A FURTHER UPDATE ON THE DISTRIBUTIONS OF MARINE RENEWABLE ENERGY PLANTS IN EUROPE.

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ABSTRACT

European seas are being impacted by a rapid expansion of marine windfarms as governments strive to meet renewable energy commitments. Other Marine Renewable Energy Developments (MREDs), particularly wave and tidal energy devices, are also starting to be deployed. Concerns have been raised that the potential impacts on cetaceans and the marine environment are not being adequately taken into account when these MRED sites are being developed. Before 2000 there were just 13 sites (11 wind farms and 2 tidal energy plants); by 2004 there were 33 sites (26 wind farms, 5 tidal energy and 2 wave energy plants); and today, there are 95 sites (67 wind farms, 15 tidal energy and 13 wave energy plants) either operational, under construction, planned, or submitted. This paper provides an update on the locations and state of development of the European MREDs.

KEYWORDS: Marine Renewable Energy, noise, UK, Europe, windfarms, tidal energy plants, wave energy plants, cetaceans

INTRODUCTION

Renewable energy projects continue to gather pace as governments attempt to meet targets to reduce their carbon emissions. Marine Renewable Energy Developments (MREDs) have the potential to contribute significantly towards these targets. They have been described as "likely to be the most intensive engineering interventions in the UK's coastal waters in the next decade" (Prior and McMath, 2007). The same may hold true for other countries. The environmental impact of these projects on cetaceans will vary according to their location and design. This paper provides an update to a previous paper submitted to the Scientific

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Committee of the International Whaling Commission on the extent of MREDs in the northeast Atlantic (Brown and Simmonds, 2008).

Of the various MREDs, windfarms are the most numerous and there are currently 67 windfarms either in operation or in various stages of development in Europe. These make up 70.5% of the total MREDs in Europe.

Tidal and wave power projects are also progressing. Tidal power consists of tidal stream energy (also called marine current energy) which is produced from the horizontal movement of water in a current (kinetic energy), and tidal range energy which is produced from the vertical movement of water in the rise and fall of the tide. Wave power is generated by the surge of passing waves and can be deployed in deeper waters where the waves are more powerful (Wright *et al*. 2009).

As many MREDs are still in development, not all of the possible adverse impacts on the marine environment are known or fully understood. The concern this raises was highlighted, for example, when the Parties to the Agreement on the Conservation of Small Cetaceans of the Baltic and North Seas (ASCOBANS) at their 5th Meeting, in 2006, called for further research to be conducted on the effects of wind farms on small cetaceans (ASCOBANS, 2006).

METHODS

A survey was conducted of web-based and other literature to determine the extent of MREDs in Europe. Some preliminary global data was also collected. Windfarms, tidal power and wave power were considered, and the results are provided as maps and tables for each.

The locations of windfarms are marked in figure 1, and the energy capacity and other details for each site are summarised in table 1. The locations of tidal power sites are in figure 2, and the details for each site are in table 2. The locations of wave power sites are in figure 3, and the details for each site are in table 3.

In all of the tables ‘energy generated’ or ‘proposed energy generation’ refers to the energy produced annually; ‘energy capacity’ refers to the maximum energy that can be generated during peak conditions (where the information is available).

‘Operational’ sites are those that have been completed and are providing electricity. The information includes the year that operation started, the developer and details of location (where the information is available).

'Under construction' sites are those that have been approved and construction is underway. The information includes the year that confirmation was given, the developer and details of the location (where the information is available).

'Approved' sites are those for which the submitted plans have been consented to, but construction has not been started. The information includes the year that approval was given, the developer and details of the location (where the information is available).

'Submitted' sites are those where plans have been completed and reports submitted for consideration. At this stage sites can either be approved or rejected. The information includes the year that plans were submitted, the developer and details of the location (where information is available).

The main focus of this paper is the wind, tidal and wave power sites in the British Isles and continental Europe (figures 1, 2, 3 and 4). However, we have also had a preliminary look at MREDs outside of this region and these are shown in figure 5. This global review is still in progress and not all countries have been covered.

DISCUSSION

The rapidly expanding number of MREDs in Europe is clearly shown; there has been over a 7 fold increase since 2000. 70.5% are wind farms, 15.8% are tidal sites and 13.7% are wave power sites.

Windfarms

Of all the types of MREDs, windfarms have been developed the most swiftly, with concentrations around the UK coastline, in the North Sea, and the Baltic Sea coasts off Germany and Denmark. There are currently 31 windfarms in operation, 9 under construction, 18 that have been given approval, and 9 where plans have been submitted. Figure 1 shows the location of these sites, and table 1 shows the details of each of the sites).

The growth of windfarms can be seen in Figure 4. Between 2000 and 2004 the number of windfarms increased by 42.3%. They then expanded rapidly between 2005 and 2009, when they increased by 257.7%.

Information on the effects on marine mammals of constructing and operating offshore windfarms is still limited. With windfarms construction moving into deeper waters, in particular around the UK, and with planned increases in the size of turbines, there are potential impacts on a greater number of species.

The most significant concerns relating to wind farms are currently related to noise production. Marine noise pollution has the potential to displace animals and populations, interfere with normal behaviour and, at very high intensities, may be physically damaging (Simmonds and Dolman, 2008). MRED construction phases, when pile-driving is typically used, have the greatest potential to cause acute effects. Increased noise, potentially including operational noise from the turbines and increased boat traffic associated with the maintenance of the turbines, may cause behavioural impacts. Noise from decommissioning of windfarms by activities such as drilling, cutting and the potential use of explosives also causes concern for the future (Prior and McMath 2008).

Tidal power

Tidal power sites have been slower to develop than windfarms and are currently concentrated around the UK coast, in particular to the west, and in northern France. There are currently 6 operational, 2 approved and 7 submitted tidal power sites in Europe. Figure 2 shows the location of these sites, and table 2 shows the details of each of the sites.

The growth of tidal power sites can be seen in Figure 4. Between 2000 and 2004, the number of tidal power sites increased by 250%, their development rose by 300% between 2005 and 2009. As tidal power devices are relatively new, very little research has been done into their impact on the marine environment.

Noise levels from construction, again in particular pile-driving, and maintenance may be a significant issue, especially in areas of high marine mammal abundance. Other potential negative impacts include collisions, contamination of water, entanglement and displacement (Wright *et al*. 2009).

