Poster number

Offshore Wind Due Diligence

How country and life-cycle stage impacts what to look for

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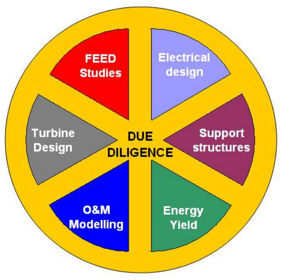
Abstract

For the Technical part of the Due Diligence process to be undertaken successfully and efficiently, the seller will have completed a suite of surveys and studies appropriate to the stage, locality and type of project. If insufficient work has been completed, the Adviser needs to provide a rapid assessment to quantify risk associated with any gaps, and this work relies on the technical competence and breadth of experience of the Adviser.

This paper summarises general and country specific key risks, the preferred stage of completeness of supporting work, how deficiencies in work or knowledge can be reduced through judgment based on experience and what the potentially resulting residual uncertainties could be.



Risk Identification and Evaluation

Risk can be divided into the following broad categories, with some key risk reduction actions listed:

Project Management: experienced team of the appropriate size

Regulatory: site lease, construction permit/consent, grid connection

Ground Conditions: comprehensive geophysical and geotechnical surveys of sufficiently wide scope, successfully and competently completed

CAPEX: credible projection based on careful and realistically assessed market-based costs, including appropriate contingencies

Energy Yield: data based assessment with appreciation of all uncertainties

OPEX: detailed studies, nature of guarantees, experience of service provider

PPA: exposure to market fluctuations; political risk

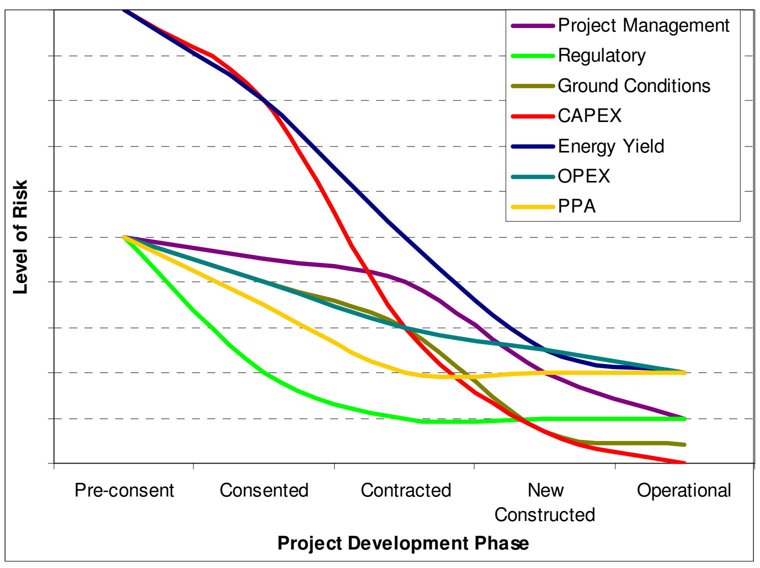
Programme: contingency, contractor experience

Other: other important risks will depend on stage, siting and country

Completeness of Work & Residual Risks

PROJECT STAGE	ENERGY YIELD [1]	SITE SURVEYS	COSTS	INCOME
Pre-consent	Atlas / General mesoscale map	Desk Study	General model	Market Study
Consented	Offshore mast / mesoscale map	Geophysical; some Geotech.	FEED [4] based	Market Study
Contracted	Onsite mast [2]	Geotechnical	Contracts & contingencies	PPA /REFIT [3]
Newly Constructed	"	Full Design Report	CAPEX: actual O&M: contracts & plans	"
Operational	Production analysis	"	O&M: actual & plans	invoices

1 Including detailed and realistic assumptions for losses
2 Not necessary if wind farm and candidate met mast both far from coast and at suitable proximity
3 PPA = Power Purchase Agreement; REFIT = Renewable Energy Feed-In Tariff
4 FEED = Front-End Engineering Design



Schematic illustration of risk reduction through the development process

Energy Yield Risk

Examining the Energy Yield Risk in greater detail, this can be managed through:

