BDO Real Estate

White paper offshore wind

Wind energy is one of the key focus points to achieve the EU's ambitions to be carbon-neutral by 2050 as wind energy's carbon footprint is estimated to be 90 times smaller than coal's and 40 times smaller than the carbon footprint of natural gas.

Wind is locally sourced, providing energy independence in a time prone to geopolitical risks and therefore also reduces the exposure to volatile fuel prices.

Yet, despite its advantages, one can wonder why wind energy is not more widespread. Why are wind towers not mushrooming on land and on sea? Why the industry has been through a perfect storm, forcing companies to reset projects, slowing down the roll-out of new wind projects?

This white paper is designed to provide the reader an overview of the dynamics of the wind energy market, looking at different aspects. Firstly, it intends to contextualise the importance of wind energy (both on- and offshore) in the energy mix in Europe. The European Union affirmed its climate ambitions for 2030 where wind energy will play a pivotal role. Yet, is the industry likely to live up to its objectives? How much effort is still required to reach the objectives? In the second part, we will look at key economic aspects of wind energy and how the wind energy differs from other sources of energy, looking at LCOE and the cash flows.

Thirdly, we will dig in the value chain of wind energy from sourcing and tendering down to the exploitation and end-of-life period. What are the key challenges and evolution we see for the next few year(s)? How is financing evolving and what are the critical factors to be considered when seeking financing for a wind project?

At the end of this paper, you will find all the links to the sources used in this document for your reference.

BDO Infrastructure & Project Finance is a team specialised in advising clients in large projects. Over the last few years, our team has witnessed the trends in sustainability and has since accompanied numerous projects on- and offshore involving wind. Our team is specialised in developing financial models to assess the feasibility and the attractiveness of business cases and in optimising the funding and fiscal structures pertaining to projects.

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1. Abbreviations

BoS	Balance of System
CapEx	Capital Expenses
CfD	Contract for Difference
EU	European Union
GW	Gigawatt
kW	kilowatt
LCOE	Levelised Cost of Energy
MW	Megawatt
MWh	Megawatt per hour
NZIA	Net Zero Industry Act
NPC	Non-priced criteria
O&M	Operation & Maintenance
OEM	Original Equipment Manufacturers
OpEx	Operational Expenses
OPI	Overriding Public Interest
PPA	Power Purchase Agreement
RAA	Renewable Acceleration Areas
TSO	Transmissions System Operator
TWh	Terawatt per hour
WACC	Weighted Average Cost of Capital
YoY	Year on Year

2. Executive summary

2023 will be remembered as a pivotal year for wind energy and, to a greater extent, renewable energy sources. Challenges such as soaring costs, quality issues, and delays in rolling out wind projects have impacted the industry's outlook and its ambitions to meet the EU's climate ambitions. The industry faced a slow-to-adapt regulatory environment with lengthy permitting or unfavourable auctions.

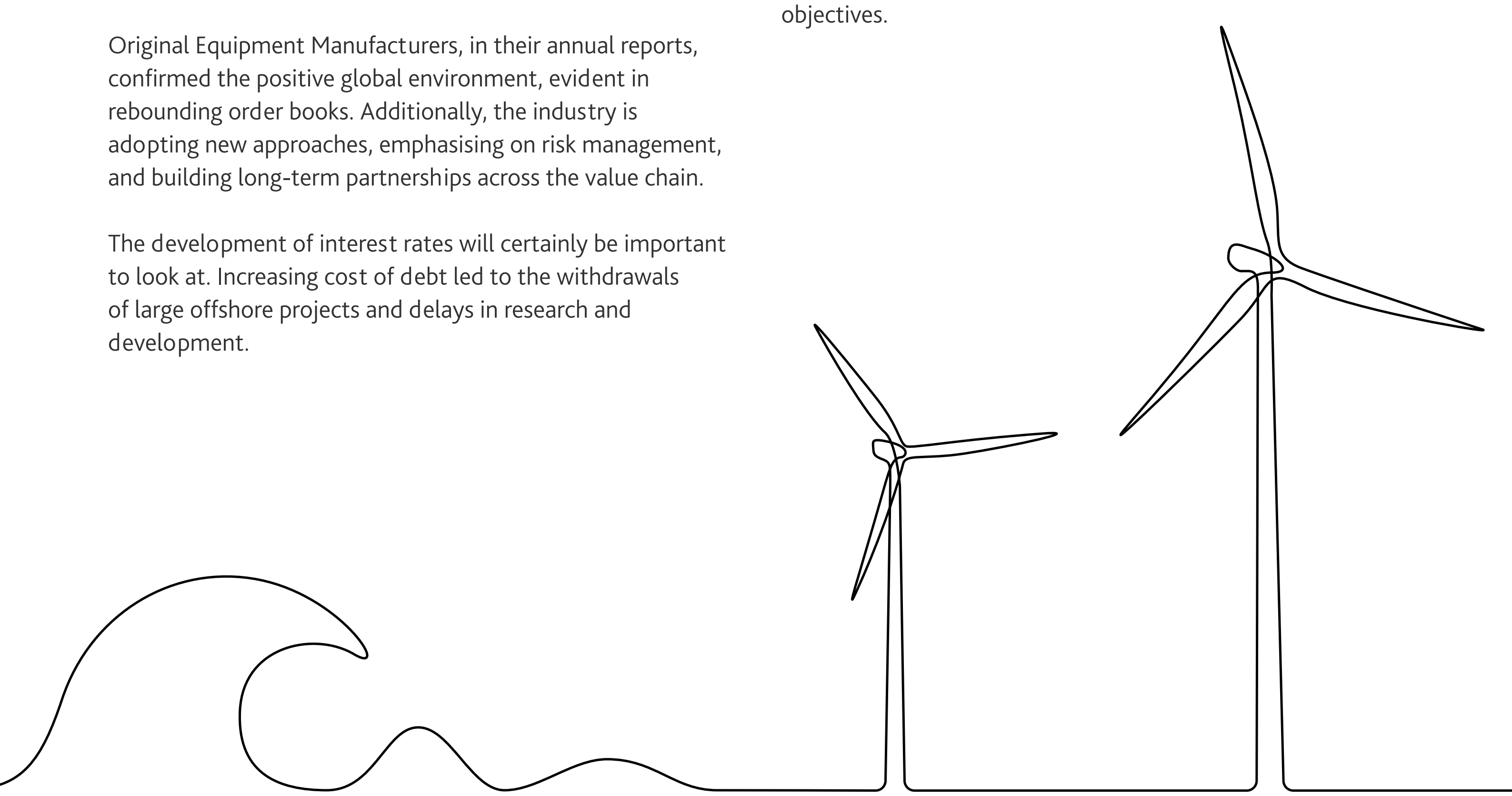
After public backlash and industry calls for more political impetus, positive changes began to unfold. The EU re-affirmed its support for the industry, releasing new directives and reaching agreements at EU level, emphasising a strong commitment to renewable energy. Individual Member States implemented measures facilitating the roll-out of new wind farms, increasing staff for permit reviews, digitising permitting processes, or enacting laws to unlock entangled projects. This resulted in an increase in permitted projects, advancing our societies away from fossil fuel.

Original Equipment Manufacturers, in their annual reports, confirmed the positive global environment, evident in rebounding order books. Additionally, the industry is adopting new approaches, emphasising on risk management, and building long-term partnerships across the value chain.

The development of interest rates will certainly be important to look at. Increasing cost of debt led to the withdrawals of large offshore projects and delays in research and development.

