Marine Energy

Global Development Review 2011

marine energy matters

Introduction

Marine Energy Matters (MEM) first carried out a review of global technology developers in early 2009. This second review, approximately two years later provides some insight into the development of the marine renewables industry. Conducted via web research, discussions with key industry players and literature reviews, the review cannot claim to be scientific but more an overview of the industry. It considers companies developing at shore, near shore and off shore Wave Energy Converters (WECs) as well as in-sea and run-of-river Current Energy Converters (CECs). We have not considered tidal range technologies. The study provides an insight into the development of the industry at both global and national levels allowing geographic comparisons to be made. Limited comparisons can also be made between technologies, illustrating the relative progress of each sector.

The final section takes a brief look at the different policies and enabling actions in place around the world and their importance to the development of the industry.

Clean Current Turbines - British Columbia, Canada.

Technology Development

Technology Readiness Levels (TRLs)

TRL1 Concept released
TRL2 Validated concept[1]
TRL3 Tank testing (scale device)
TRL4 Location testing (scale device)
TRL5 Full/large scale[2] grid connected prototype
TRL6 Pre commercial, grid connected array
TRL7 Fully certified[3] commercial array

1: Concept validated by a university or engineering research organisation.

2: Full/large scale definition:

wave	*>100kW*
tidal stream	*>100kW*
run of river	*>25kW*

3: Device fully certified by a recognised certification body.

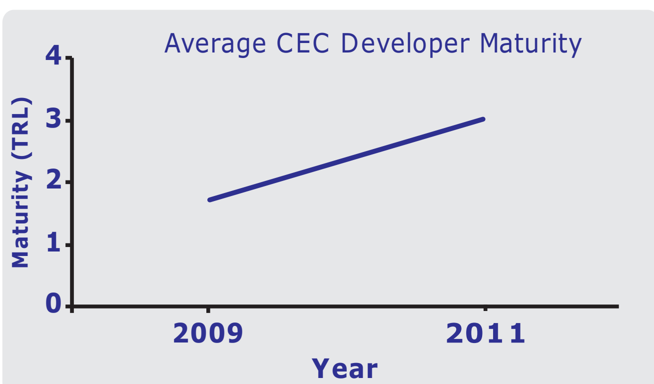
This review is based on an assessment of Technology Readiness Levels (TRLs) developed by MEM which are similar to others being developed by the industry. The seven level system covers the range of development from concept through to array testing and a commercial offering. At the time of writing, the highest level reached by any device is TRL5 (full/large scale grid connected prototype).

The use of TRL averages provides a reference of industry development. Taking a closer look at the two sectors (WECs & CECs) the respective maturities are clear. Nearly a quarter of CEC developers covered in the review have reached TRL5, split between tidal stream and in-river devices. However things are much less uniformly advanced in the WEC sector with only 5% of developers at TRL5, although there are twice as many WEC developers. The UK is home to over a third of all TRL5 developers (combined) and around a half of TRL5 WEC developers. North America (USA & Canada) provides 45% of CEC developers at TRL5 creating the other main development hub alongside the UK.

Current Energy Converter Sector

Current Energy Converter (CEC) technology is dominated by in-sea/estuarine tidal stream devices. However a significant number of developers (about a third) are also developing smaller in-river devices.

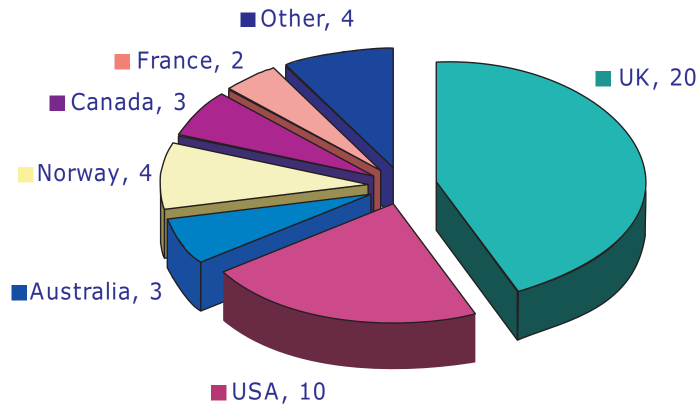
Despite a decrease in developers since the 2009 review, the CEC sector shows strong development, led by the UK. This drop in developer numbers (nearly 20%) is regarded as a positive indicator of sector development as the remaining developers have strengthened positions through company collaborations, joint ventures and takeovers. The lack of new players in the market signals the sector is settling down with new entrants, including large industrialists such as Siemens and Rolls-Royce, choosing to join forces and get behind the existing technologies. These are welcomed developments, perhaps born out of necessity as financial investment is in short supply.



