whitepaper
OFFSHORE WIND

Holistic design approaches in offshore wind:

Enhancing efficiency through integrated solutions

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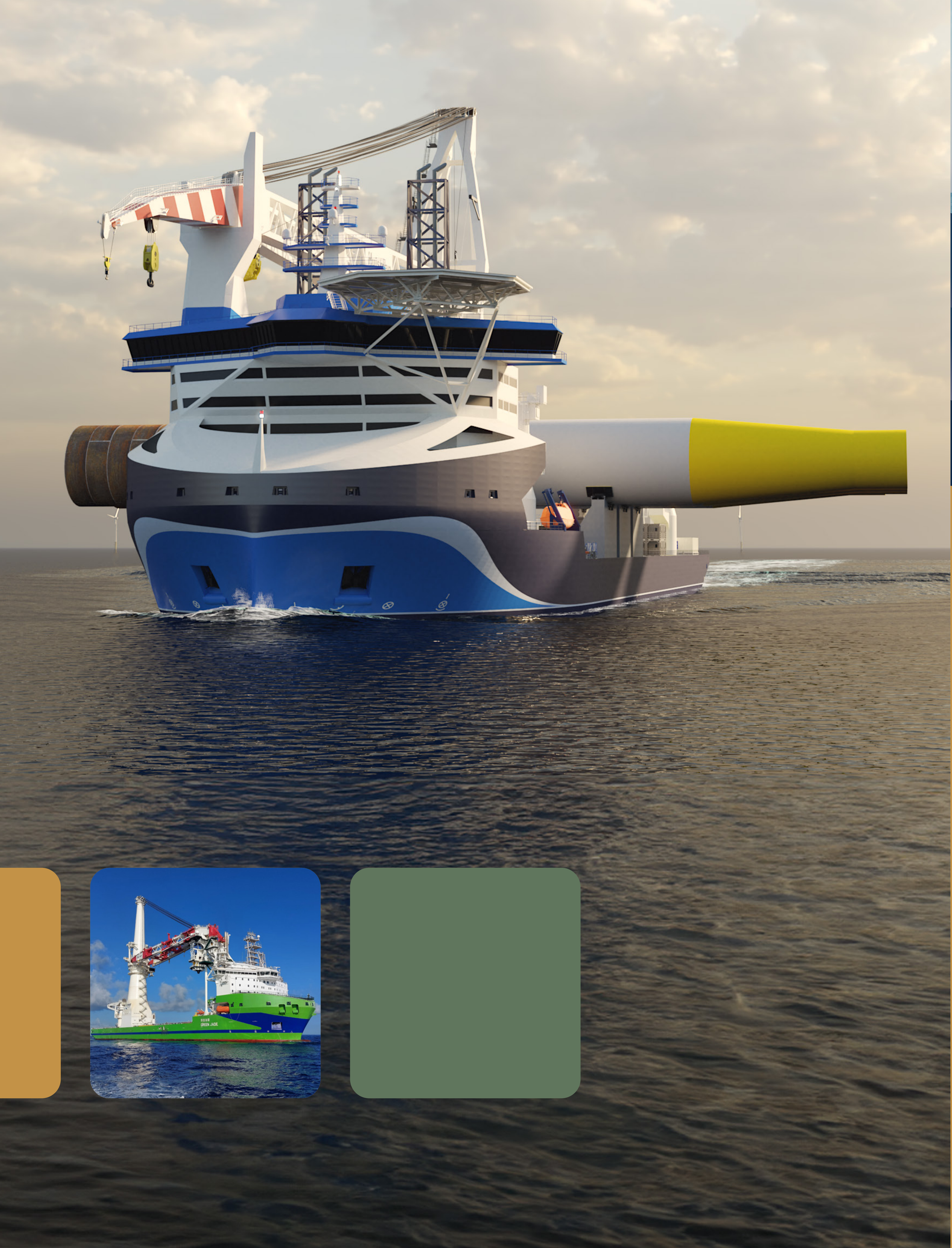


The offshore wind industry has been experiencing rapid growth, which is expected to continue in the coming years as the global political ambition for wind energy development remains strong. This is driving a parallel increase in demand for efficient and cost-effective foundation installation methods.

In this whitepaper, we explore the concept of holistic design for offshore wind installation vessels that will be required to meet this demand, emphasizing the need to consider multiple design aspects simultaneously. By adopting a holistic approach, it is possible to increase operational efficiencies, reduce installation times, and thus de-risk project execution.

