Offshore Wind Energy Development in Germany – Historical Overview, Current Challenges and Lessons Learnt

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German Offshore Wind Energy Foundation

Paris, 18 Oct. 2016

STIFTUNG OFFSHORE WINDENERGIE

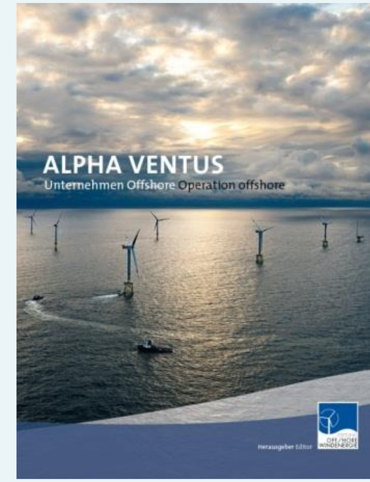
German Offshore Wind Energy Foundation
Stiftung OFFSHORE-WINDENERGIE

- Founded in 2005 as an independent, non-profit organisation to promote the utilization and research of offshore wind in Germany
- Acquisition of **ownership rights (permit) of alpha ventus** – moderated/accompanied process of Germany‘s first OWF
- Platform for **offshore wind/maritime industry**, incl. **trade associations, policy-makers and R/D**
- Involved in various **projects** (EU and national), e.g. **OffWEA** - consultation, support, moderation of the Geman government (2011-14);
  PROMOTioN (Horizon 2020), and
  Baltic InteGrid (Interreg-Programme)

Pioneering project *alpha ventus (test site)*

First Offshore Wind Farm (OWF) in Germany,
Paving the way for commercial projects

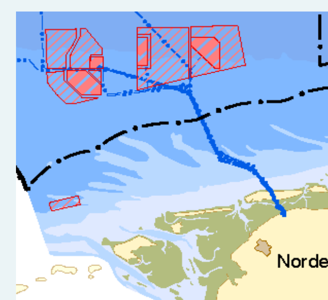
- 60 km distance to shore, 30 m water depth
- First OWF with 5 MW class (12 turbines) → 60 MW
- 2 turbine manufacturers (AREVA/Multibrid, REpower)
- 2 types of foundations (tripods, jackets)



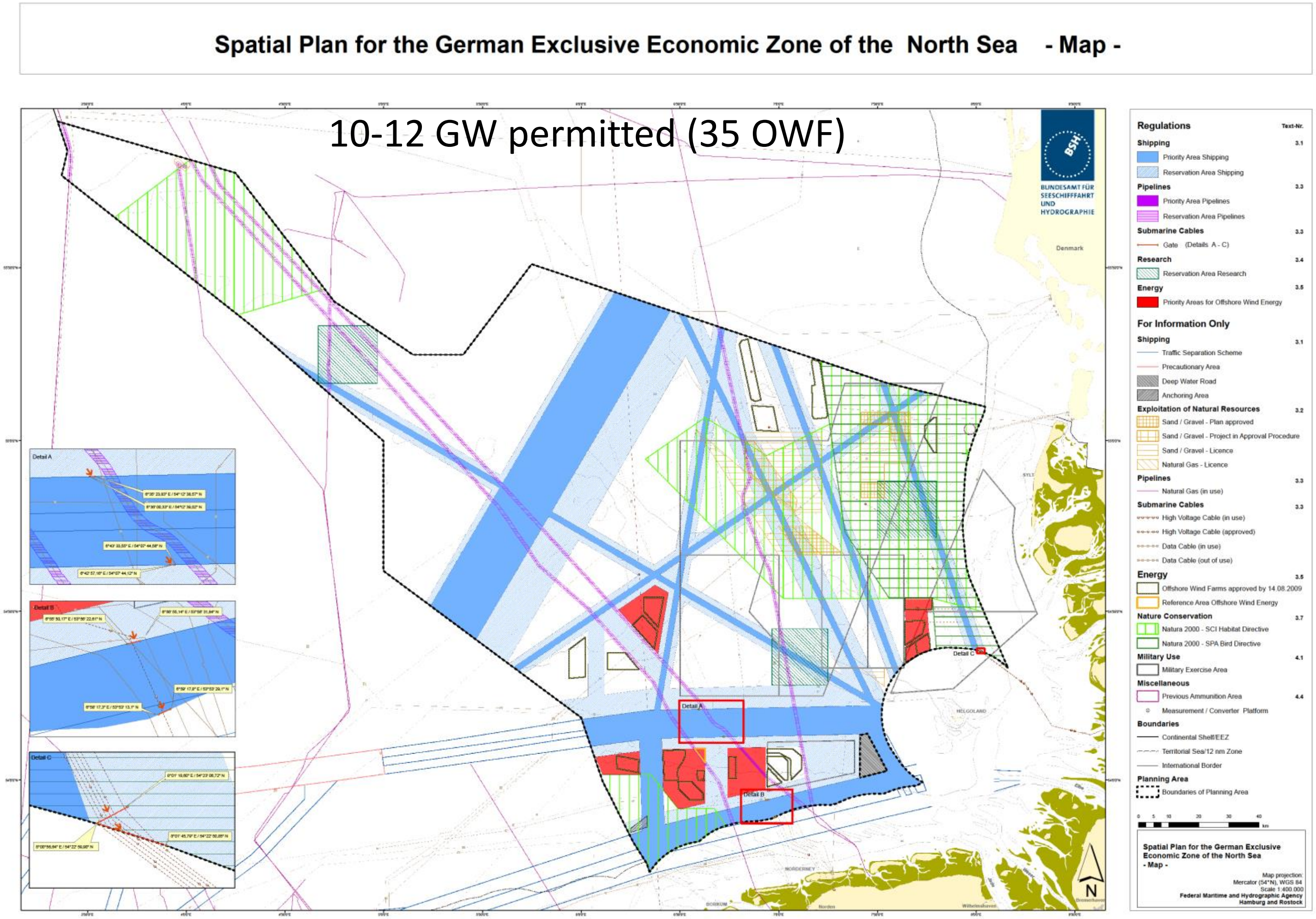
- Permits acquired by SOW in 2005
- Leased to DOTI end of 2006 (EWE, E.ON, Vattenfall)
- Construction start in 2008, **commissioning in 2009/10**