Wave power sites

Wave power sites have been the slowest of the MREDs to develop in Europe and they are scattered between the UK, Spain and Denmark. There are currently 6 that are operational, 4 under construction, 2 approved and 1 submitted. Figure 3 shows the location of these sites, and table 3 shows the details of each of the sites.

Between 2000 and 2004, the number of wave power sites increased by 200% (figure 4). Between 2005 and 2009 their development rose by 300%. As wave power devices are relatively new, very little research has been done into their impact on the marine environment; the concerns are the same as with tidal energy sites, potentially including collisions, noise, water contamination, entanglement and displacement (Wright *et al*. 2009)

Finally, figure 5 indicates the extent of MREDs worldwide, although data is still being collected and hence this figure is not complete. The map shows that countries including USA, Canada

and Australia are developing MREDs. Australia has plans for wave power only (as far as we are aware), Canada and USA have plans for both wind and wave power, with wind being favoured on the east coast and wave power on the west coast. Other countries are purchasing the technology, particularly for windfarms, from companies that are already running projects in Europe.

General Concerns

In light of the rapid expansion of MREDs in Europe, and their likely expansion globally, it is of high importance that their impacts on the marine environment are fully understood. Simmonds and Dolman (2008) noted that although the first marine wind farms have mainly been near-shore, within approximately 5 km of the coast, plans are now being made for deeper-sea developments. Wind farms are also growing in scale, with plans for hundreds of turbines at some sites. The size of turbines has also been increasing. The size of turbines, the overall size of the wind farm, and the geographical location all have implications for environmental impact.

The nature of the foundations of wind farms may be particularly important as this will affect construction noise and also affect the transmission from the operating turbines (Simmonds and Dolman, 2008). Typically turbines are seated on either steel monopiles driven into the seabed with large pile drivers or on concrete gravitational foundations placed on pebble cushion layers. In addition, cable-laying from wind farms to take the electricity generated to suitable nodes to connect with national grids may generate noise and physical habitat disturbance due to upheaval of the seabed.

The construction noise associated with MREDs operating on the water-surface or in the water column may be less than those requiring pile-driving and they may be on a smaller scale (Prior and McMath, 2008). However, there is potential for impacts between cetaceans and structures, including submerged rotating blades (Simmonds and Dolman, 2008).

Dolman *et al*. (2007) highlighted the need to achieve robust baseline data before any development site is determined. This will allow the conservation value of a site to be better evaluated and facilitate comparison of conditions prior and post construction. The authors support the view of Dolman *et al.* (2007) that guidelines need to be developed for the protection of marine mammals, and that where MREDs proceed adjacent to areas used by cetaceans, there should be mitigation measures to reduce any impacts.