Industry growth and challenges

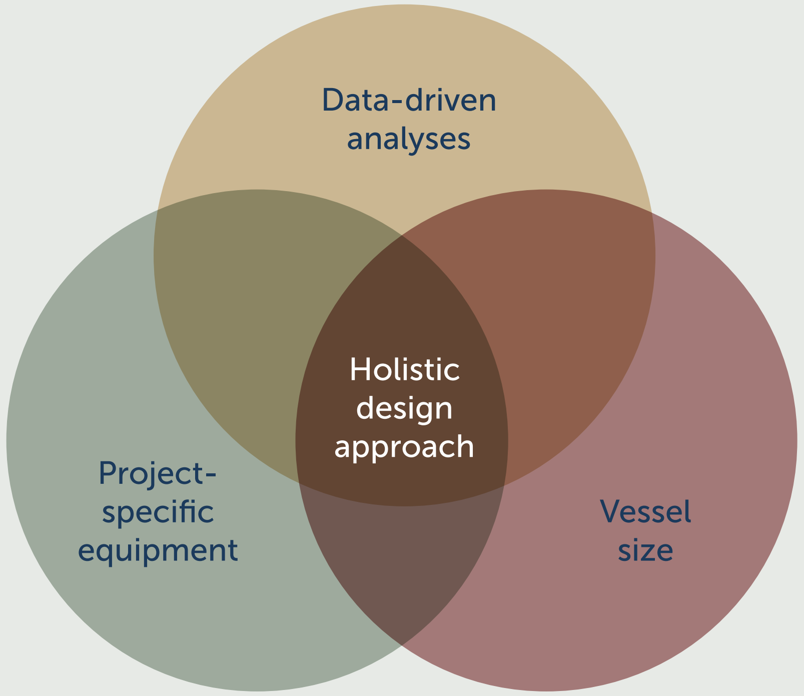
Countries across the world have set ambitious offshore wind targets, with more than 410 GW of new offshore wind capacity predicted to be added by the end of 2033, bringing total offshore wind capacity to 487 GW[1]. However, a gap exists between the demands created by offshore wind energy policies and the supply chain required to achieve these targets.

Amongst the challenges for the offshore wind industry are increased capital costs, inflation, supply chain disruption and the project execution risks of installing larger turbines and installations in deeper waters, in greater numbers each season. The biggest challenge of all, however, is the relatively small number of large wind turbine installation vessels (WTIVs), heavy lift vessels (HLVs) and feeder barges. Twenty HLVs are currently active in offshore wind foundation installation, with nine equipped for monopile installation – but only four are capable of handling XXL monopiles up to 13 meters in diameter[2].

In the next five years, only a few new-builds are predicted to enter the market, as major operators focus on increasing their jack-up fleet capacity. With current project outlooks based on installed power targets ranging from 20-40 GW per year, there is expected to be a lack of approximately eight vessels with XXL monopile installation capacity over the next ten to fifteen years. To bridge this gap, there will be a need for a larger fleet of highly efficient 'mid-range' monopile installation vessels, ideally entering the market in the coming five years. This will require upgrades to the existing fleet of HLVs, together with a number of new-build projects.

Meeting the operational requirements and high cost of constructing these purpose-built vessels is a significant part of the business case, so it is crucial that naval architects, equipment manufacturers and ship owners adopt a holistic view of vessel design and performance, which requires three key factors to be considered.

[1] GWEC Global Offshore Wind Report 2024
[2] Global Supply Chain Study: ERM International Group Limited and Norwep (P.115)



Adopting a holistic design approach

Data driven analyses

Designing for the vessel's lifetime, from the start

The business case for new build or conversion of vessels for offshore operations is a challenging one, where predictions of performance and return on investment must be made far into the future. A vessel's capacity requirement also changes rapidly and must be predicted. For example, if the current required capacity has too short an operational horizon, it will be more difficult to finance the vessel. Whereas if a vessel is designed and built to be entirely future-proof, it is likely to be excessively expensive in the current market, then more competitive later in its lifespan.

The pressure is on to reduce this gap by making the right design and engineering decisions from the start, by leveraging past experience and performing feasibility studies and data-driven analyses.

An operational profile analysis will simulate the vessel's proposed operations, and provide insights into fundamentals such as vessel size, optimizing fuel consumption or calculating the budget for mission equipment. This will include the offshore installation approach, plus an analysis of the number and type of components to be carried, at what frequency and distance, and in what environmental conditions.

Capturing these insights gives offshore vessel operators the technical feedback required to make well-balanced decisions for the business case.

For example, not building efficiency into an offshore vessel might raise fuel consumption by 10% from the start, which affects the ship's performance for its lifetime. Equally, designing a large WTIV to attain a high speed when 90% of the time the vessel may be in port, loading, or with zero forward speed at a specific position at sea will result in expensive over-engineering.

A holistic approach to vessel engineering and design should constantly align technical insights gained from an operations profile analysis with business objectives, throughout the design lifecycle. This will deliver a vessel which is tailored and optimized to meet operational and business goals.

Typically, more than 90% of total investment costs have been determined during the first 10% of a project.*

*Ship Design: Methodologies of Preliminary Design by A. Papanikolaou.

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Project-specific equipment

Achieving a ship's full potential through equipment integration

An offshore vessel is effectively an integrated floating factory with fixed processes and equipment. Its efficiency depends on aligning the vessel platform with the equipment so that both can perform to their maximum capability. A holistic design approach is essential to make this possible.

