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A cluster analysis of investment strategies in the offshore wind energy market

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Abstract—**This paper maps different investor strategies in the offshore wind energy market based on data from existing wind farms in the UK. This is realized through the employment of cluster analysis, which classifies offshore wind energy investors – who have purchased equity stakes-in terms of the entry timing, exit timing, purchase timing and stake purchased. We, then, perform a SWOT analysis to identify the major strengths, weaknesses, opportunities and threats encountered by each cluster of stakeholders. Cluster analysis revealed the existence of three distinct investment strategy profiles: i) Late entry investors, ii) Pre-commissioning investors, and iii) Own-build-transfer investors. Corporate and institutional investors tend to be late entry investors, whose strategy is based on buying assets while they are fully operational avoiding construction risks, retaining a risk aversion profile. The exit timing of OEMs and EPCI contractors usually takes place before or right after the commissioning of the wind farm. Finally, major Utilities tend to keep the operating assets on their balance sheet and divest only part of them (mostly minority stakes) during the operating stage; Independent energy companies are found in both 2nd and 3rd cluster; however, exceptions may be observed.**

Keywords — equity capital investors, offshore wind, cluster analysis, entry and exit timings, investment strategies, SWOT

I. Nomenclature

CfD:	Contracts for Difference
OEM:	Original Equipment Manufacturer
EPCI:	Engineering, Procurement, Construction and Installation
WACC:	Weighted average cost of capital
PPA:	Power purchase Agreement
O&M:	Operation and Maintenance
LEI:	Late-entry investors
PCI:	Pre-commissioning investors
OBTI:	Own-build-transfer investors

II. Introduction

Wind energy has become a significant part of the energy mix within the UK and Europe. It is now established as a mainstream rather than a developing technology, with a mature supply chain. Offshore wind offers favorable conditions for high yield energy production with higher wind shear, abundant available space and limited social impact. Currently, offshore wind farms with capacities similar to those of conventional energy technologies are already built, with higher capacity projects in the pipeline.

Within the existing market, a variety of investors exists with different investment strategies and appetite for risk. Acknowledging the vast uncertainties within the offshore wind energy sector, it becomes pertinent to identify means to systematically assess uncertainty with respect to service life valuation, hence supporting decisions of investors. Each investor develops their bespoke assessment and valuation framework projecting revenues and costs, in order to decide effectively their potential entry and exit instances of the offshore wind farm life-cycle.

As far as revenues are concerned in the United Kingdom, there is currently a transition from the Renewables Obligation (RO) scheme (set to finish on the 31st of March 2017) to the Contracts for Difference (CfD) scheme. According to the CfD scheme, an electricity generation party with CfD is paid the difference between the constant "strike price" and the average UK market price for electricity - "reference price". If the reference price is higher than the strike price, the generation party has to pay back the difference. Bottom line is that company always gets the strike price for electricity generated. The scheme lasts for 15 years (while the average lifetime of an offshore wind energy asset is 25 years), after which the electricity output is sold on the average UK electricity market price, hence imposing uncertainty to the revenues yielded by the investment after the 15th year of operation [1].

The present paper aims at mapping different investor strategies followed by stakeholders in the offshore wind industry in terms of a number of factors through a cluster analysis [2], by processing data obtained from industry for existing installations; we, then, distinguish the major strengths, weaknesses, opportunities and threats applied to each cluster of stakeholders. The study focuses on offshore wind farms installed in the UK sites, but the methodology can be applied in different regions.

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III. The existing landscape of the UK offshore wind energy investors

Offshore wind (OW) is one of the most rapidly growing markets of all RE technologies. By the end of 2016, there are 3,589 offshore wind turbines with a combined capacity of 12,631 MW fully grid connected in European waters in 82 wind farms across 11 countries, including demonstration sites [3]. The UK is the world's largest generator of electricity from offshore wind, meeting around 5% of annual demand, which is expected to reach 10% by 2020 [4]. Total installed capacity is 5,156MW, representing 40.8% of the total installed capacity worldwide.

Although offshore wind is a proven technology with an expanding supply chain, with the technology's levelised cost of electricity still being relatively high, in the region of 118£/MWh [5], the issue of financing is of major importance. To this end, debt and equity investors along with innovative financing structures are required to support the further deployment of offshore wind.

