D3.3
Design practices and guidelines for dynamic cable systems design

JDR / IREC / INNOSEA / COBRA / RAMBOLL / FIHAC / UPC / UL DEWI

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1 NOMENCLATURE

Abbreviation	Description
AEP	annual energy production
CAPEX	Capital expense
DECEX	Development expense
EPBT	energy payback time
EROI	energy return on investment
FOWT	Floating Offshore Wind Turbines Structures
LCOE	Levelised cost of energy
MW	MegaWatt
MWh	MegaWattHour
O&M	Operation and Maintenance
OSS	Offshore Substation
OPEX	Operating expense
SS	Substation

2 INTRODUCTION TO COREWIND

Floating offshore wind is still a nascent technology and its LCOE is substantially higher than onshore and bottom-fixed offshore wind, and thus requires to be drastically quantified and reduced.

The COREWIND project aims to benchmark preliminary costs and demonstrate significant cost reductions of floating wind technology through the research and optimization of mooring and anchoring systems and dynamic cables.

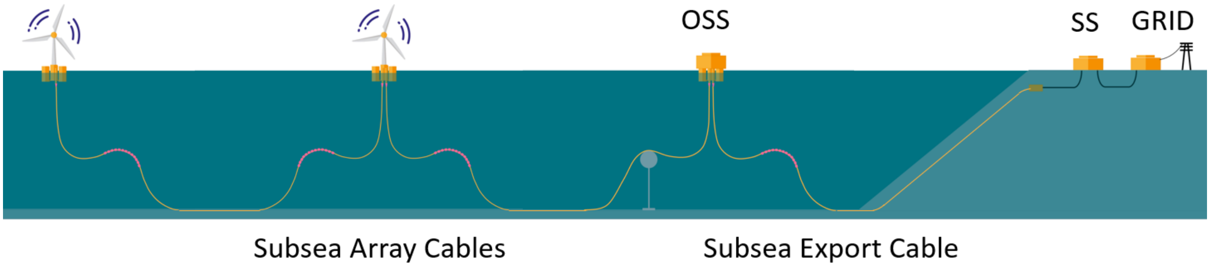


Figure 1. *Dynamic Windfarm Layout Example*

Enhancements arising within the project will be validated by means of simulations and experimental testing both in the wave basin tanks and the wind tunnel by taking as reference two concrete-based floater concepts (semi-submersible and spar) supporting large wind turbines (15 MW), installed at water depths.

Special focus is given to develop and validate innovative solutions to improve installation techniques and operation and maintenance (O&M) activities.

The project results inform guidelines and best design practices, as well as open data models to accelerate the further development of concrete-based semi-submersible and spar FOWTs, based on findings from innovative cost-effective solutions for the aforementioned key aspects.

It is aimed that the resulting recommendations will contribute to the cost-competitiveness of floating offshore wind energy, reducing risks and uncertainties and contributing to lower LCOE estimates.

COREWIND aims to strengthen the European leadership on wind power technology (and specially floating offshore wind turbines). To do so, the project consortium has been designed to ensure proper collaboration between all stakeholders (users, developers, suppliers, academia, etc.) which is essential to accelerate commercialization of the innovations carried out in the project.

3 REPORT OBJECTIVE

Initial cabling research undertaken is covered in D3.1 Review of the state of the art of dynamic cable system design and the cabling basis outlined in COREWIND project Design Basis D1.2. D3.2 outlines the modelling taken and confidential results. Additional research into windfarm layout for LCOE optimization is outlined in D3.4.

The main driver of the modelling optimization was the identification of cost saving opportunities, and secondarily to inform guidance on best practice given the new complexities of floating wind technology.

The purpose of this document D3.3 is to summarize simplified guidance for cable system design approach based on work undertaken and findings in the COREWIND project.

4 COST REDUCTIONS ACHIEVED ON COREWIND

Cost reduction for large scale floating wind farm cabling system has been identified through optimisation studies of dynamic cabling configuration and system considering more accurate operational cases for fatigue modelling to reduce ancillary hardware requirements.

Cost reduction for large scale floating wind farm cabling system has been identified to be up to almost 10% through optimisation studies considering optimal windfarm layout, accuracy of input data including platform motion and marine growth, and detailed hardware optimisation studies considered to reduce ancillary hardware requirement, as well as long length supply and manufacturing.

Key cost influences have been identified and guidance summarised within this report based on the work undertaken.

5 BASIS OF COREWIND CABLING GUIDANCE

5.1 Key Cabling Cost Influences of Cable System Design

Significant influencers identified for the cost of floating wind cabling systems are shown in the figure below.

