

The Offshore Wind Revolution

Can all the awarded projects be
realized in a dynamic German
market environment?

May 2025

Theme Pipeline

 PV	 Onshore	 Offshore	 Heat	 Flexibilities/ Batteries
 Grid expansion	 Mobility	 Hydrogen	 Gas/LNG	 CCUS

“

Offshore renewables will make a key contribution to reach the EU's ambitious energy and climate targets for 2030 and 2050 and reduce dependency on imported fossil fuels.

Offshore renewables are set to become an indispensable part of the energy mix that will be necessary to decarbonize and reach climate neutrality.

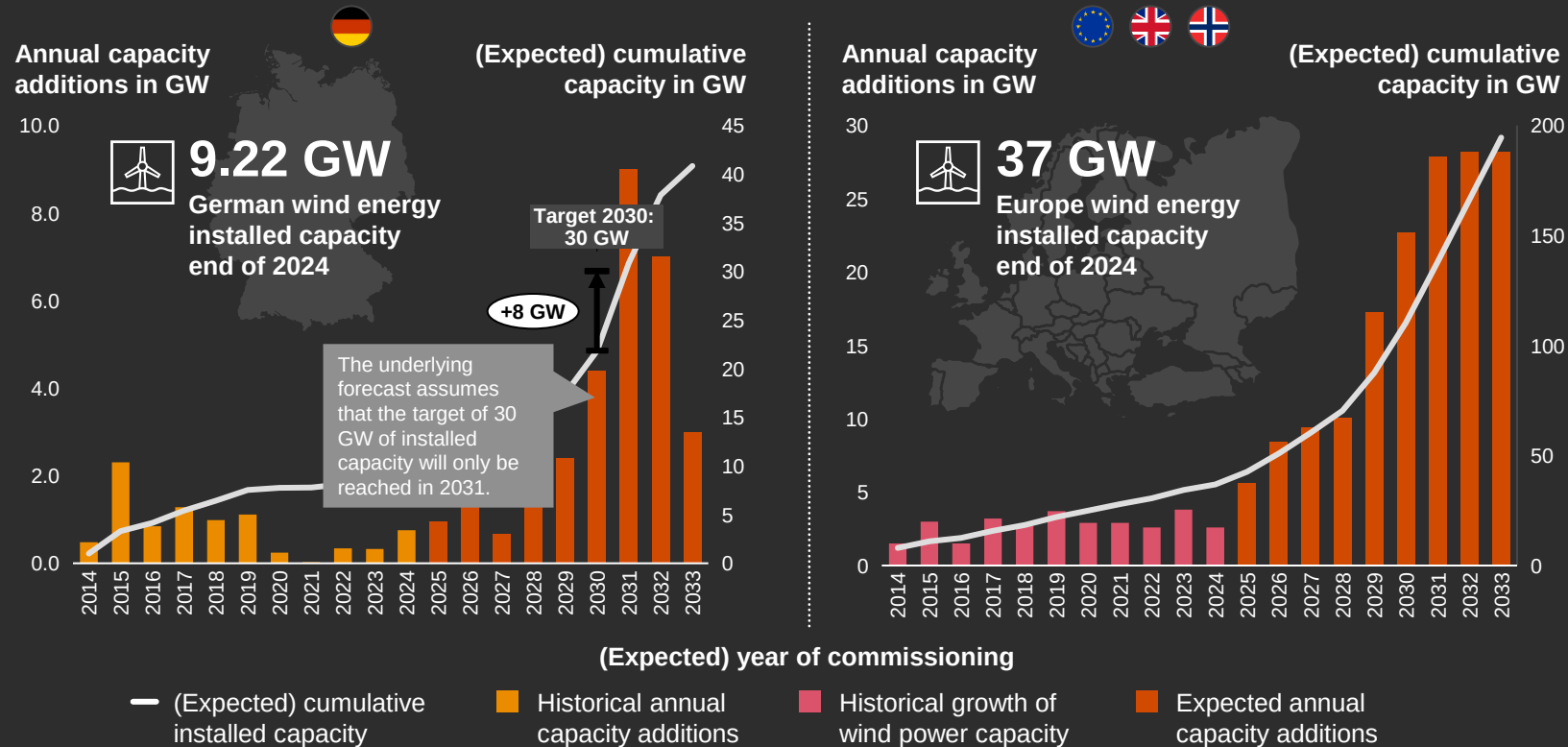
European Commission,
October 2023

”

Offshore wind energy will be an important source driving the German and European energy transition. Therefore, demand for offshore wind power systems will increase considerably in coming years

Historical and expected development of offshore wind energy in Germany and Europe

