



Vestas®



Wind. Clean & mainstream energy.

Eva Larsen, Global Public Affairs Advisor

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**100
GW**

About Vestas & MHI-Vestas



Vestas®

- Onshore wind focus
- 40 years of experience
- +100 GW installed
- +78 GW under service
- 24,000 employees

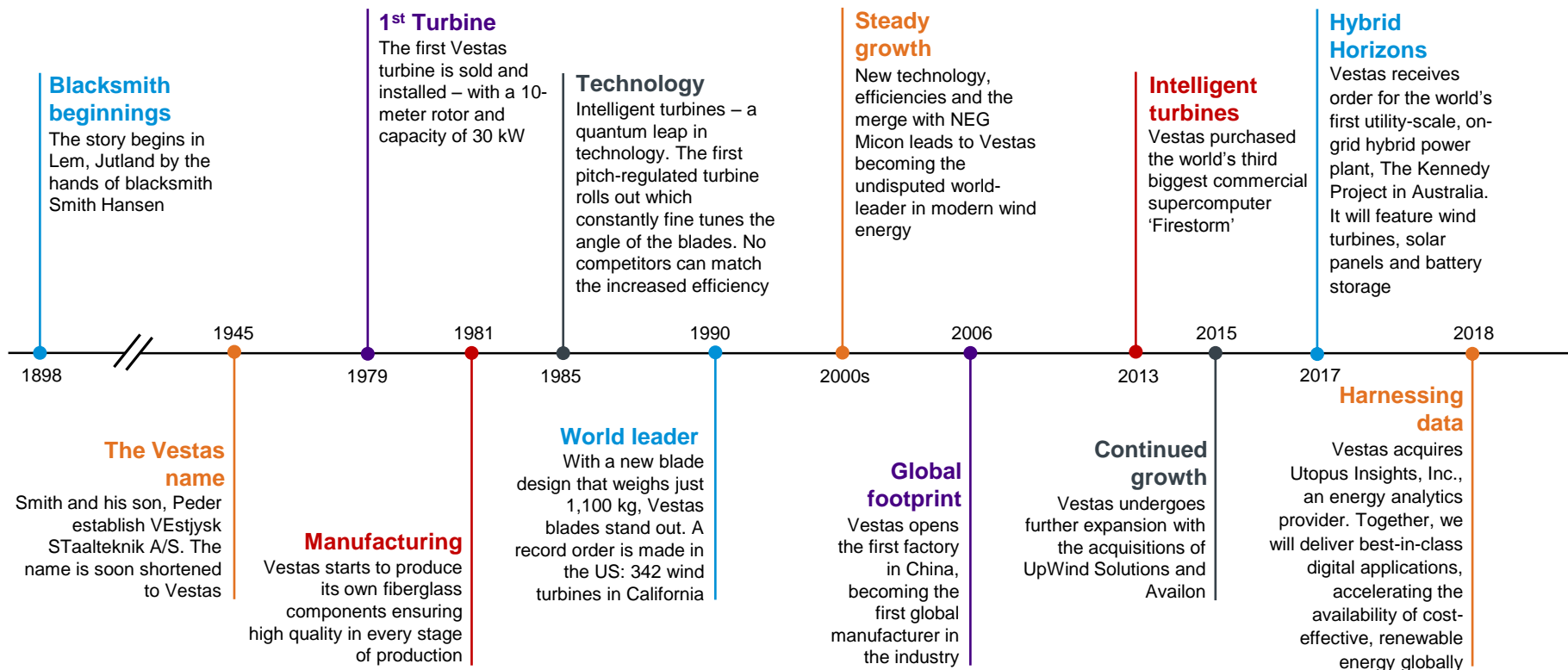


MHI VESTAS OFFSHORE WIND™

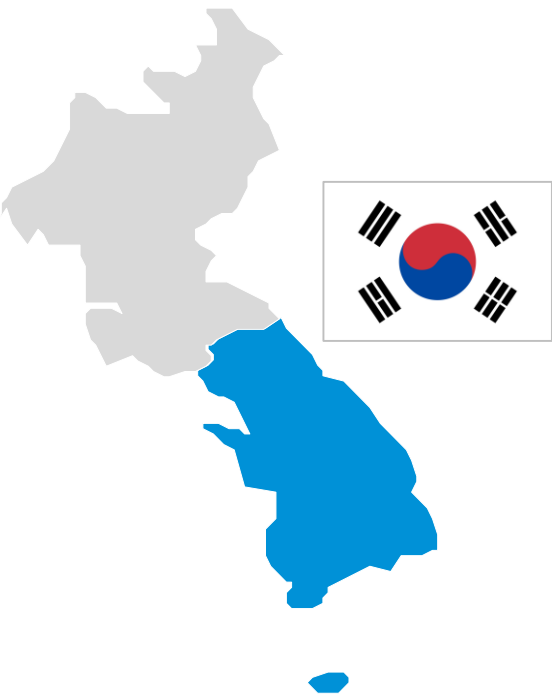
- Offshore wind focus
- 50/50 JV with Mitsubishi Heavy Industries
- First commercially available double-digit wind turbine – the V164-10.0 MW

The Vestas story

- Technology, vision and leadership build the strongest brand in the industry



About Vestas in Korea



Vestas



- Vestas Korea since 1997, +40 employees
- 430 MW installed, 405 MW under service
- Working with more than 150 Korean suppliers in and outside of Korea



Denmark 40 years ago

- energy was imported and fossil based

- Before the 1973 oil crisis: Denmark were 99% dependent on imported fossil fuelled energy generation
