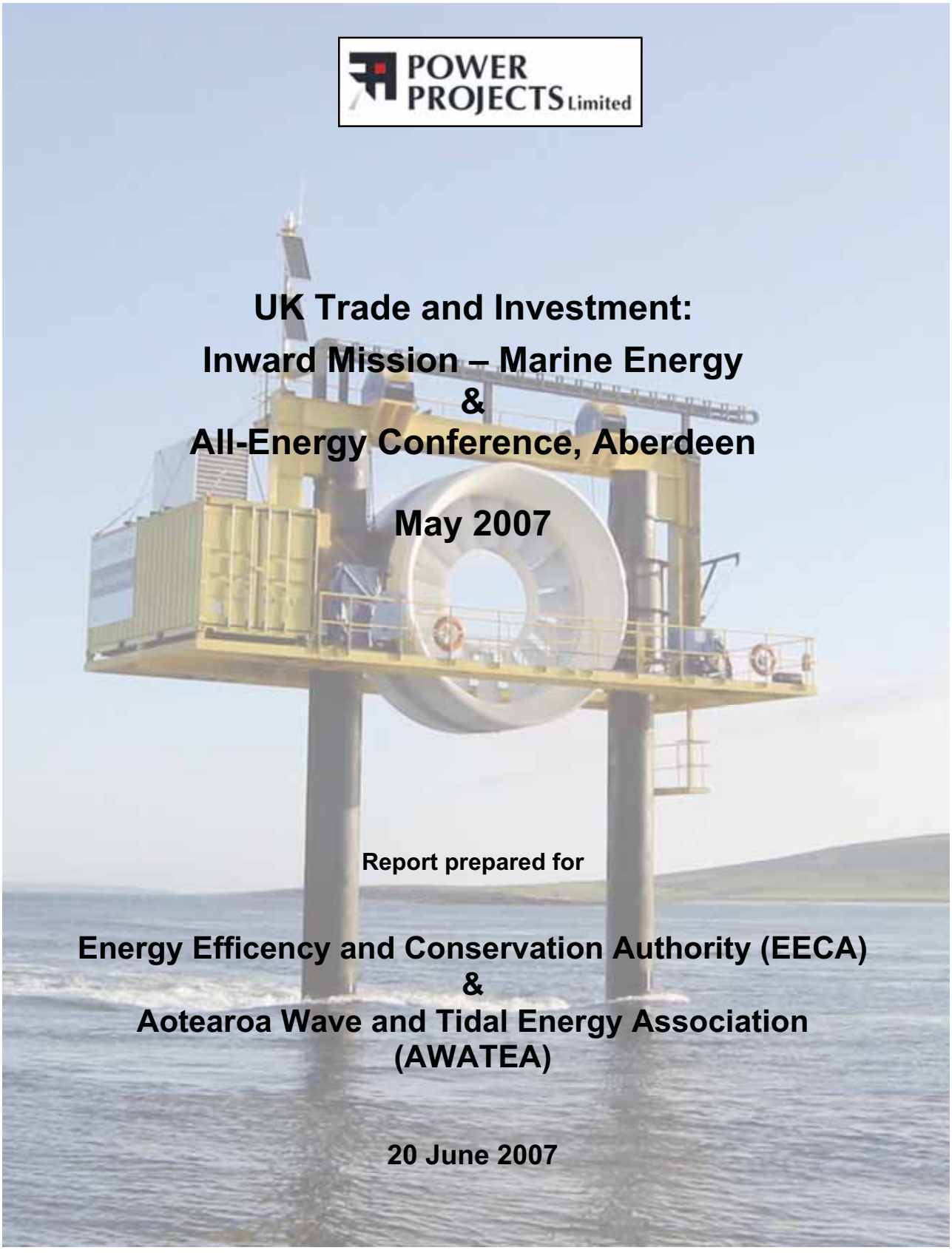

POWER PROJECTS Limited

UK Trade and Investment:
Inward Mission – Marine Energy
&
All-Energy Conference, Aberdeen

