Industry Analysis:
Wave Power Technology

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EXECUTIVE SUMMARY

Wave energy is renewable energy that generates electricity from the wind blown by the rise and fall of waves. The UK has tremendous resources and the technology is developing rapidly. The University Research Group has developed a new type of turbine that generates electricity using wave power technology and is considering starting a business in the UK.

This industry report discusses the current size of the UK market for wave power technology along with the key competitors and highlights the future trends. It identifies the key trends in the market that are likely to affect the business in the next three years. These include: the impact of government policies, technology developments, the economic situation and environmental effects. The report outlines the available opportunities and the associated threats and concludes with concrete recommendations.

Some of the key findings are as follows:

- The government is promising to be 'the greenest government ever' and 'to deliver support for the marine energy'.
- The government is strongly backing wave energy by providing financial support, giving consent, leasing sites and setting up internationally recognised test centres.
- Wave power technology is unsaturated and there is healthy room for innovative technology that addresses the cost problems.
- Wave energy is well positioned to contribute to addressing unemployment in the UK.
- With zero carbon emission, this predictable source of energy is a promising candidate for decarbonising the power supply.
- Wave power technology has an edge in transferring skills from the offshore oil and gas production and wind farms.
- The dwindling economy of the UK could pose an inevitable threat.

INTRODUCTION

'Wave energy is the extraction of energy from the motion of water in surface waves on the sea, created by the wind' (DECC).

REPORT SCOPE

The report aims to analyse and evaluate the prospects of starting a new business in the UK that will provide renewable power technology for electricity production. Three important business scenarios can be analysed for URG[1] to enter the UK electricity market. These include:

Business Scenario # 1: Wave Power Turbine integrates with other Renewable Energy markets

Business Scenario # 2: Wave Power Turbine evolves as an independent business

Business Scenario # 3: License Wave Power Technology to earn royalties

The research is conducted using the available data and information from sources such as DECC, Frost and Sullivan, Key note, Mintel and Google Scholar. The major factors that are likely to affect possible ventures in the UK market for the next three years are identified.

The industry report thoroughly analyses the external business environment using the key trends identified from the PESTEL[3] tool. It reaches conclusions that highlight the opportunities and the associated threats. Moreover, it provides concrete recommendations to help URG make sound business decisions. Only Business Scenario 3 is considered for purposes of this report.

The base year of this research is 2012 and the focus of the report is the UK.

RENEWABLE WAVE ENERGY ASSUMPTIONS

At this stage, the University Research Group is not willing to disclose any information regarding its innovation or intellectual property for commercial reasons (Webster, February, 2012) (Webster, February, 2012). Hence, all the future development listed in this analytical report pre-supposes the following assumptions:

- The Government will continue to provide suitable financial support and show its commitment towards long-term projects.
- No recession in the next three years.
- Wave Energy stats for market size are taken as one quarter of the marine energy in the UK. Clearly, one quarter is a worst-case scenario.

REPORT STRUCTURE

Chapter 1 outlines the current wave power technology, the market size and key competitors of electricity generation in the UK. Also, the future prospects of the said market are discussed.

Chapter 2 analyses the external business environment using four key trends from PESTEL that are likely to affect the new wave power technology in the next three years in the UK.

Chapter 3 concludes the report by highlighting opportunities and the associated threats and gives concrete recommendations.

CHAPTER 1 UK WAVE ENERGY MARKET

Wave energy sources have the highest energy density of all renewable energy sources (Sorenson, 2008). This abundant source of energy can potentially supply ten per cent of the global electricity needs (Frost and Sullivan, 2012). The UK possesses almost 50 per cent of the European Union's wave energy resources, estimated at 52 TWh/year, and is able to meet 14 per cent of the UK's electricity demand (Carbon Trust, 2011). The UK clearly leads in terms of its resources, as illustrated in Fig 1.

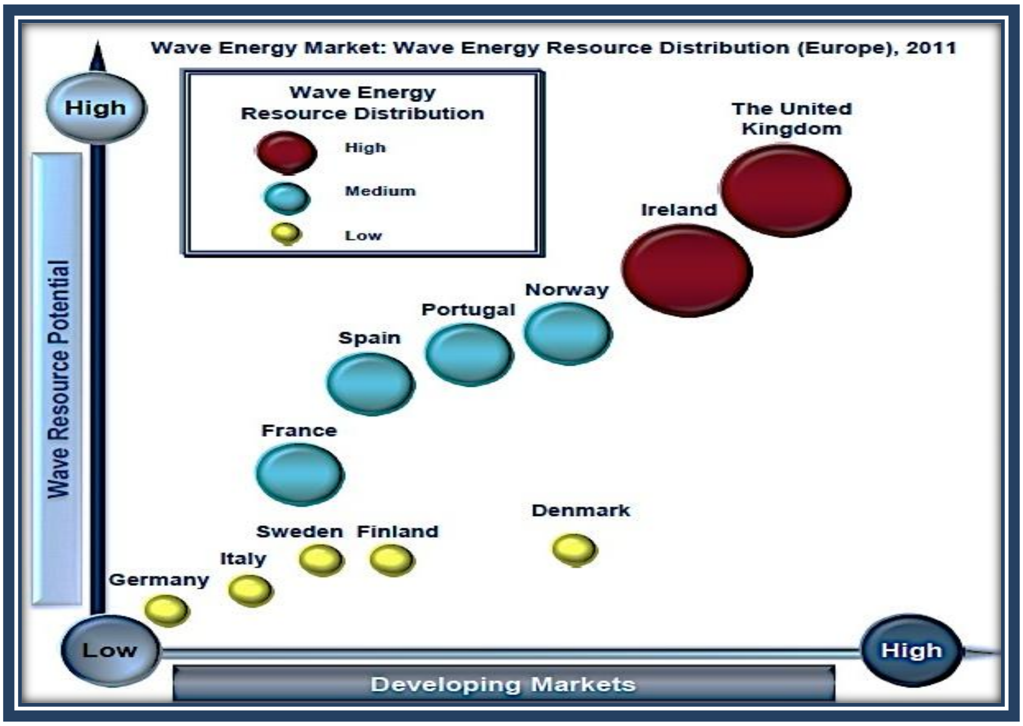


FIGURE 1: WAVE ENERGY RESOURCE DISTRIBUTION (FROST AND SULLIVAN, 2012)

MARKET SIZE AND GROWTH

The UK is the wave energy world leader; in 2009, it had an installed capacity of 0.85 MW (Energy Generation and Supply, 2010). There are ten MW of marine energy in the planning process, 20 MW of projects being developed and over 200 MW of projects to be announced by the Crown Estate (Business Insight, 2010). A 2009 study listed 17 UK wave power developers out of a worldwide total of 71 known developers (Landy, 2010). The UK is the global leader in the development of wave energy technologies [Fig 2] (Frost and Sullivan, 2012).

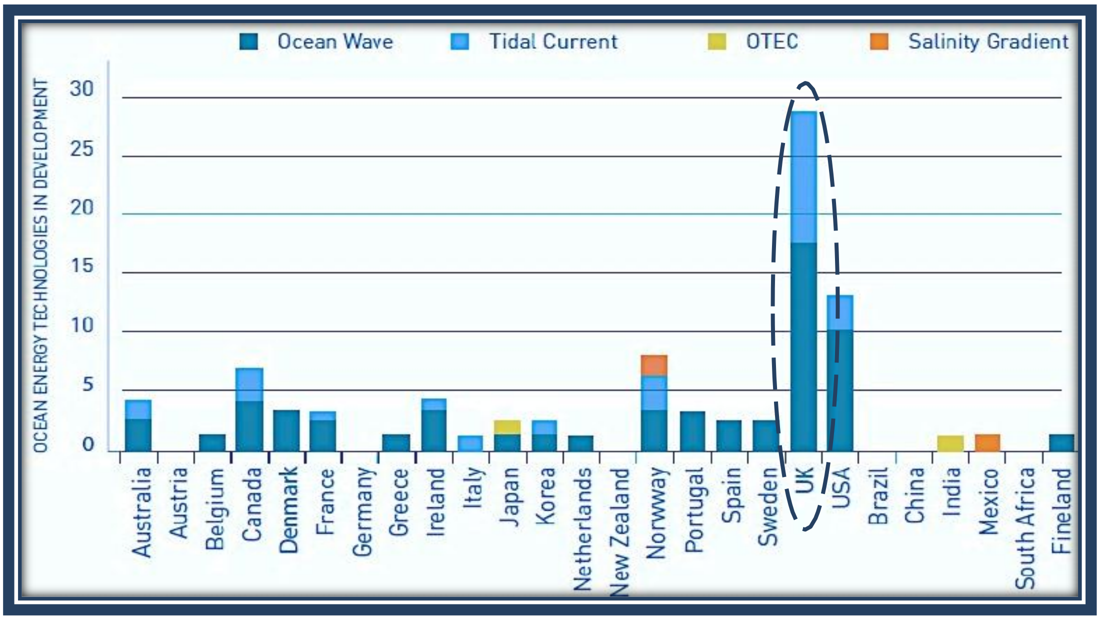


FIGURE 2: GLOBAL DEVELOPMENT OF OCEAN ENERGY TECHNOLOGY (FROST AND SULLIVAN, 2012)

Wave power technology is growing rapidly. At the end of March 2011, the UK had 1.31 MW of installed wave energy capacity, a rise of almost 50 per cent over the previous year (Waveplan, 2010). A total of 2.6 MW of prototypes are in the advanced stages of planning and fabrication for deployment, representing a more than one-hundred-per-cent increase in installed capacity by 2012 (Renewable UK, 2011)

By estimation, the UK's wave power technology market was valued at £142.49 million in 2011 (Renewable UK, 2011; Frost and Sullivan, 2012), as can be seen in Table 3.