Annual capacity additions in GW

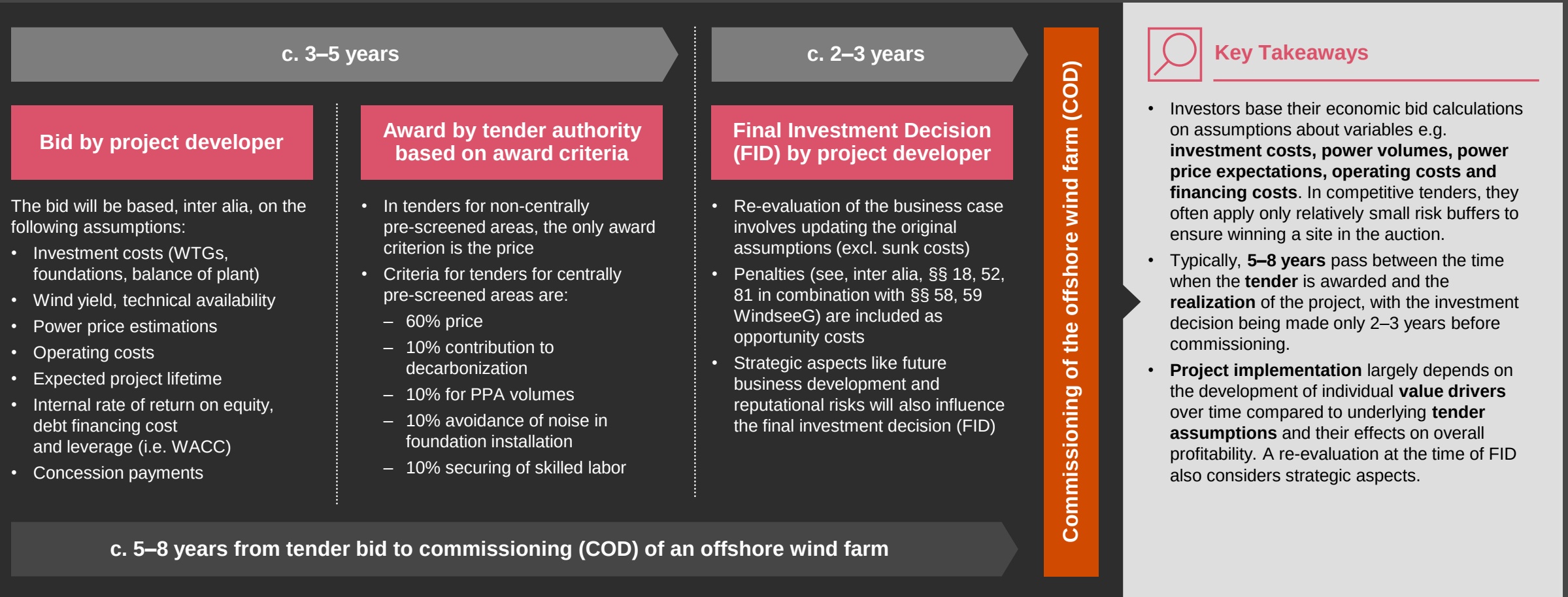


Key Takeaways

- Offshore wind energy will make a significant contribution to the security of energy supply and to reducing the overall cost of the energy transition.
- Therefore, the expansion targets in Germany were increased in 2023 to an installed capacity of 30 GW by 2030. At the European level, the eight countries bordering the North Sea agreed in the Ostend Declaration of April 2023 to install 120 GW of capacity in the North Sea by 2030.
- However, based on current trends, only a gradual increase in installed capacity is expected in Germany over the next five years, with a cumulative capacity of 17.5 GW by 2029. Projections indicate that in 2030, there will be a shortfall of more than 8 GW from the 30 GW target, which will not be reached until 2031.
- Whether the target of 30 GW can then be realized and the corresponding investments undertaken will depend crucially on the extent to which the corresponding supplier capacities can be built up.

Winning bids in competitive tenders often requires accepting minimal risk buffers to secure the tender award. However, years later, the project's economics and profitability must be re-evaluated to support the Final Investment Decision (FID)

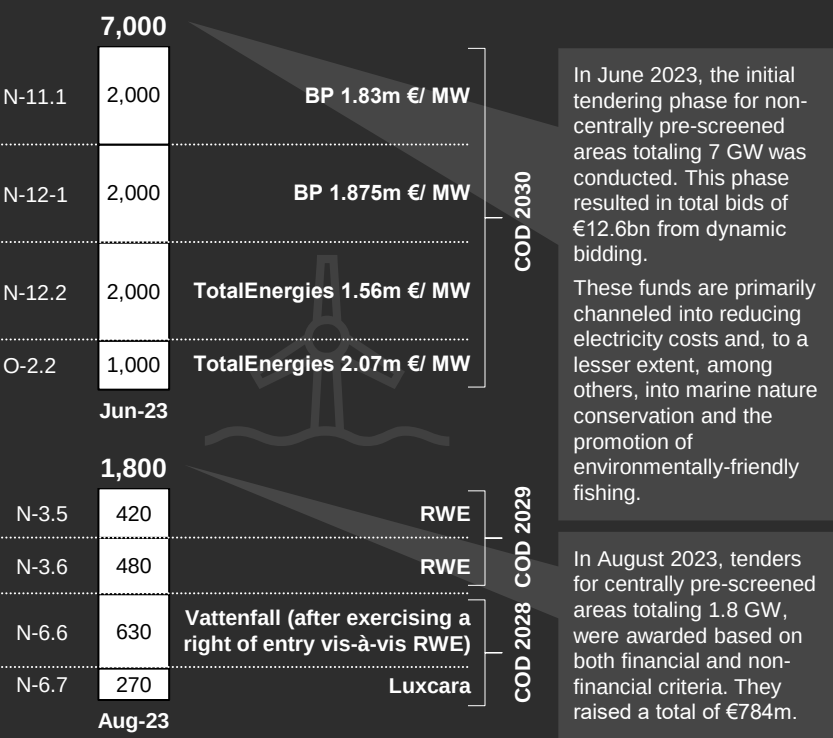
Process from the bid via the tender award until the commissioning of an offshore wind energy project



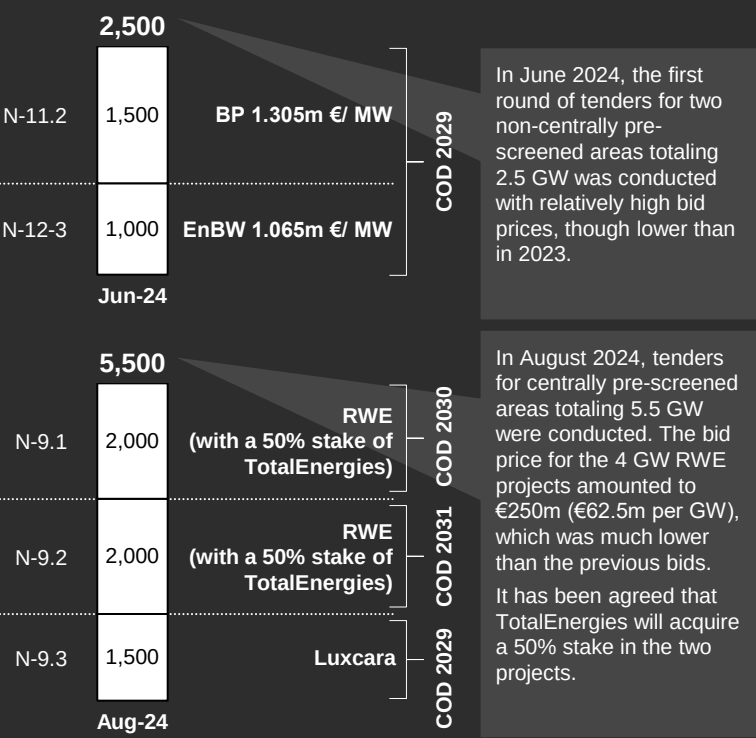
The latest tenders for offshore wind energy in Germany have led to a market concentration with very high auction revenues for non-centrally pre-screened areas, increasing significantly the future cost base after COD for these projects

German offshore wind energy auctions in 2023 and 2024 – results and conclusions

Bidders for the areas 2023 (in MW)



Bidders for the areas 2024 (in MW)



