UKERC

UKERC RESEARCH LANDSCAPE: MARINE ENERGY

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1. Overview

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Characterisation of the field

Energy can be extracted from the sea in different ways: wave, tidal currents, tidal barrages, tidal lagoons and ocean thermal currents. In the UK, technology deployment has focussed on wave and tidal currents. Therefore, this landscape document concentrates on these two methods of energy extraction from the sea.

The potential for offshore wave energy in the UK has been estimated to be 50 TWh/year with nearshore and shoreline wave adding another 8 TWh/year. The UK tidal stream potential is 17 TWh/year. Taken together, approximately 15-20% of UK electricity demand could in principle be met by wave and tidal stream. However, the marine industry in the UK is at an early stage, probably 20-30 years behind the current wind industry.

Wave energy research started in the UK in the 1970s but the Department of Energy abandoned the aim of full scale prototype trials and reduced the level of funding significantly following a 1982 review which concluded that the economics of wave power were poor. A further review of wave energy in 1999, plus recommendations from the Marine Foresight Panel has led to the reinstatement of government funding for marine energy research.

Up to the 1980s marine renewables research was University led, but since the 1990s commercial device developers have played a much larger role and recently utilities are becoming more involved. Large scale prototypes for both wave and tidal stream have been installed and tested in Europe. Many more devices are being developed at model and small scale.

Within universities, marine renewables research has traditionally sat within engineering departments. More recently, in order to take account of economic, social and environmental issues, some Universities have established research centres across a number of departments or research institutes in which academics from different disciplines are housed under one roof.

The traditional route for device development starts by testing a 1/100th scale model in a tank, developing hydrodynamic models to design the next scale model at say 1/20th or 1/10th scale, testing that in a larger tank or offshore and using results from these tests to validate the models before going to full scale.

Most marine energy technology developers are SMEs. The US Department of Energy's Marine and Hydrokinetic Technology Database list numerous devices in development around the world, with no clear winners at present. Some UK based SMEs have formed partnerships with large utilities, for example Marine Current Turbines and EDF, Pelamis Wave Power and E.ON and Scottish Power Renewables, Andritz Hydro Hammerfest and Scottish Power Renewables, and Aquamarine Power and SSE Renewables. As more prototypes are demonstrated, or current prototypes are proved further, bigger players are likely to become more active. Device developers and engineering departments tend to focus on the technology, while environmental issues and economics are dealt with by cross-disciplinary research institutions and NGOs.

Research Challenges

Device developers use off the shelf technology where possible, but it is accepted that underpinning research is required. Marine renewable energy research tends to be multi-disciplinary covering a range of topics which includes: resource modelling; fundamental hydrodynamic modelling; engineering design of devices; tank testing; electrical systems and grid connection;

environmental issues; economics; and impacts of climate change. Challenges include: predictability, manufacturability, installability, operability, survivability, reliability, and affordability.

Development of a prototype from conception to a large scale sea-going prototype is time consuming and very expensive, currently taking up to 10 years. An overarching challenge is to reduce this development time. This will require developers and academic research teams to work together to develop reliable design codes and reduce the reliance on tank testing at different scales. The form and availability of financial support for R&D has an impact on the development time. Knowledge transfer from other sectors, particularly offshore oil & gas (both academia and industry), and the supply chain will play a key role in overcoming the technical challenges and reducing development time. Access to physical data from prototype deployments would assist R&D programmes, in particular the verification of resource models and design codes.

As well as the technical challenges it is important to address the more socio-economic aspects. Engagement with important marine stakeholders, such as fishermen, leisure users, environmentalists and local communities should be initiated sooner rather than later.

2. Capabilities Assessment

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The UK has existing capacity to meet the marine energy challenges listed in the previous section, and these are outlined in Table 2.1. The UK has very high capabilities in a wide range of marine energy areas and is currently the world leader in marine energy. The list of UK capabilities covers all aspects of technology development from conception to large scale deployment. The capability has been established as a result of activity in another sector, such as Electrical System Design, Grid connection, device installation. Capability in other sectors is growing as a result of the increasing industrial activity in wave and tidal current energy in the UK, therefore providing the UK with a competitive edge.

Environmental monitoring of marine devices is very much an important growth area for the UK. Work undertaken as part of the Strategic Environmental Assessment and research taking place at the European Marine Energy Centre (EMEC), Sea Mammal Research Unit (SMRU), Scottish Association for Marine Science (SAMS), Peninsula Research Institute for Marine Renewable Energy (PRIMaRE) and Wave Hub, will be world leading and will provide the UK with a high capability to exploit a global market. The global marine renewable electricity market is estimated to be worth between £60b and £190b per annum (Carbon Trust, Future Marine Energy). There is the potential for major domestic and export markets for capital equipment, construction, installation and operation in this sector for UK manufacture.

The UK also has high capabilities with regards to testing and demonstrating facilities through University laboratories and testing tanks as well as the major marine testing facilities of EMEC, WaveHub and NaREC.

Table 2.1 UK Capabilities

UK Capability	Area	Market potential
High	• Wave device development	Global market
	• Tidal stream device development	Global market
	• Electrical system design	Global market
	• Tank & Offshore testing	Global market
	• Resource Assessment	Global market
	• Device Installation	Global market
	• Grid connection	Global market
	• System demonstration (EMEC and WaveHub)	Global market
	• Power Train Demonstration (NaREC)	Global market
	• R&D	Global market
	• Environmental monitoring	Global market
Medium	• Manufacturing	Global market

3. Basic and applied strategic research

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University based marine renewables research covers: resource modelling; fundamental hydrodynamic modelling; engineering design of devices; tank testing; electrical systems and grid connection; environmental issues; economics; and impacts of climate change. Marine renewable energy research is intrinsically multi-disciplinary.

The key marine research investment in the UK is the EPSRC funded SuperGen Marine consortium which is currently in its third funding phase with the establishment of the UK Centre for Marine Energy research (UKCMER) which includes the Universities of Edinburgh, Strathclyde, Exeter and Queen's University Belfast as its core partners.

In the 1970s and 80s many Universities developed their own devices. The Queen's University Belfast developed a prototype oscillating water column device on Islay which led to the LIMPET device. They also have close ties to Aquamarine on the Oyster device which grew out of research at Queen's University Belfast. The University of Lancaster developed the PS ("pitching and surging") Frog and was included in the Carbon Trust Marine Energy Challenge. At the University of Edinburgh, the Salter Duck was the main focus of research in the 70s and 80s. That work led to research on high power density hydraulic power take off, the development of tank test facilities purely for wave energy devices, control to optimise energy capture and interface with the grid. The University of Plymouth developed a floating oscillating water column device known as the Sperboy, which has different columns to match different incident wave frequencies and was spun out into a company called Orecon (which has recently closed its doors). Manchester University has been involved in developing a device, known as the Manchester Bobber.

In terms of tidal stream, University research has concentrated on underpinning issues. However, the University of Swansea is developing a tidal sea bed mounted tidal stream device and Edinburgh is developing a vertical axis tidal stream device in collaboration with Edinburgh Designs Ltd. The University of Strathclyde have developed the CoRMaT device, a contra-rotating turbine which is now administered by the spin out company, Nautricity.

Table 3.1: Research Funding

Programme	Funding Agency	Description	Committed Funds	Period	Representative Annual Spend
SuperGen Marine (Phase 1)	EPSRC	Generic research to reduce risk and uncertainty for marine energy development. A consortium of 5 core universities: Edinburgh, Heriot Watt, Robert Gordon, Lancaster and Strathclyde.	£2.6 million	2003 - 2007	
SuperGen Marine (Phase 2)	EPSRC	Generic research towards increasing understanding of the device-sea interactions of energy converters from model-scale in the laboratory to full size in the open sea. A consortium of 5 core universities: Edinburgh, Heriot Watt, Lancaster, Strathclyde and Queen's University Belfast.	£5.5 million	2007 - 2011	
SuperGen UK Centre for Marine Energy Research (UKCMER) (Phase 3)	EPSRC	A consortium with core universities: Edinburgh, Strathclyde, Exeter and Queen's University Belfast. Research towards array planning, turbulence, power take off development, reliability, mooring and foundations, and environmental impact.	2.75 million	2011 - 2016	
UK Energy Research Centre (UKERC)	NERC	The UK Energy Research Centre carries out world-class research into sustainable future energy systems. Coordinators of the National Research network and developers of roadmap documents for renewable energy. A roadmap for marine energy was produced in 2008 and is available on the UKERC website.	£170k for marine (phase 1) Approx £150k for phase 2	2004 - 2009 (phase 1) 2009 - 2014 (phase 2)	
EPSRC Responsive Mode	EPSRC	Research grants awarded to institutions for marine energy research.	--	1990 -	
Research Councils UK	EPSRC (lead)	The Research Councils UK Energy	Recently	--	

Energy Programme	BBSRC ESRC NERC STFC	Programme aims to position the UK to meet its energy and environmental targets, and policy goals through world-class research and training. The Energy Programme is a collaboration of research councils and is investing more than £530 million in research and skills to pioneer a low carbon future. This builds on an investment of £360 million over the past 5 years. The Energy Programme funds some marine research.	£7.7 million into marine (including SuperGen)		
European Union Framework Programmes	EU	The European Union's Framework Programmes has funded a variety of marine energy research projects and collaborative programmes which include UK partners.	--	--	
EPSRC Grand Challenge (SuperGen Marine Challenge 1)	EPSRC	Proposals were invited for collaborative research proposals for fundamental research that will overcome barriers to Marine energy deployment. The remit of this call is regarding those aspects of marine energy generation technologies, the environmental impacts of the technologies and the socioeconomic aspects of marine energy (including policy) that are holding back the deployment of marine energy.	£3 million	2011 - 2014	
EPSRC Grand Challenge (SuperGen Marine Challenge 2)	EPSRC	Proposals are invited for fundamental research that will investigate novel concepts for marine energy deployment on 2050 timescales. The remit of this call is all aspects of	£3 million	2012 -	

		marine energy generation technologies, the environmental impacts of the technologies and the socioeconomic aspects of marine energy (including policy).			
Marine Renewable Energy Research Programme	NERC	The overall aim of the research programme is to understand the environmental benefits and risks of up-scaling marine renewable energy schemes on the quality of marine bioresources (including biodiversity) and biophysical dynamics of open coasts. Funded by NERC and the Department for Environment, Food & Rural Affairs (Defra).	£2.4 million		

