Performance of Offshore Renewable Energy (ORE) Firms: An International Perspective

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Abstract

In their quest to promote renewable energy, governments often partner with industry and finance key stakeholders. This is particularly true when it comes to developing ocean resources, whether it be tidal or offshore wind energy. In such a challenging environment, it is of important therefore to understand how these different actors can best cooperate to promote sustainable ocean governance. Drawing on data from early 2000s, this paper examines how ocean energy development, subsequently referred to as offshore renewable energy (ORE) has been performing both nationally and internationally over time. It then analyzes the role of public support in the industry across countries, both theoretically and in practice. Factors, such as policies (in particular public funding in the shape of subsidies), both corporate and government Research and Development (R&D), environmental goals and policies that have played a positive role in the promotion of the industry, are then examined, and remaining challenges facing the ORE industry are outlined.

Introduction

The number of national and regional policies in place worldwide to promote the development and use of renewable energy technologies in general has been on the rise and in an increasing number of countries[1] over the past few decades. Such policies include regulatory policies and targets, such as feed-in-tariff and biofuels targets and mandates, fiscal incentives such as capital

[1] See also the Global Status report 2013 (REN21) published by the global renewable energy policy multi-stakeholder network for more detailed information.

subsidy, grants and/or energy production payment, as well as public financing in the shape of public investment, loans or grants.

The deployment of viable renewable energy sources follows from a motivation to reduce greenhouse gas emissions, slow climate change and reduce dependence on foreign sources of energy. Some positive externalities include fostering job creation and promoting improvements in health, education and gender equality. For example, based on a wide range of studies, the direct and indirect jobs created in renewable energy worldwide across industries and across countries were estimated at 5.7 million within the period 2009-2012. In the EU alone, this represented 1.2 million people working directly or indirectly in the renewable energy sector. In China, it amounted to 1.7 million (REN21, 2013).

The challenges facing this move to integrate renewable energy sources with existing infrastructure and markets are often manifold. If many experts now believe that technology and costs are no longer major challenges for the industry overall, differences still remain within the different renewable technologies used. The typical energy cost for onshore wind energy amounts to 5-16 U.S. cents/kWh in OECD countries, while offshore wind cost of energy ranges between 15 and 23 U.S. cents/kWh (REN21, 2013). Other, more difficult challenges, may relate to finance, risk-return profiles, social and environmental factors, and an overall rethinking of how energy systems are designed, operated and financed.

In this paper, we will focus specifically on offshore renewable energy (ORE), which can broadly be defined as offshore wind, wave, tidal and ocean thermal energy. Although not cost effective yet compared to other sources of renewable energy, harvesting ocean energy represents incredible opportunities for the future, especially for countries well endowed in this natural resource. For example, Canada has some of the most powerful tides in the world in the Bay of

Fundy, which makes investigating it worthwhile. Offshore winds are stronger and often out out of sight, which leads to fewer complaints than onshore wind with its potential negative effect on the aesthetics of the land.

In order to better understand how government and industry can best support ORE development, it is important to first learn about the state of affairs in the industry. Therefore, this paper first describes how the ORE industry has been performing since the early 2000s, both nationally and internationally. Using firm level data for the past 5 years, we analyze how wind, wave, and tidal industries perform, today relative to the Russell 2000 index, and in the future, looking at capital expenditures, investments in research and development, and financial position. We then look at factors, such as policies (in particular public funding in the shape of subsidies), both corporate and government Research and Development (R&D), environmental goals and policies that have played a positive role in the promotion of these industries. This research seeks to determine which countries or jurisdictions are most supportive of ORE and which policies of support are most effective. We conclude by outlining the remaining challenges the ORE industry faces.

This research builds on the work conducted by Boulatoff and Boyer (2014), who analyzed the performance of over 500 clean technology companies (solar, wind, renewable energy, transportation) in 34 different countries over the 1990-2011 period and found, among other things, that three green industries predominantly receiving government R&D during this period were the solar energy, transport and biofuels. Using regression analysis, the authors concluded that both corporate R&D and government R&D were positively correlated to firms' performance.

ORE Industry Performance in the Recent Past.

We start by looking at the ORE industry has been performing between 2000 and 2013. Table 1 below shows the number of companies involved in ORE by country, specifically Offshore Wind, Wave and Tidal Energy. As can be seen from the table, the Offshore Wind Energy industry is more developed, as more countries are involved in the industry. One reason being that the technology has certain economies of scope with the land based Wind Energy industry. The U.K. has the strongest presence in offshore wind energy. For Wave and Tidal Energy, the scale of the industry is largest in Australia, Canada, the U.K. and the U.S. As Wave and Tidal energy firms are typically smaller, with many not publicly traded, they are also underrepresented in this sample. Overall, the relatively small size of firms operating in wave and tidal energy can be attributed to it being in a relative stage of infancy compared to other renewable energy sources such as solar, geothermal and wind energy. Another possible phenomenon is that often, these firms are government owned, which makes it more difficult to assess.