However, not all the issues have been solved. While quick fixes were addressed in 2023, more long-lasting challenges persist, such as the lack of capacity down the value chain. High entry barriers and shortage of additional capacity in vessels and in cables will likely take time to resolve and pose challenges to wind farm development over the medium term. Grid connections remain another challenge, but the industry is contemplating innovative solutions, including energy islands or co-location, maximising the utilisation of the grid.

The question of EU independence in sourcing critical raw materials for the energy transition persists over the longer term. In the absence of material deposits on the continent, is recycling a feasible solution for sourcing materials? With an expected 13GW to be decommissioned over the next 10 to 15 years, recycling elements from these decommissioned projects becomes critical to ensure the EU meets its objectives.



3. Importance of wind energy

3.1. 2023: a major milestone…

3.1.1. Wind Energy output surpassed fossil fuel output

For the very first time, renewable energy sources were responsible for 44% of all electricity generated in Europe in 2023. Wind generation witnessed a record double-digit annual growth (+13%, or 55 TWh) reaching 475 TWh. This marked the first instance of wind generation surpassing both coal (333 TWh) and natural gas (453 TWh) in Europe.

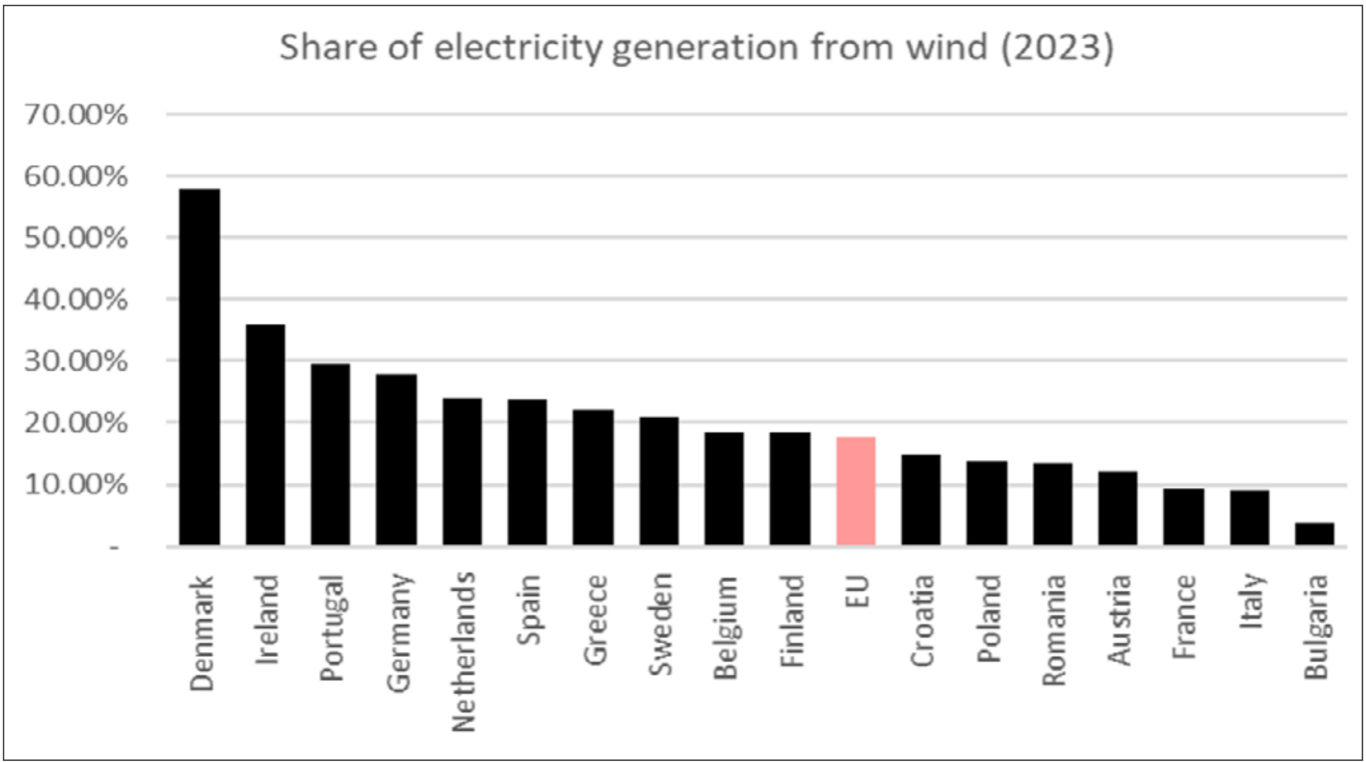
Simultaneously, fossil fuel, including coal and natural gas, experienced a significant volume decline.
Despite the temporary halt of coal plant closures in the aftermath of the energy crisis, coal generation fell by 26% YoY. Over the 2016 – 2023 period, coal generation halved and now accounts for 12% of the EU electricity mix. This trend is expected to continue in 2024 / 2025 as a fifth of the EU's coal plants will be closed.

Demand for gas in Europe was curtailed by 15%. This reduction occurred as European households and businesses cut their consumption and other more sustainable sources rebounded. Hydro power and nuclear energy output bounced back after a challenging 2022 marked by historic droughts (hydro) and extended plant outages in France (nuclear).

As a result, the total emission of the power sector in Europe decreased by 19% YoY, surpassing the previous highest annual drop observed in the Covid-19 period (-13%).

3.1.2. EU countries experienced for the first time an excess of renewable output

Furthermore, some EU countries registered an excess of renewable electricity production compared to demand for the first time. In September last year, Ireland reported a surplus of 103% compared to demand, attributed to the storm Agnes. Similarly, Portugal experienced renewable electricity production exceeding the country's needs for an uninterrupted 149 hours.

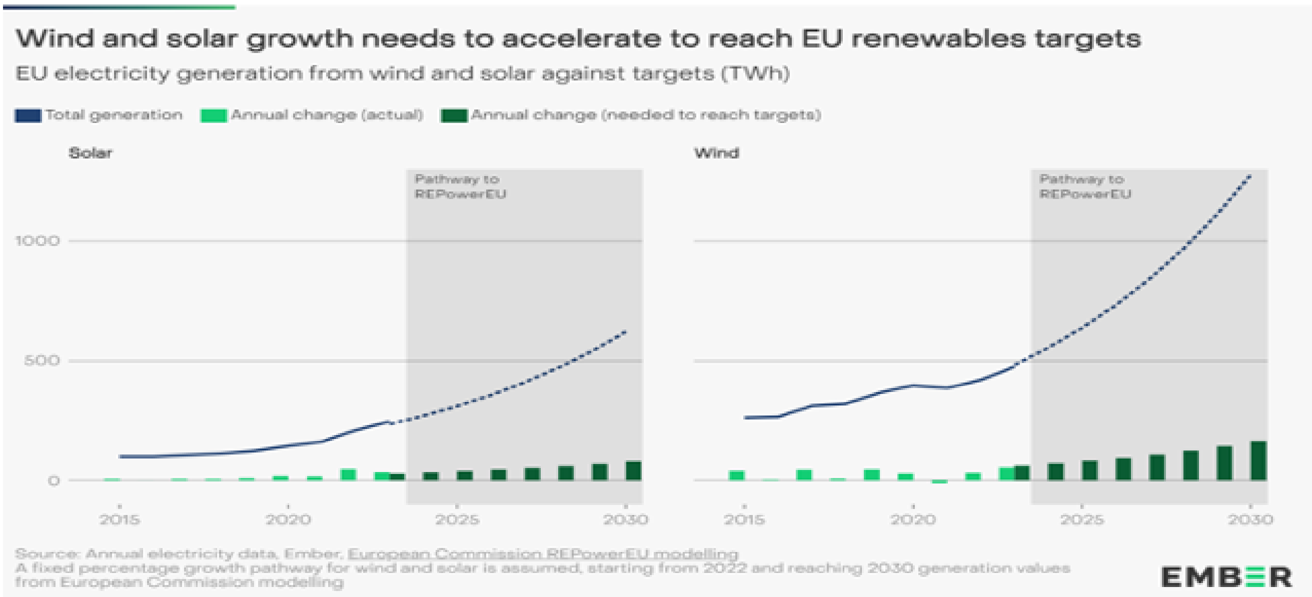


Source: Ember-climate.org

3.2. Yet more efforts are required to meet the 2030 objectives.

To align with the EU's 2030 climate ambitions, the pace of wind deployment needs to accelerate further. As depicted in the chart below: 72% of power generation needs to be from renewables by 2030, implying that the output of solar and wind need to double from 27% to 55% by 2030. Specifically, 30GW of new wind farms must be operational every year between 2021 and 2030 to meet the EU targets.