- Oil crisis caused a severe economic crisis, rising unemployment - and no non-commercial driving on Sundays!

Car free Sundays in Denmark as a result of the oil crisis in 1973



40 years later

- a totally different energy system

Quick facts:

- Net export of oil and gas (only EU-country)
- Lowest energy consumption per GDP-unit in EU
- Highest level of wind integration in the world: **43%** in 2017
- Most efficient clean coal technology in the world
- Highest export share of energy technology in the EU: Almost **12%** of total export of goods in 2016 of which almost **60%** were green energy technology
- Leading nation of advanced energy solutions (district heating and CHP, wind turbines, biomass plants, energy saving technologies, etc.)



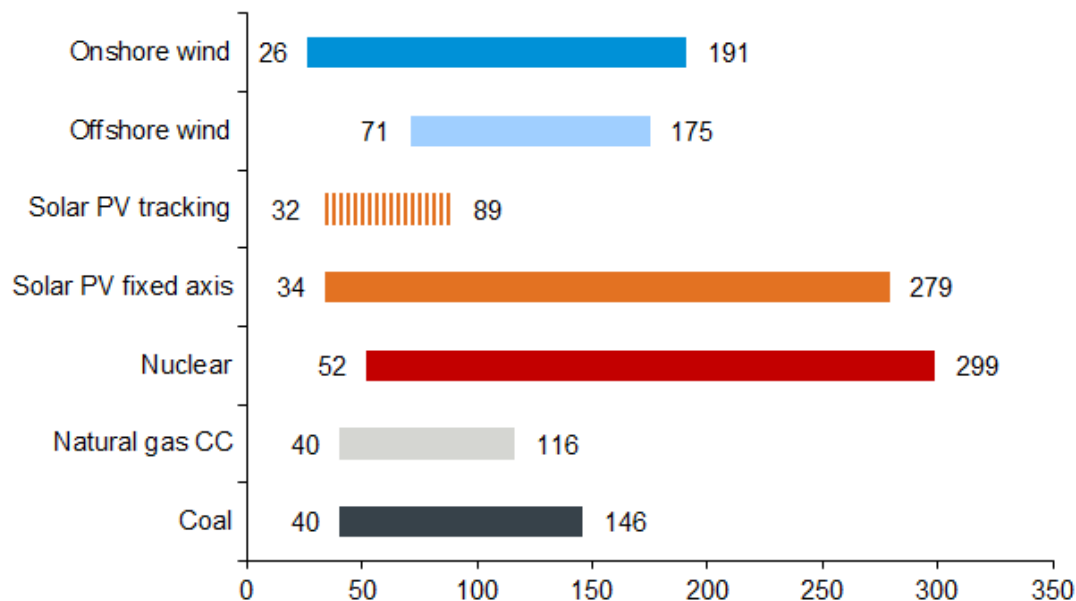
Wind, CHP plants and biomass

A close-up, low-angle shot of a wind turbine. The image shows a portion of a white blade and the dark, metallic nacelle. The background is a clear, deep blue sky. The lighting is bright, creating strong highlights and shadows on the turbine's surfaces.

