MARINE RENEWABLES INFRASTRUCTURE PLAN (M-RIP)

The Highlands and Islands

HIE
Highlands and Islands Enterprise
Iomairt na Gàidhealtachd 's nan Eilean

CONTENTS

1. EXECUTIVE SUMMARY

The report seeks to capture the marine energy industry's own view on what infrastructure, quayside, water depth, fabrication facilities, craneage and marine resources they will require for all stages of the industry. From fabrication to crew transfers, the report will provide marine energy developers – many from outwith Scotland – with a comprehensive list of port, harbours and fabrication facilities around the Highlands and Islands of Scotland that could meet their manufacturing, assembly, testing, deployment and long-term operations and maintenance needs. What is presented here is the best view the industry could offer – **a snapshot, at this time in 2014** – of what port and fabrication infrastructure will be needed. As the sector matures and develops this can only change, with differing technologies requiring quite different facilities, and what may seem critical at this time, perhaps being quite unnecessary in 2020.

In reviewing the developer feedback and capacity and capability of Highlands and Islands' ports, the key findings are summarised as follows:

1. It is too early to expect any convergence of developer needs at this stage – differences in technology will mean each will have a different set of requirements. Convergence is unlikely until later this decade because it will take until then to narrow down the commercially viable technologies.

2. Developers identified the risk of early significant infrastructure investment which may prove to be unnecessary or in the wrong place. Some developers highlighted minor investments which could be made at certain ports which would support all developers; whilst others advocated investment in bespoke vessels which could be designed to manage all maintenance activity.

3. Taking these important points into account, it is concluded that there is no **immediate need for large scale investment in new quay facilities specifically for the marine energy industry in the near term**. There may, however, be a need for bespoke onshore facilities to support early stage array deployment and developments and upgrades in specific ports or new facilities, where there is clear, demonstratable market demand.

This report is a first step in informing infrastructure providers and marine developers of the potential for key Highlands and Islands ports and facilities to meet developer requirements. Accordingly Highlands and Islands Enterprise will continue to engage directly with project/device developers and port owners and operators throughout the region to understand and meet this new sector's requirements and support the build out of Scottish projects as the industry continues to evolve.

Given the early stage of the sector, what is detailed in this report should be seen as a guide to how and where the industry may develop, based on current infrastructure provision, rather than a blueprint for the industrial development of the sector.

Nigg Energy Park.
Photograph credit: dgordon photography

2. INTRODUCTION

Development of the marine energy sector, specifically wave and tidal energy, provides a significant and sustainable economic growth opportunity for Scotland over the next decade and beyond. In order to capture the maximum economic and social benefit from the development of this new industry, the required infrastructure in terms of ports and harbours, along with supporting supply chain, will need to be competitively placed to meet developer requirements. This report seeks to provide an early assessment of the emerging industry needs and to identify the suitability of current infrastructure provision throughout the Highlands and Islands in meeting such needs.

Specifically the purpose of this report is to:

1. Provide device and project developers with an information resource on existing port and harbour infrastructure in the Highlands and Islands of Scotland to support project development and implementation; and

2. Provide infrastructure providers with a clear view of current and emerging developer requirements to inform infrastructure and service development in support of the sector; whilst recognising these requirements will change as this emerging industry continues to evolve.

3. BACKGROUND

Scotland is the world leader in the development of the sector, built on a number of strong foundations – the establishment of the European Marine Energy Centre (EMEC) in Orkney; the introduction of a supportive market tariff through renewable obligation certificates; a one-stop-shop consenting process led by Marine Scotland, and the introduction of commercial leasing rounds for marine energy by seabed owner The Crown Estate, resulting in over 2GW of commercially leased areas around our coast.

In 2012, the Pentland Firth and Orkney Waters Marine Energy Park was created, following the establishment earlier in the year of the UK's first Park in the South West of England. In 2013 the two Parks entered into a formal collaboration agreement, with the overall goals of providing a coherent, supportive business environment designed to accelerate the commercialisation of wave and tidal stream technologies.

The Scottish Government has established two Enterprise Areas in the Highlands and Islands, with a clear goal of stimulating manufacturing opportunities, investment and job creation. The most significant of these for the offshore renewables sector is the Low Carbon / Renewables North Enterprise Area which comprises Hatston (Orkney) , Arnish (Western Isles), Nigg (Highland), Scrabster (Highland) and Lyness (Orkney).

The Enterprise Area offers a range of incentives including a streamlined planning process and skills and training support. Discounted business rates are available at Hatston, Arnish, Scrabster and Lyness, while enhanced capital allowances are available at Nigg.

Together, these measures, along with a range of financial incentives, have spurred activity across the sector, and 2013 saw some very impressive progress – 11 full-scale devices undergoing testing at EMEC and announcements on the world's first fully consented wave farm in the Western Isles and the world's largest consented tidal project in the Pentland Firth.