Figure 1. Windfarm developments in Europe

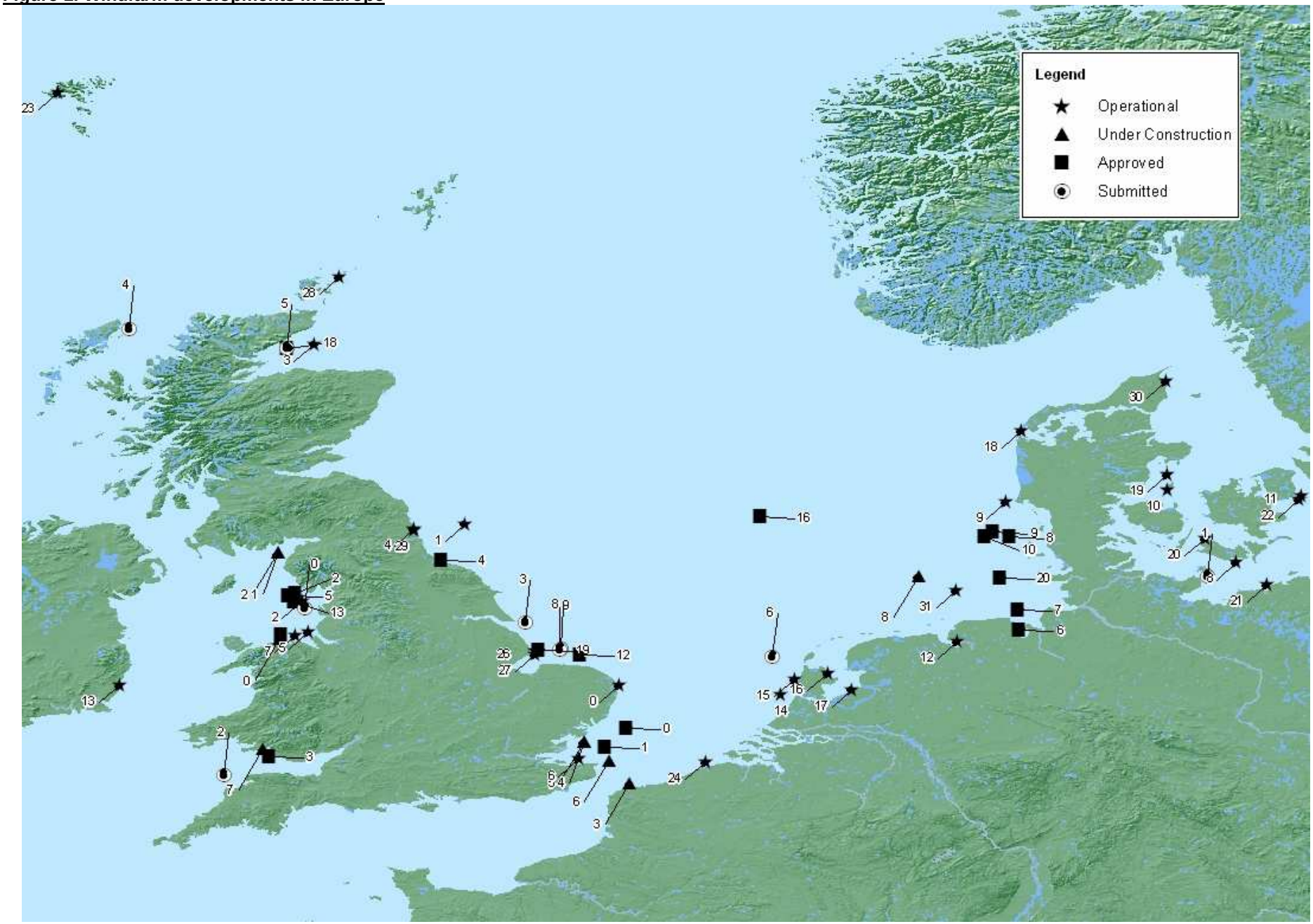


Table 1 Detail of Windfarm developments in Europe

Operational

Site No.	Name	Location	Region	Turbines	Developer	Lat Long	Country	Year	Energy Generated	Energy Capacity	Information Source
0	Scroby Sands	3km NE Great Yarmouth	Norfolk	30	E.ON UK Renewables	52 38 00N 01 47 00E	England	2004	2MW	60MW	BWEA website www.bwea.com/ukwed/operational.asp
1	Wether Hill		Dunfries & Galloway	14	Scottish Power	55 13 20N 04 02 30W	Scotland	2007	1.3MW	18.2MW	BWEA website www.bwea.com/ukwed/operational.asp
2	Barrow	7km Walney Island	North West/ Cumbria	30	DONG Energy/ Centrica Renewable Energy	53 59 00N 03 17 00W	England	2006	3MW	90MW	BWEA website www.bwwa.com/ukwed/operational.asp
3	Beatrice	Beatrice Oilfield, Moray Firth	Scotland	2	Scottish and Southern	58 06 20N 03 05 35W	Scotland	2007	5MW	10MW	BWEA website www.bwea.com/ukwed/operational.asp
4	Blyth Offshore	1km Blyth Harbour	North East/ Northumberland	2	E.ON UK Renewables	55 08 09N 01 29 25W	England	2000	2MW	3.8MW	BWEA website www.bwea.com/ukwed/operational.asp
5	Burbo Bank	5.2km Crosby	North West/ Merseyside	25	DONG Energy	53 29 00N 03 11 00W	England	2007	3.6MW	90MW	BWEA website www.bwea.com/ukwed/operational.asp
6	Kentish Flats	8.5km offshore from Whitstable	South East/ Kent	30	Vattenfall	51 27 00N 01 08 10E	England	2005	3MW	90MW	BWEA website www.bwea.com/ukwed/operational.asp
7	North Hoyle	7.5km Prestatyn and Rhyl	North Wales/ Denbighshire	30	npower renewables	53 26 00N 03 24 00W	Wales	2004	2MW	60MW	BWEA website www.bwea.com/ukwed/operational.asp
8	Nysted	10km south of Nysted on Lolland	Rodsand/ Lolland	72	DONG Energy		Denmark	2003			http://uk.nystedhavmoellepark.dk/frames.asp
9	Horns Rev	14-20km offshore from Jutland	Blavandhuk	80	DONG Energy		Denmark	2002		160MW	http://www.hornsrev.dk/Engelsk/default_ie.htm
10	Samso	3.5km south of the island Samso	Island of Samso	10	Locally owned		Denmark	2003	2.3MW	23MW	http://www.samsohavvind.dk/windfarm/
11	Middelgrunden	2km offshore from Copenhagen	Port of Copenhagen	20	DONG Energy		Denmark	2003	40MW	90TWh	http://www.windpower.org/en/pictures/offshore.htm
12	Ems-Emden	40m offshore		1	Enova		Germany	2004	4.5MW	4.5MW	Offshore-wind.de website www.offshore-wind.de
13	Arklow Bank	10km Arklow	County Wicklow/East Ireland	7	Airtricity		Ireland	2007	25.2MW		Offshore Wind Energy www.offshorewindenergy.org

14	Q7-WP	23km Ijuiden		60	Econcern, Energy Investments Holding, ENECO Energy		Netherlands	2008	2MW	120MW	Offshore Wind Energy www.offshorewindenergy.org
15	Egmond aan Zee	10km offshore from Egmond aan Zee		36	NoordzeeWind (Shell/NUON)		Netherlands	2007	3MW	108MW	Offshore Wind Energy www.offshorewindenergy.org
16	Lely	750m offshore		4			Netherlands	1994	500 KW	2MW	Offshore Wind Energy www.offshorewindenergy.org
17	Irene Vorrink	20m offshore	Dronten - Ijsselmeer	28			Netherlands	1996	600 KW	16.8MW	Offshore Wind Energy www.offshorewindenergy.org
18	Ronland	Lim fjord	NW Jutland	8			Denmark	2003	2.3MW	17.2MW	Offshore Wind Energy www.offshorewindenergy.org
19	Tuno Knob	Inland Sea 6km from shore		10			Denmark	1995	500 KW	5MW	Offshore Wind Energy www.offshorewindenergy.org
20	Vindeby	1.5km from shore		11			Denmark	1991	450 KW	4.95MW	Offshore Wind Energy www.offshorewindenergy.org
21	Brietling	500m offshore	Nr Rostock	1	Wind-projekt GmbH		Germany	2006	2.5MW	2.3MW	Offshore Wind Energy www.offshorewindenergy.org
22	Lillgrund Bank	10km offshore, just south of Oresund Bridge	Oresund, near Malmo	48	Vattenfall		Sweden	2008	2.3MW	110MW	www.offshorewindenergy.org; www.vattenfall.com
23	Vestmanna			3	Rokt		Faroe Islands		1.98MW		www.thewindpower.net/
24	Thorntonbank	30 km from Zeebrugge		60	REpower		Belgium	2008	300MW	690 GW.h	http://www.repower5m.com/index_flash_uk.htm
26	Inner Dowsing	5.2km Ingoldmells	East Midlands/ Lincolnshire	27	Centrica Renewable Energy Ltd	53 11 00N 00 26 00E	England	2008	3.6MW	81MW	BWEA website www.bwea.com/ukwed/operational.asp
27	Lynn	5.2km Skegness	East Midlands/ Lincolnshire	30	Centrica Renewable Energy Ltd	53 07 39N 00 26 10E	England	2008	3MW	81MW	BWEA website www.bwea.com/ukwed/operational.asp
28	Spurness Wind Farm	Orkney		4	Your Energy	59 11 10N 02 41 22W	Scotland	2005	2.75MW	11MW	BWEA website www.bwea.com/ukwed/operational.asp
29	Blyth Harbour		Northumberland	9	AMEC Wind	55 07 20N 01 29 25W	England	1993	0.3MW	2.7MW	BWEA website www.bwea.com/ukwed/operational.asp
30	Frederikshavn			4	Elsam essential energy		Denmark	2008		10.6MW	Offshore Wind Energy www.offshorewindenergy.org

31	Alpha Ventus	45km north of Borkum		12	E.ON Energy, EWE, Vattenval		Germany	2009		60MW	http://www.alpha-ventus.de/index.php?id=80

