Wave and Tidal Energy Market –

Global Industry Analysis, Size, Share, Growth Trends and Forecast

2016 – 2024

Transparency Market Research

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Chapter 1 Preface

1.1 Report Description

This research study analyzes the market size of the wave and tidal energy in terms of installed capacity (MW) and market revenue (US$ Mn) for the forecast period from 2016 to 2024. The market has been broadly segmented based on type and geography. Based on type, the market has been segmented as wave energy and tidal energy. Regional segmentation has been done as North America, Europe, Asia Pacific, and Rest of World (RoW). Market data, in terms of installed capacity and revenue, has been provided on a regional as well as country level. Detailed cost breakdown analysis of both wave and tidal energy plants has also been done in the study. Company market share in the sector for both wave and tidal energy plants have been shown separately for 2014. Revenue of some of the major companies could not be found for the year 2015, thus, company market share has been calculated for the year 2014.

Wave and tidal energy are essentially methods to harness the energy of the oceans for generation of power. These forms of renewable energy are increasingly grabbing the attention of countries around the world as they provide a constant and steady source of clean energy. Abundance of ocean surface and significant generation potential in nations across the world has led governments to pursue ocean energy generation as a vital part of their future renewable energy mix. Venture capital funding and government grant schemes are the vital aspects of this sector. Currently, technology development and commercial deployment of projects is at the nascent stage. Tidal energy can be broadly segmented into tidal barrage and tidal stream energy. Tidal barrage energy is a mature technology, with large-scale plant installations in France and South Korea. Thirteen countries have been analyzed separately with forecasts for installed capacity and revenue. Country-wise markets for wave, tidal or both forms of energy have been provided individually, depending upon the investment sentiment in the respective economies.

The report includes Porter's five forces model, value chain analysis and market attractiveness analysis. The attractiveness analysis is provided separately for wave and tidal energy. A detailed regulatory roadmap has been provided with incentive schemes and policy structures of governments around the world supporting ocean energy development. Tables highlighting financial grant and incentive schemes awarded to technology developers have been provided. An

important part of this report is the individual plant data, which gives a clear idea of the upcoming projects in each region. The names of said projects have been provided along with other information such as developer information, capacity declared, date of commissioning, country of commissioning and present status. Major market players in the wave and tidal energy business have been profiled in this market study. These include Pelamis Wave Power Ltd., Atlantis Resources Limited, Ocean Power Technologies Ltd. and Carnegie Wave Energy Limited. The report provides an overview of these companies followed by their financial revenues, business strategies, SWOT analysis and recent developments.

1.2 Research Scope

This research is designed to estimate, analyze and forecast the installed capacity and investments (revenue) of the wave and tidal energy market across the globe, on both regional and country levels. The research provides an in-depth analysis of the wave and tidal energy industry players, growth projections in installed capacity, trend analysis by type, and market revenue by geography. It broadly segments the market based on types as wave energy and tidal energy. On the regional front, the market has been segmented as Europe, North America, Asia Pacific, and Rest of World (RoW). Both capacity and market revenue has been provided for regional and country-specific segments in the market study. The report provides statistically refined forecasts for the regional segments covered, along with detailed plant capacity analysis.

The market for wave and tidal energy plants has been estimated based on individual plant capacity analysis. All the plants taken into account for conducting this market study have been separately represented in the regional segmentation chapter. Any project that has been proposed but is not included in the project list provided by us is either out of the scope of our market study or lacks sufficient information in the public domain. Detailed primary interviews and extensive secondary research was conducted for validating the estimated completion times for each project. Qualitative analysis such as historical installation trends, government policy structure and project deployment experience of the company were considered while including projects for computing market size. Projects that have not satisfied the validation procedures used for the study have been excluded from market size calculation, but shown nonetheless in the proposed plant tables. The revenue figures calculated indicate investments in the wave and tidal energy sector for addition of capacity in the forecast period. A cumulative revenue figure for the forecast period has been computed depending upon the year-on-year capacity installations on the country level. This

has ensured a better estimation of market growth rate. Revenues from power sales have not been accounted for because it is not possible to estimate the levelized cost of electricity (LCOE) the plants would generate. Since the electricity generated from such plants is not cost competitive and developers are yet to sign long-term sales contracts with utilities, revenues from electricity sales have not been considered in the study.

Tidal power generally comprises tidal barrage and tidal stream power plants. Although the type of tidal power plant has been specified project-wise within the qualitative write-up, sub-segmentations for tidal energy have not been given while computing market size. Both tidal barrage and tidal stream plants have been accounted together in the tidal energy market. Sub-segmentation of the wave energy market was not possible as every technology developer has different wave energy converter designs with no single design leading the market. The market size has been computed solely based on the expected wave and tidal energy projects to come online during the forecast period. Certain countries had specific installation targets for either wave or tidal energy. Countries such as South Korea that invest extensively in tidal energy have little or no investments in the wave energy sector. For such countries, the wave energy segment has not been considered while computing market size.

As revenue figures denote investments, project capacities were added in phases according to our market calculations. This gives a better estimation of the phased nature in which funds are allocated for commissioning of capacity. A detailed cost breakdown of both wave and tidal power plants has been analyzed separately. The tentative cost projections have been done for each cost component up to the end of the forecast horizon and subsequently used to arrive at the market revenue figures. Certain countries where specific project details were not given but had promising future prospects had their market sizes computed based on assumptions which have been explained in detail in the qualitative analysis. Plant cost reduction opportunities, regulatory roadmap and financial incentive schemes being provided have been analyzed separately to provide a clear view on the overall investment sentiment in this particular market.

- **Wave and Tidal Energy Market: Type Analysis**

Wave Power Plants

Tidal Power Plants

- **Wave and Tidal Energy Market: Regional Analysis**

Europe

- Scotland
- The U.K.
- France
- Norway
- Russia
- Rest of Europe

Asia Pacific

- South Korea
- Australia
- China
- Rest of Asia Pacific

North America

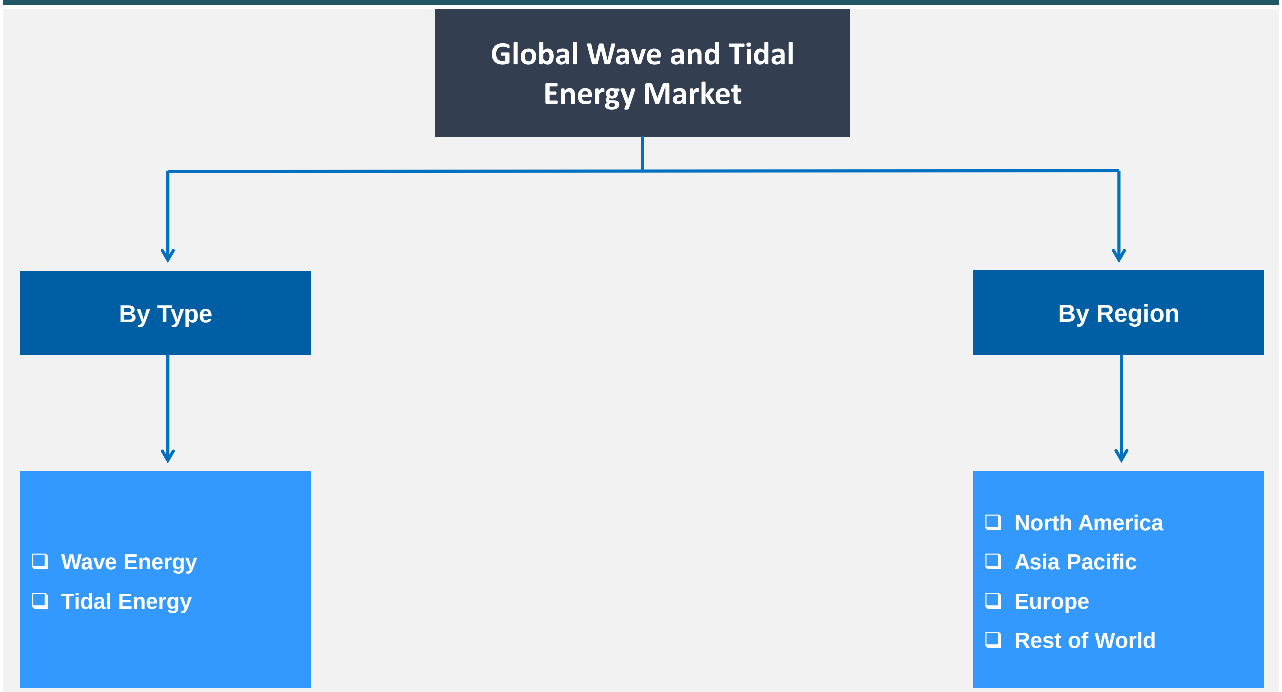
- The U.S.
- Canada
- Mexico

Rest of World

- South Africa
- Ghana
- Other Countries

1.3 Market Segmentation

FIG. 1 Wave and Tidal Energy: Market segmentation



1.4 Research Methodology

For the research report, we conducted in-depth interviews and discussions with a wide range of key industry participants and opinion leaders. Primary research represents the bulk of our research efforts, supplemented by an extensive secondary research. We reviewed key players' product literature, annual reports, press releases, and relevant documents for competitive analysis and market understanding.

Secondary research comprised a study of recent trade journals, technical writing, internet sources, and statistical data from government websites, trade associations and agencies. This has proven to be the most reliable, effective and successful approach for obtaining precise market data, capturing industry participants' insights and recognizing business opportunities.

For this study, the following methodology was used:

The market for both wave and tidal energy is extremely minute compared to other forms of power generation. Most of the wave energy plants in operation today are prototypes or pilot projects. For tidal power plants, tidal barrage plants are a relatively older technology, which is very similar to the extraction of hydrokinetic energy. On the other hand, tidal stream plants are a newer technology. We have taken the bottom-up approach to arrive at the market size. Individual plant capacities were analyzed initially and added to arrive at country-wise capacity additions. Primary interviews were attempted for validating plant capacities and tentative dates of commissioning. For those plants where the outcomes of primary interviews were not successful, secondary research was carried out to identify tentative progress of each project. Plants that could not be verified through either primary or secondary sources were excluded from the scope of the study. Country-wise capacities were determined from individual project capacities and were added up to form the regional and global markets. Some of the salient features of the methodology are:

- Plant costs are highly dependent upon a number of extraneous factors. An average plant cost was taken for market calculations. The cost may vary from project to project. Plant costs indicate the lifetime costs for tidal stream plants. These include the O&M expenditure. This cost is used for calculating the levelized cost of electricity (LCOE) generated from the plant and is higher than construction costs.
- The tidal stream and wave power plant costs are likely to decrease. The rates at which they are expected to decrease have been verified from both secondary and primary sources. This decline in plant costs is solely dependent upon the rate of commercial array deployment.
- Exact cost figures for tidal barrages were difficult to come by and depended regionally. The cost breakdowns shown in tidal plants are for tidal stream power plants. The costs of tidal barrage plants have been taken separately.
- While all the projects that have been planned, proposed or are under development have been shown, they have not been accounted for while calculating market size. Only projects verified through primary or secondary sources have been incorporated in the study. Current statuses of certain projects have been analyzed qualitatively and incorporated as well.
- As most technology developers have their own separate technology, segmentation for such was not possible. Tidal barrage and tidal stream plants have been accounted for together under tidal energy.

- Countries with a historic trend of commissioning and installing large-scale plants on time such as South Korea have been considered in the market study, irrespective of validation through primary sources. In such cases, a margin of error has been kept (i.e. a certain percentage of the total capacity to be added has been accounted for to allow for overrun in deadlines or other snags).
- Even though Scotland is essentially a part of the U.K., it has been accounted for separately in this market study. This is because a large number of plants are being established in Scotland. Similarly, multiple plants are scheduled to be commissioned in the U.K with minimal details regarding the country of installation. For this particular study, Scotland is considered a separate segment, while the U.K. refers to countries in the United Kingdom, excluding Scotland.
- For market calculation purposes, we have assumed that a project is likely to be completed in phases. For example, a plant of 30 MW capacity due to be commissioned in 2017 might have 10 MW commissioned in 2016 with the balance coming online in 2017. This was done to provide better accuracy to the market revenue (investment) figures. A plant being commissioned in 2017 does not necessarily mean that all of the investment is done in that year itself.
- All the revenue figures in US$ Mn denote the expenditure carried out by market players in this particular segment. It does not refer to the revenue generated through power sales. Power sales revenue was not considered because rates of generation are yet to be cost competitive and most developers of ocean energy still lack long-term power sales contracts.