The presence of so many leading marine technology companies in Scotland means that the potential economic rewards for the economy of the Highlands and Islands are significant – and indeed the positive economic impact of the sector is already being felt. The latest figures from trade body Scottish Renewables estimate the wave and tidal sector already employs over 800 people in Scotland[i], with another study confirming more than 200 full time equivalent jobs generating an additional £120m gross value added to the Orkney economy alone[ii]. Longer term, the wave and tidal sector could be worth £800m per annum to the UK economy by 2035 with a major part of the supply chain located in Scotland. Analysis by the Carbon Trust suggests the global marine market is likely to reach up to £9billion a year by 2050, and estimates UK could be expected to capture up to 25 per cent of the global market value and a significant share of the sub-component supply chain.

It is an exciting landscape, but there are considerable challenges ahead, and the major hurdles in the short term are technology, finance and grid.

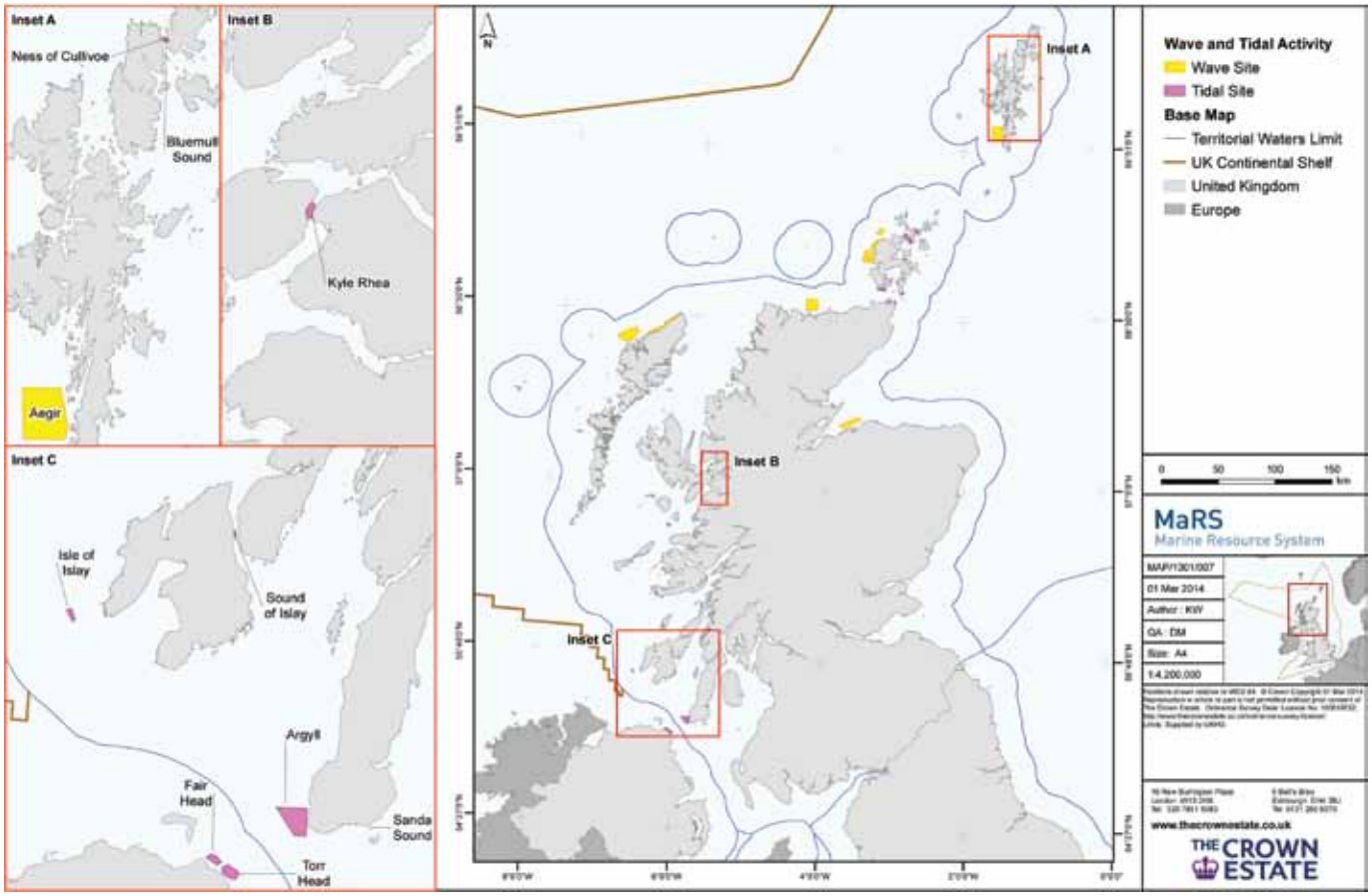
With technology, although we have seen a number of devices demonstrated at scale, there are still considerable technical challenges to overcome, particularly associated with reliability. Finance remains crucial. A number of major tidal schemes have secured significant public sector support and the capability of these projects to use these funds to leverage the considerable private sector investment required is a major step. In parallel, there remains a continuing requirement to support technology development, for both wave and tidal sectors.