Table 1: Number of companies involved in Offshore Renewable Energy by country

Offshore Wind Energy	Number of Companies	Wave and Tidal Energy	Number of Companies
Australia	2	Australia	9
Belgium	1	Canada	9
Switzerland	1	China	1
China	4	Denmark	1

Germany	6	Spain	1
Denmark	4	Finland	1
Spain	2	France	1
France	3	Germany	1
UK	10	UK	11
Ireland	2	Ireland	1
India	1	US	11
Japan	1		47 total
Korea	1		
Netherlands	3		
Norway	2		
Sweden	1		
Singapore	1		
US	7		
	52 total		

Source: Bloomberg, June 2014.

Investor behavior may also contribute to the relatively small size of firms operating in wave and tidal energy. Leete et al. (2013), analyzing the attitudes and investors' behavior towards wave and tidal energies found that one of the important barriers to investment was prior experience in these industries investment. Experienced investors were wary of the unpredictability of costs and time required to develop the needed technologies. New investment for ocean (tidal and wave) energy increased from 0.0 billion USD to 0.3 billion USD between

2004 and 2012. This is still a very small portion of total new investment across renewable industries for the same period[2].

Along with other renewable energy technologies, ORE has seen an increase in contribution to electric power global capacity in recent years. This increase is captured in particular by the growing contribution of wind power (onshore and offshore together), reaching 283 GW worldwide in 2012, which is almost 19% of the world total renewable power capacity when hydropower is included (or 59% if we exclude hydropower). In 2012, the EU-27 produced 106 GW, while BRICS countries generated 96 GW (33%). During that same year, China, the top generating country, reached 27% of the wind power global capacity reached (75.3 GW total installed capacity), followed by the U.S. with 21% (60 GW), and Germany generating 11% (31.3 GW). Canada's capacity was 2% (6.2 GW) (REN21, 2013).

As can be seen in Table 2 below, the amount of energy generated from offshore wind alone grew by a multiple of 19 over the period from 2003 to 2013. In 2003, the amount of energy generated was 364 megawatts, and mainly occurred in Denmark. It reached 6,932 megawatts in 2013, with the U.K. and Denmark generating over half of that amount. In 2003, only four countries were involved in the offshore wind industry, Denmark, the U.K., Sweden and The Netherlands. By 2013, at least thirteen countries were using the technology to generate energy, with the leaders being the U.K., Denmark, Germany, Belgium, China, The Netherlands and Sweden.

Table 2. Cumulative Mega Watts Global Offshore Wind

[2] It was 39.6 billion USD total in 2004, and reached 244.4 billion USD in 2012 (REN21, 2013).

	2013	**2012**	**2011**	**2010**	**2009**	**2008**	**2007**	**2006**	**2005**	**2004**	**2003**
UK	3,689	3,093	1,524	1,340	688	404	404	304	214	124	64
Denmark	1,271	922	871	868	661	423	423	423	423	423	258
Germany	520	280	200	72	12	12	7	7	5	5	
Netherlands	247	247	247	247	247	247	127	19	19	19	19
Belgium		490	335	195	195	30	30				
Sweden		211	163	163	163	133	133	23	23	23	23
23											
Ireland		25	25	25	25	25	25	25	25	25	25
China		419	369	240	140	2	2	2			
Finland		17	17	17	17	15					
Japan		39	15	15	15	1	1	1	1	1	1
Norway		2	2	2	2	2	3	0			
Portugal		2	2	2	0	0	0	0			
Spain		5									
.											
Total	6,932	5,469	3,501	3,085	1,816	1,277	1,012	803	710	620	364

Source: European Wind Energy Association, 2013.

Looking more precisely at offshore wind energy, the vast majority of the capacity, over 90%, was located off northern Europe, with a lead from the United Kingdom (see table 2 above). The launch, in November 2012, of the U.K. Green Investment Bank, one of several governmentbacked green investment banks devoted to investing in clean-technology infrastructure (Gilbert, 2013), further allowed the country to dominate the Offshore Wind Energy Market in 2013. It continued to lead the offshore wind energy market with 56% of EU installs at the end of 2013, followed by Denmark and Belgium. Large projects completed in 2013 included the first phase of the London Array wind farm at 630 megawatts. Siemens extended its global leadership in offshore wind with its turbine fleet expanding 58% to more than 4 gigawatts, with Vestas and Senvion (REpower) trailing (Bloomberg, Jan 30, 2014). Siemens is clearly the offshore-wind-energy leader by installations (Bloomberg, Jan 20, 2014). The closest competitor is Vestas.