- Impressive operational results – **50 % capacity factor** (4,450 full load hours) > **1 TWh** electrictiy production by 2014

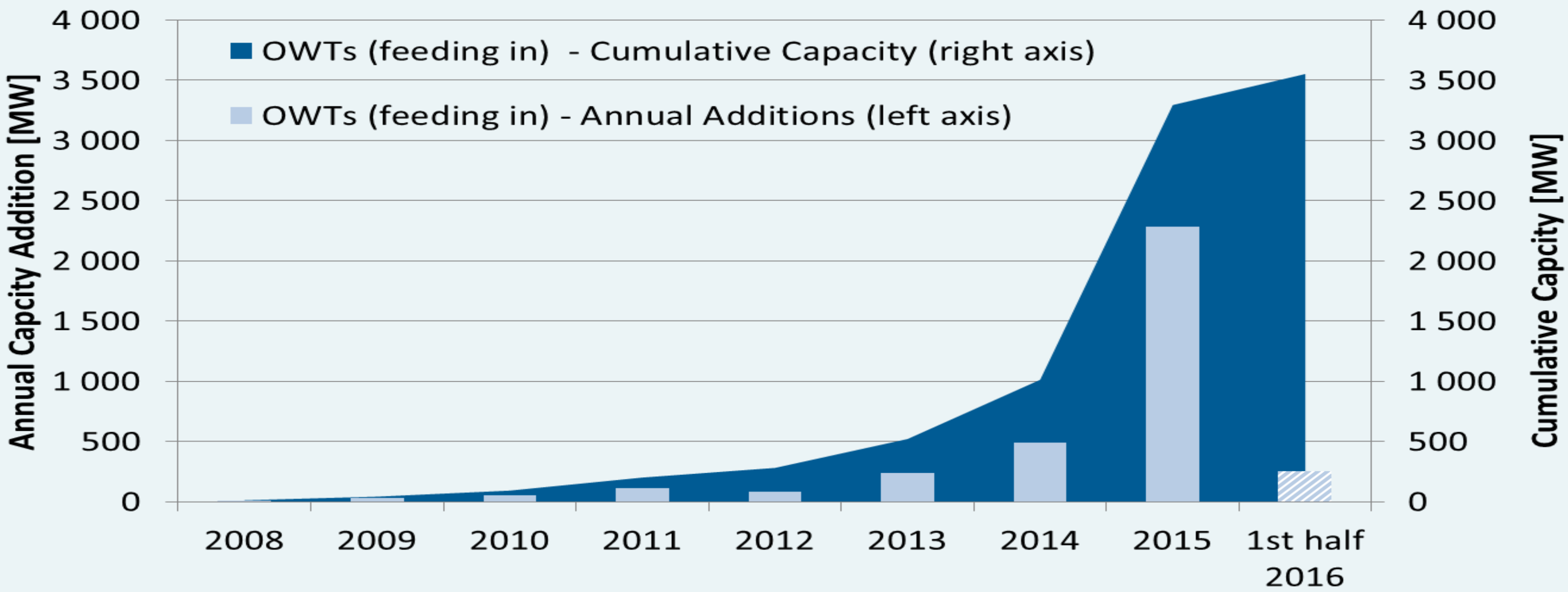
- RAVE – Research at alpha ventus
  Extensive ecological and technological R&D Program funded by the German government (50 Mio €)



MSP – German EEZ (North Sea)



TURBINES FEEDING INTO THE GRID
(AS OF 30 JUNE 2016)