May 2007

Report prepared for

Energy Efficency and Conservation Authority (EECA)
&
Aotearoa Wave and Tidal Energy Association (AWATEA)

20 June 2007

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Cover: OpenHydro tidal turbine experimental prototype at Fall of Warness site, European Marine Energy Centre, 21 May 2007

1 INTRODUCTION

This report summarizes my visit to attend the following meetings:

- The UK Trade and Investment Inward Mission visits:
    i. European Marine Energy Centre, Orkney (EMEC)
    ii. Ocean Power Delivery, Edinburgh
    iii. Edinburgh University Wide Wave Tank
- The All-Energy Conference in Aberdeen

This report is a summary of the agendas, discussion and attendees at each of these meetings. It concludes with a series of recommendations for follow-up, which collectively aim to promote marine energy in New Zealand.

1.1 ACKNOWLEDGEMENT

Both EECA and AWATEA would like to thank UK Trade and Investment for the invitation to attend the Inward Mission described below. Paul Tuckley of UKTI in Auckland extended the invitation and he and Holly Wilson in the UK worked hard to make the complicated arrangements for the NZ party to attend each of the meetings.

JH would like to acknowledge the financial assistance of EECA and AWATEA and the prompt decision-making of EECA management and the AWATEA Executive in meeting some of travel costs associated with attending these meetings. Expenses for this trip were split as follows: EECA (1/3rd), AWATEA (1/3rd) and Power Projects Limited (1/3rd).

1.2 CONTACT DETAILS

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2 UK TRADE AND INVESTMENT: INWARD MISSION

2.1 ITINERARY AND PARTICIPANTS

This trip was offered and organized by UK Trade and Investment (UKTI) as an Inward Mission. UKTI had organized over 60 people from 19 countries to participate in the visits arranged in the Mission. The Inward Mission was focussed on renewable energy with a range of visits. The New Zealand delegation (Table 1) was, however, principally focussed on marine energy.

Name	Organization
Selwyn Blackmore (SB)	Energy Efficiency and Conservation Authority
Nick Eady (NE)	Director, CREST Energy
Garry Venus (GV)	Environmental Consultant, CREST Energy
Paul Tuckley (PT)	UK Trade and Investment, Auckland
John Huckerby (JH)	Executive Officer, AWATEA

Table 1: NZ Participants in the UKTI Inward Mission

For logistical reasons the NZ party had to attend the European Marine Energy Centre and Edinburgh University wave modelling basin on different days. The itinerary below is that of SB and JH. There were so many visiting groups that NZ participants were linked with other groups for individual meetings. All the NZ party visited OPD and attended the All-Energy conference together (Table 2).

Date	Venue	Purpose
21 May 2007	European Marine Energy Centre, Orkney	Visit EMEC wave and tidal energy berths, visit offices and meet staff
22 May 2007	Ocean Power Delivery, Edinburgh	Presentation by and discussion with OPD on development of Pelamis
23-24 May 2007	All-Energy Conference, Aberdeen	Renewable energy conference, including marine energy, wind, solar and biofuels
25 May 2007	Edinburgh University	Visit to wave modelling basin

Table 2: Inward Mission Itinerary (SB and JH timetable)

SB and JH visited EMEC in the company of a group from the Maine Maritime Academy in the United States. This group was on a fact-finding visit to support a proposal to develop a tidal energy testing facility at the Academy. The visit to the Edinburgh University wave modelling basin was in the company of a South Korean delegation, which presented details of a number of wave and tidal energy projects in South Korea. In both cases, it was clear that significant levels of funding were available in these countries for the proposed marine energy projects.

The preparation and organization of the itinerary of the Inward Mission was undertaken by UKTI. All costs were borne by the participants themselves.

2.2 EUROPEAN MARINE ENERGY CENTRE (21 MAY 2007)

The European Marine Energy Centre is located at Stromness in the Orkney Islands and was established in 2003 by funding from six Government and regional development agencies:

Scottish Executive	Highlands and Islands Executive
Orkney Islands Council	Carbon Trust
Department of Trade and Industry	European Union (FP6 for tidal site only)

Current shareholders in EMEC are Highlands and Islands Enterprise, the Carbon Trust and the Orkney Islands Council.