As the number of developers narrows the remaining devices are making progress. It is those developers that have progressed from the proven concept or tank testing stage (TRL2 or TRL3) in 2009 to in-sea/river testing at either scaled or full size (TRL4 and TRL5) by early 2011 that are key to the near term development of the industry. The sector is dominated by the UK and the USA, with both countries having ample resource to exploit and the knowledge base to develop devices.
As can be expected at this stage of development there have been some technology setbacks with device installations. Reported issues relate to deployment, blade integrity, control systems and bearings.

"Global development remains strong, but with fewer device developers"

CEC Developer Location



Notable in-sea developments since early 2009 include the Atlantis Resource Corporation deployment at EMEC and the first large scale commercial seabed lease option round in the Scotland (wave and tidal). Companies with existing full scale prototypes such as Marine Current Turbines, Open Hydro, Hammerfest Strom have partnered with power utilities or others to gain access to resource via the lease round. Most of the leading tidal stream developers are using horizontal axis turbines and are targeting 1MW or greater as their first commercial offering. General testing also continues on both Atlantic and Pacific coasts of Canada, where Clean Current Turbines operate.

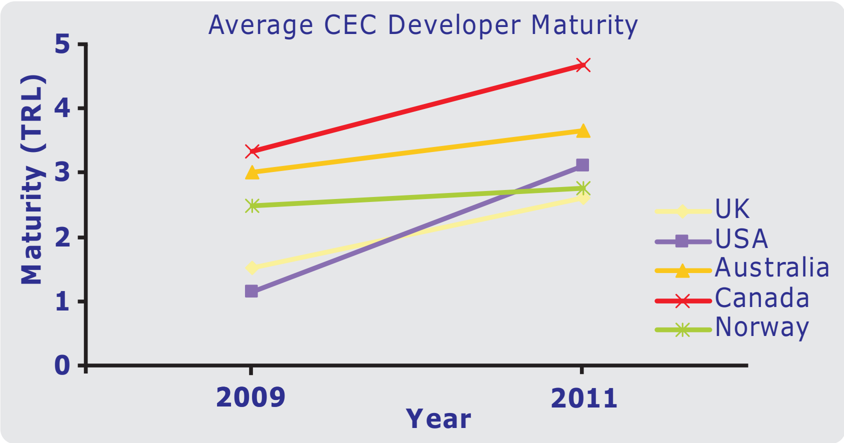
At a smaller device scale there have been a number deployments, including in UK estuaries (Pulse Tidal and Neptune Renewable Energy) and run of river schemes in the USA (Verdant) and the Netherlands (Torcardo).

MCT SeaGen - Strangford Loch Northern Ireland.

Global Development

The CEC industry is dominated by the UK (20 out of 46 developers) where the main focus is on tidal stream devices. However, a closer look at developer maturity averages shows a changing landscape. The rate of development in the USA has stepped up over the last two years and in absolute TRL terms it is nudging ahead of the UK, although with fewer developers and much more early focus on in-river technologies.
The first stages of development are the easiest (TRL1-TRL3), needing less capital and advanced engineering/business development skills. Progression from tank testing to an in-sea prototype (TRL5) is much more time consuming, technically challenging and costly, which has allowed American developers to catch their international counterparts. The UK has a much more even spread of device development, however it is still home to the highest number of devices at full/large scale (TRL5).