Status of German Offshore Wind Development
Status 30 June, 2014

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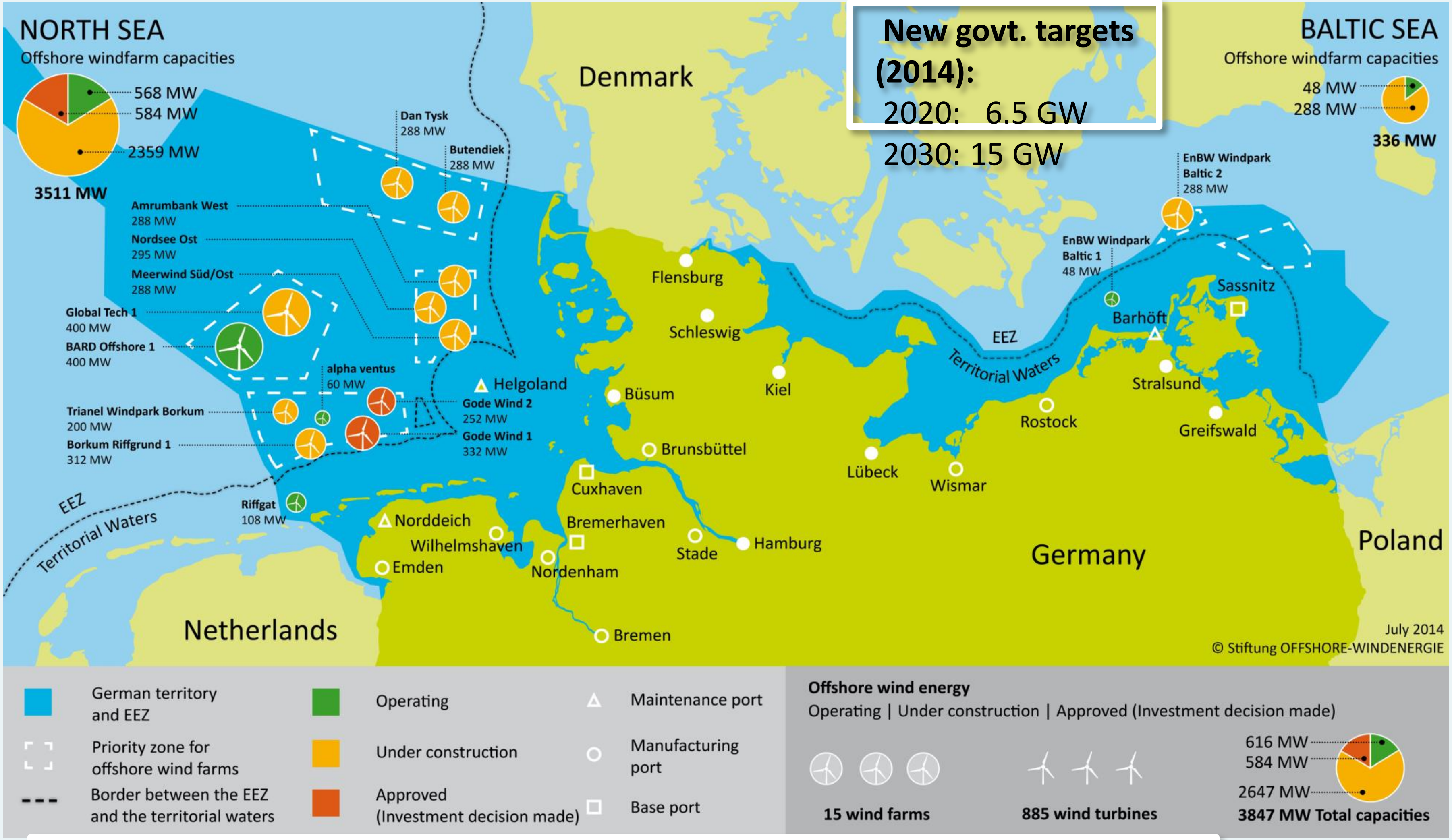
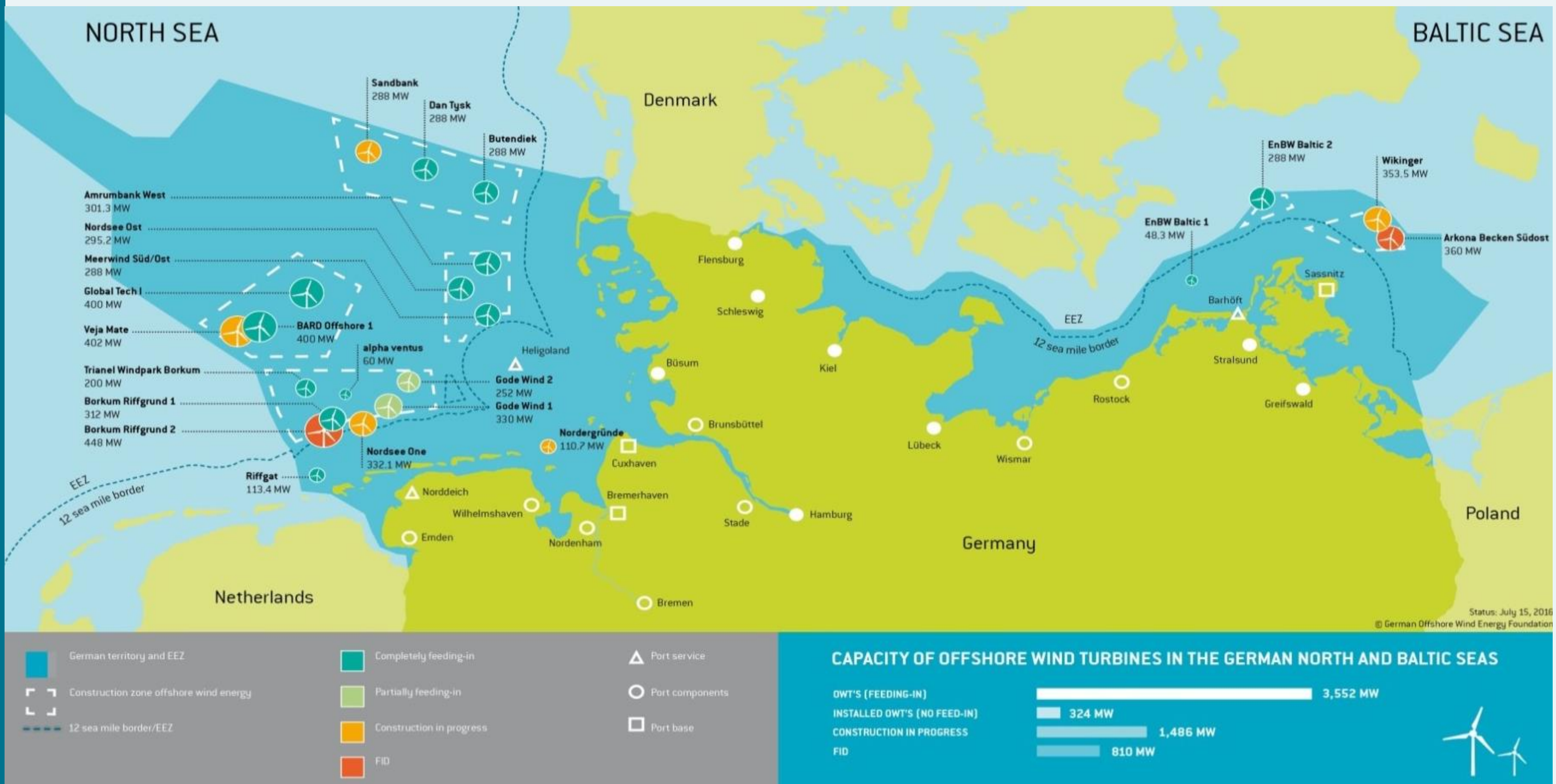
New govt. targets (2014):
2020: 6.5 GW
2030: 15 GW