This starts with a verification of requirements and ensuring they match the intended use of the vessel. For a conversion vessel, a feasibility study will evaluate whether it is indeed suitable to perform the tasks and carry the equipment intended. Questions to be answered include: What are the dimensions and weight of mission equipment? What are the loads on the vessel's structure? What is the best location for all the equipment? And how can the deck space be optimized to avoid any obstructions with planned activities?

In terms of cranes, the main crane will be the second most costly piece of hardware next to the vessel itself. Over-specification of either the crane or the vessel requirements to support it will impact costs significantly; while a crane that is operating close to its full capacity during operations is likely to be less efficient.

Naval architects and engineers should be working in close collaboration with crane suppliers, particularly on the target weight for a crane, its capacity and working limits. This allows guidance to be provided to vessel owners or operators on the technical impacts: such as, is a larger vessel required? Or is the crane fit for its operational purpose? The same applies for other complex machinery and its placement on the vessel – inefficient placement will result in many tool and equipment movements, and result in more complicated operations.

A holistic approach:

Integration design for major mission equipment

The **Green Jade** is the first heavy lift and offshore wind installation vessel built in Taiwan, and features a crane with 4,000 tons of lifting capacity and DP3 capability. The vessel is an excellent example of integration design for a Huisman-supplied main crane, propulsion thrusters and an auxiliary crane, which can be installed at multiple locations across the deck.

The deck space can therefore be configured to transport an array of monopiles, jackets, wind turbine components and structures in a single shipment, reducing transport costs and reliance on support vessels. Additional tactical reinforcements and preparations for other types of main operations help to ensure that the **Green Jade** will have the flexibility to meet a wide range of future demands for offshore wind installations.

Vessel size

Right-sizing to operational conditions

Heavy lift vessels (HLVs) are pivotal to efficient, cost-effective foundation installation for the offshore wind industry. A common assumption applied to the process is that a larger vessel – due to its greater lifting capacity and deck space – offers the most advantageous solution. However, while larger vessels may excel in certain scenarios, they also present significant challenges, including higher costs, limited port accessibility, and increased mobilization times.

In addition, analysis of different monohull vessel sizes has shown that increasing the length and width of a platform does not always result in a significant increase in performance. Instead, by closely examining specific operational conditions and optimizing the main dimensions and equipment to suit, it may be possible to find a more balanced solution, which reduces construction costs and improves operational efficiency.

As another example, larger vessel sizes provide stability in rough seas, yet there are other enablers which can make a vessel more stable, such as motion compensation technology. This can effectively allow naval architects to design a smaller vessel that offers superior performance under specific operational conditions, creating an optimized design to meet the business case.

By considering factors driving the size of a vessel, and what the perceived outcomes are, companies can challenge early assumptions that 'big is always better' in the context of offshore wind foundation installations.

A holistic approach:

Vessel size, workability, and sea states

A number of factors and events impact offshore construction, but one of the main drivers for workability are motions during crane operations; both prior to lifting operations and throughout the installation sequence. During these operations, large variations of metacentric height (GM) are typically observed.

However, contrary to conventional wisdom, the motion performance and workability of larger vessels do not necessarily surpass those of smaller vessels. In some cases, the size of the vessel can actually reduce its operational efficiency due to more pronounced motions and increased sensitivity to sea conditions, which can limit workability windows.

Typically, monohull designs are optimized for performance in wind seas, meaning that the performance is good on sea states with relative short peak wave periods of Tp<12s. Ideally, the natural roll periods of the vessel (worst responses) occur at natural periods above these sea states. However, increasing the vessel size may result in a lower natural period coinciding with the peak periods of these sea states.

To ensure both vessel and equipment will fully perform in these sea states, an operational profile analysis will provide a detailed examination of vessel size, motion performance based on ocean wave parameters, and operational efficiency – to give insights into the overall workability of the vessel.

Conclusion

Through data-driven analyses, and informed selection of vessel size, project specific equipment, motion performance, workability, and overall operational efficiency, companies explore the complex trade-offs associated with using larger HLVs.

At C-Job Naval Architects, we guide our clients through this holistic design process, in order that they can make informed decisions when selecting HLV parameters for offshore wind foundation installations. We ensure close collaboration between naval architects, equipment manufacturers, and project developers – to create vessels that are not only fit-for-purpose but also optimized for the complexities of offshore wind installations.

About C-Job

C-Job empowers clients to build more efficient, compliant and sustainable ships, that will drive the global maritime industry towards its Net Zero goals. We strive to implement the most effective solutions to decarbonate vessels, incorporating energy-efficient systems, renewable power sources, and environmentally friendly materials. We are closely involved in the design and engineering of offshore wind vessels which support the expansion of offshore wind parks globally.

For more information on our holistic design approach, click **here** or email **sales@c-job.com**.