Table 3.2: Key Research Providers

Name	Description	Sub-topics covered	No of staff	Field
Heriot Watt University School of the Built Environment ICIT Orkney Campus	The interests of this group cover a wide range of disciplines relevant to marine renewable energy: ships, offshore and coastal structures, physical oceanography and the behaviour of the seabed. The group includes the International Centre for Island Technology (ICIT) on Orkney.	• Mooring systems • Resource modelling • Coastal Engineering • Instrumentation • Oceanography • Renewable energy research • Sustainable development • Coastal zone management • Environmental risk assessment • Environmental economics • Fisheries and marine bioresources • Biodiversity	--	• Electrical and electronic engineering • Mechanical engineering • Civil Engineering • Economics
Imperial College Control and Power Group Fluid Mechanics Applied Modelling and Computation Group	Control and Power Group: A new generation of control design and state estimation techniques is emerging to take account of non-linearities in mechanical systems, of which electrical machines are prime examples. Fluid Mechanics – the group have extensive tank testing facilities: wave basin, towing tank, open Channel flume, visual tank, wind wave current flume, sediment transport flumes, shallow water coastal wave flume The Applied Modelling Computational Group (AMCG) of the Department of Earth Science and Engineering: Parallelised adaptive mesh multiphase FEM-based with free surface and turbulence models provide a robust generic core CFD platform, from Ocean flows to wave breaking and flow through to packed sediment	• Power Electronics • Control systems • Electrical Drives • Power Systems • Electrical Test Facilities • Hydrodynamics • Fluid mechanics • Test tanks • Modelling survivability of devices in marine works • Modelling transient stresses in multibody dynamics under wave loading • Modelling impact of new arrays of sea-floor structures, scour of sediment • Modelling tidal inlets and barrage scenarios	--	• Electrical Engineering • Mechanical Engineering • Civil Engineering • Department of Earth Science and Engineering

Name	Description	Sub-topics covered	No of staff	Field
	beds.			
Lancaster University Lancaster University Renewable Energy Group - LUREG	Part of the Department of Engineering. Focused on development of devices: PS Frog, Frond and WRASPA. Tank test facilities available.	• Tank testing. • Hydrodynamic modelling. • Numerical modelling • Power Take Off design. • Control of wave devices • Device development and evaluation	--	• Electrical and electronic engineering • Civil Engineering • Mechanical engineering
Manchester Metropolitan University Centre For Mathematical Modelling And Flow Analysis	The Centre for Mathematical Modelling and Flow Analysis (CMMFA) was formed in 1993 and is based in the Department of Computing and Mathematics at Manchester Metropolitan University. The CMMFA undertakes research in the area of computational fluid dynamics (CFD) and specialises in the development and application of computational hydraulics. Substantial research funding has been obtained from many sources including the EPSRC, the Health and Safety Executive and the European Union.	• Hydroinformatics: Computational Hydrodynamic Modelling • Hydroinformatics: Volume of Fluid methods for free surface flows • Environmental Modelling: Air Quality Modelling • Related Areas: Shock Wave Modelling • Related Areas: Computational Aerodynamics	--	• Computing & Maths
PRIMaRE	The Peninsular Research Institute for Marine Renewable Energy (PRIMaRE) is a joint research institute of the Universities of Exeter and Plymouth. PRIMaRE researchers are working to understand, quantify and mitigate the environmental and biodiversity impacts of marine renewable energy extraction, which are key considerations in gaining consent for marine energy projects. For example, baseline studies at the Wave Hub site will provide detailed impact assessment data for developers.	• Environmental (physical) impact and biodiversity impacts of marine devices- particularly wave. • Work closely with WaveHub site	--	• Biology

Name	Description	Sub-topics covered	No of staff	Field
Queen's University Belfast Environmental Engineering Research Centre	Marine Renewables activity is based in the Environmental Engineering Research Centre. Tank test facilities available. Also work closely with the Power Group in Electrical Engineering	• Tank testing • Device development • Hydrodynamic modelling • Power take off design • Wells turbine design • Hydraulics • Structural engineering • Environmental • Coastal engineering	--	• Electrical and electronic engineering • Civil Engineering • Mechanical engineering • Environmental sciences
Robert Gordon University, Aberdeen	Marine Energy research is part of the Centre for Research in Energy & Environment, with a specialist focus on tidal current energy	• Resource Assessment • Hydrodynamic modelling • Performance optimisation • Design review • Environmental Impact	--	• Mechanical Engineering
The North Highland College (UHI) Environmental Research Institute	The Environmental Research Institute (ERI) is researching the inherent impact of sustainable energy on the environment and communities. They have survey capability with the research vessel ERI AURORA which enables access to the Pentland Firth. ERI aims to support industry and policy makers through the measurement of energy resources and monitoring of environmental impacts.	• Resource and Risk • Environmental Impacts • Sea bird and mammal interactions with devices • Ecological change	--	• Biology

Name	Description	Sub-topics covered	No of staff	Field
The Scottish Association for Marine Science (SAMS)	SAMS aims to increase knowledge and stewardship of the marine environment through research, education, maintenance of research infrastructure, and knowledge transfer. One of SAMS key research themes is marine renewable energy. Within this theme, they have expertise in understanding and mitigating the interactions between marine renewable energy devices and the environment- particularly the physical and acoustic interactions between marine vertebrates (fish, marine mammals and diving birds) and tidal-stream devices.	• Environmental Impacts • Interactions of marine renewable devices and the environment • Accoustic interactions between vertebrates and tidal stream devices.	--	• Biology
University College London Environmental Fluids and Coastal Engineering	The fluids group focuses on fundamental aspects of fluid flow behaviour relating to river, coastal, offshore and wind engineering.	• Frictional resistance in rivers, estuaries and tidal flows • Wave energy dissipation, height attenuation and interaction with currents in the coastal zone • The influence of waves on density-driven currents and particle driven plumes • Fluid forces exerted on buildings and offshore structures and pipelines • Modelling of coastal features • Renewable wave and tidal energy devices (the WAVEJET device) • Nonlinear diffraction of water waves and wave structure interaction	--	• Civil Engineering

Name	Description	Sub-topics covered	No of staff	Field
University of Aberdeen Institute for Biological and Environmental Sciences	Marine renewable research at Aberdeen can be found in the Ecology Group at the Institute for Biological and Environmental Sciences and the Zoology Department. Particular interest in the environmental impacts of small scale tidal devices.	• Environmental Impacts • Seabird behaviour and tidal energy	--	• Biology
University of Bath Electromagnetics, Machines & Drives (EMD) Centre for Sustainable Power Distribution	The EMD Group is involved in software development and also applying simulation techniques to the design of all kinds of electromagnetic apparatus and prototypes. They are the developer of the MEGA electromagnetic finite element software used in the design of electrical machines. The Centre for Sustainable Power Distribution researches all aspects of power generation, transmission and distribution.	EMD • Electromagnetics • Design and Build of Novel Electrical Machines Power Systems Group • Power System Control • Digital Protection Systems • Real-Time Simulation • Power System Design & Simulation • Advanced Energy System • Flexible Transmission Systems • Distribution System Engineering • Embedded Generation Systems	--	• Electrical Engineering
University of Bristol Electrical Energy Management Group	Main areas of research include power electronic converters and control of electrical machines. Work mainly in automotive and aerospace applications.	• Design, Build and Optimisation of Electrical Drives • Solid State Power Devices • Advanced Motor Control • Powertrain Components for Hybrid, Electric and Fuel Cell Vehicles • Technologies for the More Electric Aircraft • Power Economy in	--	• Electrical Engineering

Name	Description	Sub-topics covered	No of staff	Field
		Consumer Electronic Products • Renewable Energy Management		
University of Durham New and Renewable Energy Group, School of Engineering	Focus is on electrical power and control in renewable energy sector. Electrical machine test facilities.	• Design of novel machines	--	• Electrical and electronic engineering
University of Edinburgh Institute for Energy Systems	Multidisciplinary research institute formed from the Wave Energy Group and the Energy Systems Group. Focus is on marine renewables and networks. Involved in three SuperGen consortia: Marine, Networks and Infrastructure. Recently formed a Joint Research Institute with Heriot-Watt University. Involved in a number of EU Projects. The University of Edinburgh is the lead member of the UK Centre for Marine Energy Research (UKCMER).	• Wave energy • Tidal stream • Tank testing • Hydrodynamic modelling • Design of electrical power take off systems • Design of novel electrical machines • Renewable resource modelling • Impact of climate change on the resource • Chemical conversion using renewables • Marine energy roadmapping	--	• Electrical and electronic engineering • Chemical engineering • Civil Engineering • Mechanical engineering
University of Exeter Camborne School of Mines PRIMaRE	The Renewable Energy Group is based at the Camborne School of Mines Campus. The marine sub-group works closely with WaveHub. The University of Exeter in partnership with the University of Plymouth have formed the Peninsula Research Institute for Marine Energy (PRIMaRE), to carry out marine renewable energy research and development.	• Resource measurement • Resource assessment • Moorings testing facility • Reliability • Electrical Systems • Social policy • Wave prediction	--	• Electrical • Mechanical • Social Science