Secondary Research

Secondary research sources that were referred to include, but are not limited to:

Company websites, annual reports, financial reports, broker reports, investor presentations, and SEC filings

Industry trade journals, scientific journals and other technical literature

Internal and external proprietary databases, and relevant patent and regulatory databases

National government documents, statistical databases and market reports

News articles, press releases and webcasts specific to companies operating in the market

Other secondary sources include:

- Company websites
- The Carbon Trust
- The Sustainable Energy Authority of Ireland (SEAI)
- The European Marine Energy Centre (EMEC)
- The Ocean Renewable Energy Group (OREG)
- The Scottish Renewables Forum
- The International Energy Agency (IEA)

Primary Research

We conducted primary interviews with a majority of technology developers in the market. The interviews were conducted with the purpose of identifying key market drivers, restraints and opportunities. Primary interviews were also conducted to validate the plant capacity data from the respective companies that had planned to add such capacities. Data obtained through such primary interviews and not publicly available through secondary findings has been incorporated in the market study as well.

Participants who typically take part in such a process include, but are not limited to:

- Industry participants: CEOs, VPs, marketing/product managers, market intelligence managers and national sales managers
- Purchasing managers, technical personnel, distributors, and resellers of technology developing companies
- Key opinion leaders specializing in various areas corresponding to different industry verticals

Companies that participated in primary interviews include, but are not limited to:

- Pelamis Wave Power
- Marine Current Turbines Ltd.

- DP Marine Energy Ltd.
- Tidal Lagoon (Swansea Bay) Plc.
- Bio Power Systems Ltd.
- Tidal Energy Ltd.

Models

Where no hard data is available, we use models and estimates to produce comprehensive data sets. A rigorous methodology is adopted, wherein the available hard data is cross-referenced with the following data types to produce estimates:

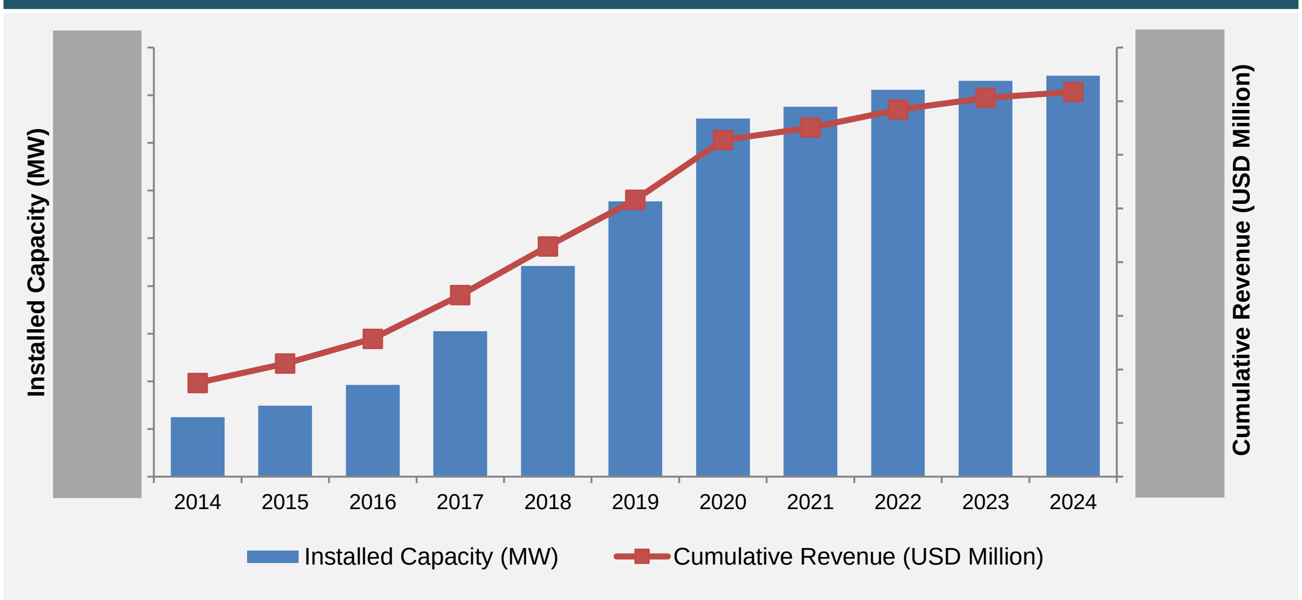
- Historical project installation trends of a country
- Technology maturity of a company. Experience in large-scale array deployment of a country.
- Macroeconomic factors in a particular region or country
- Government support initiatives and rate of project approval in a country or region

Chapter 2 Executive Summary

The global wave and tidal energy market stood at US$ XX.X Mn in 2014 and is expected to reach US$ XX.X Mn in 2024, expanding at a CAGR of XX.X% from 2016 to 2024. In terms of installed capacity, the market stood at XX.X MW in 2014 and is likely to reach XX.X MW in 2024, expanding

with tidal stream plants accounting for the remaining share.

FIG. 2 Global Wave and Tidal Energy Market Volume and Revenue, 2014 – 2024 (MW) (US$ Mn)



Source: Scottish Renewables Forum, EMEC, Carbon Trust, OREG, Tethys, NREL, IEA, European Ocean Energy Association, European Renewable Energy Council (EREC), Transparency Market Research

Tidal barrages are a proven technology for power generation with the oldest plant (La Rance) in France commissioned as early as 1966. Currently, South Korea's Sihwa Lake Tidal Power Station

is the largest tidal barrage in the world. While capacity additions in tidal barrages would be attributed primarily to South Korea, tidal stream power plants would find higher deployment rates in Europe, followed by North America. The APAC region would account for nearly XX.X% of the tidal power plants to be commissioned in the forecast period with Europe, North America, and Rest of World accounting for XX.X%, XX.X%, and XX.X%, respectively. Tidal stream power plants are still to achieve the large-scale commercial deployment phase. The sector is still focused on research and development of new turbine technology. Scotland and the U.K. would account for over XX.X MW of tidal stream plant capacity additions during the forecast period. The regions would lead in tidal stream project deployment. Tidal barrages entail large construction costs and have high environmental impacts.

The wave energy sector is likely to be dominated by Europe, followed by the Asia Pacific. Europe accounted for more than XX.X% of the wave energy installed capacity in 2015, followed by Asia Pacific and North America at XX.X% and XX.X%, respectively. The wave energy market in Asia Pacific is likely to be led by Australia. Limited project development is expected in North America during the forecast period. North America’s focus is towards tidal energy, with a project in Canada by Marine Current Turbines Ltd and Bluewater Energy Services B.V and a project in Alaska by Turnagain Arm Tidal Power Corporation among others.

TABLE 1 Global Wave and Tidal Energy Market: Snapshot

Parameter	2014	2024
Global Revenue of Wave and Tidal Energy Market (US$ Mn)	XX	XX
Global Volume of Wave and Tidal Energy Market (MW)	XX	XX
CAGR (%) Wave and Tidal Energy Market 2016 – 2024	Volume: XX %	Revenue: XX %
Geographic Share, Wave and Tidal Energy Installed Capacity (% volume basis)	North America: XX % Europe: XX % Asia Pacific: XX% Rest of World: XX%	North America: XX% Europe: XX % Asia Pacific: XX % Rest of World: XX%
Type Segment Share Wave and Tidal Energy Market (% volume basis)	Wave Energy: XX % Tidal Energy: XX %	Wave Energy: XX % Tidal Energy: XX %
Overall Tidal Energy Market Key Participant Share, 2014 (%)	Korea Water Resources Corporation: XX % Électricité de France S.A: XX % Nova Scotia Power Inc.: XX % Others: XX %	
Overall Wave Energy Market Key Participant Share, 2014 (%)	Aquamarine Power Ltd: XX % S.D.E Energy Ltd.: XX % Fortum Corporation: XX % Ocean Power Technologies Ltd.: XX % Ente Vasco de la Energía: XX % Others: XX %	

Scottish Renewables Forum, EMEC, Carbon Trust, OREG, Tethys, NREL, IEA, European Ocean Energy Association, European Renewable Energy Council (EREC), Transparency Market Research

The wave and tidal energy market has been broadly segmented based on type as wave energy and tidal energy. Europe occupied XX.X% of the wave and tidal energy market share in 2014. Its share is likely to decrease to XX.X% by 2024. This is ascribed to the high level of tidal energy capacity addition by South Korea, bringing Asia-Pacific's share in the market from XX.X% in 2014 to XX.X% in 2024. The installed wave and tidal energy capacity in the Asia-Pacific stood at XX.X MW in 2014 and is expected to reach XX.X MW in 2024, expanding at a CAGR of XX.X% from 2016 to 2024. In the European region, the installed wave and tidal energy capacity stood at XX.X MW in 2014 and is anticipated to reach XX.X MW in 2024, expanding at a CAGR of XX.X% from 2016 to 2024. In North America, the wave and tidal installed capacity stood at XX.X MW in 2014

and is projected to reach XX.X MW in 2024, expanding at a CAGR of XX.X% from 2016 to 2024. In Rest of World, the wave and tidal installed capacity stood at XX.X MW in 2016 and is projected to reach XX.X MW in 2024, expanding at a CAGR of XX.X% from 2016 to 2024. The high growth rate in Rest of World is attributed to large scale wave and tidal power capacity additions in countries such as South Africa, Ghana, and Brazil among others during the forecast period. The share of wave energy in the global installed capacity as of 2014 stood at around XX.X% as compared to tidal energy's XX.X%. The share of wave energy is likely to grow to around XX.X% in 2024, while tidal energy's share would reduce to XX.X%.

Lower technology development in wave energy devices leads to higher cost/MW for wave power plants as compared to tidal power plants. Wave energy plants had an average lifetime cost of US$ XX.X Mn/ MW in 2014. For tidal barrage plants, the construction cost stood at US$ XX.X Mn/ MW in 2014. Costs of tidal stream power plants are significantly higher. Technological advancements would significantly reduce plant costs for tidal stream; however, the trend would not be the same for tidal barrages. Large tidal barrages involve huge construction costs, which are subject to increase in labor and material costs. This coupled with environment restoration costs to be incurred resulted in an increase in costs for tidal barrage plants. Wave energy converter devices are likely to indicate major reductions in price, accounting for the higher cost decline rate in wave power plants. Key participants in the market include Pelamis Wave Power, Marine Current Turbines Ltd., DP Marine Energy Ltd., Tidal Lagoon (Swansea Bay) Plc, Bio Power Systems Ltd. and Tidal Energy Ltd.

Chapter 3 Market Overview

3.1 Introduction

Oceans are an enormous source of renewable energy waiting to be harnessed. However, in this research report, we have only discussed two methods of generating ocean energy: wave energy

Tidal energy generation can be broadly classified as tidal range energy and tidal stream energy. Tidal range energy is generated by utilizing the vertical difference between a high tide and the

Scotland is the R&D hub for both the wave energy and tidal energy industries, along with the U.K. In the Asia Pacific region, Australia is showing promising prospects for growth, especially in the wave energy industry. With major grant schemes in Europe, the region is exhibiting potential to emerge as the lead market in the future. In North America, several investments have been made in the Bay of Fundy, Canada. Similar investments are also likely to be made in South Korea, mainly in tidal range energy. Even though the ocean energy industry shows promise for growth in the future, it may still face stiff competition from renewable and conventional forms of energy, especially in cost competitiveness. Rapid, large-scale array deployment, to acquire economies of scale benefits seems to be the only feasible option for companies to achieve financial independence.

3.2 Value Chain Analysis

The value chain for the wave and tidal energy industries is a complex one, with nearly five

most value in the industry. With increasing technological improvements, the industry is witnessing large-scale technological deployment and commercialization as well.

Manufacturers and suppliers are mainly original equipment manufacturers (OEMs). A strong industry sentiment exists towards diversifying this business in the future. Numerous companies, which deal with technology development, have been acquired by major OEMs as a step towards business expansion. However, most technology developers generally prefer to assemble the

technology themselves, resulting in equipment purchases getting restricted to component procurement. The market reach of such suppliers and manufacturers are likely to remain restricted to minor, yet reliable component supply. Full-scale generation equipment manufacturing or supply is not likely to be observed until the technology itself matures. Till then, a high level of integration for technology developers and manufacturers is likely to be observed.