There is now a much greater understanding of the nature of the technology challenge, and a number of public sector schemes have been introduced supporting technology developers at all stages of company growth, from early stage research and development to testing full-scale devices and financing first array deployments, with the goal of encouraging the commercialisation of the sector and attracting private investment.

Thirdly, we need to address the lack of grid connections to our Scottish islands. Again, positive progress is being made. The UK Government now recognises the unique nature of connecting Scottish islands, and is working closely with the Scottish Government, industry and the public sector – all seeking solutions to the twin challenges of high transmission charges and the significant securities and liabilities that single island links entail.

The marine energy sector comprises a wide range of different technology types, ranging from near shore and deep water wave energy technologies to bottom mounted, floating and surface-piercing horizontal axis tidal turbines. There are a number of reliable sources of information on the broad range of technology concepts, including the Renewables UK report "Marine Energy in the UK – State of the Industry Report 2012[iii]" and EMEC's web site which has good descriptions and illustrations of all of the main technologies[iv]. These are summarised in annex 2.

FIGURE 1. WAVE AND TIDAL LEASE AREAS IN SCOTLAND



Hatston Pier, Kirkwall, Orkney

4. METHODOLOGY

Building on the National Renewables Infrastructure Plan (N-RIP) 1 and 2, and on the work undertaken by The Crown Estate ("Wave and Tidal Energy in the Pentland Firth and Orkney Waters: How the Projects Could be Built", known as "the Build Out Story[v]") the approach adopted in this exercise included consultations, workshops and one-to-one interviews with project and device developers. Further, individual port and harbour site information was gathered from published material and direct from site owner operators. A series of validation exercises were conducted to ensure accurate reflection of both developer information and port and harbour site information.

Based on the intelligence gathered, a demand assessment of wave and tidal developers' near shore infrastructure needs as they are currently understood has been produced (Section 5), and an assessment of the capacity and capabilities of ports, harbours and other infrastructure that is considered to offer the necessary capacity to support the industry has been compiled (Section 6). To illustrate supply chain activity already taking place in the sector and how different infrastructure is currently being utilised, the report also includes a number of case studies (Section 7).

The output does not, however, constitute a formal part of the NRIP series given the emerging nature of the marine renewables sector, instead it describes a range of ports, harbours and other related infrastructure throughout the Highlands and Islands that could support the early development of the wave and tidal industry in Scotland.

5. KEY FINDINGS FROM DEMAND ASSESSMENT

One of the outcomes of the N-RIP Stage 2 report was an early assessment of infrastructure needs to support wave and tidal energy projects, with a focus on the Pentland Firth and Orkney Waters commercial scale leasing round. The report concluded that priorities for investment to support the wave and tidal sector would be identified following further consultations with lease holders in the Pentland Firth and Orkney Waters.
The Crown Estate's "The Build Out Story" previously identified broad requirements for port infrastructure to support construction, operations and maintenance. The developer feedback suggested that key requirements for a construction port suitable for a range of devices include:

- A heavy lift capacity up to an upper limit of 1000 tonnes;
- Large lay-down and storage areas of several hectares to enable assembly of components and rapid deployment of devices for larger scale developments;
- Suitable space for final assembly adjacent to the quayside;
- Dry and potentially wet commissioning of electrical parts with the need for a sufficient quay length for in-water activities that could exceed 200m;
- Supply of support vessels and personnel. During installation of an individual project phase up to six vessels and several man years of support would be required on site; and
- Sufficient draft and beam to facilitate movement of vessels and devices at a range of tides.
- Key skills requirements include marine logistics, mechanical and electrical fit-out and commissioning and testing.

For any significant activity requiring return of the device to port, it will be essential to have an operations and maintenance port facility available. This will be a location to which the devices can be transported, and may be chosen for having:

- A quayside lifting capability to lift the device to shore;
- Local workshop facilities to allow strip down, refurbishment, re-assembly and testing of devices; and
- A local skills base with mechanical and electrical technicians and familiarity with devices and necessary maintenance requirements.

This information was supplemented by additional work including one-to-one interviews and a workshop aimed at developers of leased areas outwith the Pentland Firth and Orkney water area.

A) UNDERSTANDING DEVELOPERS' REQUIREMENTS

The outcome of the consultation was a series of assessments that sought to capture developers' requirements. These are necessarily limited by the current stage of industry development and represent a snapshot of industry knowledge at that time. Responses received were generic to technologies rather than tailored to specific lease sites, for instance feedback provided by one developer was an illustration of its possible deployment techniques and supply chain requirements across all of the lease sites in which it has an interest.

B) OVERVIEW OF DEVELOPER FEEDBACK

The generic requirements described by the developers have been grouped into three areas to reflect the development process:

- **Manufacturing Facilities**
- **Assembly/Construction and Installation**
- **Operations and Maintenance**

Sites will also be required for **refuge/wet storage** of devices; locations such as Loch Roag on the west coast of Lewis and Loch Eriboll in Sutherland, along with a number of smaller harbours would be appropriate for this type of activity. Some technologies may also require basic operations and maintenance from small workboats, pontoons or floating piers in such locations.