Under Construction

Site No.	Name	Location	Region	Turbines	Developer	Lat Long	Country	Year	Proposed Energy Generated	Proposed Energy Capacity	Information Source
0	Rhyl Flats	8km Abergele	North Wales/ Conwy	25	npower renewables	53 22 00N 03 39 00W	Wales	2007	3.6MW	90MW	BWEA website www.bwea.com/ukwed/construction.asp
1	Solway Firth/ Robin Rigg B	9.5km Maryport/ 8.5km off Rock Cliffe	Scotland/ Dumfries and Galloway	30	E.ON UK Renewables	54 45 00N 03 41 00W	Scotland	2006	3MW	90MW	BWEA website www.bwea.com/ukwed/construction.asp
2	Solway Firth/ Robin Rigg A	9.5km Maryport/ 8.5km off Rock Cliffe	Scotland/ Dumfries and Galloway	30	E.ON UK Renewables	54 45 00N 03 41 00W	Scotland	2006	3MW	90MW	BWEA website www.bwea.com/ukwed/construction.asp
3	Breedt/Mardyck Bench			0	Nord-Pas-de-Calais/Shell/ TFE/ Jeumont		France	2003		8MW	Offshore Wind Energy www.offshorewindenergy.org
4	Gunfleet Sands I	7km Clacton-on-Sea	East of England/ Essex	30	DONG Energy	51 43 00N 01 12 50E	England	2008	3.6MW	108MW	BWEA website www.bwea.com/ukwed/construction.asp
5	Gunfleet Sands II		East of England/ Essex	18	DONG Energy	51 43 00N 01 12 50E	England	2008	3.6MW	64MW	BWEA website www.bwea.com/ukwed/construction.asp
6	Thanet	11-13km Foreness Point, Margate	Thames Estuary	0	Warwick Energy		England	2008		300MW	BWEA website www.bwea.com/ukwed/construction.asp
7	Swansea Docks	Swansea		1	EnergyTech	51 36 33N 03 55 20W	Wales	2005	0.25MW	0.25MW	BWEA website www.bwea.com/ukwed/construction.asp
8	Bard Offshore 1	100 km north of the isle Borkum		80	Bard Engineering GmbH		Germany	2009		400MW	http://www.bard-offshore.de/proj_bard_offshore_1-e

Approved

Site No.	Name	Location	Region	Turbines	Developer	Lat Long	Country	Year	Proposed Energy Generated	Proposed Energy Capacity	Information Source
0	Greater Gabbard	26km off Orford	Norfolk, Thames Estuary	0	Airtricity	51 56 00N 01 53 00E	England	2007		500MW	BWEA website www.bwea.com/ukwed/consented.asp

1	London Array	24km off Clacton-on-Sea	Thames Estuary	271	DONG Energy/ Shell Wind Energy/ E.On Renewables	51 38 00N 01 32 00E	England	2006		1000MW	BWEA website www.bwea.com/ukwed/consented.asp
2	Ormonde	off Walney Island	North West/ Cumbria	30	Eclipse Energy	54 06 00N 03 25 00W	England	2007	5MW	150MW	BWEA website www.bwea.com/ukwed/consented.asp
3	Scarweather Sands	5.5km Sker Point (nr Porthcawl)	South Wales/ Bridgend	30	DONG Energy/ E.ON UK	51 28 50N 03 50 50W	Wales	2004	3.6MW	108MW	BWEA website www.bwea.com/ukwed/consented.asp
4	Teeside/ Redcar	1.5km NE Teesmouth	Yorkshire & Humber/ North Yorkshire	30	EdF	54 38 00N 01 05 00W	England	2007	0MW	90MW	BWEA website www.bwea.com/ukwed/consented.asp
5	Walney Island	14km Walney Island	North West	0	DONG Energy	54 04 00N 03 32 00W	England	2007	3.6MW	450MW	BWEA website www.bwea.com/ukwed/conseted.asp
6	Wilhelmshaven	550m offshore Wilhelmshaven		1	Winkra-Energie GmbH		Germany	2003	4.5MW	4.5MW	http://www.offshore-wind.de/page/index.php?id=4761
7	Offshore Windpark Nordergrunde			25	Energie-kontor AG		Germany		25MW	125MW	http://www.offshore-wind.de/page/index.php?id=4761
8	Offshore-Burger-Windpark Butendiek			80	Gmbh & Co. KG Husum		Germany			240MW	http://www.offshore-wind.de/page/index.php?id=4761
9	Dan Tysk			80	Gesellschaft fur Energi und Okologie mbH		Germay			400MW	http://www.offshore-wind.de/page/index.php?id=4761
10	Nordlicher Grund			80	GEO mbH, renergys GmbH		Germany			400MW	http://www.offshore-wind.de/page/index.php?id=4761
12	Sheringham Shoal	Sheringham, Greater Wash	East of England/ Norfolk	0	Scira Offshore Energy Ltd	53 07 00N 01 08 00E	England	2008		315MW	BWEA website www.bwea.com/ukwed/consented.asp
13	West of Duddon Sands	N. Irish Sea	North West	0	DONG Energy/ E.ON UK/ Eurus	53 58 00N 03 26 00W	England	2008		500MW	BWEA website www.bwea.com/ukwed/consented.asp
16	Whiteside Hill		Dumfries & Galloway	11	Airtricity	55 19 25 N 04 01 22 W	England	2007	2.3MW	25.3MW	BWEA website www.bwea.com/ukwed/consented.asp
17	Gwynt y Mor	Liverpool Bay (13-15km offshore)	North West	200	npower renewables	53 26 00N 03 38 00W	England	2008		750MW	BWEA website www.bwea.com/ukwed/consented.asp

18	Eishgen Estate, Beinn Mhor - Secondary Application	Western Isles		3	Beinn Mhor Power	58 01 14N 03 32 25W	Scotland	2008	13MW	29MW	BWEA website www.bwea.com/ukwed/consented.asp
19	Lincs	8km off Skegness	Greater Wash	0	Centrica Renewable Energy Ltd	53 11 00N 00 29 00E	England	2008		250MW	BWEA website www.bwea.com/ukwed/consented.asp
20	Nordsee Ost	36km offshore		80	Amrumbank West GmbH		Germany			400MW	http://www.offshore-wind.de/page/index.php?id=4761

