Storm in Shallow Waters

The 200 billion EUR drama in the North Sea

A study conducted by Implement Consulting Group

April 2024

Preface

This report explores viable pathways for the offshore wind build-out toward 2030 and 2050.

We invite authorities, investors, developers, OEMs, and sub-suppliers to take a fresh look at the way ahead.

The offshore wind industry has struggled with supply issues, cost increases, and a disconnect between political ambitions and commercial realities. This puts the achievement of the 2030-targets at risk and requires a new and viable pathway ahead to 2050.

The report explores ways to unlock the European offshore industry from the current gridlock of high inflation, increasing risk, and surging costs.

Large transformations are needed to readjust to new realities and getting back to a viable pathway.

A report of Implement Consulting Group

'Storm in Shallow Waters' is produced by Implement Consulting Group. Implement is dedicated to helping decision makers in public and private organisations across the world implement solutions, which will support the necessary energy transition to meet the objectives of the Paris Agreement.

We extend our deepest gratitude to the CxOs of leading companies cross the offshore value chain whose invaluable insights have significantly propelled this study forward. Your deep industry knowledge, market understanding, and visionary contributions are shaping a sustainable future.

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The 200 billion EUR drama in the North Sea

Three main messages

After two transition years in 2022-23 the European offshore wind industry needs a smooth and bankable build-out pathway to deliver the necessary 418 GW towards the 2050 target.

Message 1 | The European industry must deal with the immediate cost shock

- Since 2019, suppliers and OEMs have experienced a 40% increase in raw material prices implying margins have contracted significantly.
- Moreover, the break-even point for developers hiked due to increases in interest rates, capital costs, input prices, and supply chain bottlenecks reducing profitability, resulting in delayed and cancelled projects. This was parallel to lower strike prices and in some cases negative auction prices.
- Policy makers have acknowledged the new outlook and are reducing developers' risk by using CfD-like contracts with sound profit and risk sharing mechanisms.

Message 2 | Top priority is to restore investor confidence and secure financing across the value chain

- Since 2022, investor confidence has declined significantly. It must be restored fitting a new outlook characterized by an abundant risk environment, higher material and capital costs, and supply chain challenges.
- It is crucial to secure financing and profitability across the value chain to expand production capacity in a bankable manner. This requires a stable, predictable forward-guidance of the market, which is creditable.
- Achieving the 2030 build-out target of 163GW will necessitate a 4.4-fold increase in capacity over a mere 8 years, corresponding to a 24% annual growth in capacity. This reflects an 8-doubling in the yearly delivery capacity from 2022-2030.
- The acceleration requires that European suppliers must ramp-up capacity between 150% and 560%, where. e.g., castings and vessels are facing significant challenges.
- Policy makers are eager to accelerate the build-out to make up for the recent two-year setback. However, at too aggressive acceleration comes with an excessive risk of overinvestment. Specifically, 200 billion euro compared to a smooth, consistent build-out pathway, which only delays the 2030-target by 3 years.

Message 3 | An organic build-out requires reducing time to first power, developing the supply chain, and addressing the innovation race

- Regulatory uncertainty is unnecessarily high increasing investors' risk and required return. E.g., questions on state-ownership models, grid build-out plans (electricity and hydrogen) etc. are constantly up in the air.
- Lead time from lease to COD is approximately 8 years, which is too long. Time from *lease request* is accepted to *construction start* is approximately 4.5 years, which is three times the stint to complete the actual construction. This inefficiency is reducing developers and suppliers' business cases.
- It is crucial to ensure a profitable supply chain. Lengthy processes and project delays result in prolonged order-to-cash processes, which must be eliminated. An unprofitable supply chain can't attract financing to undertake necessary capacity investments.
- Developers need to rethink the signals and incentives they cascade down the value chain to alleviate costly bottlenecks. E.g., via strategic partnerships etc.
- Finally, it is time to rethink the nature of the needed innovation going forward. Since 2013, innovation has focused on increasing turbine size, which has reduced LCOE from 150 to 60 EUR/MW (in 2020). This kind of innovation challenges a stable and cost-efficient supply chain as sub-suppliers' production lines become redundant too fast. Going forward, the industry needs to industrialise to scale production capacity in an outlook with higher material costs.

The offshore wind industry is in turmoil and yet the political ambitions remain

> Harmonisation between the political ambition and the state of the industry is not apparent.

- Developer

CEO Survey, Implement Consulting Group

(Dec 2023)

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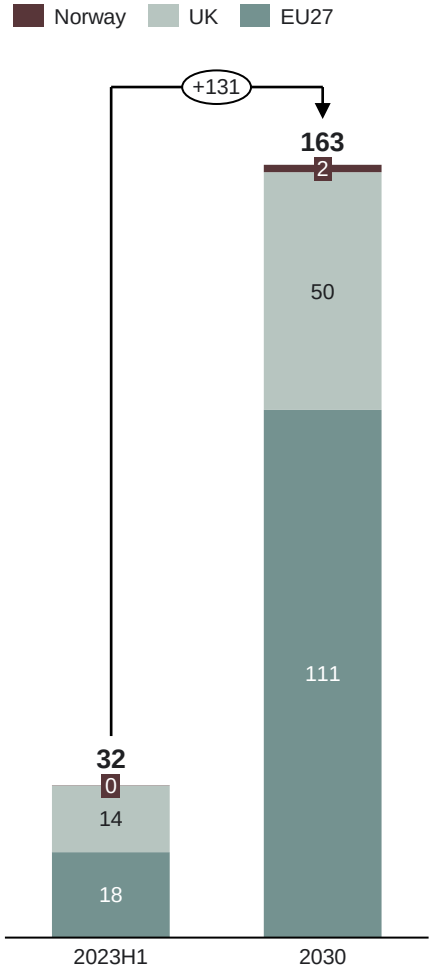
SITUATION

In 2022 and 2023, the European offshore value chain faced macroeconomic, supply chain, and regulatory headwinds slowing down the industry's growth

Capacity build-out
GW



What

Ambition

The European countries aimed to instal 131 GW new offshore wind capacity reaching a total of 163GW in 2030. This is an expansion of 400% in seven years.

The build-out will contribute to the EU's expected increase of 60% in electricity consumption between 2022 and 2030 and will require around 350 billion EUR of capital. On top of that large investments in offshore grid connections and reinforcements in onshore grid are required.

When

Year 2022 and 2023

During 2022 and 2023 the pace of the European offshore wind build-out plummeted and in some countries came to a complete stop, such as in Denmark. The trigger was a "perfect storm" of several unfavourable and destabilising factors due to a mix of the energy crises, Russia's invasion of Ukraine, and the aftermath effects of the COVID-19 pandemic.

Why

Implications

It became obvious that many European tendering processes, auction designs as well as developers' and sub-suppliers' business models were not resilient for a situation with a significant increase in inflation. Developers' capital costs increased due to increasing risk free rates and larger risk premiums. Suppliers' input costs increased leading to negative margins and higher input prices for developers.

The rising inflation combined with auctions that exposed developers to inflation risk and supply chain problems, calls for a thorough assessment as to whether this is just a 2-year adverse market development or something structural.

Message

This study argues that the recent years' developments have triggered several structural changes, which the industry and political systems must handle to accelerate sufficiently fast.

Key question

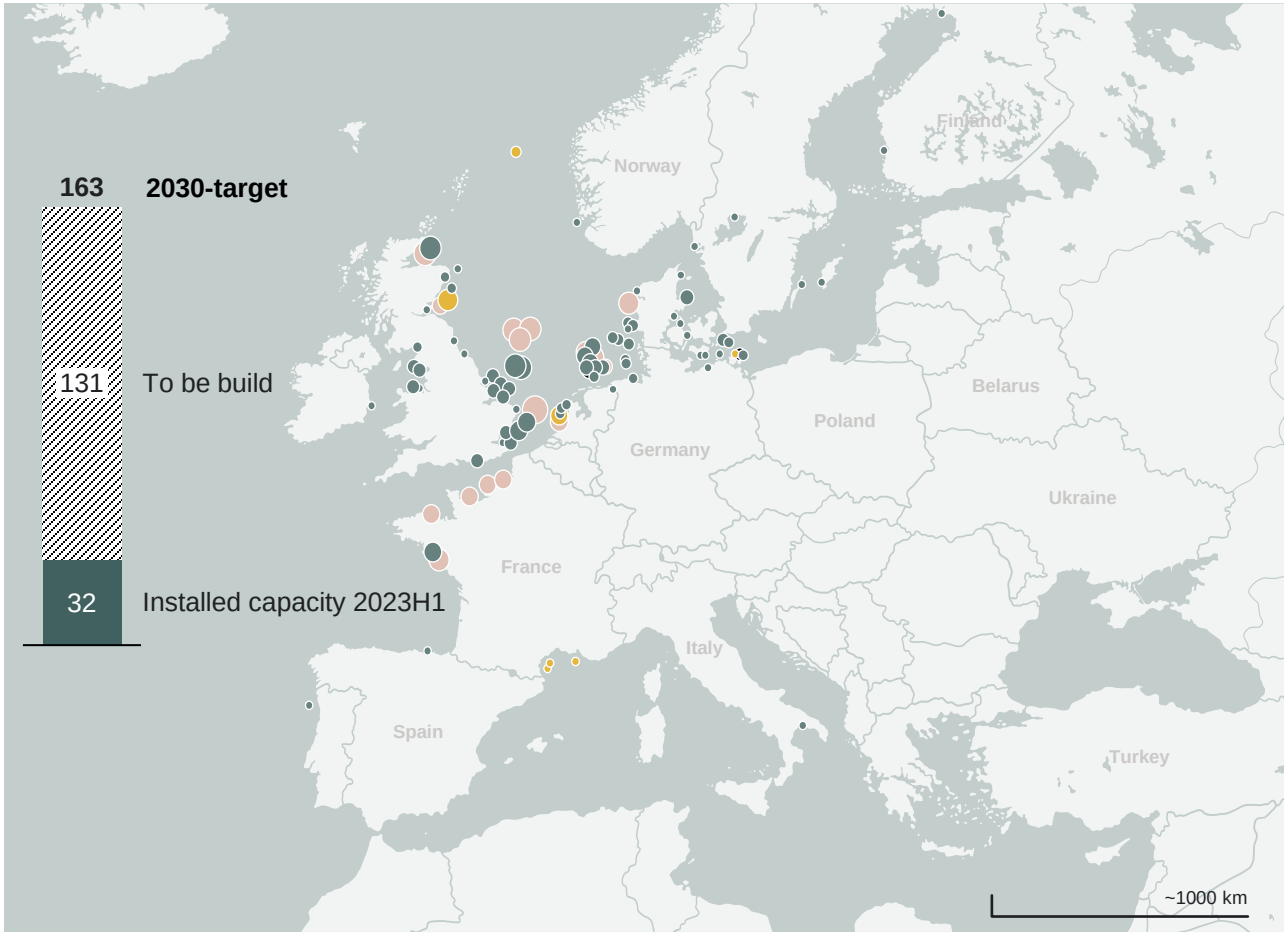
How does a viable pathway for offshore wind build-out look like towards 2030 and 2050?