The U.K. is hoping to solidify its position as the world's biggest offshore wind market in 2014 (Bloomberg, Mar 31, 2014). Committed legally to deliver 15% of energy from renewable resources by 2020, and well endowed in marine resources, the country recently opted to cut subsidies to both onshore and solar power in preference for larger subsidies for offshore power generation (Financial Times, December 2013), in particular to large-scale projects for cost considerations. The U.K. offshore wind market is expected to grow even further over the next decade as the U.K. government has approved several projects recently. Canada and the U.S. are also seeing a renewed interest in the market thanks to improvement in technology and expertise (and its associated impact on cost of production), and increased demand for renewable energy in both countries. For example, approximately 30 states in the U.S. have passed a new legislation requiring that “at least some of their energy be generated by renewable resources” (Globe and Mail, 2013).

In terms of specific companies, Dong Energy of Denmark is referred to as a power producer. It is involved in the energy generation process of offshore wind from development and ownership to operations and maintenance. The company was responsible for 48% of new installations in 2013 and had a market share of 26%, according to the European Wind Energy Association (EWEA) data. Dong Energy is majority owned by the Danish government, but due to the need for capital investment for offshore wind energy, Dong Energy sold a 19% stake (8 billion kroner or $1.5 billion) to Goldman Sachs (Bloomberg, Jan 30, 2014). It should be noted that this investment not only helps the Danish economy but helps offshore wind farms expands further. It also creates a multiplier effect boosting revenue for turbine producers Siemens and Vestas, which both manufacture in Denmark.

Due to high capital expenditure needs to create larger wind turbines, many firms are partnering with other wind turbine makers (Bloomberg, April 7, 2014). Larger wind turbines seem to be most cost effective[3]. To compete with larger, more established players in the offshore wind industry, Siemens and Vestas, are combining their complementary onshore expertise. For example, Gamesa, which was the fourth largest producer of wind turbines in 2012, is partnering with Areva who has offshore experience[4]. Vestas completed its pilot 8- megawatt offshore wind turbine, which will be the world's largest, surpassing Enercon's E126 machine rated at 7.5 megawatts. Average turbine sizes rose to 1.85 megawatts in 2012 from 1.5 megawatts in 2008 as producers strive to obtain more production from available wind resources (Bloomberg, Jan 30, 2014).

One important challenge faced by ocean energy stems from its high cost of production. The typical levelised energy cost (LCOE) associated with offshore wind ranged from 15 to 23

[3] The larger wind turbines, designed to be used offshore in the near future, are 8 to 10 megawatt machines compared with 3 to 5 megawatts today, to help benefit from economies of scale and as a result cut the cost of offshore wind.

[4] To give a sense of the size difference, Areva and Gamesa's combined offshore wind energy interests were 55 megawatts in 2013. This contrasts with the 4,051 megawatts in projects for Siemens and 1,452 megawatts for Vestas (Bloomberg, Jan 21, 2014).

U.S. cents per kWh in 2012[5] (REN21, 2013). Compared, the hydropower (grid based) LCOE cost of energy amounted to 2 to 12 U.S. cents per kWh that same year, while the cost associated with tidal range power ranged between 21 and 28 U.S. cents per kWh.

As a result and as would be expected, ocean power still contributed little to the electric power global capacity as of 2012 (0.5 GW compared to 1,470 GW total, including hydropower, 480 GW if not including hydropower). There was little addition in 2012, and most of the change related to tidal power facilities. Facilities currently in operation in the world include the 254 MW tidal project in South Korea (introduced in 2011), the 300 kW wave energy facility in Spain (also in 2011), the Cobscook Bay Tidal Energy project off the U.S. coast of Maine. Off the coast of Portugal, three 100 kW wave energy converters were deployed. Other ocean energy facilities in operation include the old Rance tidal power station (240 MW, France, in operation since 1966), tidal plants in Nova Scotia (Canada, 20 MW) and in China (Zhejiang, 3.9 MW), as well as several tidal current and wave energy projects in the United Kingdom (about 9 MW).

ORE Industry Performance Compared to Others.

In order for ocean energy to be viable, it needs to attract future investors. For this to happen it is therefore important that the returns compensate investors for the perceived risk. As was the case with the solar and wind industries, as investors become more confident in the viability of the industry and likelihood of earning a fair return, more investment flows into the industry, allowing for more research and development to be conducted, leading to advances in technology and potential reductions in energy costs.

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[5] This figure is also exclusive of subsidies or policy incentives.