Name	Description	Sub-topics covered	No of staff	Field
University of Glasgow and University of Strathclyde Dept. of Naval Architecture and Marine Engineering	The Department of Naval Architecture and Marine Engineering (NA-ME) was formed in 2001 as a department of the Universities of Glasgow and Strathclyde.	• Ocean Engineering, • Materials testing • Wind tunnel • Software development • Emerging marine technologies: wave, tidal stream	--	• Mechanical engineering
University of Liverpool Marine, Environmental and Water Systems Group	This group is interested in: • Maritime and Coastal Engineering, • Environmental Hydraulics • Water Eng., Water Resources and Hydroinformatics, • Renewable Energy & Transport	• Coastal modelling • Coastal Zone Management • Sea Defences • Sediment Transport • 2-D and 3-D flow and sediment models • Computational Fluid Dynamics • Hydrological Assessment • Flow Controls & Hydrodynamics • GIS, HIS & Remote Sensing • Tidal Energy	--	• Civil Engineering
University of Manchester Power Conversion Group Electrical Energy and Power Systems Group Energy, Environment and Climate Change Group	Power conversion group focuses on machine design and modelling, principally induction machines. The Energy, Environment and Climate Change group has developed a device: The Manchester Bobber.	• Modelling of electrical machines, mainly induction machines. • Hydrodynamics • Coastal research • Wave energy • Computational Fluid Dynamics • GIS	--	• Electrical and electronic engineering & • Mechanical engineering
University of Newcastle	The Marine Dept focuses on marine technology and marine biology. Electrical department has	• Design of novel machines. • Offshore Engineering,	--	• Electrical and electronic

Name	Description	Sub-topics covered	No of staff	Field
School of Marine Science and Technology Power Electronics, Drives & Machines Group	some experience of renewables.	Structures and Materials • Marine Engineering, Robotics and Control • Computational Fluid Dynamics • High Performance Computing • Experimental Hydrodynamics • Design for Safety		engineering • Mechanical engineering • Biological sciences
University of Nottingham Power Electronics Group	Main area of research in power electronic converters and control of electric motors	• AC drive control, power electronic converter applications, • AC-AC power conversion • Motor drive efficiency and instrumentation methods. • Expertise also includes robust control, system control of wind and hybrid generation, system control of isolated power buses; • EMC in drives and power electronic systems, • Dynamic modelling techniques for electrical machines. • Experimental facilities ranging from 50kW to 750kW.	--	• Electrical Engineering

Name	Description	Sub-topics covered	No of staff	Field
University of Oxford Civil and Offshore Engineering Ocean, Coastal and Water Resources Engineering Department of Engineering Science	The emphasis is on the wave loading and response of offshore structures. Many of the projects in recent years have involved collaborations with other universities and companies, with funding from EPSRC, EU and the offshore industry. The work has in the past been predominantly directed towards design problems originating in the offshore oil and gas industry, but the groups are now moving into a more diverse range of applications (e.g. renewable energies and floating islands). The Tidal Energy Research group are active in the fields of turbine hydrodynamics and resource assessment, and takes part in the ETI commissioned PerAWaT project.	• Design of structures • Wave statistics • Marine hydrodynamics • Structural dynamics • random processes • Marine CFD Thematic Network • Scouring (piles for offshore wind) • Transverse Horizontal Axis Water Turbine (THAWT) • Turbine hydrodynamics • Tidal resource assessment	--	• Civil Engineering
University of Plymouth Coastal Engineering Research Group PRIMaRE	The Coastal Engineering Research Group (CERG) carries out both fundamental and applied research. The Group contains recognised specialists in field experimentation, instrument design and laboratory modelling, numerical modelling and theoretical analysis. Also involved in PRIMaRE with University of Exeter.	• Coastal & Estuarine processes • Flood risk • Sediment dynamics • Morphodynamics • Hydrodynamics • Overtopping and Wave impacts • Marine technology • Tank facilities	--	• Civil Engineering
University of Sheffield Electrical Machines and Drives	Electrical Drives for automotive and aerospace applications. In Marine, they work on Sensorless control of matrix converters for thrusters on deep-sea ROV's and a high speed permanent magnet generator.	• Magnetics • Electrical Machines • Power Electronics • Control Systems • Advanced Computing • Demonstrator Prototyping/Testing • Electrical Test Facilities	--	• Electrical Engineering
University of Southampton	Cross departmental grouping covering technical and social issues of all aspects of renewable	• Hydrodynamics of marine current turbines	--	• Electrical and electronic

Name	Description	Sub-topics covered	No of staff	Field
Sustainable Energy Research Group	energy. Involved in wave and tidal energy research.	• Tidal stream resource • Wave energy resource assessment • Numerical and physical modelling		engineering • Civil Engineering • Mechanical engineering • Economics and econometrics
University of St. Andrews Sea Mammal Research Unit (SMRU)	The Sea Mammal Research Unit (SMRU) carries out interdisciplinary research into the biology of sea mammals. SMRU Ltd., owned by the University, and provides advice to commercial and marine clients (such as Marine Current Turbines). SMRU is involved in research on understanding the movement of marine mammals around marine devices and the impact of underwater noise on marine mammals.	• Environmental Impacts • Marine Mammal Interactions with tidal stream devices	--	• Biology
University of Strathclyde Strathclyde Marine Institute	The Strathclyde Marine Institute, launched in 2010, is a collaborative venture that focuses on research alliances in engineering, science and humanities. The institute's key research objective is to investigate the sustainable development of the sea's resources with key themes of energy, environment and transport.	• Tidal stream energy • Wave energy	--	• Electrical and electronic engineering • Mechanical engineering

4. Applied Research and Development

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The Carbon Trust provides R&D funding for low carbon technologies, and marine renewables have been moved up the priority list for funding. The Carbon Trust launched the Marine Energy Challenge (MEC) in June 2004. The major objective was to investigate methods of reducing the cost of marine energy devices. The MEC focused on eight devices. In 2007, the Carbon Trust launched the Marine Accelerator Fund, the successor to the MEC. The project, divided into three strands: A, B & C, will help industry accelerate cost reduction by supporting:

1. Development of new marine energy device concepts with potential for significantly lower costs than front-runner technologies;
2. Research and development into specific component technologies of marine energy devices that are common causes of high costs; and
3. Development of low cost installation, operation and maintenance strategies for marine energy devices.

The project involves device developers, component technology manufacturers, engineering consultants/contractors and academic research groups and closed in 2010.

The Technology Strategy Board (TSB) and Energy Technologies Institute (ETI) are also investing in applied marine research such as with ETI's PerAWaT project and several TSB marine funding competitions (see Table 4.1).

Regional Development Agencies were also active in the funding of marine renewable energy. One North East funded the New and Renewable Energy Centre (NaREC); The Joule Centre in the North West funded marine energy projects in local universities; and South West RDA was one of the funders of Wave Hub and has also funded local SMEs. However, it is not clear how much was invested by One North East and Joule.

The UK Government (through the former BERR), The Scottish Government, Carbon Trust and The Highlands & Islands Enterprise are some of the main funders of EMEC which supports applied research and development. Exact details of funding are not available.

There has been a lot of industrial activity in the UK since 2000, resulting in the demonstration of part and full scale prototypes at EMEC, NaREC and in University tanks. A complete list of technology developers is provided in Table 4.2 and the major demonstration projects are listed in Table 5.2.

As noted earlier, there are close links between individual Universities and device developers. For example, Queen's University Belfast has a very close relationship with Wavegen in Inverness, and more recently is working with Aquamarine to develop the Oyster device invented at Queen's; the University of Plymouth spun out a company to develop the Sperboy; Edinburgh has spun out three companies: Artemis Intelligent Power, Edinburgh Designs Ltd; and Pelamis Wave Power; Lancaster has worked closely with IHC Engineering Business (EB) on the development of the Frond device; Manchester has spun out a company to develop the Manchester Bobber; Swansea has formed a consortium for their tidal current device - Swanturbines; Southampton, Newcastle and RGU have all worked with tidal stream developers.