Source: Implement Consulting Group based on WindEurope, European Commission, and Statista.

TARGET IN 2030

European policy targets require a 131 GW expansion corresponding to a yearly growth of 400% – primarily in the North Sea

European offshore capacity and policy targets



Europe's current offshore wind

- **32,430** MW connected to the grid
- **6,166** turbines connected
- **129** wind farms
- **13** countries

Status

Online
Partially online
Under construction

Country details

	MW connected	Turbines connected
United Kingdom	14,380	2,728
Germany	8,064	1,540
Netherlands	3,449	553
Denmark	2,308	631
Belgium	2,261	399
France	482	81
Sweden	192	80
Norway	101	13
Finland	71	19
Italy	30	10
Ireland	25	7
Portugal	25	3
Spain	5	1

Updated: 10/08/2023

Ambitious build-out 2030 targets

The European offshore industry is mainly concentrated around the North Sea both in terms of numbers and size of the wind farms. As of late 2023, total capacity connected to the grid is 32GW of which 44% is connected in the UK (14 GW)

Toward 2030 European build-out will continue in the North Sea due to good wind conditions, shallow waters, and increasing infrastructure connection points.

The European Green Deal aims to make Europe climate neutral by 2050, which requires 450GW of offshore wind by 2050 on top of 760 GW of onshore wind.

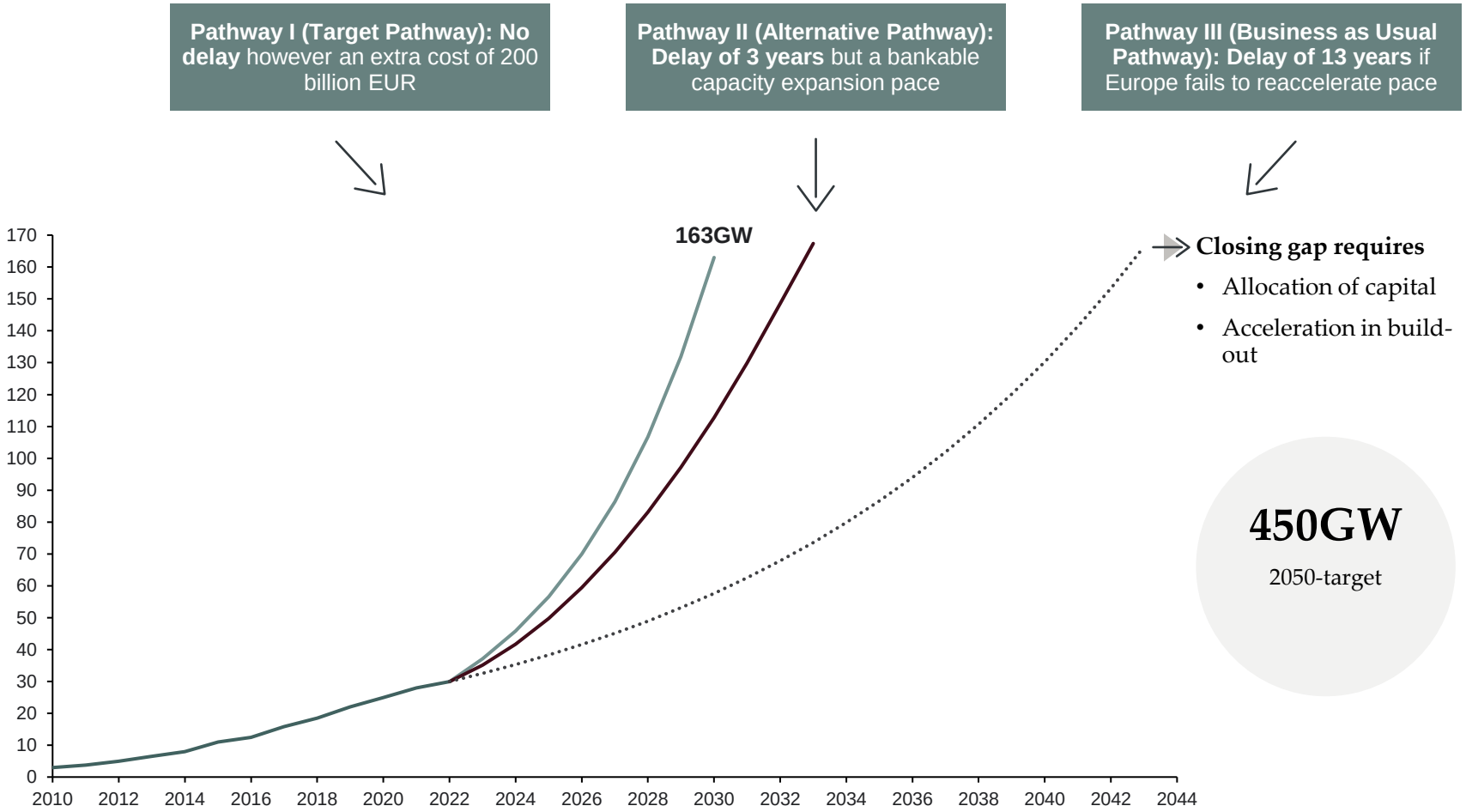
According to WindEurope, the most cost-effective deployment of the 450GW around Europe is:

- 212 GW in the North Sea
- 85 GW in the Atlantic
- 83 GW in the Baltic
- 70 GW in the Mediterranean and other Southern European waters

Source: Implement Consulting Group based on National and European targets and WindEurope.

Closing the gap between the 2030-target pathway and the historical build-out pace will require an unprecedented acceleration and allocation of capital

Installed European offshore capacity
GW



Note: The Business-as-usual (2020-23) scenario assumes that the growth rate of the European build-out in 2020-2023 (8.5% per year) continues in the future the growth rate was higher, at 18% per year for 2015-2020.
Source: Implement Consulting Group based on National and European targets, WindEurope and Bloomberg.

Need for a high-speed transformation

To reach the 1.5C temperature target of the Paris Agreement ambitious capacity targets are a requirement. In Europe, the 2030 capacity target is 163GW, which:

- Firstly, requires a historically large **reallocation of capital** to the European offshore wind industry, ~350 billion EUR
- Secondly, requires a significant **acceleration in installation speed**

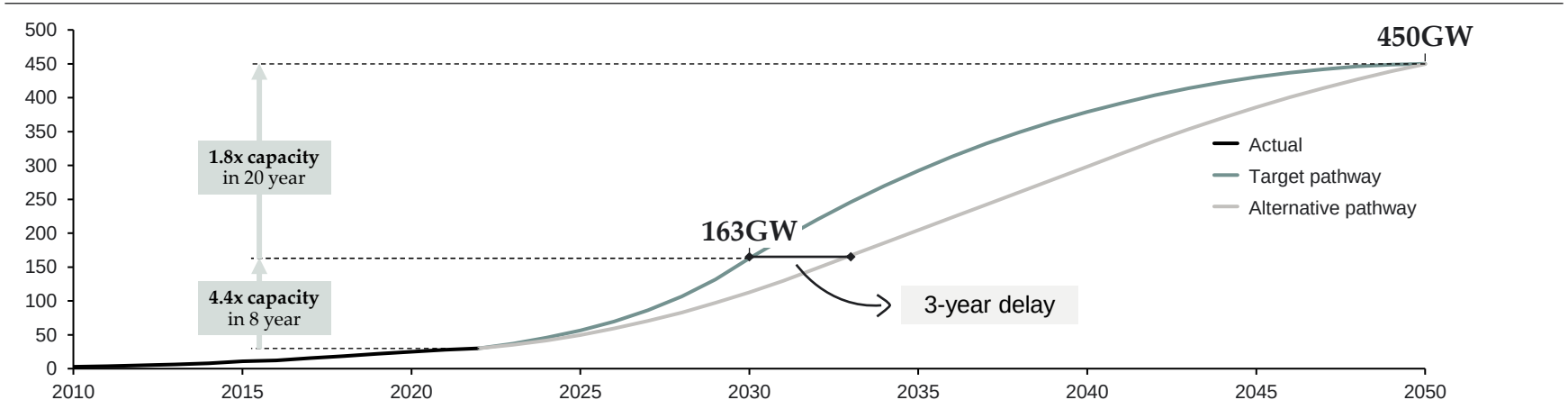
It is crucial to ensure a sustainable investment environment throughout the entire European value chain to attract the necessary capital and speed up installation to reach the 2030 target.

Therefore, this report has three main messages to the European governments and industry about reducing uncertainty and restore reliability in the offshore ecosystem. These messages are presented in the following three chapters.

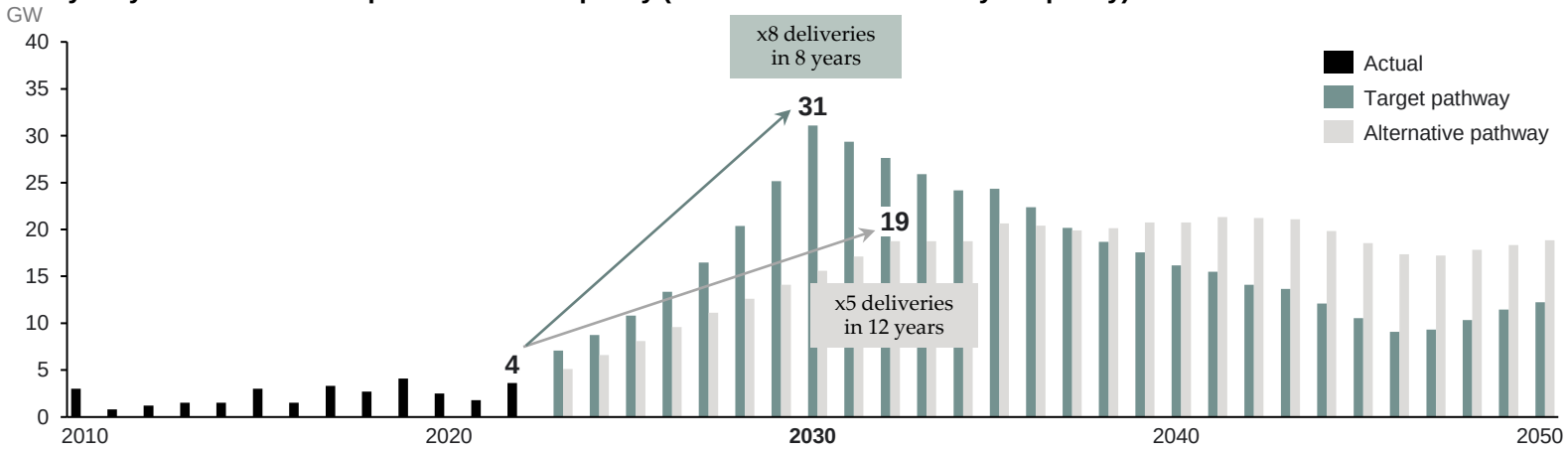
PATHWAYS

Achieving the 2030 build-out target of 163GW will necessitate a 4.4-fold increase in capacity over a mere 8 years, corresponding to a 24% annual growth in capacity

Installed European offshore capacity



New yearly additions to European offshore capacity (incl. reinstallations of 25yo capacity)



Note: The Target pathway assumes a steady growth rate (of 23.5% per year) until 2030 that satisfies the 163GW target. From 2030 the target pathway is assumed to gradually fade out from the peak 2030 delivery until 2050. For the Alternative pathway is a suggestive pathway where yearly, new installations grows by 1.5GW per year until it plateaus from 2032-2041, whereafter it gradually declines by 1GW per year.
Source: Implement Consulting Group based on National and European targets, ORE Catapult and WindEurope.