The types of near shore infrastructure that developers may require is summarised below (Table 1) together with an overview of vessel requirements (Table 2). These requirements have been drawn from the developer feedback to inform development of generic criteria. As developer feedback to date focuses only on implementation of the first arrays it only provides a guide to future requirements as technology and installation techniques will evolve.

The output of these consultations has enabled generic criteria to be identified against which ports have been assessed to produce the framework of ports and other supporting infrastructure described in **Section 6.**

TABLE 1. PORT REQUIREMENTS

MANUFACTURING	ASSEMBLY/CONSTRUCTION AND INSTALLATION	OPERATIONS AND MAINTENANCE (O & M)
Manufacturing ports will have sufficient capacity to enable manufacture of major components and onward transportation to an assembly/installation site. A number of the first priority N-RIP sites fall within this category, along with a number of other ports and fabrication facilities. Proximity to lease/development sites is not as critical to this function as is industrial capability.	This function includes the marshalling and pre-assembly of components to enable deployment to the development site. Typical activities would include unloading in bound components, assembling components, laying down products to ensure their availability when weather and vessel availability allows construction to proceed and loading of components and partially assembled devices onto installation vessels. Closer proximity to the development site is desirable in order to maximize weather window availability.	This includes deployment of vessels to arrays to support planned and unplanned maintenance activities. O&M ports will typically require infrastructure such as reinforced quays, deep berths and reasonable storage areas both wet (level and sheltered seabed) and dry. Proximity to the development site is key function to enable aspiration day shift deployment and retrieval of devices. Good supply links and personnel logistics are important.
Not less than 10ha development land or 2,000m2 of available buildings	> 1ha. laydown space	Quayside lifting capacity
Laydown space at or close to quayside	1,000m2 of covered workspace	> 80m quayside
>100m weight bearing quayside with >5m depth alongside	> 80m weight bearing quayside with 5 - 8m depth alongside	> 0.5ha laydown space at or close to quayside 2 - 8m depth alongside
Slipway	Slipway	> 1,000m2 local workshop facilities
Craneage > 300t (possibly up to1,000t)	Craneage capacity > 200t	Office space (nominal integrated with workshop)
Skills	Supply of support vessels and personnel	Slipway
Labour market	Able to accommodate tugs and other similar sized multipurpose vessels plus jack up barges	Local skills base
Road/Rail connections	Pre installation test facilities	Mobile craneage

TABLE 2. VESSEL REQUIREMENTS

The table below illustrates the range of vessel types that may be required to support manufacturing, installation and operations and maintenance. These are drawn from the information gathered by The Crown Estate.

MANUFACTURING	ASSEMBLY/CONSTRUCTION AND INSTALLATION	OPERATIONS AND MAINTENANCE (O & M)
Anchor handling and support tugs	Anchor handling and support tugs	DP vessels
Cargo vessels with cranes	Cargo vessels with cranes	Multi cats with lifting capability
Submersible barges	Submersible barges	Crew transfer ribs
DP heavy lift vessels	Multi cats	ROV and diver support vessels
Ballasted logistics barges	DP heavy lift vessels	Cargo vessels
	Jack up barges	
	Ballasted logistics barges	
	ROV and diver support vessels	
	Cable laying vessels	

Load out at Arnish Point - Western Isles, Isle of Lewis, Outer Hebrides.

6. PORT CAPACITY AND CAPABILITY ASSESSMENT

A) THE INFRASTRUCTURE CHALLENGE

There is a broad range, scale and diversity of marine energy devices. In direct contrast to offshore wind devices these are not broadly homogenous in dimensions, weight and mass which pose a challenge in identifying support port locations which may be more, or less, suited to accommodating any particular device. Equally, current technologies may not be representative of future devices as innovation drives new entrants into the market. Also, lessons learned from first array deployment will inform device design and installation and maintenance techniques in the future.

B) PORT ASSESSMENT

Given this challenge and the nature of developer feedback it is not yet possible to definitively recommend potential functions for individual ports (manufacturing, fabrication, operations and maintenance) whilst there is still variation between developers and even within options being considered by single developers. An initial assessment of the Highlands and Islands' port resource has been carried out to identify a broad spatial framework in support of the generic categories and requirements described above.

The proposed network of support sites is shown in the map and supporting table below. The framework will be subject to review as developer requirements and installation techniques become clearer.

The framework identifies existing infrastructure in appropriate locations across the Highlands and Islands with good representation across each of the functions. There are no apparent gaps in provision; existing infrastructure appears to be adequate but ongoing work will be required to monitor developer requirements and to build a deeper understanding of supply and demand and to help identify any future investment requirements. In addition, there may also be a need for bespoke onshore facilities to support early stage array deployment and modest developments and upgrades in specific ports where there is clear market demand.

For ease of reference, ports are grouped into geographic clusters: **Shetland; Argyll; Western Isles; Orkney; Highland (North/ East/West) and Moray.**

Ports have been grouped together where they are in close proximity and could operate in a complementary fashion or could be controlled by one operator – for instance Scalloway and Hamnavoe in Shetland.