Table 4.1: Research Funding

Programme	Funding Agency	Description	Committed Funds	Period	Representative Annual Spend
Marine Energy Accelerator	Carbon Trust	This aims to accelerate progress in cost reduction of marine energy (wave and tidal stream energy) technologies, to bring forward the time when marine energy becomes cost-competitive so that significant carbon emissions reductions are achieved. It is the successor to the Marine Energy Challenge.	£3.5m	2007 - 2010	
Renewable Energy Programme	DTI	The Technology Programme was one of the DTI's business support solutions designed to stimulate innovation in the UK economy through higher levels of research and development and knowledge transfer. From 2005 to 2008 the total budget for the Technology Programme was £320m, which covers all technologies.	£12.5m	2004-2006	
Marine Energy Challenge	Carbon Trust	The MEC was an 18 month programme of directed engineering support for developers of marine renewable energy technologies. It sought to study the effects of costs and performance and to determine the cost of electricity from wave and tidal stream. A total of eight devices were analysed in detail.	£3m	2004-2006	
R&D Programme	Carbon Trust	The Carbon Trust supports the development of low carbon technologies through R&D grants, incubator units for start-ups, technology acceleration and venture capital investment. Since 2001, the Carbon Trust has committed over £13m to supporting applied research in business and academia, leveraging over £21m of other investment into these projects. The Marine Energy Challenge (MEC) technology acceleration project has been an important part of the	£2.7m		

		Carbon Trust's activities in marine energy.			
Wave and tidal stream energy technologies: reducing costs and improving performance	Technology Strategy Board (TSB)	This collaborative research, development and demonstration funding competition for wave and tidal energy technologies aims to address the challenges of driving down the cost of energy and improving the reliability and performance of devices. The programme supports applied research and experimental development. Up to £9 million was made available. In July 2010, the competition results were announced with £7 million going to 9 projects. Additional funding partners involved in this competition were the EPSRC and SouthWest RDA. In 2012 a collaborative R&D funding initiative was launched to support array technologies. TSB will invest up to £6.5m in the research with input from Scottish Enterprise and NERC.	£7 million £6.5 million	2010-	
ETI Marine Programme	Energy Technologies Institute (ETI)	The ETI Marine Programme funds projects such as the PerAWaT Project (Performance Assessment of Wave and Tidal Array Systems) which is aimed at developing and validating a series of models to predict the performance of wave and tidal stream generator arrays. (ETI also funds demonstration projects which are not included in the committed total here- see section 5). A project partnering with Atlantis Resources Corp intends to assess ways of cutting costs of generating electricity from tidal arrays off the UK and to identify ways of providing a cost effective deployment of tidal stream technologies at commercial scale in UK waters. A further project intends to assess ways of cutting costs of generating electricity from wave arrays off the UK and to identify ways of providing a cost effective deployment of wave energy technologies at commercial scale in UK waters. Other ETI commissioned	£8 million Estimated £10 million	2007 – 2012 -	

		research projects include: ReDAPT, the Offshore Renewable Industrial Doctoral Centre and Tidal Modelling.			
Offshore Renewable Energy Catapult	Technology Strategy Board (TSB)	Catapults are centres of excellence that bridge the gap between business, academia, research and government by promoting collaboration and knowledge exchange. The Catapult in offshore renewable energy will focus on technologies applicable to offshore wind, tidal and wave power and is anticipated to go live for business during Summer 2012.		2012 -	

Table 4.2: Key Research Providers (Technology Developers and Utilities)

Technology Developers

Name	Description	Sub-topics covered	No of staff	Sector
Andritz Hydro Hammerfest (formerly Hammerfest Strom UK)	Andritz Hydro Hammerfest is a tidal current energy technology company. The company's objective is to be the leading technology provider of turn-key tidal power devices for the commercial market, through a non-exclusive right of use of the parent company's present and future technology. The HS3000 prototype device was developed and tested in Norway. A 1MW, full scale, pre-commercial device (the HS1000) was installed at EMEC in 2011. Scottish Power Renewables is a major shareholder, and funding has been received from the Carbon Trust's Marine Renewables Proving Fund, Scottish Enterprise and Innovation Norway. Andritz Hydro has a share-holding of 55.4%.	• Tidal Current Device Developer • Prototype Development	--	Tidal Current Energy
Aquamarine	Developer of the Oyster Wave Energy Device. A sea-bed mounted device, which pumps sea-water to a hydro power take off onshore. The first full-scale Oyster 1 wave power device was installed at the European Marine Energy Centre (EMEC) in the summer of 2009 and was connected to the National Grid in November 2009. The next generation device, Oyster 800, was installed at EMEC in 2011, with the intention of installing two further devices at the same location. The company has received funding from SSE Venture Capital, ABB Technology Venture and Scottish Enterprise and have received grants from WATERS and the Carbon Trust's Marine Renewables Proving Fund and a loan from Barclays Corporation.	• Engineering Design • Device Modelling • Wave Energy Developer	--	Wave Energy

Name	Description	Sub-topics covered	No of staff	Sector
Atlantis Resources Corp.	Atlantis is a vertically integrated marine renewable power company providing marine turbines, project origination, resource assessment, project, installation & completion management as well as operations & maintenance services to utilities and power companies worldwide. Atlantis is harnessing the power of tidal currents and is pioneering the development of large-scale tidal current generation arrays. The company has developed three families of sub-sea turbines, with testing over a decade of field trials. Atlantis has developed the AR1000 horizontal axis turbine which carried out testing at EMEC when installed there in 2011. Have received funding from the Carbon Trust's Marine Renewable Proving Fund.	• Tidal Current Device Developer	--	Tidal Current Energy
AWS Ocean Energy	Wave energy technology developer, currently based in Scotland. Developed the Archimedes WaveSwing (AWS) – a 2MW prototype was installed and commissioned off the coast of Portugal in 2004. It has received funding from the Scottish Government for its AWS-III device and intends to deploy a full scale 2.5MW prototype at EMEC in 2014. AWS have received support from the Scottish Government's WATERS fund and has a 40% share owned by Alstom.	• Engineering Design • Hydrodynamic analysis • Control systems • Design of Electrical and Mechanical plant	--	Wave Energy
Checkmate Seaenergy	Checkmate Seaenergy are developing the Anaconda Wave Energy Converter. The device has carried out exhaustive proof of concept testing at the Marine Technology Park at Gosport, Hampshire and at the testing tank in the University of Strathclyde.	• Wave Energy Device Developer	--	Wave Energy
E.ON	E.ON is a utility with interests in conventional and renewable generation. With respect to marine energy, they are involved with the 750kW Pelamis P2 machine which is currently being tested at the European Marine Energy Centre (EMEC) in Orkney, making them the first utility company to test a marine energy device at EMEC. E.On was also awarded sites in the Pentland Firth Leasing Round.	• Utility • Project developer	--	Electrical Utility

Name	Description	Sub-topics covered	No of staff	Sector
Electricite de France (EDF)	French utility, but with power stations in the UK. Principally nuclear in France. Operate La Rance, world's longest operating tidal barrage scheme. Partner in the MCT Seaflow project, and interested in marine renewables as a whole. EDF Group is also collaborating to install Open Hydro Turbines for a site in Brittany, France.	• Power generation • Power Quality	--	Electrical Utility
IT Power Ltd	Renewable Energy Consultancy. Projects include desk-based studies, resource assessments to technical design and implementation, policy and strategy development, field surveys, market research, training and financing of sustainable energy. The consultancy is involved in the development of devices such as Pulse Stream 100 Tidal Energy Converter and OWEL Grampus Wave Energy converter (WEC).	• Wave • Tidal stream • Developing country work • Device Development	--	Energy Consultancy (involved in device development)
Lunar Energy	Lunar Energy are tidal current energy device developers, with the technology being developed by Lunar's technical collaborator Rotech Engineering Ltd. Lunar Energy intend to create a 300 turbine/300MW array off the South Korean coast by 2015, and there is potential that a small scale array will be developed off the south Wales coast with E.On.	• Engineering Design • Design of Electrical & Mechanical Plant • Tidal stream systems	--	Tidal Current Energy
Manchester Bobber	A spin out company from Manchester University. It consists of an array of buoy type devices on a fixed structure. Testing at 1/10th scale of a single device has taken place at NaREC.	• Prototype design, build and testing • Device development • Electrical engineering	--	Wave energy

Name	Description	Sub-topics covered	No of staff	Sector
Marine Current Turbines	Marine Current Turbines Ltd (MCT) is developing technology for exploiting tidal currents for large-scale power generation. Installed a 300kW turbine in 2003 and then in 2008 installed the 1.2 MW SeaGen device. SeaGen is currently operational in Strangford Lough, Northern Ireland. The turbine regularly delivers its full rated power into the NI grid; as such it is accredited with OFGEM as a UK generating station. MCT is currently developing other projects in Canada and the UK. Siemens currently have a 90% share in MCT, with funding and support from DTI, DECC's Marine Renewables Deployment Fund and the Carbon Trust's Marine Renewables Proving Fund	• Engineering Design • Design of Electrical & Mechanical Plant • Tidal stream systems • Installation in the marine environment	--	Tidal Current Energy
Minesto	Developed a new tidal energy device, Deep Green, which converts energy from tidal stream flows into electricity with a device similar to a wind kite. This kite consists of a wing and a turbine which are tethered to the ocean floor.	• Tidal current device developer	--	Tidal Current Energy
Neptune Renewable Energy	Neptune Renewable Energy Ltd (NREL) is currently developing second generation, commercially focussed technology to exploit the tidal resource. The NeptuneProteus tidal stream power device is located at the mouth of the River Hull.	• Tidal Current Device Developer	--	Tidal Current Energy
Ocean Navitas Ltd.	Ocean Navitas' device, the Aegir Dynamo functions in a unique fashion by generating electrical current from the motion of the prime mover in one phase via a direct mechanical conversion and the use of a bespoke buoyancy vessel. The Aegir Dynamo is designed to be installed into a 'point attenuating buoy'.	• Wave Energy Device Developer	--	Wave Energy
Ocean Power Technology	Wave energy technology developer based in the US, but with an office in the UK. They have developed the PowerBuoy System. In December 2009, Ocean Power Technologies, Inc. deployed one of its PowerBuoys® at the US Marine Corps Base Hawaii (MCBH) at Kaneohe Bay and is demonstrating at other sites in the US and Europe. The company successfully deployed the PB150 PowerBuoy off Invergordon in 2011.	• Wave device design	52	Wave Energy