To reach the 2030-target, capacity would have to increase by a **factor 4.4x in only 8 years**. This requires yearly additions to capacity to grow by 23.5% per year towards 2030, which amounts to an **8-doubling in the new yearly delivered capacity from 2022 to 2030.**

Reaching the 2030-target entails building out manufacturing capacity at an unprecedented rate. Further, accelerating the supply chain capacity until 2030 would result in overcapacity towards 2050 as shown by the spike and subsequent drop in the additions/the green bars in the bottom chart (that is unless the 450GW target is increased substantially).

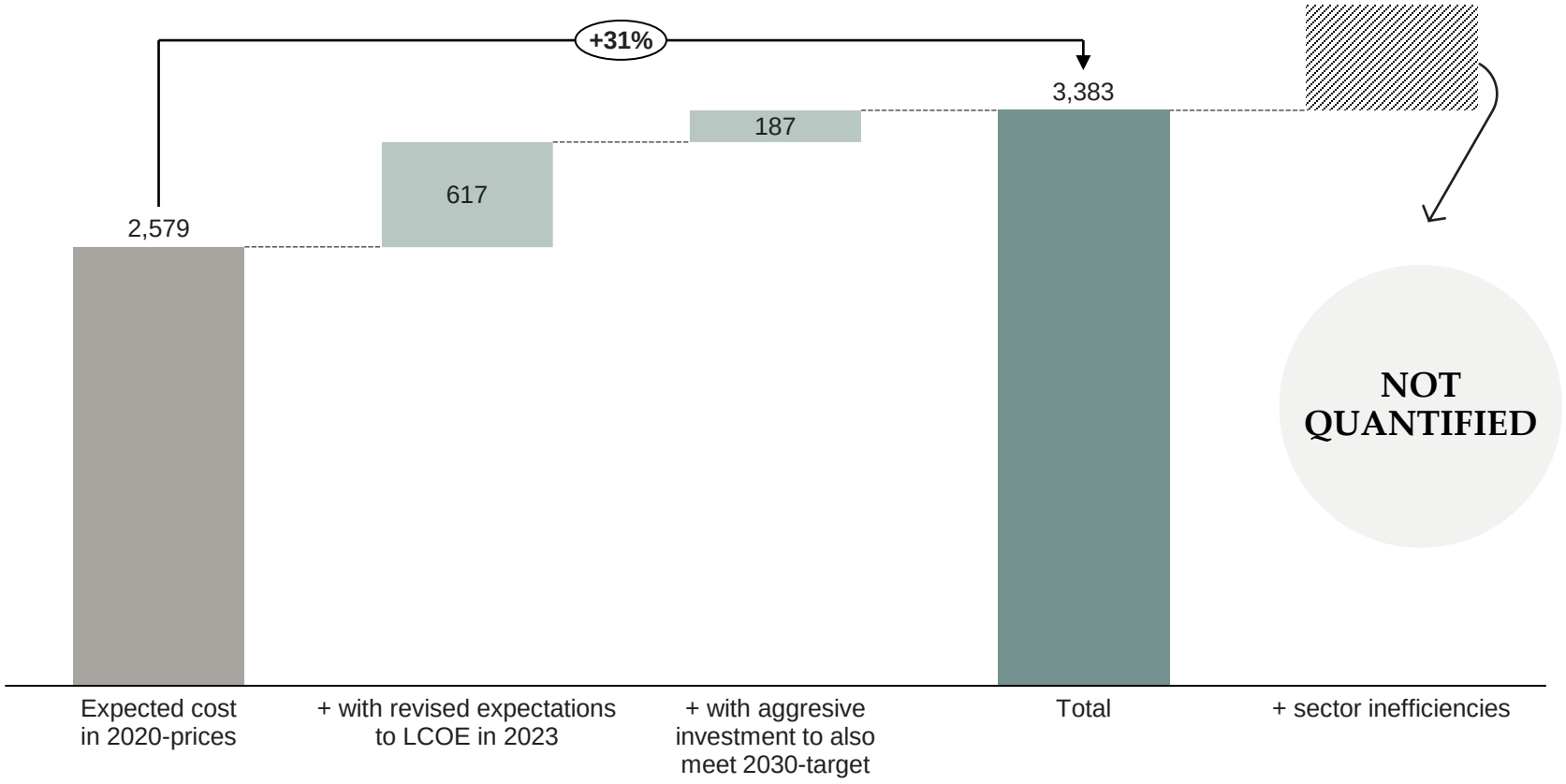
In this study we argue it is better to reach a build-out pathway, which is stable, cost-efficient, and creates the necessary investor confidence to undertake the needed investments throughout the value chain. A forward guiding steady-state approach will only delay the 2030-target of 163GW with three years.

> *Revenue opportunities reaching the supply chain have reduced significantly in the past 12 months while expectations on future capacity/capabilities have increased leading to a wider gap between expectations and commercial reality*
>
> ORE Catapult, Confidence Survey 2023

EUROPEAN CAPACITY GAP

Policy makers are eager to accelerate the build-out to make up for the last two-year setback. But a too aggressive acceleration comes with an extra cost of 200 billion EUR

Estimated cost of reaching the 2050-target of 450GW offshore wind in Europe
Billion EUR



Potential additional costs from:

1. Regulatory risk on build-out plans, auction model etc.
2. Delayed order-to-cash increasing risk and lower project value for developers.
3. Innovation race causing rapid value chain redundancy and manufacturing reinvestments.
4. General risk from geopolitical/delivery uncertainty increases required return.

The extra cost of 187 billion EUR does not account for the cost of delaying the green transition. I.e., postponing ~15% of the offshore power generation.

Source: Implement Consulting Group based on BloombergNEF and Wiser et al (2020), interviews with industry experts and Shield et al., 2023.

The European offshore wind industry must deal with the immediate cost shock

> Higher inflation and capital costs are affecting the entire energy sector, but the geopolitical situation has made offshore wind and its supply chain particularly vulnerable. Overall, we see cost increases up to 40%.

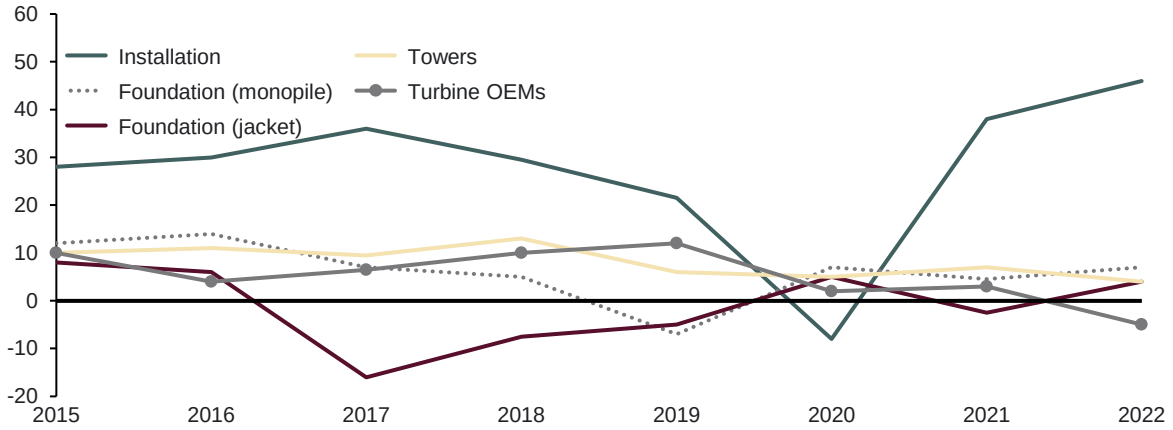
- Vattenfall on halting development of Norfolk Boreas (July 2023)

SUPPLY CHAIN PROFITABILITY

Suppliers and OEMs have seen their historical slim positive margins shrink further since 2020 as raw material prices increased by 40%

Profitability

Average EBITDA margin (excl. China), %

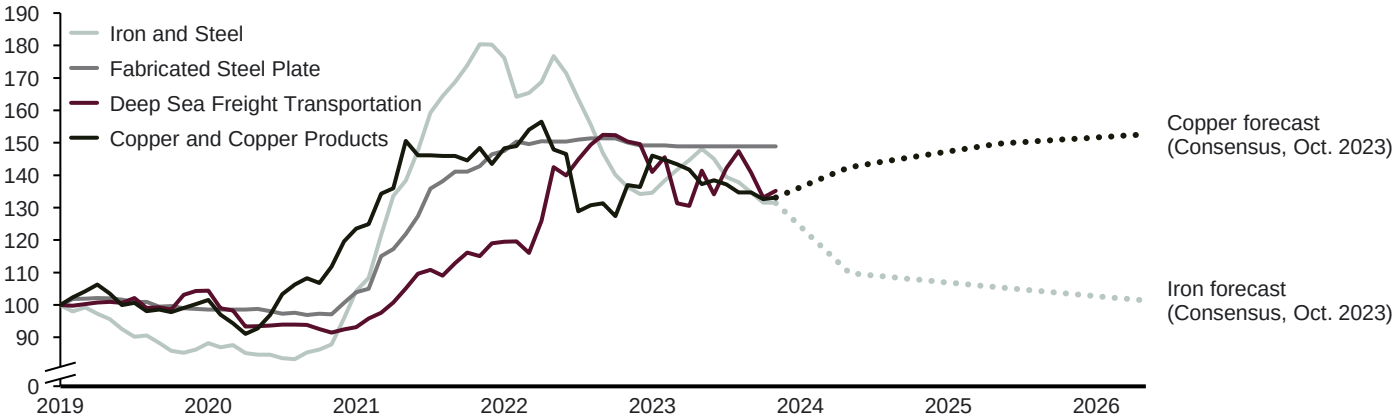


5-8%

EBITDA excl. installation and foundations (jacket)

Raw material costs and shipping rates

Producer Price Index by type from 2015-2022, Index (Jan 2019 = 100), Monthly, Not Seasonally Adjusted



40%

Index increase since 2019

Source: Implement Consulting Group based on Financial Times, FRED, and S&P Global Market Intelligence.

The elevated costs of raw materials, such as steel for wind turbines, rotor, and hub manufacturing, has affected the profitability of OEMs negatively.

