THE OCEAN: THE NEXT FRONTIER IN RENEWABLE ENERGY?

A WHITE PAPER FROM ENTERPRISE FLORIDA AND GTM RESEARCH | DANIEL ENGLANDER GTM RESEARCH

eflorida.com

1 INTRODUCTION

The ocean power industry is emerging as one of the next substantive renewable energy sectors. Ocean waves and tides are energetic and predictable, while the technology underlying their absorption and conversion into electricity is well understood. The companies developing these technologies have evolved substantially from their beginnings in the British ocean power research programs of the 1970s. Today, leading companies and research centers are developing innovative wave and tidal energy technologies across the globe, from Florida to Australia to Scotland. In September 2008, the first full-scale commercial wave power array was brought online off the coast of Portugal, and many more installations are slated to follow. With more than 600 MW of commercial projects announced for deployment over the next eight years, the consensus among the energy and investment communities is that ocean power is poised to make a significant contribution to the global energy mix.

Ocean power industry centers have typically developed in areas where the ocean wave, current and tidal resources are greatest. At the global level, harvestable ocean power resources could account for 25 percent of total global electricity generation. In the United States, we estimate more than 8 percent of total electricity generation could potentially come from ocean power resources, with roughly one third of that derived from tidal energy.

FIGURE 1: OCEAN POWER'S POTENTIAL CONTRIBUTION TO ELECTRICITY GENERATION

	Wave (TWh/year)	Tidal (TWh/year)	Percent of Total Electricity Generation (2006)
U.S.	250-260	110	8.69% (4,254 TWh)
Canada	100+	50+	25.66% (584.4 TWh)
UK	58	18	19.06% (398.7 TWh)
Global	2,000-4,000	800	25.2% (19,027 TWh)

Source: EPRI, Powertech Labs, British Petroleum

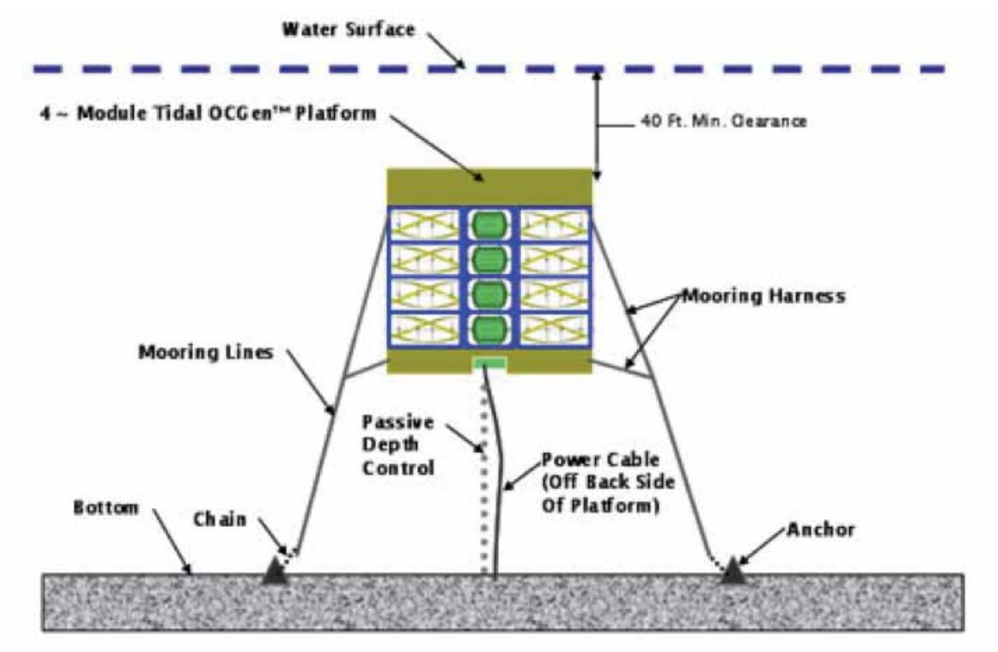
Of the 35 active companies in the ocean power industry, 24 are developing wave energy technologies. While tidal and current energy technology companies represent a smaller overall part of the market, this market segment might become the dominant technology class within the ocean power industry. First, the frequency and velocity of ocean currents and tides are predictable up to 100 years in advance. The timing of electricity delivery from current and tidal sites is much more certain than that from wave energy sites. Second, energetic current and tidal sites are closer to the shore than comparable wave energy sites. This will reduce some of the costs associated with the build out of transmission lines, as well as reduce some of the cost and risk associated with open-ocean plant operations and maintenance. Florida's Gulf Current is one of the most energy-dense ocean current climates in the world.