Name	Description	Sub-topics covered	No of staff	Sector
Open Hydro	Open Hydro's core business is the manufacture and installation of tidal energy systems. The company formed in 2005 after negotiating the rights to Open Centre Technology developed in the US in the previous 9 years. The company is based in Dublin, Ireland. During 2006, Open Hydro became the first company to install a tidal turbine at the EMEC facility. Open Hydro intend to install four 16m diameter turbines in 2012 at an array site at Brittany, France for EDF, they also have a license in the Pentland Firth for a 200MW joint venture with SSE Renewables. Funding has been received from the Scottish Enterprise WATERS budget and with shares acquired from DCNS and Bord Gais Energy.	• Tidal current Device Developer • Engineering Design • Prototype Development • Electrical & Mechanical systems	--	Tidal Current Energy
OceanFlow Energy	OceanFlow has developed the Evopod device which is a semi-submerged, floating tidal energy device. It uses a simple mooring system that allows the free floating device to maintain optimum heading into the tidal stream.	• Tidal current device developer	--	Tidal Current Energy
OWEL	The OWEL device comprises a floating horizontal duct supported by buoyancy tanks. It is intended that a 2MW multiduct platform, the OWM 200, will be available from 2016 onwards.	• Wave Energy Device Developer		Wave Energy

Name	Description	Sub-topics covered	No of staff	Sector
Pelamis Wave Power	Formerly called Ocean Power Delivery, Pelamis Wave Power is a wave energy technology developer established in Edinburgh in 1998. Developed the Pelamis device – a full scale prototype which has been tested at EMEC. Multiple Pelamis units were installed and decommissioned at the Aguçadoura wave farm, Portugal: this constitutes both the world's first, multi-unit, wave farm and also the first commercial order for wave energy converters. The P2 device is berthed at EMEC on a 3 year programme with E.ON, a similar demonstration project will take place also at EMEC with Scottish Power Renewables. Pelamis and Vattenfall have launched a joint venture to develop a wave power project off the Shetland Islands and are currently developing a 10MW wave farm project off the west coast of the Isle of Lewis. The company have secured seabed leasing from the Crown Estate off the Sutherland Coast.	• Engineering Design • Hydrodynamic analysis • Control systems • Design of Electrical and Mechanical plant	40-50	Wave Energy
Pulse Tidal	Pulse Tidal have developed a 0.1MW oscillating hydrofoil tidal stream device called the Pulse Stream 100. A scale prototype device was installed at the mouth of the River Humber in 2009. The company has secured EU FP7 grant funding for a future shallow water project at Kyle Rhea, Scotland and receives support from a number of small funds and investors.	• Tidal current Device Developer • Engineering Design • Prototype Development • Electrical & Mechanical systems		Tidal Current Energy

Name	Description	Sub-topics covered	No of staff	Sector
RWE npower renewables	npower renewables is dedicated to generating electricity using sustainable, environmentally-friendly resources. It has a wide ranging portfolio that includes both onshore and offshore wind farms, hydro plant and co-firing biomass operated through their parent company RWE npower. Collaborating with Voith Hydro Wavegen to develop the Siadar Wave Energy Project on the Isle of Lewis. Update – July 2011 : RWE npower renwables announced that it was withdrawing from the Siadar project	• Utility • Project developer	--	Electrical Utility
Scottish & Southern Energy (SSE)	SSE is the UK's second largest generation business. It owns and operates almost half of the UK's total renewable generation capacity, including the UK's largest wind farm. Scottish and Southern Renewables UK has been awarded sites in the first Pentland Firth Leasing Round. They are involved in Aquamarine's Oyster device development.	• Utility	--	Electrical Utility
Scottish Power Renewables	The company focuses on energy wholesale, retail, networks and is active in renewables. Scottish Power is working with Pelamis Wave Power. They have purchased a second generation 750kW Pelamis P2 machine that will be installed at EMEC in 2012. The Crown Estate recently awarded Scottish Power Renewables two major marine power development areas in the Pentland Firth Leasing Round. The company will develop	• Utility	--	Electrical Utility
Scotrenewables	Scotrenewables is a renewable energy R&D business based in the Orkney islands in Scotland since the company was formed in 2002. Developer of a novel floating 0.25MW tidal current turbine, SR250 The device was installed at EMEC in 2011 and will be followed in 2013 at 2MW device. The company has received investment from Fred Olsen Renewables and TOTAL, with financial backing from the Carbon Trust and the Scottish Government's WATERS scheme.	• Tidal Current Device Developer • Engineering Design • Prototype Development • Electrical & Mechanical systems	--	Tidal Current Energy

Name	Description	Sub-topics covered	No of staff	Sector
Swan Turbines	Tidal stream technology developer spun out of Swansea University. Device is a 3-bladed axial flow turbine, with no pitch control and uses a direct drive generator. The device sits on the sea-bed and is below the sea surface. A 300kW demonstration device is being assembled to be installed at the European Marine Energy Centre in Orkney in 2012. The 'Cygnet' device is currently being assembled in South Wales and at NaREC in Blyth. Partners include, CB&I John Brown, EM Renewables Ltd, NaREC and Ledwood.	• Engineering Design • Tidal stream energy systems • Modelling axial flow turbines.	--	Tidal Stream Energy
Tidal Energy Ltd.	Tidal Energy Limited was set up by a team of marine engineering and renewable energy experts to develop DeltaStream, an innovative technology designed to generate electrical power from tidal stream resources which minimises impact on the environment. Located in Cardiff, Wales, the company is funded by Eco2, Carbon Connections, Cranfield University and the Welsh European Funding Office, with the Carbon Trust providing funds towards environmental monitoring. Have received funding for a feasibility study to develop the 1.2MW 'DeltaStream' technology and assess the suitability of a site in West Wales for tidal stream testing.	• Tidal Current Device Developer • Prototype Development	--	Tidal Current Energy
Tidal Generation Ltd	Tidal Generation Ltd (TGL) has developed the 500kW three bladed, yawing tidal current turbine, the Deep Gen III, which can extract energy on the flood and ebb tide. The device has been installed at EMEC since 2010 and will be replaced in 2012 by a 1MW device. The company is a wholly owned subsidiary of Rolls Royce and has received funding from the ETI as part of the ReDAPT project.	• Tidal Current Device Developer • Prototype Development	--	Tidal Current Energy

Name	Description	Sub-topics covered	No of staff	Sector
Trident Energy	Trident Energy is a marine renewable energy company that has developed a Direct Energy Conversion Method (DECM) of generating electricity directly from ocean waves. The DECM uses floats placed in the sea to capture wave energy. The floats drive linear generators, resulting in the immediate generation of electricity. Have received a grant from Scottish Enterprise to fund sea trials of its linear generator technology.	• Electrical machine design • Mechanical design	--	Wave Energy
Voith Hydro Ocean Current Technologies	Voith Hydro Ocean Current Technologies is also developing a tidal energy device (separate from wave developments with Wavegen). The company have developed the HyTide tidal stream, horizontal axis turbine. Scale trials have been completed in South Korea and preparations are taking place in 2012 to install the 1MW device at EMEC. Investment has been provided through the Marine Renewables Proving Fund and from other small investors and the main shareholder of Voith Hydro.	• Tidal device developer	--	Tidal Current Energy
Voith Hydro Wavegen	Wave energy device developer. Installed as the first grid connected wave energy device called LIMPET in 2000, a shoreline Oscillating Water Column device on Islay. The company has experience of tank testing facilities for nearshore devices and has exported the technology to other countries, most notably the Mutriku project in northern Spain. The LIMPET was developed with investment and funding by the EU and the Scottish Government's WATERS scheme.	• Engineering Design • Hydrodynamic analysis • Control systems • Design of Electrical and Mechanical plant • Tank testing facilities	10-20	Wave Energy
Wavedragon	Danish wave energy technology developer, with an office in Wales. Built a 20kW prototype device in Denmark, and are planning to build a full scale device for installation off the coast of Wales.	• Engineering Design • Hydrodynamic analysis • Control systems • Design of Electrical and Mechanical plant	--	Wave Energy

Name	Description	Sub-topics covered	No of staff	Sector
Wello	Wello have developed a novel wave energy device, the Penguin, which is a floating assymetric vessel with an internal rotating mass. Several scale model tests have taken place in Finland, and a full scale device will be installed at EMEC in 2012.	• Wave Energy Device Developer • Engineering Design	--	Wave Energy

5. Demonstration Funding

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One of the major demonstration funding programmes in the UK is the DECC Marine Renewables Deployment Fund (MRDF) for next stage full scale prototypes. The MRDF provides a total of £42m for device developers and £8m for infrastructure building to support the marine industry. The MRDF is part of the UK Government's Environmental Transformation Fund. Given difficulties in marine renewable energy technologies accessing the MRDF, in 2009, the Carbon Trust announced its Marine Renewables Proving Fund (MRPF) which is aimed at helping technologies reach the point that they qualify for the MRDF.

In February 2007 the Scottish Executive pledged £13m of funding for a total of 9 projects under the WATES Scheme, to assist in the development or demonstration of new wave and tidal current devices at EMEC (more details provided in Table 5.2.). As of 2010, the WATES scheme was replaced by the new WATERS Scheme with £12 million funding. This funding was augmented by an additional £3 million funding from the EU Regional Development Fund for projects in the Highlands and Islands. Five projects were funded by WATERS in 2010 (see table 5.2).

Regional Development Agencies have been active in funding infrastructure to assist in the demonstration of new technology. One North East fund NaREC. Scottish Enterprise and Highlands & Islands Enterprise part fund EMEC. In April 2007 the South West Regional Development Agency approved £21.5m for the development of Wave Hub in SW England.

The Crown Estate has also been involved in the world's first commercial wave and tidal leasing round, for ten sites in Scotland's Pentland Firth and Orkney waters. The successful bidders (developers) have signed agreements for lease with The Crown Estate to take forward the development of their wave and tidal energy installations. This will allow developers to enter the statutory consenting process for their sites with security of access to the seabed.

Table 5.1 lists the major demonstration funding programmes, and the main demonstration projects arising from those funding programmes are listed in Table 5.2.

Major EU projects with UK involvement are listed in Table 8.