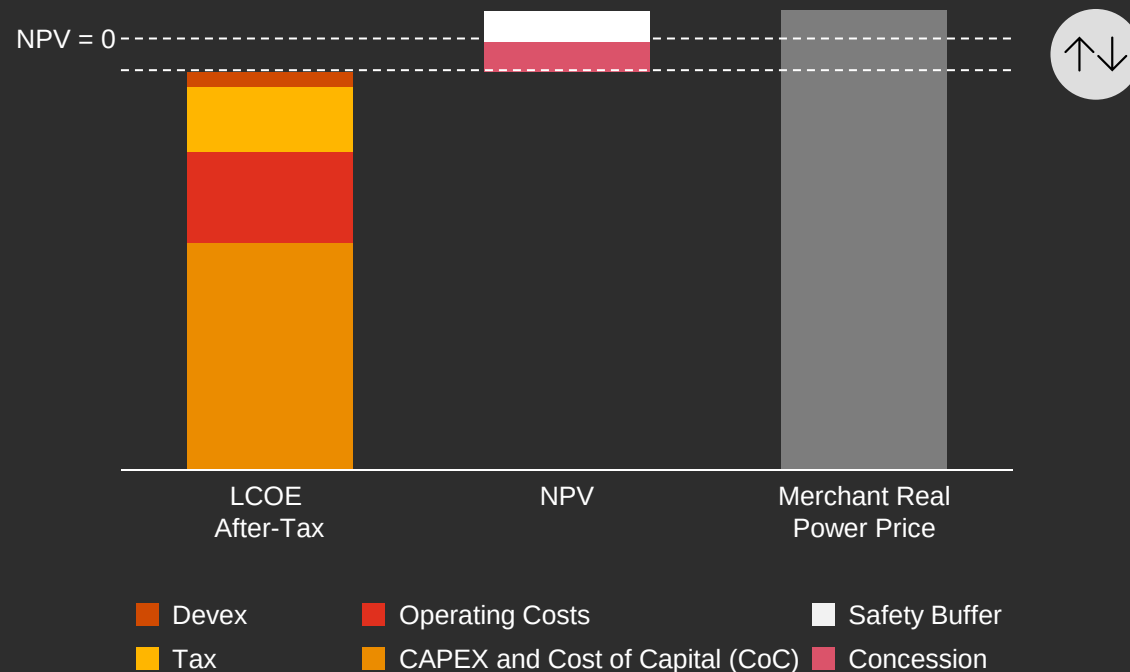
Key Takeaways

- After the introduction of the “WindSeeG” in 2023 a new tendering regime for offshore wind projects has been in place in Germany (with areas centrally pre-screened by the Bundesamt für Seeschifffahrt und Hydrographie (BSH) and other, non-centrally pre-screened, areas requiring development by bidders).
- The tenders resulted in very high auction revenues for non-centrally pre-screened areas, especially in 2023. Although bid prices are also included in the award criteria for pre-screened areas with a weighting of 60%, the auction prices realized in this tender segment were significantly lower.
- The tendering of only a few sites with large capacities has led to a concentration of projects in the hands of only a few players, with possible positive economies of scale that has to be weighed against an increase in risk in the event of project failure (less risk diversification).

An investment in offshore wind is, ceteris paribus, economically viable only if the expected (real) electricity price exceeds the calculated (real) per-unit costs, which serve as the hurdle rate

Project economics for investment decisions in an offshore wind farm

Comparison of LCOE with power prices €/MWh (real 2024)



Project economics for investment decisions in an offshore wind farm

An investment in an offshore wind farm is, ceteris paribus, economically viable if the associated net present value (NPV) is ≥ 0 . The **NPV** (Net Present Value) represents the discounted cash inflows and outflows associated with an investment, using a weighted average cost of capital (**WACC**) for equity and debt over the expected useful life of the investment.

The starting point for our analysis is the so-called **LCOE** (Levelized Costs of Energy). It represents the real per-unit cost (typically per megawatt-hour) of building and operating a power plant over its assumed lifetime. The LCOE calculation includes all the costs involved in the development, construction, operation, and decommissioning of a power generation project, such as initial capital costs, operation and maintenance costs, and the cost of financing.

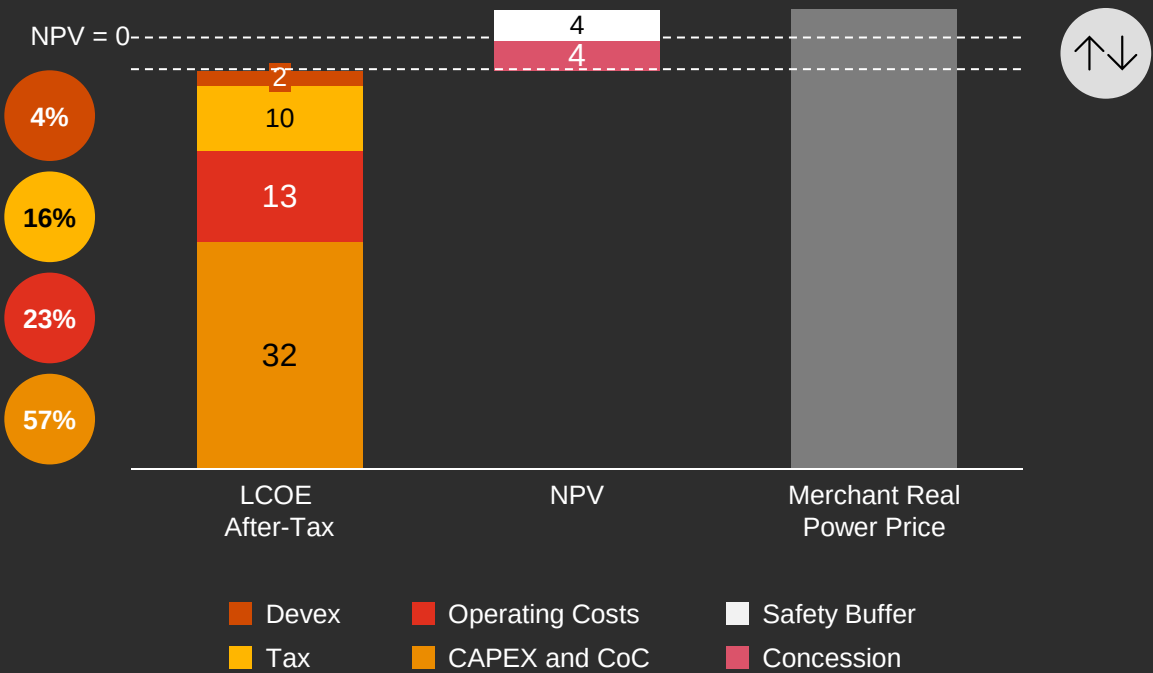
The **LCOE** represents the **hurdle rate that must be exceeded by** the discounted average **power price expectation** at a specific time for the project to remain economically viable ($NPV \geq 0$). However, in offshore wind projects in Germany, economic assessments as to the NPV in addition to the LCOE must also consider potential concession payments following the auctions.

The more clearly the NPV is positive, the greater the safety buffer and therefore the greater the probability that a project will remain profitable even under adverse scenarios at the time of FID.