**Why wind is now
mainstream**

Competitive cost of energy already today

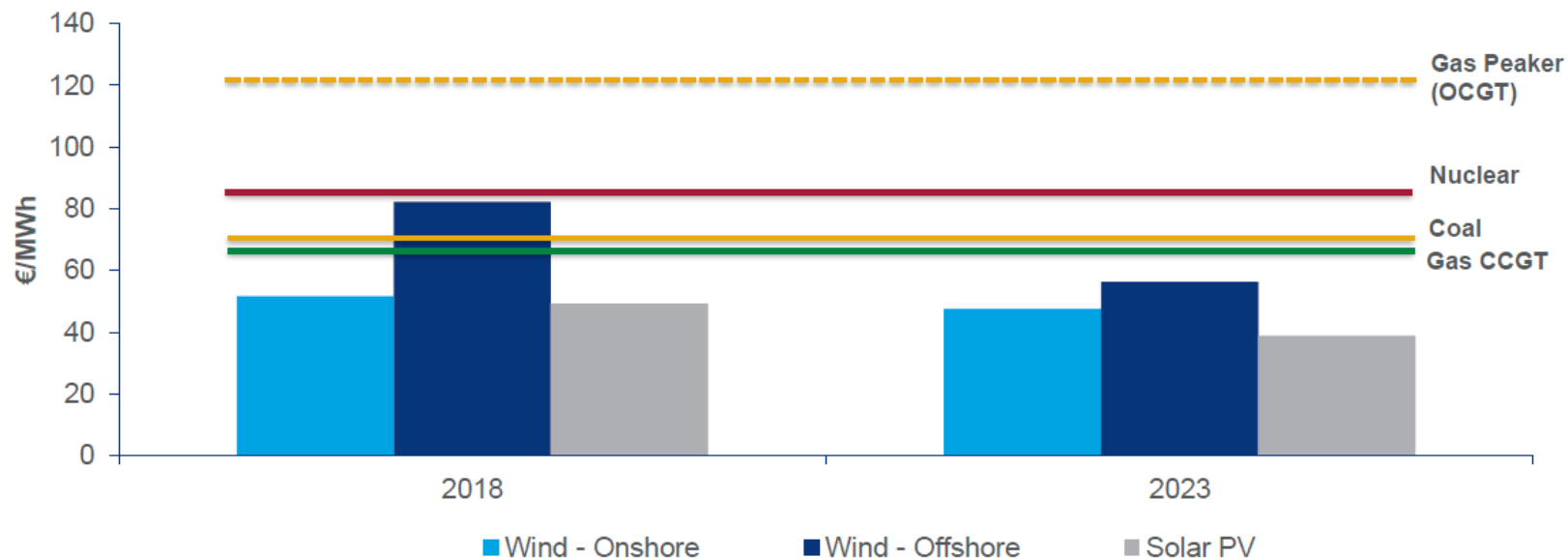
Levelized cost of energy, \$/MWh



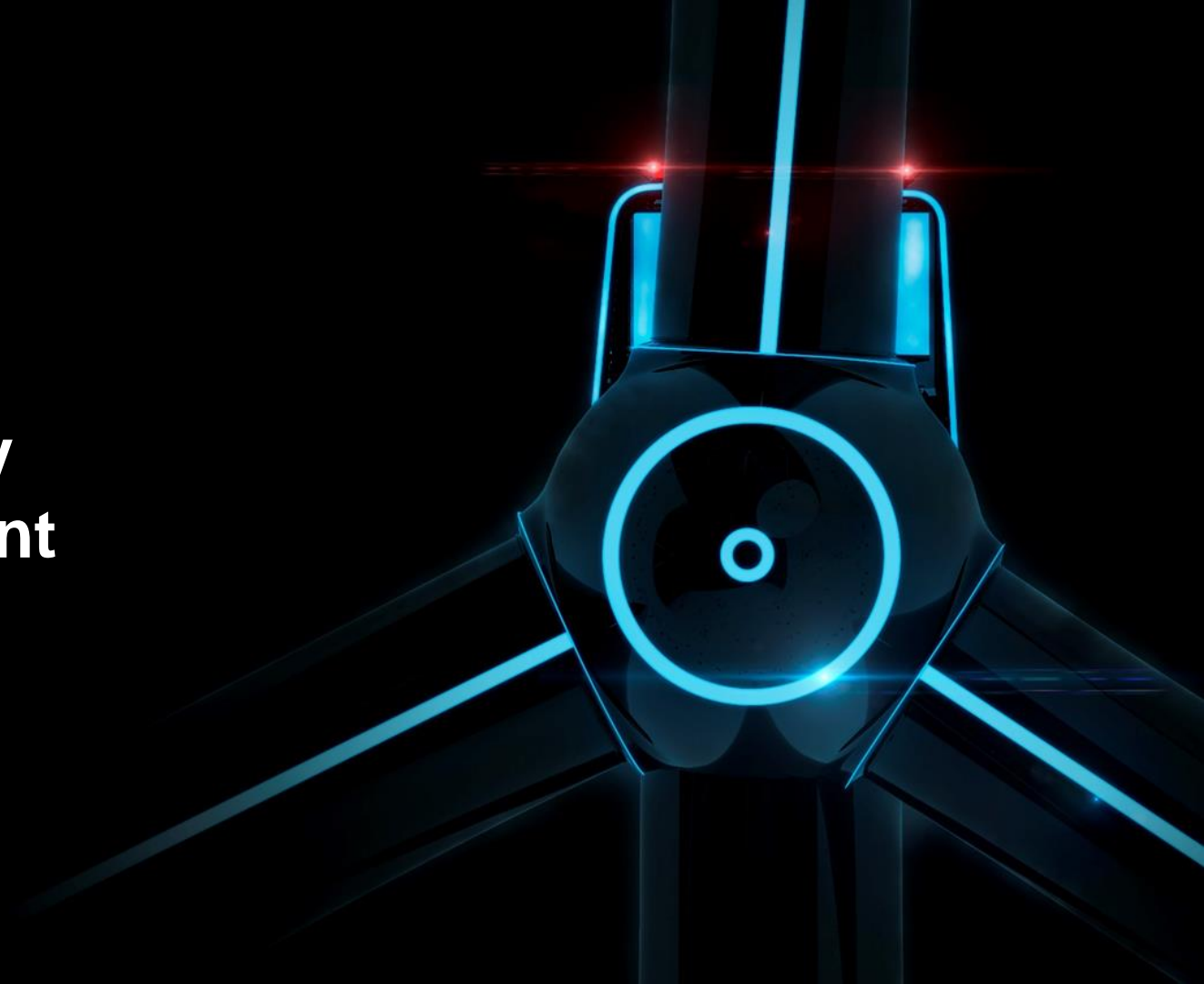
- ▶ Onshore and offshore wind are getting more and more and cost-competitive.
- ▶ Reduction are mainly driven by declining wind turbine prices and increased power output.