There is a broad range of ports across all of the key geographic areas that are capable of supporting manufacturing, assembly/construction and operations and maintenance. Currently, 8 sites have potential to support all of the functions on a single site. (see below table)

FIGURE 2. PORT LOCATIONS MAP

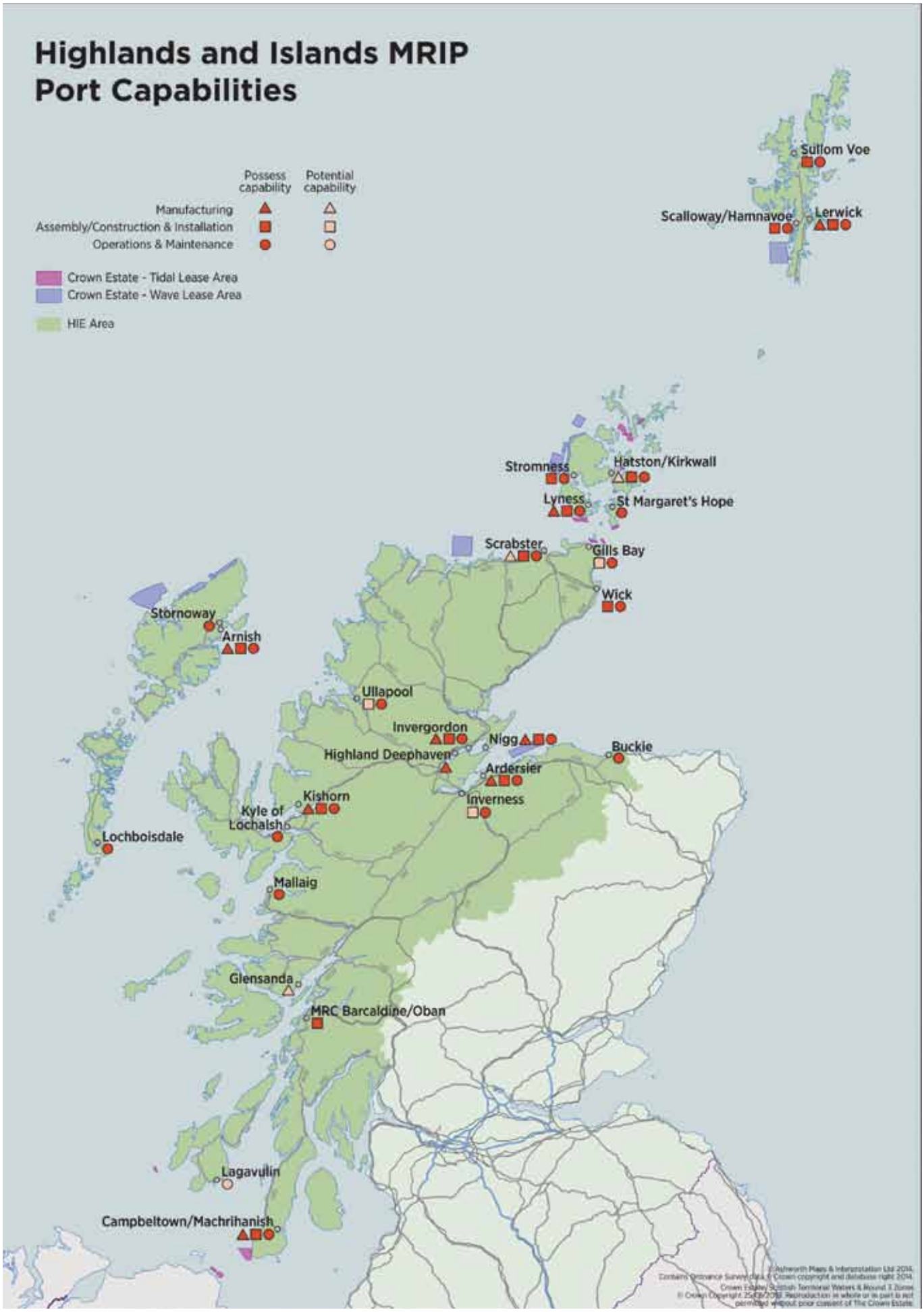


TABLE 3. HIGHLANDS AND ISLANDS PORT CAPABILITIES

PORTS BY CATEGORY /REGION	MANUFACTURING	ASSEMBLY/CONSTRUCTION AND INSTALLATION	OPERATIONS AND MAINTENANCE (O&M)
SHETLAND			
Scalloway/Hamnavoe		●	●
Lerwick (inc Dales Voe)	●	●	●
Sullom Voe		●	●
WESTERN ISLES			
Arnish	●	●	●
Stornoway			●
Lochboisdale			●
ORKNEY			
Hatston/Kirkwall	◆	●	●
Lyness	●	●	●
Stromness (inc Copeland's Dock)		●	●
St Margaret's Hope			●
HIGHLAND			
North:			
Scrabster	◆	●	●
Gills Bay		◆	●
Wick		●	●
East:			
Nigg	●	●	●
Ardersier	●	●	●
Invergordon	●	●	●
Highland Deephaven	●		
Inverness		◆	●
West:			
Ullapool		◆	●
Kishorn	●	●	●
Kyle of Lochalsh			●
Mallaig			●
MORAY			
Buckie			●
ARGYLL			
Campbeltown/Machrihanish	●	●	●
MRC Barcaldine/Oban		●	
Glensanda	◆		
Lagavullin			◆