Secondly, auction frameworks are undergoing revamping. Initially focused on price competition (a "race-to-the-bottom"), where tenderers were capped at unrealistic prices that could not be indexed, the European Commission, under the impulse of different industry representatives, has implemented some measures to adopt non-priced criteria and focus onto qualitative and circularity criteria.



Source: Ember-climate.org

So, what needs to be done? The EU industry has long identified several setbacks threatening its progress. Following extensive discussions on these issues, the EU (and other governments) are now taking significant steps to alleviate the pressure on wind energy deployment.

Firstly, administrative simplification is essential. By the end of 2023, the European Commission issued a new directive streamlining the permitting process for new and repowered wind farms. The directive sets fixed timelines for project approval by Member States. Some countries, such as Germany, have already turned the directives into laws, leading to promising revivals of otherwise blocked projects.

Thirdly, the industry has recently grappled with supply chains and uneconomical conditions, leading to project delays or cancellations. Major Original Equipment Manufacturers ("OEM") are responding by signing long-term sourcing agreement to secure critical rare earth elements (e.g., Siemens Energy) or vessels for new offshore projects (RWE). These moves suggest the industry's need to collaborate, reduce lead times, and manage risks for a rapid wind turbine roll-out. Collaboration across the value chains, from supplier selection to client engagement, will help companies restoring profitability and strengthening the business case for increased wind deployment across the globe.

4. Economics of wind energy

4.1. Levelised Cost of Energy

4.1.1. First a bit of theory

The Levelised Cost of Energy ('LCOE') is a metric used to assess and compare the cost of electricity production across different technologies and locations. It combines both cost and energy production into one single measure, typically used to benchmark a project. This methodology is grounded in a discounted cash flow analysis where future costs are discounted, considering the time value of money. Conceptually, the LCOE represents the electricity price necessary for a project to break-even, accounting for the return on the capital invested.

The LCOE is driven by several factors: (i) the investment in year t [It], (ii) the OpEx cost in year t [Mt], (iii) the electricity produced in year t [Et], (iv) the WACC of the project [rt] and (v) the project lifetime.

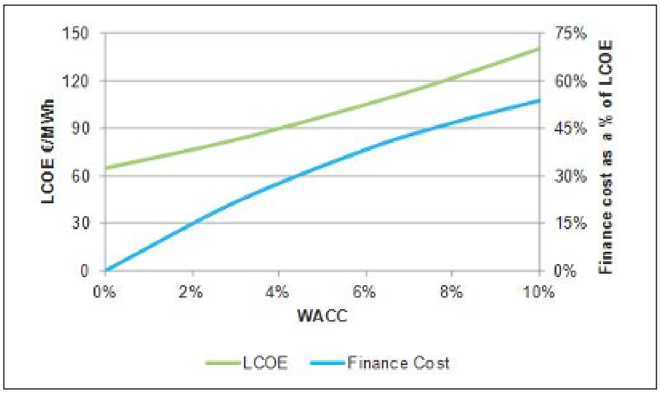
$$LCoE = \frac{\sum_{t=1}^{n} \frac{I_t + M_t}{(1+r)^t}}{\sum_{t=1}^{n} \frac{E_t}{(1+r)^t}}$$

4.1.2. LCOE and WACC

The WACC represents the average cost of financing a project, taking into account both the cost of debt and the cost of equity. As the WACC decreases, the financing cost of the project declines.

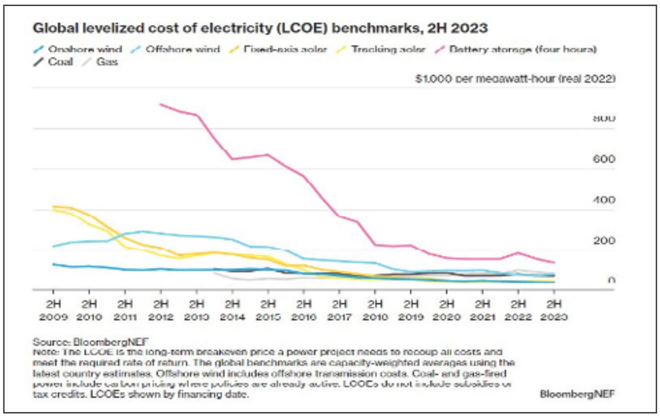
The question is then: how does the WACC influence the LCOE? Reflecting on the period from 2010 to 2020, the cost of debt for (offshore) wind projects has seen a remarkable improvement. Technological advancements, operational experience and long-term agreement fixing electricity price with reliable off-takers have collectively contributed to a reduction in the perceived project risks by the senior lender. As perceived project risks reduce, senior lenders have been more inclined to take on more leverage, thereby lowering the WACC.

As shown in the chart below, considering an offshore wind farm with a 25-year economic lifetime, a 10% WACC accounts for approx. 50% of the LCOE. A 5% reduction in the WACC leads to a decrease in the financing cost share, ultimately dropping to approx. 30% of the LCOE. This multiplier effect has been also confirmed in other analysis[1].



Source: BVG Associates

4.1.3. LCOE Evolution and benchmark



Source: Bloomberg NEF

According to IRENA, the global average LCOE for onshore wind project dropped significantly from USD107/MWh to USD33/MWh between 2010 and 2022. However, in 2022, the LCOE in wind stabilised and even slightly increased due to the rising inflation and supply chain challenges.

[1]PWC Netherlands – Financing offshore wind – a study commissioned by Invest-NL, August 2020.

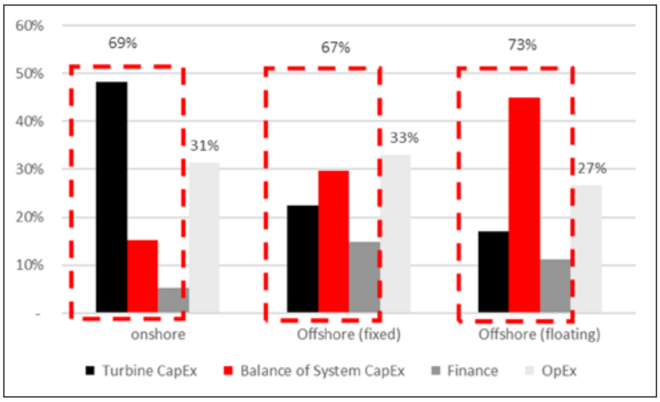
Over the past 15 years, wind energy has experienced a substantial decrease in LCOE, bringing it on par with other fossil fuels like coal and gas. This trend can be attributed to factors such as operational excellence, technical development and a favourable funding environment.