Wake Losses: full examination of offshore wake effects, neighbouring wind farms

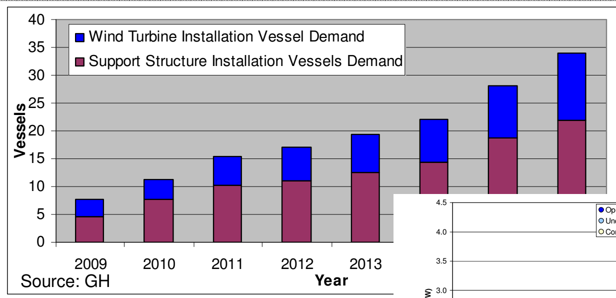
Wind Turbine Availability: accessibility due to wave climate and appropriate strategy (vessel, port etc.), contractual mitigation

Electrical Network Efficiency Losses: level of detail within assessment

Electrical Network Downtime Losses: redundancy, contractual mitigation

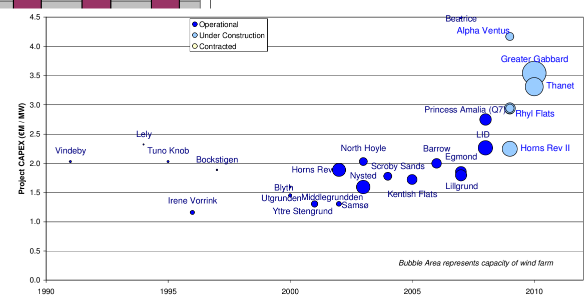
Wind Turbine Power Curve: independent verification, warranty

Other Selected Risks



Projected demand of installation vessels for support structure and turbines

Publicly reported CAPEX figures for offshore wind farms



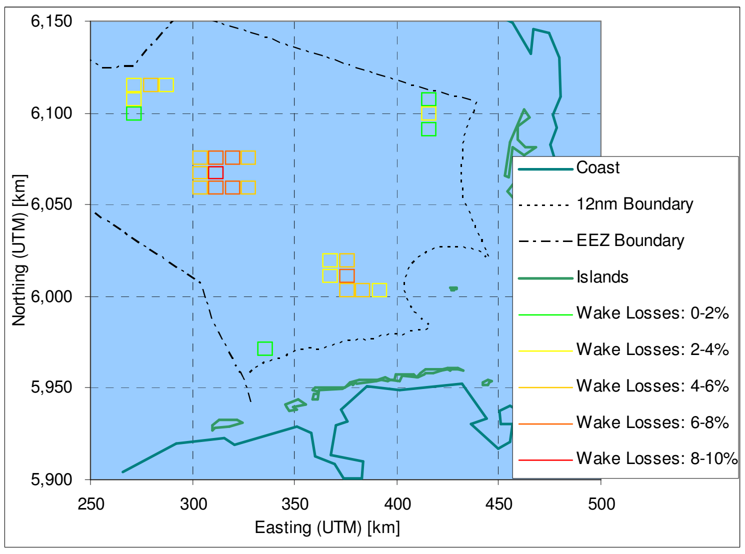
Comparison of German and UK Country Specific Offshore Risks

UK:

- PPA Volatility (Market and ROCs)
- OFTO
- Ground Conditions (drilling at some sites)
- Exchange rates
- Capacity to deliver (in particular UK based capacity)
- Ports

Germany:

- Foundations and installation vessels for deep water sites
- Small size of project developers, limited site availability
- Grid costs (if support removed)
- CAPEX (water depth & distance to shore)
- Wake losses due to neighbouring wind farms

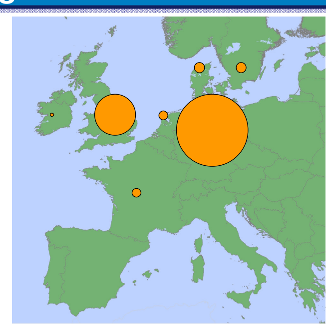


Indicative estimate of wake losses **due to neighbouring wind farms** in the German Bight (fictitious wind farms)

Source: GH

GH Offshore Wind Due Diligence

Denmark, France, Germany, Ireland, Netherlands, Norway, Sweden, United Kingdom
- >20 projects
- >8000 MW



Foundation of GH's Due Diligence expertise is the wide range of offshore wind studies and services provided by GH over the last fifteen years totalling around 200 commercial contracts in offshore wind alone and including regulatory studies, market assessments, energy yield analysis, O&M studies, electrical and structural engineering design

Offshore wind due diligence - how country, and life-cycle stage, impacts what to look for

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Abstract: For the technical part of the due diligence process to be undertaken successfully and efficiently, the sponsor will have completed a suite of surveys and studies appropriate to the development stage, locality and type of project. If insufficient work has been completed, the Adviser needs to provide a rapid assessment to quantify risk associated with any gaps, and this work relies on the technical competence and breadth of experience of the Adviser.