MAP KEY:

● Possess capability

◆ Potential capability

Loch Eriboll, Caithness. Photograph credit: Sutherland Partnership

TABLE 4. POTENTIAL SUPPORT SITES

There are a number of other smaller ports throughout the region which may have potential for wet storage, basic unscheduled operations and maintenance activities or as ports of refuge. These include:

LOCATIONS	SHETLAND	WESTERN ISLES	ORKNEY	HIGHLAND	MORAY	ARGYLL
			PORTS			
	Hamnavoe	Bragar	St. Margaret's Hope	Loch Eriboll		Port Ellen
	West Burrafirth	Breasclete	Burwick	Altanavaig		Tiree
	Walls	Brevig		Uig		Tobermory
	Symbister	Callanish				
	Baltasound	Carloway				
	Uyeasound	Kirkibost				
	Mid Yell	Loch Roag				
	Cullivoe	Miavhaig				
		Skigersta				

Oyster 800 wave energy device installation at European Marine Energy Centre in Orkney

7. CASE STUDIES

7.1. PELAMIS WAVE POWER LTD

Headquartered in Leith, PWP has offices and facilities in Stromness and Lyness in Orkney. The company directly employs around 55 staff skilled in mechanical, electrical, structural and offshore engineering, software and electronic design, project development, R&D, finance, procurement and administration. Over the past ten years the company has attracted more than £70m of funding - including over £40m of investment, £10m of grants and £20m of sales (even whilst being in a pre-commercial phase of development). In this period six full scale test machines have been designed, built and operated both in Scotland and in Portugal. The vast majority of the company's expenditure in this period has been within the domestic economy via component suppliers, service providers and through direct employment. Assembly and fabrication activities have been carried out at various sites throughout Scotland including Rosyth, Lewis, Methil, Stonehaven, and most recently Leith. For the E.ON and Scottish Power P2 projects, fabrication was carried out by Steel Engineering Limited based in Renfrew. Operational vessel support has been provided for all PWP's projects by Shetland based Delta Marine.

7.2. OPEN HYDRO

OpenHydro is headquartered in County Louth, Ireland but also has a base in Kirkwall, Orkney, where all in-sea development of the Open-Centre six-metre turbine has been carried out. Since 2005 the company has attracted more than €50m in investment with expenditure of >£10m in support of operations in Scotland. The French defence group DCNS has acquired majority control of the company and has plans to achieve annual sales of >€1bn by 2025. In 2013 the seventh six-metre Open-Centre turbine will be installed at EMEC. From the construction and installation of the original test rig to the present day, a number of north of Scotland suppliers have been involved with OpenHydro. Examples of these include: Aquatera, an environmental consultancy, Currie Brothers, specialists in marine construction and piling services, Isleburn, the Nigg based fabricator, part of Global Energy Group, Leask Marine, a commercial diving company and Roving Eye Enterprises, a provider of underwater ROVs. These companies have in turn built on their experience to supply to others in this sector. OpenHydro is also working with SAMS, part of UHI as part of a consortium to monitor wildlife behaviour to facilitate commercial

projects. Notable amongst the company's commercial projects is the 200MW Brims Tidal project in the Pentland Firth, being developed as a joint partnership with SSE. In time, this project is likely to require a capital investment of up to £600m to build out to its fullest potential with corresponding opportunities for local companies in the supply chain.

7.3. EMEC

EMEC – A Vision Becomes Reality

2013 was a new high-water mark for the European Marine Energy Centre (EMEC) in Orkney. Ten years after the site was first inaugurated, the centre celebrated a decade of operation with a global energy symposium and eleven berths occupied by wave and tidal energy clients.

EMEC is a genuine global success story – and a good illustration of the length of time and the vision required to build the foundations of a new industry. The decision to site EMEC in Orkney was announced by the Scottish Government in July 2001 with the intention that "Scotland would become a world leader in energy production from wave and tidal power as a result". A HIE study recognised Orkney's natural advantages in terms of wave power and tidal currents, port facilities, sheltered waters in Scapa Flow and businesses and organisations which could support marine operations and new industrial growth.

The results of that vision can be seen today. Orkney in 2014 is synonymous with the wave and tidal industry. More than 250 local jobs are supported by EMEC, with dozens of firms – ranging from car hire and photography to environmental consultancy and dive services – generating significant business from the still-nascent sector. EMEC continues to respond to developer needs, and now provides 14 grid connected berths for wave and tidal energy devices, with new off-grid test facilities available for earlier stage wave and tidal energy device prototypes. An incredible critical mass of activity is taking place in and around the EMEC test sites – fundamentally 'learning by doing'. For any offshore engineering there is no substitute for real sea experience. Many solutions are still to be found, and this creates opportunities for developers and the supply chain.