And wind will be even more cost competitive in the future

Levelized cost of electricity



**Technology
development**



Onshore wind technology are more powerful than ever before



- ▶ The reduction in cost of energy is driven by technological progress and scale

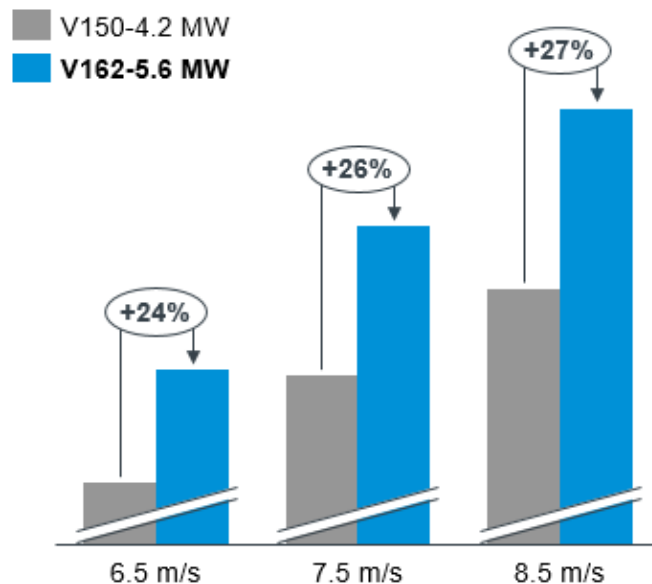
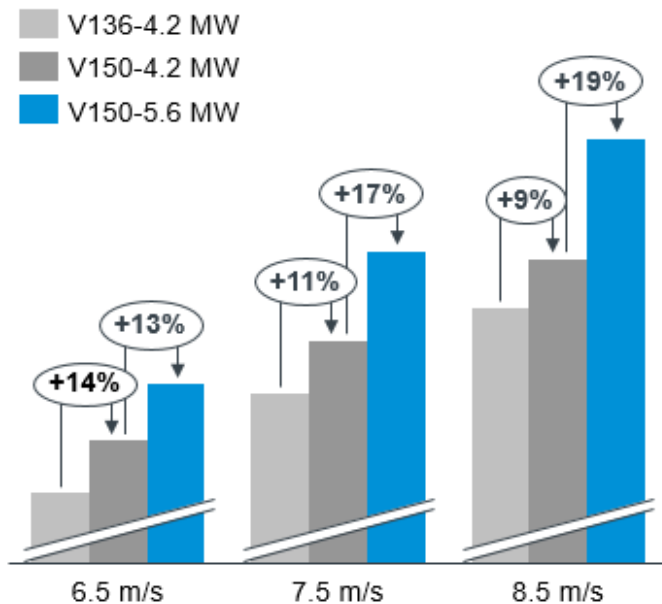