> 1 GW online by 2014, > 3 GW by 2015

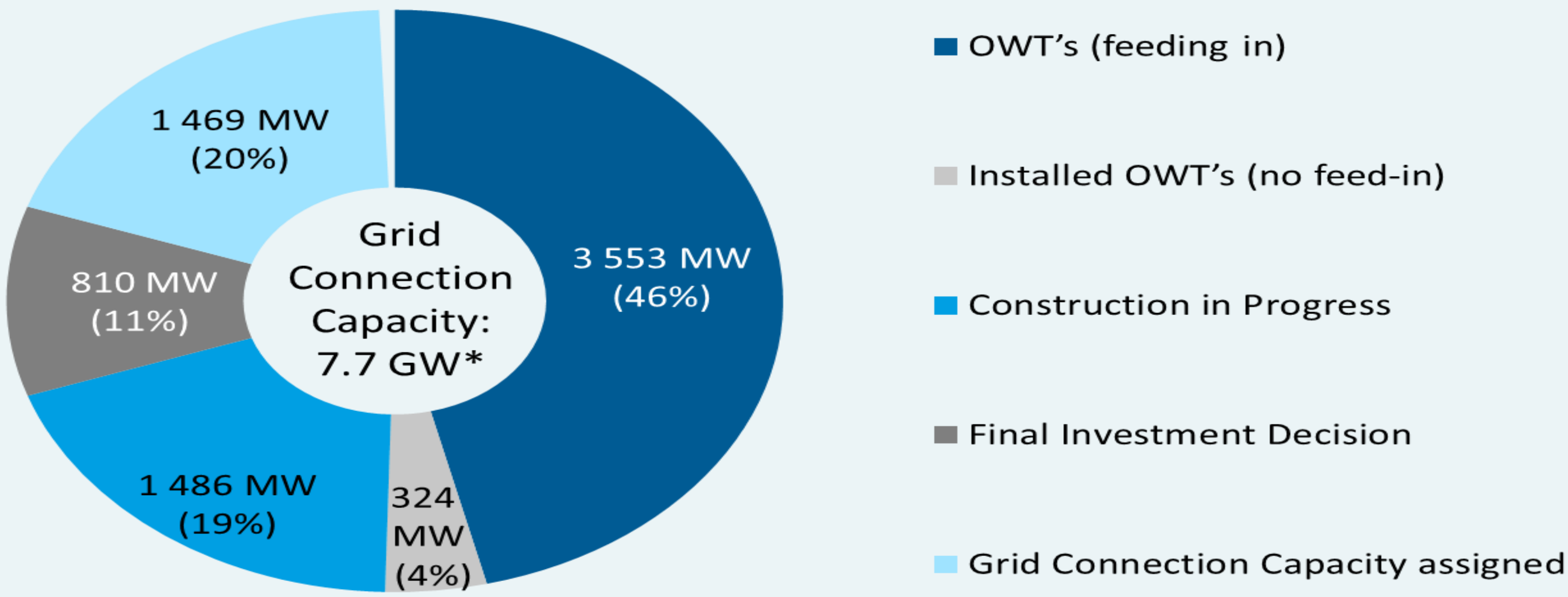
OFFSHORE-WIND FARMS IN GERMANY
STATUS BY 30 JUNE, 2016