"The rate of development in the USA has stepped up"

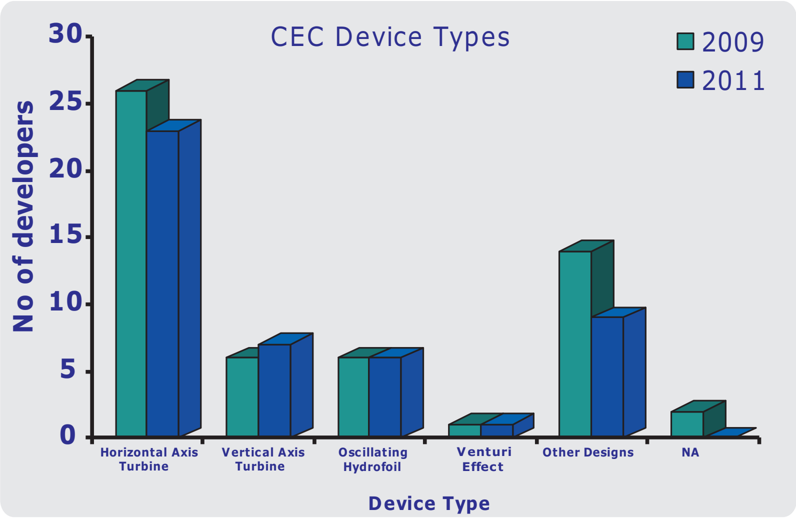


Australia and Canada are leading the way in terms of average development, although its important to note the very low number of developers in each country. Our general conclusion is that the world's top 5 countries are making significant progress, with the possible exception of Norway where development appears almost static.

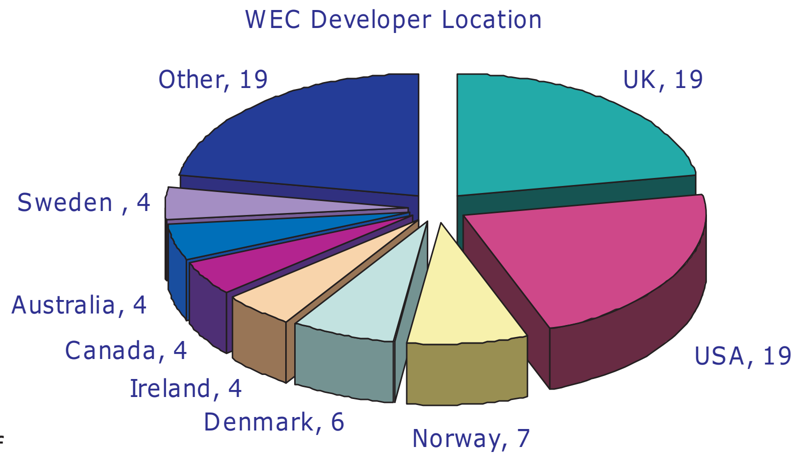
Technology Convergence

Atlantis Resource Corporation EMEC, Scotland.

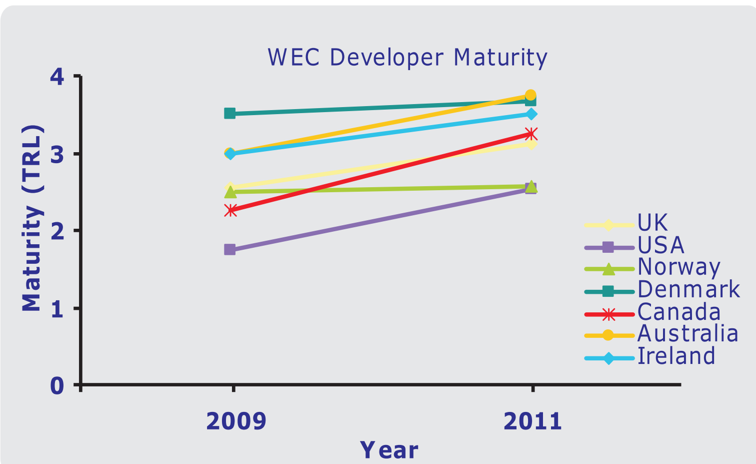
The CEC sector shows a clear convergence of technology, with nearly 50% of devices being horizontal axis turbine technology. However there are still substantial differences in size, suggested operations & maintenance regimes and anchoring/mooring systems. Initial convergence towards this technology isn't surprising as the choice of a horizontal axis turbine is a logical development from the ships propeller and the ubiquitous horizontal axis wind turbine.