KEY COMPETITORS

The market is in its pre-commercial stage and is attracting a variety of developers to compete in the technology. The key competitors, their technology and the capacity of the wave power turbines have been collected from different sources (Renewable UK, 2011; Energy Generation and Supply, 2010) and are tabulated below.

TABLE 1: KEY COMPETITORS

S No	Developer	Technology	Type	Capacity	Year
1	Aquamarine Power	Oyster 1	C	0.315 MW	2009
2	Wavegen	Limpet		0.500 MW	2010
3	PWP and E.On	Pelamis	A	0.750 MW	2010
4	Wello Oy			0.500 MW	2011
5	Aquamarine Power	Oyster 2 (UK WET)	C	0.800 MW	2011
6	Hammerfest Strom UK Ltd	Hammerfest Strom		1.000 MW	2011
7	Atlantas Resource Co	AK 1000 (UK WET)		1.000 MW	2011
8	Pelamis and SPR[1]	Pelamis P2	A	1.500 MW	2011
9	Aquamarine Power	Oyster 800	C	2.400 MW	2011
10	AWS Ocean Energy	AWS-III single cell	B	1.250 MW	2012

Technologies such as Oyster and Pelamis are at the forefront with a capacity of 3.315 MW and 2.250 MW respectively. It should be noted that these technologies that are penetrating the market are Type C and A respectively and use the Oscillating Wave Surge Converter and Attenuator as WEC[1]. AWS Ocean Energy has taken a relatively short time to enter the market for a commercial business and is an inspiration for URG.

At the moment, there are over 30 competitors (EMEC) which are tabulated in Appendix A.

FUTURE PROSPECTS

The future of wave power technology is very promising. Marine renewable energy will be a necessity in the long term as a condition of decarbonizing the UK's electricity supply (Carbon Trust, 2010). Pre-commercial wave array demonstrations are planned between 2013 and 2015. The next two years, 2013 and 2014, are expected to bring a significant increase in activity with the deployment of six to eight arrays at a scale of 3–10 MW, totalling an installed capacity of 44 MW, as illustrated in Figure 3.

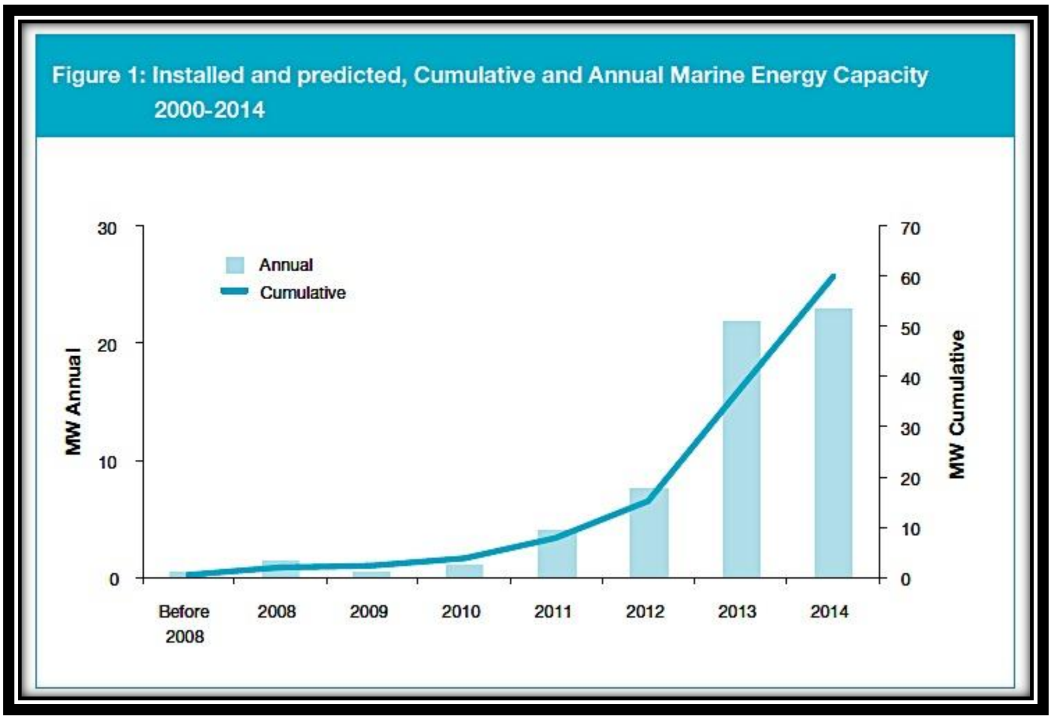


FIGURE 3: INSTALLED AND PREDICTED WAVE ENERGY CAPACITY (RENEWABLE UK, 2011)

By 2020, the UK is expected to produce 1-2 GW of ocean energy; this would supply electricity to 1.4 million homes.

CHAPTER 2: PESTEL ANALYSIS

'*Business does not exist in a vacuum; it exists within an external environment consisting of the actions of other players who are outside the business*' (The Times, 2012). An analysis of the external environment is necessary, as effective marketing strategies cannot be developed without first analysing the environment in which the company operates (Vorontis, 2008). A PESTEL[1] analysis tool was used to analyse the external environment. It included six important factors, as shown in Figure 4 below.

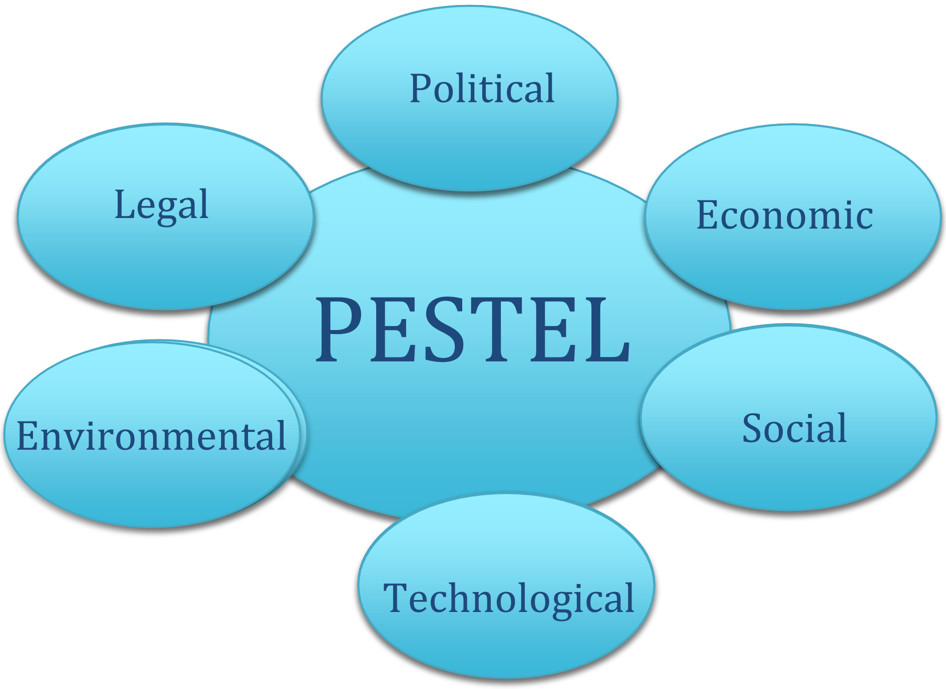


FIGURE 4: PESTEL ANALYSIS

This chapter analyses the four most important trends – political, technological, economic and environmental.

POLITICAL TRENDS

Energy is a major political issue because of concerns over the security of UK energy supplies, the contribution of carbon emissions to global warming and rising energy prices. The UK government is at the forefront of the wave renewable energy industry through its R&D[1] programmes and test facilities (Renewable UK, 2011). This is highlighted in Figure 1 and is detailed below.