OFFSHORE WIND ENERGY DEVELOPMENT BY 30 JUNE 2016

	Status of Offshore Wind Energy Development	Capacity [MW]	Number of OWT
Additions 1st half 2016	OWT's (feeding in)	258.0	43
	Installed OWT's (no feed-in)	312.0	52
	Foundations w/o OWT		76
Cumulative (2016-06-30)	OWT's (feeding in)	3 552.22	835
	Installed OWT's (no feed-in)	324.00	54
	Foundations w/o OWT		142

OFFSHORE WIND IN GERMANY – POLITICAL DEVELOPMENT TARGET FOR 2020, INCL. ASSIGNED GRID CONNECTION CAPACITY



*Due to differences between the installed or planned capacity of offshore wind projects and the assigned grid connection capacity the sum of the projects does not reach exactly 7.7 GW.

PRESENT OFFSHORE TURBINE CONFIGURATIONS

Average Turbine Configuration of OWT (feeding in)	Additions 1st half 2016	Cumulative (2016-06-30)
Average Nameplate Capacity	6 000 kW	4 254 kW
Average Rotor Diameter	154 m	121 m
Average Hub Height	110 m	90 m

EEG 2014/2017 – *Support instrument*

Current Remuneration Scheme (based on FITs)

- Offshore wind energy producers can chose between the basic model and the acceleration model. The latter is valid until the end of 2019 (final commissioning date for an OWF).
- The **basic remuneration is set at €0.039/kWh** only (for a period of 20 years).
- Under **basic model** the **initial tariff is €0.154/kWh for at least 12 years**. This may be extended given a water depth of more than 20 meters and a distance to shore of more than 12 nautical miles.
- **Initial tariff** under the **acceleration model is €0.194/kWh for the first eight years** of operation. extension conditions apply, only the initial tariff of basic model is paid in extension period.
- Degression component for offshore wind farms is built into the law. Initial tariff under acceleration model is reduced by €0.01/kWh for all projects which go online after 31st Dec. 2017.
- Under the basic model, the degression is €0.005 as of 1st Jan. 2018, and another degression of €0.01 as of 1st Jan. 2020 (para 30 of the EEG)2014.

EEG 2017 – *Support instrument*

Flexible market premium

- Electricity generated from OWF is remunerated via a flexible market premium on top of the spot market price, has to be sold directly at the electricity market
- All forms of EEG remuneration is granted through 20 year-contracts.
- OWF which are commissioned until the end of 2020, and which have grid connection guaranteed by the regulator, are eligibile of the FIT, according to the EEG2014.

Negative prices:

- The remuneration level reduces to zero, if the hourly contracts in the day-ahead auction at the EPEX-Spot are negative for at least six consecutive hours. This does not apply for wind energy projects (WEPs) with an installed capacity < 3MW, nor for pilot-WEPs (on- and offshore).

EEG 2017 –
Offshore targets and installation trajectories by 2030

- Target for total capacity is 6.5 GW (2020) and 15 GW (2030)
- +1.2 GW buffer for offshore grid capacity will be completely exploited by 2020
- Total capacity by 2020 may potentially grow to a max. of 7.7 GW
- New installation trajectory for 2021 – 2030 is based on the differential of a maximum volume of 7.7 GW by 2020, and 15 GW by 2030
  → a total of 7.3 GW during the decade until 2030, equals an average of 730 MW/yr from 2021-2030
- Offshore wind tender volume was reduced to 500 MW in 2021 (exclusively in Baltic Sea) and 500 MW in 2022 (up to 50 % for Baltic Sea), plus 700 MW per year during 2023-2025, and 840 MW per year during 2026-2030
- The political reasoning for reducing short and medium term ambitions for offshore wind lies in a better synchronisation of onshore grid expansion and offshore wind development.
- Offshore wind industry called for at least 900 MW/a for cost reduction and industry targets.

EEG 2017 – *Support instrument*

Allocation mechanism – tenders

Responsible authority: BNetzA (electricity regulator) organising the tenders

Auction volume and rounds:

- Two auction rounds will be organised for OWF for the transitional period (2021-25).
- Eligible projects are all OWF in Cluster area 1-9 (EEZ North Sea), in Cluster area 1-3 (EEZ Baltic Sea) which have received a permit, or can prove an advanced application state prior to 1st August 2016. This includes those projects in coastal waters with a similar permitting status.
- The first auction in transition phase is scheduled on 1st March 2017, second auction on 1st March 2018.
- Each of the two tenders will have a volume of 1.550 MW.
  This equals a total of 3,100 MW tendering capacity during the five-year transitional period until 2025. On average, this is only 620 MW per year

EEG 2017 – *Support instrument*

Allocation mechanism – tenders

- Only 500 MW will be granted to OWF commissioned in 2021 (in the Baltic Sea only), and in 2022 respectively.
- The calls for tenders have to be announced by the electiricty regulator (BNetzA) at least 8 weeks prior to the tendering dates.
- For OWF which will be commissioned **from 2026 onwards**, a new so-called **'Central Model'** (similar to the Danish tendering approach) will be introduced with an annual capacity foreseen of 840 MW. The first call for tenders under the Central Model is scheduled on 1st Sep. 2021.
- BSH, is developing a so-called **Flächenentwicklungsplan (FlEP)**, Site development plan) for the EEZ under the 'Central Model'.
  The first FlEP has to be published until 30 June 2019, after stakeholder consultation, and following prior agreement with BNetzA and TSOs.
  It contains information on the areas to be tendered between 2026 and 2030.