Thus, it is key to look at the stock performance of the Offshore Renewable Energy firms. Results here are somewhat mitigated. As shown in Table 3 below, the one year return for the Offshore Wind (38 firms) and Wave (3 firms) industries is greater than that of the European Stoxx 50 Index (26.27% compared to 16.13% respectively). The ORE industries also compare favorably to the FTSE 100 UK (4.66%), the TSX Canada (18.83%) and US indexes S&P 500 (15.21%) and Nasdaq (19.22%). However, for both the 3 year and 5 year returns, the trend is switched with the ORE industries underperforming all major European, Canadian and US indexes. Then again, when looking at the 10 year returns, the ORE industry returns are at par with equity indexes[6].

Interestingly, the returns for the Wave and Tidal Energy firms are higher than that of the Wind Energy firms, but this is probably due to the smaller sample size (n=3) and a few outlier firms, although it should be noted that small firms in new industries can exhibit tremendous growth. Here again, it should also be added that this sample only includes the firms that are publicly traded. Several firms involved in Offshore Wind Energy and Wave and Tidal Energy are either government owned or privately held.

Table 3: Performance of Offshore Renewable Energy firms compared to stock indexes measured by Stock Price Returns

Offshore Renewable Energy (ORE)

Wind and Wave combined

(n=41)	**Returns**	**1yr**	**3yr**	**5 yr**	**10 yr**
	Mean	26.27	4.44	-1.91	5.84

[6] The average 10 year stock performance for the ORE industry is 5.84%, compared to 5.49% for the Europe Stoxx 50 at 5.49%, the FTSE UK at 8.45%, the TSX Canada at 8.78%, the S&P 500 at 7.65%, and Nasdaq at 8.99%.

	Median	9.85	8.81	-0.15	7.62
	St. Dev.	36.20	13.18	7.34	5.42
Indexes (means)					
Europe Stoxx 50		16.13	8.19	9.84	5.49
FTSE 100 UK		4.66	8.86	13.23	8.45
TSX Canada		18.83	5.18	11.38	8.78
S&P 500		15.21	14.58	18.18	7.65
NASDAQ		19.22	15.17	20.35	8.99
Offshore Wind					
(n=38)	Mean	23.36	4.18	-2.10	5.53
	Median	9.01	8.75	-0.53	7.24
	St. Dev.	48.33	18.07	10.20	7.25
Wave Energy					
(n=3)	Mean	66.97	7.56	2.70	12.42
	Median	66.97	13.17	2.70	12.42
	St. Dev.	13.56	3.06	0.37	1.73

In terms of future growth in the industry, opportunities exist for ORE in North America and in Asia, as well as in Europe, which has seen the most growth in the past decade. In February 2014, Alstom (France) won a U.S. order for five 6-megawatt offshore wind turbines from Deepwater Wind for the Block Island offshore wind farm. Block Island may be one of the first U.S. offshore wind sites to be developed along with the Cape Wind project of the coast of Cape Cod in Massachusetts. Other potential sites in the U.S. that have been announced are in Massachusetts, Rhode Island, Delaware and Virginia. In terms of the western U.S. coastline, the

U.S. Bureau of Ocean Energy Management allowed Principle Power to submit a plan for a 30-megawatt floating offshore wind farm in Oregon waters. The project may be the first on the U.S. West Coast (Bloomberg, Feb 6, 2014). Ideas have been proposed for the deep water of the western seaboard, which may require floating foundations.

The U.S. and Asian markets offer the best growth potential. Site lease auctions are proceeding in the U.S., while projects such as Cape Wind, offshore Massachusetts, are making progress. China, Japan and South Korea are all developing offshore plans, with floating turbines in deep waters (Bloomberg, May 2, 2014)

ORE firms need to be reasonably large because they need significant capital investments in order to undertake projects of such a large size. The average market capitalization of ORE firms is $13.4 billion, which is smaller than the average company listed on the S&P 500, but larger than the average Nasdaq stock (see table 4 below). The median market capitalization of ORE firms is much smaller at $11.7 million, indicating that the sample has some very large firms. This also explains why it makes sense for such firms to be government owned.