Investment decisions in offshore wind rely on tightly calculated business cases. To provide a sufficient buffer for potential changes before FID, future power price expectations must significantly exceed both the LCOE and any additional concession payments

Evaluating the impact of assumption changes on project viability

Generic base-case LCOE
€/MWh (real 2024)



Case Study – base case

In a simplified generic base case for a case study, the LCOE was estimated at approximately **€57 per MWh**, based on **generic assumptions** for a typical offshore wind project in Germany **at the time the bid** is submitted at an auction.

In this example, an electricity price expectation of roughly €65 at the time when the bid is submitted would result in a safety buffer of approx. €8 per MWh in comparison to the LCOE.

However, an assumed **concession payment** (nominal €0.7m/MW) resulting from auction further increases the project costs and the actual hurdle rate in this generic case to €61 per MWh, while reducing the safety buffer to €4 per MWh.

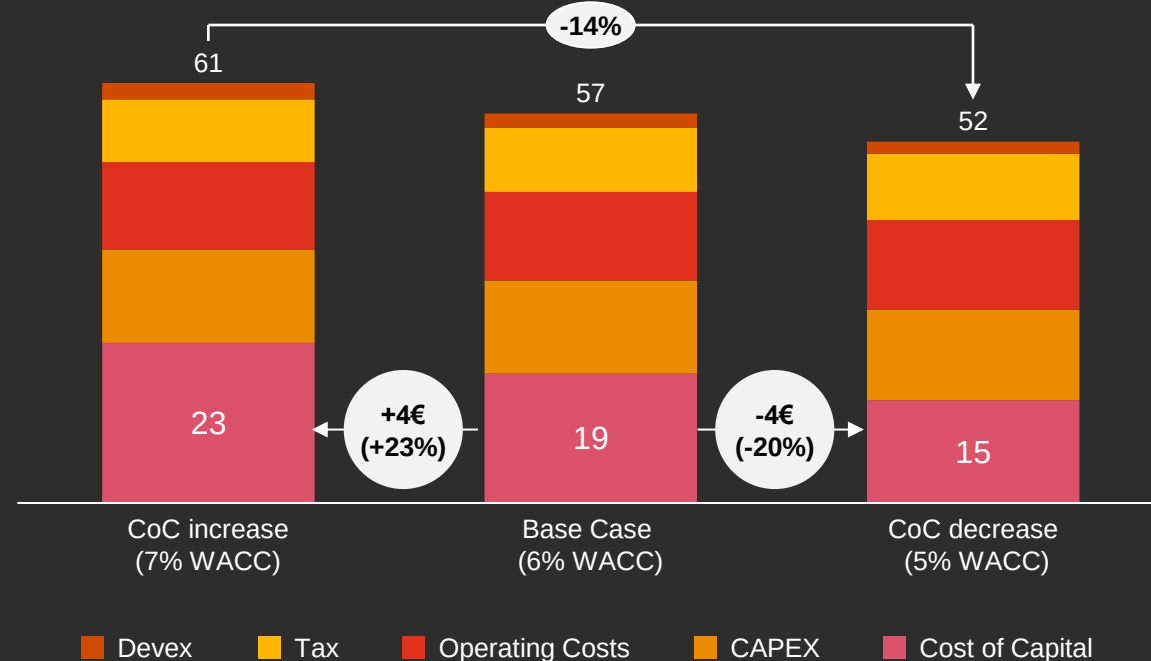
Due to the decreased buffer, there is a higher likelihood that at the time of the FID the project will no longer be economically viable if either the hurdle rate (LCOE) increases* or the power market price expectations decreased. In the following sensitivity considerations, we analyze the effects of negative deviations in individual parameters on the economic viability of this generic offshore wind project.

* The 10% down payment of the concession, in this case €0.07 m/MWh, is no longer to be considered at the time of FID, as these costs should be treated as sunk costs.
Sources: IRENA (2024), EnBW (2025), PwC analysis (2025). LCOE analysis based on a hypothetical 1 GW offshore wind farm with a 35-year lifetime, 40% load factor, €2.5m/MW CAPEX and 6% WACC.
PwC | The Offshore Wind Revolution

In our case study, the Cost of Capital must increase by ~1% to 7% to eliminate the safety buffer. In this case, the project would no longer be financially feasible at FID

Cost of Capital sensitivity analysis – Impact on project returns

Generic base-case LCOE €/MWh (real 2024)



Key Takeaways

In our base-case scenario, we used a Weighted Average Costs of Capital (WACC) of 6%, which in our generic case led to an LCOE of €57 per MWh. However, the WACC may vary over time due to changes in the capital market environment.

The WACC as a discount factor is highly dependent on the general level of interest rates, which have risen in recent years as central banks have responded to inflation. If interest rates were to decline to pre-inflation levels (with a current downward trend already visible), this would likely result in a decrease in the WACC and consequently the LCOE. On the other hand, a further increase in the interest rate level would also be conceivable, which is why we analyze both the effects of a WACC of 5% and of 7%.

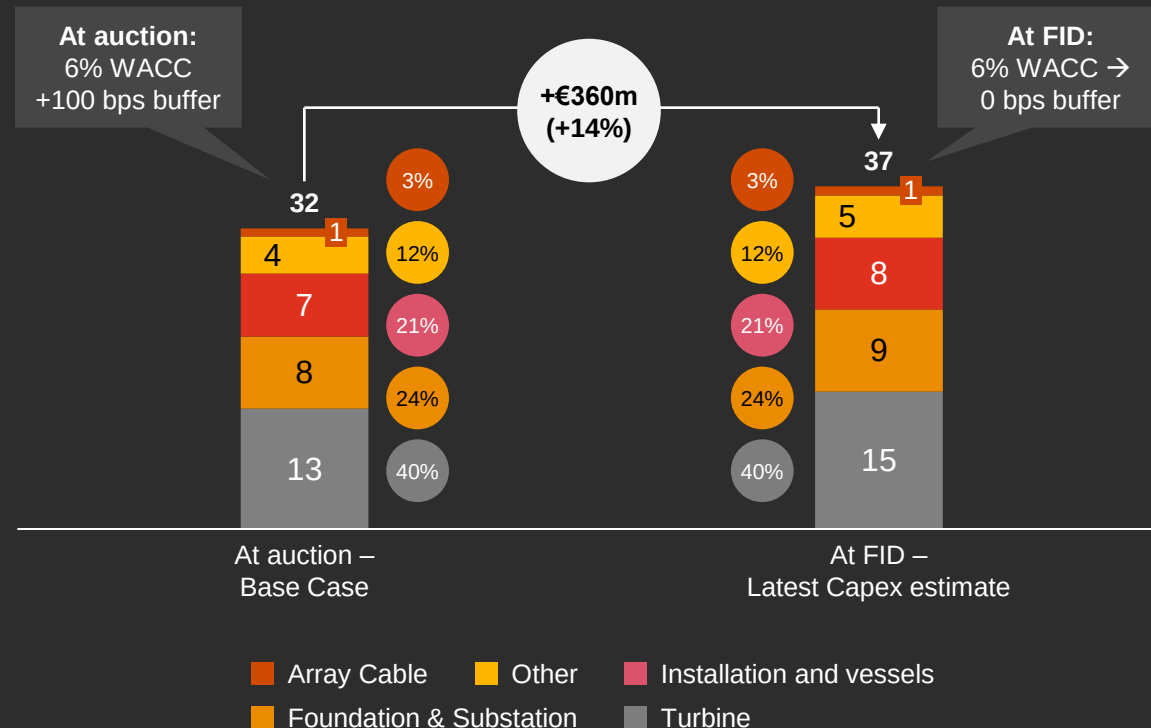
An increase of the WACC to 7% would lead to an increase of the LCOE to approximately €61/MWh. In this case, assuming all other factors remain constant (*ceteris paribus*), the safety buffer would be exhausted with concession payments and diminished in the case without concession payments.