Submitted

Site No.	Name	Location	Region	Turbines	Developer	Lat Long	Country	Year	Proposed Energy Generated	Proposed Energy Capacity	Information Source
0	Cirrus Array (Shell Flats)	7km Cleveleys	North West/ Lancashire	90	Celt Power/ DONG Energy/ Shell Wind Energy	53 31 00N 03 15 00W	England	2003		270MW	BWEA website www.bwea.com/ukwed/planning.asp
1	Sky 2000			50	GEO		Germany	2004		175MW	Offshore Wind.de www.offshore-wind.de
2	Atlantic Array	12 miles offshore Ilfracombe, near Lundy Island	Devon	350	Farm Energy2		England	2007		1.5 GW	http://en.wikipedia.org/wiki/Atlantic_Array
3	Humber Gateway	Humberside		70	E.ON UK Renewables	53 37 00N 00 16 00E	England	2008	3MW	300MW	BWEA website www.bwea.com/ukwed/planning.asp
4	Shawbost & Dalmore		Western Isles	5	Tuscar Technology Ltd	58 19 58N 06 04 11W	Scotland	2004		5MW	BWEA website www.bwea.com/ukwed/planning.asp
5	Eishgen Estate, Beinn Mhor		Western Isles	53	Beinn Mhor Power	58 01 14N 03 32 25W	Scotland	2001	3MW	159MW	BWEA website www.bwea.com/ukwed/planning.asp
6	Fewcott		Oxfordshire	4	Bolsterstone PLC	53 04 49N 4 13 33W	England	2008	2MW	8MW	BWEA website www.bwea.com/ukwed/planning.asp
8	Race Bank	Greater Wash		88	Centrica Renewable Energy Ltd		England	2009		620MW	BWEA websitewww.bwea.com/ukwed/planning.asp
9	Docking Shoal	Greater Wash		0	Centrica Renewable Energy Ltd		England	2008		500MW	BWEA websitewww.bwea.com/ukwed/planning.asp

Data last updated 23/03/2009

Figure 2. Tidal Power developments in Europe

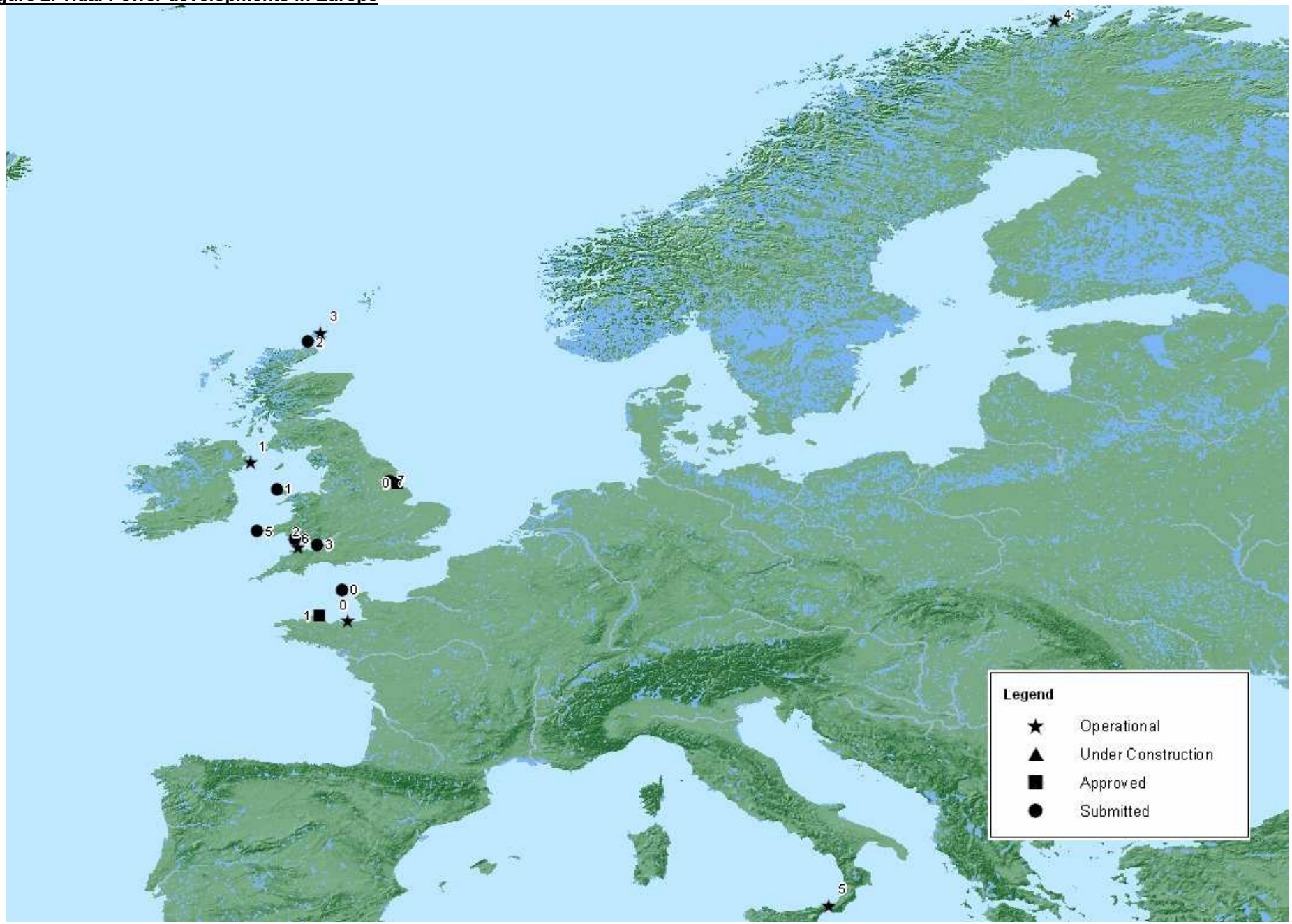


Table 2. Tidal power developments in Europe

Operational

Site No.	Name	Location	Region	Developer	Country	Year	Device	Energy Generated	Energy Capacity	Information Source
0	Rance Power Station	Rance River	Bretagne	EDF	France	1966	24 bulb type turbine generators	68MW	240MW	www.edfenergy.com
1	Sea Gen	Stangford Lough	Co Down	Marine Turbines Ltd	Northern Ireland	2008	tidal energy convertor	1.2MW		www.marineturbines.com/18/projects/19/seagen/
2	Sea Flow	2km offshore Foreland Point, Lynmouth	Devon	Marine Turbines Ltd	England	2003	1 tidal turbine	300kW		www.marineturbines.com/6/background/14/seaflow/
3	Fall of Warness Test Site	Eday	Orkney Islands	European Marine Energy Centre	Scotland					www.emec.org.uk/tidal_site.asp
4	Kvalsund Sound	Kvalsundet	Finnmark	Hammerfest Stroem	Norway	2003				http://www.hammerfeststrom.com/content/view/45/72/
5	Enermar	Straits of Messina	Sicily	Ponte di Archimede	Italy	2001				http://www.pontediarchimede.com