EEG 2017 – *Support instrument*

Allocation mechanism – tenders

Bid size: dependent on the available grid capacity. One bidder can submit more than one bid per auction round, but not for the same project.

Tendering subject: remuneration level/price per kWh

Awarding procedure and criteria: "Pay as bid", lowest price wins.
Awards and support licenses must not be transferred to other projects.
Maximum awarding price for offshore wind is 12 ct/kWh in the first auction (03/2017). Provisions for further measures may be taken by the BNetzA if deemed necessary.

Prequalification criteria:
A financial security of 100 EUR/kW of planned installed capacity has to be deposited for bids during the transitional period.
For auctions under the 'Central Model', starting in Sep. 2021, a financial security of 200 EUR/kW is foreseen. Bids who don't win in the auction will be reimbursed by BNetzA immediately after the results of the auctioning have been published.

EEG 2017 – *Support instrument*

Allocation mechanism – tenders

Penalty regime:

- Realisation period for the OWF is set by the BNetzA, dependent on the completion date of the offshore grid connection

Special regime for pilot offshore wind installations:

- First three of a new and innovative offshore wind installation, i.e. turbine or foundation
- Maximum of 50 MW/year can be granted to a pilot scheme during transitional period (2021-25)
- Eligible to receive the maximum price of 12 cents/kWh during the first auction round, if commissioned between 1st Jan. 2021 and 31st Dec. 2025.
- Grid capacity for the pilot installation is awarded by BNetzA (electricity regulator).

EEG 2017 – *Support instrument*

Allocation mechanism – tenders

Lack of differentiated remuneration:

Under the EEG2017 (WindSeeG), no more differentiation of remuneration is foreseen for water depth or distance to shore.

Lack of financial compensation:

Permitted or advanced projects which have not won a contract in the transitional tendering rounds (2017 and 2018), are not eligible for any financial compensation. Some market players have already indicated to take legal measures against this provision.

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Talking about Cost Reduction …
Costs, what kind of Costs?

- Technology progress
- Efficiency
- Economies of scale
- Standardisation
- Competition
- Supply Chain
- Water depth
- Distance to shore
- Availability and load factor
- Reliability
- Planning delays
- Finance availability and cost
- Exchange rate impacts
- Commodity prices
- Permitting and regulatory cost
- …

DEVEX
CAPEX
OPEX
DECEX

AEP

LCOE

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Cost Reduction Roadmaps – UK, Germany

Cost reduction pathways TCE, 2012 (LCOE vs. Time/Capacity)