Table 5.1 Demonstration Funding Programmes

Programme	Funding Agency	Description	Committed Funds	Period	Representative Annual Spend
Marine energy: Supporting array technologies	Technology Strategy Board Scottish Enterprise Natural Environment Research Council	This competition call is an investment in collaborative research and development to support the successful deployment and operation of the first series of wave and tidal energy arrays. This competition opened in March 2012.	Total= £10.5 million Technology Strategy Board will invest up to £6.5m, Scottish Enterprise up to £3m and NERC up to £1m.	2012 -	
Marine Renewables Deployment Fund (MRDF)	DECC	The MRDF was set out in 2004 with an aim to support and stimulate the development and deployment of wave and tidal-stream energy. It has four components: the Wave and Tidal-stream Energy Demonstration Scheme, environmental research, related research and infrastructure support. The largest part of this programme is the Wave and Tidal-stream Energy Demonstration Scheme with a budget of £42 million and aimed at supporting visionary businesses in bringing their research and development on wave and tidal stream energy devices to market.	£50 million	2004 -	
Marine Renewables Proving Fund (MRPF)	Carbon Trust	Carbon Trust's Marine Renewables Proving Fund was set up in 2009 to accelerate the development of promising marine energy devices in order to help move those devices towards the point at which they qualify for support from DECC's Marine Renewables Deployment Fund (MRDF) and eventually be deployed at commercial scale.	£22.5 million	2009 -	

Wave and Tidal Support Scheme (WATES)	Scottish Government	This programme awarded funds to companies to assist in the deployment and development of wave and tidal current devices in Scotland (mostly sited at EMEC). Includes £2.5M to upgrade EMEC infrastructure.	£13 million	2006 - 2010	
Wave and Tidal Energy, Research, Development and Demonstration Support fund (WATERS)	Scottish Government	The WATERS Programme follows on from the previous WATES Scheme. The WATERS Scheme will be managed by Scottish Enterprise, Scottish Government and Highlands and Islands Enterprise with an aim to support the deployment of wave and tidal stream energy. The fund will support development and testing of new prototype devices and related infrastructure in Scottish waters. The additional £3 million EU funding is to support projects in the Highlands and Islands.	Total= £15 million £12 million from Scottish Government £3 million from EU Regional Development Fund	2010 -	
Wave and tidal stream energy technologies: underpinning deployment	Technology Strategy Board	This competition is targeting pre-commercial full-scale devices installed and operating in the sea, including those supported by Carbon Trust's Marine Renewables Proving Fund (MRPF). The scope includes verifying performance; improving reliability in a real environment; and developing installation, operation and maintenance methodologies. The competition was open to wave and tidal stream device manufacturers, and also to collaborations that will develop the UK supply chain and the skills needed to deploy these technologies. The competition opened in September 2010.	£3 million	2010 -	

Wave Hub	SouthWest RDA, DTI, European Regional Development Fund	The Wave Hub is a groundbreaking renewable energy project to create the UK's first offshore facility to demonstrate the operation of arrays of wave energy generation devices. Wave Hub is a grid-connected offshore facility in South West England for the large scale testing of technologies that generate electricity from the power of the waves. It holds a 25 year lease of 8 sq. km of sea bed connected to the grid by an 11/33kv subsea cable.	£21.5 million	2007 -	
Marine Energy Array Demonstrator (MEAD) capital grant scheme	DECC	The MEAD will support up to 2 pre-commercial projects to demonstrate the operation of wave and/or tidal devices in array formation for an extended period of time.	£20 million	2011 -	
European Marine Energy Centre (EMEC)	BERR, Carbon Trust, Scottish Government, Highlands and Islands Enterprise, EU	EMEC offer developers the opportunity to test full scale grid connected prototype devices in unrivalled wave and tidal conditions. EMEC has been funded by a grouping of public sector organisations convened by Highlands and Islands Enterprise on behalf of the Scottish Government. This follows a recommendation by the House of Commons Science and Technology Committee in 2001.	£14.5 million (initial)	2003 -	
ETI Marine Energy Programme	ETI	The ETI Marine Programme has thus far funded demonstration projects such as ReDAPT (Reliable Data Acquisition Platform for Tidal) which is demonstrating a tidal turbine and other demonstration projects including PerAWaT and Wet-mate Connector.(Total here does not include applied research funding- see section 4)	£13.5 million	2007 -	

Marine Renewables Commercialisation Fund (MRCF)	Scottish Government	The MRCF is a Scottish Government fund administered by the Carbon Trust. Its goal is to help commercialise the marine energy industry in Scotland. £18m million is available, providing capital support for projects that will accelerate the deployment of commercial-scale wave and tidal stream energy arrays in Scottish waters. The MRCF will initially provide capital support to commercial-scale arrays of multiple devices.	£18 million	2012 - 2013	

Table 5.2: Major Demonstration Projects

Name	Description	Sub-topics covered	Total Project Cost	Public Sector Funder	Public Sector Funding	Period
Andritz Hydro Hammerfest - HS1000 Device	The MRPF grant assisted the prototype development of the HS1000 device which was installed at EMEC in2011. After a test period, the company will work with ScottishPower Renewables who have plans to install the device as part of a 10MW tidal power array in the Sound of Islay in 2012. The Norwegian parent company intends to raise a further £12 million for further commercial development of the company.	• HS1000 Device Development	Unknown	Carbon Trust MRPF	£3.9 million	2010 -
Aquamarine-WATES	This support will enable the company to deploy a hydro-electric power conversion unit for testing and demonstration with the full-scale Oyster™ prototype, which was installed at EMEC in 2009.	• Demonstrate a single grid connected Oyster device at EMEC	Unknown	Scottish Government, Carbon Trust's Marine Renewables Proving Fund	£0.275 million	2007-
Aquamarine - WATERS	Aquamarine Power plans to demonstrate its third-generation Oyster wave energy device at the European Marine Energy Centre in Orkney.	• Demonstrate Oyster wave energy device	Unknown	Scottish Government (WATERS), Carbon Trust's Marine Renewables Proving Fund	£3.15 million	2010-

Aquamarine Power- Oyster 2 Device	The Carbon Trust funding supported the manufacture of Aquamarine's second generation wave energy device, Oyster 2.	• Oyster 2 Device Development	Unknown	Carbon Trust MRPF	£5.1 million	2010 -
Atlantis Resources- 1MW AR-1000 (tm) turbine	The MRPF funding will support successful development of Atlantis' one megawatt AR-1000(tm) turbine. With the support of the Carbon Trust, Atlantis will continue to take significant steps during the next 12 months towards the deployment of commercial scale tidal power farms in UK waters.	• Develop 1MW tidal turbine.	Unknown	Carbon Trust MRPF	£5.1 million	2010 -
AWS Ocean Energy	2.5MW full-scale device of AWS-III to be installed at EMEC in 2014	• Demonstrate and verify operation of AWS Mk2	Unknown	Scottish Government	£2.128 million	2007-
AWS Ocean Energy	This project will support further development of its AWS-III device, a ring-shaped multi-cell surface-floating wave power system which is being demonstrated on Loch Ness	• Further develop and demonstrate the AWS-III device.	Unknown	Scottish Government (WATERS)	£1.39 million	2010-

CRE Energy Ltd	4 Pelamis machines will be installed at EMEC giving an installed capacity of 3MW.	• Demonstrate a small array of devices.	Unknown	Scottish Government	£4.141 million	2007-
IT Power Ltd	Development, test and demonstration of a high efficiency, shallow flow tidal device	• 1/5th scale device (100kW) to be built • Installation in the Humber • Cross flow turbine consisting of oscillating hydrofoils with efficiency > 40%.	Unknown	DTI	Unknown	2006-
Lunar Energy	Demonstration and testing of a full scale prototype device to be carried out at EMEC	• Ducted turbine • Southampton University to carry out experiments on the duct and support structure	unknown	DTI	£2.25 million	2006-
MacArtney Wetmate Connector	This project will develop an 11kV wet-mate connector, which will be tested and demonstrated under workshop and real-sea conditions. The wet-mate connector project could considerably reduce the cost of cabling from offshore wave and tidal farms to the shore by allowing cables to be connected on the seabed and increasing the voltage rating.	• Develop and demonstrate a 11kV wet-mate connector	Unknown	ETI	£1.1 million	2009-

Marine Current Turbines – SeaFlow Project	Installation and testing of the first commercial-scale, monopile-mounted, experimental 300kW single 11m diameter rotor system off Lynmouth, Devon, UK. This was successfully installed in May 2003.	• Verify operation of device • Gain operational experience • Not grid connected • Operational and Maintenance	£3.4 million	DTI, European Commission	unknown	1999-2006
Marine Current Turbines – SeaGen Project	Design, manufacture, installation and testing of the first "full scale" twin rotor system rated at 1.2MW. This is grid-connected and functions with the flow in both directions - it is the prototype and test-bed for the commercial technology. Location: Strangford Narrows, Northern Ireland.	• Grid connection • Monitor impact on environment. • Operation in both tidal directions.	£8.5 million	DTI	£4.27 million	2004-
Marine Current Turbines- SeaGen	The award from the Carbon Trust will help MCT continue the research and development of the SeaGen device in Northern Ireland, as well as help facilitate the company's continued development	• Development of SeaGen Tidal Energy Device	Unknown	Carbon Trust MRPF	£2.7 million	2010 -
OceanFlow Energy- Evopod	This project will support the deployment of a small-scale 35kW floating grid-connected tidal energy turbine at Sanda Sound in South Kintyre.	• Demonstrate the Evopod tidal device	Unknown	Scottish Government (WATERS)	£560,000	2010-
Ocean Power Technology	The grant is for the construction, installation and in-ocean demonstration of OPT's latest 150 kW PowerBuoy® design, the PB150.	• Demonstration of the PB150	Unknown	Scottish Government	£0.275 million	2007-
Open Hydro	Sea-bed mounted 300kW tidal current device tested at EMEC in 2006-2007.	• Demonstrate installation. • Verify operation and performance	Unknown	Private Funding	Unknown	2006-