Table 4: ORE size measured by Market Capitalization and number of Employees

		Market Capitalization	**Employees**
Offshore Renewable Energy - All			
(n=40)	Mean	13.45 billion	32,365
	Median	11.75 million	3,787
Offshore Wind			
(n=38)	Mean	14.34 billion	40,536

	Median	13.51 million	6,600
Wave Energy			
(n=2)	Mean	1.3 million	589
	Median	1.3 million	26
<u>Indexes</u>			
NASDAQ		6.49 billion	
Euro Stoxx 50			
	Mean	39.39 billion	
	Median	33.32 billion	
Toronto TSX			
	Mean	$1.9 billion	
	Median	$115 million	
S&P 500		$17 billion	

Importance of Government Policies in Fostering ORE Industry Performance

Over the years, support from governments has been essential in promoting renewable energy industries. This support has come in many different shapes, whether it be financial support aiming at improving technology development, or regulatory and economic instruments devised to lower the cost of production or consumption to end users. Table 5 below outlines some of the key policy measures countries have adopted in the renewable energy industry (and

ORE in particular), following these countries' involvement in the ORE industry[7]. These can serve as policy ideas to be adopted by countries seeking to promote renewable energy industries.

Table 5. Key elements of renewable energy policy framework in force as of 2013 by country, for ORE in particular.

Country	**Year established**	**To be reached by**	**Policy Type**	**Policy Target**
Australia	2010	2020	Carbon Pricing Mechanism	20% of electricity supply to be generated from renewables
Belgium	2010	2020	Quota and green certificate systems	13% of RES* in gross final energy consumption
Canada	2007-2009	In force	- Accelerated capital cost allowance -research, Develoment and Deployment (RD&D)	9 provincial RES targets but no national one.

[7] These countries were described in Tables 1 and 2 earlier.

China	2012	2015	Feed-in tariff	9.5% of RES in gross final energy consumption
Denmark	2010	2020	Feed-in tariff	30% of RES in gross final energy consumption
France	2010	2020	Feed-in tariff	23% of RES in gross final energy consumption
Germany	2010	2020	Feed-in tariff	18% of RES in gross final energy consumption
Ireland	2010	2020	Feed-in tariff	16% of RES in gross final energy consumption
Netherlands	2010	2020	Feed-in tariff	14.5% of RES in gross final energy consumption
Norway	2010	2020	Norway-Sweden Green Certificate Scheme	67.5% of RES in gross final energy consumption

Spain	2010	2020		22.7% of RES in gross final energy consumption
U.K.	2010	2020	- Feed-in tariffs - Research and Development (R&D)	22.7% of RES in gross final energy consumption
U.S.			- Grant and subsidies, tax incentives - ORE program regulatory instruments, codes and standards - State and local climate and energy programs (voluntary approaches, information and education…)	20% of RES in gross final energy consumption

*RES = Renewable Energy Supply

Note: For a more detailed description of all policies in place in each country to promote renewable energy (ORE in particular), we suggest the reader go to the IEA agency website.

Source: International Energy Agency. IEA/IRENA Joint Policies and Measures database. http://www.iea.org/policiesandmeasures/renewableenergy/. Accessed online October 7, 2014.

As can be seen from the above table, many European countries have renewable energy policy targets of some type, which requires of electricity retailers to source specific proportions of total power sales from renewable sources (at least 20%). There are at present at least 67 countries with such targets. These targets typically follow the Intergovernmental Panel on Climate Change (IPCC), which suggested greenhouse gas emission cuts by the year 2020 (sometimes 2025). While it has many provincial targets, Canada does not have a national target overall. The U.S. approach also differs by state.

To reach this renewable energy source target, several policies have been implemented since the late 2000s. Many European countries' main policy scheme relies on Feed-In Tariffs (FIT). A FIT is an economic policy instrument whereby renewable energy producers are offered long-term contracts that are typically based on the cost of generation of renewable energy. Renewable energy sources such as tidal power or offshore wind, which may be higher at the moment, are offered a higher per-kWh price. By providing price certainty and long-term contracts, this policy promotes renewable energy investments and financing.

Northern European Economies such as Sweden and Norway have opted to rely on a market-based mechanism, the Norway-Sweden Green Certificate Scheme. Here also, this support scheme aims at expanding the production of electricity coming from renewable resources. Under this program, power producers are issued certificates for each mega-watt-hour (MWh) of renewable electricity they produce. These certificates are sold on the power certificate market, where supply and demand determine the price, and producers receive additional revenue from the sale of these certificates. Each year, obliged parties must present equivalent number of certificates to their obligation quota levels. If certificates are not produced or if an obliged party falls short of the required number of certificates, a penalty of 150% of the average certificate value for a given period of time must be paid per each certificate missing. Here again, the goal of the measure is to provide energy producers an added incentive (lower risk) of generating power from renewable sources.

