LCOE

Update of recent trends (Offshore)

Morten Kofoed Jensen

30th August 2022

Offerings

Aegir Insights offers advanced solutions for offshore wind investment decisions and strategy

Aegir Quant

- Aegir Quant provides a holistic business case view by integrating technology modelling, annual energy production (AEP), CAPEX, OPEX, installation logistics, financials and more.
- A solution for advanced economic assessment of opportunities in both fixed-bottom offshore wind and floating wind projects.

Aegir GAMMA

- Aegir's Geospatial Analytics Model and Mapping (GAMMA) provides high resolution market financial mapping as a supplement to traditional environmental constraints mapping.
- The solution helps clients develop long-term profitable investment plays based on site conditions, supply chain and local infrastructure.

Market Intelligence

- Comprehensive global coverage of +20 offshore wind markets. Market reports are regularly updated to reflect recent development.
- Market reports help developers pick the right markets by assessing market attractiveness and challenges, market reference cases and related LCoE levels.

Floating Intelligence

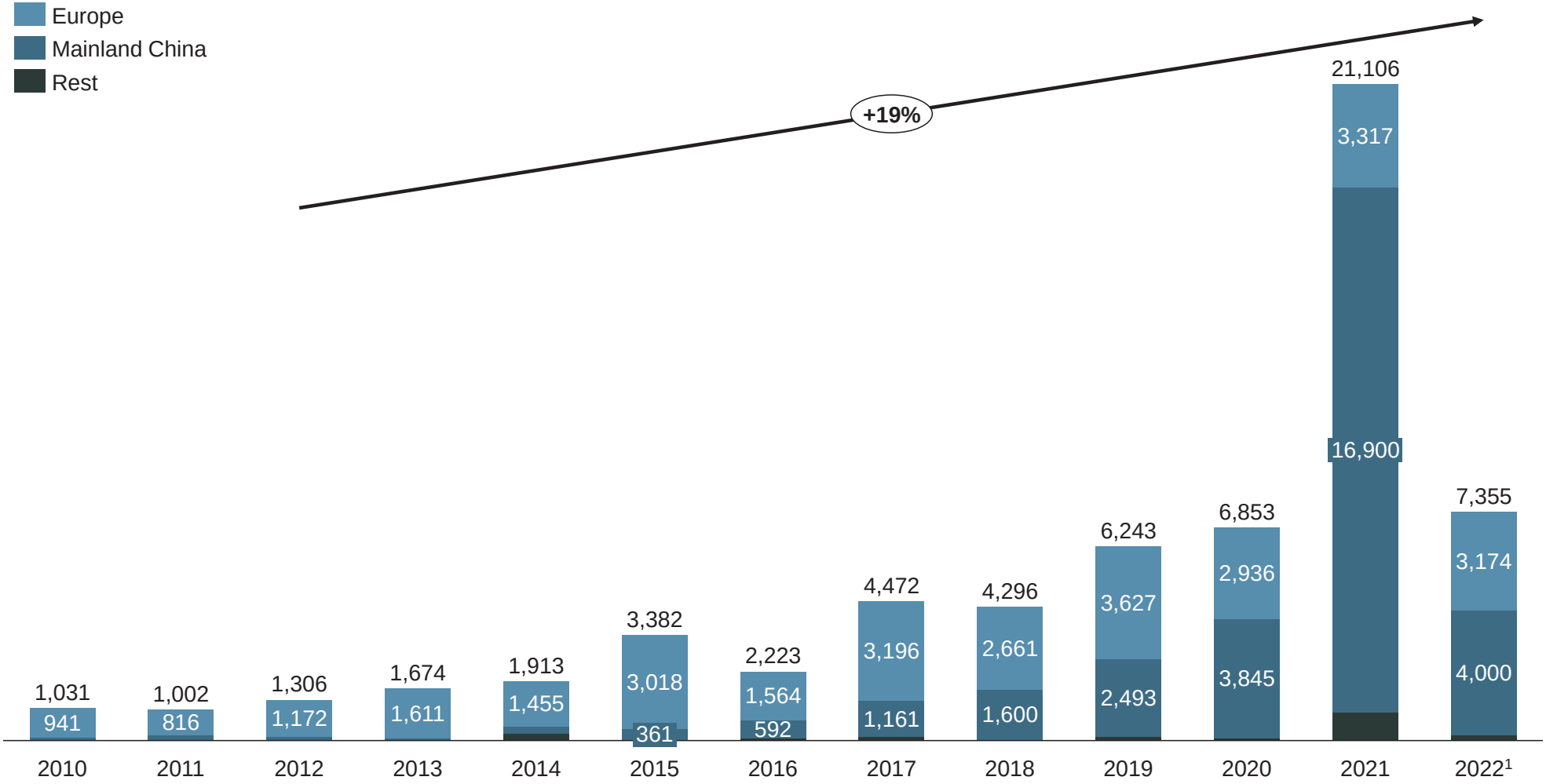
- Aegir offers a monthly release of floating project database and partnership analysis, a tool focused to help clients pick right markets, project and partners.
- The main features of the floating intelligence products include Global market forecasts, Country level project list, and Partnership network analysis.

Key highlights

1. Offshore wind is on course to play a key role in the decarbonization of the global economy
2. Cost reduction is mainly driven by upsizing of turbines and park size
3. Upsizing and systems engineering improvements will continue to reduce the cost of offshore wind
4. Headwinds from increasing inflation and raw material prices
5. Tenders on the rise will demand more from offshore wind energy