FIG. 3 Value chain analysis of Wave and Tidal Energy

sSource: Transparency Market Research

Project development on a large-scale requires high levels of mobilization and commercialization

sector. However, as more technologies become commercially viable, increasing market entrants may be observed. Such EPC contractors may also integrate their business with equipment supply and manufacture to steepen the learning curve. However, it would be unlikely for technology developers to move into the EPC contracting business as it requires enormous capital base. EPC contractors might provide O&M services in the future. Moreover, there is a higher chance for technology developers to enter the O&M business. This is largely due to their better understanding of the technology, which helps them justify the O&M contract better. Long-term contracts may be observed between technology developers and component suppliers for participating in the O&M business competitively.

Even though, at present, power generated from wave and tidal plants are not cost competitive

3.3 Market Drivers

TABLE 2 Drivers of Wave and Tidal Energy Market: Impact Analysis

Market Drivers	2015 - 18	2018 - 21	2021 - 24
	Impact		
Predictable and constant source of renewable energy	High	XX	XX
Scalability within a small area allowing large project development in phases	XX	XX	XX
Generation of power for remote locations where drawing grid connections are not cost effective or feasible	XX	XX	XX
Conducive government policy framework and incentive schemes	XX	XX	XX

Source: Transparency Market Research

3.3.1 Predictable and constant source of renewable energy

Numerous global firms are investing in ocean energy resource development owing to the

energy generation. Water bodies cover more than 72% of the earth's surface, thus providing an abundant source of renewable energy. Locations with the best potential for wave power include the western seaboard of Europe, the Pacific coastlines of North America and South America, and the northern coast of Australia and New Zealand.

The annual intensity of waves at certain locations follows a specific trend that is relatively

3.4 Market Restraints

TABLE 3 Restraints of Wave and Tidal Energy Market: Impact Analysis

Market Restraints	2015 - 18	2018 - 21	2021 - 24
	Impact		
High capital investments and lack of funding channels	High	XX	XX
Lack of commercial deployment of projects due to low Technology maturity	XX	XX	XX

3.4.1 High capital investments and lack of funding channels

The operating expenses of ocean power plants are moderate. However, the initial installation

The general trend in the wave energy and tidal energy markets is a gradual shift towards private equity financing, significantly increasing the risk perception of investors towards projects. Unless large-scale project deployment with proven technology becomes a reality, lack of adequate funding channels would be a significant restraint for the market. Large companies are likely to buy major stakes in such projects once the technology has been proven in a prototype phase at least.

3.5 Market Opportunities

3.5.1 Massive cost reduction opportunities through technological innovations and capacity up-scaling

The cost of technology is likely to drop as a result of commercial deployment of existing wave and

there would always be an opportunity for technological innovators to develop a more efficient technology than their counterparts. As long as the industry transformation phase continues, such opportunities are bright for both the wave and tidal energy markets.

3.6 Porter’s five forces analysis

FIG. 4 Porter’s five forces analysis

Supplier Power
Low → Medium

- Most technology developers prefer to develop their energy devices in-house
- Strong prospects of forward integration by major OEM manufacturers
- Possibility of long term equipment supply contracts with technology developers
- Chances of increasing lease rates for submerged land owned by federal bodies, Multiple project stakeholders
- Possibility of increasing demand for low cost standardized components

Threat from substitutes
High → Medium

- Threat from conventional energy sources
- Threat from both onshore and offshore renewable energy sources

Degree of Competition
Low → Medium

- Fragmented market players with diverse technological offerings and equally balanced competitors
- Competition for existing government funding, grant schemes and venture capital
- No guaranteed return on investment with relatively high exit barriers
- Significant opportunities for exploiting economies of scale benefits
- Possibility of establishment of first market economies
- Competition in signing of long term electricity sales contracts with large utilities

Buyer Power
Medium → Medium

- High perception of technology and finance risk until technology develops further
- Very limited product differentiation and low switching costs
- Credible threat of backward integration by major IPP’s rendering existing market players as mere technology licensors
- Strong regulatory support mechanisms, capacity installation mandates and financial incentive schemes
- Existing players might pursue branding strategies if technology in question proves to be immensely efficient

Threat from New Entrants
High → Medium

- High capital costs for development of new technology
- Technology not commercially deployed on a large scale yet. Incumbent players highly dependent on grants and venture capital
- Chances of large companies with strong capital base entering the market through acquisitions
- Ample prospects of developing newer technology through aggressive R&D initiative by entrants
- Patented and proprietary technology of most incumbent market players
- Economies of scale dependent industry

Source: Transparency Market Research

3.6.1 Bargaining power of suppliers

Currently, suppliers do not exercise much bargaining power in this industry. This is mainly [redacted]

per acre, annually. The majority of the submerged land being leased out is essentially federal property.

3.6.2 Bargaining power of buyers

Buyers in this particular industry would include power utilities, major independent power

sell their electricity at preferential rates. As ocean energy technologies are in the nascent stage

of development, most being in the prototyping phase, there is immense possibility of technological innovation through strong research and development.

3.6.3 Threat from new entrants

venture capital financing. However, the recent industry trend has moved from venture capital financing to equity financing. This would undoubtedly increase the risks associated with market entry, and lower the number of entrants.

The ocean energy sector is extremely dependent on economies of scale to become cost competitive. Large-scale array deployment and strong learning curves would undoubtedly reduce costs to a large extent, even bringing ocean energy generation to cost competitive levels with other renewable energy generation. It would be very difficult for technology developers to enter the market in the future once commercialized technology has been tested and commissioned on a large-scale. In the presence of existing, large-scale deployed technology, investing in new technology is not a risk large buyers would be willing to take. At present, however, in the absence of commercialized technologies, entrants do pose a credible threat to incumbent players. Another deterrent to entrants would be large-scale patenting of technologies by incumbent players.

3.6.4 Degree of competition

The ocean energy market is highly fragmented in nature, having diverse technological offerings

technological offerings fall short of efficiency and performance standards. Industry consolidation is unlikely to occur in the near future until technology development is done on a commercial scale.

There are significant opportunities to reap economies of scale benefits in this industry. The competition is likely to intensify between players who have already developed their technology to the commercial deployment phase. The degree of competition is likely to increase as the technology matures. This is because only the efficient and tested technologies are likely to be licensed good quality submerged land for project development. The same applies to large utilities looking for highly efficient technologies and project developers to enter long-terms power purchase agreements with. Economies of scale benefits would expand the overall field for players to compete in. Competition is likely to diversify not only in terms of technology development, but also for O&M contractors, plant installers, and EPC contractors, among others.

First mover market economies are likely to be established in Europe, especially in the U.K and

3.6.5 Threat from substitutes

There are no imminent substitution threats for electricity as a form of energy. However, the only

wind being the more developed in terms of commercial deployment. The predictability of waves and tides in general makes wave and tidal energy less intermittent compared to offshore wind energy. Substitution threat is likely to remain high in the short term. However, in the long term, once large-scale wave and tidal arrays are deployed and the economies of scale kick in, ocean energy may start competing in terms of cost. Substitution threat, however, is likely to go from high to medium in the future.

3.7 Wave and Tidal Energy: Lifetime Plant Cost Analysis

Wave and tidal energy devices generally come with high costs per kW, which ultimately results in

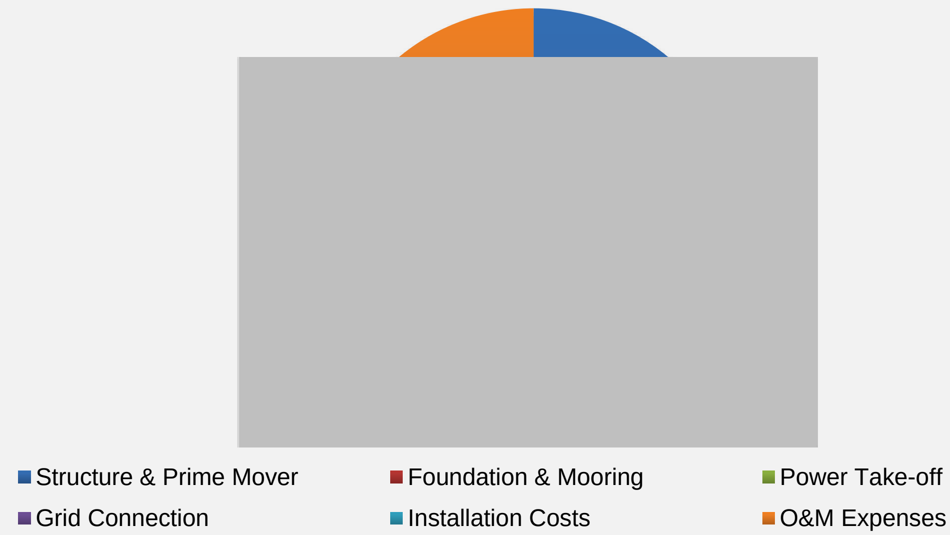
individual cost components have implications on the levelized cost of electricity (LCOE) that a particular plant is able to generate. The cost breakdowns for wave and tidal power plants have been shown and discussed separately.

3.7.1 Wave Energy Generation

competitiveness in this industry would be unlikely in the future. However, there exists considerable opportunities for increasing power output from WECs through device and control system optimization.

Foundations and mooring costs for wave energy is not that high. Substantial scope for cost reduction exists in this segment. This is mainly because increased number of WECs in a wave farm would allow mooring costs to be shared among greater number of machines. Large wave farm installations are likely to derive economies of scale benefits, leading to lower mooring costs per kW.

FIG. 5 Wave Energy Generation Market, individual cost breakdown of lifetime plant cost, 2015



Source: Transparency Market Research

Significant potential to optimize configuration of power takeoff devices (PTOs) exist in this

resonating with a wider range of sea states. Moderate cost reductions can be found in this area in the future.

3.7.1.1 Global Wave Energy generation cost reduction opportunities, By cost type

TABLE 4 Global Wave Energy generation cost reduction opportunities, By cost type

Cost Type	Reduction Opportunity
Structure and Prime Mover	• XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
	• XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
	• XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
Foundation & Mooring	• XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
	• XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
	• XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
Power Take-off	• XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
	• XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
	• XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
Grid Connection	• XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
	• XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
Installation Costs	• XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
	• XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
	• XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
O&M Costs	• XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
	• XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
	• XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
	• XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
	• XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX

Grid connection costs pose chances for cost reduction in the future. However, since majority of

lesser cable. Large wave farms are likely to require such high voltage cables in the future. Grid connection costs are likely to escalate as we move from on-shore to off-shore wave farms.

Rent for specialized vessels used for plant installation occupy a big chunk of the overall installation costs. Wave energy plants have comparatively lower installation costs than tidal. However, in the event of technological changes in the WECs which allow lower cost vessels to be used for installation, cost savings may be reached. Favorable climatic conditions and continuous project development would also optimize production schedules and normalize installation costs.