Further afield, its reputation is growing. Countries around the world, buoyed by EMEC's success, are now seeking support in establishing test centres of their own. Canada, Japan, South Korea, Taiwan, Singapore, China, and the USA are all establishing their own national infrastructures – and each has signed commercial memorandums of understanding with EMEC to secure advice and consultancy services as they begin their own journeys.

Rather than being viewed as competition, the Scottish Government recognise that overseas test centres are an opportunity – not only to generate new business for a Scottish success story, but to create excitement, political will and ultimately new markets for home-grown wave and tidal technologies in the decades ahead.

7.4. AQUAMARINE POWER

Aquamarine Power – Creating Jobs Potential

Aquamarine Power's proposed wave farm on the Western Isles could create hundreds of long-term skilled jobs in one of Britain's most remote communities, according to an independent study. The Edinburgh firm's 40MW Lewis wave farm - which was fully consented by the Scottish Government in 2013 – could generate between 98 and 200 jobs during construction and inject up to £9 million a year into the Western Isles and wider Highland economy.

The project would involve installing up to 50 of Aquamarine Power's Oyster near-shore energy machines along the north-west coast of Lewis. The company is currently testing their second full-scale prototype, the Oyster 800, at the European Marine Energy Centre (EMEC) in Orkney. The figures come from an in-depth assessment carried out by Aquamarine Power using a methodology developed by consultants ABP Marine Environmental Research and Risk & Policy Analysts Ltd.

The consultants were commissioned by seabed owner the Crown Estate, using funds from their Pentland Firth and Orkney waters enabling actions programme, to develop an objective technique which project developers could use to identify the economic opportunity presented to the UK by the wave and tidal industry. Aquamarine Power's study showed that their 40MW wave energy project in the Western Isles could generate:

- 200 jobs in the Outer Hebrides and wider Highlands and Islands during the construction phase, generating an estimated £4.49 million to £9 million gross value added per year;
- 23 to 37 jobs during the 20 year operations and maintenance phase, generating £1.3 million to £2.1 million per year.

The calculation includes all direct employees and contractors used by Aquamarine Power, indirect jobs such as shops, hotels and local services, and induced jobs created by the increased overall activity in the area.

The first two Oyster devices have been almost entirely British-built. Oyster 1 was fabricated by Isleburn at Nigg Fabrication Yard, and Oyster 800 by BiFab at Methil in Fife. The company is currently working with numerous businesses across Orkney, including Leask Marine and Heddle Construction in Orkney and Calder Engineering in Caithness. The study confirms that future machines could be manufactured wholly in the UK, with the potential to source a hundred per cent of the farm's manufacturing supply chain within Britain.

Kishorn Port

8. CONCLUSIONS

Wave and tidal energy is an economic growth opportunity for Scotland and while good progress has been made towards overcoming the challenges to full scale deployment, the industry is still at an early stage of development.

Engagement with project and technology developers has produced valuable information that allows us a better understanding of the generic requirements of the industry to be established. It is clear that future installation methodologies will change on the basis of learning gained from the delivery of the first arrays and full scale prototypes. Understanding of infrastructure requirements will evolve as these initial projects are developed.

Consultation with developers has identified a requirement for:

- Manufacturing facilities
- Sites for final assembly and Installation
- Operations and maintenance sites

Drawing on the outcome of developer engagement an assessment of the capacity and capability of ports throughout the Highlands and Islands has been carried out. Existing facilities appear to be adequate at this stage but investment may be required as developer needs are refined. The report highlights opportunities for small ports to provide support, particularly for operations and maintenance functions. This will potentially provide economic benefits to island communities adjacent to the resource, helping to grow their economic base.

What is presented in this report is the best view of the industry on what port and fabrication infrastructure is needed, and as the sector matures and develops this can only change, with differing technologies requiring quite different facilities. Accordingly what is detailed in this report should be seen as a guide, rather than a blueprint.

Based on these findings, **there is no need for large scale investment in new quay facilities specifically for the marine industry in the near term.** There may, however, be a need for bespoke onshore facilities to support early stage array deployment and modest developments and upgrades in specific ports where there is clear market demand.

Accordingly Highlands and Islands Enterprise will continue to engage directly with project/device developers and port owners and operators to understand and meet this new sector's requirements and support the build out of Scottish projects as the industry continues to evolve.