2 OCEAN POWER TECHNOLOGIES

Ocean power technologies fall into one of two general camps. Wave energy converters absorb energy from the wave climate in which they are submerged. The up-and-down movement of the waves is captured by the device and transferred to the power-take off system and prime mover, where electricity is generated. Devices able to capture a significant amount of the energy in their wave site and that are able to convert a higher percentage of that energy into power perform better and produce cheaper electricity than those that lack these qualities.

Current and tidal energy technologies have inherited a number of design elements from the wind power industry. An interesting aspect of the current and tidal energy industry is its acceptance of vertical axis turbines. This kind of technology was largely abandoned within the wind power industry because of issues related to their low conversion efficiency, which is then related to the effects of drag and wind shear. Underwater, however, these issues are largely mitigated. All current and tidal energy technologies rely on a kinetic water stream to rotate a set of blades that turn a generator inside a gearbox mounted on the device. The basic mechanics of these devices are simpler than those of wave energy technologies.

FIGURE 2: SCHEMATIC OF THE ORPC OCGEN™ MODULE



Source: Ocean Renewable Power Co.

3 THE OCEAN POWER INDUSTRY

A number of factors have contributed to the growth of the ocean power industry. First, interest among governments, the private sector and consumers for renewable energy technologies has helped foster the development of technologies and companies in this space. The effect is most noticeable in regions where the available resource may make a significant contribution to the country's energy portfolio. A principle component of industry support is the development of ocean energy research centers where primary engineering research, resource modeling and technology development take place. The University of Edinburgh, Florida Atlantic University and Oregon State University are considered the leading academic centers for ocean power research.

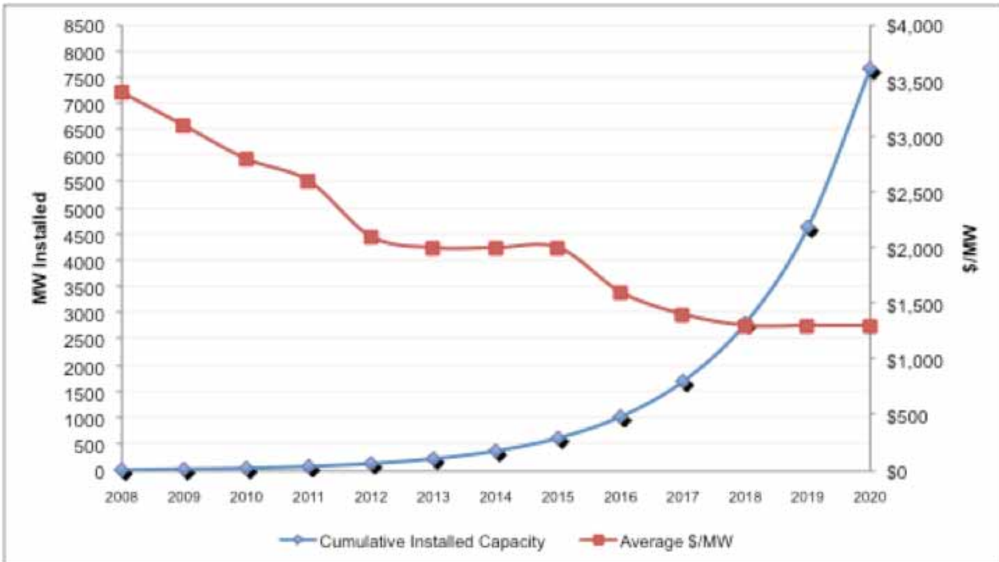
The United States has taken a leading role in the ocean power industry. As in the rest of the world, areas that have spearheaded growth in this sector are those that have the greatest ocean wave, current and tidal resources. In 2007, the State of Oregon created the Ocean Wave Energy Initiative using a $5.23 million grant from the Oregon Innovation Council. OWEI connects the Oregon Department of Energy, the Oregon State University O.H. Hinsdale Wave Research Lab, Oregon Iron Works and several regional utilities. The Massachusetts Technology Collaborative and the Maine Technology Institute have invested close to $1 million in Ocean Renewable Power Co., a tidal energy company with projects in Maine and Florida.

