems
- **Commercialisation of the technology**
  - Is the technology already a commercial solution?
  - Are there re-sellers of the technology, or is the technology available only from the manufacturer?
  - Identified main market area
- **Cooperation partners and networks**
  - Description of the roles of the co-operation partners and networks in the RE technology project.
  - How have they supported the market access of the technology?
- **Assessment of the technical and economic risks**
  - What kind of procedures have been made for assessing the technical and economic risks of the project
  - Who is bearing the risk of the investment (manufacturer, client, shared between them)?
  - Is the public sector involved in risk sharing? (e.g. co-financing, or platform for technology demonstration)
- **Drivers and barriers in the RE technology project**
  - Main drivers in carrying out the RE technology project
  - Barriers, and how they have been overcome (such as price of energy, availability of resource, specific expertise, policy enabling the technology)
- **Funding and support mechanisms**
  - The financial support received by the project: amount/support rate, type and purpose of the support, agency providing the support, significance of the support for the project
  - Types of soft support/advisories received during the project: the use of soft supports (advisory, training, mentoring etc.) during the technology development or implementation, and how successful these have been
- **Monitoring the performance**
  - How are the technical/non-technical aspects of the RE technology case monitored?
  - Information on the design, installation requirements and procedures, operational performance, and costs/financial arrangements
- **Conditions for the technology transfer & adaptation in different partner regions**
  - What are the main requirements/preconditions for transferring the technology and applying it in other partner regions?
  - Description of the main drivers and barriers for the technology transfer (such as. Energy price, resource needs, certain support etc.)
- **Project results**
  - Benefits & lessons learnt
  - Post- project benefits

Technology Description

WaveNET is an offshore array-based wave energy converter that utilises the motion of waves to produce electricity. WaveNET arrays are fashioned by interconnecting the unique SQUID generating units. Each SQUID component consists of a hollow central riser tube connected to 3 buoyancy floats by linking arms. The links between each of these mechanisms is made by 6 identical fully articulated pumping modules. The buoyancy floats also have hollow structures, allowing them to house the PTO (Power take-off unit) along with other components for communications and hydraulic operation.

Figure 1. Albatern 6 Unit Device

Each SQUID of the unit's 6- Series identical pumping modules converts the mechanical power of the waves, first into hydraulic power, and then to electrical power via an on-board generator set. The second stages of this power conversion process take place within WaveNET's unique 'Plug and Play' PTO units. Each PTO unit is contained inside an impenetrable case, which is built-in inside a buoyancy float. WaveNET is Series-6 is intended to work in a minimum water depth of 20m and to generate electricity in waves with heights ranging from 0.3 to 6m.

SQUID 6 v1 Testing: From summer 2011 until spring 2012 work was undertaken to build the first prototype of the SQUID modular generating unit to be used in the WaveNET coupled array system. Initial testing concentrated on proving the simplicity of launching, deployment and recovery of the technology. The testing proved that the SQUID unit could be launched from a road trailer pulled by a Landrover, then be towed to the deployment site by a small workboat. Recovery of the unit back onto its trailer was also demonstrated. This testing was carried out in a benign wave location to maximise testing time for these operations. In March 2012, the unit was recovered and returned to the workshop where the full hydraulic and electrical systems were integrated. From April until November 2012, the unit was then deployed for power tests. Substantial knowledge on deployment methods, handling and production was built up which informed the outline design for the second version.

Kishorn Hydrostatic Testing: The second version of the SQUID generating unit was designed and built through the second half of 2012 and early 2013. The first of 3 SQUID units for testing were finished in November 2013 and transported by road from Roslin to Kishorn Port for still-water testing before open-water deployment. Extreme weather conditions in December 2013 and through to early February 2014 made it challenging. However, the dry dock at Kishorn delivered surroundings where testing could continue despite the weather making offshore operations nearly impossible. Initial tests focused on lift and weight testing, with the first launch of the unit in early December 2013. By December, the first deployment into operational mode was complete despite challenging weather with short daylight hours and tidal restrictions. In late February 2014, the second SQUID was transported to Kishorn and the procedures for coupling the units were practiced and polished prior to deployment in an offshore environment.