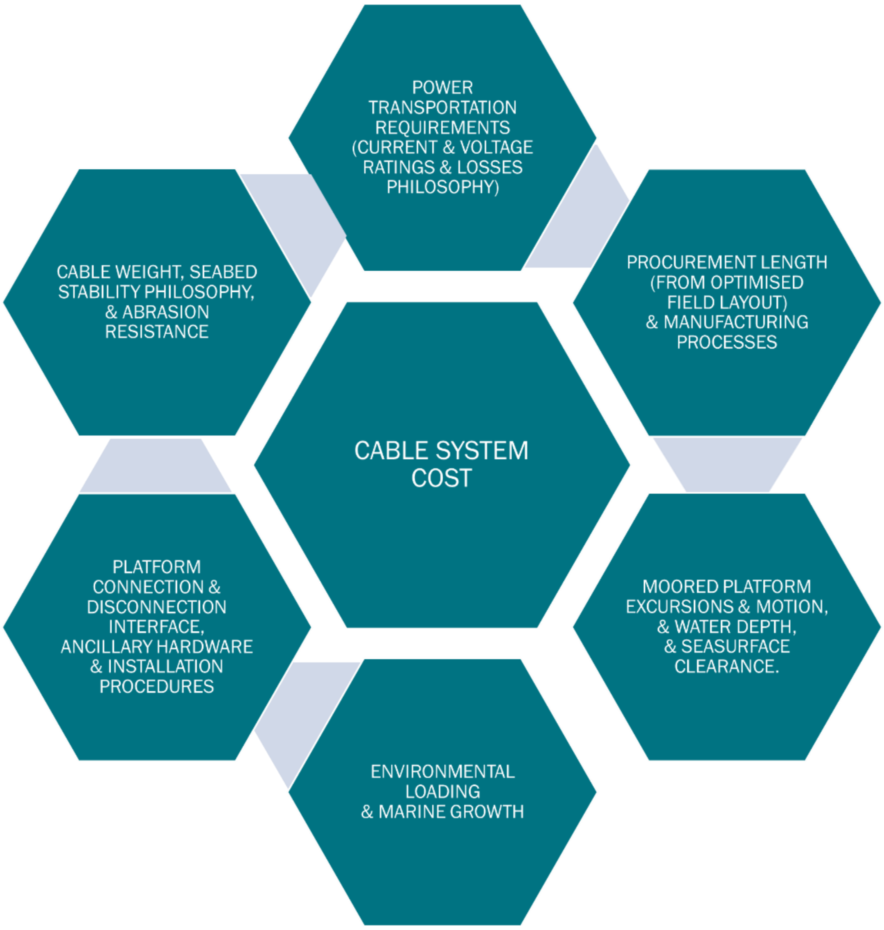


Figure 2. *Key cable system cost influencers*

Cable designs, and associated costs, are influenced by a number of parameters which are site specific, project specific and manufacturing specific.

Given multiple parameters, it is vital to identify your primary system design drivers to target during optimization studies. The main driver of your system design influence the approach and development to the development of the cable design.

For COREWIND the main driver was cost reduction philosophy for commercial scale floating wind rather, than other drivers which could be relevant to other projects such as maximized design life, risk aversion or tolerance for extreme offset design, etc. This informed the modelling approach.

Guidance provided has been developed from modelling and analysis undertaken to understand the key system cost influences should best be approached to reduce overall costs of the cabling system.

5.2 Dynamic cable systems configuration modelling approach

A comprehensive literature survey and industrial engagement was performed to define current dynamic cable state of the art technology applicable for floating wind projects currently installed or being engineered to ensure specifications and requirements developed for current industry status and took into account current technology readiness (D3.1). A key aspect was the learning from static offshore wind and dynamic oil and gas applications that are directly applicable to floating offshore wind. The following dynamic cabling configuration possibilities were identified.

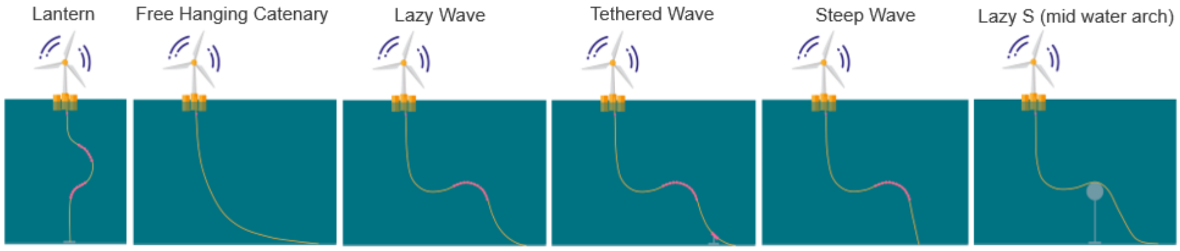
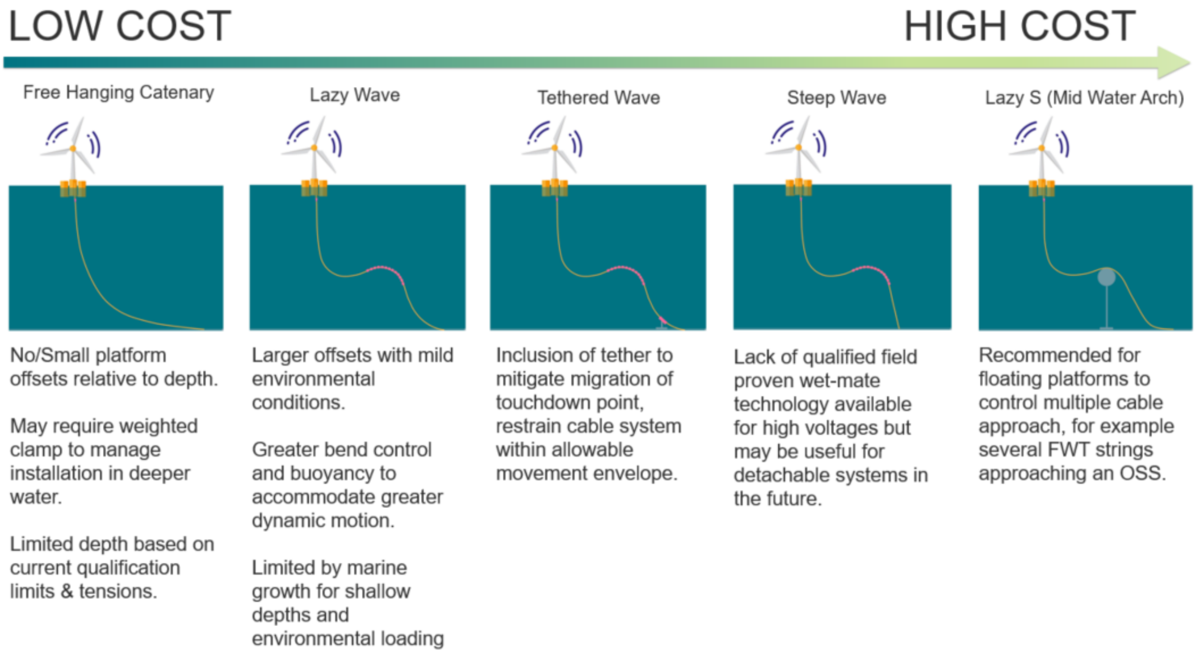