As we see, the Cost of Capital is a key value driver. Increasing Cost of Capital can be partially mitigated by more complex (project) financing structures.

In our case study, the CAPEX must increase by ~14% to eliminate the safety buffer. In this case, the project would no longer be financially feasible at FID

By how much do CAPEX and CoC have to increase to reduce the project IRR by 100 bps?

Generic base-case LCOE (with concession payments) €/MWh (real 2024)



Case Study – sensitivity analysis

As shown on the previous page, CAPEX with the corresponding Costs of Capital account for more than 50% of the LCOE of our generic offshore wind project. Due to its significant economic effects, CAPEX is a particularly important success factor for a project.

In our generic case, a project IRR of 7% at the time of tender award with concession payments of €0.7bn was 100bps above an assumed WACC requirement of 6% (i.e. buffer of 1%). In this case, the existing safety buffer would already be used up, ceteris paribus, with an increase in CAPEX of ~14% (increase in CAPEX by €360m to ~€2.86bn instead of €2.5bn).

Without concession payments the project IRR might have been 8% with a higher safety buffer of 200bps and such a case would be more robust against an increase of CAPEX (in this case, the safety buffer would be exhausted only after a CAPEX increase of ~30%.)



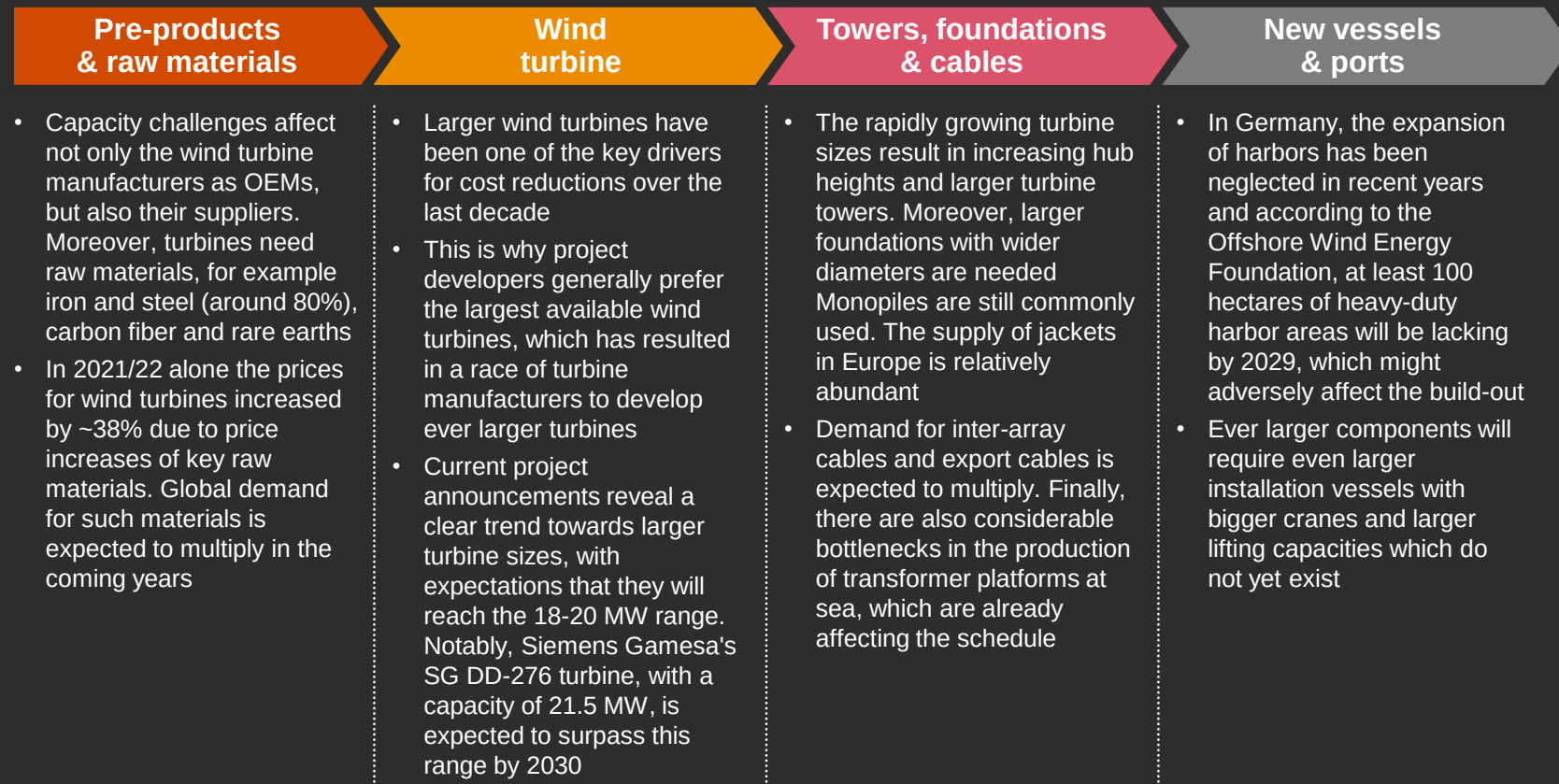
Low risk buffers considering the challenges along the offshore wind energy value chain

The safety buffer determined in the generic case appears relatively small in light of the existing challenges along the entire value chain.

On the following pages, we will outline these challenges and explore potential strategies for addressing them.

In order to achieve the very ambitious German and European expansion targets, a rapid ramp-up along the entire offshore wind energy value chain is required

Trends and requirements in the value chain for offshore wind energy



Key Takeaways

- Paradoxically, the enormous growth of the offshore industry not only presents an opportunity but also poses a challenge. The industry must set the course for the future and build and expand capacities at almost all stages of the value chain.
- This challenge is further intensified by the fact that the number of European manufacturers of offshore wind turbines has dwindled to just two companies over the past two years.
- Suppliers do not only have to cope with exponentially increasing demand, but also the ongoing technological change towards larger and more powerful turbines.
- This applies not only to the wind turbines, towers, foundations and offshore cable connections, but also to the supporting harbor infrastructure, the required heavy-lift vessels and all pre-products and the supply of raw materials.