Offshore wind is the most rapidly growing renewable source

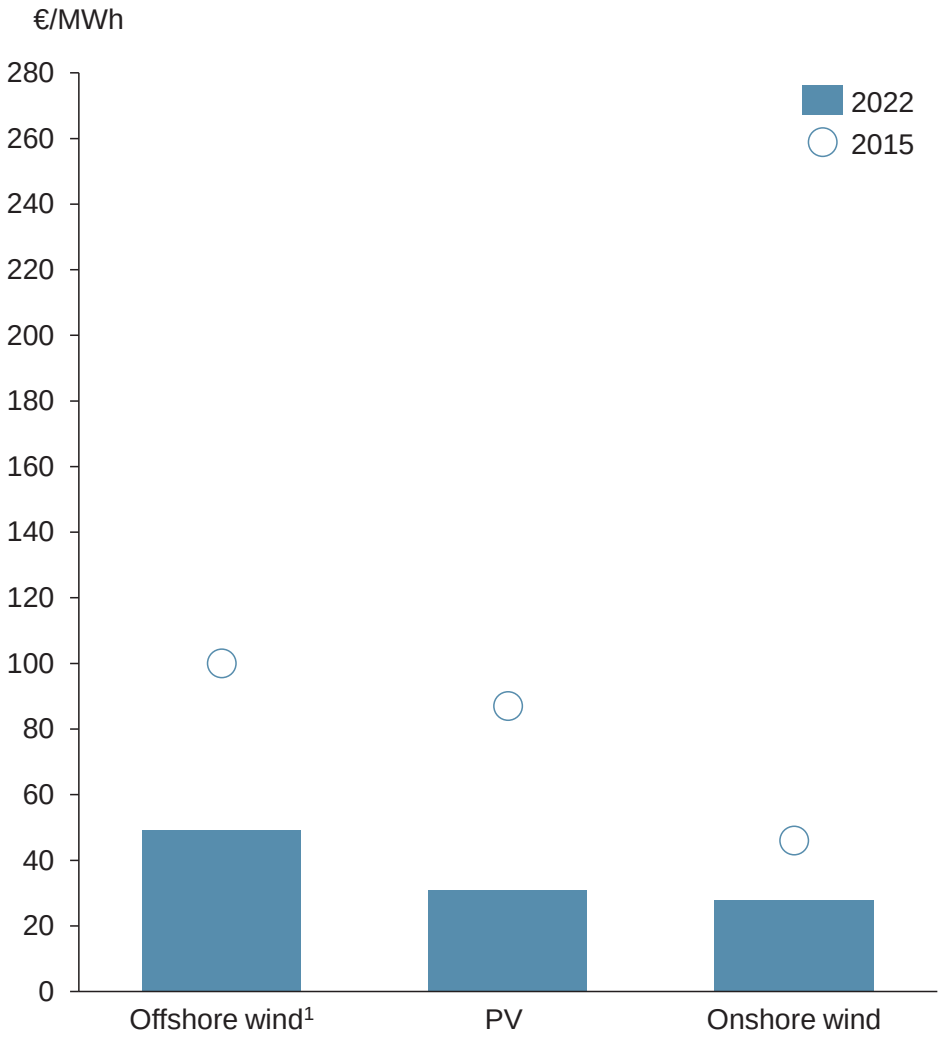
New Offshore wind installation 2010-2022 (MW)



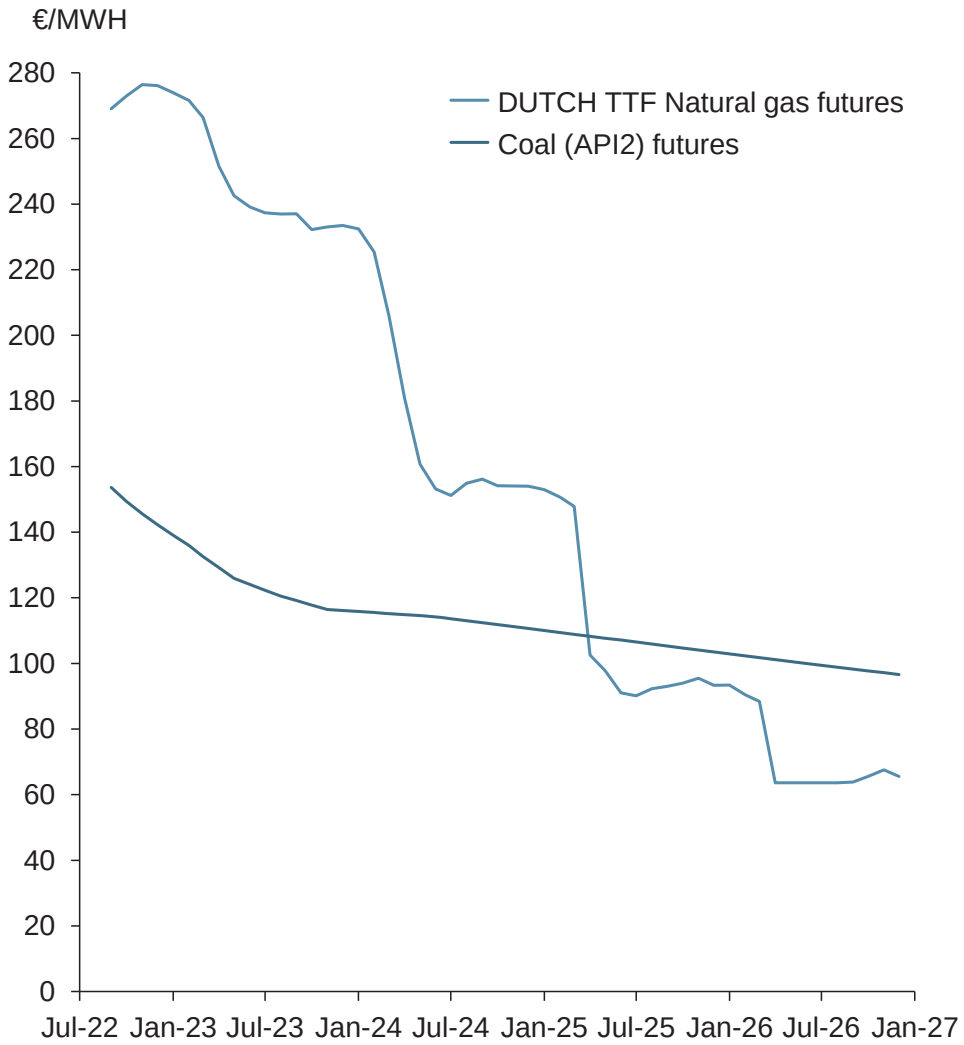
Sources: GWEC – 2022
Notes: 1) Including projects expected to be completed in 2022

Wind and solar in developed wind countries are below the fuel cost of fossil sources in Europe

LCOE offshore wind vs. onshore wind and PV



European Natural Gas and Coal[2] futures from Sep-22 to Dec-26



Sources: Aegir Insights (offshore wind), Danish Energy Agency(PV and Onshore wind), and CME Group (Coal and gas futures accessed 24-Aug-22)
Notes: 1) Fixed bottom for North Europe reference case, incl. transmission. 2) 2.46 MWh of electricity generated per ton of coal.

Deconstructing cost reduction shows the relative contributions from three key drivers: Project scale, turbine size and performance improvements

Project scale, 200 MW → 704 MW
Positions increased from 50 to 176

Increased project size drives cost down by almost 10 EUR/MWh.

Cost reductions stem from (not exhaustive):

- Scale benefits reducing relative contribution of fixed costs, decrease supply cost, etc.
- Decreased OPEX/MWh due to scale

Wind turbine size, 4 MW → 11 MW
Positions decrease from 176 to 64

Increased turbine size drives cost down by 31.5 EUR/MWh.