RECENT GOVERNMENT CONSENT

The level of government support has significantly increased in the recent past. In October 2011, the UK Government launched its public 'Consultation on proposals for the level of banded support under the Renewables Obligation for the period 2013-17' for England and Wales. The Government is proposing to introduce five ROCs for wave and tidal stream energy up to a 30 MW project capacity for deployment in the period to 2017 (DECC).

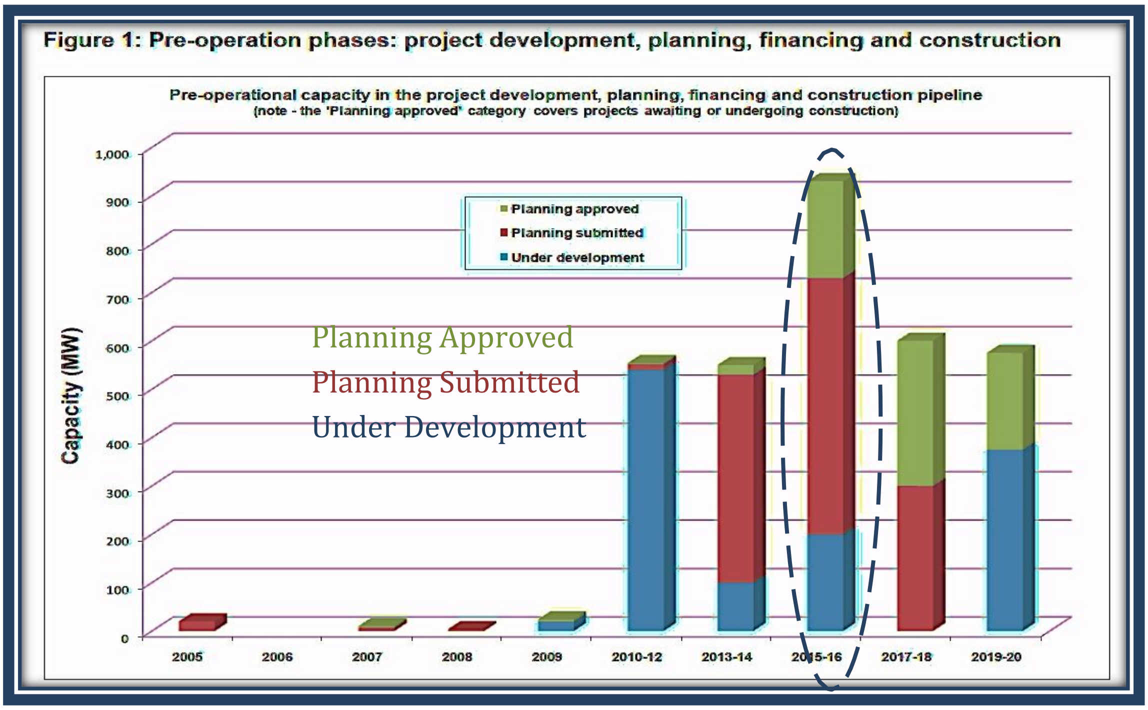


FIGURE 5: WAVE ENERGY PROJECT: DEVELOPMENT, PLANNING AND APPROVAL (DECC, 2011)

A realistic review of this planned activity is reflected in Figure 5 (Landy, 2010) where a total of 300 MW of wave energy prototype devices out of 700 MW of marine energy devices will be awarded planning consent in the next three years.

GRANTS FOR INITIAL CAPITAL COST

The UK has the highest wave energy target for 2020, at 2 GW (Frost and Sullivan, 2012). Access to funding for commercialisation can be a major barrier and which can curb development and deployment. The government is providing market support mechanisms to compensate the current cost gap (Frost and Sullivan, 2012). The RO[1] and financial grants drive the marine energy market (Business Insight, 2010). The major grants so far include:

- £130 million of capital support for marine energy projects during the last 12 months at the scale of 2-10 MW (Frost and Sullivan, 2012)
- £50 million has been set aside as the 'Marine Renewables Deployment Fund' (MRDF) to achieve the 'Marine Energy Action Plan 2010' (BIS, 2009)
- £22 million to offset the large capital cost during the installation stage (The Scottish Government, 2007)
- £8 million for setting up EMEC, an internationally recognised testing facility (BWEA)

PROVISION OF TESTING FACILITIES

The government has been very supportive of marine energy, introducing a number of generous support measures of which a first-class test centre in the form of EMEC is an example. This provides developers with the facilities to test, develop and evaluate their technologies. Other internationally recognised testing facilities include:

- Full scale and part scale testing – EMEC[1], Orkney, Scotland
- Land-based testing – NAREC, Blyth, North East England
- Array testing – WAVEHUB, Cornwall, South West England

PRIZE INCENTIVE

The 'most green government' is appreciating the wave power technology by introducing prize incentives. A £10 million Saltire Prize will be awarded to the team that can demonstrate, in British waters, a commercially viable wave energy technology that achieves a minimum electrical output of 100 GW over a continuous two-year period using only the power of the sea (The Scottish Government, 2011). The timeline of the prize is illustrated in Figure 6 (Scottish Development International).

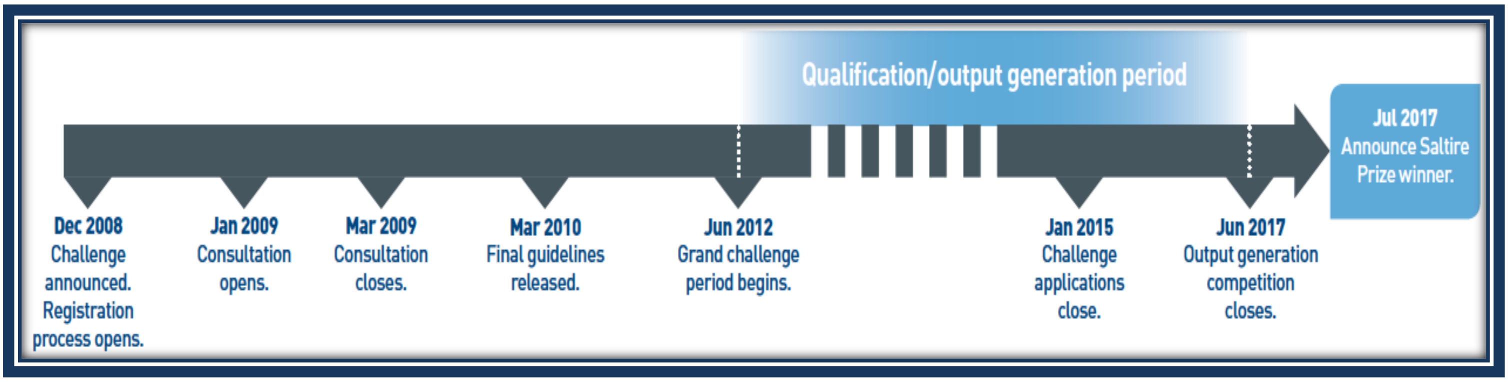


FIGURE 6: TIMELINE OF SALTIRE PRIZE (SCOTTISH DEVELOPMENT INTERNATIONAL)

A sum of up to £20 million has been announced for the development of CCS innovative technologies (DECC, 2012).

COMMERCIAL LEASING

The Crown Estate has awarded commercial leases for ten sites in the Pentland Firth and Orkney Waters for 1.6 GW of marine generation, the first of its kind anywhere in the world (BBC, 2011). It includes 600 MW from wave energy alone (The Crown Estate, 2011). Several other leases (Renewable UK, 2011) include:

- SE Renewables Developments Ltd, 200 MW for Costa Head site
- Aquamarine Power Ltd & SSE Renewables Developments Ltd, 200MW for Brough Head site
- Scottish Power Renewables UK Ltd, 50 MW for Marwick Head site
- E.ON, 50 MW for West Orkney South site
- E.ON, 50 MW for West Orkney Middle South site
- Pelamis Wave Power Ltd, 50 MW for Armadale site.

Any industry is highly reliant on its technology. Wave technology is still very much in its nascent stage and the technical challenges remain significant especially when the variable nature of wave power is considered. This section explores the technological trends in the wave power turbine industry. Broadly speaking, wave power technology develops in five phases as shown in Figure 7.