Another key factor potentially in promoting the use of renewable energy sources in the long run is the amount of research and development (R&D) conducted in these industries. Renewable energy industries, including the Offshore Renewable Energy industries of Wind, Wave and Tides all make use of technologies requiring consequent R&D. The sources of R&D can come from either the corporate level (or private R&D) or government level (public R&D). Table 6 below shows corporate research and development in the ORE industry. The median amount of R&D being conducted in that sector is relatively similar to that being conducted by firms in the Euro Stoxx 50 (European firms) and FTSE 100 (U.K. firms). The median amount of R&D being conducted by an Offshore Renewable Energy firm is $76 million, compared to $87 million for a typical European firm and $86 million for a British firm. Compared to U.S. firms, this is about half of that for a typical Nasdaq firm ($140 million) but double that of an S&P 500 firm ($32 million).

Table 6: Corporate Research and Development

Research and Development

	Median Expenditures (*millions*)
Offshore Renewable Energy - All (n=41)	76
Offshore Wind (n=38)	83
Wave Energy (n=2)	30
Indexes	
NASDAQ	140
S&P 500	32
Euro Stoxx 50	87
FTSE 100	86

Following the belief, in the aftermath of World War II, that R&D expenditures were vital to stimulate economic growth in the long run, public support has been called for. Government agencies were created to support science and engineering in many civilian industries, among which is the renewable energy industry. As such, the Environmental Protection Agency (EPA) was created in the U.S. in 1970, Nature Canada in Canada in 1994. These were created to deal with environmental issues in general. The Australian Renewable Energy Agency (ARENA) was implemented in 2012 and its goals are to improve the competitiveness of renewable energy technologies, and to increase the supply of renewable energy in Australia.

Public support or funding can take the form of tax incentives to reduce the cost of R&D, and direct subsidies that increase the return on investment for the industry. In addition, government can promote R&D as it conducts research in research labs and universities. For example, as early as 1974, and still in force, Canada implemented the *Program of Energy Research and Development (PERD).* Through this federal and interdepartmental program, Natural Resources Canada funds research and development in ocean development (as well other renewable energy sources). Since 2007, the industry also benefits from the Accelerated Capital Cost Allowance (ACCA). By advancing the timing of capital cost deductions for tax purposes, businesses are able to defer taxation and this improves the financial return from investment in the industry. Along the same vein, Australia implemented in 2014 alone, the Regional Australia's Renewables (RAR), the Supporting High Value Australian Renewable Energy (SHARE), and the Research and Development initiatives.

The underlying rationale for government support through these policy measures is that scientific and technological knowledge have "public good" characteristics. These characteristics have to do with incomplete appropriability of R& D returns, high risk associated with R&D, and problems of markets tarred with incomplete information (Stiglitz, 1988). In this context, public R&D for socially desirable projects such as renewable energy sources are hoped to be complementary to private R&D, both in the short and long run, as informational spillovers from public R&D and training of new scientists and engineers might stem from public funding.

Following the model developed by David, Hall, and Toole (2000) for understanding the impact of government R&D on private R&D, firms' investment behavior is said to depend on the cost of and expected return associated with private R&D. The return portion, also called the marginal rate of return of capital (MRR), in effect the derived demand for R&D, is downward sloping. As R&D investment increases, the expected return of the additional (or marginal) investment decreases. In contrast, the marginal cost of capital (MCC) is expected to be upward sloping. The additional cost of capital increases as the firms undertakes more R&D. Following David, Hall and Toole (2000) notations[8], the following two equations capture the above schema:

MRR = f(R, X) (1)

MCC = f(R, Z) (2)

Where R is the level of R&D expenditure, and X may include technological opportunities, the (potential) market or line-of-business, and/or institutional and other conditions affecting the appropriability of innovation benefits. As for Z, it includes technology policy measures that affect the private cost of R&D projects, macroeconomic conditions and expectations affecting the internal cost of funds, bond market conditions affecting the external cost of funds, and/or the availability and terms of venture-capital finance, as influenced by institutional conditions.

The firm's profit maximizing equilibrium is reached when the additional benefit from R&D equates its extra cost, or when MRR = MCC. This is also the level at which the optimal level of R&D investment is found (R*)

R* = h(X, Z) (3)

Any change in X and/or Z variables would be reflected in a shift in the corresponding MRR or MCC. For example, if we assume that government R&D provision is exogenous, then an 'injection' of public funding would shift the MCC or the MRR to the right, or both, increasing the overall optimal level of investment in the industry to say R**. Similarly, direct R&D subsidies or tax incentives (as described in Table 5 above) might lower the cost of doing research to renewable energy industries firms. It might also send a positive signal to consumers who will be more apt to demand energy from these renewable sources.

Data on government R&D allocated by countries for each ORE industry was obtained

[8] Page 504 in the original text.

from the European based International Energy Agency (IEA) research and development budget/ expenditure statistics, showing data from 1990-2011 for member countries. The IEA government R&D data covers basic research, applied research and experimental development, most of which is conducted at universities and research institutions. This data can be seen in Table 7 below.