Figure 1. *Dynamic cable system configurations*

Dynamic cable system configurations were developed for each site's conditions with consideration of moored platform movement and cable system limitations identified for each configuration type in D3.1, with a focus on lazy wave and tethered wave solutions to minimize costs.



Free Hanging Catenary	Lazy Wave	Tethered Wave	Steep Wave	Lazy S (Mid Water Arch)
No/Small platform offsets relative to depth. May require weighted clamp to manage installation in deeper water. Limited depth based on current qualification limits & tensions.	Larger offsets with mild environmental conditions. Greater bend control and buoyancy to accommodate greater dynamic motion. Limited by marine growth for shallow depths and environmental loading	Inclusion of tether to mitigate migration of touchdown point, restrain cable system within allowable movement envelope.	Lack of qualified field proven wet-mate technology available for high voltages but may be useful for detachable systems in the future.	Recommended for floating platforms to control multiple cable approach, for example several FWT strings approaching an OSS.

Figure 2. *Dynamic cable system configuration cost implications*

The Lazy wave and, where needed, the Tethered wave configuration were developed bespoke to each site and moored platform modelled, given the significant platform offsets relative to water depth excluded simple catenary option.

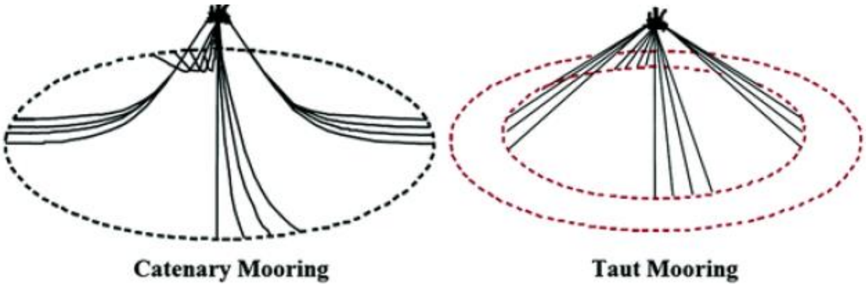
The WTG platform studies within the COREWIND project were modelled as moored at 3 locations as summarised within the table below.

Site A	Site B	Site C
104m water depth	200m water depth	870m water depth
West of Bara Island (Scotland)	Grand Canaria Island (Spain)	Morro Bay (USA)

Table 1. *Overview of sites considered within the COREWIND Project*

Two floating platforms were modelled within COREWIND modelling assessments: Activefloat and Windcrete. Activefloat is a semisubmersible-type platform, which means that it has enough water plane area inertia to face tilting angles with large righting moment. Stability was achieved by employing three separated columns piercing the water surface. A central column supports the WTG tower while three prismatic pontoons link all the system together below the sea level. Windcrete is a monolithic concrete spar platform including both the tower and the floater in a unique concrete member. The station keeping system is designed with three mooring lines distributed each 120º with delta arrangement.

Platform maximum excursions are critical to cable system development. For floating wind, platform excursions are limited by the mooring design. Catenary mooring systems which allow for greater platform excursions are generally lower cost systems as the tensions are lower within the mooring system over the operational life when reviewed against taut mooring systems which limit the platform excursions to a smaller area. Chain mooring systems often are employed in a catenary mooring system and generally have lower anchor costs but larger footprints. Synthetic fibres generally have a smaller footprint but may have higher cost of anchors as employed in taut mooring systems.


Catenary Mooring

Taut Mooring

Figure 3. *Mooring strategy examples (WP2)*

Depending on the strength and direction of the prevailing weather, the floating structure will drift to an offset position based on the environmental loading on the platform and the moored platform reaction. For cabling design there are 4 critical parameters of moored platform motion that must be considered:

- Environmental loading applicable to induce an excursion
- The excursion of the platform induced
- The 6 degrees of freedom motion of the platform at that excursion
- The probability of the duration at that excursion