Operational performance played a major role, with the average size of wind farm significantly increasing from 25MW to 468MW in 2022. This expansion has leveraged economies of scale, resulting in notable efficiency gains, particularly in terms of OpEx per MWh and increased metered annual energy production, thanks to higher turbines.
The decline in LCOE can also be attributed to the deployment of larger and higher wind turbines and technical advances in offshore wind farm installation, including the use of new vessels capable of installing and operating wind farms in deep-sea locations.

4.2. Cost components of wind energy

4.2.1. Installation costs

The production and installation of a wind turbine are inherently capital intensive, as shown in the graph below. Unlike other fossil fuel sources, such as a natural gas power plant, a substantial portion of the costs, between 65% to 75%, for wind turbines are incurred upfront[2].



Sources: NREL 2021 Cost of Wind Energy Review

Between 2015 and 2021, CapEx for new EU onshore wind farms declined from EUR1.9m/MW to EUR1.3m/MW but increased in 2022 to EUR1.4m/MW due to rising input costs. Notably, when comparing individual countries, those with less established value chains or facing land constraints[3] exhibit higher investment cost than the EU average.

For an onshore wind turbine, it is estimated that about 55% of the CapEx will come directly from the acquisition of the nacelle, rotor, and tower[4].

Additional costs, grouped under the BoS CapEx, contribute to approx. 20% of the total CapEx in a wind project. These costs include foundations, underground cabling, transformers, transportation, assembly, and administrative costs.

[2] Data based on estimated LCOE for United States as of 2021. Other EU-based papers hint that OpEx contributes to 25% of LCOE for 2022 offshore wind farm in Europe.
[3] That was the case for Germany, Ireland, France and the Netherlands in 2022
[4] As per a 3.3MW wind turbine located in the US.

4.2.2. Exploitation costs

O&M costs constitute the primary costs for wind turbine operators during the exploitation phase. These costs include insurance, regular maintenance and repairs, spare parts, administration fees, etc. Comparing O&M costs across projects is challenging, given the differences across turbines power, number of towers in a wind farm and years of operation. As the turbines age, the likelihood of technical failure or obsolescence increases, necessitating more frequent controls and interventions.

O&M fees can be both fixed and variable. Fixed O&M, including insurance, administrative expenses, and regular servicing, are presented in EUR or USD per kW per year. Variable O&M costs depend on the turbine output and are presented in EUR or USD per MWh. As a results fixed O&M costs are stable over time whereas maintenance and repair costs do fluctuate depending on the age of the technology, weather hazards, etc.

O&M costs are significantly influenced by the types of activities / services covered and vary with the technology. It is common for O&M costs to be 4 to 5 times higher for offshore compared to onshore wind projects. Additionally, O&M costs have shown a declining trend with the emergence of new technologies. While older turbines incur annual maintenance cost of approx. 3% of their original cost of the turbine, newer turbines average between 1.5% and 2% annually. This is explained by different factors, like economies of scale and development of less maintenance-intensive materials.

4.3. Revenues

4.3.1. Power Purchase Agreements

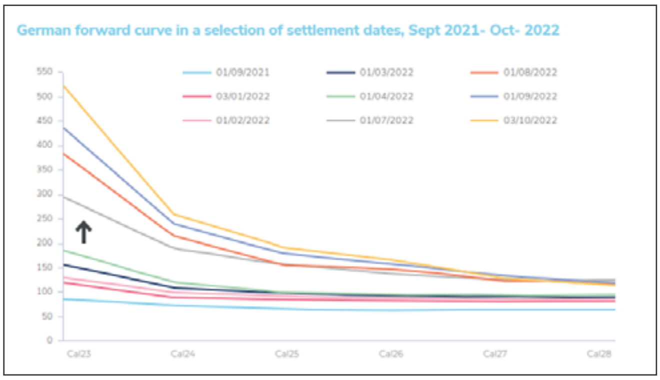
As incentive mechanisms are gradually being phased out or becoming less generous, renewable electricity projects are increasingly turning to Power Purchase Agreements ("PPAs"). PPAs are agreements between an electricity provider and a customer for energy supply. These contracts, whether long or short, typically outline the volume, price, potential fees (e.g., balancing costs) and risk allocation mechanisms.

PPAs offer an excellent alternative for buyers to seeking a stable energy source while mitigating the risks of price volatility. Meanwhile, sellers benefit from a constant cash flow over time.

PPA structure vary widely. In some cases, production risk is allocated to either the buyer (where the producer is under no obligation to deliver any electricity volume) or the seller (i.e., through baseload volume). In the latter, the seller faces market price volatility if the power generation unit fails to supply the agreed volume. PPAs can be direct (i.e., the electricity is sold directly to the client) or may be indirect (i.e., involving an intermediate such as a utility). They can be virtual, where the client benefits from pre-agreed price and attached green certificates, or physical.

The PPA's price, depending on the tenor, is derived from corresponding forward curves, ultimately determined by traded forward contracts. After a turbulent 2022, with a monthly average EURO composite Index increasing 23% to EUR90/MWh, the market found some reliefs with an average EURO composite Index hovering around EUR60/MWh.

Amid the electricity crisis, a new paradigm shift has emerged, with electricity providers observing significantly higher short-term forward prices compared to longer maturities, leading to the negotiation of shorter PPAs with maturities nearing one to two years.



Sources: Pexapark

4.3.2. Contract for Differences

Contract for Difference ("CfD") is a dynamic government scheme that defines a long-term[5] guaranteed remuneration per MWh, known as the "strike price", through a tendering. This mechanism provides a long-term stability to the electricity suppliers and consumers, offering comfort to investors to reduce their required cost of capital.

In this set-up, the Authority pays to the electricity producer the difference between the spot price and the strike price when the market price is lower, and conversely, the supplier pays the difference to the Authority in case the market price is higher.

As part of the October 2023 announcement regarding the reform of the electricity market design, the European Council intends to promote PPA's[6] and generalise CfDs.
Two-way CfDs will become mandatory for renewable projects when public funding is involved in long-term contracts. These two-way CfDs are expected to apply after a transition period of three years, extending to five years for offshore hybrid asset projects connected to two or more bidding zones.

[5] Between 15 and 20 years
[6] Via different instruments such as State-backed guarantee schemes, private guarantees or facilities pooling the demand for PPAs

5. Value chain in wind energy

Building on the insights discussed in part 1, it is clear that the current deployment of wind energy as part of our electric mix falls short of the objectives outlined by the European Commission. Despite the recognised advantages of wind energy and its role in decarbonising the power sector, the industry faces numerous challenges. This chapter intends to provide an overview of specific setbacks faced by the wind energy sector, shedding light on the hurdles that hinder its development.

5.1. Tendering

In September 2023, the UK government unveiled the results of its 5th CfD auction, aiming to award up to 5GW of new offshore wind. Unfortunately, no offshore wind projects developers submitted an offer mainly due to the uneconomical level of the ceiling price, capped at GBP44 per MWh, including grid connection costs. Transitioning beyond the UK, between 2021 and 2022, the capacity for new onshore wind farms in Europe dropped by almost one third, with tenders undersubscribed in several markets such as France, Germany, Italy or Spain.