This paper summarises general and country specific key risks, the preferred stage of completeness of supporting work, how deficiencies in work or knowledge can be reduced through judgment based on experience and what the potentially resulting residual uncertainties could be.

Risk Identification and Evaluation

Risk can be divided into the following broad categories, with some key risk reduction actions listed:

- **Project Management:** experienced team of the appropriate size
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- **Ground Conditions:** comprehensive geophysical and geotechnical surveys of sufficiently wide scope, successfully and competently completed
- **CAPEX:** credible projection based on careful and realistically assessed market-based costs, including appropriate contingencies
- **Energy Yield:** data based assessment with appreciation of all uncertainties
- **OPEX:** detailed studies, nature of guarantees, experience of service provider
- **Power Purchase Agreement (PPA):** exposure to market fluctuations; political risk
- **Programme:** is the timeframe realistic, including appropriate contingencies
- **Other:** other important risks will depend on stage, siting and country

Progress of Preparatory Work and Associated Risk Reduction

Ideally, a project will have completed a degree of preparatory work, appropriate to the stage and status of the project, at the time of the Due Diligence work. In general, GH would expect this to be as summarised in Table 1.

PROJECT STAGE	ENERGY YIELD [1]	SITE SURVEYS	COSTS	INCOME
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Notes: [1] **Including detailed and realistic assumptions for losses**
[2] **Not necessary if wind farm and candidate met mast both far from coast and at suitable proximity to each other**
[3] **PPA = Power Purchase Agreement; REFIT = Renewable Energy Feed-In Tariff**
[4] **FEED = Front-End Engineering Design**

Table 1: Appropriate Completeness of Development Work

Of course, the individual circumstances of the wind farm may provide a good reason to deviate from the above, however in general, the above schedule would result in minimised risk and hence maximised risk-adjusted return and value for the offshore wind farm.

This risk reduction process is illustrated in a simplified manner within Figure 1. As the project is progressed, key risks need to be identified, analysed and assessed in terms of the impact on the overall economics and indeed viability of the project.

For the example shown in Figure 1, it is concluded that the key risks initially are Energy Yield and CAPEX, hence effort should be invested in installing a mast on site and identifying methods to reduce procurement, fabrication and construction costs. This might be achieved through framework-contracts and currency hedging however since the investments at early stages will be low and the option of abandonment will remain, it may be preferable to have completed a thorough engineering study providing definitive guidance over support structure, electrical infrastructure and wind turbine options.

For other projects, at other locations and countries, the risk profile might be very different. For example in the German North Sea, the presence of a publicly funded mast with good quality data may mean wind resource is well understood at an early stage. Likewise shallow waters with stable sand means monopiles will be the preferred option and contractor choice and appetite will be relatively good.

In other countries, the regulatory regime might have a history of frequent and major changes, which could result in that being the main risk factor.