Off-shore maintenance is extremely cost intensive in nature. Device reliability, which can reduce

3.7.1.2 Global Wave Energy generation lifetime plant cost breakdown and forecast, by cost type, 2014 – 2024, (US$ Mn / MW)

TABLE 5 Global Wave Energy generation lifetime plant cost breakdown and forecast, by cost type, 2014 - 2024 (US$ Mn / MW)

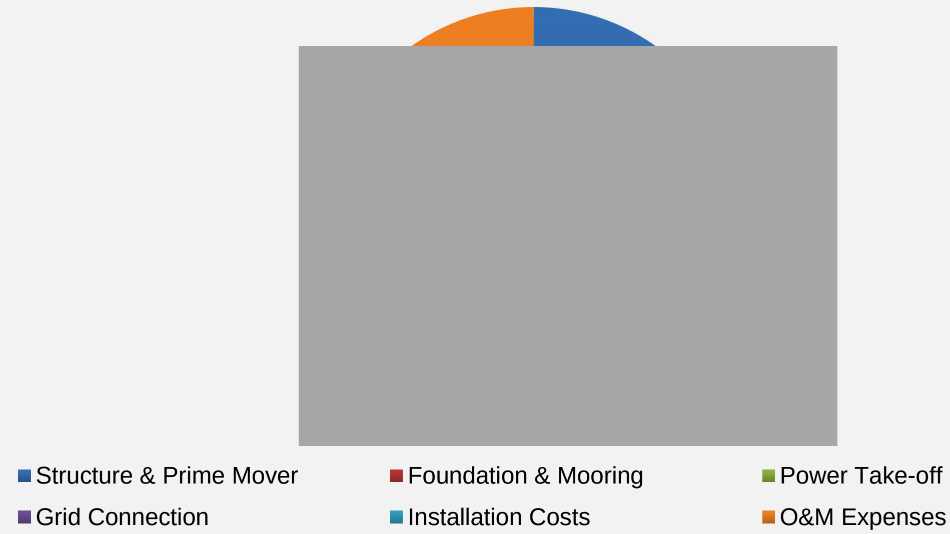
Application	2014	2015	2016	2017	2018	2019	2024	2021	2022	2023	2024
Structure & Turbine cost	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX
Foundation and Mooring	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX
Power Take-off	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX
Grid connection	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX
Installation	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX
Lifetime O&M	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX
Total Cost	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX

The overall average lifetime cost for installing a wave power plant is likely to come down from. A

3.7.2 Tidal Energy Generation

Installation costs form a major part of the overall capital expenditure for tidal power plants. Technology for tidal energy generation is widely developed with highly installed capacity in France and South Korea. However, innovations in turbine blade design to make these more robust are a major possibility. Major areas for tidal energy such as Pentland Firth have extremely hostile conditions that require improvements in both turbine blade design and plant structure engineering. While fatigue failure is a major issue with tidal turbines, exploring new materials for making turbine blades and structures (Carbon Fiber) can alleviate this restraint.

FIG. 6 Tidal Energy Generation Market, lifetime plant cost breakdown of overall development cost, 2015



Source: Scottish Renewables Forum, EMEC, Carbon Trust, OREG, Tethys, NREL, IEA, European Ocean Energy Association, European Renewable Energy Council (EREC), Transparency Market Research

Structural and actual generator costs for tidal energy occupy a lower percentage share (XX%) of

Plant installations in hostile environments with high tidal currents are highly expensive, but using methods such as subsea drilling may reduce these costs moderately in the future. Tidal devices may be installed with or without foundations depending on the design, each with its own engineering challenges. While devices without foundations allow access to deeper water and better generation, lack of stability and engineering difficulties plague the technology. Floating tidal device installation costs are significantly lower than foundation-based tidal plants.

3.7.2.1 Global Tidal Energy generation cost reduction opportunities, By cost type

TABLE 6 Global Tidal Energy generation cost reduction opportunities, By cost type

Cost Type	Reduction Opportunity
Structure and Prime Mover	• XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
	• XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
	• XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
Foundation & Mooring	• XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
	• XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
Power Take-off	• XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
	• XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
	• XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
Grid Connection	• XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
	• XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
Installation Costs	• XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
	• XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
	• XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
	• XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
O&M Costs	• XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
	• XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
	• XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX

	• XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
	• XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX

O&M expenses for tidal plants are higher compared to wave energy. Foundation-based tidal

3.7.2.2 Global Tidal Energy generation lifetime plant cost breakdown and forecast, by cost type, 2014 – 2024, (US$ Mn /MW)

TABLE 7 Global Tidal Energy generation lifetime plant cost breakdown and forecast, by cost type, 2014 – 2024, (US$ Mn /MW)

Application	2014	2015	2016	2017	2018	2019	2024	2021	2022	2023	2024
Structure & Turbine cost	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX
Foundation and Mooring	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX
Power Take-off	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX
Grid connection	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX
Installation	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX
Lifetime O&M	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX
Total Cost	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX

The overall average lifetime cost for installing a tidal stream power plant is likely to come down A

3.8 Wave and Tidal Energy: Global Regulatory Landscape

Policy and regulatory support mechanisms are integral to developing ocean energy resources.

rest of the world.

3.8.1.1 U.K & Scotland Wave and Tidal Energy financial incentive schemes

TABLE 8 U.K & Scotland Wave and Tidal Energy financial incentive schemes, By scheme name and description

Name of Scheme	Description
Ocean energy Array Demonstrator (MEAD) Scheme	• XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
The Crown Estate Fund	• XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
Ocean energy: Supporting Array Technologies (MESAT)	• XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
Marine Renewables Commercialization Fund (MRCF)	• XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX

WATERS and WATERS2	• XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
Renewable Energy Investment Fund (REIF)	• . XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
The Energy Technologies Institute	• XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX

The U.K. and Scotland are undoubtedly leading in terms of financial incentive and policy support [redacted]

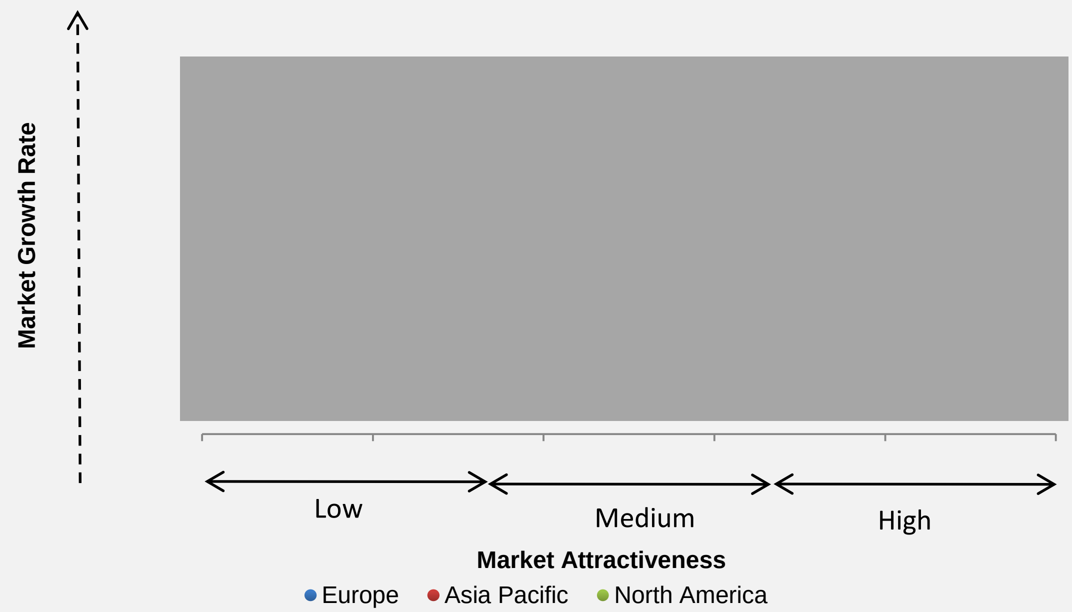
The U.S. government has enacted a Water Power Program to assess opportunities associated with development of ocean energy. Japan has set up its own Ocean Energy Technological

Development Research Center to further R&D in this sector. Australia has a few major policy [redacted] XX Mn, to be disbursed within a 10-year period.

3.9 Market attractiveness analysis of the Wave and Tidal Energy Market, by region, 2015

The market attractiveness of both types of energy was established using six parameters. These [redacted] likely to come out with the first large scale commercial wave arrays.

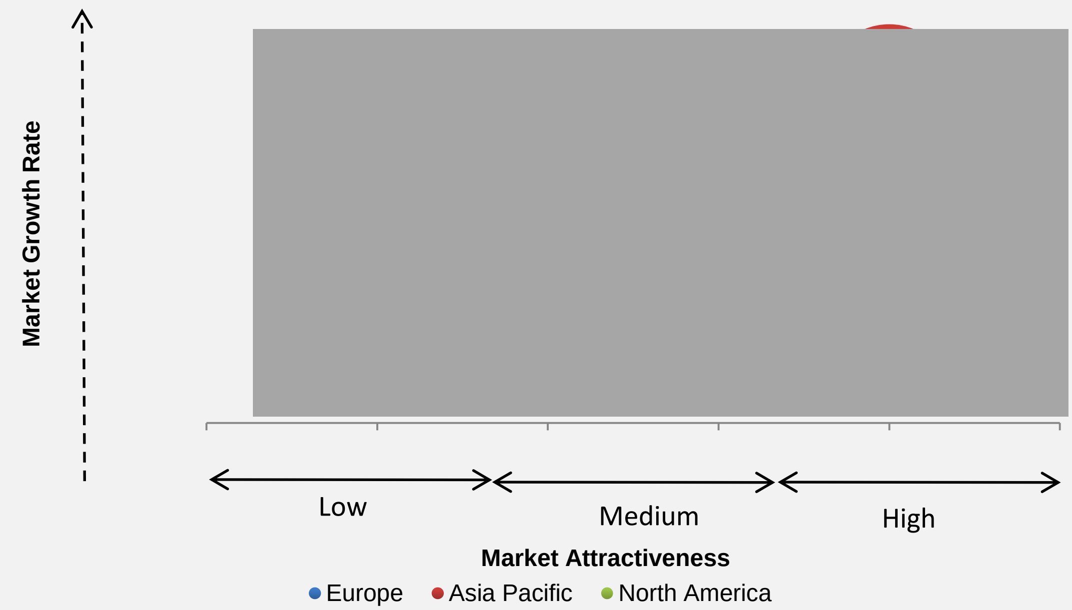
FIG. 7 Market attractiveness analysis of Wave Energy Market, by Region, 2015



Source: Scottish Renewables Forum, EMEC, Carbon Trust, OREG, Tethys, NREL, IEA, European Ocean Energy Association, European Renewable Energy Council (EREC), Transparency Market Research

The Asia Pacific market is majorly dictated by the Australian wave energy sector. Moderate

FIG. 8 Market attractiveness analysis of Tidal Energy Market, by Region, 2015



Source: Scottish Renewables Forum, EMEC, Carbon Trust, OREG, Tethys, NREL, IEA, European Ocean Energy Association, European Renewable Energy Council (EREC), Transparency Market Research

The tidal energy scenario is slightly different. South Korea is extensively developing its tidal

energy market is still underdeveloped and hence ranks low on attractiveness within the forecast horizon.

3.10 Company market share analysis

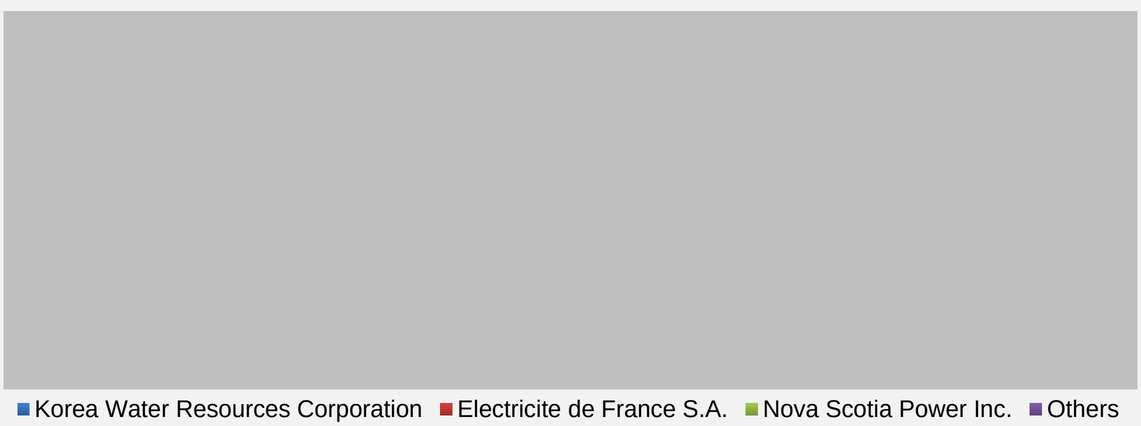
3.10.1 Company market share analysis : Tidal Energy

The total installed capacity accounted for in the study was XX MW in 2014. The tidal power

tidal power plant in 2011.