Wave Energy Converter Sector



As in the CEC sector, the UK and USA lead the way in the Wave Energy Converter (WEC) sector accounting for over 40% of device developers. Other significant technology development areas are Scandinavia, Canada, Ireland and Australia. As with the 2009 review, WEC technology is on average less well developed than CEC technology. WEC technology progression has been slower for two main reasons; firstly there has been little convergence towards a leading technology type (unlike the CEC sector) and secondly there are double the number of developers world-wide in the wave sector with new entrants still emerging. Rather than being a sign of development, we feel this indicates a less developed industry.



The number of countries involved in wave energy is more than double that of the CEC sector, perhaps a reflection that wave resource is much more widely distributed, with the worlds best current resource concentrated in fewer locations.

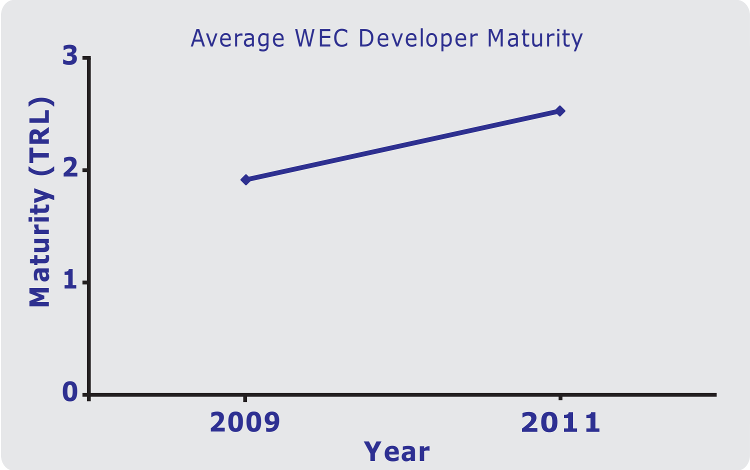
Progress within the wave sector has been steady with a number of developers moving towards in-sea testing and the leading developers testing full/large scale prototypes (TRL5). Denmark, Ireland and Australia appear to be the most advanced, but with a small pool of developers. Canada has made the most progress but also has a limited number of developers. The USA and the UK are both making steady progress with a much larger developer community.

Pelamis P2 at EMEC, Scotland.

Since the last review there has been some notable developments within the WEC sector. We've seen deployment of new full/large scale prototypes from Aquamarine, Ocean Power Technologies, Pelamis, and Oceanlinx. This has been matched by increased testing capacity with Wave Hub installed in south west England and infrastructure improvements at EMEC in Scotland. The commercial seabed leasing round in Scotland also saw Pelamis and Aquamarine take up lease options working with power utility companies.

As one would expect when developing new technology and businesses there have also been some notable setbacks. These include the loss of leading developer Orecon in the UK, problems associated with development projects relating to the global financial crises and the inevitable technical issues with early in-sea deployment.

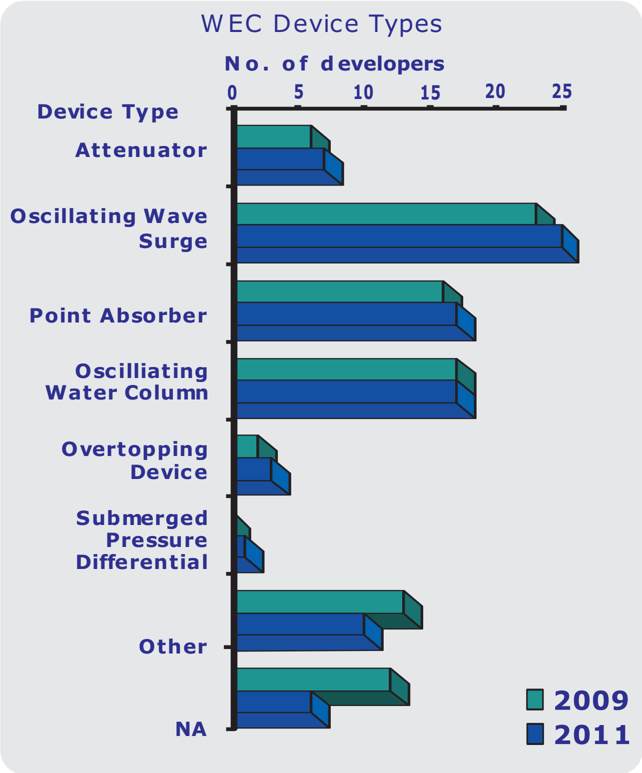
"Wave devices spread globally but UK & USA dominate"