In 2006, the Florida Technology, Research and Scholarship Board provided $5 million in funding to create the Florida Center of Excellence in Ocean Energy Technology at Florida Atlantic University. The Center works with the U.S. Navy, Florida Power & Light, the National Renewable Energy Laboratory and a number of private ocean power and energy companies to conduct ocean energy research, develop and test prototype technologies in the open water, and work toward the commercialization of ocean energy technologies. The Center's primary focus is on tidal energy technologies that could take advantage of the abundant resources in Florida's Gulf Current.

Continued support at the government and university level is necessary if ocean power technologies are to reach commercial deployment. Nine companies have announced commercial ocean power projects totaling roughly 650 MW of installed capacity between 2008 and 2013. To achieve these goals researchers and technology companies are actively working to iron out challenges associated with grid connection, manufacturing and installation, and operations and maintenance costs. These are many of the same problems faced by the offshore wind industry. However, because ocean energy technologies tend to have lower capital costs than offshore wind technologies, it is likely the development of this crucial industry may outpace that of its open-air relatives.

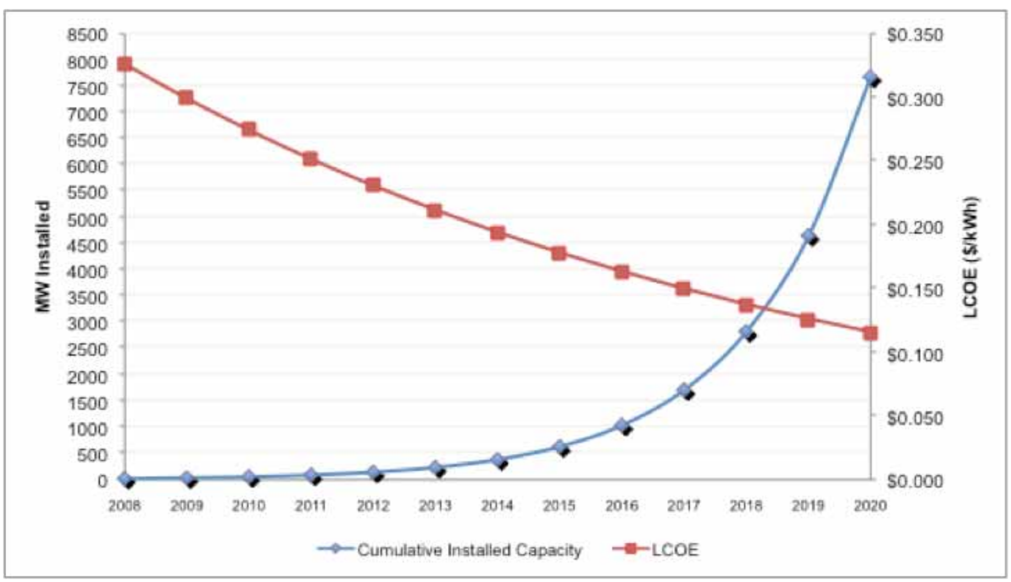
GTM Research has estimated that by 2016, the ocean power industry could reach 1 GW of cumulative installed capacity. The industry's annual market size will break $650 million at this point, and will continue growing as installations increase over time.