3.10.1.1 Tidal Energy, company market share analysis (MW), 2014

FIG. 9 Company market share of Tidal Energy industry (MW), 2014



Source: Scottish Renewables Forum, EMEC, Carbon Trust, OREG, Tethys, NREL, IEA, European Ocean Energy Association, European Renewable Energy Council (EREC), Transparency Market Research

This is followed by the Annapolis Royal Generation Station, in Nova Scotia, Canada, which has

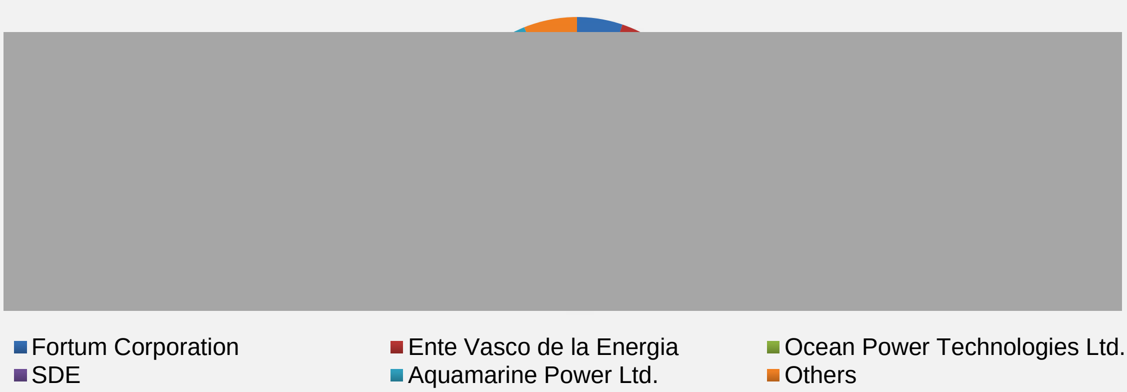
Power Ltd (XX MW), RusHydro (XX MW), and Voith Hydro Wavegen Ltd. (X MW).

3.10.2 Company market share analysis : Wave Energy

The wave energy industry is still in its nascent stage of development. As of 2014, only XX.X MW of installed capacity was identified and used for computing the company market share. The industry was extremely fragmented in nature. However, a majority of the actual and planned investments are targeted in Europe. One company Aquamarine Power Ltd. occupied a majority of the overall market share. Nevertheless, this should not be mistaken as a type of market leadership.

3.10.2.1 Wave Energy, company market share analysis (MW), 2014

FIG. 10 Company market share of Wave Energy industry (MW), 2014



Source: Scottish Renewables Forum, EMEC, Carbon Trust, OREG, Tethys, NREL, IEA, European Ocean Energy Association, European Renewable Energy Council (EREC), Transparency Market Research

Chapter 4 Wave and Tidal Energy Market: Type Analysis

4.1 Global Wave and Tidal Energy Market: Type overview

The increased need to mitigate risks associated with global warming is making the world inclined

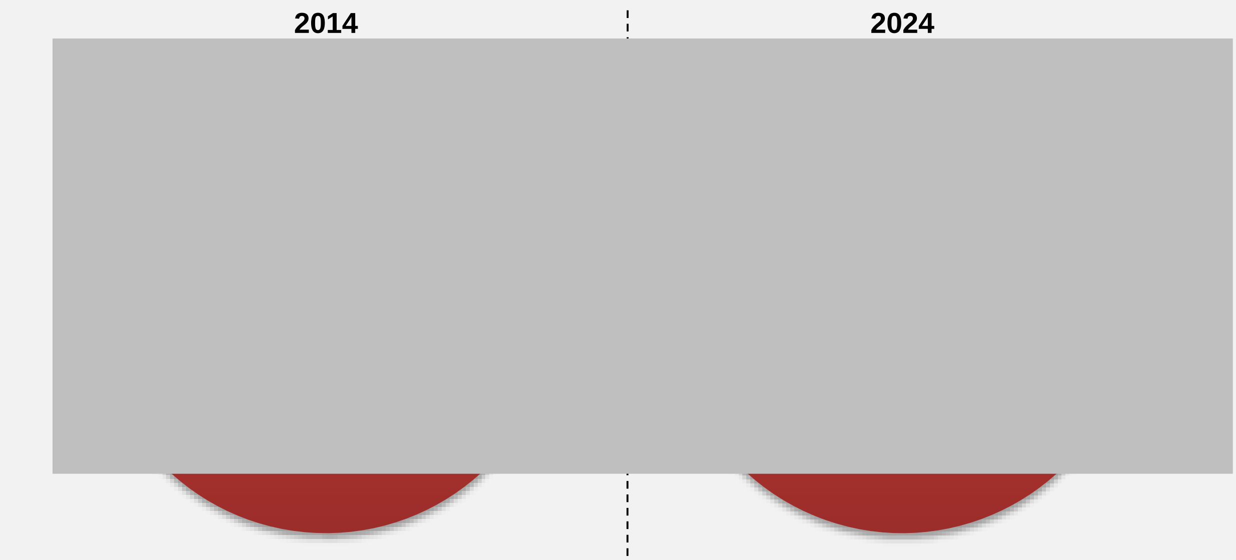
negligible on a global scale.

Tidal power is a form of hydropower that converts the energy of the tides into electricity or other

Lake Tidal Power Station in the Republic of Korea as the largest tidal barrage in the world having a capacity of XX MW.

4.1.1 Global Wave and Tidal Energy Market, volume share by type, 2014-2024

FIG. 11 Global Wave and Tidal Energy Market, volume share by type, 2014 - 2024



Source: Scottish Renewables Forum, EMEC, Carbon Trust, OREG, Tethys, NREL, IEA, European Ocean Energy Association, European Renewable Energy Council (EREC), Transparency Market Research

Government agencies in many developed countries, especially the UK and Scotland region, are

commercial deployment of large-scale wave energy plants.

4.2 Wave Power Plants

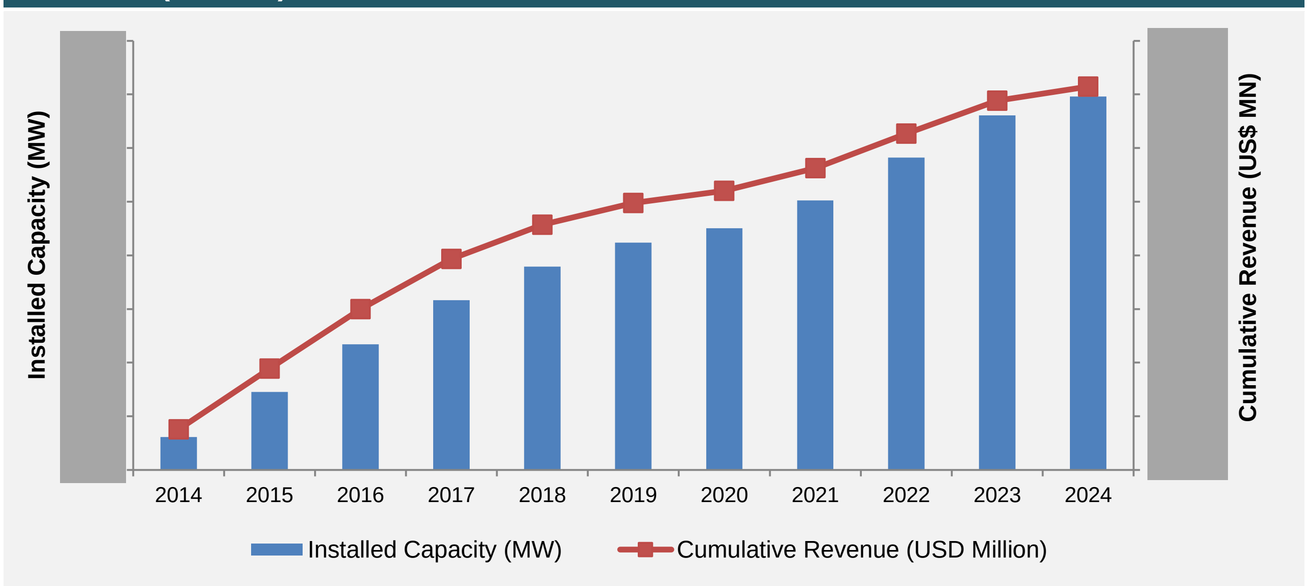
Wave energy can be extracted by placing electricity generators on the ocean's surface. The

Financial incentives from government bodies are the flesh and blood of wave energy developers

competent market players.

4.2.1 Global wave power plant capacity estimates and forecasts, 2014 - 2024 (MW) (US$ Mn)

FIG. 12 Global wave power plant capacity estimates and forecasts, 2014 - 2024 (MW) (US$ Mn)



Source: Scottish Renewables Forum, EMEC, Carbon Trust, OREG, Tethys, NREL, IEA, European Ocean Energy Association, European Renewable Energy Council (EREC), Transparency Market Research

The global installed capacity of wave energy plants was estimated to be XX MW in 2014, and is likely to reach XX MW by 2024, growing at a CAGR of XX% from 2016 to 2024. Though the costs

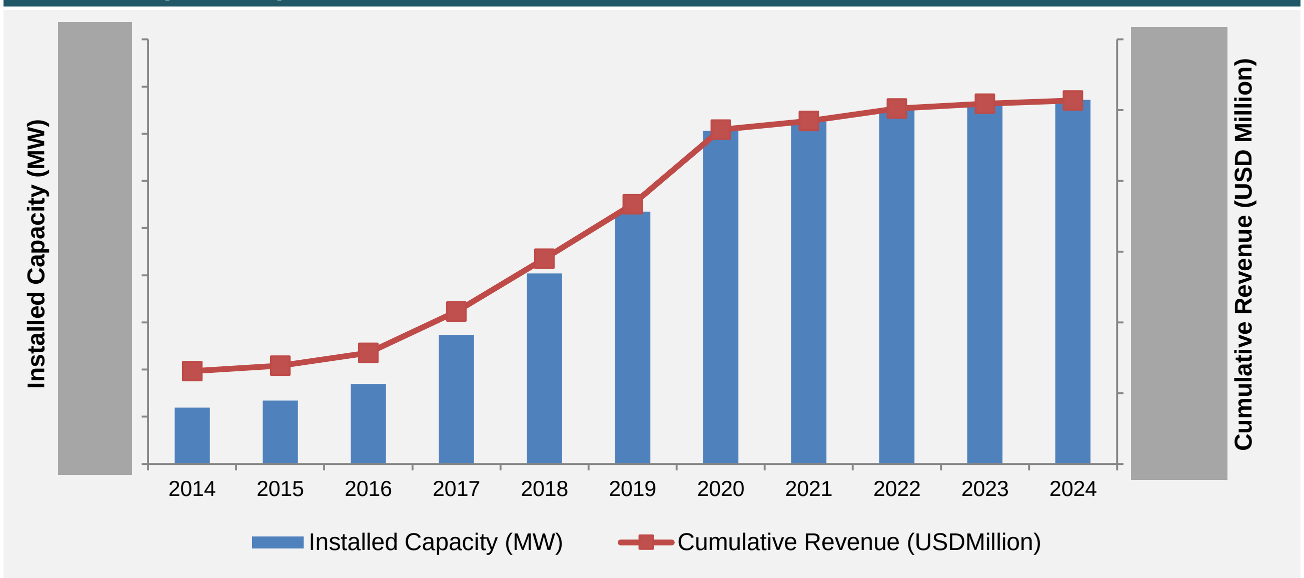
4.3 Tidal Power Plants

Gravitational forces between the moon, the sun and the earth cause the rhythmic movement of ocean water around the world, resulting in tidal waves. Most locations have two tidal cycles per day; diurnal at about 24 hours and semidiurnal at 12 hours 25 minutes. Tidal energy can be extracted using two different technologies depending on the location. The first method, tidal range technology, works on the same principle as that of a hydroelectric system. This technology requires a dam or a barrage over a tidal bay and at some areas along the dam; turbines are installed to extract energy from the water. Because of the massive infrastructure requirements of tidal range projects, they are highly capital-intensive and require multiple environmental clearances. Tidal range energy conversion technology is mature in nature but as with all large civil engineering projects, there would be a series of technical and environmental risks that need to be addressed.

The other technology, tidal stream, is similar to that used for wind energy conversion, using turbines of a horizontal or vertical axis. An advantage of tidal current devices over tidal range devices is that the installation of the former causes limited environmental impact. These devices require a small area for installation and can be fully submerged in the ocean, thus, having a limited impact on their surroundings. Large-scale technological innovation is likely to be observed in tidal stream power plants in the future. While major tidal barrage project installations in South Korea have enabled this technology to attain cost maturity, significant cost reduction opportunities still exist for tidal stream. Towards the end of the forecast period, when large scale commercial array deployment begins, the cost per unit capacity of such plants is likely to reduce.