Approved

Site No.	Name	Location	Region	Developer	Country	Year	Device	Proposed Energy Generation	Proposed Energy Capacity	Information Source
0	Humber Estuary	Upper Burcom near Stallingborough	Lincolnshire	Pulse Tidal Ltd	England	2008	Pulse generator		0.15MW	www.pulsetidal.com
1	Paimpol-Brehat	Offshore from Paimpol	Brittany	EDF	France	2008	4-10 tidal turbines		4MW	http://press.edf.com/

Submitted

Site No	Name	Location	Region	Developer	Country	Year	Device	Proposed Energy Generation	Proposed Energy Capacity	Information Source
0	Alderney	Alderney Island	Channel Islands	Alderney Energy Renewable Ltd	England	2007	Tidal turbines			www.reuk.co.uk/Alderney-Tidal-and-Wave-Power.htm
1	Anglesey Skerries Tidal Stream Array	The Skerries	Angelsey Island	Marine Current Turbines and npower renewables	Wales	2008	Seven 1.5MW SeaGen turbines		10.5MW	www.marineturbines.com
2	Pentland Firth Tidal Energy Park	Caithness/ Orkney Islands	North Scotland	Tocardo	Scotland	2007	Turbines		10MW	http://www.tocardo.com/?Projects:Master_Plan_P.Fir

3	Severn Barrage	Bristol Channel	Somerset/ Glamorgan	Severn Tidal Power Group	England/ Wales	2005	214 40MW turbines		17 billion kWh	http://www.reuk.co.uk/Severn-Barrage-Tidal-Power.h
5	DeltaStream Demonstration	Ramsey Sound	Pembrokeshire	Tidal Energy Limited	Wales	2008	1 DeltaStream Unit			www.tidalenergyltd.com
6	Swansea Bay	I mile off coast from Swansea	Swansea	Tidal Electric	Wales	2007	hydro-electric turbines		60MW	http://www.cprw.org.uk/pdfs/spring05_tidalenergy.p
7	Humber St Andrews	North Ferriby	Yorkshire and the Humber	Neptune Renewable Energy	England	2009	Tidal turbines	1,000 MWhr/year		http://news.bbc.co.uk/1/hi/england/humber/7932388.