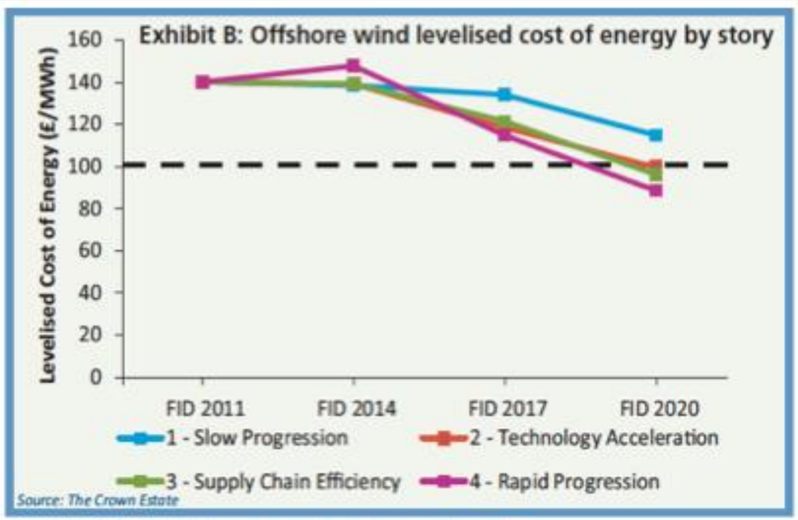
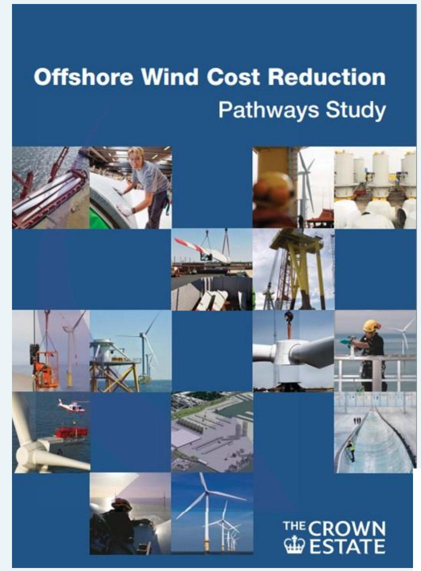
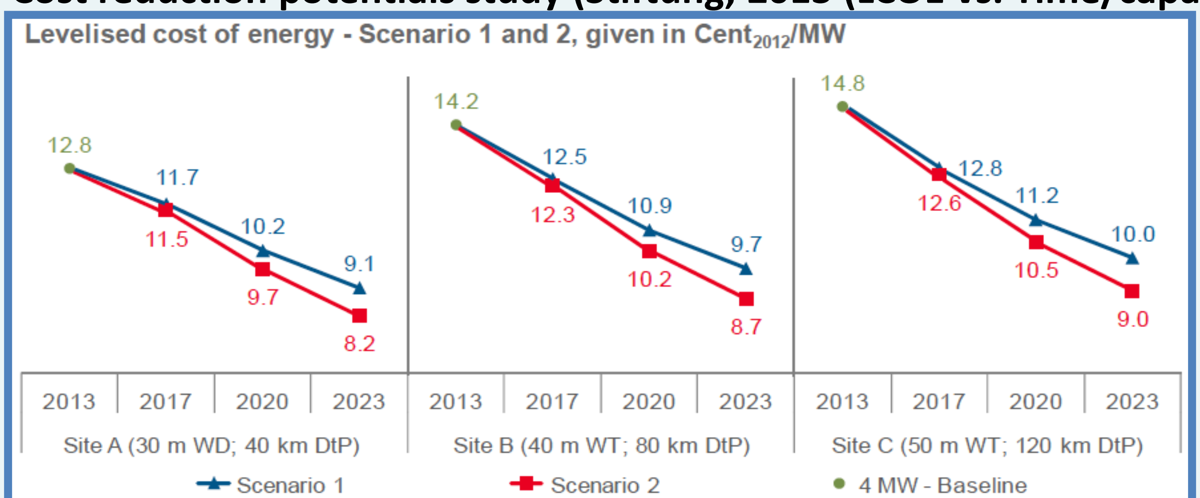


Figure 7, Pathway cost reduction scenarios TCE



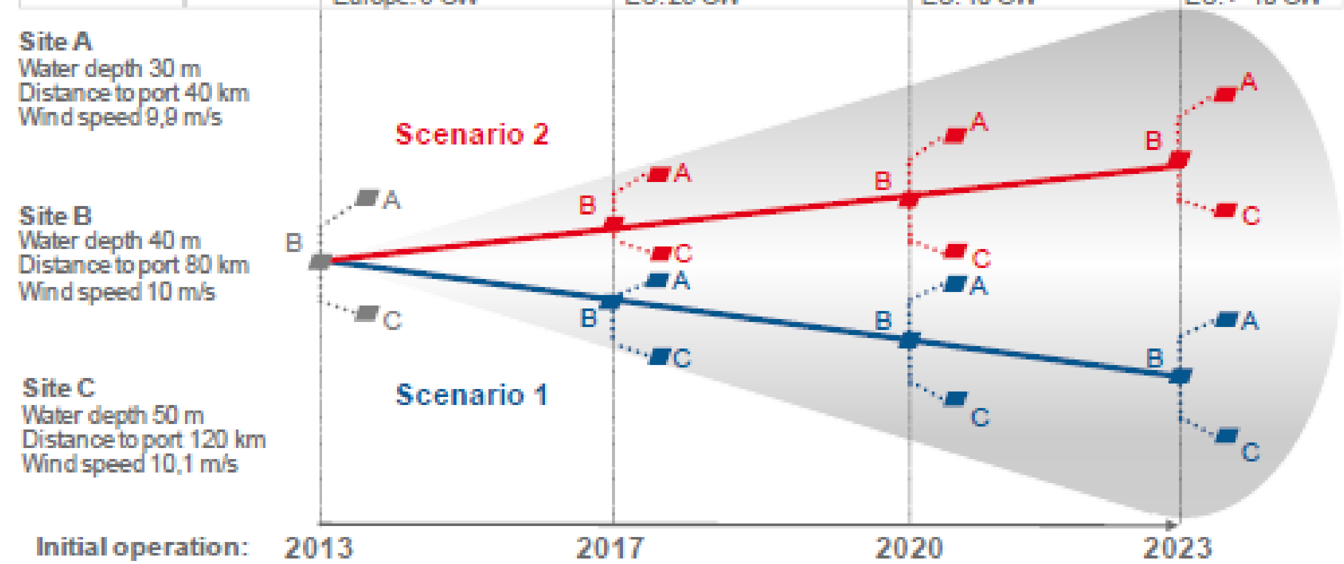
Cost reduction potentials study (Stiftung, 2013 (LCOE vs. Time/capacity)



Prognos/Fichtner scenario assumptions

Scenario definition

		2013	2017	2020	2023
Installed capacity	Scen. 1	Germany: 0,6 GW* Europe: 6 GW	GER: 3,2 GW EU: 13 GW	GER: 6 GW EU: 20 GW	GER: ≥ 9 GW EU: > 20 GW
	Scen. 2	Germany: 0,6 GW* Europe: 6 GW	GER: 5-6 GW EU: 25 GW	GER: 10 GW EU: 40 GW	GER: ≥ 14 GW EU: > 40 GW