Total investment to date has been GBP 15 million. The majority of this expenditure has been on assets, particularly the submarine cables, which cost GBP 50–60/ m. Operating expenses are approximately GBP 1 million *per annum*. Given the experimental nature of EMEC's activities, insurance is very expensive.

EMEC comprises three facilities:

1. An office in Stromness, which houses nine staff and a computer system, connected to the device berths.
2. A wave energy testing area at Billa Croo, commissioned in 2003
3. Five tidal energy test berths at Fall of Warness with a network connection to the island of Eday, which were commissioned in 2005.

The tidal energy berths are about one hour's boat ride out of Kirkwall Harbour. At present one of the berths is occupied by the OpenHydro turbine, which is an Irish device still under pre-testing development (Figure 1).

Figure 1: OpenHydro Turbine at Fall of Warness site (EMEC)

The turbine was jacked up out of the water and commissioning work was due to proceed later that day. The device will apparently be operational in the near future.

Submarine work is limited to about 20 minutes around high tide. The landfall of the submarine cable and the onshore substation were also visible from the boat.

During the visit to the OpenHydro device, the boat skipper allowed the boat to drift with the current to determine its speed. At the time of our visit the tide was flowing at 5.1 knots (~2.6 m/sec), although peak surface velocities reportedly reach 8 knots (~4.1 m/sec). The power of the current can be seen in the wake effects around the piles of the device and are truly impressive at the site.

The five tidal sites are connected by 5 MW capacity cables, although the present grid connection has a capacity of only 4 MW.

The wave testing site is located about 5 kms west of Stromness at Billia Croo and this site was visited too (Figure 2). The four berths are connected by 2 km cables in 50 m water depth. Each cable is 11 kV*, i.e.,* 2.25 MW capacity. There is also a 7 MW grid connection. Like the tidal sites, the wave sites cannot be fully occupied until the grid connection is upgraded.

Figure 2: Wave Testing Site at Billia Croo (EMEC)

There is a small substation buried into the hillside above the site, which is marked by four marker buoys (Figure 3). The submarine cables come ashore under a rocky beach and there is no evidence of the cables on the beach itself. Offshore the cables rest on the seabed uncovered. There are four berths, although none was occupied at the time of our visit. One of the Pelamis devices had been located at the site until recently and this was due to return to site before the end of May, following maintenance on the nearby island of Hoy.

EMEC's offices are located in Stromness with office space for developers and a SCADA system to manage devices on site. Developers receive feeds into their own equipment so that they can do confidential work, in which EMEC takes no interest.

Figure 3: Electrical Substation at Billia Croo Site

The nine current staff are divided as follows:

Three administrative staff (including the Chief Executive)

Three operational staff, providing services to the developers

Three research officers, including environmental and consenting functions

Device developers are charged the use of the facilities and for performance testing services undertaken by EMEC staff. EMEC services are provided at flat rate charges.

EMEC is currently a non-profit organization, which provides independent testing facilites (physical connections as well as procedures and protocols) that can be used by device developers to provide independent verification of performance characteristics.

EMEC holds generic resource consents for a series of assets and operations, particuarly the submarine cables and substation and operation of the facilities. Blanket consents were declined because the permitting authorities did not want to take undue risks. Device developers therefore have to apply for individual consents for their devices. Devices of less than 1 MW can avoid this process and the Chief Executive commented that local planning legislation and regulation was both out-of-date and not specifically designed for marine generation.

Environmental baseline studies have been undertaken by impacts and changes caused by the infrastructure and device deployments have not been fully followed up

as yet. Billia Croo itself is both a Site of Special Scientific Interest (SSSI) and an area of Outstanding National Beauty.

EMEC has a Power Purchase Agreement, which is held on behalf of developers. Alternatively, developers can negotiate their own PPAs with the local network operator. Either way, developers receive all revenues from electricity produced by their devices and sold to the network operator. EMEC also collects a Renewable Obligations Certificate on behalf of the developers.