4.3.1 Global tidal power plant capacity estimates and forecasts, 2014 - 2024 (MW) (US$ Mn)

FIG. 13 Global tidal power plant capacity estimates and forecasts, 2014 – 2024 (MW) (US$ Mn)



Source: Scottish Renewables Forum, EMEC, Carbon Trust, OREG, Tethys, NREL, IEA, European Ocean Energy Association, European Renewable Energy Council (EREC), Transparency Market Research

The key challenge facing the emerging tidal stream power generation industry over the next

Chapter 5 Wave and Tidal Energy Market: Regional Analysis

5.1 Global Wave and Tidal Energy Market: Regional overview

For the purpose of this market study, three regions have been considered, namely, North

5.1.1 Global tidal energy market, volume share by region, 2014 and 2024 (MW)

FIG. 14 Global tidal energy market, volume share by region, 2014 and 2024 (MW)

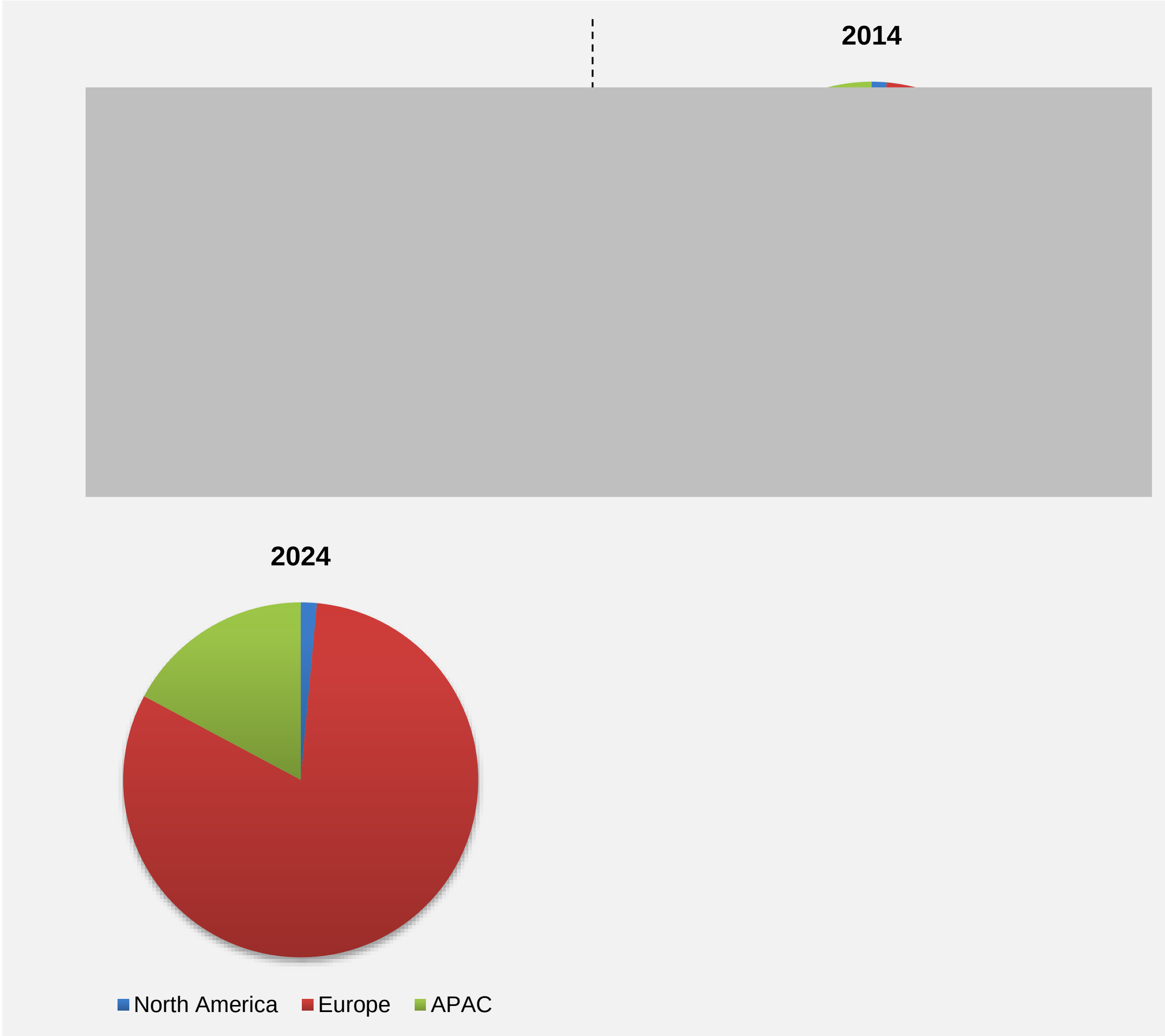
Source: Scottish Renewables Forum, EMEC, Carbon Trust, OREG, Tethys, NREL, IEA, European Ocean Energy Association, European Renewable Energy Council (EREC), Transparency Market Research

Scotland and U.K. have emerged as the technology capital of the world in terms of wave energy development. There are over 80 companies extensively involved in either technology

development or project management of wave energy devices. A strong policy framework and [redacted]

5.1.2 Global wave energy market, volume share by region, 2014 and 2024 (MW)

FIG. 15 Global wave energy market, volume share by region, 2014 and 2024 (MW)

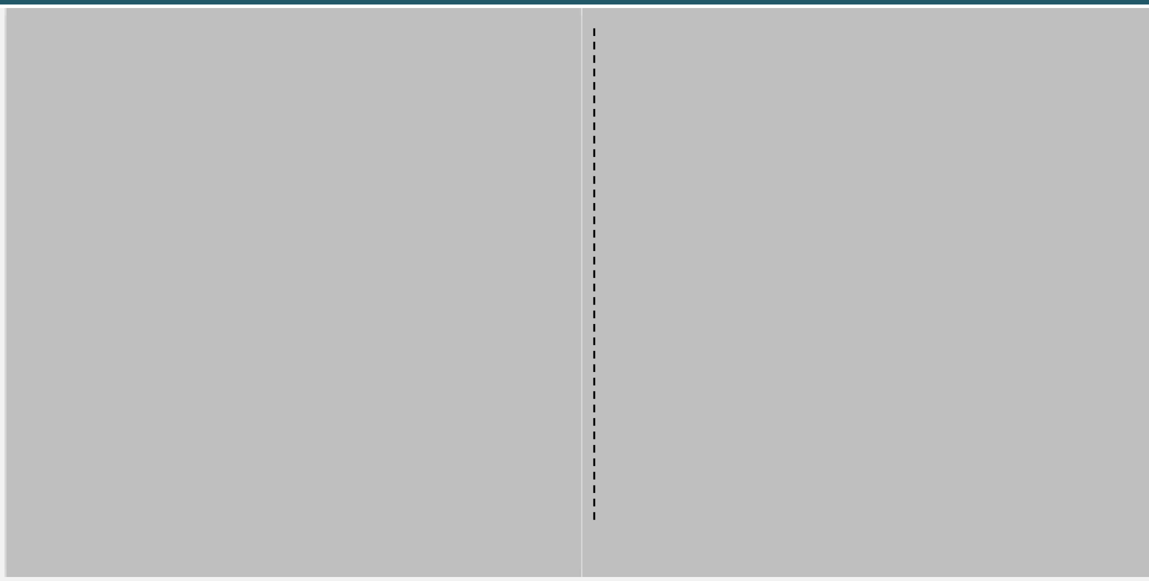


Source: Scottish Renewables Forum, EMEC, Carbon Trust, OREG, Tethys, NREL, IEA, European Ocean Energy Association, European Renewable Energy Council (EREC), Transparency Market Research

region, there are projects planned in Canada and Alaska. Canadian tidal energy projects are directed towards the area around the Bay of Fundy, which has excellent tidal resources.

5.1.3 Global wave and tidal energy market, volume share by region, 2014 and 2024 (MW)

FIG. 16 Global wave and tidal energy market, volume share by region, 2014 and 2024 (MW)



Source: Scottish Renewables Forum, EMEC, Carbon Trust, OREG, Tethys, NREL, IEA, European Ocean Energy Association, European Renewable Energy Council (EREC), Transparency Market Research

Because the regional share scenarios are vastly different in the case of tidal, wave, and both

tidal barrages being constructed in Korea.

There are a large number of projects which have been proposed around the world. However, not all of these projects are likely to be developed, as certain companies declare projects aggressively to boost their stock prices. For this reason, we have selectively accounted the projects to be installed. A majority of the projects accounted for have been verified with project developers to ascertain the timeline of commissioning. Other projects were analyzed depending on their progress in terms of project management and historical installation trends in the particular region. This was combined with a margin of error (an event where only a part of the project is commissioned) to come to the expected capacity to be installed. Projects, for which information was not available through primary or secondary sources, have been excluded while calculating the market size.

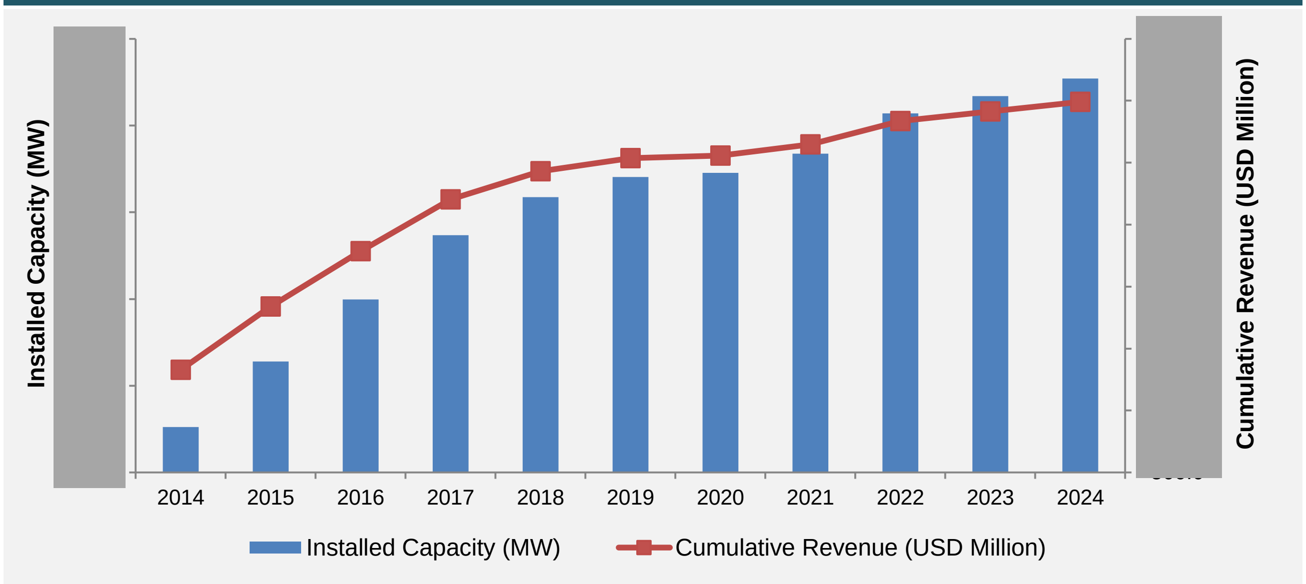
5.2 Europe

Europe is one of the major markets for wave energy generation globally, with Scotland emerging

forecast period. This is likely to drive down the cost of project development and give rise to robust technologies in this region. The wave energy market beyond 2020 is likely to witness high levels of market share capture by major European technology developers in other regions of the world as well.