- ▶ Taller turbines with longer blades capture more wind and can support more powerful generators

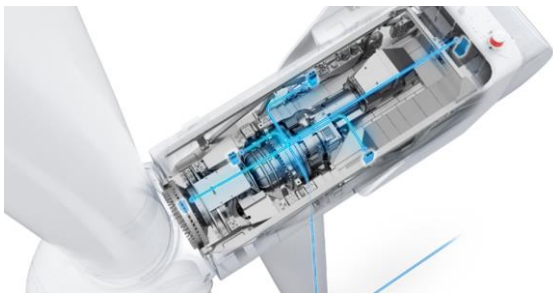
Larger turbines for increased energy production

- Double-digit energy production improvements in low and medium wind speed conditions

Energy Production*



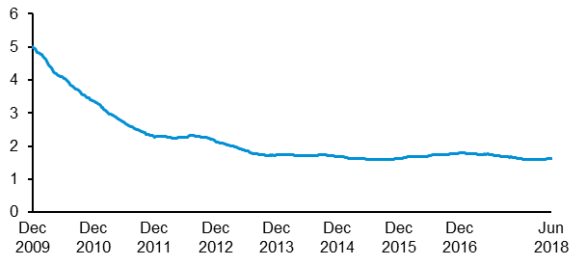
Reliability and data



Vestas applies learnings from 33,000 WTGs worldwide to deliver quality products, world-class siting capabilities, and maintenance.

Lost Production Factor (LPF)

Percent



Turbines under surveillance feed back **data** to the rest of Vestas value chain

PRODUCT DESIGN

Data
is the fundamental prerequisite for a design life of 20+ years

VALIDATION TESTING

Data
ensures that accelerated lifetime simulations on key components are as realistic as possible

PROJECT SITING

Data
enables siting to optimise component loads and production

SOURCING & PRODUCTION

Data
ensures that the most significant CtQs (critical-to-quality) are thoroughly managed in manufacturing

OPERATIONS & MAINTENANCE

Data
allows us to (through condition monitoring) implement timely predictive maintenance, thereby minimising lost production

Lessons learned from Europe



Lessons learned



Onshore wind

- Investing in **wind energy is a safe bet**. Not only from a climate change perspective, but also from a pure cost perspective.
- Onshore wind is today among the **most cost-efficient power generating technologies**, mainly due to declining wind turbine prices, O&M optimisation and increased power output.
- National and local **planning frameworks** have spurred growth in onshore wind strengthening European energy security.



Offshore wind

- Offshore wind is not onshore wind. It requires a **larger, stronger and different infrastructure** in order for offshore to realise its full potential.
- Wind maps, seabed conditions, infrastructure, **supply chain**, ports, ships and manufacturing centres, to support construction and maintenance activities, are key enablers for the industry.
- In order to accelerate the build out, arrive at scale and hence the pace of cost reductions, **long term market visibility** and early planning is key.