Data last updated 23/03/2009

Figure 3. Wave Power developments in Europe

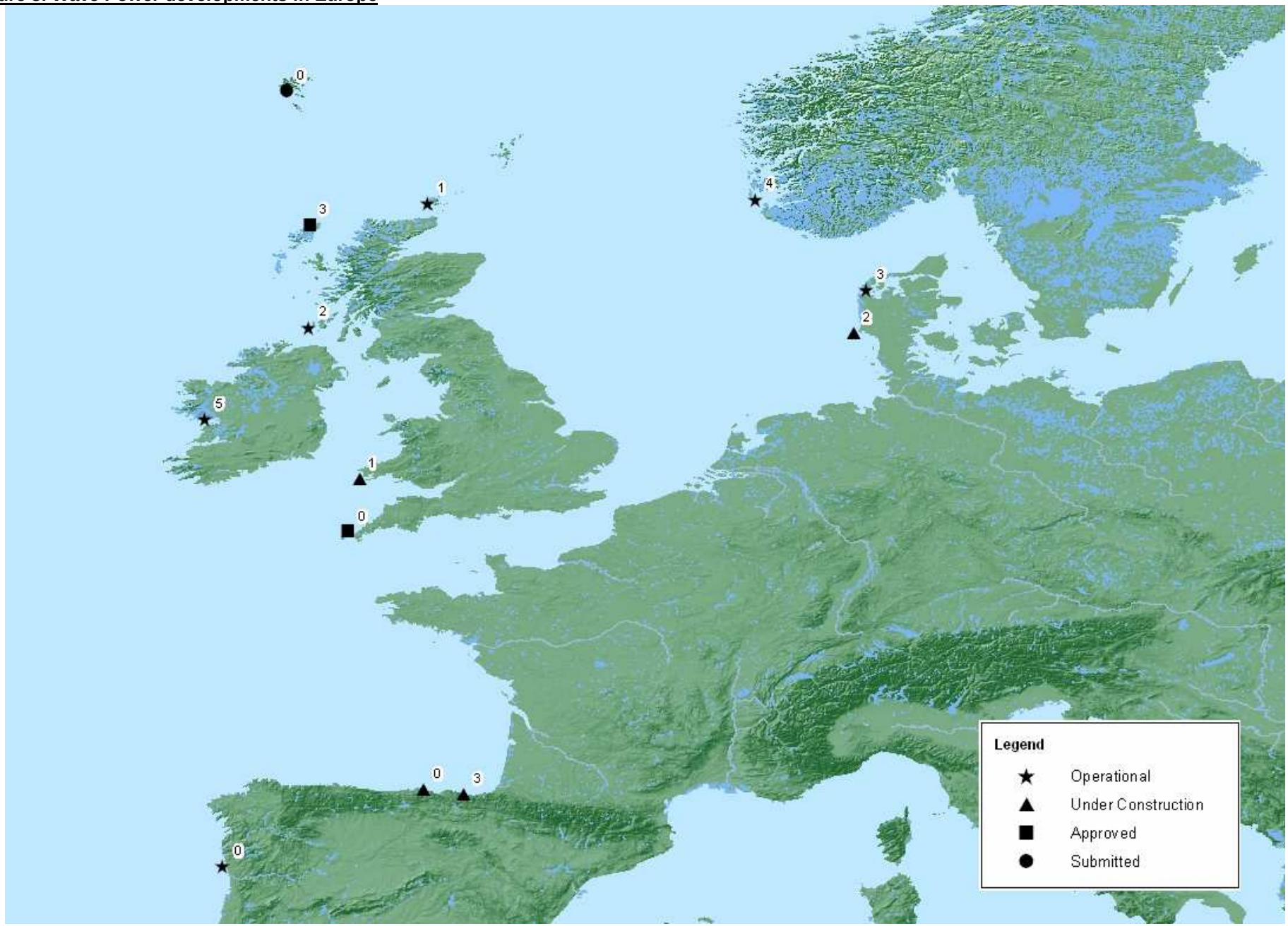


Table 3. Wave power developments in Europe

Operational

Site No.	Name	Location	Region	Developer	Country	Year	Device	Energy Generated	Energy Capacity	Information Source
0	Aguçadoura	5km offshore from Agucaduora		Energias de Portugal	Portugal	2006	3 Pelamis P-750 machines	2.25MW	22.5MW	www.power-technology.com/projects/pelamis/
1	Billia Croo Test Site	2km offshore from Billia Croo	Orkney Islands	European Marine Energy Centre (EMEC)	Scotland	2003				www.emec.org.uk/wave_site.asp
2	Limpet 500	Portnahaven	Isle of Islay	Wavegen	Scotland	2000	Inclined oscillating water column	500KW		www.wavegen.co.uk/what_we_offer_limpet_islay.htm
3	Nissum Bredning	Nissum Bredning Fijord		Wave Star Energy	Denmark	2006	20 floats	5.5KW		www.wavestarenergy.com/
4	Kvitsoy Pilot Project	Kvitsoy	Rogaland	Wave Energy	Norway	2007	SSG wave energy converter		200KW	www.wavessg.com/WAVESSGProject.htm
5	Galway Bay Wave Energy Test Site	N side Galway Bay, 1 mile East of An Spideal	Co. Galway	Marine Institute and Sustainable Energy Ireland	Ireland	2006				www.marine.ie/

Under Construction

Site No.	Name	Location	Region	Developer	Country	Year	Device	Proposed Energy Generation	Proposed Energy Capacity	Information Source
0	Santoña	4km offshore from Santona	Cantabria	IBERDROLA RENOVABLES	Spain	2008	10 PowerBuoy devices		1.39MW	www.iberdrolarenovables.es/
1	Wave Dragon Pembrokeshire	5km offshore from St. Anne's Head	Pembrokeshire	Wave Dragon	Wales	2008	Wave Energy Converter		70MW	www.wavedragon.net/
2	Horn's Rev	14km offshore		Wave Star Energy	Denmark	2007	20+ floats		500kW	www.investindk.com/visNyhed.asp?artikelID=18099
3	Mutriku	Mutriku Harbour	Pais Vasco	Wavegen	Spain	2008	Oscillating Water Column		300KW	www.wavegen.co.uk/news_mutriku.htm

Approved

Site No.	Name	Location	Region	Developer	Country	Year	Device	Proposed Energy Generation	Proposed Energy Capacity	Information Source
0	Wave Hub test site - Hayle	16km offshore from Hayle	Cornwall	South West Regional Development Agancy	England	2007				http://download.southwestrda.org.uk/

3	Siadar Wave Energy Project	350m offshore in Siadar Bay	Isle of Lewis	npower/ Wavegen	Scotland	2009	Oscillating Water Column	4MW	4MW	www.npower-renewables.com/siadar/index.asp

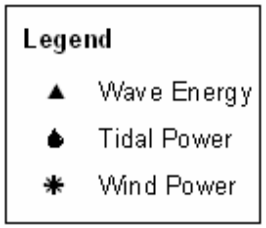
Submitted

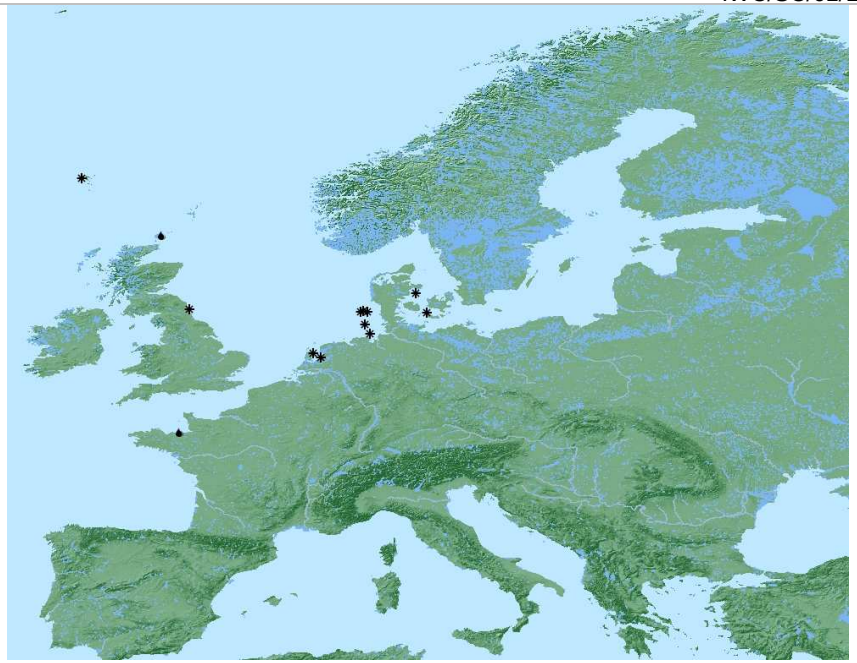
Site No.	Name	Location	Region	Developer	Country	Year	Device	Proposed Energy Generation	Proposed Energy Capacity	Information Source
0	Faroes		Faroe Islands	Wavegen	Scotland	2007	Oscillating water column			www.wavegen.co.uk/what_we_offer_limpet_faroes.htm