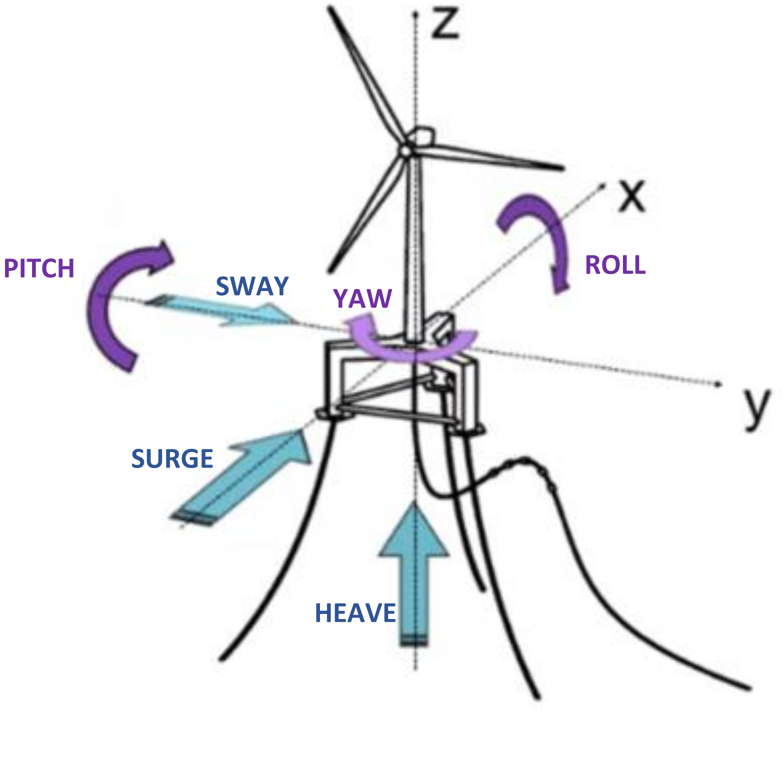


Figure 4. *Moored platform motions (WP4)*

Unlike typical O&G moored platforms where wave and current loading generally dominate the drift of the platform to different excursion points, for floating wind turbine moored models the wind loading and the turbines reaction to it is also a significant influencer on platform excursions and motion over the life of the windfarm.

Given the nature of the floating wind moored turbine structure, it was identified by those modelling within the project for cases in COREWIND the platform position is likely to be more influenced by the wind loading than the environmental loading, therefore the COREWIND group have considered the probability of the wind as the base case probability, and then identified what wave and current loading is most likely with that wind profile. This wave, wind and current joint-environmental loading profile was then applied to the WTG to determine excursion point of the platform and moored motion induced.

On this basis cable system modelling was undertaken. Results of COREWIND modelling indicated an optimised dynamic configuration for site and moored platform motion specific conditions can lead to LCOE reductions between 2.6-6.6%, compared to initial cable static configurations based on limited input data. It is clear the quality and accuracy of the input data directly influences the cost of the cable system developed. Cost saving opportunities are most significant through greater supply lengths manufacture at site, standardisation of hardware optimized for positioning and size, considering interactions between hardware, as well as detailed operational cases for fatigue modelling. Given the high costs of the floating wind technology, the cost reduction potential is significant for large-scale windfarms.

5.3 Windfarm Layout modelling

The electrical system of a floating offshore wind farm, understood as the cables and their hardware (i.e., ancillary components), accounts for a significant share of its total CAPEX (as a reference, it can be considered as a 20% for 100 m water depth and 20 km to shore). With regard to the OPEX and DECEX, the amount is again not negligible.

The electrical system has a direct effect on the annual energy production of the wind farms. On the one hand, the electrical losses are closely linked to the selected cables, their voltage and power transmitted by each of them. On the other hand, different topologies present different reliabilities, which allows redundant systems to keep producing energy after a major failure, avoiding the urgent necessity of a repair and the reduced power output in the meantime. This makes the electrical system an important part of the projects from the economical perspective.

The environmental impacts of the electrical system is also relevant. The equivalent CO_2 emissions during the production, transport and installation account for around a 10% for the previous reference, but in relative terms (per MWh) its effect on the annual energy production (AEP), the energy return on investment (EROI) and the energy payback time (EPBT) extends to the whole wind farm. Together with the economical aspects, all the previous reasons justify the importance of the cable system of a floating offshore wind farm, and therefore the effort required during its design.

One of the key aspects related to the dynamic cable system is the positioning of the floating wind turbines, addressed in the deliverable 3.4 of COREWIND project: “Stochastic optimisation of floating offshore wind farm layout with electrical interconnection”. The aim of such work was reducing the LCOE of the technology during the micro-siting stage, considering the variations in costs and energy production of the wind farm. The main drivers of such optimisation were the mooring lines and the dynamic cables.

The bathymetry plays a major role in the dynamic cable system design. Deep waters require longer cables to connect turbines equally spaced over the sea surface; this increases the purchasing cost of the cables and at the same time the power losses. Furthermore, the required armour of the cable may have to be reinforced, or additional buoyancy modules may have to be included to withstand/limit the tensions on the cable. Globally, longer cables also weight more, therefore the installation vessels may have to be bigger, and therefore more expensive and with greater emissions.

The mooring system design appeared to be critical during the study. The global optimisation revealed that if the mooring footprint overlapping is forbidden, such restriction is usually active (it must be noted that no TLP was considered). In other words, the anchors of different platforms tend to be relatively close. This spacing reduction increases the wake losses in the wind farm, but the cost and losses reduction due to shorter dynamic cables has a greater weight on the LCOE.

An optimised layout can lead to LCOE reductions up to a 3% compared to a regular distribution of the generation units. Given the high costs of the technology, the absolute cost reduction potential is significant, and the dynamic cables are greatly affected by this.