In conclusion

- 1 Wind is today mainstream and cost competitive
- 2 Technology, data and scale are driving down cost
- 3 Long-term and predictable policy frameworks as well as system flexibility will be key to get the best out of wind



Vestas[®]

Wind. It means the world to us.[™]

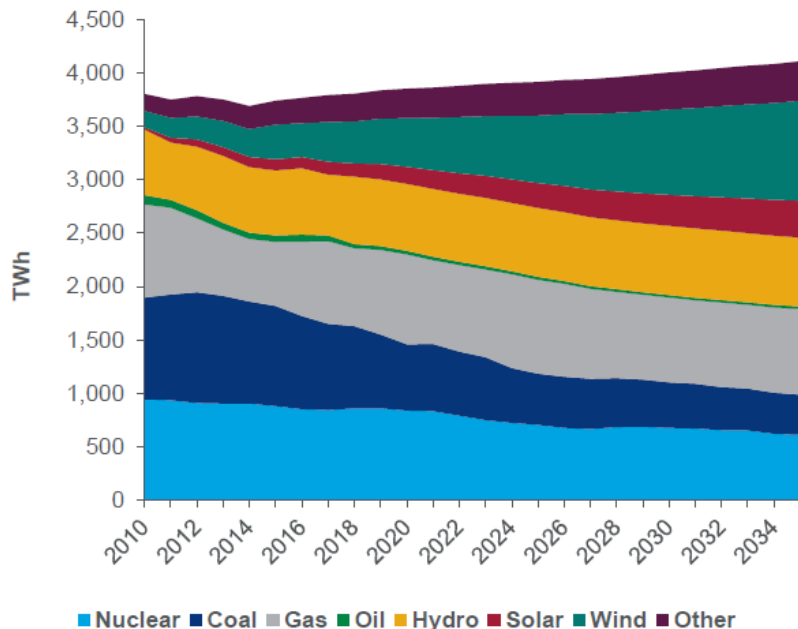
Thank you.

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Transformation of European power

Europe power supply mix



Key outcomes

Coal 		<ul style="list-style-type: none"> Coal phase-out policies enacted by national governments High coal and carbon prices continue to challenge
Nuclear 		<ul style="list-style-type: none"> Persistent operational issues Accelerated plans to remove capacity across several markets New-build delivery & cost risk point to downside
Renewables 		<ul style="list-style-type: none"> Despite reduction/removal of subsidies, cost reductions and competitive markets allow subsidy-free renewable to become a reality
Gas 		<ul style="list-style-type: none"> Lower coal and nuclear output offset more bullish renewables Loss of coal capacity narrows the coal-to-gas switching range – offering more certainty for gas