Isle of Muck Deployment: In collaboration with Marine Harvest Scotland, Albatern deployed a 3 unit WaveNET array on marine Harvest's new Am Maol salmon farming site off the NE side of the Isle of Muck off the west coast of Scotland. The pilot test was for a short period of time (14 weeks) and was undertaken before the fish had arrived. Two SQUID units were brought from Kishorn port where pre-deployment trials had been carried out, the third SQUID was deployed from Albatern's workshop in Roslin through the port at Mallaig.

The objective of the pilot campaign was to test the survivability of the device and how it performs in wave conditions on a more exposed site. The Isle of Muck project was consented as an ancillary equipment to an existing fish farm since Albatern was working closely with the fish farm. Consenting took around 3 months and it was the first one that had been performed on that basis. Since then, Albatern have received consent for a number of alternative sites which took between two to three months to consent.

TRL and Technology Scale

TRL 7 - Technology Readiness Level (TRL) is considered to be 7-9. WaveNET Series-6 arrays are now being tested at a commercial scale on real operating sites in Scottish waters for smaller scale off-grid power requirements. However, there is not yet full scale commercial deployment of the technology, or competitive manufacturing of key enabling technologies, which would allow the technology to compete efficiently against other energy systems.

The scale of the unit was based on what can be fitted on the back of an articulated trailer, to allow simplicity of transportation. Using small repeated units to build large arrays helps to reduce the capital and operational costs of wave energy. Small unit size helps minimise the costs of deploying and maintaining WaveNET arrays. The most substantial benefits of this array-based approach to wave energy come from enhancements in power yield and possible substantial reductions in project costs. WaveNET arrays are configurable to match site conditions and project power requirements. By increasing the length of the array, WaveNET can capture more power from longer waves, whilst increasing the width allows WaveNET to capture more energy from lower density sites.

Figure 2. Albatern 6 Unit Device

Cooperation partners and networks

Albatern are currently working Marine Harvest Scotland, Wave Energy Scotland and HNI (high net worth individual).

Project Delivery Partners: KPL, Ferguson Transport and Shipping, Gael Force Marine Equipment, Mallaig Marine, Aquatera, PuperPipe, Zeus Engineering. Project delivery partners provide for wide range of services – funding, equipment, engineering, and consultancy supports that are essential for the successful demonstration and market deployment of the technology.

Risk assessments and supports received

The project has received supports from both public and private partners:

- 2010 SMART: Scotland funded WaveNET 1:7 Scale Feasibility Tests which helped to build a bigger model and test the behaviour of the technology in open water. This enabled the first external investment to be received.
- Later raised finance from high net worth individual (HNI), who continues to be the main investor at present.
- WATERS2 Grant – R&D Scheme providing funding for wave and tidal projects.
- 2013 UK Government – Green Genius Award – one of 25 successful project selected for feasibility studies.
- 2013-2015 – Out of the mentioned above 25 projects, Albatern was one of six selected for a demonstration project.
- Wave Energy Scotland (Financing) - £720 000 partnership between Albatern and seafood company Marine Harvest to demonstrate wave energy converters as a means of powering offshore aquaculture installation.
- Funding Partners: The Scottish Government, Scottish Enterprise, The Department of Energy and Climate Change (DECC), Department for Environment, Food & Rural Affairs (DEFRA), Department for Business, Innovation & Skills (BIS).

Risk Assessments

- Albatern has carried out a significant amount of techno-economic modelling and part of the earlier deployments are done to confirm them.