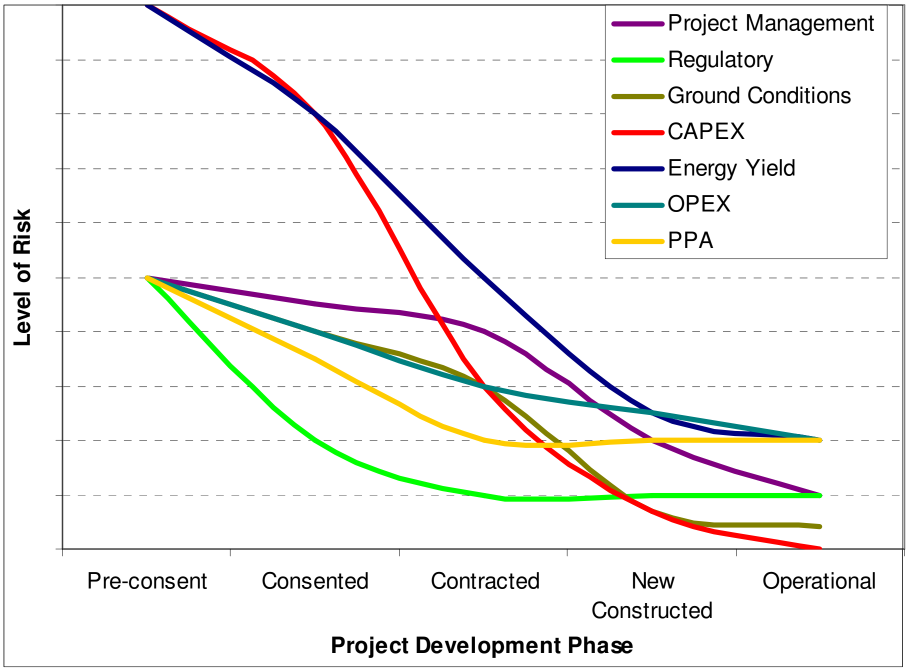


Figure 1: Risk Reduction through the Development Phase

In many cases, the developer will not have undertaken a sufficient range of studies and surveys. This could be for a wide range of reasons, including lack of financial and managerial resources, or because the ground conditions at the site were found to differ significantly from what could be reasonably anticipated at the early stages. In that case, the Potential Investor will need to make an informed decision on level of risk. This is a situation where the Potential Investor will benefit greatly from having selected an experienced and broadly skilled Technical Advisor.

Energy Yield Risk

Examining the Energy Yield Risk in greater detail, this can be managed through:

Wake Losses: full examination of offshore wake effects, including state-of-the-art methodologies based on experience at Horns Rev and Nysted; also an assessment of potential impacts due to neighbouring wind farms, bearing in mind the inherent uncertainty

Wind Turbine Availability: wave climate and appropriate strategy (vessel type, port details etc.) will drive the accessibility levels realisable; contractual mitigation

Electrical Network Efficiency Losses: level of detail within assessment; reliability statistics would suggest that downtime due to the export system would be low, however these statistics are invariably based on very different circumstances and the limited experience of operating offshore wind farms suggests that failures have occurred at some sites more frequently than expected

Electrical Network Downtime Losses: degree of redundancy of the electrical assets; contractual mitigation with grid operator and maintenance contractor for offshore substation; call-off arrangements for spares of critical components, such as sub-station transformers

Wind Turbine Power Curve: independent verification, appropriate warranty

Critical Risks by Country

As acknowledged earlier in the paper, the risk profile of a project can vary significantly, depending on the stage of development and the individual characteristics. However there are also particular risks that projects may be particularly vulnerable to, for example due to their country. Table 2 lists some key national risks specifically related to the United Kingdom and German markets.

United Kingdom	Germany
• **PPA Volatility**: the value of both the electricity as well the ROCs is volatile; to a certain extent, the two risks are uncorrelated, however both are complex and require effort to understand and assess • **OFTO:** it is proposed that in future the transmission assets for UK offshore wind farms will be owned and operated by independent third parties; the regime continues to be developed and hence the details, including any potential for derogation, are not fully defined • **Ground Conditions:** specifically drilling at sites with hard substrates present • **Exchange Rates:** due to the euro-zone's dominance of the European wind energy industry, pricing has been driven by that currency; countries outside the euro-zone whose currency does not track that Euro are susceptible to fluctuations in cost of imports • **Capacity to Deliver:** the projected build rates cannot be completed by the current contractor capacity, in particular there is a shortage of UK based companies • **Ports:** it is acknowledged that many UK ports have not been set up for serving the industry, hence in some cases more distant continental ports have been used; this issue is being actively addressed hence should change in the coming years	• **Foundations:** for deep water sites, conventional monopile solutions cease to be applicable; although numerous technical solutions have been developed, including jackets, tripods and tri-piles, the cost, deliverability and installability remains to be demonstrated in practice • **Installation Vessels:** similar to foundations, the installation vessels used for offshore wind farms to date have been developed for shallower sites and smaller lighter wind turbines • **Project Developer Size:** in general and until recently, German offshore wind projects have been developed by small project developers, some of whom had limited technical and financial resources; hence a greater degree of risk than expected may remain • **Grid Costs:** grid connection costs for distant offshore projects will be considerable; currently the utility provides a grid connection at the wind farm site at no cost to the project owner; clearly if this requirement were to lapse, some projects would cease to be viable • **CAPEX and OPEX:** generally high and uncertain costs due to water depth and distance to shore • **Neighbouring Wind Farms:** due to the high density of consented and planned projects, wake losses due to neighbouring wind farms will have a significant impact on energy yield at the most susceptible sites if all projects are realised