EMEC is an independent, internationally accredited testing facility (accredited with the UK Accreditation Society. The Chief Executive describes EMEC as a "*performance laboratory*". Its aim is to facilitate the process of open-ocean testing for device developers. Although uptake of berths at the centre has been relatively slow, this has been largely due three reasons:

1. Maturity of industry – insufficient mature devices ready for testing
2. Track record of EMEC
3. Issue of financing

In the longer term, it is intended that EMEC will also become a commercial generation facility (with multiple wave and tidal energy devices) and will move to a commercial revenue funding model. However, the independent testing function will remain.

2.3 VISIT TO OCEAN POWER DELIVERY'S HEAD OFFICE (22 MAY 2007)

The New Zealand delegation visited Ocean Power Delivery's (OPD) main office in Leith together with both Korean and Canadian delegates. They were given a comprehensive marketing presentation by OPD's Commercial Director, Mr. Max Carcas.

OPD was founded in 2002 and though a series of venture capital injections and smaller Government grants has increased in size to 75 staff at four locations, of which 25 staff are engaged in device fabrication at OPD's production facility at Methil. OPD is a device manufacturer, rather than a project developer or device owner. OPD has received GBP 30 million of funding from sources in the United Kingdom, United States, Switzerland, Italy, Norway and Portugal.

The first full-scale Pelamis prototype was built in 2004 and OPD made its first commercial sale in mid-2005. In 2006 it secured GBP 13 million in a second round of funding.

Max reviewed the potential marine energy around the UK coast and other parts of the world and described both the benefits of marine energy and the policy drivers that were leading the UK Government and Scottish Executive to promote and support marine energy developments. He then reviewed the development of the Pelamis device from test tank model to 1/7th scale prototype to full scale commercial device. The current device is a four cylinder, three power unit assembly with a capacity of 750 kW. To date capacity factors have been 25-40%, depending on location. The device is self-reacting and, although anchored using catenary moorings, it does not drag on its anchors in operation. The device design was based on survivability criteria and has a 15-20 year design life. To date Pelamis devices have survived 28 m storm waves. The device is also self-tuning, adjusting to individual waves.

Max stated that Pelamis's unique selling points were:

1. Survivability
2. Higher power capture (claimed to be 3 times power/tonne of competitors)
3. 100% available technology

He also discussed the benefits of marine energy generated by Pelamis:

1. Forecastable generation
2. Negligible visual intrusion
3. Minimal environmental impact
4. Minimal on-site construction
5. Off-site maintenance

These last two are interesting. Minimizing on-site operations, whether construction or other work, is obviously important and could be vital, given that waiting for weather and sea-state conditions to enable work to take place could be very costly. Further being able to easily remove the devices for maintenance is valuable. Indeed, OPD is currently modifying the mooring system of Pelamis to simplify hook-up and removal of the device.

Max showed some experience curve graphs (unit costs in kW/$ *versus* cumulative device production in MW), which show that marine energy devices should eventually cost less in unit terms than solar panels or wind turbines. A doubling of device production should result in a 15% reduction in costs. Current unit capex costs for Pelamis are GBP 2,000/kW, which equates to somewhere between 5-16 pence/kWh for the Portuguese deployment.

OPD's evaluation indicates that the market for marine devices in the UK and Scotland could be about Euro 270 million, whilst the Portuguese market is about Euro 60 million.

Max then detailed the three currently announced deployments of the Pelamis device.

2. Enersis (Portugal)
   - 3 devices being assembled and tested in Peniche
   - Permits and consents in place
   - Substation and submarine cable in place
   - Installation in the Summer of 2007 (delayed from Autumn 2006)
   - Phase 2 – 24 additional machines - under consideration
3. Scottish Power
   - 4 Pelamis devices (3 MW)
   - To be installed at EMEC in 2008
   - Phase 2 – 30 additional machines – 22.5 MW to be located at new site in Orkney
4. WestWave Project (E.On)
   - 7 Pelamis devices at WaveHub in SW England (5 MW)
   - Consenting in progress
   - DTI has provided GBP 4.5 million for WaveHub
   - SW Regional Development Agency has awarded GBP 21.5 million for WaveHub

Clearly if all these projects proceed to development, OPD will have a full order book for some time to come.