Installation of the Hammerfest Strom Tidal Turbine at the test site at Eday

9. APPENDICES

ANNEX 1 – CROWN ESTATE LEASED AREAS IN SCOTLAND

LEASE SITE	SECTOR	LEASE TYPE	SIZE (MW)	DEVELOPER	TECHNOLOGY
Farr Point, Sutherland Coast	Wave	Demo	50	Pelamis Wave Power	Pelamis P2
Brough Head, Orkney	Wave	Commercial	200	SSE/Aquamarine Power	Oyster
West Orkney Middle South	Wave	Demo	50	E.ON	Pelamis P2
West Orkney South	Wave	Demo	50	E.ON	Neutral
Brough Ness, Orkney	Tidal	Commercial	100	Sea Generation (Brough Ness) Ltd	Sea Gen
Marwick Head, Orkney	Wave	Demo	50	Scottish Power Renewables	Pelamis P2
Ness of Duncansby, North of Caithness	Tidal	Commercial	100	Scottish Power Renewables	HS 1000
Westray South, Westray Firth	Tidal	Commercial	200	SSE	Neutral
Costa Head, Orkney	Wave	Commercial	200	Alstom/SSE	AWS
Brims, Orkney	Tidal	Commercial	200	Open Hydro/SSE	Open Hydro
Inner Sound, Pentland Firth	Tidal	Commercial	400	MeyGen Ltd	Atlantis AR1500
North West Lewis	Wave	Commercial	30	Aquamarine Power	Oyster
Galson, Lewis	Wave	Commercial Demo	10	Aquamarine Power	Oyster
Kyle Rhea, Isle of Skye	Tidal	Commercial Demo	8	Sea Generation (KR) Ltd	Sea Gen
Sound of Islay, Islay	Tidal	Demo	10	ScottishPower Renewables Ltd	Andritz Hydro Hammerfest / Alstom
South West Shetland	Wave	Commercial Demo	10	AEGIR	Pelamis P2
Bernera, Lewis	Wave	Commercial Demo	10	Pelamis Wave Power	Pelamis P2
Lashy Sound, Orkney	Tidal	Commercial Demo	30	Scotrenewables	Scotrenewables SR2000
Isle of Islay, Islay	Tidal	Commercial	30	DP Marine Energy	
Mull of Kintyre, Kintyre Peninsula (SW Scotland)	Tidal	Engineering Demo	3	Argyll Tidal Ltd	Nautricity CoRMat 500

ANNEX 2 – WAVE AND TIDAL ENERGY TECHNOLOGIES

The marine energy sector comprises a wide range of technologies. The range of technologies is described in detail in Renewables UK report "Marine Energy in the UK – State of the Industry Report 2012[vi]". EMEC's web site also has good descriptions and illustrations of all of the main technologies, including examples of these devices[vii].

The main technology types which have progressed to full-scale prototype are:

TIDAL DEVICES

A) HORIZONTAL AXIS TURBINE

Horizontal axis turbines extract energy from moving water in much the same way as wind turbines extract energy from moving air. The tidal stream causes the rotors to rotate around the horizontal axis and generate power.

B) VERTICAL AXIS TURBINE

Vertical axis turbines extract energy from the tides in a similar manner to that above, however the turbine is mounted on a vertical axis. The tidal stream causes the rotors to rotate around the vertical axis and generate power.

D) Enclosed Tips (Venturi)

Venturi Effect devices house the device in a duct which concentrates the tidal flow passing through the turbine. The funnel-like collecting device sits submerged in the tidal current. The flow of water can drive a turbine directly or the induced pressure differential in the system can drive an air-turbine.

E) Archimedes Screw

The Archimedes Screw is a helical corkscrew-shaped device (a helical surface surrounding a central cylindrical shaft). The device draws power from the tidal stream as the water moves up/through the spiral turning the turbines.

F) Tidal Kite

A tidal kite is tethered to the sea bed and carries a turbine below the wing. The kite 'flies' in the tidal stream, swooping in a figure-of-eight shape to increase the speed of the water flowing through the turbine.

WAVE DEVICES

A) Attenuator

An attenuator is a floating device which operates parallel to the wave direction and effectively rides the waves. These devices capture energy from the relative motion of the two arms as the wave passes them.

B) Point absorber

A point absorber is a floating structure which absorbs energy from all directions through its movements at/near the water surface. It converts the motion of the buoyant top relative to the base into electrical power. The power take-off system may take a number of forms, depending on the configuration of displacers/reactors.

C) Oscillating Wave Surge Converter

Oscillating wave surge converters extract energy from wave surges and the movement of water particles within them. The arm oscillates as a pendulum mounted on a pivoted joint in response to the movement of water in the waves.

D) Oscillating water column

An oscillating water column is a partially submerged, hollow structure. It is open to the sea below the water line, enclosing a column of air on top of a column of water. Waves cause the water column to rise and fall, which in turn compresses and decompresses the air column. This trapped air is allowed to flow to and from the atmosphere via a turbine, which usually has the ability to rotate regardless of the direction of the airflow. The rotation of the turbine is used to generate electricity.

E) Overtopping/Terminator device

Overtopping devices capture water as waves break into a storage reservoir. The water is then returned to the sea passing through a conventional low-head turbine which generates power. An overtopping device may use 'collectors' to concentrate the wave energy.

H) Rotating mass

Two forms of rotation are used to capture energy by the movement of the device heaving and swaying in the waves. This motion drives either an eccentric weight or a gyroscope causes precession. In both cases the movement is attached to an electric generator inside the device.

10. REFERENCES

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Campbeltown harbour

FOR MORE INFORMATION CONTACT:

Energy team

T: +44(0)1463 234171
E: energy@hient.co.uk

www.hie.co.uk

Highlands and Islands Enterprise
Iomairt na Gàidhealtachd 's nan Eilean