Notes **1 ROCs Renewable Obligation Certificates (green certificates)**

Table 2: Comparison of German and UK Specific Risks

Selected Critical Risks

In this section, three important and widely applicable risks are illustrated. Firstly, it is widely acknowledged that there are insufficient wind turbine and support structure installation vessels available to construct all planned projects, even if a healthily sceptical discount is applied to project build rates, Figure 2. This has led to conventional offshore engineering crane ships being contracted for some projects at offshore engineering day rates, these being significantly higher than the offshore wind energy industry had been used to. Installation vessel ownership and operation is a variable business and indeed owners need to make healthy profits in the good times to ensure survival during lean periods.

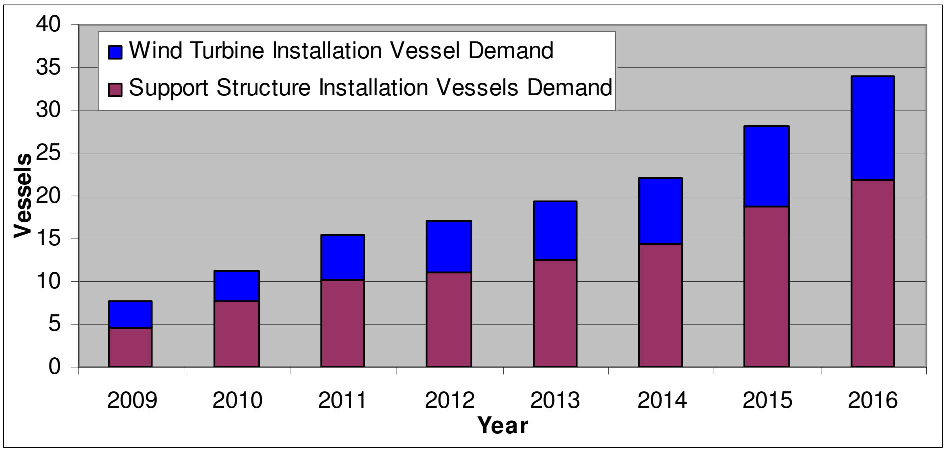
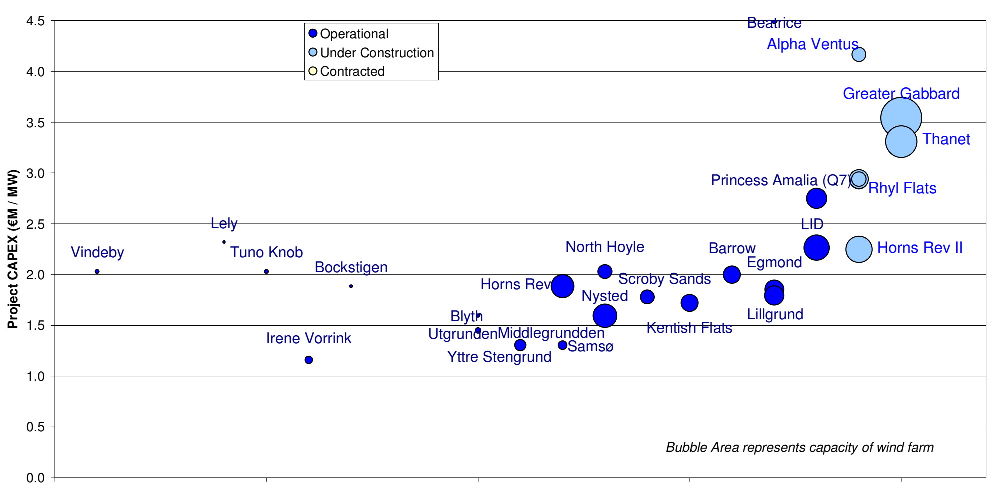