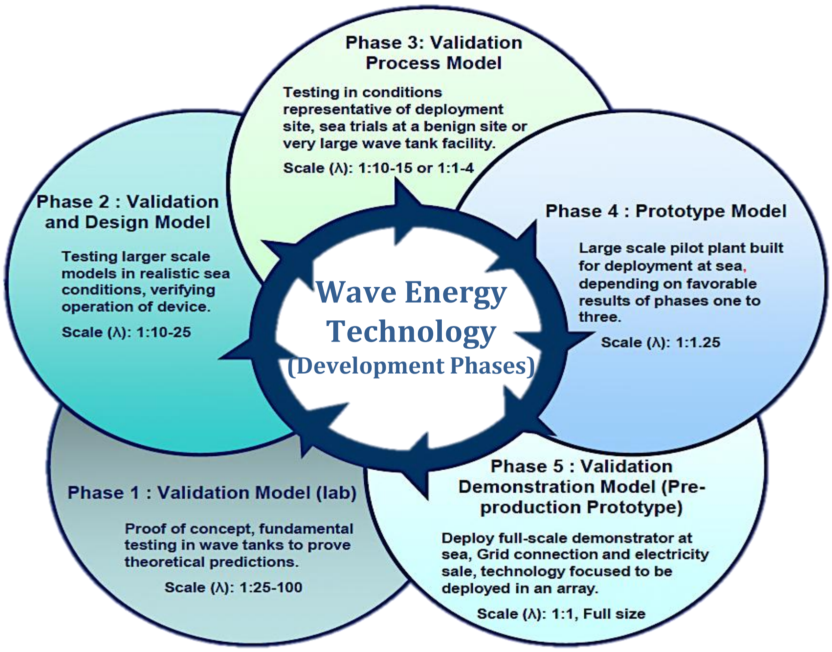


FIGURE 7: PHASES OF WAVE POWER TECHNOLOGY (FROST AND SULLIVAN, 2012)

STATE OF THE CURRENT TECHNOLOGY

There are currently two main types of wave energy technology (Business Insight, 2012):

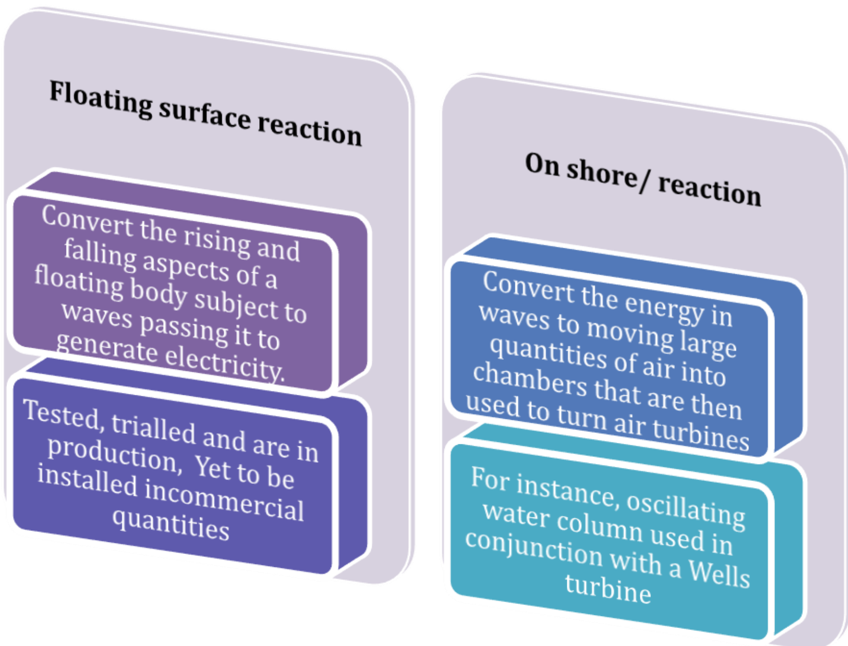


FIGURE 8: CURRENT TECHNOLOGY

UNSATURATED WAVE POWER TECHNOLOGY MARKET

The UK is a global leader in the development of ocean technologies (Fig 2). However, the technology is still in its pre-commercial state as shown in Figure 8 and is undergoing testing in small arrays of 2 – 10 MW (Renewable UK, 2011).

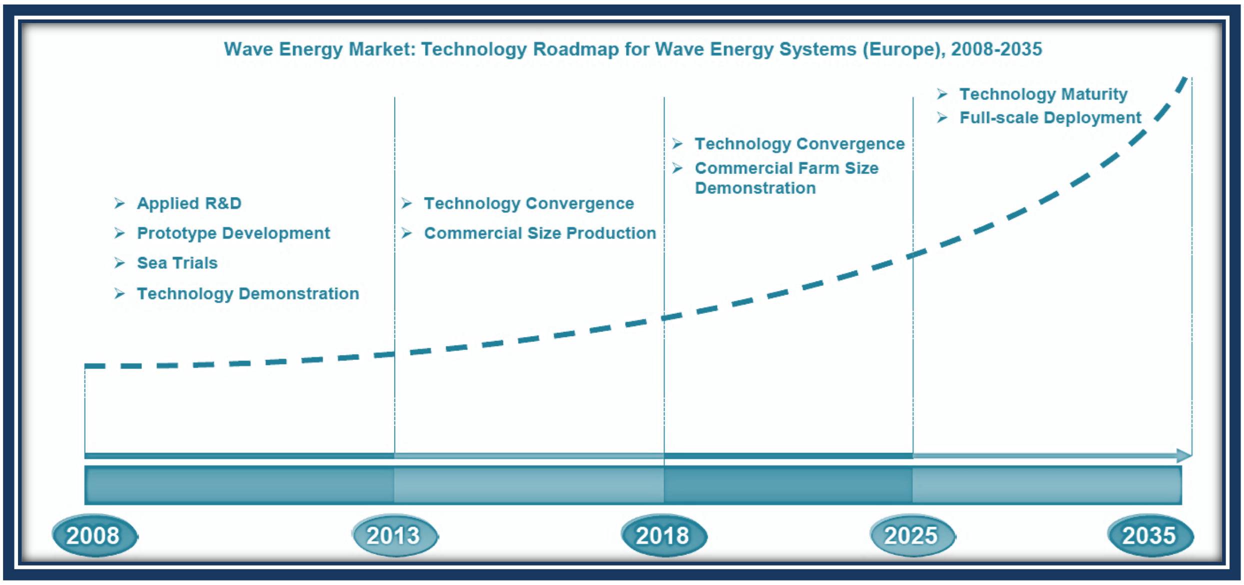


FIGURE 9: TECHNOLOGY ROADMAP FOR WAVE ENERGY (FROST AND SULLIVAN, 2012)

As the market is not mature and lacks any mainstream technology, the number of WEC device concepts will dramatically reduce as the industry matures. Over the long term, this reduction is very likely (Energy Generation and Supply, 2010)

FIRST-CLASS TEST CENTRES

Technology development is one thing; its successful testing and demonstration is another. The UK has world-class test centres as identified in the political trends above. These centres not only provide a free testing environment for the new prototype devices but also assist the wave energy developers in terms of the financial viability of the relevant devices, their capital requirements, and relevant operation and maintenance costs (Business Insight, 2010).

The TSB[1], along with SWRDA, is investing up to £9 million in innovative collaborative R&D and demonstration in the wave energy technologies. (UKERC, 2010)

KNOWLEDGE TRANSFER FROM OFSHORE INDUSTRIES

The wave energy sector can significantly benefit its hardware and engineering capabilities with the knowledge transfer from the offshore oil and gas operations and the offshore wind farms (Frost and Sullivan, 2012). Fostering cross-sectoral technical knowledge, experience, expertise and know-how transfer can reduce costs and efforts in the learning process.

LIMITED AVAILABILITY OF GRID INFRASTRUCTURE

Grid capacity has been an issue for renewable energy as a whole. As the testing of the wave energy has to be conducted in the ocean (offshore), unlike wind or solar, the wave energy projects need to be connected to the grid onshore for the transport of electricity. The issues facing the wave power industry are the availability of a grid, its network capacity and the lack of infrastructure in coastal areas (Frost and Sullivan, 2012).

FEED IN TARRIF

With the advent of feed-in tariffs in 2010 in the UK, there are now many opportunities for renewable and low-carbon technologies, like wave energy, that can, under scrutiny, present a viable business case for investment, coupled with unique sets of added values (Business Insight, 2012). In contrast to the RO then, the FIT for small-scale generation offers both price and market certainty (BERR, 2008).

CHOICE OF LOCATION

When developing wave energy solutions, the most important indicators are wave height and wave period.