Drivers and barriers

A key driver for the wave energy technology is the resource availability. The UK has some of the best wave energy resource in the world due to strong westerly Atlantic winds: an estimated 35% of the European wave resources. The actual resource that could be economically extracted from UK waters is predicted to be between 7 and 10 GW, with the most significant contribution offshore from the west coast of Scotland. The upper limit is equivalent to approximately 18% of UK peak demand (60 GW).

The wave energy resource is also easier to forecast, and less variable than the wind and also has a higher energy density.

In addition, there are relatively benign environmental impacts even when compared to other renewable energy technologies and small visual impact.

The devices are installed offshore, which is a relatively less challenging environment to install and maintain wave devices than the near shore environment, thus overcoming typical barriers of the wave energy. The nearshore environment is characterised by more horizontal energy and breaking waves, which presents a challenge to performing work activities.

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.

A barrier identified is that fish farmers may see the technology as a potential threat to their fish farms, if anything is to go wrong.

Conditions for the technology transfer, adaptation and new market deployment

The main drivers for the technology transfers are identified as follows

- The wave energy resource is easier to forecast and less variable than the wind and has a higher energy density.
- The relatively benign environmental impacts even when compared to other renewable energy technologies and small visual impact.
- Island communities, aquaculture and off-grid platforms can benefit from the power stability, reliability (security of supply) and lowering the costs of electricity.

- The WaveNet device would ideally be placed in waves between 2 and 6 meters and this compliment aquaculture specifically, since they don't go into aggressive waves and they look for a reasonable amount of shelter to operate the site. However, fish farms see that in moving to waves up to 3 meters there is an improved fish growth.

Potential barriers identified for the technology transfers include policy, technology and economic factors:

- Environmental impact – as a result of the ambiguity surrounding environmental regulation. For better understanding of the effects on the environment and restructuring of the licensee process, the EU has funded the Streamlining of Ocean Wave Farms Impact Assessment (SOWFIA) project, which has provided a set of guidance documents for assessment of environmental and other impacts of wave energy farms.
- High capital costs – needed for investment in wave technology development. The market is still led by start-up companies and university spin-offs, focused on taking along technologies to pre-commercial status, facilitating access to research facilities and/or supporting the establishment of new demonstration sites. Government funding through public R&D investments has been vital in this progression. However, for the scaling up of wave energy technologies new and different kinds of investments are required. Government grants and policy support are desirable to appeal to the private investment needed for large scale deployment.
- Insufficient infrastructure: offshore grid connections, such as port facilities to perform O&M, are very costly and in most cases absent. Wave energy farms deployed in deeper waters and further offshore will necessitate specific substation designs to connect the arrays, distinct underwater power, and economical long-distance grid connections (IRENA, 2014).
- Planning and licensing procedures - Due to the fact that wave energy, as well as other marine energies, are reliant on precise geographical settings, a predefined zoning plan will help the sector to get a feel for how to overcome their local impediments (IRENA, 2014)

WaveNET is at a stage of demonstrating its potential as a commercial solution. Market areas identified for the technology include:

- Aquaculture- WaveNET is perfectly apt to deliver power to isolated offshore fish farm sites, which currently rely on diesel generators. Albatern are currently working with Marine Harvest Scotland. These demonstrator projects are helping to validate and test 6-Series WaveNET arrays for the supply of initially supplementary power to working fish farms.
- Island and remote communities - where waves are available and power is required, WaveNET can be part of a sustainable solution as it can allow communities to tap into their own local wave resource, providing a reliable and secure supply of electricity. It can also offer opportunities to use and cultivate local skills and infrastructure due to local content in the deployment and maintenance of individual units and mooring systems.
- Offshore Platforms - Later-stage production platforms, lighthouses, commissioning wind turbines and offshore instrumentation platforms all have offshore and off-grid power requirements. If an appropriate climate exists, wave energy with its high energy density can be used to provide sustainable and low-carbon power on site.