During the initial stages of the offshore wind market development, major Utilities have been the main investors, bearing all risks from the consenting up to the decommissioning stage of the investment. With the scaling up of the market, new entrants became active in different aspects of the business. Currently, market comprises of a diverse pool of equity investors: Utilities, OEMs (Original Equipment Manufacturers) and EPCI contractors (Engineering, Procurement, Construction and Installation), Independent Power Producers, Pension Funds, Infrastructure Funds, Institutional investors, and Sovereign wealth funds. Different classes of investors usually accept to uptake risks of higher or lower magnitude and of different nature; while, a considerable number of Banks have gained experience in lending to projects and taking construction risks as well [6], improving the financial landscape of the sector.

Corporate finance is dominant in the European offshore wind energy sector, according to which both debt and equity are raised at corporate level (owner's balance sheet), with the corporation's weighted average cost of capital being the weighted average of the required returns as determined by the market. On the other hand, in project finance, funding is raised at the level of each project, individually. Since, project finance investments apply only to the given project, the cost of capital considered provides a good insight for the effective cost of capital of the project and hence the discount rate [7]. Nevertheless, project finance has been underused by power producers since it was considered too expensive; further, the risk of damaging their credit rating is higher, while the due diligence processes are quite time consuming [6].

3. Cluster analysis of investors in the offshore wind industry

Cluster analysis partitions data into groups so that everything within a group are similar, but different to everything outside that group [8]. A cluster analysis of investors in the offshore wind industry was employed to identify whether specific elements from specific groups of investors can be detected. The analysis gathers knowledge gained by the existing UK offshore wind installations based on data collected from desktop research (e.g. 4C Offshore online database [9] and market reports/online announcements such as: Centrica Company news).

A. Selection of variables and data collection

The 'objects' to be clustered in this analysis are the offshore wind energy investors who have acquired a stake in offshore wind energy projects and the 'observations' are: entry timing, exit timing, purchase timing and stake purchased. There are numerous additional variables that could be considered depending on the aim of the grouping task. Such variables include: the value of stake, the capacity of the wind farms, the O&M costs, the capital cost, the corporate WACC, the divestment stakes and timings, among others. We, nevertheless, focused on above-mentioned parameters since the focus of the study is to explore whether there are distinct trends of investment timings throughout the life of the offshore wind farm, along with the ownership share that different types of investors are willing to buy.

To normalize the data acquired from all currently operating UK offshore wind energy projects investigated (so as to eliminate specificities of each project with regards to the timing of the investment e.g. due to delays during the licensing process or other stages), a scaling of the timing was adopted which is illustrated in Table 1. The scaling was considered appropriate, taking into account that offshore wind projects have often very different characteristics to each other. For instance, the construction of a project with high total power capacity (over 500MW) will probably last longer (since it would require more complex installation operations) than the construction of a lower capacity one, while a project whose location is more likely to cause public opposition or has higher environmental impacts may be subject to longer licensing processes. Since this study focuses on the stage each type of investor enters, exits and purchases stake, rather than the actual year before or after the commission of the project, the time scaling of Table 1 was assigned to the observations (exit, entry, purchase timing).

Table 1 Time scaling of the different stages of an offshore wind farm

Offshore wind energy life stages	Scaling
Consenting period (from pre-consenting up to consent authorization)	-3
Production and acquisition	-2
Construction and installation	-1
Commissioning	0
Operation and maintenance (throughout the 5 year OEM warranty)	1
Operation and maintenance (following the 5 year OEM warranty)	2
Long Term Operation (towards Decommissioning)	3

B. Results

Cluster analysis starts with a data matrix, where objects are rows and observations are columns. Results of the cluster analysis method applied to operating installations, indicated the formation of distinct groups following similar strategies in terms of their entry, exit, purchase (of equity stake of the investment) timing, as well as the stake purchased.

The resulting scores in the afore-mentioned observations vary among the different stakeholders. A hierarchical cluster analysis was employed, using SPSS software, to maximize the variability between clusters and minimize distance between objects of the same cluster [2]. Following the calculation of the distances between the objects (using the “squared Euclidean distance”), next step in the clustering process is to determine the number of clusters. The dendrogram in Fig. 1 shows the sequence by which the observations and clusters were merged. As mentioned above, the objects of the analysis are the equity capital investors who have purchased stakes in the UK offshore wind sector, while the underscore number refers to the relevant offshore wind energy project. A list of the projects that were considered for the analysis is presented in Appendix A. Figure 2 indicates the composition of the different investor classes found in each cluster along with the mean values of the observations applying to each cluster.