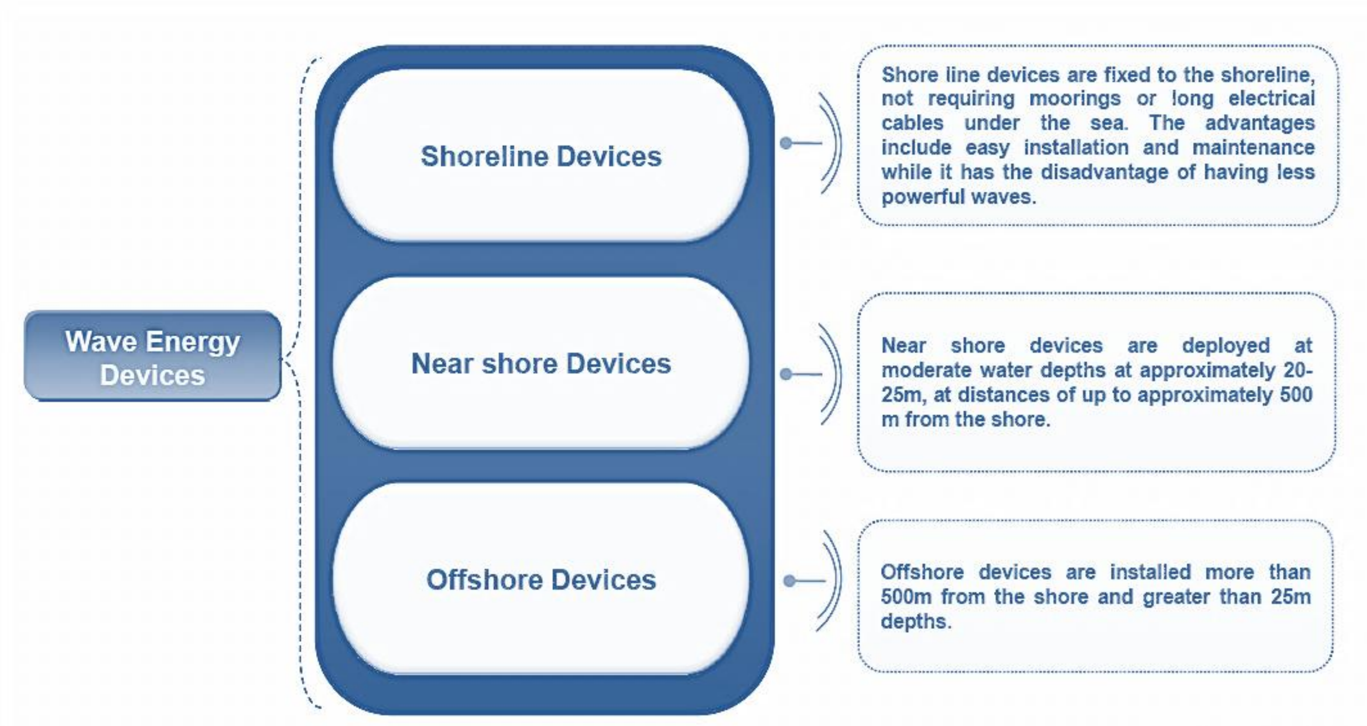


FIGURE 10: GEOGRAPHICAL LOCATION (FROST AND SULLIVAN, 2012)

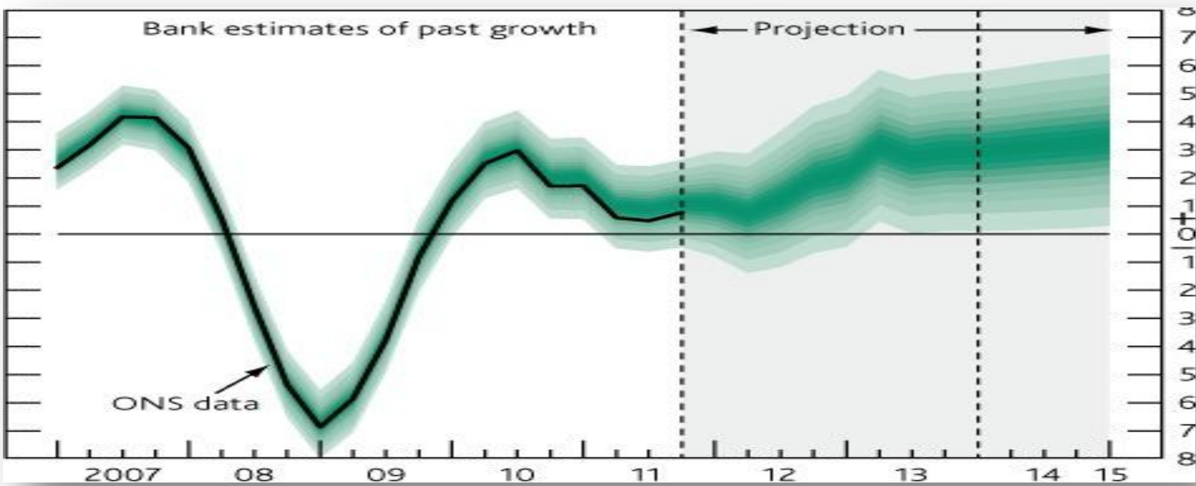
Shore line devices do not require mooring but have the disadvantage of having access to less powerful waves whereas the near-shore and offshore devices have the advantage of being able to utilise higher waves for converting to electricity.

ECONOMIC TRENDS

The future of a nascent industry, particularly when it is in its development stage, depends significantly on the economic situation at the time. This section outlines the key economic trends that can have an impact on wave power technology.

RECESSION

The increasing growth of wave energy very much depends on the financial support of the government. Recessions can affect the ventures of the government if the funding is withdrawn. Figure 11 illustrates the current GDP and forecasts the growth for the next three years (Bank of England, 2012). The economy seems to grow in the next three years and ensures the supply of the funding to the current as well as future long-term wave energy



projects.

FIGURE 11: PERCENTAGE GROWTH IN ECONOMY (BANK OF ENGLAND, 2012)

CAPITAL COST

The total expenditure to set up a wave energy plant that can generate 600 MW is estimated to be £1.8 billion (Brewster, 2011). The installation cost of a standard WEC alone is approximately $2 million (Frost and Sullivan, 2012). Clearly, the high start-up and production costs are a major challenge facing investors and the new entrants. However, the continuous funding from the government, as shown below in Table 2, the increased R&D activity and the provision of testing sites, as highlighted in the above two trends, is encouraging.

	Phase I	Phase II	Phase III	Phase IV	Phase V
Duration (Months)	3-9	6-12	6-36	24-36	24-60
Cost (€, 000)	5-125	50-250	500-2500	5000-15000	
Funding (%)	100-50	100-50	75-50	75-25	0
Grant Type	Capital	Capital	Capital	Capital + FiT[1]	Investment + FiT[1]

TABLE 2: PHASES, THEIR COST AND FUNDING

Capital costs will inevitably fall with time, experience and the growth of the industry. Moreover, the Carbon Trust has organized a MEA fund of £3.5 million with the focus on accelerating progress in cost reduction of wave energy technologies (Carbon Trust, 2011). Likewise, large-scale offshore renewable energy projects will be tendered and hence, offshore transmission owners, rather than energy developers, will absorb the large initial capital cost (Frost and Sullivan, 2012).

PRIVATE FUNDING – AN INCREASING INTEREST FROM THE INVESTORS

Having identified the wave energy resources in the UK, the private sector is showing an increased interest in pushing a number of wave devices from the R&D laboratories and testing tanks to actual sea-trials and operational projects (Frost and Sullivan, 2012). The increasing interest is reflected by the collaboration with other investors in making large investments, as tabulated below (Renewable UK, 2011; Frost and Sullivan, 2012):

TABLE 3: FUNDERS AND FUNDING (RENEWABLE UK, 2011; FROST AND SULLIVAN, 2012)

JOB CREATION

Wave energy is well positioned to contribute to address unemployment in the UK. The manufacturing, transportation, installation, operation and maintenance of wave energy facilities will generate revenue and employment. It is estimated that wave energy has a significant potential for positive economic impact and job creation, with approximately 10 – 12 jobs created per MW. This is illustrated in the Figure 12 below (Renewable UK, 2011):

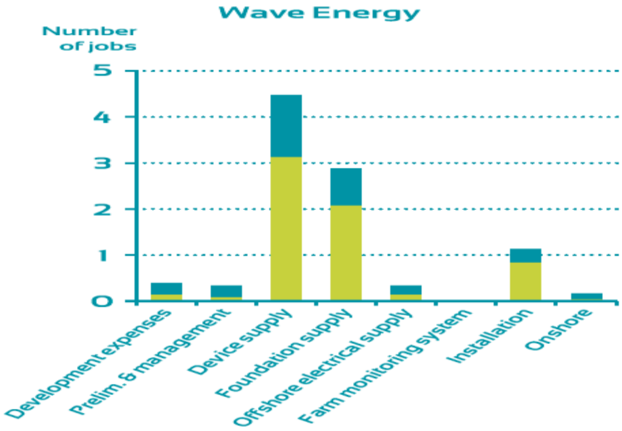


FIGURE 12: JOB CREATION (RENEWABLE UK, 2011)