6 OVERALL GUIDANCE FOR CABLE SYSTEM DESIGN

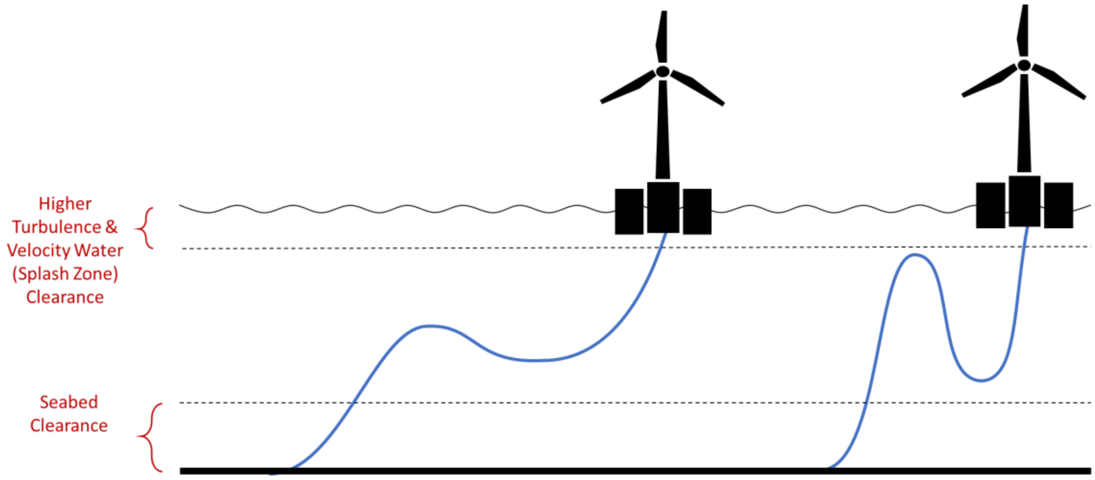
Guidance for dynamic cable system design is summarised in this section to facilitate targeted development of floating wind farms.

6.1 Guidance for dynamic cable system design

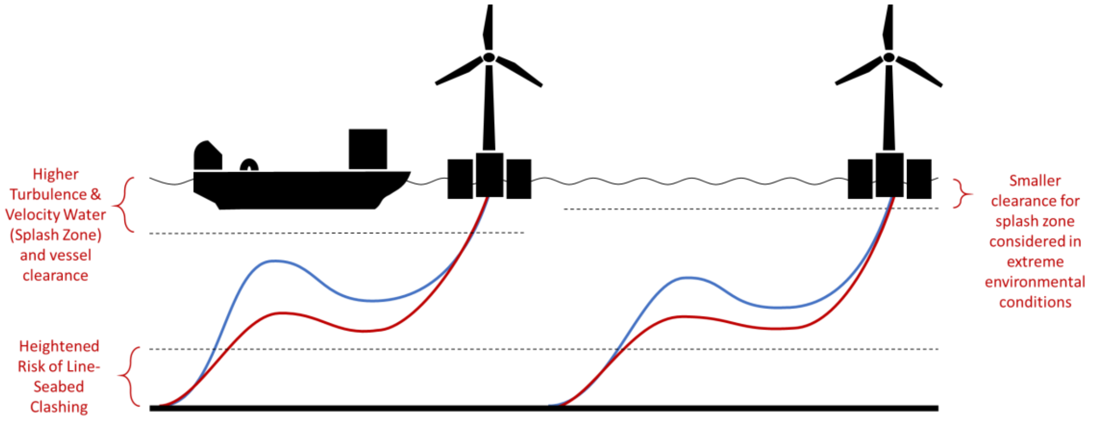
Based on the results and conclusions extracted from dynamic cable system design and LCOE driven optimisation in the reference scenarios, the recommendations for dynamic cable system design for the ends of the cables between the seabed and the floating platform for floating offshore wind farms, are as follows:

1. **Identify and prioritise the main drivers for the cable system design philosophy and moored platform design philosophy:** Along with cost reduction, objectives may need to be weighed against fatigue endurance requests or risk aversion considerations. Site or moored platform motion directly influences cable system design so limits to system motion and platform behavior may be prudent to ensure overall system development with the cable is viable. Installation or O&M techniques may adjust risk levels perceived. The main drivers of the system need to be well understood at the outset to achieve the optimal system design for purpose. Outcomes will be highly dependent on the balance between objectives, particularly where developing systems for onerous site environmental loading, excessive platform motions, or restrictions on cable movement envelopes.
2. **Undertake initial cable design prior to finalising mooring system design:** Based on modelling and tank testing, it has been concluded the relative weight and tension of the cable at the connection to the platform has a negligible effect on the FWT platform structure in comparison to mooring lines for both spar and semi-submersable platforms used. However, it is prudent to model the cabling system design as early as possible prior to finalising the mooring system design, due to the iteration that may be beneficial for overall cost reduction between cabling system and mooring system governing platform motion and excursion. Engagement of those designing the cable system should be undertaken through Analysis FEED studies using realistic cable cross section designs to identify challenges of the cabling system so this can be considered in the moored platform design phase. This will provide confidence a joint solution is possible, help inform upfront cost estimates and identify areas of cost reduction potential across both systems. This means cable suppliers should be engaged in a greater much earlier in the development stages for the windfarm than is current practice for static windfarm development. This will help reduces costs across the wind farm systems overall and help inform developer choices, as well as identify and mitigate risk levels across the project.
3. **Set reasonable limits for moored platform offset distances relative to water depth:** Moored platform offsets in ULS & ALS conditions have a major influence on the cable length required for a pliant system. This directly correlates, not just to cable length cost in the system, but also the complexity of the system and subsequent hardware demands that are required to manage the cable length in the water column in all conditions and mitigate violation of clearance limits. For platform horizontal offsets greater than 20% of water depth, and vertical offsets greater than 10% of water depth, it becomes increasingly challenging to find a solution. The maximum platform excursions a cabling system may typically tolerate are ≈30% of water depth, provided

conditions at the surface are not onerous, however cable fatigue should always be evaluated to capture and assess the impact of relaxed moored platform systems.