Project Results

Benefits

Non-linear yield - Interlinked WaveNET units respond to the rest of the array to supply non-linear yield enhancements, as array dimensions increase. This is a distinctive characteristic of WaveNET that has a strong effect on the economics of future wave technology development.

Reduced costs - Using small recurrent components to build large arrays helps to cut down the capital and operational costs of wave energy. Small component size helps reduce the costs of deploying and maintaining WaveNET arrays.

Lessons Learnt

WaveNET's uniquely flexible design allows it to track the full orbital motion of the fluid particles in the ocean waves, as well as, providing very efficient use of sea space and wave resource. As much as 300 MW per km^2 is possible for large arrays. This compares to 15-20 MW/ km^2 for other wave devices, with offshore wind typically in the range of 10 MW/km^2

High survivability- The SQUID generating units consist of a pioneering patented pumping module design, which evades the use of mechanical end-stops. This is a particularly significant characteristic for wave energy converters, especially where storm conditions can create large waves with very high energy levels that can destroy normally vigorous systems.

Reliability - WaveNET arrays are fully redundant systems and have a number of distinctive features to uphold high accessibility irrespective of individual component or device failures.

- ✓ Each unit makes three connections to the mooring grid and can be isolated from the rest of the array for maintenance or in the event of failure.
- ✓ Multiple power-take-off (PTO) modules within the array act in parallel – if one fails the others will automatically maintain production.
- ✓ The array's hydraulic network has automatic cut-off valves to protect against local failures. Any failed region is automatically isolated allowing continued operation

The costs of the wave energy technology prototypes are very high and that becomes a funding challenge in improving technology, as a lot of the learning comes when faced with real conditions.

The fate of Pelamis and Aquamarine, which aimed for too big waves too early, left both a legacy and warning. If a company wants to be in the wave technology business, in the current conditions, smaller is safer.

Post Project Benefits

The new project of Albatern, again in collaboration with Marine Harvest Scotland, and this time working on an active fish site provided by Marine Harvest, is in Mingary Bay.

Albatern applied for marine license and sea bed lease, as a marine renewable energy project, because they wanted to validate some of the marine renewables consenting models. This took a considerable amount of time, around 6 months in order to put the project in place. This was a result of delays, dealing with objections from fisherman and working with a greater number of stakeholders. In contrast with the Isle of Muck project, this was not an addition to an existing license that already has gone through consenting, and most of the processes and ideas were new to the company.

The project is financially supported by the HNI and by Wave Energy Scotland, which has enabled Albatern to put the project in place.

The 6 Unit array is providing energy from the waves, which goes to a shore station and through a cable to the barge. It is placed at a considerable distance from the fish farm in order to mitigate the risk to the fish farm if anything goes wrong with the technology. In a case like that, Albatern's equipment will end up on the beach, rather than anywhere near the fish farm site. This was undertaken in consultation with Marine Harvest to make sure they have their confidence to proceed with the project. Another difference from the Isle of Muck project is that the closest 11kW line is only 1 km away from the shore station; thus the project is also grid connected.

A challenge that Albatern is faced with currently, is the reliability of the electrical systems onshore. Albatern will be looking into the viability of incorporating storage by monitoring peak loads at the fish site.

Risk is too great to offer the technology on the market as customers are seeing the technology for the first time, so Albatern's objective is to demonstrate the viability and reliability of the technology. Albatern sees their progress in three different stages:

- First stage is Mingary Bay, which has a power purchase agreement (PPA) and Marine Harvest is paying for the electricity generated by the wave device.
- Next stage, as risk is eliminated and it's proved that the device is viable and reliable, is working more closely with fish farms. Most of the revenue stream of fish farms is coming on a regular basis, so capital cost would be still a difficult area, until there is more evidence of performance in the medium term. Thus, Albatern is looking at working with asset finance to provide a rental stream available for fish farms, similar to the current cost profile of purchasing diesel generators and fuel for running them.
- David Campbell, CFO at Albatern, estimates that between 18 months and 5 years, there will be sufficient confidence that Albatern devices are reliable and fish farms would consider acquiring the wave energy component as part of a standard farm.