Cost reductions stem from (not exhaustive):

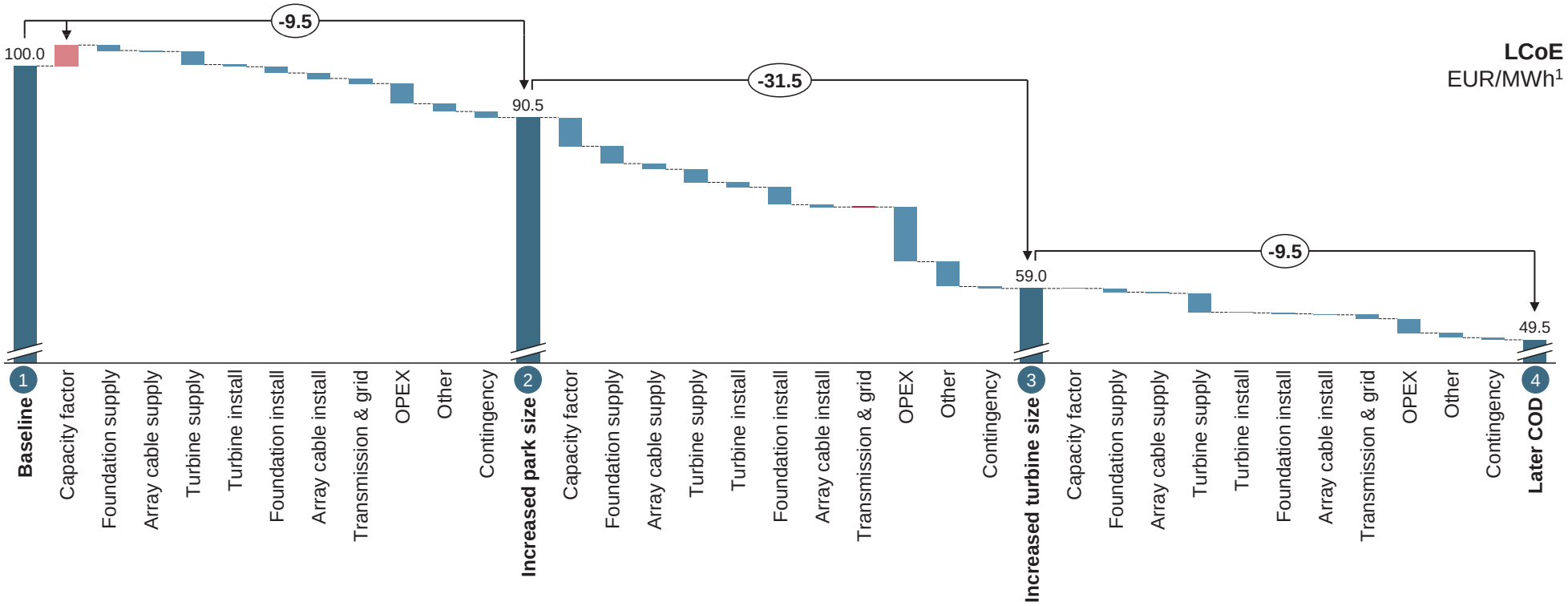
- Decreased CAPEX cost per MW OPEX decrease by position reduction
- Improved AEP due to better wind resource with higher hub height and more

Project year 2015 → 2022
Positions and park size kept constant

Performance benefit with later COD drive cost down by 16%.

Cost reductions stem from (not exhaustive):

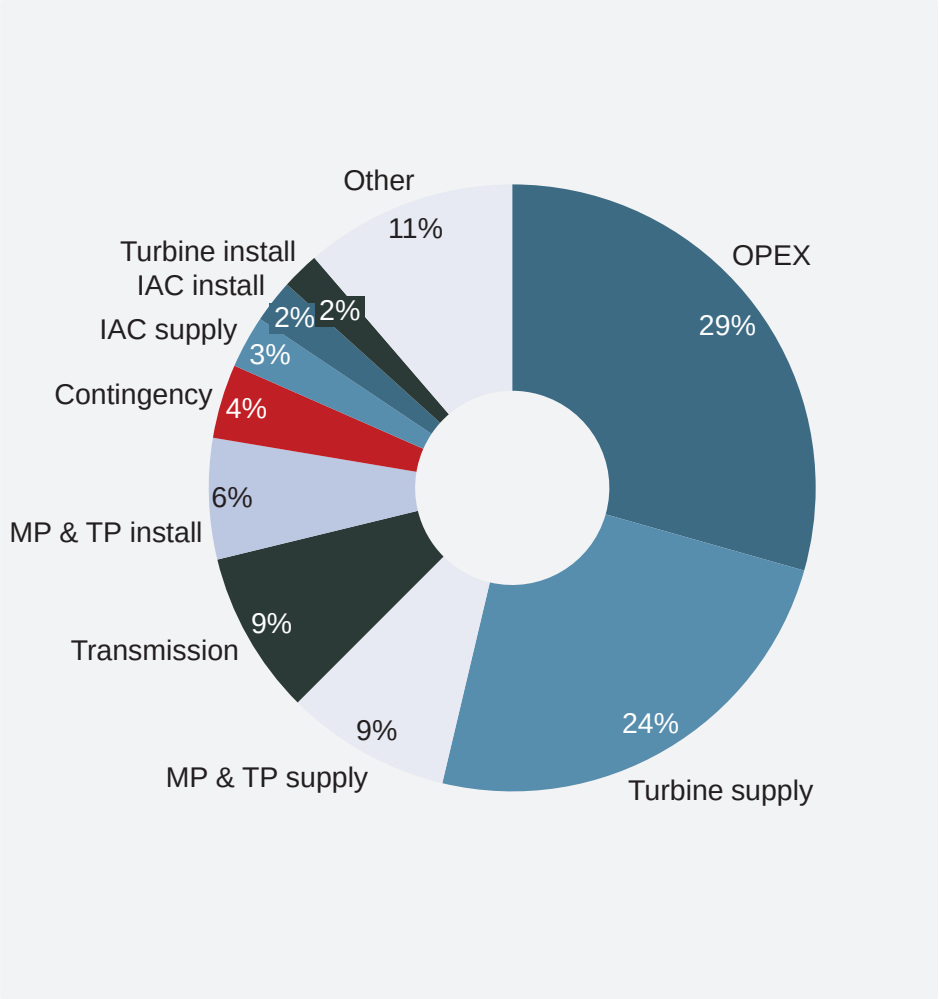
- Decrease in supply cost
- Technical improvements reduce working time and increase availability
- OPEX decrease w/ operational optimizations