Finding the suitable number of clusters can be determined through a variety of statistical methods. Yet, the clustering should ultimately fit the purpose of the analysis [2, 10] to conceptually support the relevance of the objects of the same cluster. A three-cluster solution was thus adopted and the distinct investor strategy scenarios are documented below:

i) Late entry investors

The first group of investors primarily comprises third party capital investors. Third party financing originates from investors seeking to contribute equity capital without having an involvement on the core activities of the asset. Corporate investors (Marubeni corporation, BlackRock Investment Management, TCW), infrastructure funds (Green Investment Bank) and institutional investors (Development Bank of Japan, AMF Pensionsförkäkring) tend to be late entry investors, buying equity stakes usually a few years after the plant is fully commissioned or, less often, during the late construction phase. The strategy of institutional investors is traditionally based on undertaking exclusively operational risks and avoiding construction risks, retaining a low risk profile with stable returns [6]. The purchased stakes are in general minority stakes (a mean value of 40.7% stake was calculated as shown in Fig.2) and the exit timing is usually long term, most frequently surpassing the 5 year-warranty period of the offshore wind farm. A representative case is the consortium consisted of Green Investment Bank and BlackRock Investment Management in the Lynn and Inner Dowsing offshore wind project, who purchased 61% and 39% equity stake respectively, from Centrica and EIG Global Energy Partners during the 7th year of operation of the above offshore wind project, while Centrica is committed to purchase 100% of the power produced and 50% of the Renewable Obligation Certificates until 2024 [11]. A 49.9% equity stake was sold to Marubeni Corporation on operation year 1 of the Gunfleet Sands wind farm, while 2 years later the Development Bank of Japan purchased the 25% of Marubeni’s stake.

ii) Pre-commissioning investors

Independent energy companies (AMEC Offshore wind power, Statkraft, Warwick Energy & Partners, Shell WindEnergy, Eurus Energy, Ecoventures, SLP energy, Eclipse Energy, WIND Prospect Ltd, Enxco AS, Zilkha Renewable Energy), as well as EPCI (Engineering, Procurement, Construction and Installation) contractors,

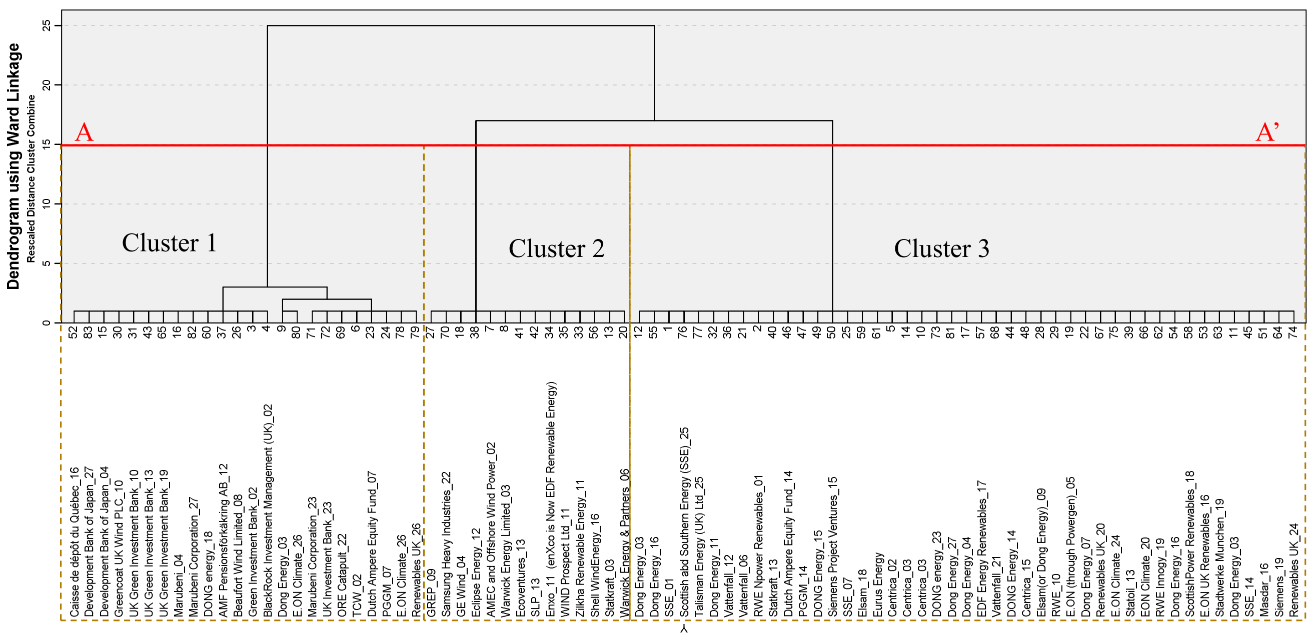

Figure 1 Dendrogram of clusters of organizations divesting stakes of offshore wind energy assets