Funder	Fund	Private Partners	Funding	
			Public	Private
ETI	WET	RR, EOn, EMEC, EDF, GH, PML, UoE	5.2	5.2
ETI	WET	EOn, EDF, GH, UoE, OU, QUB, UoM	4	4
ETI	WET	MacArtney	0.55	0.55
CT	MRPF	PWP Ltd	4.8	8.4
CT	MRPF	AP	4.56	10.44
CT	MRPF	MCT	2.7	3.5
CT	MRPF	HF	3.9	6.8
CT	MRPF	ARC	1.85	4.45
CT	MRPF	Voith	2	8.2
SE, HIE	WATERS	AP	3.15	10
SE, HIE	WATERS	AWS, BCF, STV	1.39	2
TSB, SG, SE, CT, DECC	WATERS, MRPF	AP, BAE, ABB, SSE	8.55	11
TSB	Development of WET	FO, SR, UoE	2.4	5
TSB, CT	Deployment, MRPF	PWP, E.On, RUK	5.9	9

Based on the projections for installed capacity shown in Figure 5, by 2015 the wave energy sector will generate another 850 jobs.

The cost of generating electricity using wave energy is currently high, as is the case for any emerging technology. This can be seen in Figure 13.

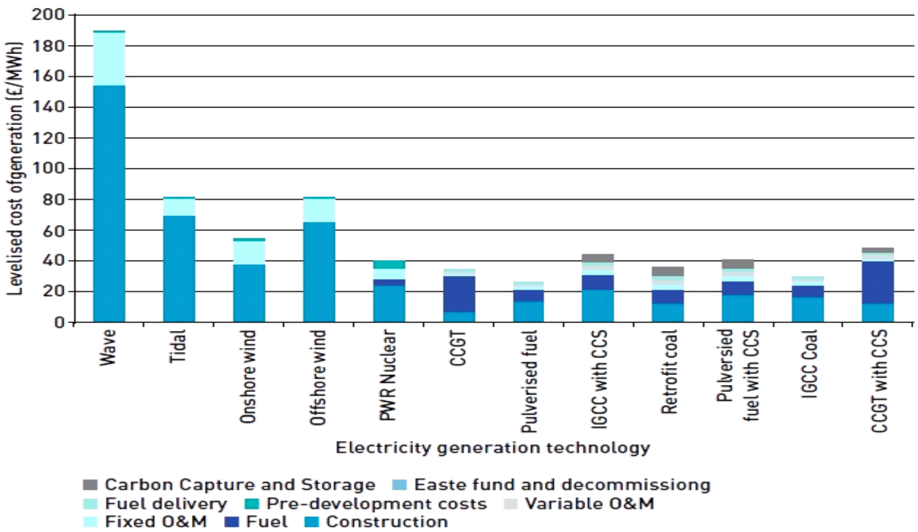


FIGURE 13: LEVELLED COST OF ELECTRICITY GENERATION (FROST AND SULLIVAN, 2012)

The reason for the high levelled cost of generation using this predictable renewable source of energy is the initial installation cost. However, this installation cost will decrease exponentially as soon as the technology moves into the commercial stage. This is elaborated on in Figure 14.

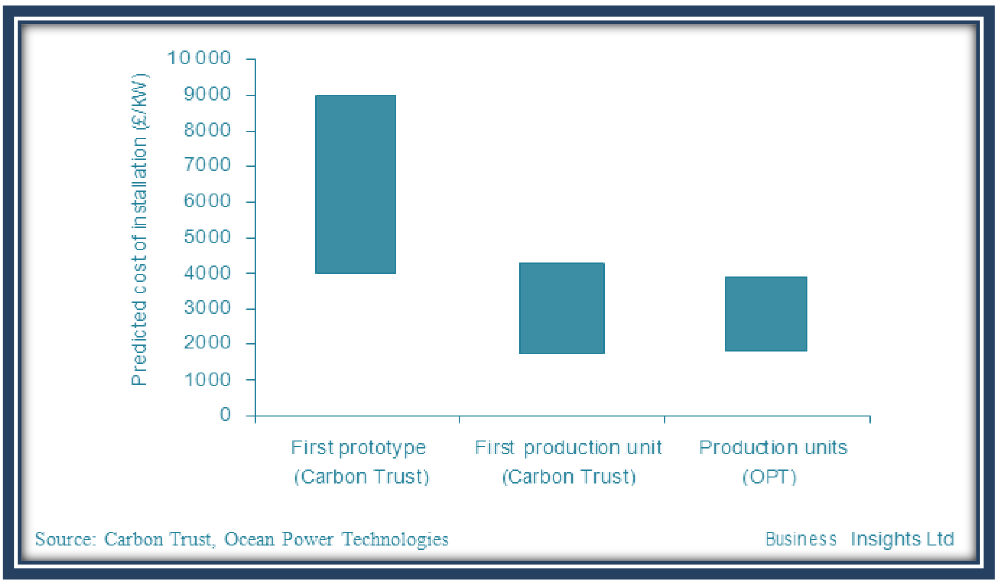


FIGURE 14: PREDICTED COST OF INSTALLATION (BREEZE, 2010)

The cost must be at least as attractive as fossil fuel prices to be worth investment consideration. As the scope of this report is to analyse the market for the next three years, the cost of the generating electricity from this renewable source would remain comparatively high.

ENVIRONMENTAL TRENDS

With the current administration promising to be the 'greenest government ever' (Guardian, 2010), the impact on the wave energy industry becomes self-evident. This section discusses the effect of wave power technology on the environment and compares it with the impact of conventional sources of energy on the environment. The blue arrow on the ocean, in Figure 15 below, depicts how the wave energy resource naturally recycles from one carbon reservoir to another.

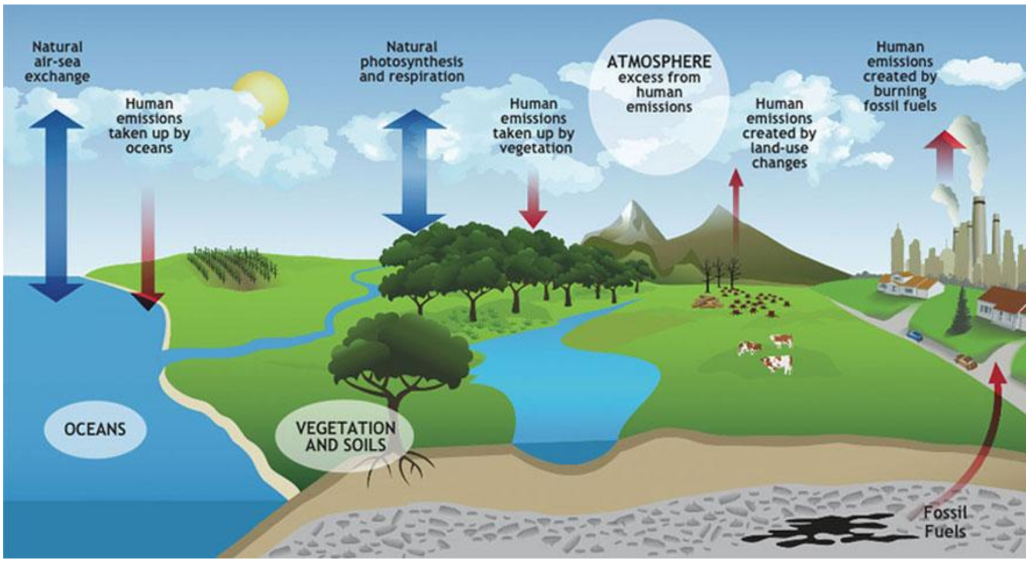
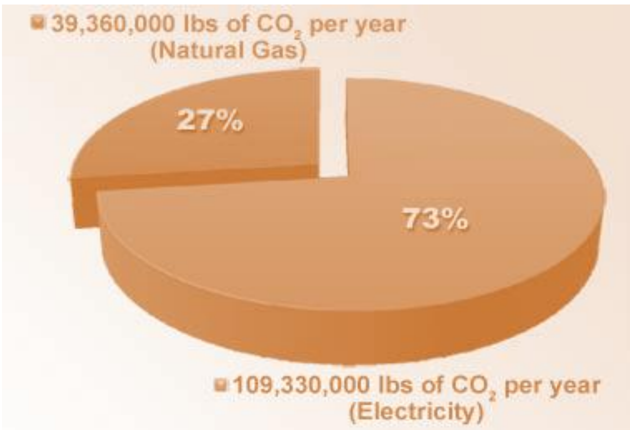


FIGURE 15: THE CARBON CYCLE (LANDSCAPES FOR LIFE)

DECARBONIZING ELECTRICITY SUPPLY

Wave energy will be a necessary condition of decarbonizing the UK's electricity supply (Frost and Sullivan, 2008). Currently, the amount of CO_2 released in generating electricity alone accounts for 73 per cent of the total CO_2 in the atmosphere (UMU). This is shown in Figure



16.