FIGURE 3: CUMULATIVE INSTALLED CAPACITY AND CAPITAL COST PROJECTIONS, 2008–2020



Even more important than estimated annual declines in installed capital cost are the resulting annual declines in the typical levelized cost of energy for a typical ocean energy facility. Because both capital cost and levelized cost of energy are directly related to economies of scale in manufacturing and installation, the larger the industry becomes, the more cost effective ocean power technologies will be.

FIGURE 4: CUMULATIVE INSTALLED CAPACITY AND LCOE PROJECTIONS, 2008–2020



4 OCEAN POWER COMPANIES

There are a number of successful ocean power companies developing technologies for commercial deployment in the United States. Ocean Renewable Power Co. is developing a device aimed at capturing energy from ocean currents and tides. The company was recently granted six permits from the Federal Energy Regulatory Commission to develop sites in Florida along the Gulf Current. In 2009, ORPC will launch prototype installations at two ocean current sites with the aim of refining both its technology as well as its installation and site maintenance capabilities. By 2011, the company will launch a full-scale commercial device in Florida that will help meet the rising demand for base-load power in that state.

New Jersey-based Ocean Power Technologies is one of the most established ocean power companies. Ocean Power Technologies has deployed a number of its PowerBuoys at sites in Hawaii, New Jersey and Spain. The PowerBuoy project in New Jersey is the industry's oldest commercial power installation. The successful deployment of a PowerBuoy off the New Jersey coast is significant because it demonstrates the potential for wave energy technologies on the East Coast of the United States, which is an area many had previously considered unsuited for wave energy production. In January 2009, the company announced it will work with Lockheed Martin to develop utility-scale wave power plants in the United States.

Irish company OpenHydro is another successful tidal energy company. OpenHydro is the successor company of Florida Hydro Inc., which was acquired in 2005. Florida Hydro worked closely with the U.S. Navy Carderock Lab to deploy four prototype open-center turbines in Palatka, Florida. OpenHydro deployed a prototype of its advanced open-center turbine technology at the European Marine Energy Centre in Scotland in November 2006.

5 CONCLUSION

For ocean power technologies to make a significant impact on global energy supply, there are certain technological barriers that must be overcome. The first is designing robust devices able to withstand punishment in the ocean for decades on end. The second is designing ocean power devices that can be installed easily and cheaply, and that can be removed for maintenance at little expense. The third is integrating power electronics and power take-off systems with environmental tuning in dynamic environments for smoothed power flows that allow for easier grid integration. Devices meeting these requirements will exhibit lower over installed system costs than devices failing to meet these challenges. Ultimately, there will be design convergence around modular devices that are scalable into larger arrays. Pursuing such designs will give developers access to economies of scale in production, manufacturing and installation at a faster rate than developers pursuing multi-megawatt, standalone devices.

Central to meeting these challenges is the robust and continued support of government-funded organizations that are able to bear some of the development risk associated with deploying ocean power technologies. This support extends from providing laboratory space for early-stage startups to providing open-water testing facilities and grid connection points for pre-commercial companies. This all-encompassing range of support was pioneered in the United Kingdom, whose universities and research centers provide significant technical and financial support for ocean power companies. More than any other reason, this level of institutional support is the primary reason why the United Kingdom has developed into the center of the global ocean power industry.

A number of locations in the United States are following the lead of the United Kingdom. Massachusetts, with its strong technology and engineering base and a history routed in the sea, has provided funding for a number of ocean power startups and a technology development center the University of Massachusetts, Dartmouth. Oregon's active wave energy climate and world-class hydrodynamics research institute at Oregon State University provided the impetus for that state to become one of the centers of the U.S. ocean power industry. Florida's proximity to the Gulf Current, one of the most energetic and dense natural energy sources in the world, as well the commitment of the state government, local utilities, universities and the technology community, are making Florida the center of tidal and current energy development in the United States.

eflorida.com GTM RESEARCH