Inflation is coming down, which eventually will bring prices somewhat down. However, OEMs are expected to face challenges in the future due to forward-signed contracts, which must be honoured.

From 2015-2020 EBITDA for turbine OEMs was approximately 7.5%, which decreased to -1% in 2021 and 2022 (average). The numbers for foundation (jacket) were respectively -1.5% versus 0.75% and towers realised a decline from 9% to 5.5%.

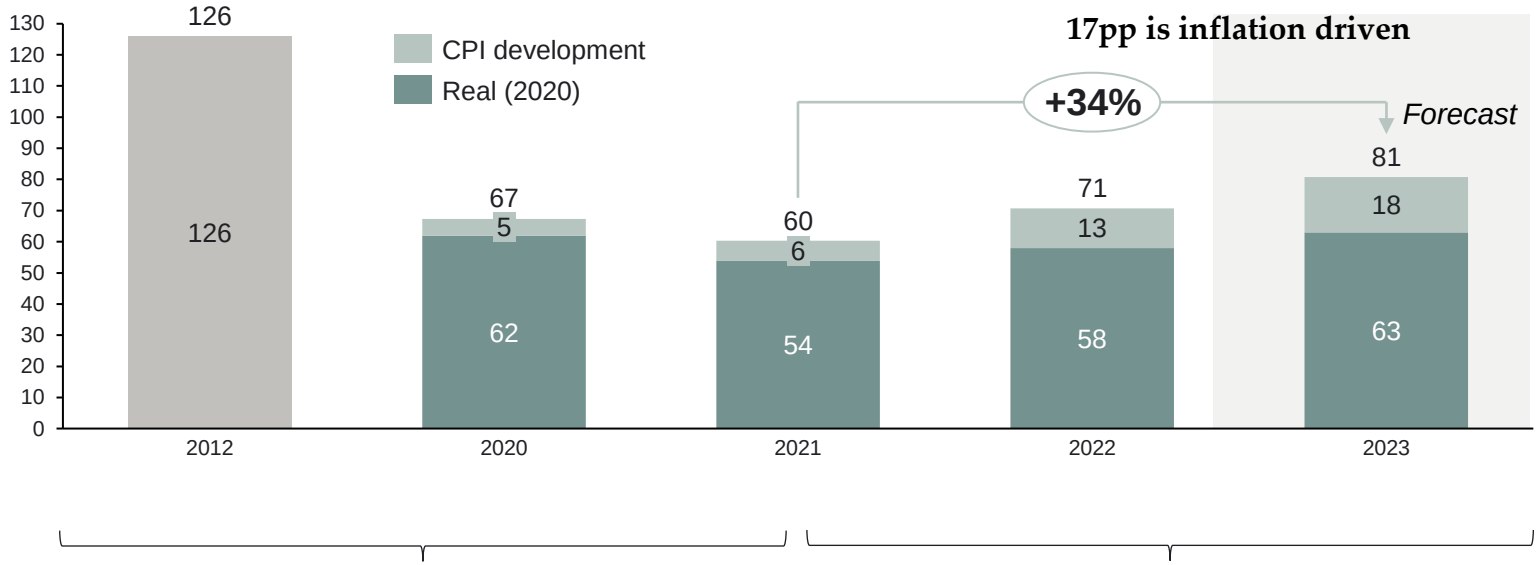
The particularly hard hit to the profitability of tower and turbine OEMs can be explained by increasing raw material costs and shipping rates in 2021 and 2022.

Forecasts expect the price of some components e.g. iron to slowly fall back to pre-pandemic levels, while other materials such as copper is expected to increase further.

COSTS

The total cost of offshore wind farms has increased by 34% in just two years

Levelized cost of electricity (LCOE) for bottom-fixed offshore wind
USD/MWh



LCOE driven **down** by three main factors:

1. Turbine size increased by 3x from 4MW to 11MW (accounts for ~60% of reduction).
2. Project scale increased by 3.5x from 200MW to 700MW (~20% of cost reduction).
3. Cheaper input and processes (20% of reduction).

LCOE driven **up** since 2021 by**:**

1. Increased WACC from 5% to 8.5% in EO2023.
2. Input prices across productions inputs (cables, foundation, towers etc.) are up ~10-25%.
3. Further, the LCOE has increased even further in nominal terms with prices up by 17% since 2021.

The business case for offshore wind farms (proxied by LCOE) has been steadily improving even accounting for developments in prices until 2021. 60% of the cost reduction comes from increasing the size of the turbines.

The picture has flipped dramatically in 2021-2023 with nominal LCOE prices increasing around 34% driven by inflation and higher costs of financing (WACC).

This has shaken the business case for many developers that maybe didn't sufficiently price in the cost risk previously.

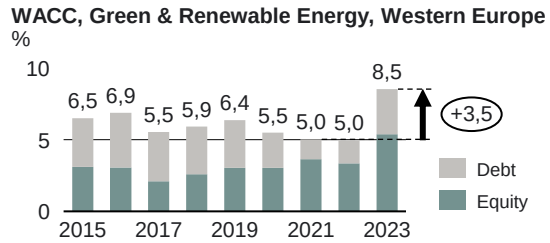
> *Higher inflation and capital costs are affecting the entire energy sector, but the geopolitical situation has made offshore wind and its supply chain particularly vulnerable.* ***Overall, we see cost increases up to 40%.***
>
> Vattenfall on halting development of Norfolk Boreas (July 2023)

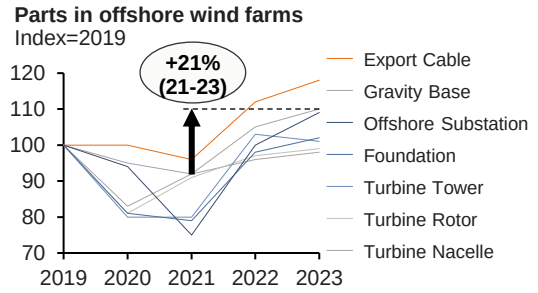
Source: Implement Consulting Group based on Aegir Insights Analysis and Vattenfall.

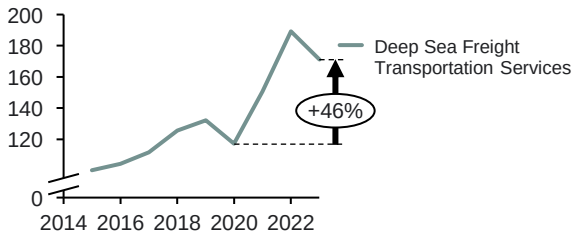
The break-even point for OSW has increased by 20EUR/MWh in 2023 due to large increases in developers' WACC and the price of wind farm components

Effect on LCOE from higher costs
EUR/MWh

Project cost increase from…		Change since 2021	LCOE effect in 2023
1 1pp increase in WACC	4.6	WACC, Green & Renewable Energy, Western Europe, %	~16 EUR/MWh
2 15% increase in CAPEX	5.5	Parts in offshore wind farms, Index=2019	~8 EUR/MWh
3 300% increase in shipping	0.4	Shipping costs, Index=2015	~0.1 EUR/MWh







Note: Average betas were 1.14 between 2015-2018 but have decreased to 0.9 in 2019-2023. I.e., from a risk perspective the offshore industry (proxied by the overall Green & Renewable Energy sector) has become less risky/correlated with the overall market.
Source: Implement Consulting Group based on Aegir Insights, FRED and Aswath Damodaran.

Cost of capital

Cost of capital has increased significantly since 2022 driven by increasing interest rates, which both drive required return on equity and debt. Cost of capital is quite important for the LCOE with a high elasticity. 1pp increase in the WACC will increase the LCOE with 4.6 EUR/MWh.

Input costs and CAPEX

Input costs have generally declined until 2021, where it took a step hike. The raw materials have also increased but are expected to come down towards 2030 (see next slide).

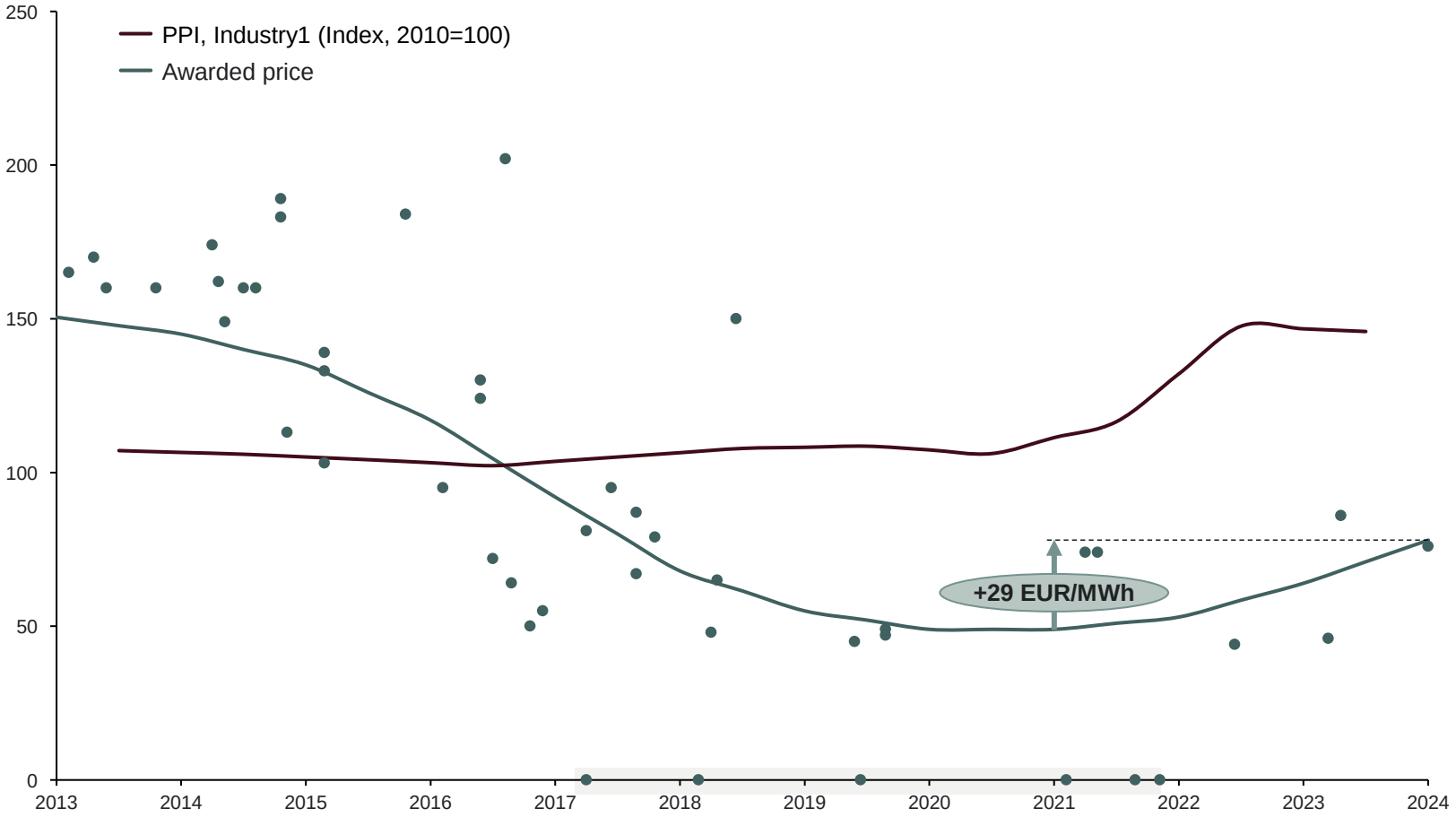
Shipping costs

Shipping costs have increased by 46% since 2020 and came down marginally since 2022. However, shipping costs are not driving the overall LCOE with a quite low elasticity.