and Original Equipment Manufacturers (OEMs) (GE Wind and Samsung Heavy Industries, GREP, SLP and Shell Wind Energy) are the majority of investors included in this cluster. Investors in this cluster enter the investment at the beginning of the project's lifecycle, usually from the tendering process of the offshore wind site; the exit timing also takes place prior the commissioning of the wind farm either during the pre-construction (Consent submission, consent authorization, pre-construction period) or during the construction period. The exit year often coincides with the year of disinvestment suggesting that the percentage of stakes disinvested usually amounts to 100%, with the exception of SLP energy and Ecoventures, who have initially disinvested half their stake from Sheringham Shoal project during the initiation of the project (preconstruction phase) and the rest of their stake during the construction stage. On the other hand, the SeaScape Energy joint venture formed to develop the later called Burbo Bank was a venture among: Zilkha Renewable Energy, Enxo AS and WIND Prospect Ltd. Nevertheless, the full ownership and development rights were sold to DONG Energy during the preconstruction stage of the asset.

iii) Own-build-transfer investors

The third group represents investors/project developers who tend not to divest their assets once fully permitted or constructed; rather, they prefer to keep the operating assets in their balance sheet and divest part of their stake (minority stakes) during the operating stage of the asset. The majority of this group consists of Major Utilities like DONG Energy, RWE, Vattenfall, SSE Renewables and E.ON and Independent power producers. As such, this cluster tends to invest equity from the licensing period, work on the development and operation of the wind farm, and divest minority stakes usually during the construction period; holding, however, their remaining share of equity capital for longer periods. Nevertheless, this cluster also includes investors who act as turnkey developers entering the venture at an early stage of its lifecycle, in order to get involved in the construction and installation stage, and following a few years after the project is fully commissioned, they tend to sell the majority (if not the entire) stake they own exiting during the operating stage of the asset. A representative example of such an investor type is Centrica acting as a turnkey developer, assuming the project development risks, running the wind farm for the first years of its operation and exit usually before the end of the 5-year warranty period provided from the wind turbine manufacturer (OEM) [12].

IV. SWOT ANALYSIS OF DIFFERENT PROFILES OF INVESTORS' STRATEGIES

A SWOT (Strengths, Weaknesses, Opportunities, and Threats) analysis was further developed in order to map the characteristics of the different investor strategies.

A. SWOT analysis of "late-entry investors"

As shown in Fig. 2 Corporate investors, infrastructure funds and institutional investors account for approximately 70% of the "late entry investors" cluster. Institutional investors consist of pension and life insurance funds. Infrastructure funds' motivation to join the sector is driven by a requirement to promote green energy; hence, they typically invest during the late construction or early operation of the wind farm contributing corporate financing and using their corporate WACC to evaluate the investment.

Strengths: Institutional investors and infrastructure funds typically manage very large amounts of money (mostly in the scale of billions). Institutional investors are interested in owning projects during their operating life and the cost of capital for this class of investors lies in the region of 6%-12% [6, 13]. This group benefit from the lack of construction risk and known factors that affect operational risks (thoroughly investigated through due diligence reports). Institutional investors are interested in