Figure 2: Projected Turbine and Support Structure Installation Vessel Demand

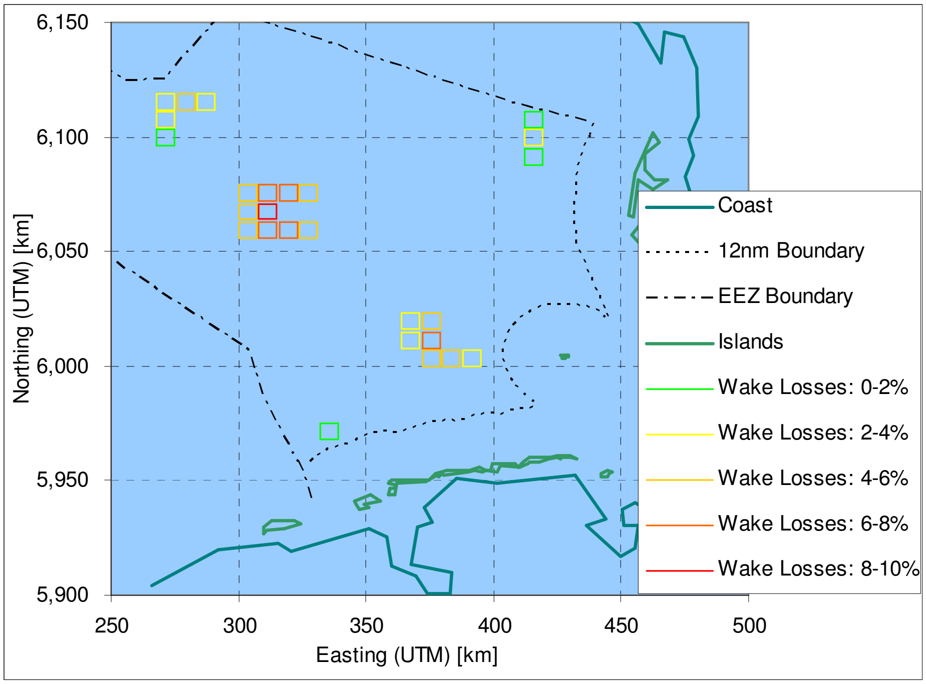
Second considered here, is the risk of capital cost escalation. Figure 3 summarises available public CAPEX figures for offshore wind farms. It shows that costs have risen significantly in recent years. A common and simple mistake for inexperienced developers has been to assume that historic costs could be assumed for current build plans.



Based on public announcements

Figure 3: Historical Offshore Wind Farm CAPEX

Third specific risk considered is that of wake effects from large "neighbouring" projects. Large concentrations of wind farms, either offshore or onshore in locations such as Texas or Inner Mongolia, are unprecedented, hence certainty regarding the impact can not be gained until real life measurement and analysis has been undertaken. However our current knowledge and experience clearly suggests that there will indeed be an impact and that this impact could be significant. In order to make an initial assessment of the potential extent of these wake losses, GH has analysed wind speed deficit measurements in and around the Danish offshore wind farms at Horns Rev and Nysted and implemented a model capable of analysing arbitrary layouts and different sensitivity scenarios. The results for a fictitious wind farm layout in the German Bight are shown in Figure 4. For this fictitious but potentially realistic scenario, the most severely affected offshore wind farms could suffer wake losses, additional to those generated within the wind farm itself, in the order of 10%.



GH Neighbouring Wind Farm Wake Model: Central Wake Loss Scenario (only inter-project effects shown)
German Bight: fictitious layout of offshore wind farms

Figure 4: Indicative Estimate of Wake Losses due to Neighbouring Offshore Wind Farms

Conclusions

In order to undertake the Due Diligence Review of offshore wind farms, a wide range of expertise and knowledge needs to be applied. Risks are diverse in nature, type and extent although there are also commonalities across all projects, for example by development stage, or country.

Illustrations of the added value that GH can bring to the process through its wide-ranging knowledge and experience, in both offshore wind energy as well as Due Diligence itself, have been provided, in terms of examples looking at Market Knowledge regarding competition for installation vessels as well as realistic CAPEX budgets and Technical Knowledge and Judgement, in this case making a preliminary examination of wake losses due to the presence neighbouring wind farms.

GH has undertaken over 8,000MW of Due Diligence work, to various degrees of detail, including 1,500MW to the detailed level. This has covered over 20 wind farms spread throughout Europe: in Denmark, France, Germany, Ireland, Netherlands, Norway, Sweden and the United Kingdom. Projects have ranged from those in early development to those with substantial operating experience.

The foundation of GH's Due Diligence expertise is the wide range of offshore wind studies and services provided by GH over the last 15 years totalling around 200 commercial contracts in offshore wind alone and including regulatory studies, market assessments, energy yield analysis, O&M studies, electrical and structural engineering design, all in tandem with 25 years experience in wind energy onshore including the analysis and design of wind turbines.