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The supply chain's role in the journey to 'subsidy free'

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Hamburg

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Agenda

The supply chain's role in the journey to 'subsidy free'

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Selected clients

BVG Associates

Business advisory

- Analysis and forecasting
- Strategic advice
- Business and supply chain development

Economics

- Socioeconomics and local benefits
- Technology and project economic modelling
- Policy and local content assessment

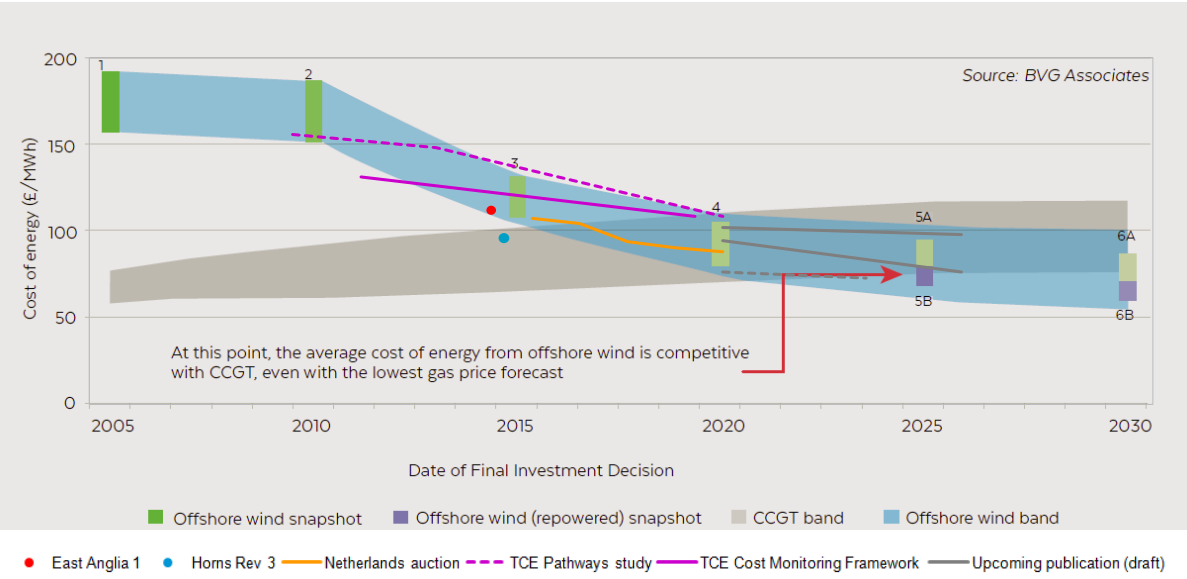
Technology

- Engineering services
- Due diligence
- Strategy and R&D support

1. Journey to ‘subsidy free’ – why it’s important

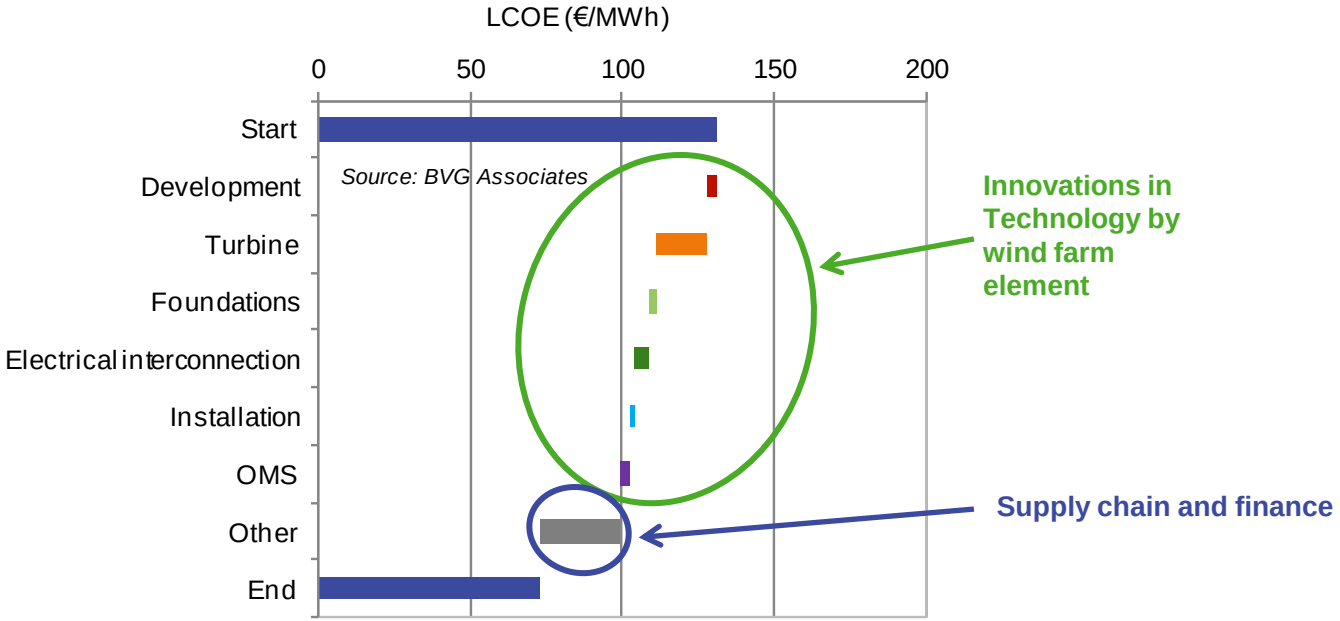
Going slow is not an option…we could already see in 2015 that costs were falling fast