FIGURE 16: CARBON IN ELECTRICITY GENERATION (UMU)

The UK wave energy action plan aims to provide power to 15 million homes and to save 70 million tonnes of CO_2 by 2050 (Business Insight, 2010).

PUBLIC AWARENESS

The increasing environmental awareness in public as well as the government has had a major impact on the wave energy industry. Figure 17 shows that nearly three in ten (28 per cent) adults would prefer a supplier that uses renewable energy (Mintel, 2010). Environmental organisations are taking initiatives to educate about carbon emissions. Companies have also started using carbon footprints to bring make the public more aware of the issues.

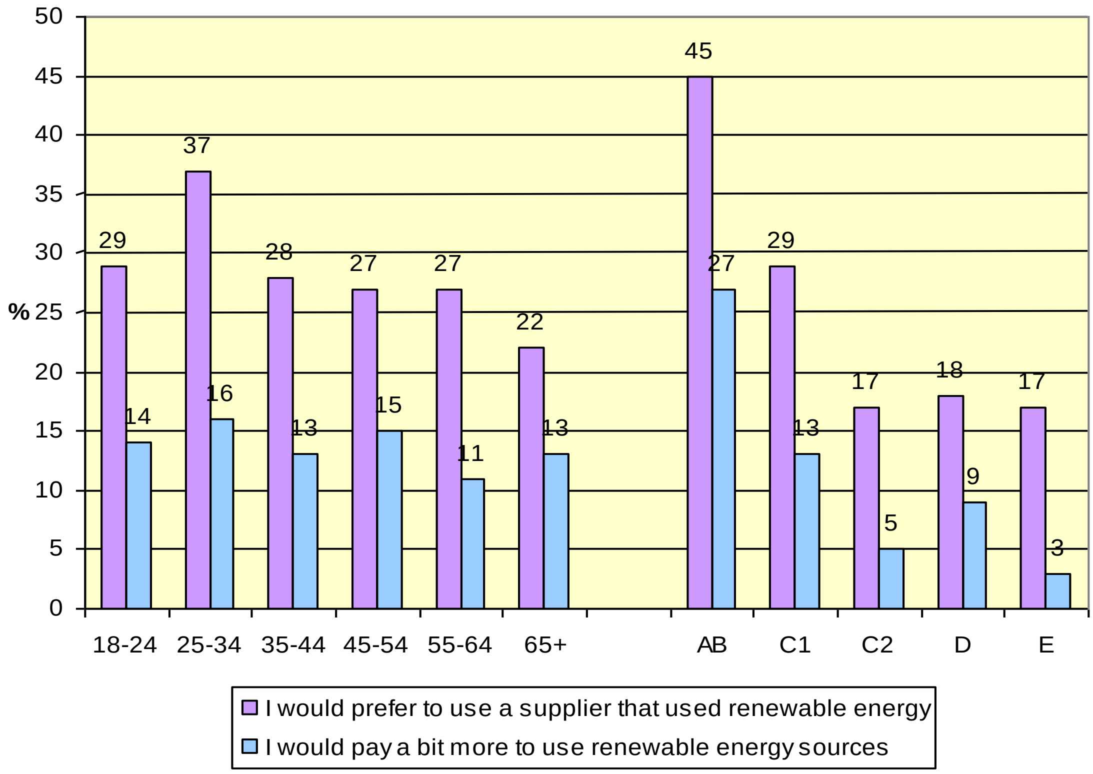


FIGURE 17: PUBLIC ENTHUSIASM FOR RENEWABLE ENERGY (MINTEL, 2010)

STRATEGIC ENVIRONMENTAL ASSESSMENT

UK is now considering the over-all impact on the environment quite seriously. The Scottish Executive has launched a SEA that 'aims to assess the effects of deploying wave and tidal energy devices around the Scottish coastline and the results will be used to inform future policy for the marine renewables industry' (Scottish Government, 2011). Several SEAs have recently been produced or are under development across the UK. The completion of a SEA for wave and tidal energy also shows significant progress.

RENEWABLE UK

The National Renewable Energy Action Plan for the UK (DECC, 2011) identified a three-point action plan:

- Financial support for *renewables*
- Unlocking barriers to delivery
- Developing emerging technologies

This three-point plan is encouraging for the wave power technology developers. Moreover, UK electricity generation will undergo a major shift towards renewables in the coming years as illustrated in the graph below (Black, 2009).

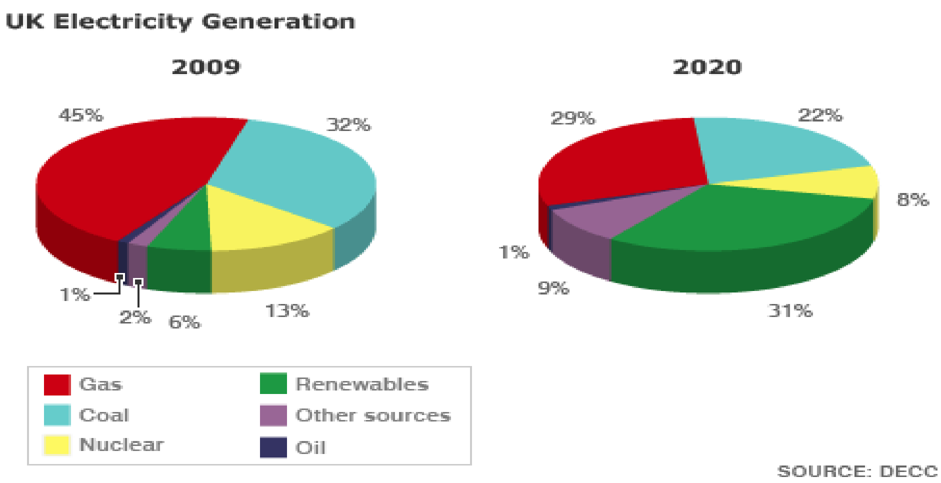


FIGURE 18: SHIFT FROM CONVENTIONAL TO RENEWABLE ENERGY (BLACK, 2009)

It can be extrapolated that, in the worst-case scenario, by 2015, the electricity generated by renewable sources will account for more than 15 per cent of the total electricity. Wind and wave energy would evidently be the major contributors towards the 15 per cent.

It should also be noted that the electricity generated using fossil fuels would show a major decrease.

GREEN INVESTMENT BANK AND LOW-CARBON INNOVATION FUND

Wave power technology is an emerging technology and attracting large amount of funding because of its renewable nature. Low Carbon Emission Fund and Green Investment Bank, as indicated by their names, are dedicated to renewable energy. ICF (International Climate Fund) will be another leading player until 2015 (DECC). It aims to provide climate change-related aid that will account for seven-and-a-half per cent of UK Official Development

Assistance (ODA) by 2015. DECC has allocated £200 million towards 'the development of low-carbon technologies' (Barker, 2011). The £60 million that has been allocated to wind and wave energy is likely to attract most of the remaining £ 140m (Renewable UK, 2011).

CHAPTER III: CONCLUSION

In conclusion, four prospective stakeholders have been assessed for the potential impacts of the proposed wave power technology in the next three years. It can be deduced that the United Kingdom is active in efforts to develop wave energy provided the economy behaves as forecasted by the Bank of England.