Technology Types

There is still considerable diversity of technology types being perused within the WEC sector. The sector in dominated by three different technologies, point absorbers, oscillating water column and oscillating surge devices. It is worth noting that technology types are not country specific and one of the leading developers (Pelamis) uses the less common attenuator principle. This lack of convergence is partly explained by the diversity of potential wave resource extraction locations - at shore, near shore and off shore. Each location providing different technical challenges to the device developer resulting in different device technologies being pursued.

"Little technology convergence in the WEC sector"



Ocean Power Technologies (OPT) Power Buoy - Spain.

The Future - bright but needing investment

Both WEC and CEC sectors are heading towards a vital crunch point. There are a significant number of developers now testing devices in the working environment (TRL4) with a number testing full/large scale prototypes (TRL5). The next step for many is to build, install and test full scale prototypes and arrays. For many organisations this is the acid technical test and where costs start to escalate dramatically. A single full scale in-sea prototype can cost in excess of £10 million while a small pre-commercial array will cost tens of millions. Funding sources will be the balance sheet of companies involved, the public sector or the investment community. To date, with a few notable exceptions, there is little evidence of investment community involvement, so it looks like the industry will be reliant on public sector funds and balance sheets for some time. However, leading countries are starting to provide the legislation and market support frameworks that will help encourage the investment community into the sector.

Wave Hub terminus prior to installation - Cornwall, UK.

"Building full scale prototypes and arrays is the acid test and where costs start to escalate dramatically"

Technology Development

Global governments recognise the need to assist technology developers at the stage where significant capital is required to complete the next phases of technical development. Typically assistance is taking place in three ways:

Knowledge Development

Knowledge and development partnerships are now active in most leading countries, often being led by academic institutions. The most recently established being the federal backed initiatives in the USA creating three development centres; the North West (Oregon/Washington) the South East (Florida) and Hawaii.

Capital grants for technology development

Typically developers competitively bid for funding to assist development and possibly deployment. An example would be the UK's Marine Renewables Proving Fund.

Test facility investment

These are development areas or facilities equipped to allow developers to test either single devices or arrays at reduced cost.

The best examples of public funded facilities are EMEC (wave and tidal stream) in Scotland where individual devices can be tested, the FORCE test area in the Bay of Fundy (tidal stream) in Canada and the recently installed Wave Hub in south west England. There is also a dedicated wave energy zone in Portugal, a proposed wave test facility in Spain (BIMEP) and an established test area in Ireland. In addition to the centralised national/state initiatives, in some cases the state assists developers in establishing their own test areas.

Market Development

As technologies progress towards commercial installations, perhaps from as early as 2015/16, very significant capital investment will be needed. Alongside technology development, the investment community will naturally look for "market visibility". Government leadership is needed to ensure commercial scale access to the resource and that adequate power transmission systems are in place. The provision of appropriate market support regimes that allow early stage profitability are also essential to attract investment.

MEM (UK) Limited
Cleaveland House
Cleaveland Rise
East Ogwell
Newton Abbot
Devon
TQ12 6FF

Phone: +44 (0)1626 362411
E-mail: info@marine-energy-matters.com
www.marine-energy-matters.com

This review was compiled using MEM's Wave and Tidal Technologies (WATTs) database.

Images kindly supplied by Ocean Power Technologies Ltd, Marine Current Turbines Ltd, Pelamis Wave Power Ltd, Wavebob Limited, Atlantis Resource Corporation and Wave Hub.

marine energy matters