Cost of Energy Reduction = Offshore Wind — **Subsidy free by ‘23**



2. It’s not just about the technology….

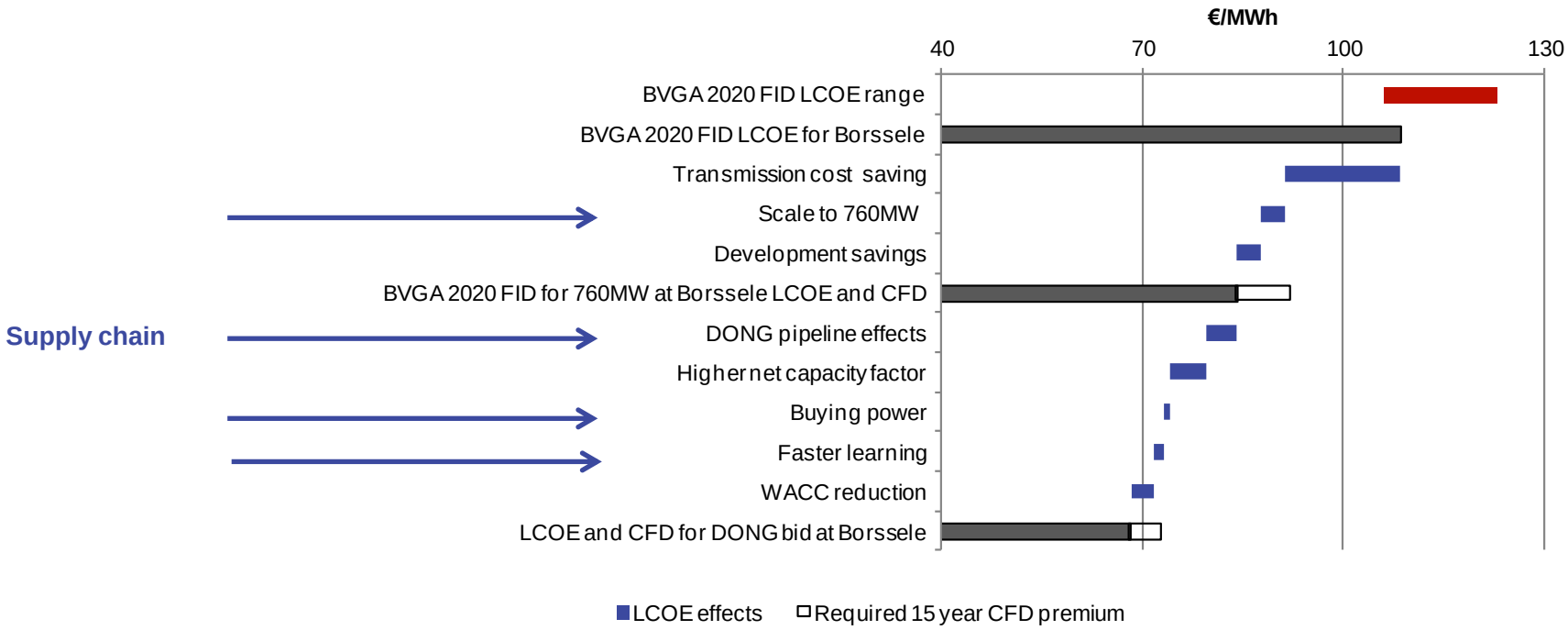
Supply chain, cost of finance and technology improvements together deliver LCOE reductions



Anticipated LCOE reductions from 2015 to 2030 – fixed 2015 €

3. Progress this year has been faster than expected

The Borssele auction brought forward technology, supply chain and finance benefits



4. LCOE benefits summary by element

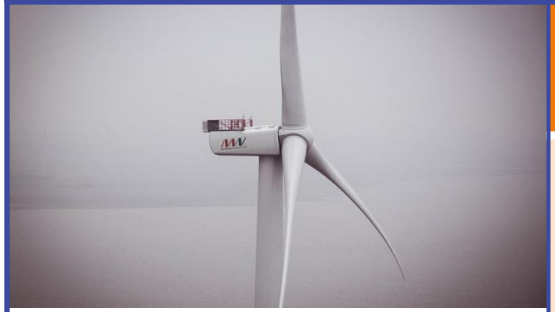
What progress needs to be made?

Turbine	Foundation & tower	Transmission	Installation	OMS	Development
Technology contributions to reducing LCOE					
10%	1.5%	3%	1.5%	2%	2%
Supply chain contributions to reducing LCOE					
2%	1.5%	2%	1.5%	1%	1%

4. LCOE reductions and role of the supply chain

What progress needs to be made?