As an expansion of production capacities is crucial for achieving offshore wind targets, the state should play a supporting role in order to foster private investments. The possible role of Chinese suppliers remains to be seen

Development and provision of production capacities to meet market demand

Expanding German and European supply chain capacities and the pivotal role of the public and private sector

- Only two European companies produce offshore wind turbines with stable supplier relationships within and outside Europe. Although the industrial base is solid, existing capacities are insufficient to meet the rapidly growing demand
- To build production capacities, the private sector needs credible signals from the public sector supporting a sustainable expansion path beyond 2030. The public sector must also actively develop port infrastructure. The example of Sandbrook Capital's entry into Havfram to finance a fleet of specialized vessels for offshore wind farms shows that when there is a sustainable market development, corresponding investments are also made by the private sector
- International coordination, e.g. between the neighboring countries of Germany, Denmark and the Netherlands, is essential to make optimal use of the available sea area (minimizing wake effects in the North Sea)
- The offshore industry requires financing programs at both the German (e.g. KfW Bank) and European (e.g. EIB) levels to cover the significant investment needed for expanding production capacities not primarily for OEMs, but in particular for small and medium-sized companies along the value chain, and to provide guarantees

Potential role of Chinese suppliers

- China has led the world in annual offshore wind developments for six consecutive years, adding 6.3 GW in 2023, bringing its total to 38 GW, which is 50% of global capacity. In 2024, capacity increased further to 42 GW. According to GWEC, following recent investments, China's annual offshore wind turbine manufacturing capacity has likely surpassed 20 GW
- Chinese manufacturer Ming Yang Smart Energy is set to supply wind turbines for Luxcara's 270 MW project awarded by the Federal Network Agency in August 2023
- Chinese manufacturers like Ming Yang, Goldwind, and Envision have formed strategic partnerships with European utilities and energy companies
- Some project developers and operators hope these manufacturers will help to ease supply-side pressure and offer more cost-effective solutions for project realization
- Apart from possible contributions to production capacities and cost advantages, the integration of Chinese suppliers can also be associated with disadvantages, e.g. a possible loss of market share due to unbalanced competitive conditions, increased supply chain dependency, risks to critical infrastructure (which is more and more regarded as a serious security issue by politicians of major parties) and the loss of European technological leadership



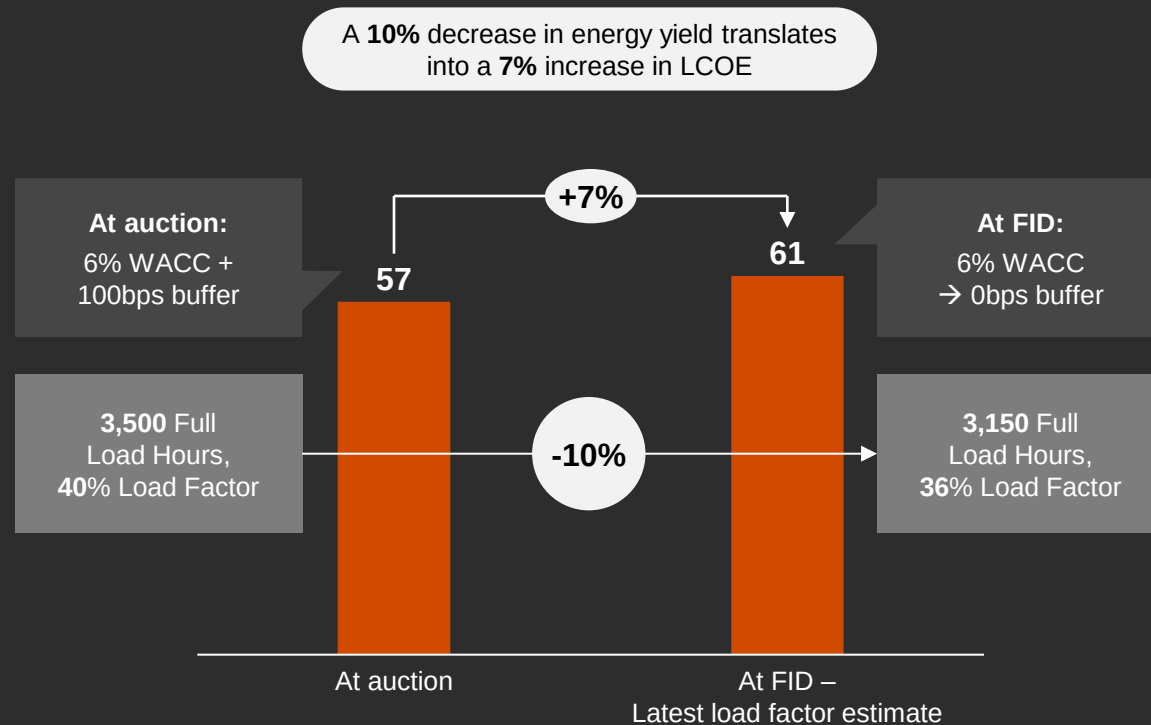
Key Takeaways

- The planned offshore wind energy expansion poses a challenge for the industry and requires a significant increase in current production capacities along the entire value chain.
- Such investments depend on a reliable, sustainable expansion path in Germany and Europe up to and beyond 2030. The substantial short-term financing needs and associated risks require suitable government support measures alongside private capital. Existing instruments for the promotion of foreign trade (e.g. ECA facilities) could also serve as a model for offshore wind energy, given the extreme challenges.
- The future role of Chinese manufacturers in Europe's offshore wind energy expansion and its impact on turbine prices remain to be seen.

In our case study, if full load hours decrease by only ~10%, the initial auction safety buffer is eliminated. This puts the significance of future North Sea cluster wake effects under the spotlight

By how much do full load hours have to decrease to reduce the project IRR by 100 bps?

Generic base-case LCOE (with concession payments)
€/MWh (real 2024)



Case Study – sensitivity analysis

At lower full load hours, the project costs are spread over fewer MWh and the LCOE increases. A decrease in the load factor from 40% to 36% (i.e. a 10% reduction), or in full load hours from 3,500 to 3,150, **eliminates the initial safety-buffer of 100bps at auction** (with again a concession payment of €0.7bn). Thus, the project's financial health is highly sensitive to changes in the load factor, highlighting the importance of accurate yield forecasting and conservative assumptions.