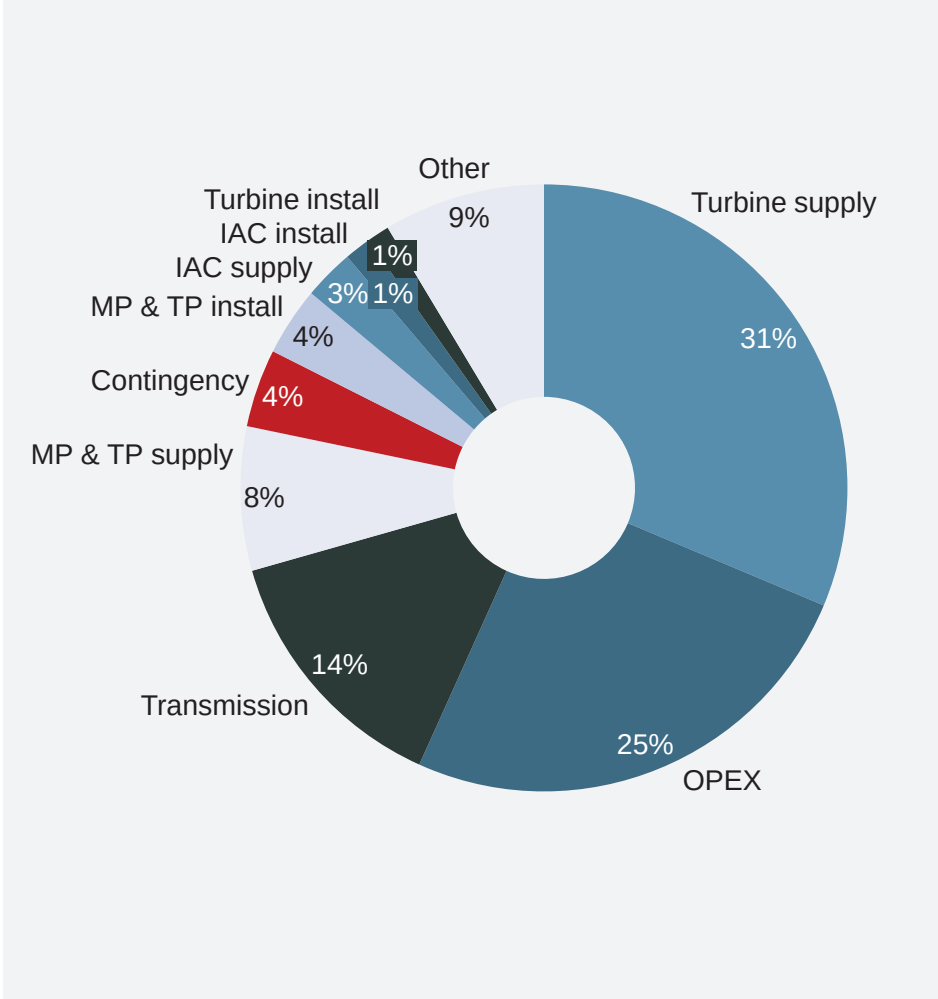
Sources: Aegir Insights analysis
Notes: 1) Real 2021, pre-tax 2) Other includes development cost, Resources cost, operations preparation, Construction management, insurance and decommissioning

LCOE Cost breakdown for a specific European offshore wind farm

LCOE cost breakdown for an offshore wind farm COD = 2015



LCOE cost breakdown for an offshore wind farm COD = 2022



Sources: Aegir Insights analysis, Siemens Gamesa

Notes: 1) Real 2021, pre-tax 2) Other includes development cost, Resources cost, operations preparation, Construction management, insurance and decommissioning

Next generation of offshore wind turbine in the horizon

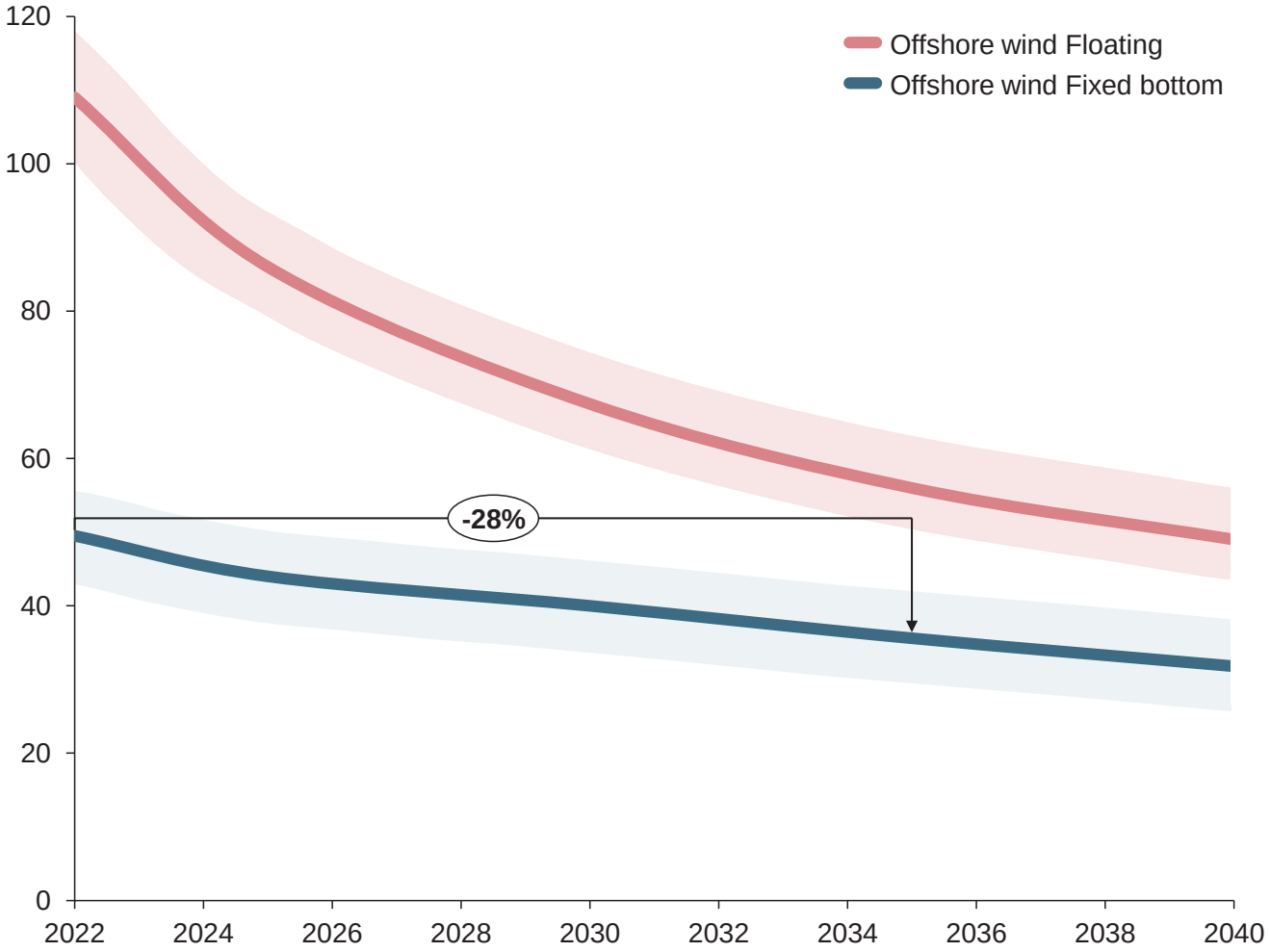
New turbines announced in the market by mid-twenties

Model	Company	Nameplate capacity (MW)	Serial production year	Height (m)	Blade Length (m)	Rotor Diameter (m)	W/m2
SG 14-220 DD	Siemens Gamesa	14 MW	2024	Site Specific	108	220	368
SG 14-236 DD	Siemens Gamesa	14 MW	2024	Site Specific	115	236	320
Haliade-X	General Electric	14 MW	2024	260	107	220	368
V236-15.0	Vestas	15 MW	2025	280	116	236	343
MySE 16.0-242	MingYang Smart Energy	16 MW	2026	264	118	242	348
TBD	TBD	20 MW	2030	300	136	270	350