Contact Information

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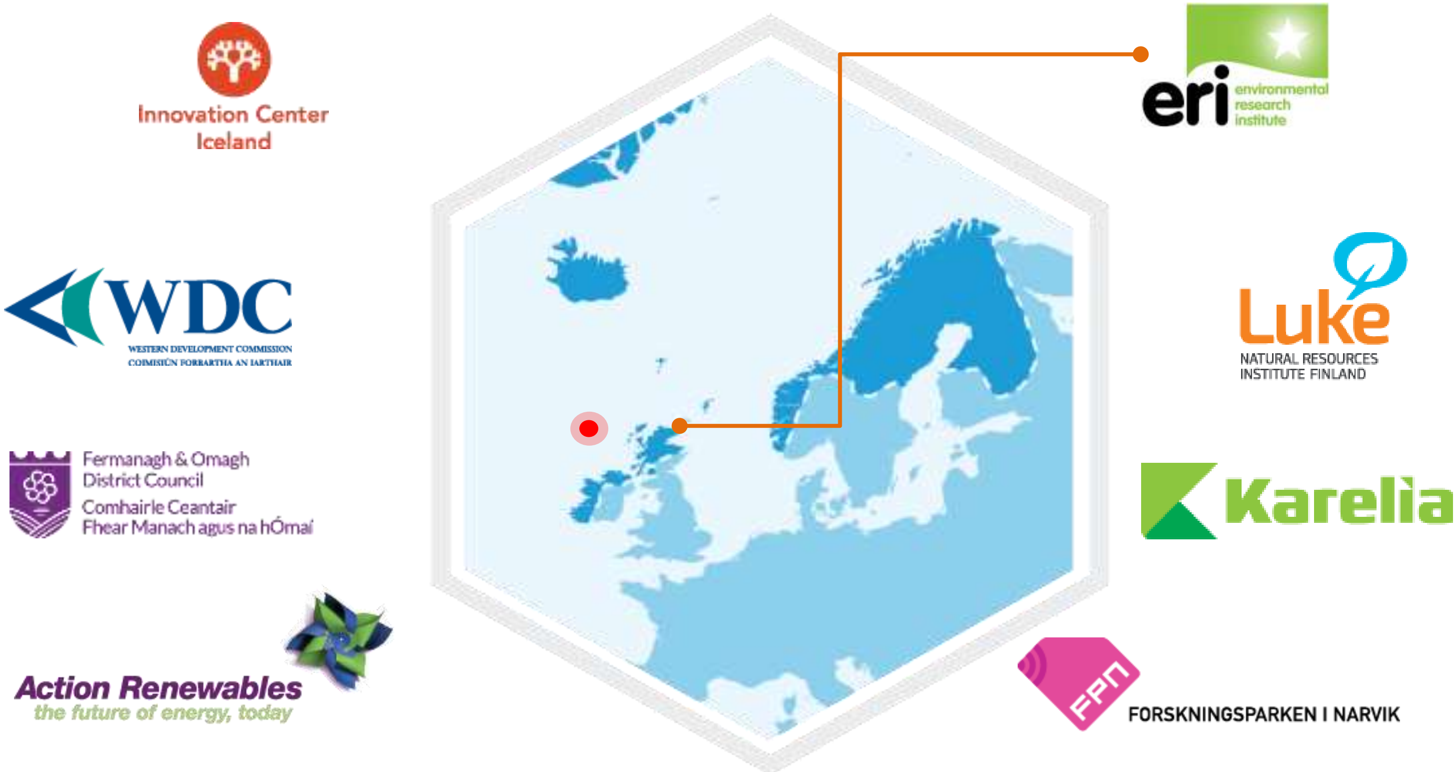
PARTNERS

GREBE will be operated by eight partner organisations across six regions:

ERI



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