From the detailed analysis in Chapter 2, it is evident that there is a well-positioned triangle of political support, industry desire and accessible sites. The potential opportunities and the associated threats for a new wave power turbine technology are illustrated below:

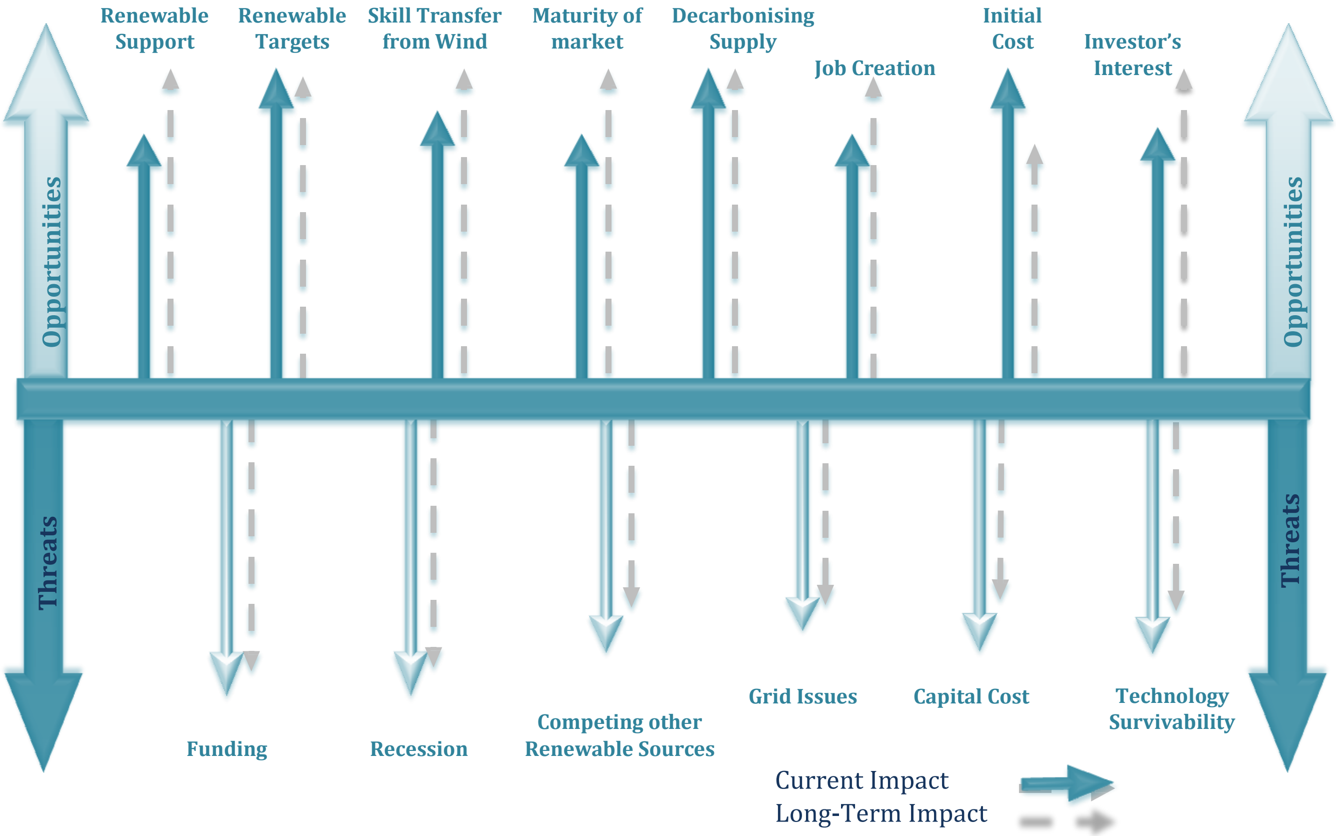


FIGURE 19: OPPORTUNITIES AND THREATS

OPPORTUNITIES

The long-term economic opportunities are very promising and they overshadow the negatives. In the next three years, the start of a turbine business in the marine industry will result in continuous growth.

- With vast global resources in the UK and high targets for renewable energy, rapid expansion and growth is expected in this industry that is at its early stages of development.
- A ripe time for business as the market is unsaturated and is backed by the government funding and favourable policies.
- A cornerstone in mitigating climate change and CO_2 emission, developing the energy mix and creating more than 800 jobs in the next three years.
- Healthy room for innovative technologies in reducing the capital costs to attract funding from the potential investors.
- Learning from other's experiences by transferring skills from the offshore oil and gas operations and wind farms.
- Increasing public awareness of renewable sources of energy
- Far greater potential than solar and wind energy.

THREATS

At present, wave energy devices face a range of challenges that need to be dealt with in order to meet their potential and the industry is now at a critical stage of development. (WET).

- Funding is key and this is very much driven by a signal from the government showing long-term commitment.
- The dwindling economy of the UK and the significant downfall due to recession.
- Higher cost for installation and larger expenditure for operation and maintenance.
- Availability of the grids and the on-going debate over transmission access.
- Lack of operating devices creating uncertainty over future viability, especially since costs are currently high compared to other renewable energy technologies.

RECCOMENDATIONS

A well-positioned triangle of political support, industry desire and accessible sites indicates that the time is ripe for the URG to enter the market with its new innovative technology. There may be an inevitable threat with the withdrawal of financial support that depends upon the recession and the government policies. However, there seems to be little chance of a recession in the next three years (Bank of England, 2012) and the current government's tenure has still got another three years to run.

This industrial report concludes with the following recommendations made to the URG for starting a business in wave power technology:

- Develop a coordinated approach with an aim to fast-track consent of prototypes and pre-commercial arrays
- Keep an eye on the technology of the key competitors; pin down the shortcomings and address the problems in order to secure funding and gain the trust of potential investors
- Employ innovation to cut down the capital cost in generating cheaper electricity
- Foster cross-sectoral technical knowledge, experience and expertise to reduce cost and efforts in the learning process
- Review the UK's R&D capabilities and internationally recognised test facilities to determine how to obtain the greatest benefit from the services available
- Make use of the financial incentive schemes from the government and keep environmental impact under consideration
- Keep tabs on the dwindling economy, changes in the government policies and progress with the grid issues
- Attend the European energy conference to be held on 17 April, 2012 to keep updated about the latest progress in the sector

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APPENDIX A

Key Competitors (EMEC):

S No	Company	Technology	Device type
1	**Atlantis Resources Corp**	AK-1000	A
2	**Hydromine**	The Hydro Mine	-
3	**Firth Tidal Energy**	Sea Caisson & Turbine System	A
4	**Hales Energy Ltd**	Hales Tidal Turbine	A
5	**Marine Current Turbines**	Seagen, Seaflow	A
6	**Nautricity Ltd**	CoRMaT	A
7	**Ocean Flow Energy**	Evopod	A
8	**Rotech**	Rotech Tidal Turbine	A
9	**Scotrenewables**	SR250	A
10	**SMD Hydrovision**	TiDEL	A
11	**Sustainable Marine**	PLAT-O	A
12	**Starfish Electronics Ltd**	StarTider	A
13	**Swanturbines Ltd**	Swan Turbine	A
14	**Tidal Energy Ltd**	Delta Stream	A
15	**Tidal Generation Limited**	Deep-gen	A
16	**TidalStream**	TidalStream triton Platform	A
17	**Lunar Energy**	Rotech Tidal Turbine	A/D
18	**Current2Current**	Tidal turbine	B
19	**Edinburgh Designs**	Vertical-axs, variable pitch tidal	B
20	**Kepler Energy**	Transverse Horizontal Axis	B
21	**Neptune Renewable Energy**	Proteus	B
22	**Pulse Tidal**	Pulse-Stream	C
23	**The Engineering Business**	Stingray	C
24	**Hydroventuri**	Rochester Venturi	D
25	**Aquascientific**	Aquascientific turbine	E
26	**Greener Works Limited**	Relentless Turbine	E
27	**Greenheat Systems Ltd**	Gentec Venturi	E
28	**Rugged Renewbales**	Savonius Turbine	E
29	**Tidal Electric**	Tidal Lagoons	E
30	**Woodshed Technologies**	Tidal Delay	E

APPENDIX B

PESTEL Analysis:

Political	• Government promising to be 'the greenest government ever' and to deliver 'measures to support marine energy' • High future targets for renewable energy sources and ROCs • Growing financial assistance • Provision of first-class test centres like EMEC • Leasing of sites for wave power deployment • Prize incentives
Economical	• Dwindling economy • Risk of recession and consequent withdrawal of funding • Generation of employment • In long term, huge amount of turnover which is beneficial for the economy.
Social	• Job creation • Benefitting people who are trying to cut carbon emission • A more economical source of generating electricity in the long run
Technological	• Unsaturated technology • First-class test centres • Learning from the experiences of offshore oil and gas production and wave energy farms at low cost • Innovative ideas to lower the capital cost • Fish-friendly turbines
Environmental	• Decarbonising the carbon supply • Public awareness and attracting potential investors • Diminishing conventional sources of energy and an opportunity to meet the electricity demands in the form of renewable energy
Legal	• Leasing the sites • Government acts and bills supporting wave energy • High renewable energy targets • Establishing the relevant departments to foster the development of wave energy

GLOSSARY

TSB	Technology Strategy Board
DECC	Department of Energy and Climate Change
EMEC	European Marine Energy Centre
URG	University Research Group
SWRDA	South West Regional Development Authority
R & D	Research and Development
ROC	Renewable Obligation Certificate
FiT	Feed in Tariff
WEC	Wave Energy Converter
GDP	Gross Domestic Product
MEA	Marine Energy Accelerator
CCS	Carbon Capture and Storage
SEA	Strategic Environmental Assessment