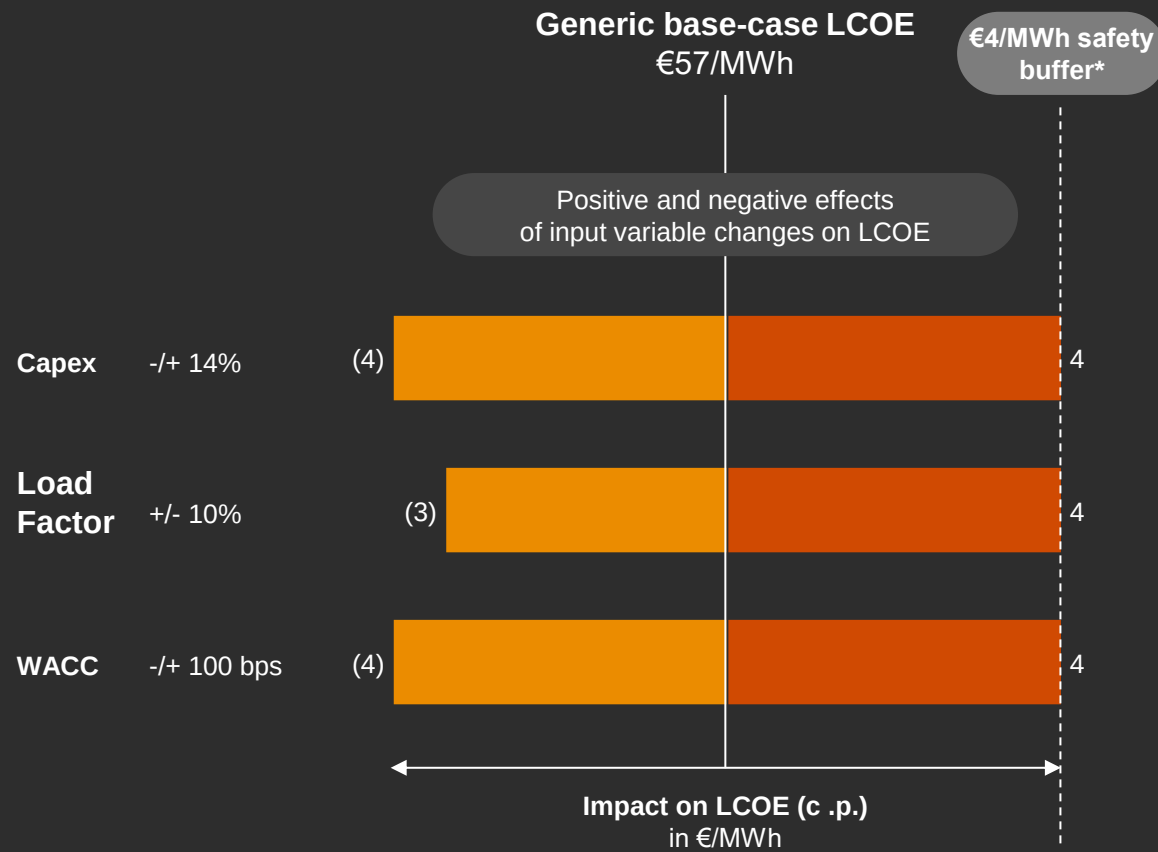
Without concession payments the project IRR would have been 8% with a higher safety buffer of 200bps, which, ceteris paribus, would only be exhausted in the event of a 19% decline in full load hours.

The results of RWE's energy yield modeling suggest that a significant build-out in the North Sea could result in an overall 10% reduction in wind energy yield. This highlights the need to maintain a robust buffer threshold to absorb potential shortfalls in energy production.

In a January 2025 statement, the BWO and BDEW called for future land-use planning to focus more on cost-efficient energy yield targets without reducing overall expansion. They also advocate optimizing tender and commissioning times to minimize and delay wake effects.

Adverse changes to input parameters such as Capex, load factor and Cost of Capital between bid award and FID can render a project uneconomical or increase its profitability