Table 7: Government R&D - Total RD&D in Million USD (2011 prices and exch. Rates)

Country	**Industry**	**Government R&D 1991-2011 20 year Total**	**Current GDP per capita (2009-2013)* in USD**
Netherlands	Wave	4.79	47,617
US	Wave	103.83	53,143
US	Wind	1004.89	53,143
Germany	Wind	647.00	45,085
Denmark	Wind	369.90	58,894
UK	Wind	353.78	39,337
Netherlands	Wind	270.37	47,617

Japan	Wind	253.55	38,492
Korea, Rep.	Wind	185.54	25,977
Spain	Wind	129.81	29,118
Italy	Wind	123.62	34,619
Canada	Wind	123.62	51,958
Sweden	Wind	102.33	58,269
Finland	Wind	64.03	47,219
France	Wind	40.94	41,421
Australia	Wind	34.34	67,468
Switzerland	Wind	24.41	80,477
Belgium	Wind	3.70	45,387

Portugal	Wind	2.29	21,035
New Zealand	Wind	2.01	41,556

Source: The World Bank, http://data.worldbank.org/indicator/NY.GDP.MKTP.CD. Accessed October 22, 2014.

As can been seen in the table, 18 countries are conducting research in wind energy improvements. The governments with the highest amounts of R&D are the U.S., Germany, Denmark, the U.K., The Netherlands, Japan, Korea, Spain, Italy, Canada and Sweden. R&D for the wave industry remains sporadic and limited. As mentioned in part 1, the industry still faces important challenges, which very often deter investors. Despite the limitation of the Wind data associated to the fact that these figures above include both Onshore and Offshore Wind, Offshore Wind energy is showing promise and since the technology experiences economies of scale, it also shows increasing potential to investors.

Studies have been conducted over the years to test the impact of public funding on private R&D investment. Of particular interest is to know whether public R&D acts as a complement to private R&D or as a deterrent (or substitute) to it. The most recent work on the topic was done by Zúñiga-Vicente et al. (2014), who conducted a review of the empirical literature on the relationship between public subsidies and private R&D investment over the past fifty years. Their findings indicate that differences in the results obtained from these studies are still considerable. Still, despite the heterogeneity in (a) the industry, (b) the type of public funding, (c) the country considered, and (d) the methodology used, complementarity between public and private R&D seem to prevail. David, Hall, and Toole (2000) also reached similar conclusions. When looking at our raw data, and even though the portion of funding allocated to

ORE energy (wind in particular here) is minuscule compared to total GDP of the above countries, if we compare it with GDP per capita, we can observe that some countries' relative public R&D (such the U.K or the U.S.) is more consequent than for others (such as France or Canada). When considering now the prevalence of public R&D by these countries and its associated impact on the ORE industry, it would appear that higher public R&D are leading countries to be more prevalent in that industry. Since time is an important factor, it will be interesting to see how public involvement in ORE industry impacts how the industry is faring in these countries over time.

Conclusive Remarks

When concerned with ocean governance, the topic of ocean resource development and management often comes to mind. Offshore renewable energy encompasses both far reaching potential and limitations, in particular when it comes to tidal energy. In this paper, we reviewed the performance of ORE firms over time (since early 2000s) and examined different factors, such as policies (in particular public funding in the shape of subsidies, both corporate and government Research and Development (R&D), environmental goals and policies) that have played a positive role in the promotion of the industry.

Our findings indicate that along with other renewable energy technologies, the industry overall has seen an increase in contribution to electric power global capacity in recent years. This increase is attributed in large part to the development of offshore wind energy. The vast majority of this capacity, over 90%, was located off northern Europe, with a lead from the United Kingdom. The launch, in November 2012, of the U.K. Green Investment Bank, further allowed the country to dominate the Offshore Wind Energy Market in 2013. It continued to lead the offshore wind energy market with 56% of EU installs at the end of 2013, and is followed by Denmark and Belgium. For Wave and Tidal Energy, the scale of the industry remains small, but it should be noted that the stock price returns for the three publicly traded Wave and Tidal Energy firms are impressive. Nonetheless, Wave and Tidal Energy was largest in Australia, Canada, the U.K. and the U.S. Still, ocean power contributed little to the electric power global capacity. There was little addition in 2012, and most of the change was related to tidal power facilities.