2.4 ALL-ENERGY CONFERENCE, ABERDEEN (23-24 MAY 2007)

The All-Energy conference is described as the "Renewables Show in the Energy City", Aberdeen being the operational centre of the UK North Sea oil and gas industry. The details of the conference can be found at:

http://www.all-energy.co.uk/Conference.html

The conference covered most renewable energy forms with an emphasis on marine energy, wind energy, biofuels, hydrogen and carbon capture and storage. The conference coincided with the UK Government's release of it Energy White Paper, essentially a draft Energy Strategy, similar in basic content to that released in December 2006 by the New Zealand Government. The UK differs in that geothermal energy has a lower potential than in New Zealand, although there were displays and presentations on ground-source heat pumps. There was also significant debate about the replacement of Britain's aging fleet of nuclear power stations, an energy source that is of only peripheral interest in New Zealand.

One very obvious observation is that the UK's energy problems are arguably much more serious than those of New Zealand's. The decline of North Sea oil and gas are leading to an increasing reliance on imported gas and electricity. Further, the UK's aggressive carbon emissions reductions targets will almost have to be met by future investment in nuclear energy as well as renewables. The UK is the current world leader and investor in marine energy because of this situation and the fact that onshore wind farms are reaching saturation (or testing local support for their development).

A rough headcount indicates that between 600 – 800 people were present at the conference and the meeting sessions held about 300 people each.

2.4.1 Presentations

There were two parallel sessions on the first day (23 May). The plenary session focussed on the political viewpoint of renewable energy and comment on renewables meeting the forthcoming target of 10% of electricity generation from renewables sources by 2010 and 20% contribution by 2020 (it was only 4% in 2005). The remainder of that session was spent on reviewing onshore and offshore wind in the UK.

The other session on marine energy was attended by the author. This included the following presentations:

1. An initial response to the Energy White Paper by the British Wind Energy Association's Marine Renewables Development Manager
2. The Scottish Executive's approach to promoting marine Energy
3. An interesting review by a Norwegian Ph.D. student of 90 wave and energy device projects.
4. The UK marine energy atlas
5. Tidal barrage and lagoon developments
6. Wave and tidal energy resources and projects in Canada
7. Brief presentations on financing projects and the CETO project in Fremantle

After lunch this session continued with reviews of academic research in the UK (by Professor Ian Bryden), testing facilities and standards at NAREC and EMEC. Brief updates were given on the development of the Pelamis device (by OPD), the OpenHydro tidal turbine (see Figure 1) and the Marine Current Turbines' deployment in Strangford Lough. The day was completed by a panel session, delivered by

stakeholder groups, focussing on environmental issues, wildlife concerns and coastal issues.

The second day was a more general group of sessions with specific sessions on the following:

1. Supply chain opportunities
2. Skills
3. Finance and funding
4. Carbon capture and storage
5. Aviation/radar
6. Health and safety

The author did not attend these sessions, preferring instead to attend side sessions, which aggregated innovative projects from different countries. Norway, Canada, Denmark and Austria all held these innovation sessions. A group of presenters from each country was given 15 minutes each to present their projects. The Norwegian presentations were largely marine projects (see Section 2.4.3), whilst Canadian session had two marine energy presentations (Clean Current Power and Wave Energy Technologies). The Danish session was dominated by wind projects whilst the Austrian session was a general review of renewable energy in that country.

> **Note:** a country-specific session by New Zealand would have been within the capabilities of the party present but the conference timetable was already fixed. Paul Tuckley was given 10 minutes to present a brief review of the NZ opprotunity. If there was sufficient interest in future, New Zealand could well benefit from organizing a group of speakers to present at this conference. It would be excellent exposure for New Zealand both in terms of identifying the country as an active innovator in renewables and exposing some of our project developers to a wider (potential) investment community. AWATEA will take up this proposal with EECA and NZ Trade and Enterprise for future conferences.