Turbines



Main per MW benefits
Decreased foundation and installation CAPEX
Decreased OPEX
Increased energy production

Turbine	2016	2025	LCOE benefit
Technology	164m rotor 8MW @ 10rpm Ongoing development through life	200m rotor 11MW @ 8rpm More intense initial development A few evolutionary ‘steps’ through life	10%
Supply chain	Short pipelines Short-term supply contracts	Longer pipelines Long-term supply arrangements Additional investment in manufacturing quality and efficiency	2%

4. LCOE reductions and role of the supply chain

What progress needs to be made?

Foundation and tower

Main per MW benefits
Decreased CAPEX

Foundation & tower	2016	2025	LCOE benefit
Technology	XL monopiles up to 35m and 8.xMW Pin-piled 3 and 4-legged jackets	Monopile use pushed further (up to water depths of 50m?) Jackets 3-legged and use pin-piles or suction-buckets	1.5%
Supply chain	Tower and foundation designed separately Short pipelines/split supply Some standardisation	Integrated design of structure and standardisation Longer pipelines and supply arrangements Investment in manufacturing quality and efficiency	1.5%

4. LCOE reductions and role of the supply chain

What progress needs to be made?

Transmission

Main per MW benefits
Decreased CAPEX

Transmission	2016	2025	LCOE benefit
Technology	Up to 100km: 220kV HVAC and 1-2 substations Beyond: 800kV HVDC with collector platforms and offshore substation	HVAC beyond 100km through low frequency, intermediate corrector stations and up to 400kV Lightweight structures	3%
Supply chain	Custom design for each wind farm Some use of modules Single project pipelines	Standardisation of some designs Increased use of modules Multiple project pipelines	2%

4. LCOE reductions and role of the supply chain

What progress needs to be made?

Installation

Main per MW benefits
Decreased CAPEX
Decreased cost of capital

Installation	2016	2025	LCOE benefit
Technology	Jack-up vessels for foundation installation and turbine installation (5-lift strategy) Capable vessels, but not optimised	Reduced sensitivity to weather, better risk management, optimised fleets and scheduling. Greater use of floating DP2 vessels for foundation installation	1.5%
Supply chain	One project at a time, new PM team & build-out port Custom hardware	Vessels contracted for pipelines of projects Fewer build-out ports Re-use of most hardware from project to project	1.5%

4. LCOE reductions and role of the supply chain

What progress needs to be made?

Operations, maintenance and service

Main per MW benefits
Decreased OPEX
Increased AEP

OMS	2016	2025	LCOE benefit
Technology	Scheduled maintenance Some condition-based, but mostly reactive service	Full health and usage management Fully condition-based service with active health management Improved forecasting	2%
Supply chain	Turbine suppliers, developers in-house and 3rd-party service providers Contract ranges from 1-15 years (turbine)	In-house monitoring and data control by owners Emergence of integrated 3rd part service suppliers Portfolio approach	1%

4. LCOE reductions and role of the supply chain

What progress needs to be made?

Project development

Main per MW benefits
Decreased CAPEX
Decreased risk and cost of capital

Development	2016	2025	LCOE benefit
Technology	Met mast and some LiDAR Manually optimised layouts supported by CFD	Multiple floating LiDAR Improved wind resource measurement and wind farm layout	2%
Supply chain	Projects developed in isolation Developer uses a mix of 3rd party suppliers Developments often don't lead to projects	Projects developed in pipelines Increase in use of Dutch 'Borssele' model (government undertakes and shares site characterisation)	1%

4. LCOE benefits summary by element

Supply chain benefits will play a significant role in reducing LCOE

Turbine	Foundation & tower	Transmission	Installation	OMS	Development
Technology contributions to reducing LCOE					
10%	1.5%	3%	1.5%	2%	2%
Supply chain contributions to reducing LCOE					
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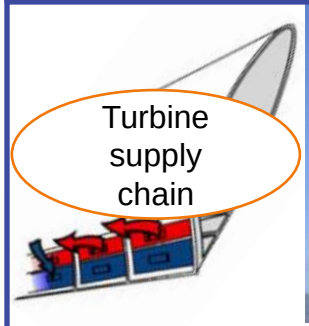
5. Beyond subsidy free…

Plenty more evolution but also disruption

Technology changes also drive supply chain changes



Aero control	**Float-out-and-sink**	**Floating**	**Multi-rotor**	**Kites**
Huge blades need better control	Avoid offshore crane cost	Access new areas	Better use foundations	Aim higher
Main per MW benefits				
Increased AEP Decreased OPEX	Decreased installation CAPEX	Increased AEP	Decreased CAPEX Decreased OPEX	Decreased CAPEX

Conclusions

The supply chain's role in the journey to 'subsidy free'

Key points

1. The journey to subsidy free is important
2. Going slow is not an option…we could already see in 2015 that costs were falling fast
3. It's not just about technology
    - Supply chain, cost of finance and technology improvements **together** will deliver the LCOE reductions
    - Supply chain benefits will play a significant role
4. Beyond subsidy free there will be more technology disruption and supply chain contribution to further LCOE reductions

Thank you

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