In order to predict how ocean energy sources will be performing in the future, we looked at the stock performance of the ORE firms compared to other firms. Indeed, to attract future investment to the ORE sector, it is important that the returns compensate investors for the perceived risk. As investors become more confident in the viability of the industry and likelihood of earning a fair return, more investments flow into the industry. This capital allows for more research and development to be conducted, leading to advances in technology, and potential reductions in energy costs. These reductions in costs of production in turn make the production of renewable energy from ocean sources more sustainable in the long run. Our findings show a somewhat puzzling result. The 1 year return for the Offshore Wind and Wave industries is higher (26.27%) compared to the European Stoxx 50 Index (16.13%). The ORE industries also compare favorably to the FTSE 100 UK (4.66%), the TSX Canada (18.83%) and US indexes S&P 500 (15.21%) and Nasdaq (19.22%). However, for both the 3 year and 5 year returns, the trend is switched with the ORE industries underperforming all major European, Canadian and US indexes. As for the 10 year returns, the ORE industry experienced similar returns to the other indexes. The average 10 year stock performance for the industry is 5.84%, compared to 5.49% for the Europe Stoxx 50 at 5.49%, the FTSE UK at 8.45%, the TSX Canada at 8.78%, the S&P 500 at 7.65%, and Nasdaq at 8.99%. In terms of future growth in the industry, there are opportunities for ORE in North America and in Asia, as well as in Europe, which has seen the most growth in the past decade.

Interestingly, the returns for the Wave and Tidal Energy firms are higher than that of the Wind Energy firms, but this is due to the smaller sample size and a few outlier firms, although it should be noted that small firms in new industries can exhibit tremendous growth. It should also be noted that this sample only includes the firms that are publicly traded. Several firms involved in Offshore Wind Energy and Wave and Tidal Energy are either government owned or privately held.

ORE firms are also found to be very large. This is important, as the industry often needs significant capital investments in order to undertake large projects and fund R&D specific to ORE. This is reflected by the median market capitalization (stock price multiplied by the number of shares outstanding), which is $13.4 billion (smaller than the average company listed on the S&P 500, but larger than the average Nasdaq stock). It also explains why in many cases, government support has been seen as quintessential to allow for a smoother industry ‘take-off’. Over the years, this support has come in many different shapes, whether it be financial support aiming at improving technology development, or regulatory and economic instruments devised to lower the cost of production or consumption to end users. There are at present at least 67 countries with renewable energy targets of some type. These targets typically follow the IPCC suggested greenhouse gas emission cuts by the year 2020 (sometimes 2025). European countries typically all require of electricity retailers to source specific proportions of total power sales from renewable sources (20%). While it has many provincial targets, Canada does not have a national target overall. The U.S. approach also differs by state.

To reach this renewable energy source target, several policies have been implemented since the late 2000s. Many European countries' main policy scheme relies on Feed-in tariffs (FIT). Northern European Economies such as Sweden and Norway have also opted to rely on a market-based mechanism, the Norway-Sweden Green Certificate Scheme.

The amount of research and development (R&D) conducted in different renewable energy industries is also key in promoting renewable energy sources in the long run. Renewable energy industries, including the ORE industries of Wind, Wave and Tidal all make use of technologies requiring research and development (R&D), both at the corporate level and government level. The median amount of R&D being conducted in ORE is relatively similar to that being conducted by firms in the Euro Stoxx 50 (European firms) and FTSE 100 (U.K. firms), but compared to U.S. firms, this is about half of that for a typical Nasdaq firm ($140 million) but double that of an S&P 500 firm ($32 million).

Finally, this paper discussed the importance of public funding in contributing to the ORE industry development. In particular, the amount of public support through government R&D was evaluated. Data on government R&D allocated by countries for each ORE industry was obtained from the European based International Energy Agency (IEA) research and development budget/ expenditure statistics, showing data from 1990-2011 for member countries. The IEA government R&D data covers basic research, applied research and experimental development, most of which is conducted at universities and research institutions.

Our data show that the portion of funding allocated to ORE energy (wind in particular here) is quite insignificant compared to total GDP of the above countries. Still, some countries' relative public R&D (such the U.K or the U.S.) is more consequent than for others (such as

France or Canada). When considering now the prevalence of public R&D in these countries and its associated impact on the ORE industry, it would appear that there is a correlation between higher public R&D and the countries prevalence in that industry. Since time is an important factor, it still remains to be seen whether and how public involvement in ORE industry will impact how the industry is performing in these countries over time. Ocean energy (in particular the wave and tidal industry) still faces important challenges, which very often deter investors. Technology and costs are still major challenges for the ORE industry. The typical energy cost for onshore wind energy amounts to 5-16 U.S. cents/kWh in OECD countries, while offshore wind cost of energy ranged between 15-23 U.S. cents/kWh. Other, sometimes more important challenges, relate to finance, risk-return profiles, social and environmental factors, and an overall rethinking of how energy systems are designed, operated and financed.

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