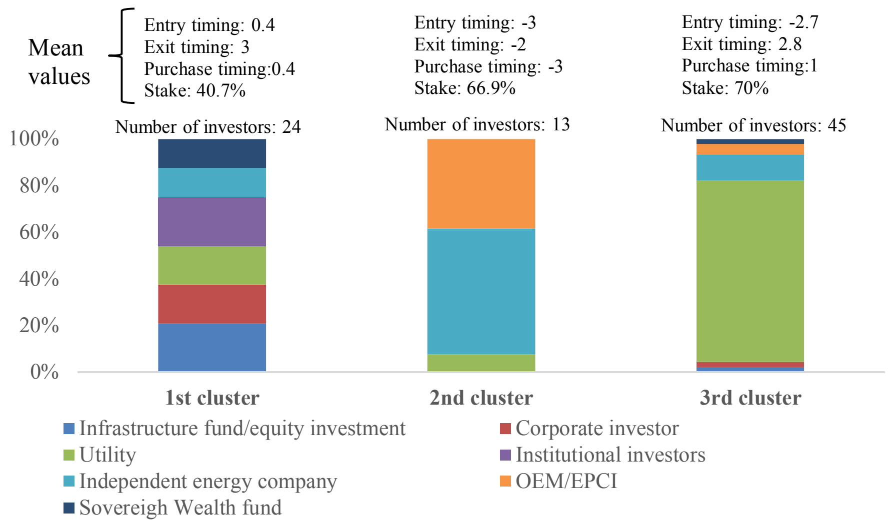

Figure 2 Composition of Owner classes in each cluster

making long term investments so as to meet their commitments in terms of pension and insurance claims [6].

Weaknesses: Because of the nature of their business model, third party financing investors are low risk, low return investors. They require warranties (mostly from partners power producers) to cover risks such as power price, construction, variability of wind speeds and O&M costs; however, this results in relatively low returns (low profit margins) also due to unanticipated contingencies. Institutional investors are generally unexperienced in directly investing in infrastructure projects and hence need to employ high cost due diligence surveys in order to evaluate the investment and account for entailed risks when taking on stakes during the operating stage [6]. Nevertheless, recently under project finance deals, infrastructure and institutional funds have started taking construction risks while working together with major power producers who can evaluate in detail the entailed risks. A representative example is PGGM & Ampere Equity Fund refinancing of their 24.8% stake bought from Dong Energy in Walney offshore wind farm [14].

Opportunities: Offshore wind can be a suitable investment for corporate and institutional investors for a number of reasons. Considering the costs of due diligence and their business model orientation, managing fewer large-scale investments is more cost-effective than numerous cheaper ones. Additionally, pension and insurance funds are suitable for providing financing to investments yielding long term returns (until investees claim their life insurance or pension), constituting a good match with the offshore wind energy investments, whose revenues are paid out over the lifetime of the asset (namely 20-25 years), while the break-even of the investment has already taken place and the institutional funds can fulfill their liabilities [6].

Threats: The investment period usually exceeds the subsidy contract period, following which revenues are calculated based on undefined market electricity spot prices. Therefore, the period beyond which power sales are contracted, called merchant tail [15], is difficult to predict, impeding the accurate estimation of the internal rate of return of the project. There are still no reference projects to allow for a confident estimation of decommissioning costs and further for an accurate assessment of O&M costs of assets within the second half of their service life.

B. SWOT analysis of "Pre-commissioning investors"

The second cluster comprises mostly of independent power producers and OEMs/ECPI providers. Independent power producers (IPPs) develop, construct and operate offshore wind energy projects; accordingly, they usually sell the generated energy to the grid or to large scale power providers through Power Purchase Agreements (PPAs). Nevertheless, there is a considerable number of IPPs (found in the 3rd cluster), tending to keep the operating assets on their balance sheet or divest smaller stakes. OEMs/ECPI providers bring technical expertise not only during the construction and installation stage of the project but also during the maintenance operations of the wind farm. Nevertheless, above stakeholders contribute equity capital mainly up to the construction and early operation.

Strengths: IPPs with a background in the offshore oil & gas industry (such as Shell) can bring their long experience in the sector. OEMs/ECPI providers' investment strategy is aligned to their business model, gaining profit margins from the installation, manufacture and maintenance of the wind farm. The latter type of investor has the flexibility to consider building a higher-CAPEX asset (more conservative designs through higher material factors in accordance to Industrial Standards [16]) aiming at reducing the OPEX associated with inspections and maintenance (by increasing the intervals between consecutive inspections) and accordingly increase the value of the asset aiming at selling it to another investor at a higher price. OEMs dominate the offshore wind O&M activity and the main reason is the warranties that are sold alongside the procurement of the turbines. These warranties refer to minimum levels of availability and have a typical duration of five years [12].