Sources: Aegir Insights analysis, Siemens Gamesa, Vestas, Ming yang, Wind Catching Systems
Notes:

Aegir forecasts that an average North European fixed-bottom offshore wind farm will reduce costs by almost 30% to ~35 EUR/MWh by mid-thirties

Cost reduction forecasts, LCOE EUR/MWh[1]



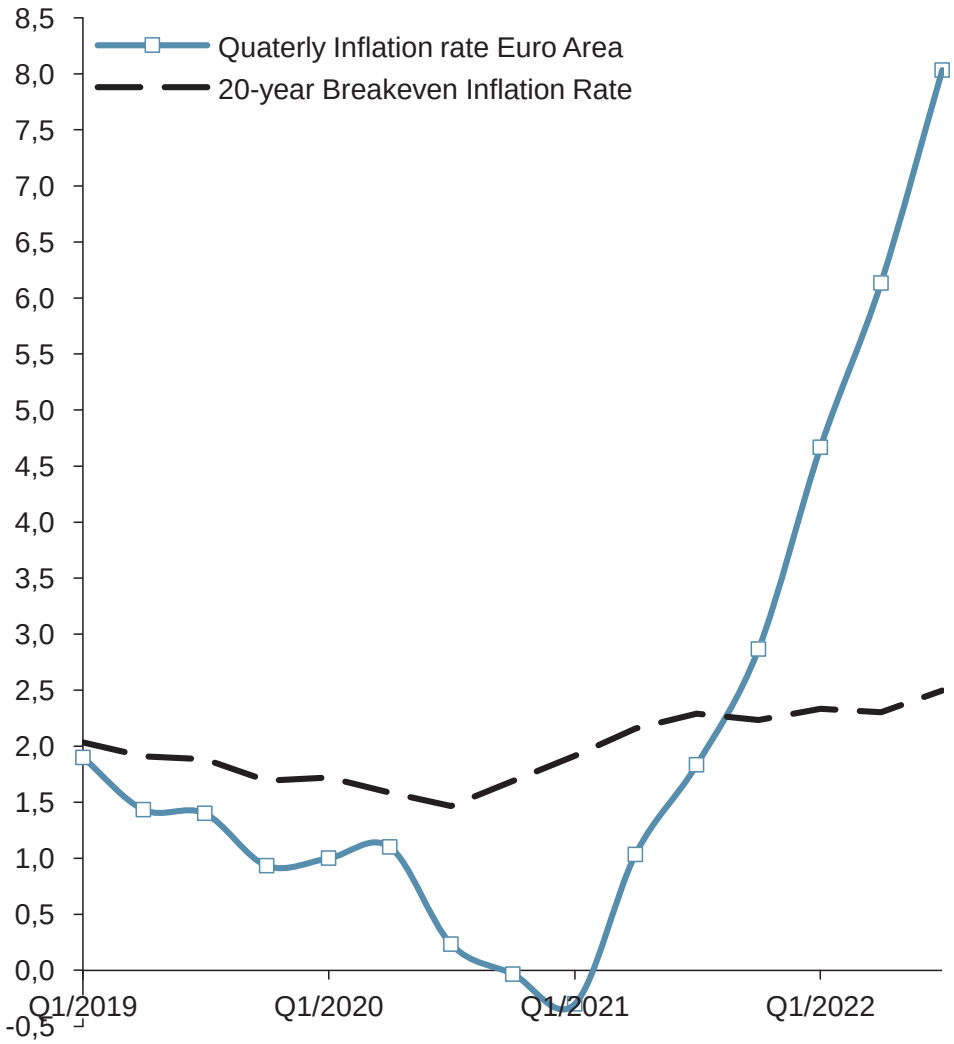
Systems engineering improvements

- Upsizing of generator, larger rotor, higher hub height.
- Integrated turbine design
- Wind farm layout optimization
- Turbine reliability
- Wind farm supportability and maintainability
- Standardisation of interfaces
- Installation method
- Grid integration

Sources: Aegir Insights analysis
Notes: 1) Real 2021, pre-tax 2) Other includes development cost, Resources cost, operations preparation, Construction management, insurance and decommissioning

Dark clouds of supply-led cost inflation and rising cost of debt are looming large