Open Hydro – WATES	Install a second 300kW prototype at EMEC	• Demonstrate installation. • Verify operation and performance	Unknown	Scottish Government	£1.214 million	2007-
Open Hydro - WATERS	This project will support the development of new technologies capable of connecting devices in tidal arrays.	• Demonstrate an economic and efficient method of grid connecting and controlling large scale commercial tidal arrays	Unknown	Scottish Government (WATERS)	£1.85 million	2010-
Pelamis Wave Power (formerly OPD)	1/7th Scale Prototype of the Pelamis Device in the Firth of Forth.	Develop and prove the full scale Pelamis hydraulic, control and data acquisition systems.	unknown	DTI	unknown	
Pelamis Wave Power (formerly OPD)	Full-scale prototype P750 demonstration at EMEC	• Prove operation of the full scale prototype. • Installation techniques	unknown	DTI	unknown	
Pelamis Wave Power- P2 Machine	The Carbon Trust MRPF Funding will support the manufacture, deployment and testing of the second generation Pelamis 'P2' machine. The P2 encompasses both real at-sea operating experience with the first generation of machines, and a number of major technical innovations to improve manufacturability and enhance economic performance. The funding allocated accelerated deployment of the device in EMEC, and intends to increase the scope and pace of sea trials.	• Manufacture, Deploy and Test the Pelamis P2 Wave Energy Device.	Unknown	Carbon Trust MRPF	£4.8 million	2010 -

ReDAPT	ReDAPT (Reliable Data Acquisition Platform for Tidal) will install an innovative tidal generator with comprehensive data collection system at EMEC. ReDAPT will accelerate the development of tidal energy by installing and testing a commercial scale, horizontal flow, tidal turbine.	• Demonstrate a commercial scale tidal turbine	Unknown	ETI	£12.4 million	2009-
RWE npower renewables-Siadar Project	The 4MW Siadar project was funded. This project which aims to deploy 10 wave generators provided by Inverness-based Wavegen off the Western Isles. Update – July 2011 : RWE npower renwables announced that it was withdrawing from the Siadar project	• Demonstrate a small wave array	Unknown	Scottish Government (WATERS)	£6 million	2010-
Scot Renewables	Install a 1.2MW prototype tidal current device, SRTT, at EMEC in 2008	• Demonstrate a floating tidal current generator	Unknown	Scottish Government	£1.796 million	2007-
SMD Hydrovision	1/10th scale prototype built and tested at NaREC	• Verify operation of device • Test mooring system	unknown	DTI	unknown	2002-2003
The Engineering Business Limited	150 kW Stingray Tidal Stream Device was tested in Yell Sound, Shetland	• Verify operation of device. • Installation techniques.	Unknown	DTI	Unknown	2001-2003

Voith Hydro	Voith Hydro develops tidal power stations that do not utilize water storage but, similar to wind power stations, exploit the kinetic energy of the current and are operated fully under water. For this purpose, up to three turbines, each with a nominal power of 1 MW, are installed within a bridge-like structure. These turbines can be rotated around their horizontal axis, which allows them to make optimum use of the water and its flow direction, which changes every six hours.	• Tidal Energy Device Development	Unknown	Carbon Trust MRPF	Unknown	2010 -
Wavegen	500kW LIMPET Shoreline OWC on Islay	• In-situ construction • Operation & Maintenance • Data collection • Monitoring and Control • Assessment of Efficiency	Unknown	EU (funded construction) DTI (funding for early monitoring)	unknown	1999-2002

6. Research Facilities and Other Assets

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Some universities in the UK involved in marine energy research have test tank facilities – these have been highlighted where appropriate in Table 3.2. In addition to these, new test facilities such as EMEC and WaveHub have been established specifically for marine renewable energy, and are listed below. Another test facility, NaREC has marine testing facilities in addition to other renewable energy testing facilities.

Table 6.1: Research Facilities and Assets

Name	Description	Type of asset	Number of Supporting Staff	Annual Operating Budget
EMEC	EMEC's wave testing site has four test berths situated along the 50m water depth contour off Billia Croo on the Orkney mainland (some 2km offshore), with a shallow water berth situated close to the substation . EMEC has a tidal test site at the Fall of Warness where there are facility offers seven test berths at depths ranging from 25m to 50m in an area 2km across and approximately 4km in length. Both the wave site at Billia Croo and the tidal site at Fall of Warness have an 11kv cable running from an on-shore sub station out to each open-sea berth.	Test Facilities	--	
HR Wallingford Ltd	• Wave Basin • Wave Flumes • Coastal Research Facility (wave and current basin)	Test Facilities	--	
Imperial College Hydrodynamics Lab	• Wave Basin • Towing Tank • Open Channel Flume • Visual Tank • Wind Wave Current Flume • Shallow Water Coastal Wave Flume	Test Facilities	--	
Lancaster University, LUREG	• Wave tank	Test Facilities	--	

NaREC (Test Facilities)	• 3MW Drive Train Rig (Operational in 2011) • Tidal Test Facility • Wave Flume Tank • Linear Test Rig • The EnergyLINK low voltage (LV) laboratory • High Voltage Laboratory – Clothier Labs. • Full Scale Blade test facility	Test Facilities	--	
Queen's University Belfast, Environmental Engineering Research Centre	• Narrow wave tank • Large wave tank • Propeller tank • Stratified flow tank • Continuous flow / saline wave tank	Test Facilities	--	
University of Edinburgh, Institute for Energy Systems	• Wave tank • Flow-table for tidal currents • Flowave TT (combined wave and current tank)	Test Facilities	--	
University of Manchester, Mechanical Engineering	• Tilting flume for basic shallow and atmospheric flow studies, with a wave maker for marine energy and coastal studies • General-purpose wave flumes	Test Facilities	--	
University of Newcastle, School of Marine Science and Technology	• Towing Tank • Cavitation Tunnel • Dove Marine Lab • Combined Wind, Wave and Current (WWC) Tank	Test Facilities	--	
University of Plymouth, Coastal Engineering Research Group	• Wave Tank	Test Facilities	--	

University of Southampton, School of Engineering Sciences	• Wave test facilities	Test Facilities	--	
Dept. of Naval Architecture and Marine Engineering, Strathclyde/ Glasgow	• Denny Ship Model Experiment Tank at Dumbarton • Kelvin Hydrodynamics Laboratory at the West of Scotland Science Park; • Wave Tanks	Test Facilities	--	
WaveHub	Wavehub is an offshore test facility in SW England with a potential 20MW installed capacity. It is primarily for wave energy developers to demonstrate small arrays of wave devices. Installation took place in 2010. The project will work with up to four different technologies at any one time. A 1km x 2km sea area will be leased to each developer for installation.	Test Facilities	--	

7. Networks

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A number of marine networks within the UK and Europe are listed below in table 7.1.

Table 7.1 Networks

Network	Date Established	Description	Membership Profile	Activities
European Energy Research Alliance (EERA)	2011	Acts to strengthen, expand and optimise energy research capabilities throughout Europe through a sharing of knowledge and facilities. The EERA Ocean Energy Joint Programme was developed based on existing roadmaps and works towards identification of critical areas of research required for the growth of the ocean energy sector.	• Collaborative Project • 8 member countries • Coordinated by The University of Edinburgh/SuperGen Marine • Several UK universities and research institutes	The Ocean Energy Joint programme is based around six key themes: 1. Resource, 2. Devices and technology, 3. Deployment and operations, 4. Environmental impacts, 5. Socio-economics impacts, 6. Research infrastructure, education and training.
Energy Generation and Supply Knowledge Transfer Network: Wave and Tidal Energy Group	2009	The marine energy Knowledge Transfer Network has been funded by the TSB to promote collaboration and knowledge sharing in the energy generation and supply sector. The Wave and Tidal Group is managed by AEA. AEA is an energy and climate change consultancy.	• Wave and Tidal Energy Group currently has over 127 members	The KTN carried out a variety of activities such as: - Workshops/round-table discussions - Networking events - Dialogue with key external stakeholder groups to improve understanding and highlight opportunities for collaboration - Insights into new funding opportunities and key developments across the landscape -Support for supply-chain development -Formation of expert working

				groups/special interest groups to provide focused effort in key areas
European Ocean Energy Association (EU-OEA)	2005	EU Ocean Energy Association was established in August 2005. Among its objectives are to: • strengthen the development of the ocean energy market and technology in Europe; • act as the central networking hub for its members; • disseminate and exchange information and experience; • act as a focal point for ocean energy sector contact with the European Community.	• 60 International Companies • Members from every sector of the industry, representing a wide range of interests within the upstream and downstream value chains	EU-OEA hosts workshops and conference series, provides first hand information from key stakeholders, provides site visits for members to key sites worldwide.
Forum for Renewable Energy Development in Scotland (FREDS) Marine Energy Group (MEG)	2003	FREDS builds a partnership between industry, academia and Government. The Marine Energy Group (MEG) is one of the FREDS groups and aims to accelerate delivery of the world's leading marine energy industry that will provide a substantial contribution to the sustainable economy and environment of Scotland.	• Members include Government, Industry (large and small companies) and University representatives.	FREDS MEG released a marine energy roadmap for the sector in 2009.
Renewable Energy Association	2001	The Renewable Energy Association (REA) was established in 2001 to represent British renewable energy producers and promote the use of sustainable energy	• 600 + corporate Members • Members from whole spectrum of renewable energy technologies and across all sectors:	REA provides policy input to government on behalf of the renewables sector and organises workshops, seminars and networking events. Hold a Marine Energy

		in the UK. REA represents a wide variety of organisations, including generators, project developers, fuel and power suppliers, equipment producers and service providers.	power, heat, transport and renewable gas.	Conference annually called WATTS (Wave and Tidal Technologies Symposium)
Renewable UK	1978 2010 changed to Renewable UK	Renewable UK, formerly called BWEA, is the trade and professional body for the UK wind and marine renewables industries. The primary purpose is to promote the use of wind, wave and tidal power in and around the UK.	• 648 Company Members • Members from all sectors of the offshore wind and marine renewables industries.	Renewable UK acts a central information point for its members, acts as a lobby group on behalf of offshore wind and marine renewables, performs research and acts as a forum for the industry by organising annual conferences and events.
Scottish Renewables	1996	Scottish Renewables supports the development and provision of a sustainable energy future for Scotland and acts as a voice for the renewable energy industry in Scotland.	• Approximately 200 members. Range from small developers to large plcs, charities to government agencies. Represent the main organisations involved in renewables in Scotland.	Mailings, Briefings, Meetings, Large Conferences/Events, Networking opportunities