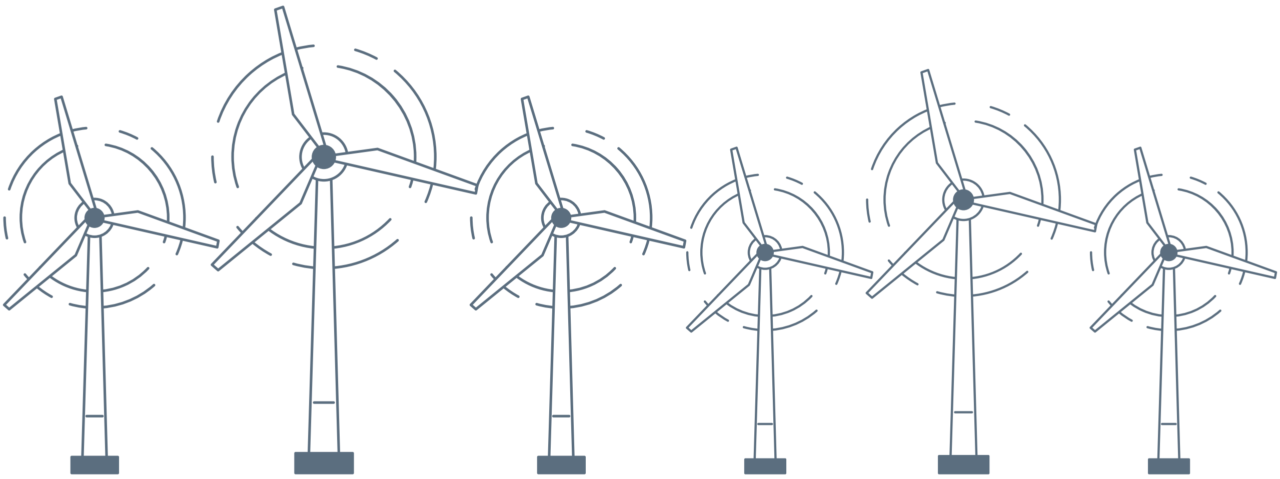
These examples underscore the need for the public sector to establish a coherent framework that fosters collaboration with the private sector. Such a framework should pivot from a cost-focused approach to a more holistic one. Consequently, new framework designs are emerging, based on a comprehensive perspective, considering factors such as renewable power production targets, economic growth, social value creation, job generation and energy security (i.e., non-pricing criteria or “NPC”).

5.1.1. Uncapped negative bidding

Uncapped negative bidding is a wind project auction design that requires from the project developers to pay for the right to build their wind farm without state support. The absence of state support and the obligation to develop on its own a new site means ultimately that the additional costs will either be passed downstream (to end-customers) or upstream, creating a rippling effect throughout the value chain. According to an analysis of Rabobank, this approach tends to place an extra financial burden on developers and favours large, cash-rich, Oil & Gas (“O&G”) companies.

Recently, Germany awarded 7GW of offshore wind project via a negative pricing mechanism. Although the auctioned seabeds were not pre-emptively analysed, the grid connection was guaranteed until 2030. The German government capped the price of the bid to EUR62 per MWh. In case of multiple zero bids, a second round of “dynamic bidding” was organised, where companies willing to pay for the concession could participate.
For this concession, the starting price was fixed at EUR30,000/MW with the subsequent round seeing an increase of EUR15,000/MW.

For each of the four tendered sites, more than one company pledged to build a wind farm without state support, triggering an additional “dynamic bidding procedure”. As a result, the awarded developers (Total Energies & BP) will have to pay a total of EUR12.6bn to the German Government, the vast majority being directed to the building of the grid connection (90%), the rest being used to fund marine preservation and sustainable fishing projects.



5.1.2. Emerging examples of qualitative criteria used in auctions

In February 2024, the European Parliament and the Council reached an agreement for the Net Zero Industry Act (NZIA), which aims to enhance the design of auctions for renewable projects. Among the key changes are the introduction of pre-qualification criteria and of NPCs. Examples of pre-qualification criteria include dealing with cybersecurity, responsible business conduct, a proven track record in similar projects, sustainability & circularity, supply chain resilience and energy system integration.

Local Contents Requirements ("LCRs") are increasingly influential in auctions across different regions, accounting for a significant portion of the total points allotted to bidders. In Japan, for instance, LCRs make up one-third of the total points. Meanwhile, in Taiwan, developers are mandated to locally produced 26 so-called "Key Development Items" for at least 60% of a project's proposed capacity.

In the Netherlands, the upcoming permits that will be granted for the 4GW offshore wind project Ijmuiden Ver will include criteria such as circularity and responsible business conduct.
Circularity criteria will introduce requirements with respect to recyclability, reusability, lifetime extension, the phasing out of hazardous substances and the use of secondary and renewable resources in the manufacturing process. Companies interested in the tender will have to adhere to the UN principles for human rights and guidelines for business and OECD .

5.2. Permitting

Across the globe, lengthy permitting processes have either delayed or stalled wind projects, with offshore projects being delayed by up to 9 years. Wind Europe estimated in April 2023 that approx. 80GW of wind projects in Europe were held up in the permitting procedure.
Consequently, developers face risks of deploying outdated technologies or installing sub-optimal scaled wind turbines, potentially deterring investors from supporting these projects.

However, by the end of 2023, the number of issued permits increased, largely supported by released permitting rules from the European Commission. The new directive, set to be translated into domestic law by July 2024, aims to accelerate the deployment of renewable energy projects, and enhance the transparency and predictability of the permitting process for all involved parties.

The new directive marks a significant milestone on various fronts. Firstly, it defines Renewable Acceleration Areas ("RAAs") identifying specific parts of land/marine areas suitable for renewable energy projects and whose development will not have a significant environmental impact. Permitting processes in RAAs will be fast-tracked, with durations not exceeding one year for onshore and two years for offshore projects. RAAs must be designated within 30 months after the directive's entry into force.

Secondly, the directive introduces the concept "Overriding Public Interests" ("OPI") for RAAs, aiming to limit legal challenges during permitting. The Spanish region of Galicia, for instance, has enacted through a new Law (Law 10/2023 of 28 December 2023) that wind turbines are of superior public interest. This declaration has retro-active effect and will apply on all projects challenged by courts without a definitive permit by 30 December 2022.

Thirdly, Member States will establish one single contact point to assist applicants throughout the permitting process and will digitise all permit-granting procedures.
Lastly, the Commission emphasises public consultations for RAA designations and active involvement through energy communities in renewable energy projects to address public resistance.