Inflation rate



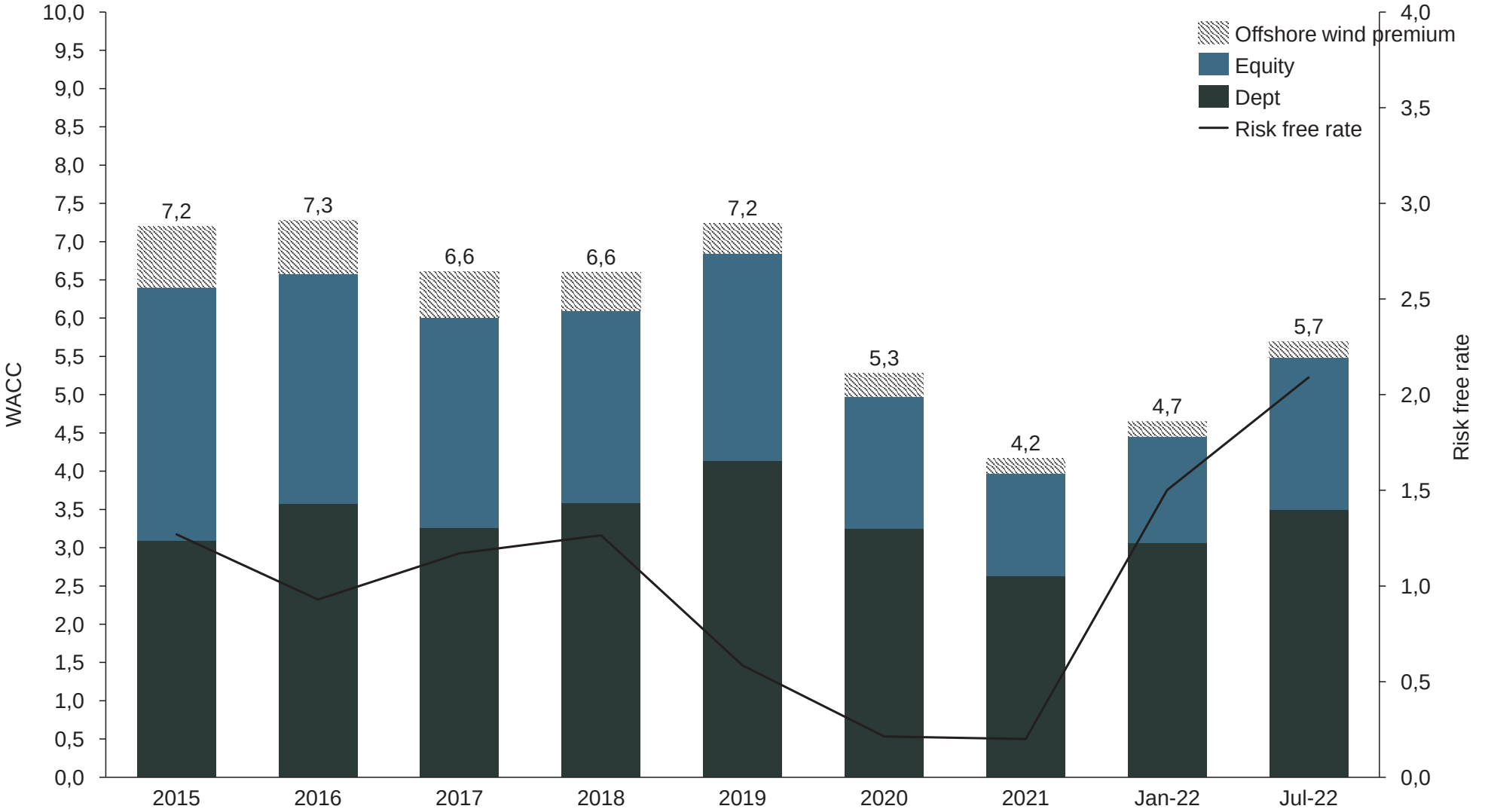
Inflation effect

- Increase cost of debt – The cost of debt will rise as the expected inflation rises, pushing up the risk-free rate and the default spreads.
- Increase cost of equity – Inflation will increase the risk-free rate, and the uncertainty about inflation will increase the equity risk premium, with the cost of equity rinsing for more riskier projects.
- Decrease the willingness to invest – Uncertainty about inflation will make it more difficult to justify large upfront investments

Sources: OECD, "Main Economic Indicators - complete database", Main Economic Indicators (database),http://dx.doi.org/10.1787/data-00052-en (Accessed on 08/16/2022)
Notes:

Lower capital costs help bring down weighted average cost of capital

Development in cost of capital for Western Europe (levered WACC $_{\text{pre-tax nominal}}$) for selected industries[1] from Jan-2015 to Jun-2022

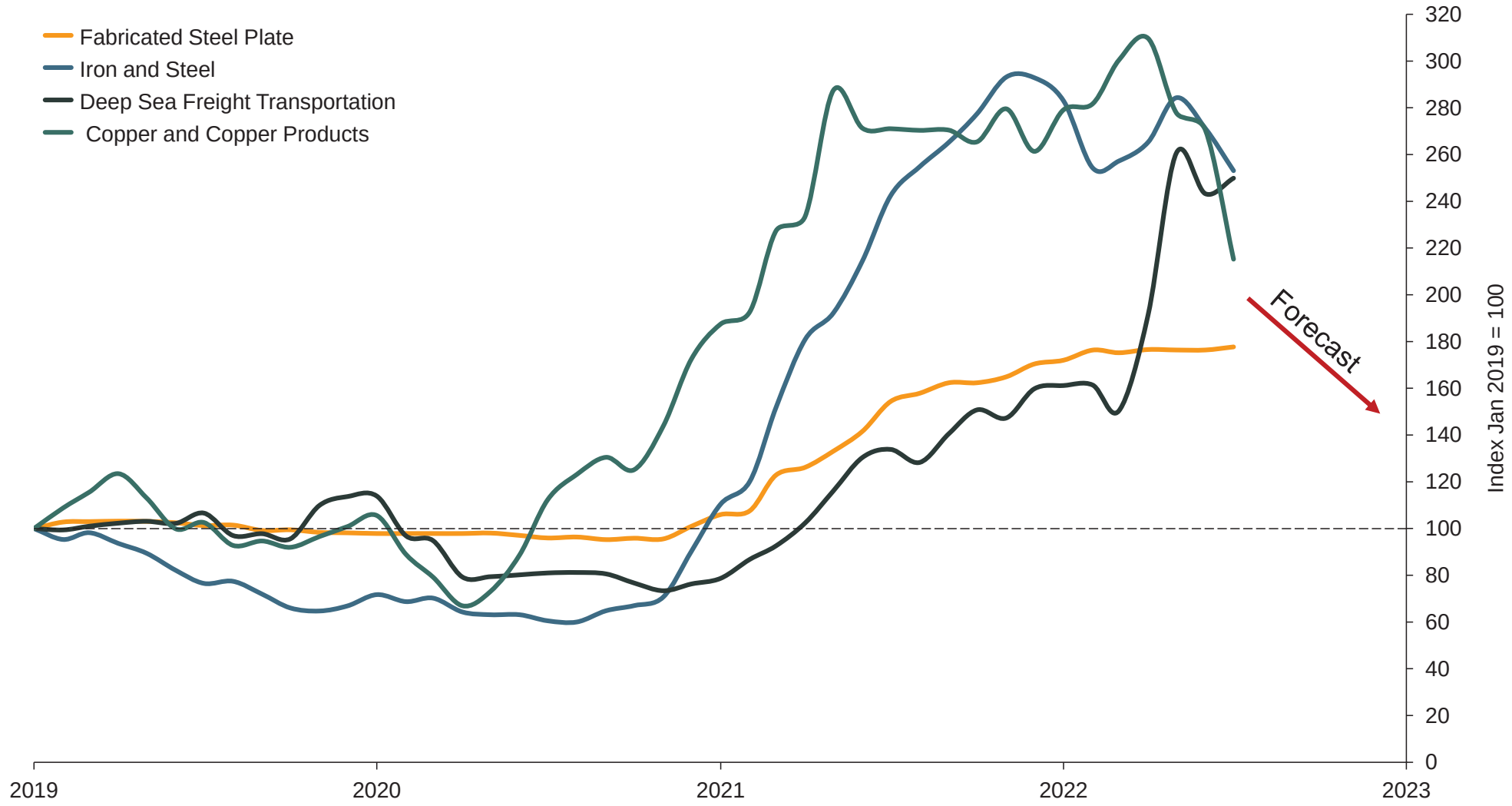


Sources: Aswath Damodaran - www.damodaran.com/, Aegir insights

Notes: 1) Engineering/Construction, Green & Renewable Energy, Engineering/Construction, Oil/Gas (Production and Exploration) & Power. Debt share of 70% in 2015, 75% from 2016-2019 and 80% from 2020 in all years.