2.4.2 Exhibition Hall

The most impressive element of this conference was the large number of booths and displays. The exhibition hall was large and there was reportedly over ??? exhibitors.

There were large and impressive booths presented by countries, including UK Department of Trade and Industry, Scottish Executive, Denmark, Austria, Norway as well as some regional UK authorities and US states. The Orkney Islands, Highlands and Islands Enterprise Board and Aberdeen City had multiple-presentation booths. Some marine energy companies, notably Lunar Energy and Ocean Power Delivery, had organized large, conspicuous booths and large staff contingents to deal with the high level of interest.

There was an unusually large range of service contractors, ranging from resource analysts, engineering companies, materials and equipment suppliers, insurance companies and banks.

2.4.3 Summary

Somewhat contrary to the author's expectations, this conference was very worthwhile. There was a slight dominance of focus on marine energy, probably because the utility scale of potential developments and the recognition of its potential to meet the UK's ambitious renewable energy targets. As noted, New Zealand developers and the Government would do well to consider arranging to showcasing a number of projects through Innovation session at a future All-Energy conference.

Perhaps the most interesting benefit was to see a number of marine energy projects, which have garnered little publicity to date. It was surprising to see how many projects, previously unheard of, are now making progress through the investment process. Rather than review each of these projects, the interested reader may wish to pursue them via the following links:

Wave Devices

Langlee Wave Power	www.langlee.no
The Manchester Bobber	www.manchesterbobber.com
WAVEnergy AS	www.wavenergy.no

Tidal Devices

StarTider	www.starfishelectronic.co.uk
Hammerfest StrØm AS	www.e-tidevannsenergi.com
Scotrenewables SRTT	www.scotrenewables.com
Atlantisstrom	www.atlantisstrom.de
Tidal Sails	www.tidalsails.no

With respect to deployments various device developers gave forecast of their capacity growth. The following generation capacity for different devices in UK waters has been proposed for installation by 2010 by their developers:

Pelamis	30 MW
MCT	12 MW
OpenHydro	12 MW

Not wishing to end on a sour note, but it must be pointed out the facilities of the Aberdeen Conference Centre were far from ideal. The Conference Centre is on the northern edge of the city, some distance from all but one hotel. During the day, there were insufficient and inadequate outlets for the purchase of food and what was available was very unattractive (the much-vaunted deep-fried Mars Bars would have been a welcome addition to the tawdry fare on offer). Similarly, the Exhibition Hall and conference rooms were inadequately air-conditioned. The unseasonal heat made the lengthy sessions almost unbearable. The facilities were, overall, barely adequate for such a large attendance and need to be addressed by organizers in future years.

2.5 EDINBURGH UNIVERSITY WAVE TANK (25 MAY 2007)

SB and JH also visited the Edinburgh University wave tank and were introduced to Professor Stephen Salter (of Salter Duck fame), Jamie Taylor, who runs the wave facility and Douglas Rogers, whom some readers will remember from his presentations in Christchurch, Wellington, Auckland, Sydney and Canberra last year.

Jamie and Douglas described the test tank, which is approximately 10m x 5m in area and 1.5m water depth. The tank was designed and constructed by the Edinburgh wave research group (including the three listed above).

http://www.mech.ed.ac.uk/research/wavepower/wide%20tank/widetank.html

The tank is designed for testing scale models. The tank comprises a series of approximately 50 hinged paddles on one side and an absorbent matrix at the opposite side to avoid reflected waves. There is also a glass viewing panel at one end. Douglas demonstrated the tank's capabilities by generating a series of model waves

Douglas also demonstrated a variable pitch vertical axis tidal turbine that he is developing with colleagues at the university.

3 PAPER DOCUMENTS

During the conference, the author collected a range of paper documents from device developers, contractors and service providers. Interested parties may view this material in the AWATEA office by appointment. Since there is generally only one copy, the copies held are for reference only and will not be sent out or copied.