Data last updated 23/03/2009

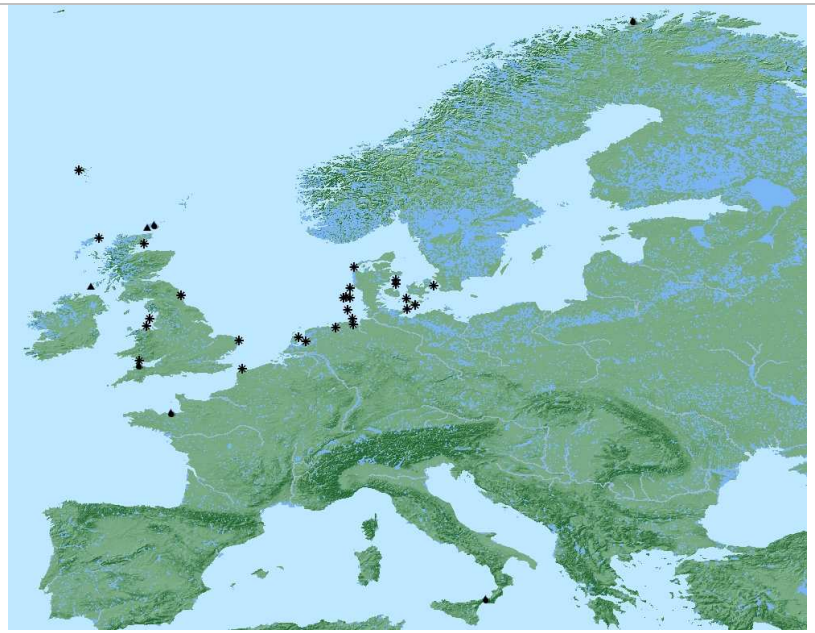
Figure 4. The growth of marine renewables in Europe

These maps include all operational, under construction, approved and submitted MREDs.

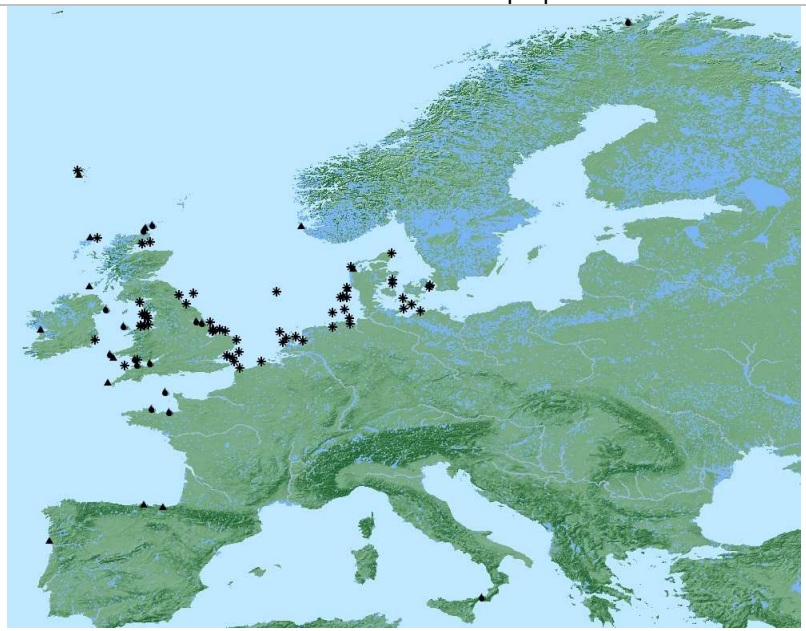




All marine renewables in Europe pre 2000

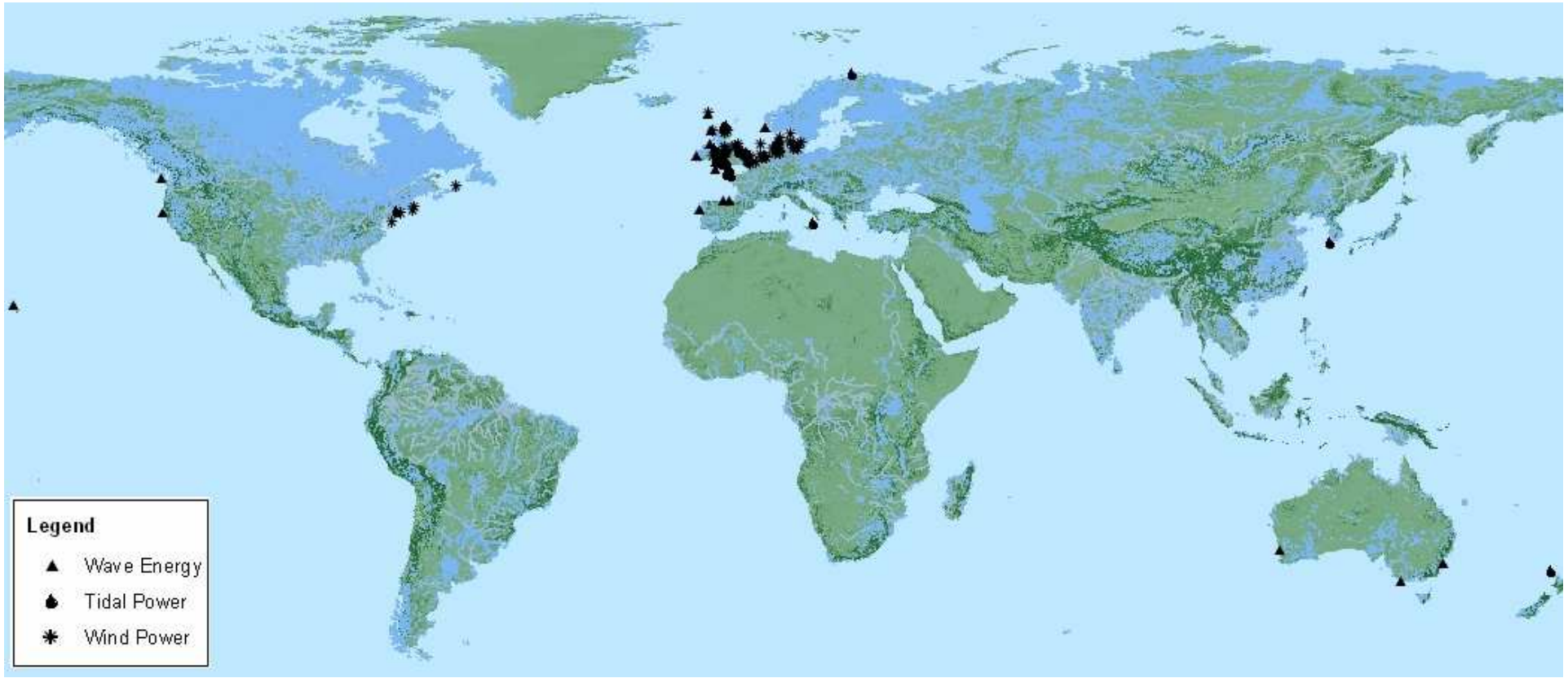


All renewables in Europe 2000-2004



All renewables in Europe 2005-2009

Figure 5. All marine renewables worldwide



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