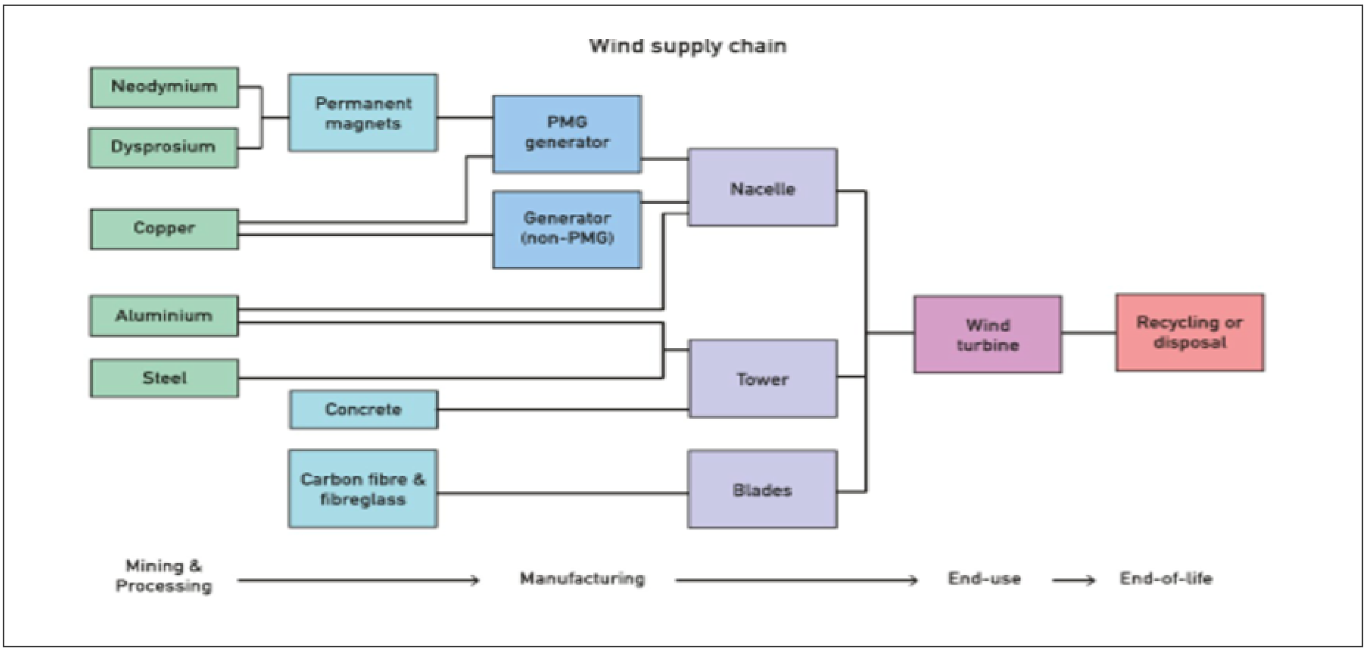
Germany and Spain experienced a 70% YoY increase in permitted capacity in 2023, reaching 7.5GW and 3GW, respectively.
According to Wind Europe, Germany's success is attributed to the swift implementation of OPI, expediting several projects entangled in legal disputes. The growth observed in Spain is mainly explained by the increasing staffing dedicated to permitting process.
In Poland, legislation regarding the minimum distance between the turbine and settlement changed, allowing a minimum distance of 700 metres. This important change paves the way for the deployment of more modern turbines on land. Finally, digitalisation efforts in Denmark and Poland have improved agents' efficiency, enabling them to track three times more files simultaneously, as reported by Wind Europe.

5.3. Sourcing

5.3.1. Inflationary pressures on most of the components

The manufacturing of wind turbines and their components relies on a cost-competitive supply of diverse raw materials such as concrete, iron, steel (making up 90% of the turbine's weight) and various metals such as aluminium, chromium, copper, manganese, molybdenum, nickel, neodymium, dysprosium and praseodymium (the last three known as rare earth elements). Enabling the transition towards a decarbonisation pathway requires securing a stable and cost-competitive supply of these materials. However, the EU's full dependence on imports for several critical elements, particularly rare earth materials, poses significant risks from both industrial and environment perspectives.

Specifically, the figure below summarises how these elements enter into the conception of new wind turbines:



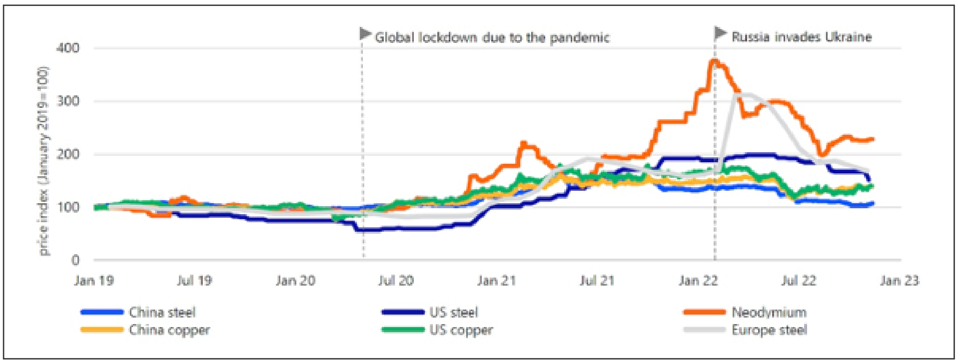
Sources: EU's JRC – Raw materials demand for wind & solar PV technologies in the transition towards a decarbonised energy system

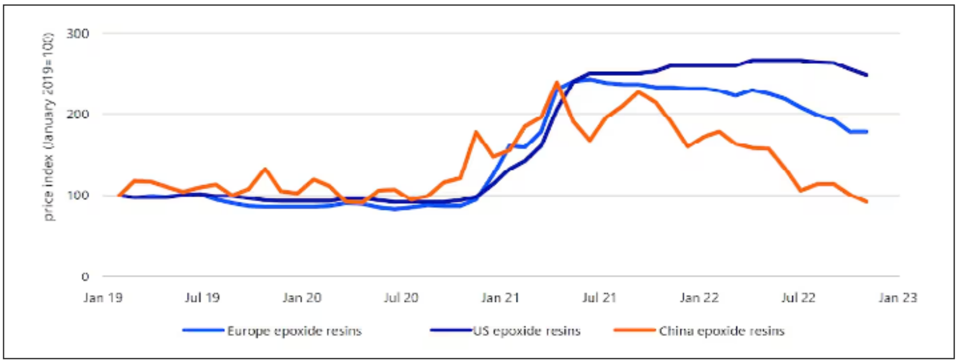
In the aftermath of Covid-19's impact on the supply chain, combined with high inflation due to the energy crisis of 2022-2023, prices for critical raw materials for wind turbines experienced a significant escalation. While there are some early signs of stabilisation in prices for raw materials and shipping costs in 4Q2023[7], the average cost to build a 1MW wind turbine is estimated to have increased by 38% between 2021 and 2022.

EU steel prices were up 69% between 2019 and 2022. Copper – a key conductor in wind energy transition - showed an increase of close to 40% over the same period. Neodymium has been through a severe price correction over the last quarter of 2022 but remains close to 130% higher vs. its 2019 average. Epoxide – a key component to make rotor blades and to coat the wind turbines' steel and foundations – have seen two interesting trends: first, the EU and US price for epoxide decoupled from China and second, EU epoxide prices are surging 79% vs. their January 2019 levels.

Chinese players, benefiting from a near total control over rare earth elements and extremely favourable pricing in both steel and epoxide resins, pose increased competition to European wind turbine manufacturers. As European players are grappling with a high inflation impacting their cost structure and inability to pass-through in a timely fashion price increases to customers[8], Chinese players are now entering the market and benefit from favourable pricing to outbid established players.

Meanwhile, the industry is adopting new contractual provisions, such as linking contract values to indexes tracking input costs or implementing cost-plus contract. Alternatively, OEMs are forming long-term partnerships to secure the supply of vital rare earth elements for the building of new turbines[9].





Sources: Rabobank

[7] Vestas' 4Q2023 transcript
[8] Some existing contracts between OEMs and clients were fixed price with limited possibility to adjust the sales price. The pressure on the OEM's margin was further exacerbated as hedging on raw materials is not a common practice in the industry.
[9] Siemens Energy 2023 annual report.

5.3.2. Constraints from the supply chains

Constraints on the supply chains pose a long-term threat to the roll-out of wind farms, as the industry is likely to take several years to meet these challenges. Other events, such as the diversion of shipping traffic out of the Red Sea, add additional delays to the shipping of turbines and other key parts but are deemed manageable so far, according to Vestas' comments.

Let's consider the example of vessels used to install and maintain offshore wind farms. As newer wind farms are more distant from the shores and are larger in scale, the majority of vessels have not undergone upgrades for transporting and installing these turbines. In 2020, GWEC counted only nine vessels capable of transporting large-scaled wind turbines (over 10MW), owned by 3 established players with significant bargaining power. Given the substantial time required to commission and receive upgraded vessels, further delays and costs pressures are inevitable.