Change of LCOE as a result of changes in key value drivers



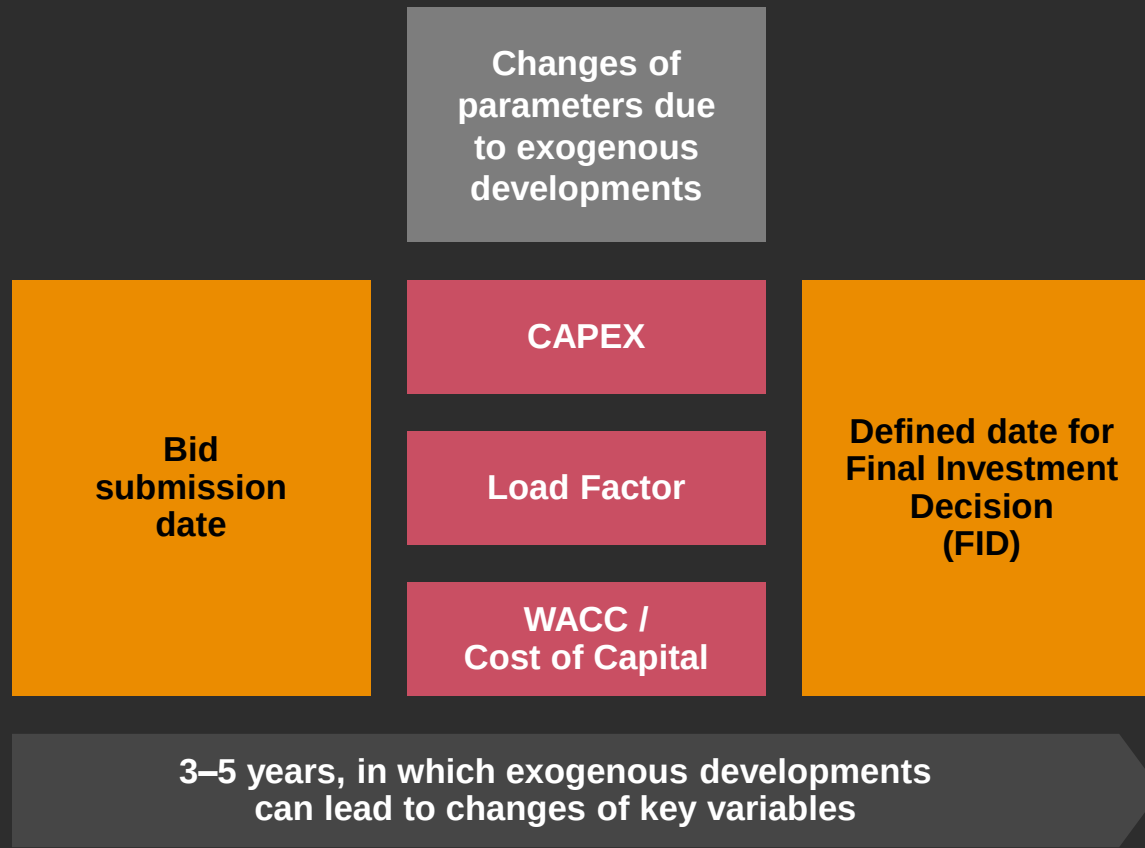
Key Takeaways

- Even without concession payments, in our generic base case a project without subsidies has only a moderate safety buffer, and there is a risk that the economic viability deteriorates until Final Investment Decision (FID). High concession payments significantly reduce the risk buffer and increase the likelihood of an uneconomic project at the time of FID.
- The project is relatively sensitive to becoming uneconomic with respect to key variables, particularly the load factor, CAPEX and the assumed WACC, which is of considerable importance. By contrast, operating costs play a comparatively minor role.
- The risk of a significant deviation in at least some variables is relatively high. Therefore, the business case is likely dependent on the ability to offset negative deviations in some variables with positive developments in other parameters.
- Finally, electricity prices, as an external variable factor, will also play a significant role - potentially having positive or negative effects. Sponsors of offshore wind projects in this respect often try to conclude PPAs before FID in order to limit trading exposure.
- **Overall, the potential risk that a specific project may no longer be economically viable at the time of FID is significant**, particularly if other investment criteria, such as strategic reasons, are disregarded. However, in a positive scenario, positive developments of parameters could also lead to an increase in project profitability.

*The 1% safety buffer is depleted once the threshold of €4/MWh is reached.

As key parameters depend heavily on exogenous developments beyond the operator's control, concession payments could be adjusted based on suitable reference values to mitigate the risk of a project becoming uneconomical at FID

Which reference values are suitable for different parameters?



Possible adjustment mechanism for concession payments

Our calculations have shown that with high concession payments, a safety buffer would be depleted much more quickly. If individual parameters can deteriorate due to uncontrollable external factors, it therefore might be prudent to include an adjustment mechanism for concession payments in future auctions. Such adjustments might take place in response to relevant changes between the time of bid submission and the FID (the timing would need to be clearly defined). For instance, the following reference values might be suitable as individual parameters:

- For a **weighted average cost of capital (WACC)**, internationally recognized reference interest rates such as the EURIBOR might be suitable
- For **CAPEX**, a producer price index for offshore components (e.g. foundations, turbines or cables) would generally be suitable. Alternatively, commonly used price indices, such as those for machinery products or raw materials (e.g., steel), could be applied, potentially in a weighted form.
- Regarding the **load factor**, the risk of shading losses due to site developments that cannot yet be assessed appears relatively high. Therefore, it might be worthwhile to consider linking ongoing concession payments to the level of wind yield, similar to the approach used in onshore wind projects (in terms of the remuneration tariff). In this context, the concession grantor would need to define a reference yield in advance as part of the tender.

As CAPEX are a key variable that is heavily dependent on the market environment, stable investment conditions are required to achieve the ambitious expansion targets in Germany and Europe

Key take-aways and implications



Importance of offshore wind energy in German power sector decarbonization

Germany has set itself the ambitious target of generating 80% of its power from renewable energies by 2030. Offshore wind energy plays an important role with an expansion target of 30 GW by this time (currently 9.2 GW are installed) in the North and Baltic Seas.

According to current forecasts, less than 30 GW will be installed by 2030 (22 GW) and the 30 GW target will only be reached in 2031. The project rights to achieve this target have already been awarded in the latest auction rounds, but final investment decisions (FID) for many projects are still outstanding (expected between 2026 – 2029).



Calculations of investors regarding the Levelized Costs of Electricity (LCOE)

Investors make assumptions about variables such as CAPEX, power prices and energy yield and financing and operating costs. As offshore wind capacities are put out to tender in a competitive process with negative bidding, investors may often take relatively small risk buffers into account in their calculations to secure the project rights.

Calculations of offshore projects under the current conditions show that, in addition to full load hours, investment costs are particularly significant value drivers in determining the LCOE. Due to the great importance of CAPEX for project economics, it is essential for the realization of tendered projects to keep such costs within reasonable limits.



Strengthening of the offshore wind value chain is a key success factor

In order to cope with the installation figures planned in Germany and Europe, particularly from 2028 onwards, and to keep prices at acceptable levels, the corresponding production capacities will be required. Their development depends, in particular, on favorable framework conditions in the coming years.

Favorable framework conditions include, in particular, the reliability of the planned expansion path and better international coordination, the improvement of financing conditions for companies along the entire value chain and the expansion of port infrastructure. The future role of Chinese manufacturers remains to be seen and will need to be critically evaluated.



PwC occupies a leading position on the market for auditing and consultancy. PwC provides support to clients from all sectors to enable them to obtain their objectives – thanks to our worldwide network, the opportunities are boundless.

PwC advises groups and family-owned companies, industrial and service companies, global players and local heroes, the public sector, associations and NGOs. Because they are able to rely on us, we are the leading auditing and consultancy company in Germany. And because more than 15,000 specialists with around 600 partners at 20 locations in Germany are working every day to ensure that this trust is justified.

Our dedicated PwC Germany Renewable Energy team was established in 2000 and has ever since been working exclusively on renewable energies. We focus on commercial and financial advice for solar PV, on- and offshore wind and battery projects. We offer M&A advice, bench-marking, valuation and financial modelling as well as strategic advice. Our clients include project developers, utilities, banks, strategic and financial investors.

Contact us:



Heiko Stohlmeyer

Director, Head of Deals Renewable Energy
PwC Germany
heiko.stohlmeyer@pwc.com



Maximilian Kurth

Senior Manager, Deals Renewable Energy
PwC Germany
maximilian.kurth@pwc.com



Dr. Janosch Ondraczek

Senior Manager, Deals Renewable Energy
PwC Germany
janosch.ondraczek@pwc.com



Tolga Seremet

Manager, Deals Renewable Energy
PwC Germany
tolga.seremet@pwc.com



Dr. Peter Claudy

Senior Associate, Deals Renewable Energy
PwC Germany
peter.claudy@pwc.com

Additional contributors: Ashwin Fernandes and Helena Schulte-Huermann

www.pwc.com

© 2025 PricewaterhouseCoopers GmbH Wirtschaftsprüfungsgesellschaft. All rights reserved. In this document, “PwC” refers to PricewaterhouseCoopers GmbH Wirtschaftsprüfungsgesellschaft, which is a member firm of PricewaterhouseCoopers International Limited (PwCIL). Each member firm of PwCIL is a separate and independent legal entity. Please see www.pwc.com/structure for further details. No reproduction is permitted in whole or part without written permission of PwC. Disclaimer: This content is for general purposes only and should not be used as a substitute for consultation with professional advisors.