Weaknesses: IPPs do not have as strong balance sheets as Utility companies and their cost of capital lies in the region of 10-20% (with the exception of IPPs with a background in the offshore oil & gas industry) [6]. They, therefore, seek for third party financing or sell their consent-authorized projects to other parties able to inject cash for the construction of the wind farm, keeping part of the ownership. OEMs and EPCI providers invest equity primarily to ensure the sales of their equipment and technical services for the project; nevertheless, projects they invest equity in, need to be reliable in order to fulfill certain return requirements [17]; indicative risk adjusted return of this class of investor lies between 12-14% [13]. OEMs and EPCI contractors with weak balance sheets typically do not intend to be long-term owners; they, rather, exit either during the construction, commission or a few years following the commission of the asset. However, they may be required by the debt covenants not to divest their stake at an early stage and therefore usually investment in offshore wind projects are taken by OEMs/EPCI providers with strong balance sheets.

Opportunities: EPCI providers and OEMs can mitigate risks by providing turnkey solutions and demonstrating successful track records in their balance sheets, which will contribute to attract new sources of equity and debt funding. Although multi-contracting might be an attractive solution to sponsors, lenders prefer to reduce contract interface risks (increasing counterparty risks) [6]. Following the 5-year warranty period, increasing opportunities for ECPI providers and OEMs are disclosed to increase their market share, diversifying their business and secure additional revenues [18]. Independent power producers' need for capital can also attract financing innovation. By bringing their experience in renewable energy projects, they can create partnerships with equity providers who lack the technical knowledge, such as institutional investors and infrastructure funds.

Threats: OEMs face barriers related to entry in the supply chain due to the significance of the reputation of the firm, keeping the supply of main equipment closed to large manufacturers such as Vestas and Siemens (~65% of total installed capacity) [6]. A study conducted by Deloitte [18] highlighted that one of the biggest challenges in the wind services sector is the lack of qualified technicians to undertake O&M activities.

Table 2 SWOT analysis key points

Strengths	**"Late-entry investors"** - Large amounts of money available - Lower cost of capital - No construction risk - Known operational risks (due diligence reports) **"Pre-commissioning investors"** - IPPs from the offshore oil & gas experience in the sector - OEMs/EPCI providers have flexibility to decide on the specifications of the asset influencing its future value **"Own-build-transfer investors"** - Major utilities hold a strong position in offshore wind energy - Strong balance sheets - High competence through the whole value chain of the offshore wind asset - Vertical integration	***Weaknesses***	**"Late-entry investors"** - Risk adverse - No opportunity to influence specifications of the structure - High costs for conducting due diligence surveys **"Pre-commissioning investors"** - OEMs and EPCI providers lack the financial strength to finance the project **"Own-build-transfer investors"** - Financial crisis has impacted financial performance of Utilities
Opportunities	**"Late-entry investors"** - More efficient to manage a few large scale investments rather than many smaller ones (e.g. due to due diligence reports); - Matching of asset's long term returns with liabilities of institutional investors (such as pension funds) **"Pre-commissioning investors"** - OEMs/EPCI providers ensure sales of their equipment and O&M services; - OEMs/EPCI providers can provide turnkey solutions to attract financing from institutional and infrastructure funds **"Own-build-transfer investors"** - Political support for offshore wind; - Strategic agreements	***Threats***	**"Late-entry investors"** - No reference projects to estimate decommissioning costs and late O&M costs - Uncertainty during the merchant tail period **"Pre-commissioning investors"** - High competition to enter the supply chain **"Own-build-transfer investors"** - Competitive environment - Risk management of the project

C. *SWOT analysis of "Own-build-transfer investors"*

The Own-build-transfer group is dominated by major Utilities, Independent energy companies and Sovereign wealth funds.

Strengths: Utilities hold a very strong position in offshore wind energy market. Their strategy focuses on developing the offshore wind farm from the initial stage, and operate it following its commission, divesting mostly minority stakes to institutional and infrastructure investors after a few years of operation. Major Utilities follow a vertical integration business model, operating across the value chain from energy production to retail and trading (to end customers), which drives synergies and places a competitive advantage of the company, while also meeting the requirements under the Renewable Obligations scheme. They are able to finance the project from their own reserves or through corporate finance at a low cost of capital (~8-10%) [6]. Sovereign wealth funds are state funds and hence their cost is typically low, while they typically have large amount of capital to invest in their disposal.

Weaknesses: Although Utilities still dominate the offshore wind energy market, their financial performance has been impacted by the financial crisis, and they hence need to look for other sources of equity and debt financing. To this end, other financing schemes are gaining popularity such as project financing and joint ventures.