EARNINGS

The rising offshore wind costs have gradually been passed through to the recent auctions where the winning bids are up by 29 EUR/MWh from the low-point in 2021

Offtake awards of European offshore auctions
EUR/MWh, nominal



Note: Except construction, sewerage, waste management and remediation activities.
Source: Implement Consulting Group based on Eurostat, 4C Offshore, and Global Wind Energy Council.

The price of European offshore wind has been dropping steadily since 2013 from 150 EUR/MWh to around 50 EUR/MWh in 2021. The falling trend was a result of the decreasing cost side from technological innovation of larger turbines. Simultaneously, the industry experienced close to no price increases of raw materials.

However, the trend stopped as the cost shocks experienced in 2021-2023 are now passed on to the latest auctions, where the awarded prices increased by almost 30 EUR/MWh since the bottom in 2021.

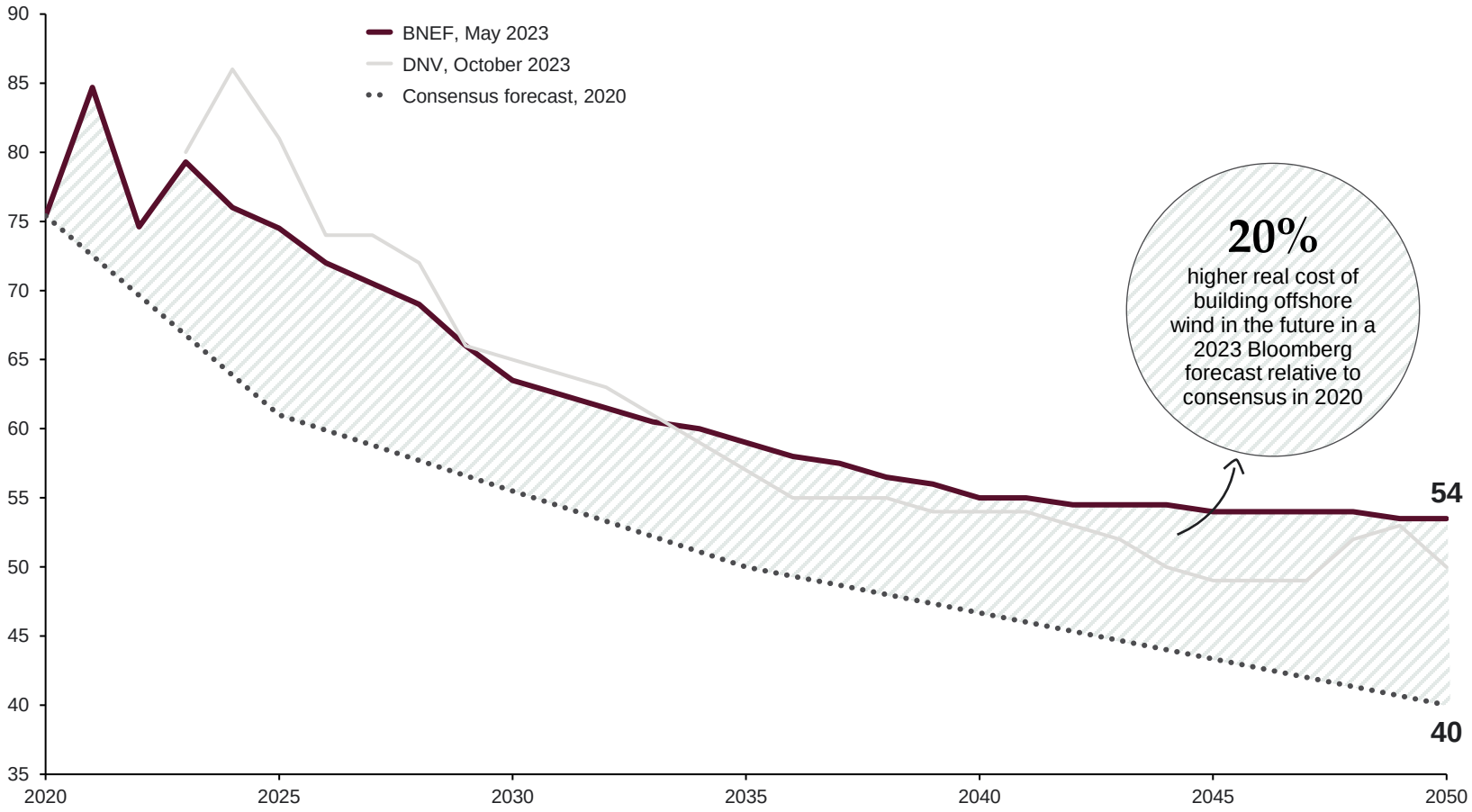
Consensus is that most of the costs/effect from especially higher CAPEX is fully reflected in new auctions as of end-of-2023. We therefore expect the curve/awarded price to flatten and resume the downward trend in the longer horizon albeit at a slower pace.

Policy makers have acknowledged the new outlook as well as taking steps towards increased risk sharing. By reducing developers' risk through CfD-like contracts governments ensure both a healthier business case for developers with less risk/required return and cheaper power for the end-user.

LCOE

Real LCOE has hit a temporary bump – however a conservative 2023 Bloomberg forecast implies that the offshore wind build-out cost could be 20% higher towards 2050 than expected in 2020

Levelized cost of electricity (LCOE) for bottom-fixed offshore wind
USD/MWh, real (2020-prices)



Source: Implement Consulting Group based on BloombergNEF, DNV, and Wiser et al (2020).

In the short-term, the lifetime cost of producing a MWh of electricity from offshore wind (LCOE) has increased in by ~30%. Of the 30%, 15-20pp comes from increases in real-terms i.e. disregarding inflation (as shown in the figure).

However, this short-term bump could materialise into a more permanent change in the offshore wind price trajectory going forward, making the build-out more expensive than anticipated. Comparing a 2020 pre-shock consensus forecast to 2023 indicates that the price shock could be more permanent.

According to a Bloomberg 2023 forecast, the LCOE could be 20% higher towards 2050 than consensus expectations in 2020. Other forecasters are less pessimistic projecting prices returning to 2020 trajectory around 2030.

In a scenario with a 20% permanent increase in the real LCOE, the cost of building out towards the 2050-target would become **600 billion euro more expensive**.

The relative expensiveness of offshore wind towards 2025 also makes frontloading more expensive. If governments stay committed to a “no-delay” pathway towards 2030, it could become **almost 200 billion euro more expensive** relative to a 3-year delay pathway.

The industry must restore investor confidence and secure financing across the value chain

> Capacity development has been driven by a lack of coordination between governments and their auctions. This has created a distinct lack of trust in the industry.

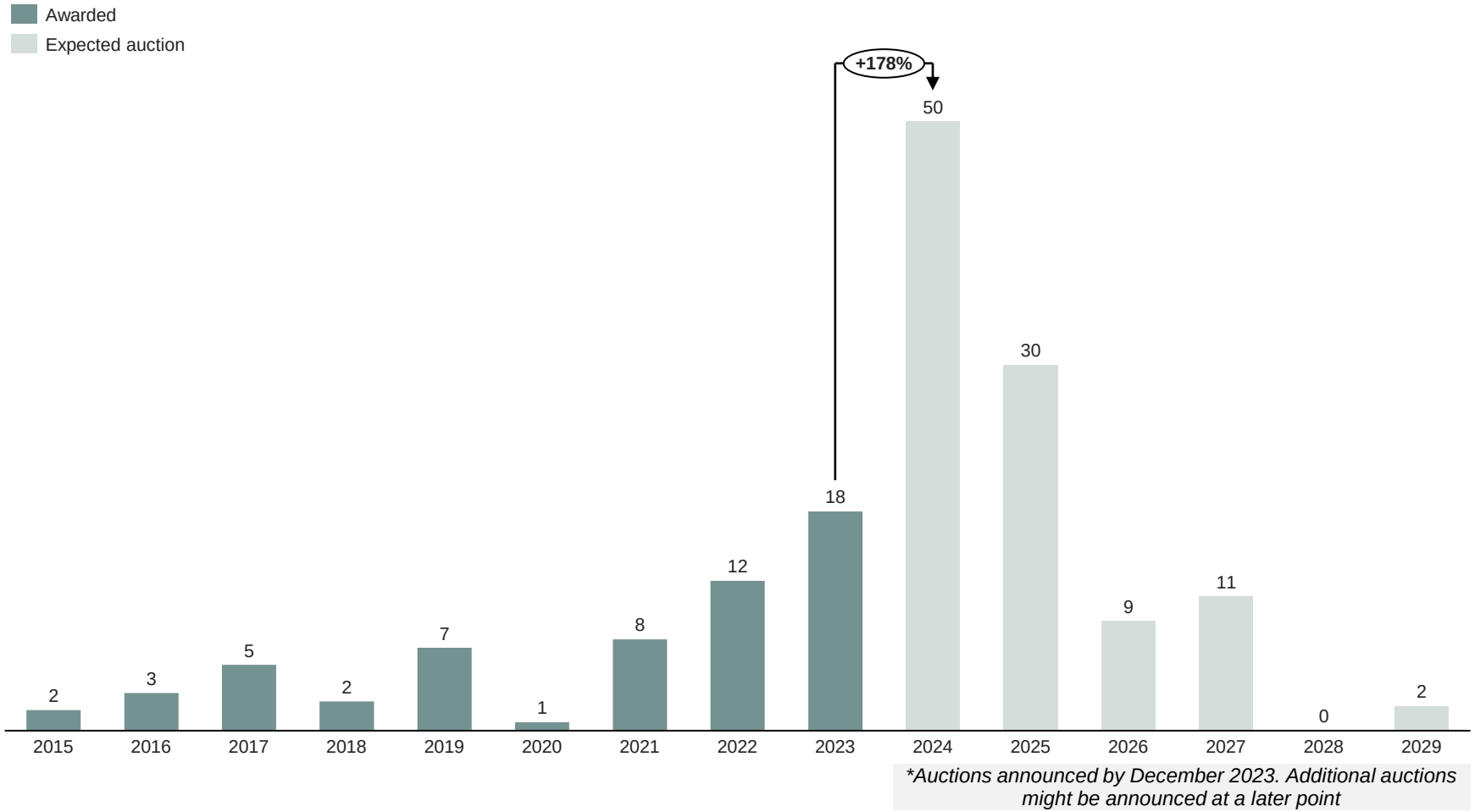
- OEM

CEO Survey, Implement Consulting Group

(Dec 2023)

Fluctuating auction frequency increases industry uncertainty making it difficult for the industry to prepare, plan, and execute on projects

European offshore capacity auctioned
GW



The release of offshore wind auctions has fluctuated making it an uncertain environment for the industry and investors to predict and plan for.