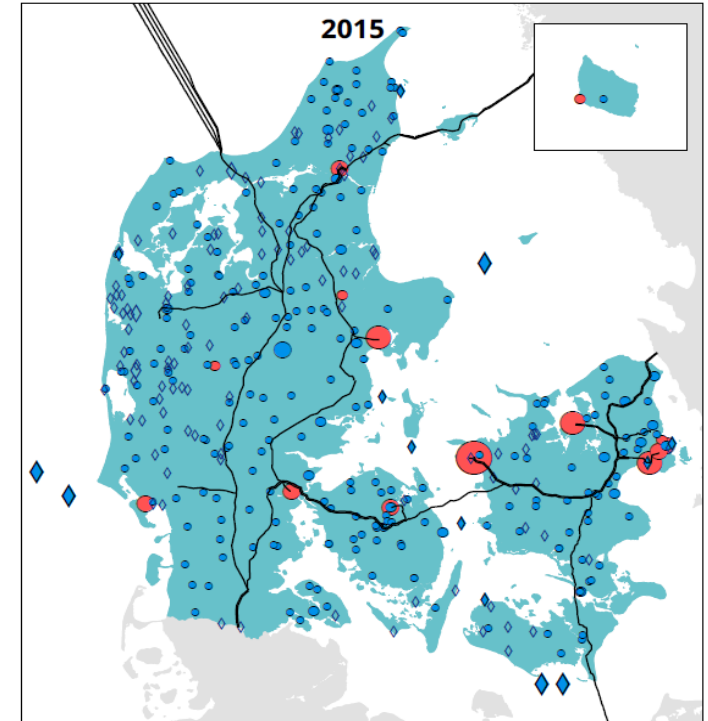
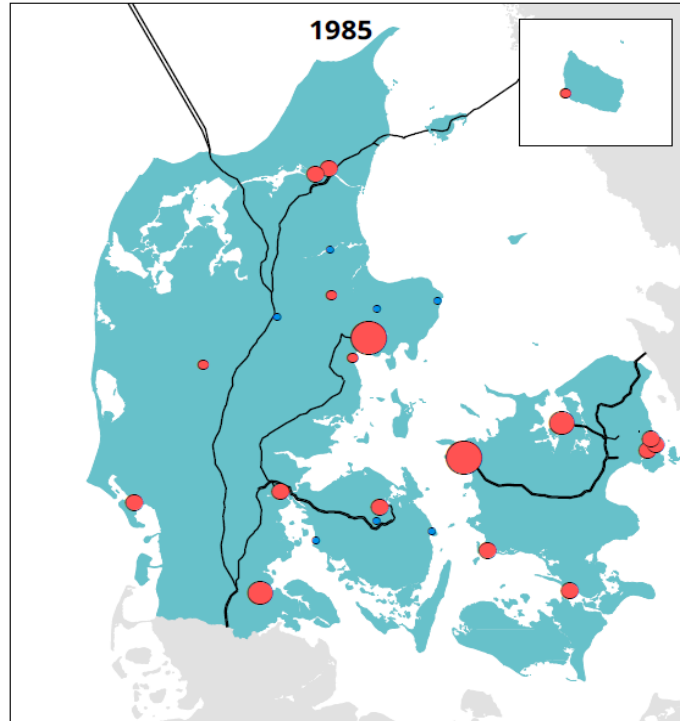
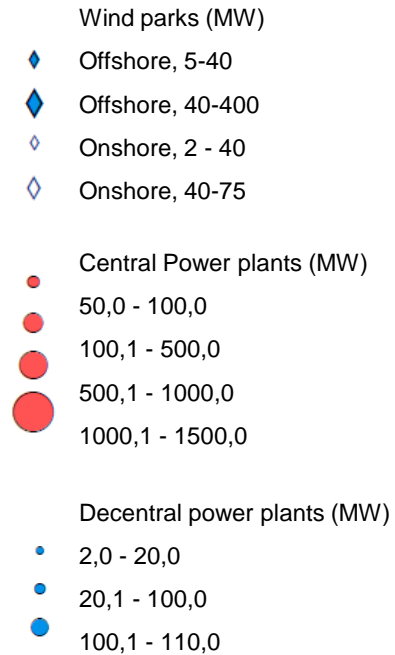
Offshore wind is gaining momentum



- ▶ The cost of generating electricity through wind off the coast of Europe, the one region where the industry has gained critical mass, has decreased sharply.
- ▶ Increased energy production per wind turbine will add greater value for many projects and save on capital expenditure (CAPEX) costs as fewer machines will be needed to meet the park capacity.