Raw material costs and shipping rates

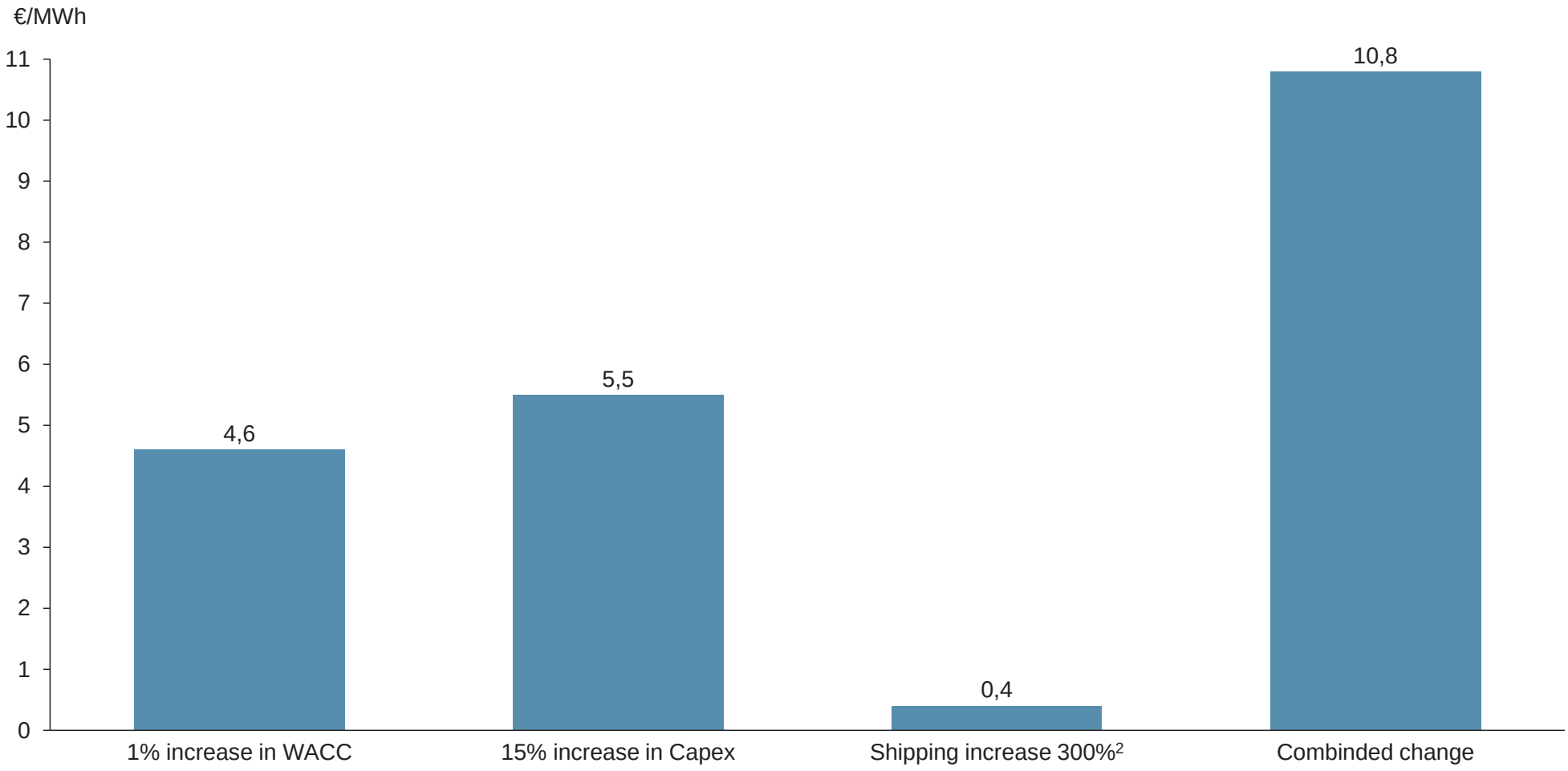
Producer Price Index by type from 2015-2022, Index (Jan 2019 = 100), Monthly, Not Seasonally Adjusted



Sources: U.S. Bureau of Labor Statistics, Producer Price Index by type retrieved from FRED, Federal Reserve Bank, August 19, 2022.
Notes:

Short term increase in LCOE due to inflation and rise in commodities

Effect on LCOE EUR/MWh[1] from increasing WACC and raw materials

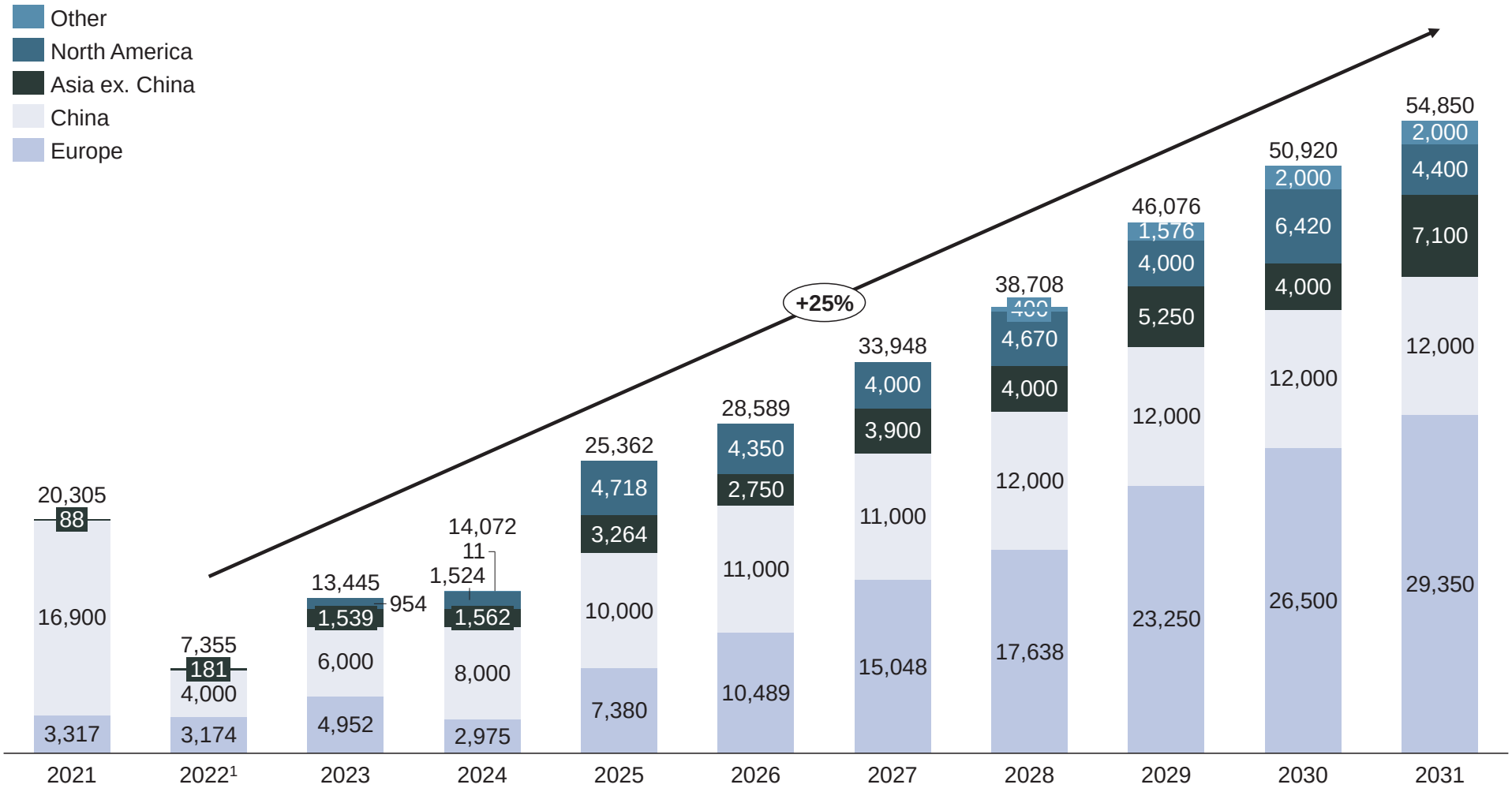


Sources: Aegir Insights

Notes: 1) Real 2021, pre-tax 2) Shipping of monopiles and turbine components from Denmark to the Netherlands.