This uncertainty, partnered with poorly developed auctions, has undermined the needed expansion and left the industry in turmoil.

The projected auction pipeline far exceeds the industry's existing capacity. A consistent and competitive flow of deals are essential for the industry's organic development and long-term competitiveness. In other words, a smoother and more consistent auctioning profile will facilitate a synchronised development of the supply chain alongside infrastructure build-out initiatives.

> *Governments need to help create consistent auctions that promote stable risk-debt positions to ensure the industry reaches the build-out targets.*

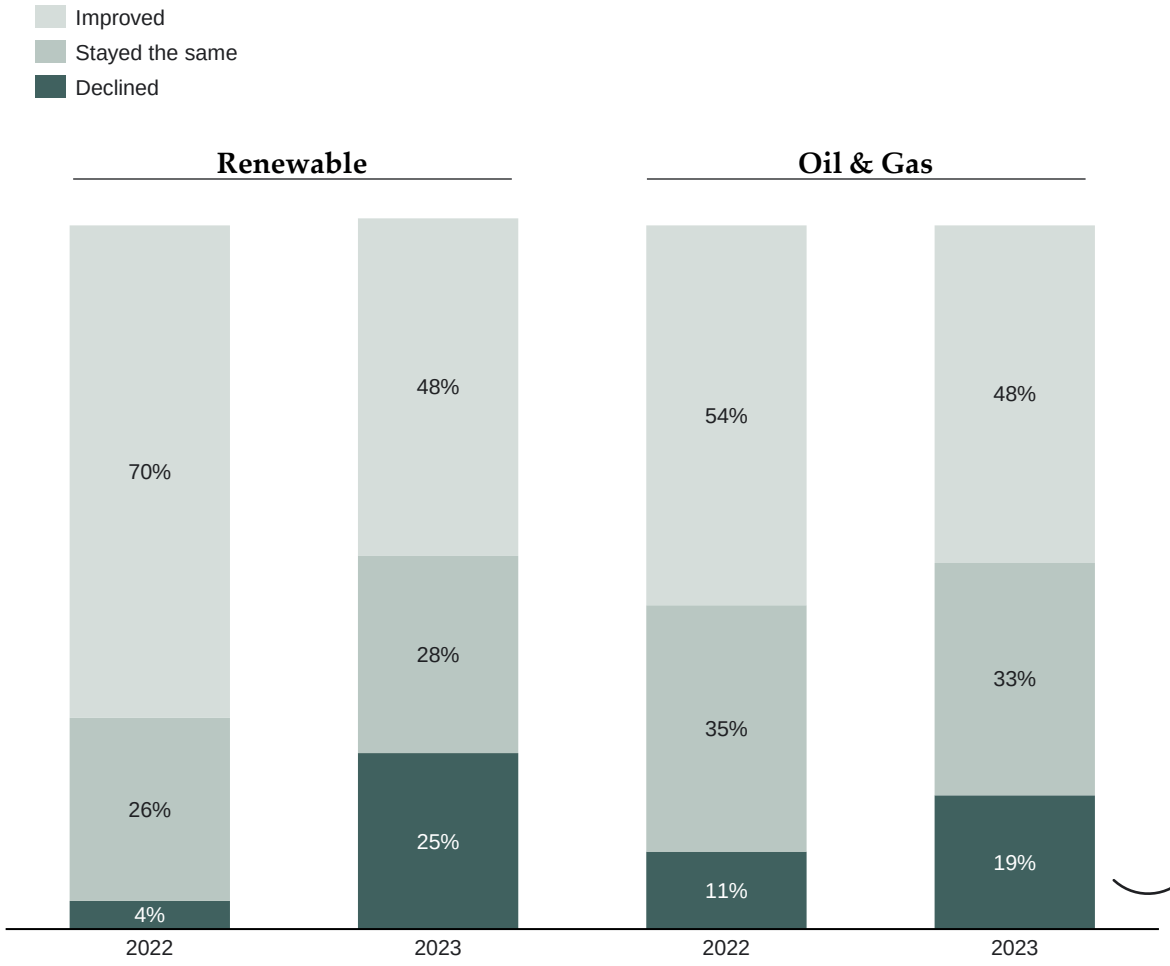
Developer, CEO survey
Implement Consulting Group (Dec 2023)

Source: Implement Consulting Group based on policy choices and outcomes for offshore wind auctions globally (2022), Aegir Insights, European Commission, WindEurope, and 4C Offshore.

CONFIDENCE

Simultaneously with the fluctuating auctions, the confidence in the offshore wind industry has declined driven by increasing project impairments

Overall confidence in future growth in the offshore wind market



Typical impairments in the industry

1. **Supply chain issues** leading to project delays, lost income and possible penalties.
2. **Increased cost of capital** that is passing through to financing costs.
3. **Higher input costs** from a higher level of raw materials.
4. **Stranded assets** related to production facilities and raw material sourcing from areas with conflicts.

Over the last 12 months, the overall confidence in the future growth in the offshore wind market has decreased in organisations within renewable and oil and gas.

Within renewable organisations the fraction of people, who's confidence declined increased from 4% to 25% within one year. The same trend was experienced in oil and gas with percentages of 11% to 19%.

It is crucial to restore investor confidence. Back to 'the old normal' is however not enough, because costs have increased, tender models have changed, capital costs and risk have increased, returns have been delayed due to delivery gaps etc.

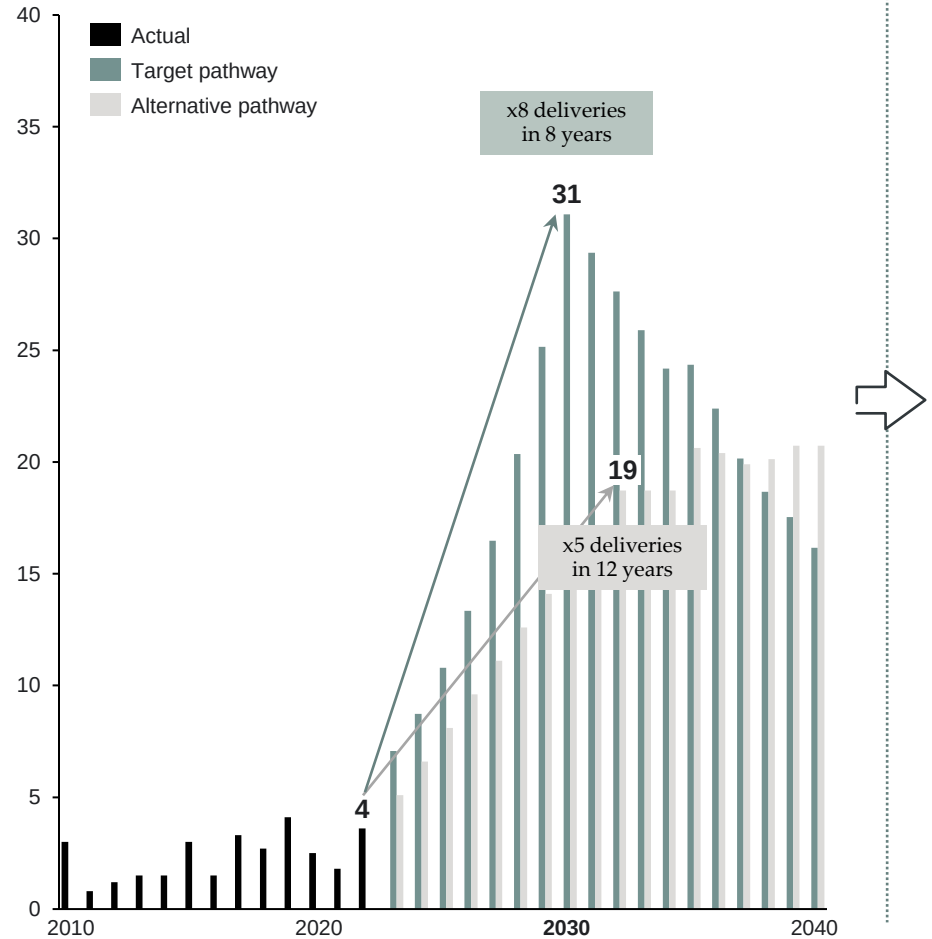
Restored investor confidence is crucial to attract necessary capital to undertake the needed investments throughout the supply chain as well as for developers. Confidence in the industry is the foundation developers need to create sustainable agreements with manufacturers and sub-suppliers. Without this confidence, developers can't 'distribute' cash flows via new orders to sub-supplies, which is crucial for them to dare to undertake the required invests to built out production capacity.

Source Implement Consulting Group based on ORE Catapult.

REQUIRED FINANCING

The production capacity of the European offshore wind supply chain requires a massive two-digit billion financing to accommodate the 500% increase in deliveries

New yearly additions to European offshore capacity
GW



Implications for the offshore industry supply chain

Current production *amounts to ~15MW turbine per day*

Target pathway	Alternative pathway
8 turbines/d by 2030	5 turbines/d by 2034

Across all European OEMs, 7-day work week – on average basis

x8	x5
Has 8 years to expand production capabilities by 8x	Has 50% more time and only needs to scale 50%
2.6bn EUR per year	**1bn EUR per year**

Conservatively estimated investment to reach turbine only (i.e. blades, nacelle and tower) manufacturing capacity

Note: The Target pathway assumes a steady growth rate (of 23.5% per year) until 2030 that satisfies the 163GW target. From 2030 the target pathway is assumed to gradually fade out from the peak 2030 delivery until 2050. For the Alternative pathway is a suggestive pathway where yearly, new installations grows by 1.5GW per year until it plateaus from 2032-2041, whereafter it gradually declines by 1GW per year. The estimated investment disregards construction time (2-4 years), capacity is built out linearly towards peak, and a full/100%-utilisation of the newly added capacity. Thus, the actual investments needed to reach the turbine capacity is probably larger. The new additions also model reinstallations of old wind farms after 25 years.
Source: Implement Consulting Group based on European targets, interviews with industry experts and Shield et al., 2023.

The total capacity of European offshore wind was 32GW in 2023H1 with 2GW newly installed capacity that half year. Thus, the current production of offshore wind turbines is equivalent to around one large 15MW turbine per day.