5.2.1 Europe wave energy market estimates and forecast, 2014 – 2024 (MW) (US$ Mn)

FIG. 17 Europe wave energy market volume and revenue, 2014 – 2024 (MW) (US$ Mn)

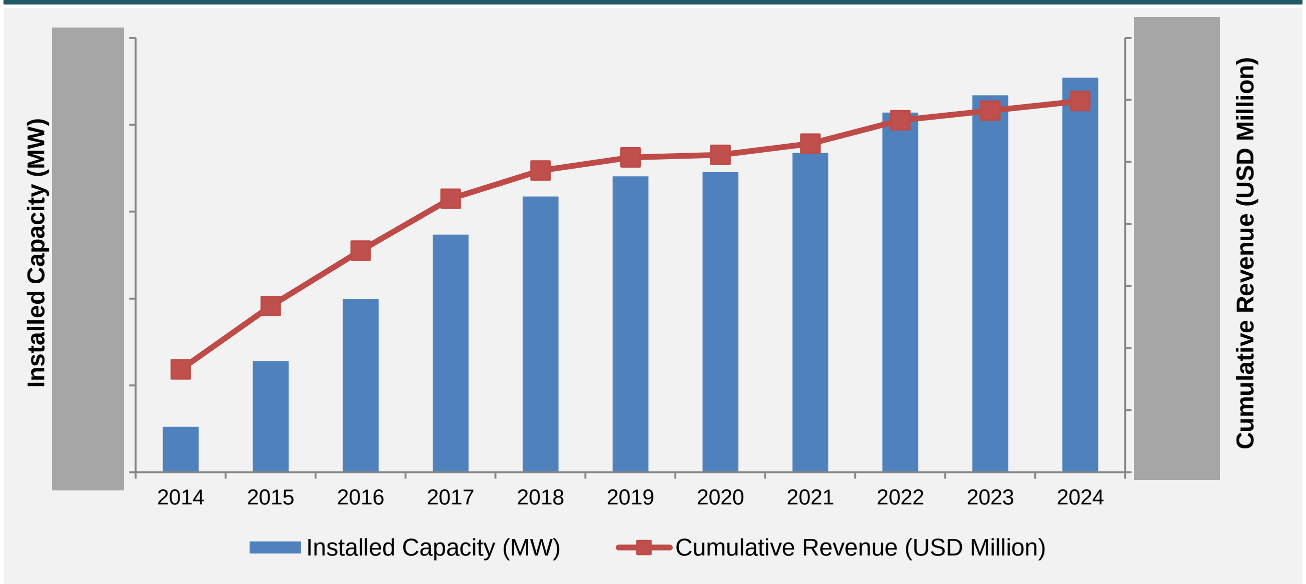


Source: Scottish Renewables Forum, EMEC, Carbon Trust, OREG, Tethys, NREL, IEA, European Ocean Energy Association, European Renewable Energy Council (EREC), Transparency Market Research

The European wave energy installed capacity was estimated to be XX MW in 2014 and is expected to grow to XX.X MW in 2024 growing at a CAGR of XX.X% from 2016 to 2024. In terms of revenue, the market was worth US$ XX.X Mn in 2014 and is anticipated to reach US$ XX.X Mn by 2024, growing at a CAGR of XX.X% from 2016 to 2024.

5.2.2 Europe tidal energy market estimates and forecast, 2014 – 2024 (MW) (US$ Mn)

FIG. 18 Europe tidal energy market volume and revenue, 2014 – 2024 (MW) (US$ Mn)

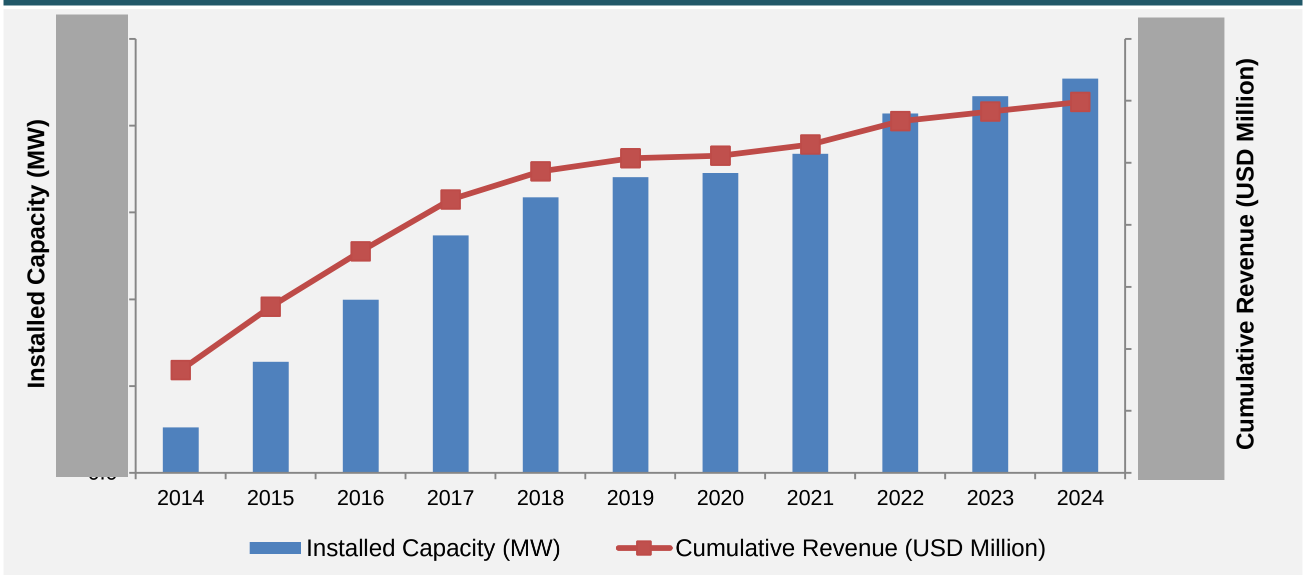


Source: Scottish Renewables Forum, EMEC, Carbon Trust, OREG, Tethys, NREL, IEA, European Ocean Energy Association, European Renewable Energy Council (EREC), Transparency Market Research

The European tidal energy installed capacity was estimated to be XX MW in 2014 and is expected to grow to XX.X MW in 2024 growing at a CAGR of XX.X% from 2016 to 2024. In terms of revenue, the market was worth US$ XX.X Mn in 2014 and is anticipated to reach US$ XX.X Mn by 2024, growing at a CAGR of XX.X% from 2016 to 2024.

5.2.3 Europe wave and tidal energy market estimates and forecast, 2014 – 2024 (MW) (US$ Mn)

FIG. 19 Europe wave and tidal energy market volume and revenue, 2014 – 2024 (MW) (US$ Mn)



Source: Scottish Renewables Forum, EMEC, Carbon Trust, OREG, Tethys, NREL, IEA, European Ocean Energy Association, European Renewable Energy Council (EREC), Transparency Market Research

The European wave and tidal energy installed capacity was estimated to be XX MW in 2014 and is expected to reach to XX.X MW in 2024 growing at a CAGR of XX.X% from 2016 to 2024. In terms of revenue, the market was worth US$ XX.X Mn in 2014 and is anticipated to reach US$ XX.X Mn by 2024, growing at a CAGR of XX.X% from 2016 to 2024.

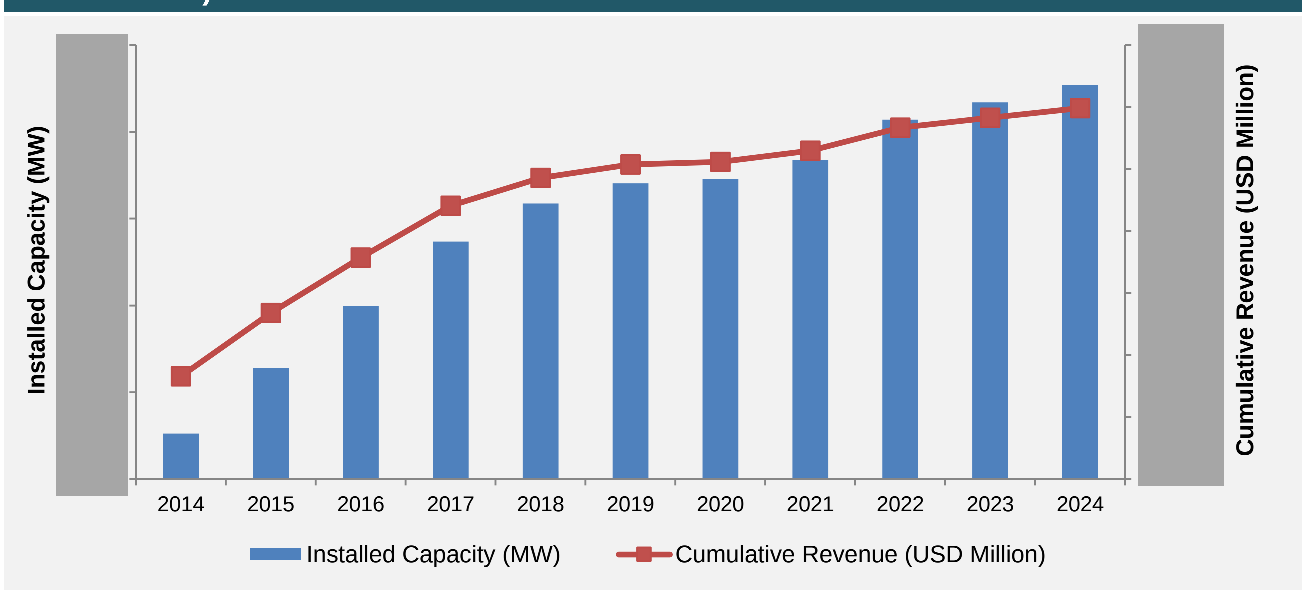
5.2.4 Scotland

Scotland is one of the key hubs for both wave and tidal energy development. It is sometimes

to our projections.

5.2.5 Scotland wave energy market estimates and forecast, 2014 – 2024 (MW) (US$ Mn)

FIG. 20 Scotland wave energy market capacity and generation, 2014 – 2024 (MW) (US$ Mn)



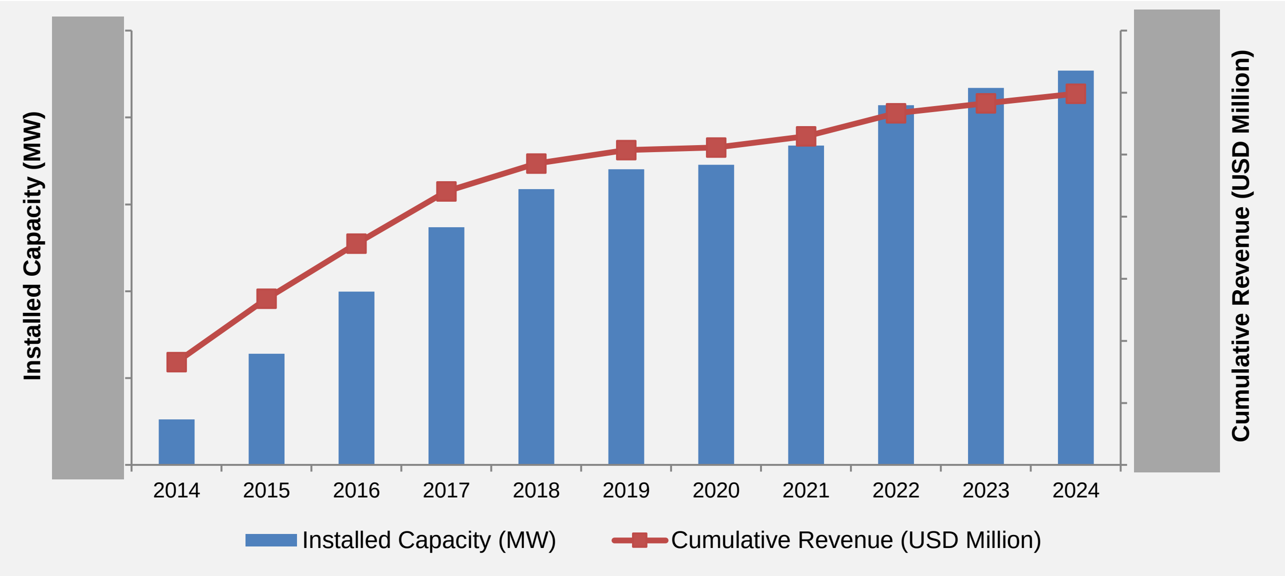
Source: Scottish Renewables Forum, EMEC, Carbon Trust, OREG, Tethys, NREL, IEA, European Ocean Energy Association, European Renewable Energy Council (EREC), Transparency Market Research

Scotland's installed wave energy generation capacity was estimated to be XX MW in 2014 and is likely to grow to XX.X MW in 2024 growing at a CAGR of XX.X% from 2016 to 2024. In terms of revenue, the market was worth US$ XX.X Mn in 2014 and is anticipated to reach US$ XX.X Mn by 2024, growing at a CAGR of XX.X% from 2016 to 2024.