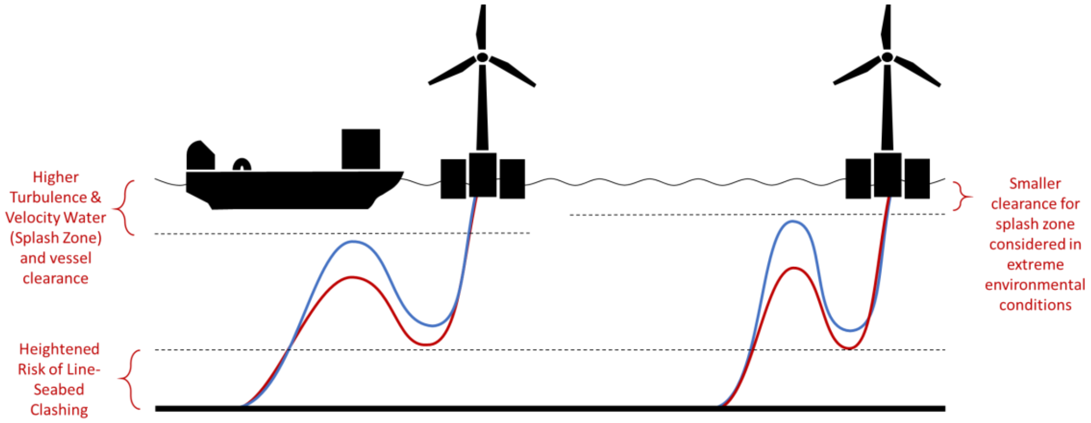
4. **Clearance limits from sea surface and seabed should be defined upfront and should be provided relative to environmental condition:** Clearance levels should be identified as early as possible as this limits the envelope in the water column which the cable system catenary and hog bend needs to be retained within. This directly influence the complexity of the system. This parameter is particularly critical to consider carefully for shallow water applications (less than 150m) where available space for the cable may be narrow in the water column, and for sites with high level of marine growth projected given the impact of marine growth on cable position. It is prudent in these cases to clearly define what is driving clearance distances and confirm under which conditions this driver influences. For example, a vessel may be expected during small sea states, but is unlikely to be present during a storm, so larger clearance distances from the surface to avoid vessel clashing may only be applicable to some FLS cases, rather than all FLS, all ULS and all ALS cases.



5. **Dynamic cable emergency disconnection system should inform platform structure cable pathway and connection locations:** The emergency and planned disconnection method will influence the hardware requirements and fitment to structure and subsequent cable system cost. This will also influence any abandonment scenarios possible and cable length based on risk mitigation so will directly influence the cable system design and costs, the complexity of the system design challenges, as well as the analysis that will need to be undertaken. Planned disconnection cases with a light structure potentially detached from the main structure is

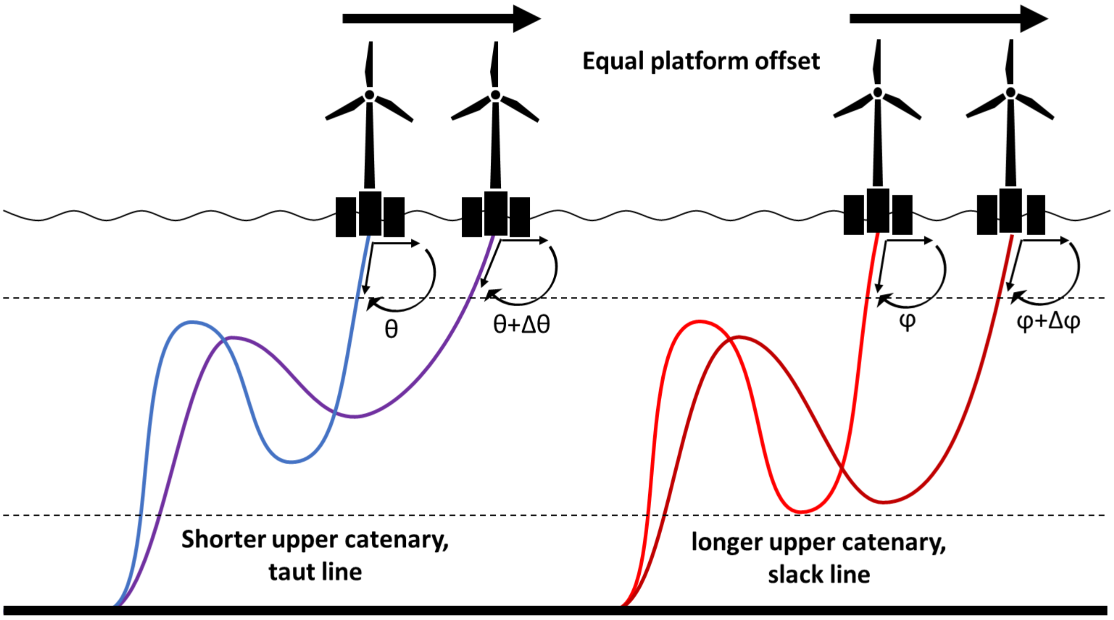
likely to add higher fatigue damage into the cable and therefore may influence cable design and associated cost directly. Disconnected case motions may need to be limited to develop a cable system that works for main platform connection and disconnected cases. Refer to D1.6 for further information on cable disconnection.