Regardless of the chosen build-out pathway, the offshore supply chain will need to **increase the production capacity by at least 5x.**

A very conservative estimate of the **necessary investment in the wind turbine supply chain production capacity** (e.g. blade factories, equipment for towers etc.) is:

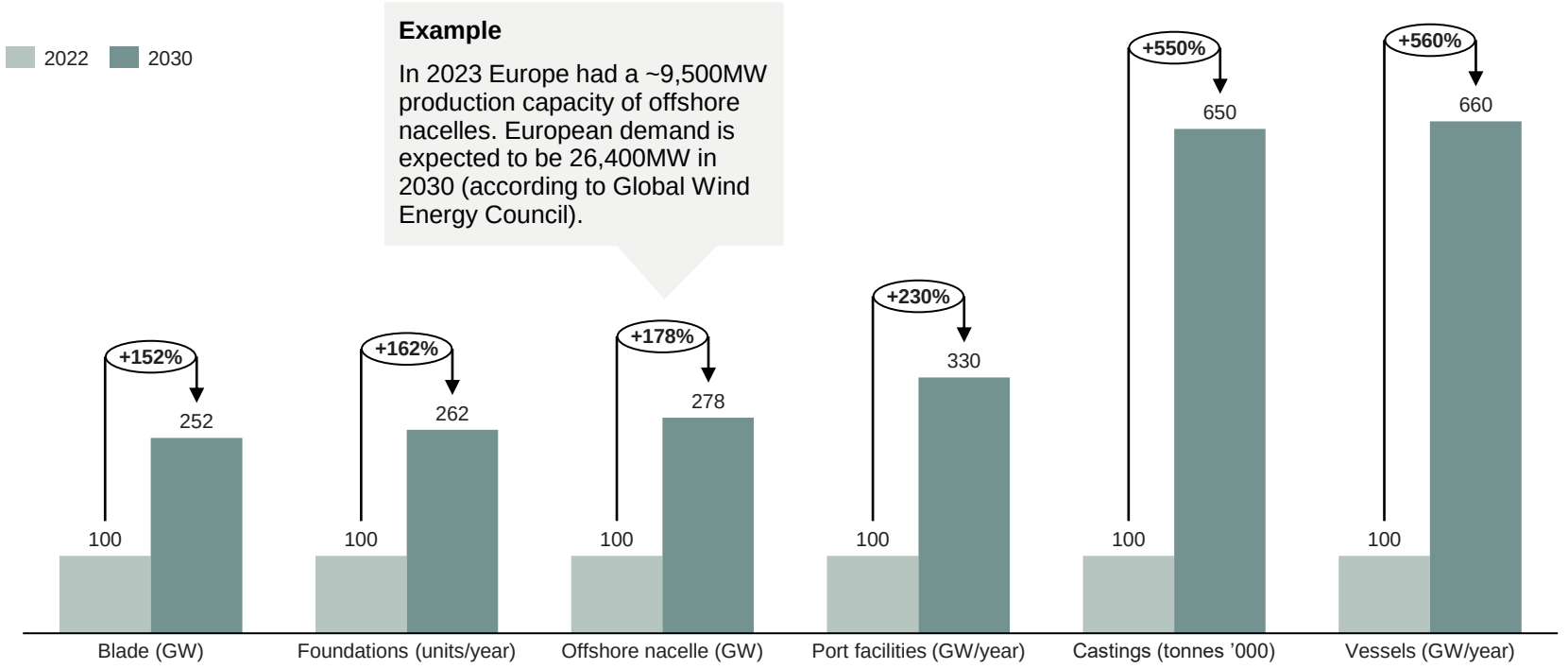
- 2.6 billion EUR each year between 2022 until 2030 (Target pathway)
- 1 billion EUR each year between 2022 until 2034 (Alternative pathway)

The estimate only includes the CAPEX cost for the supply chain related to the turbine itself (i.e. doesn't include cables, monopiles etc.). Further, the costs do not include capacity redundancy from innovation or the need for replacement.

MINIMUM CAPACITY

European suppliers need to increase capacity between +150% and 560% to facilitate the 2030-target with especially casting and vessel capacity needing a ramp-up

Minimum capacity (under 100%-utilisation) development to meet the 2030-target demand
(Index, 2022=100)



Lead time

2 yr	2 yr	2 yr	3 yr	2 yr	5 yr

Source: Implement Consulting Group based on Rystad Energy and GWEC.

For the industry to be able to produce +20GW additional offshore wind capacity per year all parts of the supply chain must grow.

The acceleration requires that European suppliers must **at least increase capacity between 150% and 560%.** This is a minimum expansion as it assumes full production utilisation/100%-utilization. A rate that is currently around 50-80% depending on component.

Currently, castings and vessels are the parts in the supply chain that are furthers from being able to meet future demand and therefore also risks becoming bottlenecks.

> *There is a structural deficit in the production capacity for all areas of the supply chain and rapid innovation is creating further complexities. There is no global model in place to rectify this.*
>
> Tower manufacturer, CEO survey
> Implement Consulting Group (Jan 2024)

An organic build-out requires reducing time to first power, developing the supply chain, and addressing the innovation race

> Nobody in the industry dares stop innovating on the fear of missing out. There is a short sightedness with companies only looking to fulfil an order rather than looking to scale.

- Developer

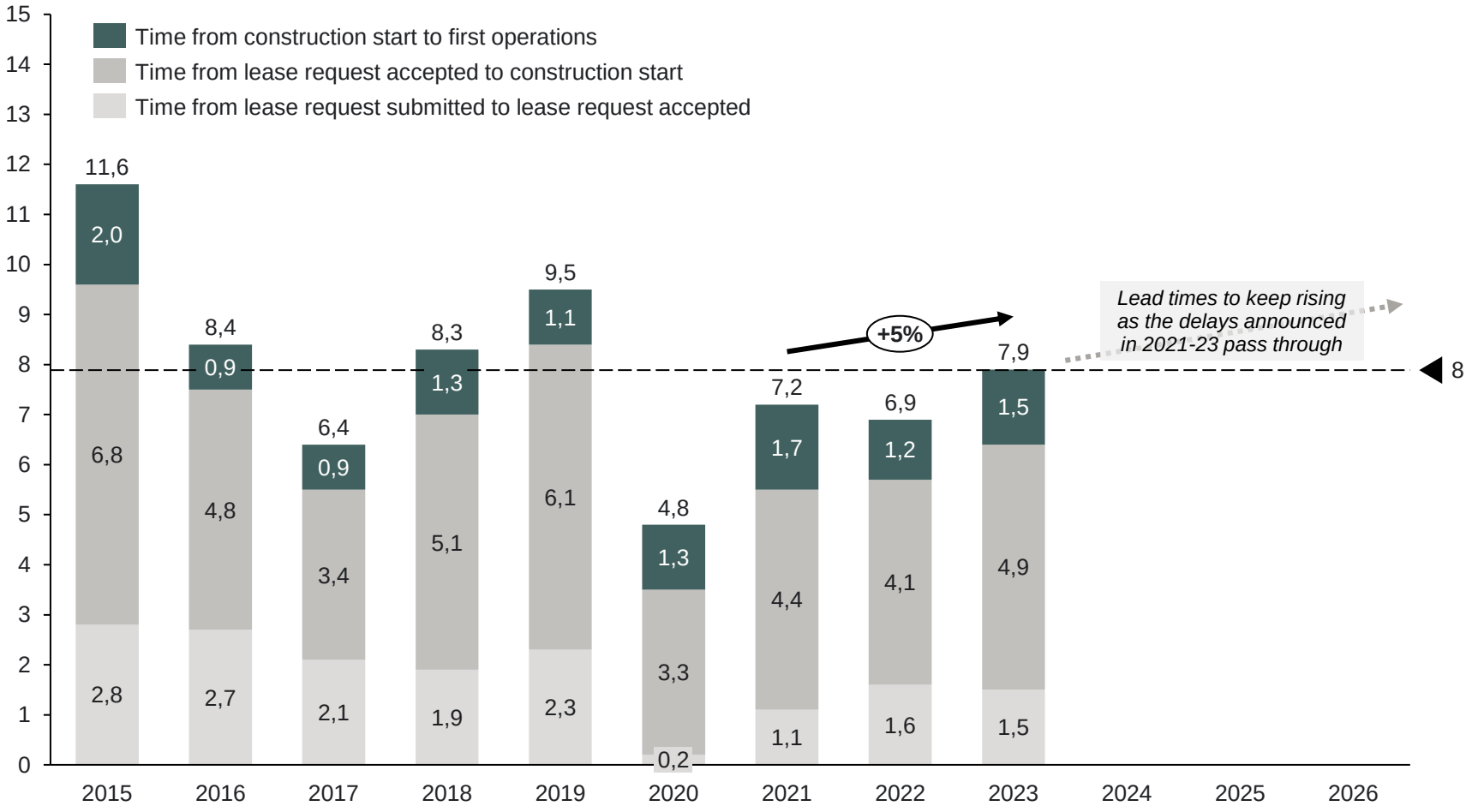
CEO Survey, Implement Consulting Group

(Dec 2023)

TIME TO FIRST POWER

Lead time from lease to COD came to a low of 5 years in 2020, but has increased again to 8 year in 2023 primarily driven by the slowdown in regulatory processes and supply chain bottlenecks

Time from lease to commercial operation date (COD)[1]
Years



Notes: Capacity weighted years on lead times of European offshore wind.
Source: Implement Consulting Group based on 4C Offshore.

Over the last nine years the average lead time from lease to commercial operation date has been eight years.

The time from the lease request is accepted to the construction start amounts to approximately 4.5 years, which is three-fold the time to complete the actual construction.

Regulatory uncertainty (state-ownership models in projects, local content, and grid build-out plans) accompanied with gridlock delays and delays in building transmission lines is challenging the lead time (other than global events like COVID-19 etc.). Overall, this uncertainty is unnecessarily increasing investors' risk and required return.

Looking to 2030 and the number of announced delayed projects, one would expect an increase in lead time. This is a key factor that needs to be changed.

> *There is no civil apparatus that can review all the necessary applications and permit requests, which is increasing permitting lead times.*

Installation contractor, CEO survey
Implement Consulting Group (Dec 2023)

Supply chain bottlenecks have exacerbated the lead time, and several critical bottlenecks need to be closed to meet the delivery gap

Bottleneck risk

Type		Risk of bottleneck	Analysis
Raw materials	Rare earths		• China is the near exclusive producer of rare earth elements (mining and refining). Western companies are required to import REEs and therefore heavily reliant on Chinese exports. • China has a fast-growing demand for carbon fibre and is therefore increasing the capacity of carbon fibre production. Western companies will soon be reliant on China for not only REEs but also carbon fibre.
	Steel		
	Copper		
	Concrete		
	Carbon Fibre		
Components	Gear-boxes		• Manufacturing bottlenecks are expected leading up to 2030, particularly within turbines, towers and foundations. This is the result of an ‘arms race’, quality issues and performance drops. Therefore, capacity developments have been paused in favour of innovation and development. • Europe has a well centralised component market but is reliant on the availability of key raw materials (e.g. REEs). • Supply chains will be challenged should innovation continue in the current pace it is. Suppliers will have to contend with capacity increases and R&D to meet the innovation requirements set by developers.
	Generators		
	Blades		
	Power Converters		
	Castings		
	Towers		
	Foundations		
	Cables		
Housing	Onshore nacelles		• Uncertain outlook to the industry and a risk of bottlenecks in key materials/components means nacelle production is likely to slow.
	Offshore nacelles		
Other	Installation vessels		• Competition for vessels has started to occur and due to the long lead times on constructing vessels, there is a risk for bottlenecks. • Due to significant growth in the industry globally, there are currently bottlenecks in access to skilled labour, both white and blue collar.
	Parts		
	Workforce		

Source: Implement Consulting Group based on GWEC.