The investment sentiment for tidal energy is buoyant in the country. Most projects planned here

5.2.5.1 Scotland tidal energy market estimates and forecast, 2014 – 2024 (MW) (US$ Mn)

FIG. 21 Scotland tidal energy market capacity and generation, 2014 – 2024 (MW) (US$ Mn)

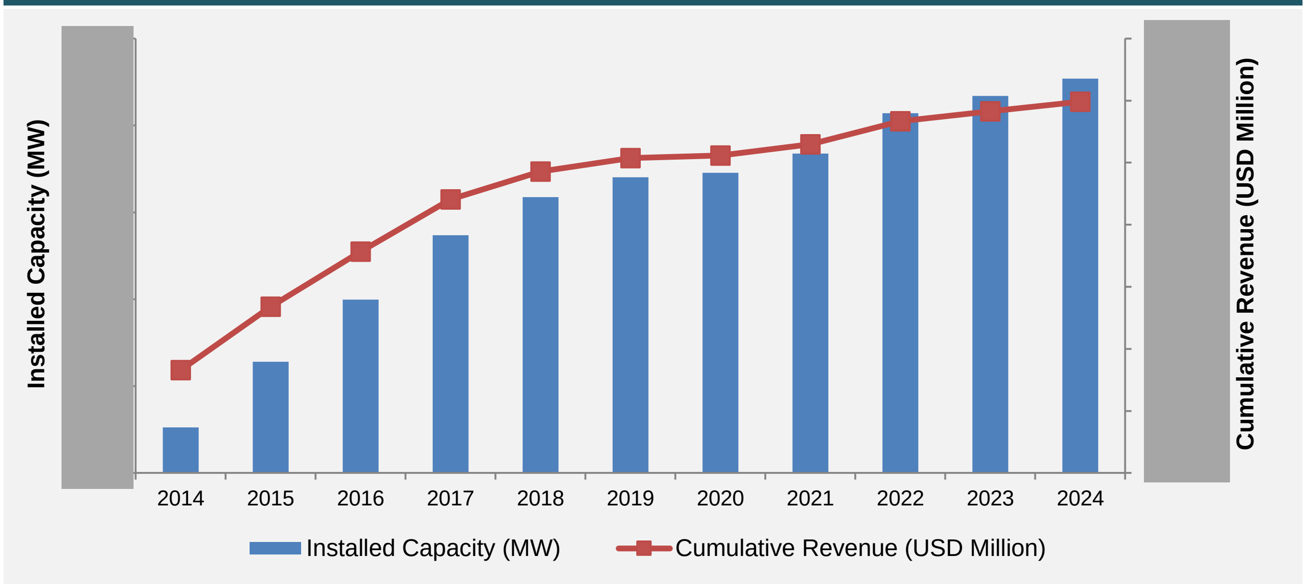


Source: Scottish Renewables Forum, EMEC, Carbon Trust, OREG, Tethys, NREL, IEA, European Ocean Energy Association, European Renewable Energy Council (EREC), Transparency Market Research

Scotland's installed tidal energy generation capacity was estimated to be XX MW in 2014 and is likely to grow to XX.X MW in 2024 growing at a CAGR of XX.X% from 2016 to 2024. In terms of revenue, the market was worth US$ XX.X Mn in 2014 and is anticipated to reach US$ XX.X Mn by 2024, growing at a CAGR of XX.X% from 2016 to 2024.

5.2.5.2 Scotland wave and tidal energy market estimates and forecast, 2014 – 2024 (MW) (US$ Mn)

FIG. 22 Scotland wave and tidal energy market capacity and generation, 2014 – 2024 (MW) (US$ Mn)



Source: Scottish Renewables Forum, EMEC, Carbon Trust, OREG, Tethys, NREL, IEA, European Ocean Energy Association, European Renewable Energy Council (EREC), Transparency Market Research

Scotland's installed wave and tidal energy generation capacity was estimated to be XX MW in 2014 and is projected to reach XX.X MW in 2024 growing at a CAGR of XX.X% from 2016 to 2024. In terms of revenue, the market was worth US$ XX.X Mn in 2014 and is anticipated to reach US$ XX.X Mn by 2024, growing at a CAGR of XX.X% from 2016 to 2024. From the graph, it is

5.2.6 Proposed Wave and Tidal Power Projects: Europe

We have considered select plants while computing market numbers for ocean energy. The logic behind a limited selection of plants is specified in detail in the research methodology chapter. The following tables account for all the prospected wave and tidal energy power plants, either proposed or in various stages of development. The project's scope is limited to these particular

plants. Any other ocean energy projects declared, and which do not feature in this list, are outside the scope of our market study. The market numbers have been derived by accounting for certain plants from within the following list in accordance with our research methodology.

5.2.6.1 Proposed Wave projects

Name of Project	Capacity (MW)	Company	Date of Completion
Reunion Island Project (France)	XX	XXXXXXXXXXX	The project completion date is not disclosed Current Status: XXXXXXXXXXX
XXXXXXXXXXX	XX	XXXXXXXXXXX	The project will be completed by XX Current Status: XXXXXXXXXXX
XXXXXXXXXXX	XX	XXXXXXXXXXX	The project will be completed by XX Current Status: XXXXXXXXXX
XXXXXXXXXXX	XX	XXXXXXXXXXX	The project will be completed by XX Current Status: XXXXXXXXXXX
XXXXXXXXXXX	XX	XXXXXXXXXXX	The project will be completed by XX Current Status: XXXXXXXXXXX
XXXXXXXXXXX	XX	XXXXXXXXXXX	The project completion date is not disclosed Current Status: XXXXXXXXXXX
XXXXXXXXXXX	XX	XXXXXXXXXXX	The project completion date is not disclosed.
XXXXXXXXXXX	XX	XXXXXXXXXXX	The project will be completed by XX Current Status: XXXXXXXXXXX
XXXXXXXXXXX	XX	XXXXXXXXXXX	The project completion date is not disclosed Current Status: XXXXXXXXXXX
XXXXXXXXXXX	XX	XXXXXXXXXXX	The project completion date is not disclosed
XXXXXXXXXXX	XX	XXXXXXXXXXX	The project completion date is not disclosed.

XXXXXXXXXXX	XX	XXXXXXXXXXX	The project completion date is not disclosed.
XXXXXXXXXXX	XX	XXXXXXXXXXX	The project completion date is not disclosed

5.2.6.2 Proposed Tidal Projects

Name of Project	Capacity (MW)	Company	Date of Completion
Inner Sound, Pentland Firth (Scotland)	9	XXXXXXX	The project will be completed by XX Current Status: XXXXXXXXXXXX
XXXXXXXXXXX	10	XXXXXXX	The project will be completed by XX Current Status: XXXXXXXXXXXX
XXXXXXXXXXX	300	XXXXXXX	The project will be completed by XX Current Status: XXXXXXXXXXXX
XXXXXXXXXXX	10	XXXXXXX	The project will be completed by XX Current Status : XXXXXXXXXXXX
XXXXXXXXXXX	320	XXXXXXX	The project will be completed by XX Current Status: XXXXXXXXXXXX
XXXXXXXXXXX	0.035	XXXXXXX	The project will be completed by XX Current Status: XXXXXXXXXXXX
XXXXXXXXXXX	1.2	XXXXXXX	The project is due for completion by XX
XXXXXXXXXXX	10	XXXXXXX	The project will be completed by XX Current Status: XXXXXXXXXXXX
XXXXXXXXXXX	1.2	XXXXXXX	The project will be completed by XX Current Status: XXXXXXXXXXXX
XXXXXXXXXXX	30	XXXXXXX	The project will be completed by XX Current Status: XXXXXXXXXXXX
XXXXXXXXXXX	8	XXXXXXX	The project will be completed by XX Current Status: XXXXXXXXXXXX
XXXXXXXXXXX	12	XXXXXXX	The project completion date is not disclosed

XXXXXXXXXXX	200	XXXXXXX	The project completion date is not disclosed Current Status: XXXXXXXXXXXX
XXXXXXXXXXX	100	XXXXXXX	The project completion date is not disclosed Current Status: XXXXXXXXXXXX
XXXXXXXXXXX	200	XXXXXXX	The project completion date is not disclosed Current Status: XXXXXXXXXXXX
XXXXXXXXXXX	0.12	XXXXXXX	The project completion date is not disclosed
XXXXXXXXXXX	0.5	XXXXXXX	The project completion date is not disclosed Current Status: XXXXXXXXXXXX
XXXXXXXXXXX	8	XXXXXXX	The project will be completed by XX Current Status: XXXXXXXXXXXX
XXXXXXXXXXX	0.03	XXXXXXX	The project completion date is not disclosed
XXXXXXXXXXX	XX	XXXXXXX	The project will be completed by XX Current Status: XXXXXXXXXXXX

5.2.7 Regulatory Framework Snapshot: Europe

In Europe, public sector financing is mainly focused on encouraging the commercialization of

support technologies through different stages of development. This has attracted overseas enterprises to invest in this region. Similarly, France has also supported tidal stream projects by announcing revenue and capital incentives.

Chapter 6 Company Profiles

6.1 Aquamarine Power Ltd.

Elder House

24 Elder Street

Edinburgh

EH1 3DX

Tel: +44 131 524 1440

Fax: +44 131 524 1444

Website: www.aquamarinepower.com

6.1.1 Company overview

Aquamarine's origins date back to 2001 when researchers from Queen's University began studying flap-type wave power systems. In 2005, the research team went on to form Aquamarine Power Ltd. The company specializes in developing wave energy projects in the U.K., and during the initial research phase, developed a proprietary oyster wave energy device. Initial funding for development of this technology was provided by Scottish and Southern Utility (SSE) and the Sigma Capital Group Plc.

Aquamarine Power Ltd. has completed fabrication and prototyping of its oyster wave energy technology, and named its first near-shore prototype device Oyster 1. The oyster device is currently installed at the European Ocean energy Centre (EMEC) and supplies power to the grid. The company has developed a newer version of its wave energy capture device named Oyster 800. The company also provides fabrication and installation services. Aquamarine Power's operations have diversified geographically to the U.S., Scotland and Ireland. Swiss-Swedish industrial giant Asea Brown Boveri (ABB) is a major shareholder in the company.

6.1.2 Product portfolio

Aquamarine Power's primary product offering is its Oyster wave energy converter technology developed for harnessing wave energy.

Product	Product Grade
Ocean Energy systems	• Idea generation and assessment • Intellectual property management • Design and engineering • Prototype manufacturing and testing • Computational fluid dynamics (CFD) modeling

6.1.3 Financial overview

Aquamarine Power Ltd.'s total revenue stood at US$ XX.X in 2015 against US$ XX.X in 2014 and US$ XX.X in 2013.

6.1.4 Business strategy

Securing investments and continual progress in wave energy technology development are key strategies employed by Aquamarine Power Ltd. The company leverages its oyster wave energy device technology for acquiring projects around the world. Aquamarine Power Ltd. has secured grants and investments from companies such as SSE and Sigma Capital Group for developing its technology. A large chunk of the grants came in from venture capitalists, making the company's business model robust and attractive for other investors in the future.

The company adopted rapid R&D initiatives to develop a product prototype to justify returns and show progress to capital/grant providers. Aquamarine Power Ltd. also made ABB a major shareholder in its business. This has enabled the company to push its product offering in multiple countries and regions, as well as benefit from ABB's technology and automation brilliance.

6.1.5 SWOT analysis

Strengths	Weaknesses
• Proprietary technology developed till prototype stage • Robust business model • Alliances with major companies	• Technology not fully commercially proven
Opportunities	**Threats**
• Opportunities to get grants • Leverage product offering to different geographies	• Other market players with patented technologies

6.1.6 Recent developments

- On June 4, 2015, Aquamarine Power Ltd. secured a three month contract with Wave Energy Scotland (WES) to share knowledge gained through the development of its Oyster technology
- On September 15, 2015, Aquamarine Power Ltd. secured a US$ 833,118 European Union (EU Horizon 2020) grant to accelerate development of its Oyster wave energy converter and make it commercially viable
- On November 23, 2015, Aquamarine Power Ltd. decided to liquidate its assets after failing to attract a buyer for the business

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