6. **Marine growth at site should be reviewed to identify accurate profiles ahead of cable system development:** Marine growth levels significantly influence the cable start of life (installed configuration) position and projected end of life position. Marine growth levels adds weight to the cabling system, which can influence topside loading and proximity of the system to the seabed. The cable system designer may need to raise the SOL system to mitigate risk of clashing, however this increases demands for hardware which potentially increases installation time and costs. Accurate marine growth specified relative to water depth leads to reduced costs of the cabling system and eases configuration development. This is applicable to all water depths. Its of particular importance for shallow water sites, which already have a narrow water column envelop in which to retain the majority of the dynamic cabling length. It can be critical for deeper water sites where topside tension is high and needs to be minimized. It can also be critical for any case where lateral movement of the cabling system needs to be minimized to avoid or mitigate clashing with nearby lines and objects. Where alterations are not possible in extreme shallow water cases, options considering anti-biofouling coatings on hardware or external intervention (cleaning) if thick marine growth levels develop may need to be explored.



7. **Cable connection point to the structure should be selected to minimise motion imparted into the cable, while allowing for installation:** Careful selection of the connection point should be taken as the position off the platform directly influences the motion imparted into the cable. Consider ease of installation access, planned and emergency disconnection philosophy for termination hardware design requirements, and minimising motion imparted into the cabling system to increase fatigue life and reduce cable system costs. For semisubmersibles, directly into the turbine would simplify installation and emergency disconnection, however the further from the centre of gravity of the platform the higher the motion that can be imparted into the cabling system. For spar platforms, connection should again be selected where motion imparted into the cable, however consideration is driven significantly by depth considerations for installation.
8. **Dynamic cable modelling should inform cabling J-tube structure exit design:** Based on the multiple influences in developing a cable system, the entrance angle should be informed by the cable system development to ensure costs for the system are kept to a minimum. Increased challenge and complexity may need to be added to the system if the cable exit angle

is set ahead of the analysis. Where platform motion is dominant (over wave and current influence), optimizing configuration through exit angle studies (supported by buoyancy module adaptation) can lead to greater cost reduction of overall bending hardware.



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9. **Dynamic Cable design philosophy:** For the dynamic section, cable design philosophy should be established ahead of cable system design. Important factors for cable design include function (e.g. energy needed to be transported with minimal losses), survival duration in the environment under loading within the application, reliability, ease of transport, installation and decommissioning, maintenance, and risk management. The balance across these factors significantly influence costs of the cable design itself and the approach to development of the dynamic cable system. Cables for dynamic applications are required to be of optimized bend stiffness and torsional balance to prevent damage during installation where longer lengths are managed under elevated tensions, and able to withstand greater fatigue during operation. Higher voltage ratings are resulting in larger cable diameters, which require review of cable strength member to increase fatigue endurance of the overall cable design.
10. **Hardware optimization studies specific for site and platform motion conditions are needed to reduce system costs:** Each set of design philosophies, disconnection plans, site conditions and platform motions seen are bespoke, and therefore the cabling system developed for the project will be customised to the application. Optimisation studies undertaken where time permits typically lead to reductions in costs. Consideration of hardware interaction and cable limits is critical to developing the lowest possible cost based solution for all hardware items. Optimization pointing to more than one design of buoyancy module design being applied can overall still result in reduce costs across multiple systems if designs and positioning is optimised.
11. **Consider development of an optimized cabling system for floating wind typically will require longer upfront project analysis durations than O&G applications:** Wind farm cabling system development are on the forefront of innovative development. Wind farm floating moored platform motion is more complex for cable dynamic configuration development than typical O&G applications have been, due not only to wind but to turbine reaction to the wind and

ballasting reaction of the platform. There is also a greater requirement to perform optimization studies to reduce costs. Wind farms and demo projects developed in the industry to date appear to be tending towards shallower water applications and relaxed mooring systems. This can reduce costs associated with mooring systems, transport and OPEX considerations, but have significant challenges for the development of the cabling system (e.g. higher marine growth levels, higher current speeds through the water column, greater influence of wave loading on the system, narrower column for cable system, greater platform motions relative to water depth, larger platform excursions, etc.) In addition, there is a greater drive to reduce costs even marginally for the cable system configuration through detailed optimization studies because wind farm cabling systems will be made in much higher quantities so even small cost reductions in the system design can have a huge impact on the overall cost for the project. The increased complexity and drive for iteration to reduce costs in the cabling system results in longer duration for system development than typically required for O&G systems.

6.2 Guidance for cable system layout across windfarm design

Based on the results and conclusions extracted from topological optimisation in the reference scenarios, the recommendations for the cable system layout across windfarm design for floating offshore wind farms, are as follows:

1. **Avoid cable crossings**. While designs with cable crossings may be feasible, at least one of them must be buried or protected even in very deep waters. Furthermore, in the event of a failure of the lower cable, the upper cable may have to be removed, which leads to increased maintenance costs.
2. **Prevent cables running in parallel**. Cables placed close to each other can increase the ohmic losses due to the higher temperature caused by them. Spacing the cables leads to better heat dissipation and, as a consequence, lower power losses.
3. **Locating the turbines in the shallowest areas may be beneficial**. While this may seem obvious, the consequences are very relevant. Not only the mooring system will benefit of this, but also the overall length of cabling is typically shorter, reducing the purchasing, installation, decommissioning and end-of-life costs, and increasing the energy yield. Moving the turbines to shallow waters may increase the cost of the export cables, but this may be worth it.
   However keep in mind that for very shallow water applications, the shallowest location may not be best suited to develop a relaxed lazy wave configuration. Consider limitations in developing a dynamic system section of the cable (i.e. cable end sections between seabed and turbine) and the likely cost impact of this section should be considered carefully when employing this strategy. Shallow water sites have restricted envelope in the water column for which the cable system operates within combined with greater length coverage of higher marine growth levels, higher influence of wave loading impacting cabling system and higher chances of higher current loading on cables. Developers may have to carefully limit moored platform excursions so that a LCOE cable system can be developed. External stabilisation and potential burial requirement implications should also be considered as well in shallower water depths due to increase likelihood of volatile environmental conditions relative to water depth, and risk of seabed top soil movement.
4. **Consider redundant systems.** The topology of the dynamic cable system may be branched or cyclic. The former leads to reduced purchasing and installation costs, while the latter, due to

the additional electrical components and cables, is more expensive. However, harsh climates and sites far from maintenance ports or suppliers may benefit from these designs to a point where they compensate the extra investment. Ensuring the energy production after a failure of a major cable that may not be fixed in months due to the supply chain or the weather windows can deliver profits higher than the costs of the redundant system.