8. UK Participation in EU Activities

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The EU Framework Programmes fund a variety of marine energy programmes including demonstration projects of specific device technologies, networks known as Coordinated Actions, and other research collaborations. UK universities, large companies and SMEs are involved in a large number of the EU marine energy programmes as partners and in some cases as the project co-ordinator. The current UK activity in EU Framework Programmes is shown in Table 8.1 (previously completed EU marine projects are not listed here).

There are also important marine projects being funded by Intelligent Energy Europe (European Commission) that although not part of the EU Framework programme are also represented in Table 8.1.

Table 8.1: EU Framework Programmes

Project	Objectives	Action Line	Type of Action	UK Participants	Co-ordinator and Partners	Total Funding	EU Funding	Duration	Representative Annual Spend
CORES	The CORES project focuses on the development of new concepts and components for power take-off, control, moorings, risers, data acquisition and instrumentation based on floating Oscillating Water Column Wave Energy Converters (OXS).	FP7-Energy	Small or Medium Scale Focused Research Project	Queens University Belfast University of Exeter	University College Cork, Ireland 12 partners	€4.52 million	€3.45 million	2008-04-01 to 2011-03-31	
EquiMar	The EquiMar project is	FP7-Energy	Small or Medium	University of Edinburgh	University of	€5.44million	€3.99 million	2008-4-15 to	

	developing a suite of protocols for the equitable evaluation of marine energy converters (based on either tidal or wave energy).		Scale Focused Research Project	University of Manchester University of Exeter University of Strathclyde Scottish Association for Marine Science University of Southampton Feisty Productions Ltd. Pelamis Wave Power Ltd. University of St. Andrews European Marine Energy Centre (EMEC)	Edinburgh, UK and 22 partners			2011-04-14	
MARINA Platform	The MARINA Platform aims to bring offshore renewable	FP7-Energy	Collaborative Project (Generic)	University of Edinburgh	Acciona Energia S.A., Spain and 16	€12.76million	€8.7million	2010-01-01 to 2014-06-30	

	energy closer to the market by creating new infrastructure for offshore wind and ocean energy converters.				partners				
MARINET	The Marine Renewables Infrastructure Network for Emerging Energy Technologies (MARINET) aims to accelerate the development of marine renewable energy by bringing together testing facilities at all scales to offer periods of free access, coordinated research, common test standards, industry networking and focused training in testing	FP7	Collaborative Project	Queens University Belfast University of Exeter University of Edinburgh University of Plymouth NAREC EMEC University of Strathclyde	Hydraulics and Maritime Research Centre, Cork, Ireland and 28 partners	€9 million	€9 million	2011 - 2015	

	techniques.								
MERIFIC	Project: Merific Marine energy in Far peripheral and island Communities: Sharing engineering know how, policy and good practice Identifying marine energy hotspots, prioritising island communities Investigating the needs for energy generation and distribution Encouraging business opportunities Engaging with communities, helping them to see the need for renewable energy	Interreg IVA	Promotion of Renewable Energies	University of Exeter, University of Plymouth, Cornwall Council, Cornwall	Marine Network Co-ordinator and Partners: Cornwall Council and 8 partners	€4.6 million	€2.3 million	2011-04-01 – 2014-03-31	
ORECCA	The ORECCA project (Offshore Renewable Energy	FP7-Energy	Coordination (or Networking) Actions	Offshore Wave Energy Ltd. University of	Fraunhofer IWES, Germany and 27 partners	€1.8million	€1.6million	2010-03-01 to 2011-08-31	

	Conversion Platforms Coordination Action) aimed to create a framework for knowledge sharing and to develop a research roadmap for offshore renewable energy. The project stimulated collaboration in research activities.			Edinburgh North Highland College IT Power Ltd.					
Pulse Stream 1200	The Pulse Stream 1200 project demonstrates an innovative tidal energy converter at full scale in UK waters (at a site with potential for further commercial development).	FP7-Energy	Collaborative Project (generic)	Bosch Rexroth Ltd. Gurit (UK) Ltd. Pulse Tidal Ltd.	IT Power Ltd, UK and 7 partners	€13.9 million	€8million	2009-11-01 to 2013-10-31	
SNAPPER	The SNAPPER Project is developing a novel low-cost, high efficiency linear	FP7-SME	Research for SMEs	NAREC EM Renewables Ltd.	New and Renewable Energy Centre (NAREC), UK and 7	€1.3million	€9.9million	2009-09-01 to 2011-08-31	

	generator for wave energy extraction. The concept aims for a step change in the economic potential for the conversion of wave energy to electricity.			Ecotricity Group Ltd. University of Edinburgh	partners				
SOWFIA	The SOWFIA Project (Streamlining of Ocean Wave Farm Impacts Assessment) aims to facilitate the development of European wide coordinated, unified and streamlined environmental and socio-economic Impact Assessment tools for offshore energy conversion developments.	Intelligent Energy Europe		The University of Exeter The University of Plymouth	The University of Plymouth and 9 partners		Unclear, under negotiation	unclear	
TIDALSENSE	The TidalSense project has been conceived by SMEs so that they can exploit a new	FP7-SME	Research for SMEs	TWI Limited IT Power Ltd.	TWI Limited, UK and 9 partners	€1.5million	€1.1million	2009-09-01 to 2011-08-31	

	market that has huge potential for growth. The project will allow the SMEs to improve their capabilities so that they can gain a lead in providing condition monitoring services to tidal energy operators.								
Tropos	The key objective of the TROPOS project is the development of a floating modular multi-use platform system for use in deep waters, with an initial geographic focus on the Mediterranean, Tropical and Sub-Tropical regions but designed to be flexible enough not to be limited in	FP7 - Ocean	Collaborative Project (generic)	The University of Edinburgh The University of Strathclyde	The Oceanic Platform of the Canary Islands - PLOCAN	4.5million Euro		2012-02-01 to 2015-02-01	

	geographic scope.								
Waveplam	The Wave Energy Planning and Marketing (WAVEPLAM) project aims to develop tools, establish methods and standards, and create conditions to speed up the introduction of ocean energy onto the European renewable energy market, tackling in advance non-technological barriers and conditioning factors that may arise.	Intelligent Energy Europe		Wavegen	EVE- Ente Vasco de la Energia and 7 partners		£1 million	2007-01-11 to 2010-10-31	
WAVEPORT	The WAVEPORT project aims to deal with the lack of large commercial scale demonstrations of wave power by demonstrating a large scale	FP7-Energy	Collaborative Project (generic)	The UK Intelligent Systems Research Institute Ltd. University of Exeter	The UK Intelligent Systems Research Institute Ltd. and 5 partners	€8.5million	€4.59million	2010-02-01 to 2014-01-31	

	grid connected point absorber wave energy converter. It also aims to accelerate the development of other devices by installing a ten port open platform 1.5MW rated underwater substation pods for the validation of future wave energy converters.								
Wavetrain 2	WAVETRAIN 2 continued the work of its predecessor to create a pool of specialised wave energy research professionals in order to support the emerging wave energy industry, which thus far lacks dedicated training curriculum.	FP7-People	Marie Curie Action: Networks for Initial Training	AWS Ocean Energy Ltd. Wave Dragon Ltd. University of Edinburgh Queen's University Belfast	Wave Energy Centre, Portugal and 12 partners	€3.58million	€3.58million	2008-10-01 to 2012-06-30	

9. International Initiatives

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There is only one IEA implementing agreement – IEA Ocean Energy Systems (OES-IA), in which the UK is represented by the Department for Energy and Climate Change (DECC).

Table 9.1: International Activities

Name	Type	Description	UK Contact Point
IEA Ocean Energy Systems Implementing Agreement (OES-IA)	IEA Implementing Agreement	The OES-IA aims to facilitate and co-ordinate ocean energy research, development and demonstration through international co-operation and information exchange, leading to the deployment and commercialisation of sustainable, efficient, reliable, cost-competitive and environmentally sound ocean energy technologies. The OES-IA membership consists of the European Commission and 19 member countries: Denmark, Portugal, UK, Ireland, Japan, Canada, USA, Belgium, Germany, Mexico, Norway, Italy, New Zealand, Spain, Sweden, Australia, Korea, China and South Africa.	Mr. Trevor Raggatt Department of Energy and Climate Change (DECC) + 44 20 7215 2204 Trevor.Raggatt@decc.gsi.gov.uk