In light of these challenges, it is not surprising that major players active in the wind turbine industry have long-term contract with companies operating such vessels. A recent example is the contract between RWE and Jan de Nul for securing two vessels over the long term.

5.4. Cables and Grid connection

As the world is increasingly rolling out (offshore) wind farms, the demand for cables linking these to the grid has doubled to 95,000 kilometres of cable between 2018 and 2022. However, cable supply has remained stable, creating a (new) possible bottleneck for the industry[10]. Between 2015 and 2020, the average annual new orders across the different cable suppliers hovered around USD3bn. In 2022, the total value of new orders surged to USD11bn, with expectation of further increases ranging from USD18 to USD20bn per year throughout this decade. Prysmian – the leading cable manufacturer – indicated that its order book is full until 2026/2027.

Additionally, as (offshore) wind farms become larger and more distant from the shores, cables need to be bigger, longer, and capable of dealing with higher voltage. Consequently, cables are now manufactured based on specifications and are becoming less standardised commodities.

In response to these challenges, we see operators and Transmission System Operators ("TSOs") entering long-term partnership with cable suppliers. For instance, Dutch TSO TenneT entered into a multi-year contract worth EUR5.5bn for 7,000km of electricity cables with NKT, Prysmian, Nexans and others.
Other solutions for Authorities, such as grouping cables order together, could also be envisaged, to ensure an EU-wide timely deployment of wind energy.

The optimalisation of the grid is another issue with which the industry is grappling as the widespread electrification of our societies relies on adequate infrastructure.
Historically, the grid is being built for constant, unidirectional electricity flows from a production point to the end customers. Now, with the renewable energy and emergence of alternative uses of electricity (e.g., Electric Vehicles), the grid infrastructure needs to be more flexible and available in time.

To mitigate these risks, the industry has identified different solutions.
For instance, by pursuing co-location, renewable energy developers are optimising the use of a grid connection, instead of using a grid connection point for 20%-30% of the available hours, different entry points can use the same grid injection point.
Alternatively, in the Netherlands, in 2022, TenneT awarded 11 contracts for the North Sea offshore wind project connections. Other solutions such as energy islands (e.g. Princess Elisabeth energy island) are also explored to offer a reliable and efficient answer to grid challenges.

[10] Usually, agreement to supply cables were signed 2 years prior to the delivery of the cable. Now the trends is to sign these contracts 10 years in advance.

5.5. O&M

O&M activities encompass preventive and repairing maintenance activities. Monitoring systems and planned visits are meant to prevent long downtimes of wind turbines. O&M costs typically fluctuate over the plant's lifetime. As wind farms grow in complexity and size, and new technologies, like floating wind farms, are being rolled out, O&M costs are expected to increase. Offshore wind farms, situated further from the coasts with harsher weather conditions, are expected to see more complex interventions, likely leading to higher costs.

The advent of new technologies is prompting O&M operators to adapt their approaches. Compared to fixed bottomed structures, floating structures present more points of failures and challenges. For instance, mooring lines may require more frequent replacements. Some operators envisage a widespread use of predictive robots for maintenance planning, while others explore "tow-to-site" models, bringing turbines back to the maintenance port for repairs and maintenance.

As innovation and new business models emerge, the future arrangement of wind turbine maintenance activities is uncertain. Depending on their size and on their risk management policies, operators may opt for a hybrid model, insourcing more general activities and outsourcing special tasks to the OEM or specialised O&M players.

5.6. End-of-life

Wind turbines have an average economic lifetime spanning between 20 and 25 years, influenced by different factors, such as maintenance frequency, manufacturing quality, technology, location, and surroundings. Consequently, in the next 10 to 15 years, a significant number of wind farms, particularly in early adopters (i.e, Denmark, Portugal, Spain), are expected to reach their economic end-of-life. Developers face different options for addressing the end-of-life of their wind turbines: 1) extending the lifetime of the equipment, 2) repowering or 3) decommissioning the plant.

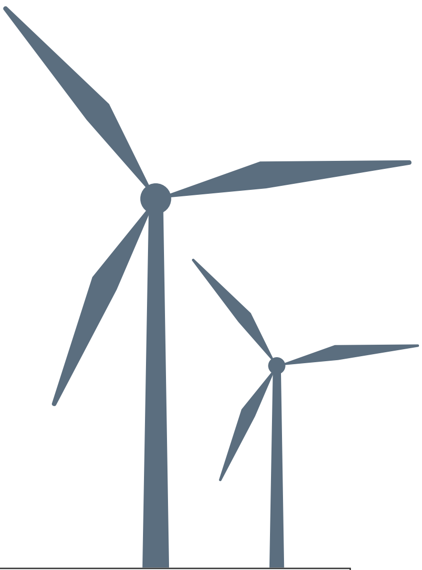
Extending the lifetime of an existing wind farm offers advantages, contributing to national decarbonisation objectives, without straining raw materials further. Well-managed life extension provides additional revenue streams for operators and bigger windfalls for investors. However, life extension can only be economically attractive if the asset maintenance was rigorous over its lifetime. Other challenges include the scarcity of replacement parts and lack of technicians familiar with older components. While upfront costs can be avoided, wear rates could lead to increased and more frequent maintenance costs and longer downtime.

Alternatively, repowering may take different forms. Partial repowering, the replacement of the existing turbine by either a smaller or a more powerful one and keeping the tower and foundation as is, has different implications. If the turbine is downsized the energy output will be lower but the maintenance cost and wear rates are likely to be reduced as well. Conversely, in case of larger and more powerful turbines, the output will increase as will the O&M expenses. The other option – or 'full repowering' – consists of replacing the entire installation (incl. foundation) with a higher and more powerful wind turbine platform. As new turbines grow in size, they capture more wind, increasing their electricity output. Europe Wind estimates that repowering on average triples a facility's annual electricity output, with a 25% reduction in the number of towers. Repowering can be an interesting solution for countries with limited landfill availabilities.

Decommissioning is the final option available to wind farm developers. If extending the lifetime or repowering the plant is technically or financially not feasible, developers will have to consider decommissioning the wind farm. Between 2010 and 2020, approx. 4.95GW were decommissioned in Europe with an additional 13GW expected until 2030.