Offshore wind keep momentum and projected to grow 25% over the next decade

Offshore wind capacity built out



Sources: GWEC – 2022

Notes: 1) Including projects expected to be completed in 2022

Are we reaching the end for LCOE?

Criteria for offshore wind auctions

Region	Country	Sustainability	Environmental impact	System Innovation & integration	Local Content	Price
Asia	China		○	○	●	○
Asia	Japan		●	○	●	●
Asia	South Korea		○		○	●
Asia	Taiwan		○		●	○
Asia	Vietnam					●
EU	Belgium		●	●		
EU	Denmark			●		○
EU	Finland			○		●
EU	France	●	●		○	○
EU	Germany	●	●	●		○
EU	Italy		●			●
EU	Netherlands		●	●		○
EU	Norway			○		●
EU	Poland		○	○	○	●
EU	Sweden			○		●
EU	UK			●	○	●
US	US		○		●	●

Sources: Aegir Insights, WindEurope
Notes:

● High Importance ○ Low Importance

Experience

Aegir is founded by industry thought leaders having central roles in market development and investment analysis in Orsted and Vattenfall, covering offshore wind and PtX opportunities in global emerging markets

Scott Urquhart
Chief Executive Officer

Relevant expertise:

1. Strategic advisor to governments on market development of offshore wind and PtX
2. Fixed and floating wind technology modelling
3. Project development and construction

Background:
- 19 years of energy sector experience spanning offshore wind, upstream oil and gas and investment banking
- Senior management positions in Orsted, Vattenfall and Stiesdal
- Extensive experience in resource economics, technology and commercial strategy

Qualifications:
- Executive Education in Climate Policy, Economic Growth, Harvard Kennedy School of Government
- LLM International Commercial Law, University of Edinburgh
- MBA Finance, University of Calgary
- BSc Mechanical Engineering, Dalhousie University

Companies:
- Orsted, Vattenfall, Stiesdal, Macquarie, Pengrowth

Rikke Nørgaard
Chief Commercial Officer

Relevant expertise:

1. Advisor to developers on offshore wind promotion in emerging markets (e.g. GWEC)
2. Project development and bid strategy
3. Early-stage project assessment

Background:
- 12 years of offshore wind experience covering development of large offshore wind projects and competitive bids in Orsted, and as Consultant for Copenhagen Infrastructure Partners, Bladt Industries and Stiesdal
- Commercial and project development expertise, as well as new technologies

Qualifications:
- Executive courses in Climate Policy and Economic Growth, Harvard Kennedy School of Government
- MSc in International Business, Copenhagen Business School / Indian Institute of Management Bangalore, India
- BSc in Business, Language and Culture, Copenhagen Business School / Queen's School of Business, Canada

Companies:
- Orsted, Treetop Partners, Novozymes

Maria Bohsen
Head of Research and Analytics

Relevant expertise:

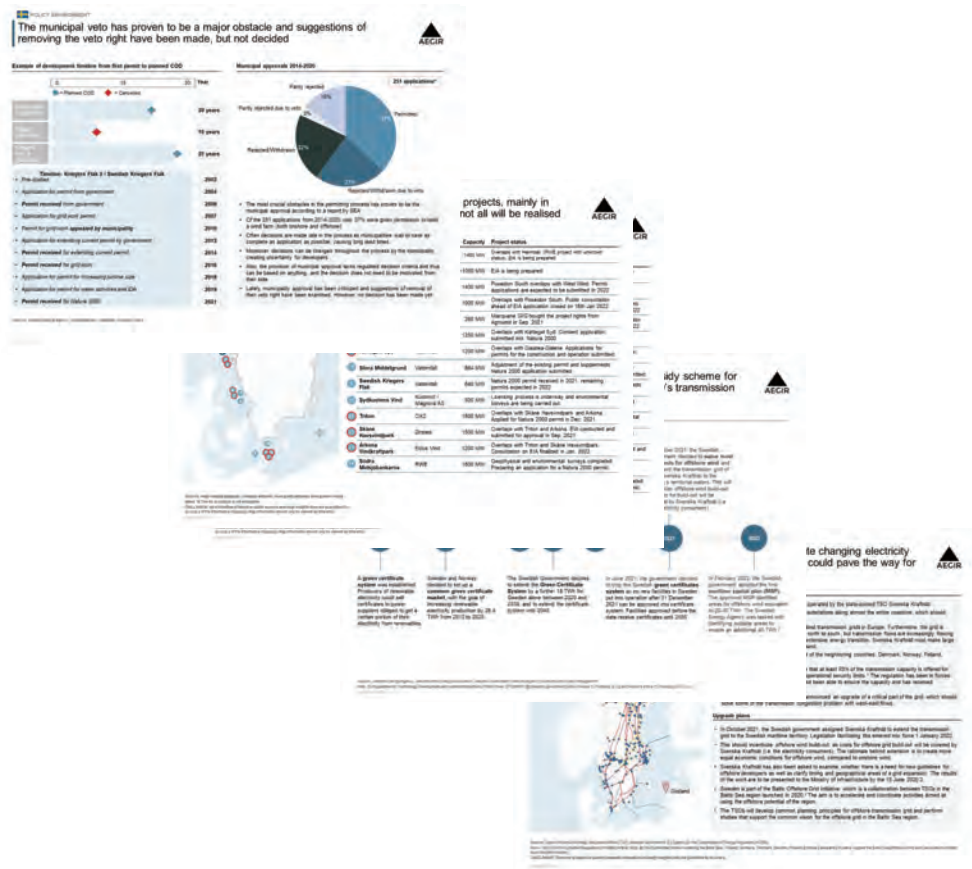
1. Hydrogen and energy market policy
2. Techno-economic modelling
3. Market strategy and general expertise in energy market dynamics

Background:
- 10 years of energy sector experience covering technical valuation of offshore wind, market development and analysis, as well as energy policy and regulation in renewables and hydrogen
- Senior advisor positions at the Danish Utility Regulator and the Danish Energy Association focusing on hydrogen and EU energy regulations

Qualifications:
- Courses on European energy regulation and policy, Florence School of Regulation (European University Institute)
- MSc, International Economic Consulting, Aarhus University, Denmark / Indian Institute of Management Calcutta, India
- BSc, Business Administration, Aarhus School of Business, Denmark / RMIT Melbourne, Australia

Companies:
- Orsted, Vestas, Danish Utility Regulator, Danish Energy Association

For key insights about floating wind and Energy transition coverage follow Aegir Insights on LinkedIn



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