5. **Think of mooring systems with small footprints.** Crossing mooring lines imply high risk of failures and unexpected behaviours, therefore are typically avoided. For this reason, the minimum distance between platforms is limited. The high cost of the dynamic cables may lead to compensate the increasing losses due to wakes when the turbines get closer, to a point in which the mooring system prevents the turbines from getting closer. Mooring systems with small footprints allow shorter dynamic cables, and the increased wake losses may be partially reduced by wake steering.
6. **Use different cable ratings, but not too many.** Selecting each cable to withstand the maximum power that may have to transmit will reduce the overall costs of the system, while only slightly increasing the losses. This avoids the oversizing of the network, considering only the currents of the upstream turbines for each cable. However, due to the economies of scale, an increased number of cable types may lead to increased costs, as higher lengths lead to reduced costs per length unit. Additionally, multiple cable types may be harder to install, leading to increased rental costs of the vessels.
7. **Avoid submarine joints.** Most of the systems can be designed without joints, thus reducing the cost of the system. Furthermore, joints represent weak spots that need to be reinforced or located in protected areas, and cannot be tolerated in highly dynamic sections. In case a joint is required, such as the transition from dynamic to static export cable, it should be joined ideally at the factory to avoid in-situ works, which have higher costs and risks. However, the inter-array dynamic cable system can be designed without static to dynamic submarine cable joints (subject to maximum cable manufacturing lengths) or with internal static to dynamic design joints, which allows main cable connections to take place at turbines. Transition from dynamic to static sections in inter-array cables for the sections on the seabed can lead to reduced costs of the cable itself but appears only beneficial over very long lengths outside what is likely to be demanded for inter-arrays. Wet mate solution technology is not yet developed sufficiently to allow quick mate connection joints to facilitate O&M planned disconnection studies or ease of replacement of sections.
8. **Do not ignore the export cabling while positioning the offshore substation.** When the export cable(s) are not taken into account in the wind farms that include an offshore substation, such substation tends to be in the centre of the offshore site, surrounded by the turbines. This configuration usually reduces the cost of the inter-array cabling. However, the global design should also consider the export cables, which is likely to slightly increase the dynamic cables cost but on the other hand the cost of the export cables will be reduced, therefore lowering the overall LCOE of the farm.
9. **Consider the mooring lines.** The cable lengths of the inter-array system of the floating offshore wind farms cannot be estimated by only using the generation units coordinates. The bathymetry plays a significant role, but the extra length required to prevent the dynamic cables from clashing into the mooring lines can be a 40%. Such a high value is explained because the mooring lines may extend hundreds of meters horizontally, and the cable configuration should avoid the contact with them even with high turbine offsets and strong currents.

10. **Consider directional wind climates.** Sites with directional winds, i.e., sites where the wind usually blows from a single direction as opposed to a regularly distributed wind rose, are likely to present different spacing in the wind turbines in the parallel and perpendicular directions to the prevailing wind. With such layouts, cable cost savings may be achieved if the dynamic cables are aligned perpendicular to the prevailing wind direction, as the spacing between turbines in that direction may be smaller and therefore the total cabling lengths may also be smaller.

7 RECOMMENDATION FOR FURTHER AREAS OF TECHNOLOGY DEVELOPMENT

Based on current industry information and research undertaken in COREWIND project, the following recommendations are made of topics that would be of benefit to pursue to reduce costs to the cabling system and extend the application of dynamic cabling beyond current limits:

- Further investigation into non-touchdown solutions for deeper water applications
- Non-standard shallow water solutions for larger platform offsets
- More detailed evaluations of Turbine reaction on platform motion influencing imparted motion into cable system and associated fatigue
- Extended modelling of larger higher voltage cabling that is being developed for dynamic application
- Standardisation of detailed industry guidance for aspects of evaluating FOWT cabling systems
- Development of power core design and testing to deeper water touchdown applications.
- Development of higher voltage wet-matable technology to allow for further maintenance and planned disconnection options
- Further development of higher voltage inter-array cables.

There are a high number of optional platform designs and mooring solutions under consideration in the industry for different sites. Therefore it appears prudent the majority of emerging technology for floating wind, including planned disconnection from platforms, wet-mate connections, and any associated modifications to cabling system configurations/management be well established in service at 66kV for reliability baseline purposes before higher voltages are considered.

8 CONCLUSIONS

Cost reduction opportunities for large scale floating wind farm cabling system have been demonstrated to be up to almost 10% through optimisation studies considering optimal windfarm layout, accuracy of input data including platform motion and marine growth, detailed hardware optimisation studies considered to reduce ancillary hardware requirement, as well as long length supply and manufacturing.

By following the guidance outlined in this report, future projects will have a greater understanding of the main cost influences and challenges on the development of the cabling system, and routes to reducing costs of the cabling systems to ensure accelerated successful LCOE development for both small and large-scale wind farms.