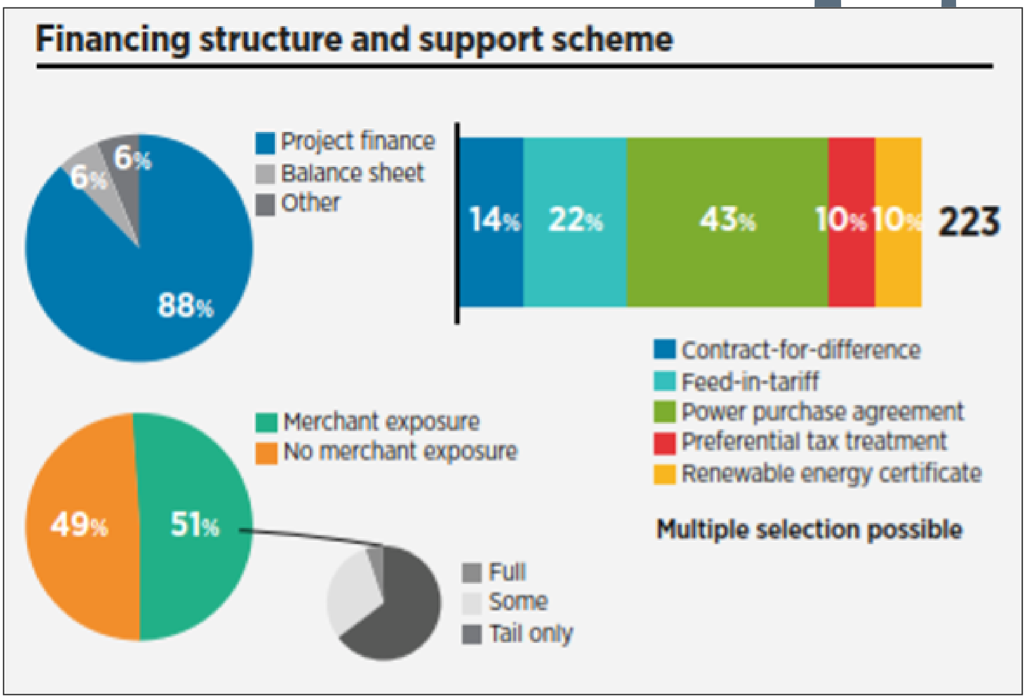
6. Financing

Costs associated with wind industry development, including foundation and installation, tend to be front-loaded compared to other electricity sources. As a result, when central banks started to raise interest rates, the impact was disproportionally felt on renewable energy projects[11]. Danish offshore developer Ørsted announced withdrawals of two wind projects in the US, Ocean Wind 1 and Ocean Wind 2, leading to an impairment of DKK19.9bn. Additionally, Ørsted reported a pause in the development of new technologies in light of the challenging environment[12].



6.1. Financing landscape

Based on an IRENA analysis of the financing costs of renewable projects, the project finance structure emerged as the primary debt structuring for such projects. Interestingly, a slight majority of the projects were exposed, at some point in their lifetime, to merchant risks. This exposure occurred either because offtakes covered less than 100% of the nominal output or through tail exposure. The absence of a 100% stable revenue stream is expected to adversely impact the WACC, with estimates pointing to a potential increase of 1 to 3%.



Sources: IRENA – the cost of financing renewable power

[11] Natural gas project that have a more balanced mix of costs and thus are less sensitive to increases in financing rates.
[12] Financial Times, 13 February 2024

6.2. Cost of capital and underlying drivers

The weighted average cost of capital ("WACC") is influenced by different factors. The macroeconomic environment and the prevailing interest rates play a significant role, but other factors are equally important:

- **The maturity of the technology:** Untested or technologies with insufficient track record may have a higher WACC over the short term, gradually migrating toward WACC levels for more mature technologies.
- **Cost structure:** Different technologies, such as offshore and onshore, have distinct cost structures. Offshore wind farms, due to their distance from the coasts and exposure to hazardous weather, entail higher preparation and resource requirements for maintenance.
- **Experienced parties:** Involvement of experienced parties in the construction and maintenance activities, supported by long-term contractual agreement.
- **Geographies:** Discrepancies are observed within the European Union, with reported WACC significantly lower in Northern and Western Europe compared to other regions[13].
- **Long-term Power Purchase Agreement:** The ability for a project to generate stable cash flows over a meaningful economic period and for a significant portion of the electricity output.
- **Stability of the subsidy mechanism:** The structure, stability and degree of support of the local government in guaranteeing prices or fiscal structuring.
- **Manufacturers' guarantee:** Compensation paid by the OEMs for long downtime due to technical defaults, limiting the ability of the project company to generate revenues.

A 2020 study of the financing of 318 wind farms concluded that the leverage obtained is mainly dependent on the cost side of the project (i.e. capital and operational costs). This is interesting as it highlights the ability of the projects to generate stable revenues over time (via a PPA or via other government-backed scheme) playing a limited role in defining the leverage of the project.

[13] A 2019 EU analysis concluded that for onshore energy, WACC across Germany, France and Denmark ranged between 1.3% - 4.3% vs. 7% - 10% in the Baltics, Spain or Portugal.

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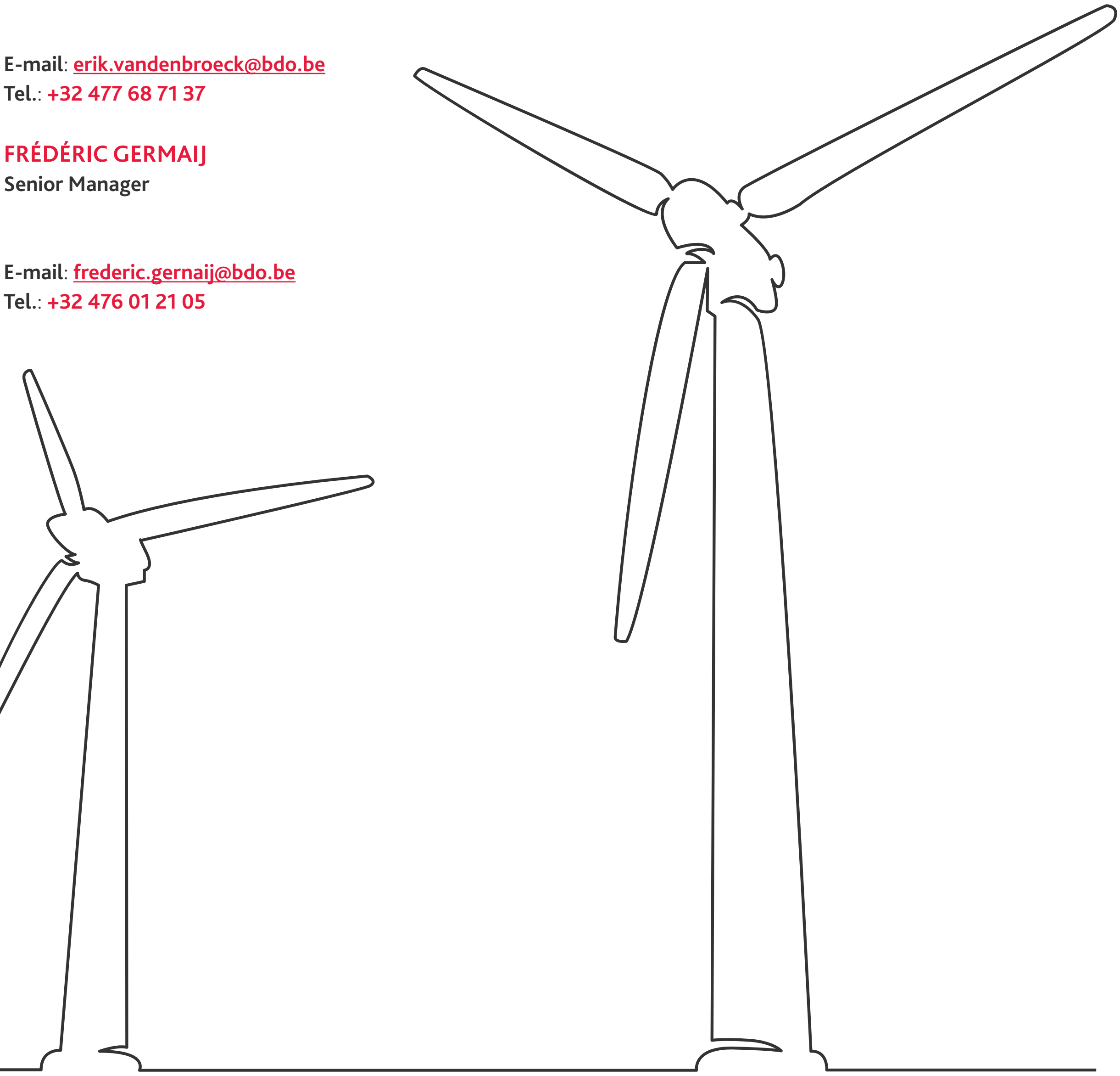

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