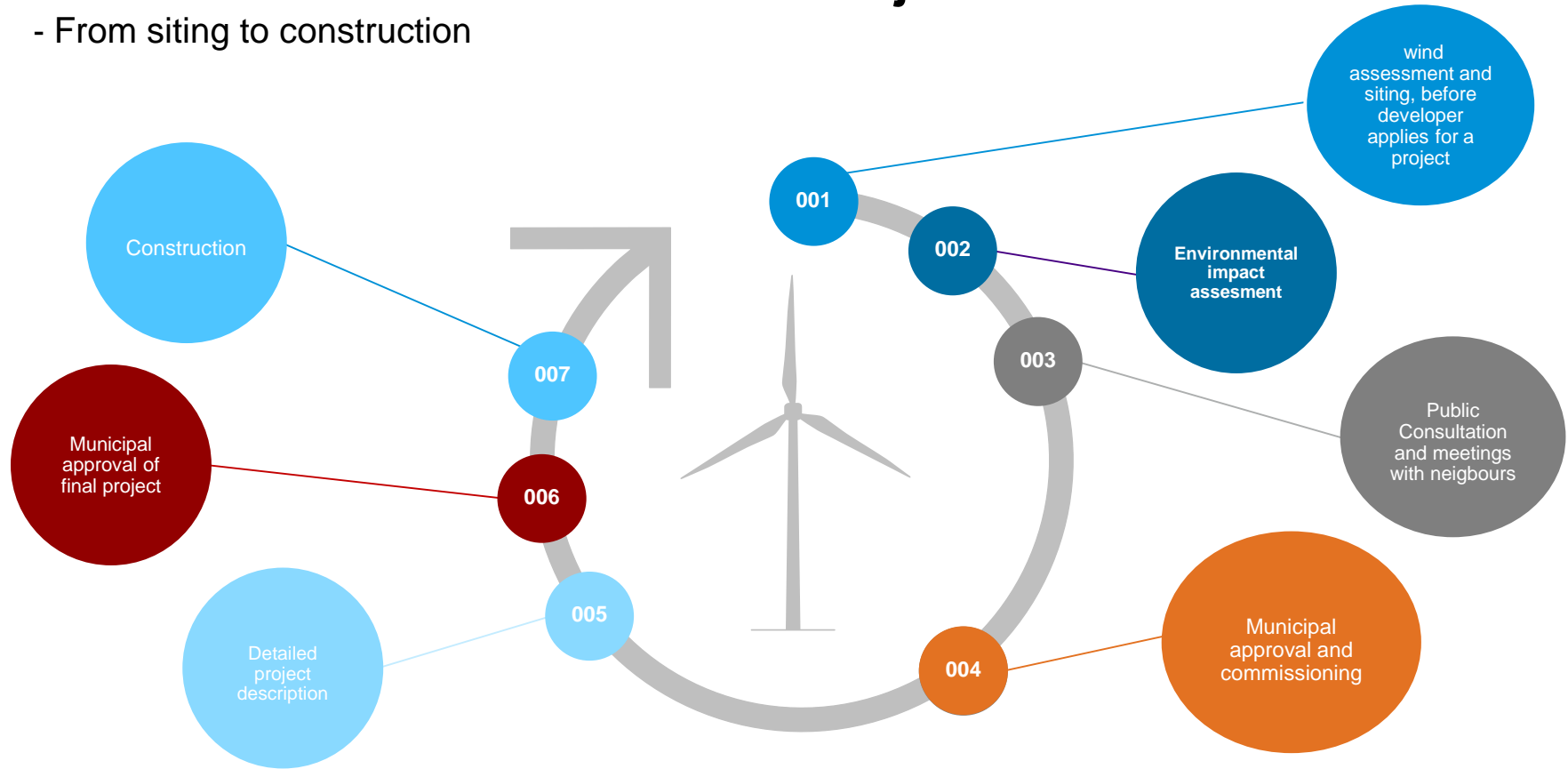
Renewable energy system integration

- from centralized to decentralized power generation



Proces for a Decentralised Wind Project in Denmark

- From siting to construction



Framework for Environmental assessments in Denmark

Environment and Landscape

Large and uniform landscapes will usually be more suitable for large wind turbines. Regarding nature and environment it should be underscored that wind power is a clean way to produce electricity as there are no fuel emissions during operation.

Local Wind Assessment

Regardless the type of landscape – experience shows that any location requires customized planning including tailored wind farm patterns.

Shadow effects

A minimum distance to housing in the regulation reflects the visual impact of the wind turbines (shadows and flicker effects).

Noise

The developer must demonstrate that the limits for noise in habituated areas are met before the wind turbines can be set up

Framework for Community engagement in Denmark

- **4 Schemes to ensure public engagement**
- Local citizens' option to purchase wind turbine shares
- Guarantee fund to support financing of preliminary investigations by local wind turbine cooperatives.
- Compensation for loss of value to neighbouring real estate.
- Green scheme to enhance local scenic and recreational values.



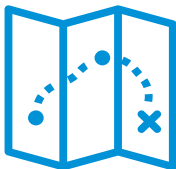
Recommendations

-Based on the Danish Case



Grid planning

- Timely planning
- Fair and balanced cost-sharing framework for grid connection of wind turbines.



Siting and Environment

- Consider designating areas to wind turbines through a local planning process with due consideration to optimal wind, distance to neighbours etc
- Cluster wind turbines in the landscape by placing them in wind farms



Public engagement and acceptance

- public consultation early stage of a project proposal.
- Consider incentives and measures to sustain or increase public acceptance.

Wind creates local jobs

- A wind project is a large investment in local jobs, even without local content requirements

- A considerable part of a wind farm investment will always create local jobs (civil works, cabling, O&M etc.)
- The size of components is in itself a driver to localize manufacturing
- Vestas will hire local staff to do service and maintenance