Opportunities: The political consensus on promoting clean energy technologies creates great opportunities for big energy companies to participate in the transformation of the energy system. Opportunities lie within the creation of strategic agreements and partnerships, as well as the reduction of the cost of energy.

Threats: Stakeholders within this group operate under a competitive environment, while since they get involved from the development to the operation stage, they need to manage all risks entailed: complex approval processes causing delays or higher payments, regulatory/policy risks related to the uncertainties in policy support schemes, counterparty risks either from equipment/O&M services suppliers or from PPAs not kept, revenue variability due to the intermittency issues or/and due to the grid availability, and electricity price risk, among others [19].

V. Discussion

Results of the cluster analysis have highlighted the existence of three distinct clusters. Considering that the earlier developed wind farms are now reaching the middle of their service lives, i.e. approximately 10 years, we might expect to see another cluster forming concerning investors choosing to enter or exit the market as the assets approach the end of their service life with the view to repowering or proceeding to the service life extension of the assets. This paradigm has been observed in onshore wind energy assets where a secondary market has developed. Moving on to the next generation to offshore wind energy assets, their potential to allow multiple entry/exit points could be built in even from the planning and design stage.

Typical example comprises the potential decision to employ appropriate provisions of standards to initially over-design the assets or decide to install appropriate integrity monitoring systems with a view to reduce required inspection and unplanned maintenance, hence reducing expected CAPEX. Such an approach will also allow certification, which is a pertinent provision towards transferring risks during operation.

It becomes apparent that evaluating an offshore wind energy project needs to take into account the presence of risk, through appropriate analytical methods [20]. For instance, common industry practice in order to account for the uncertainty in electricity prices after the 15 years (during which revenues are determined by the strike price secured) is to apply forward curves to predict future electricity prices and sensitivity analysis in key input parameters, such as cost of capital, CAPEX and OPEX components, etc.

VI. Conclusion

As the offshore wind energy market expands and the number of operating wind farms increases, commercial aspects begin to receive a lot of attention. Currently, investors from different backgrounds and with different strategies seek for opportunity instances throughout the lifecycle of the asset to invest by purchasing stake of the ownership and contribute equity capital. To better understand whether specific trends can be observed by the different stakeholders, we performed a cluster analysis, where objects were assumed to be investors who have purchased stake in offshore wind energy projects and the observations were the entry timing, exit timing, purchase timing and stake purchased. This process indicated three distinct clusters: the late-entry investors, the pre-commissioning investors and the Own-build-transfer investors.

Late-entry investors represent corporate investors, infrastructure funds and institutional investors who tend to invest equity capital a few years following the commissioning of the plant or, less often, during the late construction. Being, on the most part, a risk adverse group of stakeholders, they tend to avoid construction risks. Long term returns of offshore wind energy assets match with the long term liabilities of institutional investors (such as pension funds), while the high costs of due diligence reports urge third party financing stakeholders to prefer investing in fewer capital intensive assets rather than numerous less expensive ones.

Pre-commissioning investors include independent energy companies and OEMs/EPCI contractors, who enter the venture at the beginning of the project's lifecycle, in order to contribute their technical expertise and knowledge deriving from long term experience in the development of energy projects. An additional incentive for OEMs to invest in the early stage of the development of the wind farm is to ensure the sales of their equipment as well as the O&M contracts of the wind farm. This group usually lacks the balance sheet strength (with the exception of large oil and gas IPPs) to provide large amounts of equity and rely on third party financing for the funding of the project.

Finally, "Own-build-transfer investors" represent principally Utilities; however, IPPs and Sovereign wealth funds were also found to follow a similar trend in terms of the examined criteria. In general, Utilities hold a very strong position in offshore wind energy market operating across the value chain of the wind energy asset. Their strategy focuses on developing the offshore wind farm from the initial stage, and operate it following its commission, divesting mostly minority stakes to institutional and infrastructure investors after a few years of operation.

Similar clusters can also be observed in the offshore oil and gas industry where assets have been operated significantly beyond the end of their service life and an additional cluster is present offering opportunity to invest or disinvest as the assets approach their nominal service life.