Long lead times and project delays has resulted in prolonged order-to-cash processes, that has triggered the supply chain to struggle with attracting financing to undertake the necessary capacity investments. Without the required capacity developments, the supply chain has developed several critical bottlenecks.

To meet the required growth targets and capacity developments, the supply chain requires innovation, entrepreneurship, and renewed regulation, supported by end-to-end cooperation and collaboration, and profits.

However, the current situation sees a lack of the above, with market players concentrating on self-preservation over market growth.

For the offshore wind industry, it will require a transformation in the mindset, moving away from self-interest and self-preservation to industry interest and industry preservation and growth.

> *There is an imbalance between players in the supply chain with competition dominating rather than cooperation.*

WTIV, CEO survey
Implement Consulting Group (Jan 2023)

To overcome the current bottlenecks in the forthcoming acceleration, investments need to be undertaken across the supply chain

Deep dive on bottlenecks in the supply chain

Gearboxes	• Historically, gearboxes have been the main cause for turbine downtime due to failures. These quality risks continue to pose a threat to the industry with suppliers needing to ramp-up production up to 2030 (that could also lead to further quality reductions). • Europe currently has sufficient production capacity to satisfy 2024, however bottlenecks are expected due to growing geopolitical polarisation. European gearbox producers have production capacity in China, so there is a risk that these producers will have difficultly moving their gearboxes from China to Europe.
Generators	• Europe currently has sufficient production capacity to satisfy 2024, however bottlenecks are expected due to growing geopolitical polarisation. European generator producers have production capacity in China, so there is a risk that these producers will have difficultly moving their generators from China to Europe. • China are the main rare earth metal (REE) producer globally with a market share of 70%. This centralisation around China leaves a large risk for generator producers to acquire the necessary quota of REEs to meet the growing demand for generators up to 2030.
Blades	• As the innovation race continues, the historical production capacity becomes redundant when the size of wind turbines continues to increase. This will require blade manufacturers to not only innovate new solutions to satisfy larger turbines but also to increase capacity simultaneously to meet the demand of developers up to 2030.
Castings	• Due to the reduction in LCOE in the last decade, foundries have moved from Europe to China to reduce the costs of manufacturing. As a result, China has 83% market share of castings worldwide meaning there is a risk for bottlenecks because of geopolitical tensions. Demand in Europe for castings has surpassed supply, making future capacity growth (whilst catching up on the existing lack of supply) challenging and requiring considerable CAPEX.
Towers	• As the innovation race continues, the historical production capacity becomes redundant when the size of wind turbines continues to increase. This will require blade manufacturers to not only innovate new solutions to satisfy larger turbines but also to increase capacity simultaneously to meet the demand of developers up to 2030. • Furthermore, the lead times on building new coastal-located manufacturing sites is 3 years (not accounting for longer permitting) which will further set back the ability to scale.
Foundations	• Foundation manufacturers face both scaling and innovating challenges. Should the industry continue to create larger turbines then the foundations manufacturers will need to continue to create new solutions to support these turbines. Currently, Europe has enough capacity to satisfy the next two years of offshore wind growth, but the foundation supply chain requires a large ramp-up to reach the 2030 demand, and an even greater ramp-up should innovation continue.

Source: Implement Consulting Group based on GWEC.

Despite Europe starting the offshore wind industry, China has emerged as the world-leader in offshore wind manufacturing, components and raw materials.

Supply chain diversification towards the start of the century by European players has supported this Chinese emergence. However, the offshore wind supply chain is beginning to see the effects of the recent geopolitical unrest that can have a big effect on the dynamics between Europe and China.

Many of the key components (to the left) are in high risk of facing bottlenecks due to the reliance on Chinese mining, refining and/or manufacturing.

It is therefore critical that the EU ensures raw materials, components, manufacturing and investments are not halted due to trade barriers, policies and regulations, and disputes.

On the industry level, developers need to rethink the signals and incentives they cascade down to the value chain to promote profitability and development, in aim of alleviating the costly bottlenecks.

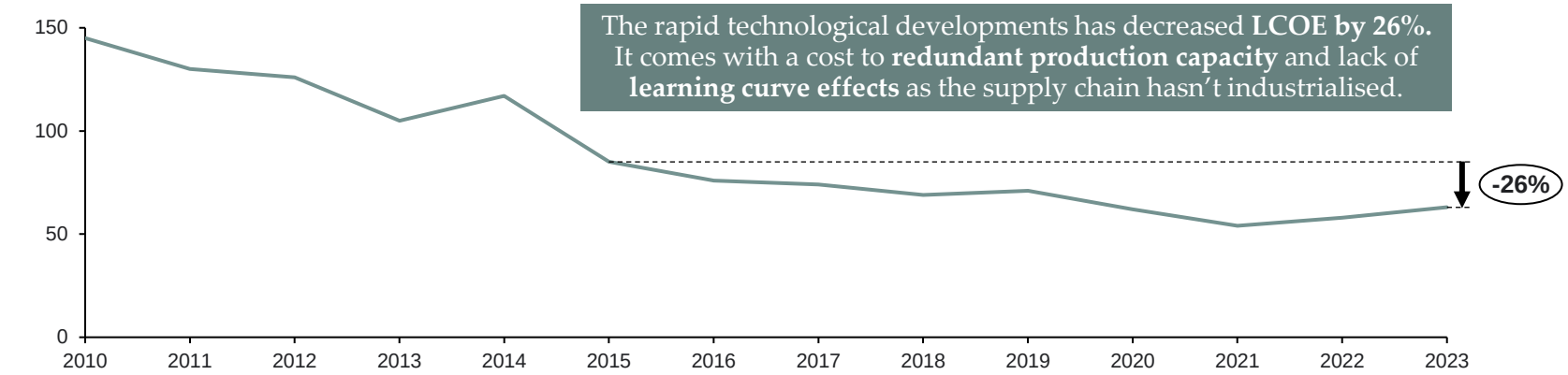
> *The EU needs to ensure fair competition both on an EU industry level (profit cascading) and an EU global level, to ensure that the reliance on China for raw materials and other components doesn't slow down the ramp-up of the EU build-out.*

Monopile manufacturer, CEO survey
Implement Consulting Group (Jan 2023)

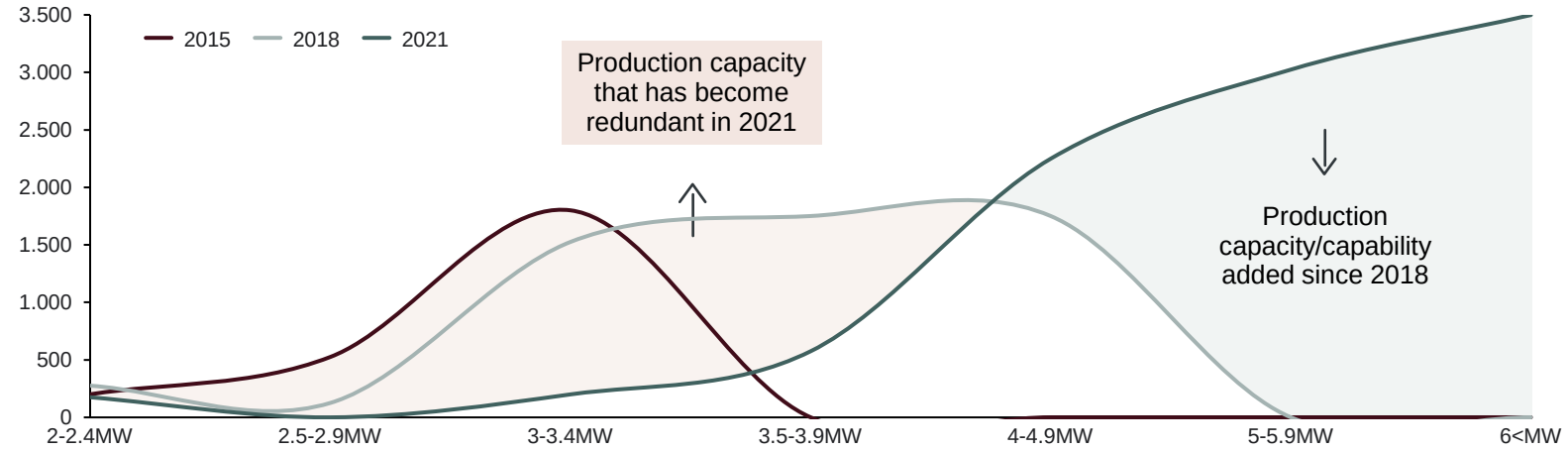
INNOVATION RACE

The rapid innovation of larger turbine sizes has caused older production lines to become redundant, forcing the supply chain to continually innovate instead of growing capacity and closing the bottlenecks

LCOE
EUR/MW



European wind turbine orders
MW



Source: Implement Consulting Group based on WindEurope.

Within 6 years, the smaller turbines (<3.4MW) have become near redundant with larger turbines filling more orders.

Continued innovation and turbine size growth at such a pace will inevitably collide with the need for suppliers to grow capacity.

With current lead times exceeding 2030, suppliers' risk having to re-design factories and facilities to accommodate larger turbines, creating a knock-on effect to the lead time.

Therefore, to reach the 2030-target should the industry decide on standardising and modularising, instead of creating larger turbines?

Furthermore, with the rapid expansion of China's wind manufacturing industry and the production of >20MW turbines, is there value in the European market innovating larger turbines or is standardisation more effective?

> *The race for greater turbines is not optimising the industry, making the supply chain continually re-innovate creating great costs across the supply chain.*
>
> Installation contractor, CEO survey
> Implement Consulting Group (Jan 2024)

Meet our experts

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Practice: Energy & Climate

Christian Romer Vingtoft
Partner
+45 4138 0059
crv@implement.dk

Kristian Kold Deleuran
Partner
+45 3051 0371
kkde@implement.dk

Anders Lehmann
Partner
+45 6124 6355
anle@implement.dk

Jan Rabe
Partner
+49 160 94968568
janr@implement.eu

Jake Callum Bookham
Senior Consultant
+45 5385 2023
jacb@implement.dk

Practice: Implement Economics & Strategy

Malte Lisberg Buhr
Partner
+45 6134 4459
malb@implement.dk

Martin Thelle
Partner
+45 2993 7221
mthe@implement.dk

Stine Hattestad Bratsberg
Partner
+47 928 94 411
stil@implement.no

Anders Thor Lundberg
Senior Consultant
+45 2392 2961
anlu@implement.dk

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→ Working globally

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