Appendix

A. Offshore wind energy projects

1.Greater Gabbard	15. Lincs
2. Lynn and Inner Dowsing	16. London Array Phase One
3. Barrow	17. Teesside
4. Gunfleet Sands 1 & 2	18. West of Duddon Sands
5.Robin Rigg	19. Gwynt Y Mor
6. Thanet	20. Humber Gateway
7. Walney 1	21. Kentish Flats Extension
8. North Hoyle	22. Levenmouth Demonstration Turbine (Energy Park Fife)
9. Kentish Flats	23. Westermost Rough
10. Rhyl Flats	24. Scroby Sands
11. Burbo Bank	25. Beatrice Demonstrator
12. Ormonde	26. Blyth Offshore
13. Sheringham Shoal	27. Gunfleet Sands Demonstration Project
14. Walney 2	

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References

[1] DECC, 2014. *Contract for Difference : allocation process high level summary*.

[2] Spyridaki, N.-A., Ioannou, A. and Flamos, A., 2016. *How Can the Context Affect Policy Decision-Making: The Case of Climate Change Mitigation Policies in the Greek Building Sector*. Energies 2016, 9(4), 294; doi:10.3390/en9040294

[3] Wind Europe, 2017. T*he European offshore wind industry, Key trends and statistics 2016*. January 2017.

[4] Crown Estate, Offshore wind electricity map. Available at: https://www.thecrownestate.co.uk/energy-minerals-and-infrastructure/offshore-wind-energy/offshore-wind-electricity-map/ (Accessed 02/2017)

[5] Ioannou A., Angus, A., Brennan, F., 2016. *"Stochastic Prediction of Offshore Wind Farm LCOE through an Integrated Cost Model"*. Energy Procedia 107C (2017) pp. 383-389. DOI: 10.1016/j.egypro.2016.12.180.

[6] EWEA (European Wind Energy Association), 2013. *Where's the money coming from? Financing offshore wind farms*. November 2013.

[7] Levitt, A. C., Kemptona W., Smithb, A. P., Musial W., Firestone, J., 2011. Pricing offshore wind power. Energy Policy 39 (2011) 6408–6421.

[8] Mooi, E., Sarstedt, M., 2010. *Cluster Analysis BT - A Concise Guide to Market Research: The Process, Data, and Methods Using IBM SPSS Statistics*. Chapter 9, pages 237-284.

[9] 4C Offshore Wind Industry Database: www.4coffshore.com. (Accessed 02/2017)

[10] Köbrich, C.; Rehman, T.; Khan, M. *Typification of farming systems for constructing representative farm models: Two illustrations of the application of multi-variate analyses in Chile and Pakistan*. Agric. Syst. 2003, 76, 141–157.

[11] OffshoreWIND.biz. *Centrica and EIG Sell Lynn and Inner Dowsing OWFs*. Available at: http://www.offshorewind.biz/2016/02/05/centrica-and-eig-sell-lynn-and-inner-dowsing-owfs/ Posted on February 5, 2016 (Accessed 02/2017).

[12] Garrad Hassan GL, 2013. *A guide to UK offshore wind operations and maintenance*. Scottish Enterprise and The Crown Estate, UK

[13] The Crown Estate, 2015. *UK Offshore Wind: Opportunities for trade and investment.* May 2015.

[14] PGGM. *PGGM & Ampere Equity Fund refinancing of their 24.8% stake in the 367 MW Walney offshore wind farm in the Irish Sea*. Available at: https://www.pggm.nl/english/who-we-are/press/Pages/PGGM--Ampere-Equity-Fund-refinancing-of-their-24-8-stake--in-the-367-MW-Walney-offshore-wind-farm-in-the-Irish-Sea.aspx (Accessed 02/2017)

[15] US Department of Energy. (2008). Annual report on U.S. wind power installation, cost and performance. Trends 2007. Energy efficiency and renewable energy

[16] DNV (2014). Offshore Standard. DNV-OS-J101. *Design of Offshore Wind Turbine Structures*. May 2014.

[17] Global Capital Finance and Clean Energy Pipeline, 2014. *The European Renewable Energy Investor Landscape*.

[18] Deloitte, 2012. *European Wind Services Study. Find out which way the wind blows.* August 2012.

[19] Gatzert, N. and Kosub, T. "*Risks and risk management of renewable energy projects: The case of onshore and offshore wind parks"*, Renewable and Sustainable Energy Reviews, Volume 60, July 2016, Pages 982-998.

[20] Ioannou, A., Angus, A., Brennan, F. *"Risk-based methods for sustainable energy system planning: A review"*, Renewable and Sustainable Energy Reviews, Volume 74, July 2017, Pages 602-615.