Source: [Prognos / Fichtner]; * expected installed capacity by the end of 2013

2 growth scenarios at 3 sites (North Sea)

Plant and wind farm configuration in the two scenarios

	Scenario 1					Scenario 2				
Initial operation	Number WTG	Capacity WTG	Size wind farm	Hub height	Rotor diameter	Number WTG	Capacity WTG	Size wind farm	Hub height	Rotor diameter
2013	80	4 MW	320 MW	90 m	120 m	80	4 MW	320 MW	90 m	120 m
2017	75	6 MW	450 MW	100 m	145 m	75	6 MW	450 MW	100 m	145 m
2020	75	6 MW	450 MW	100 m	154 m	56	8 MW	450 MW	110 m	164 m
2023	75	6 MW	450 MW	105 m	164 m	56	8 MW	450 MW	115 m	178 m

Source: [Prognos / Fichtner]; WTG = Wind Turbine Generator

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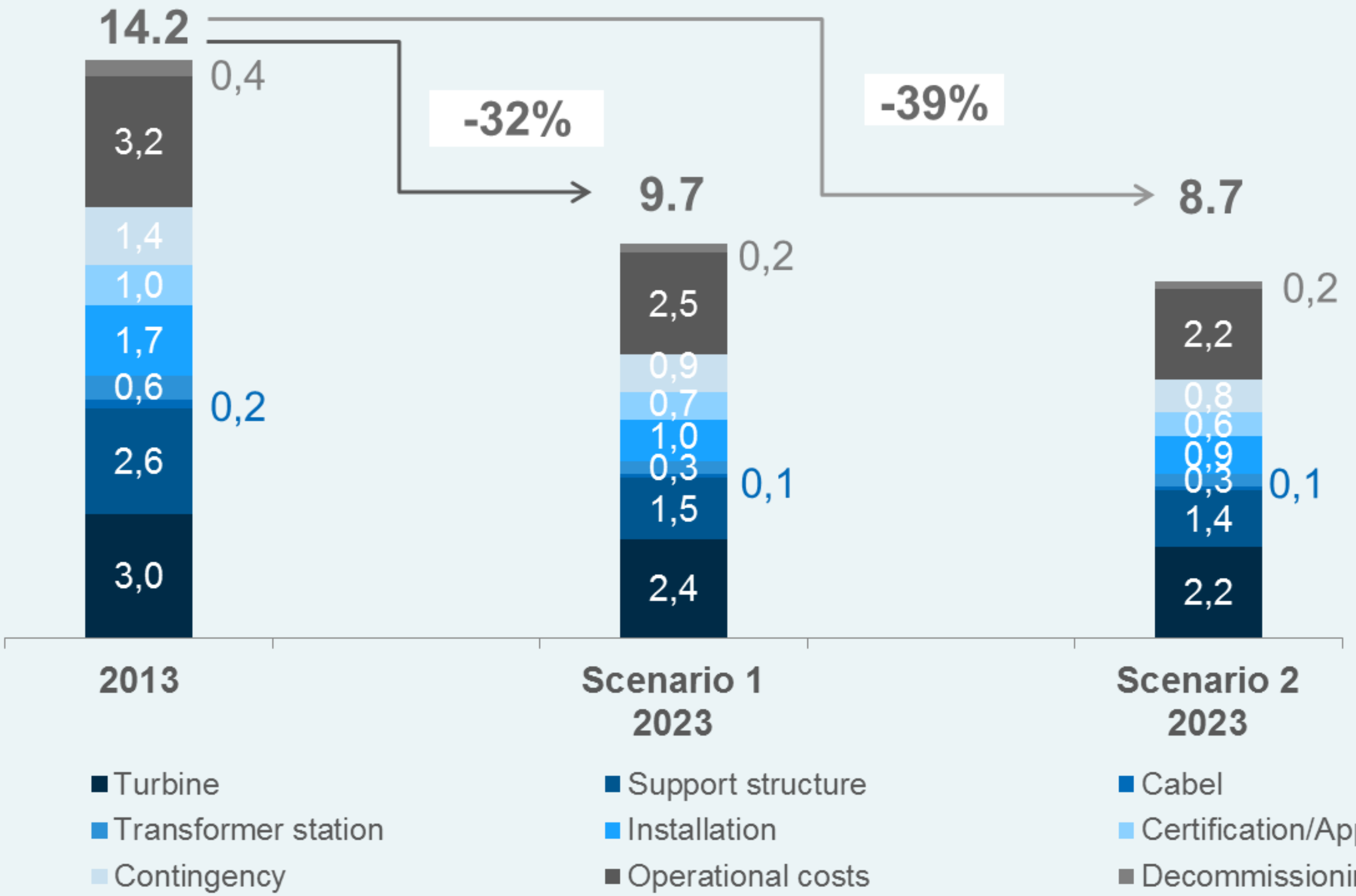
Cost Reduction Potentials for Offshore Wind in Germany

Site B, results in €cent/kWh, based on 2012 real terms



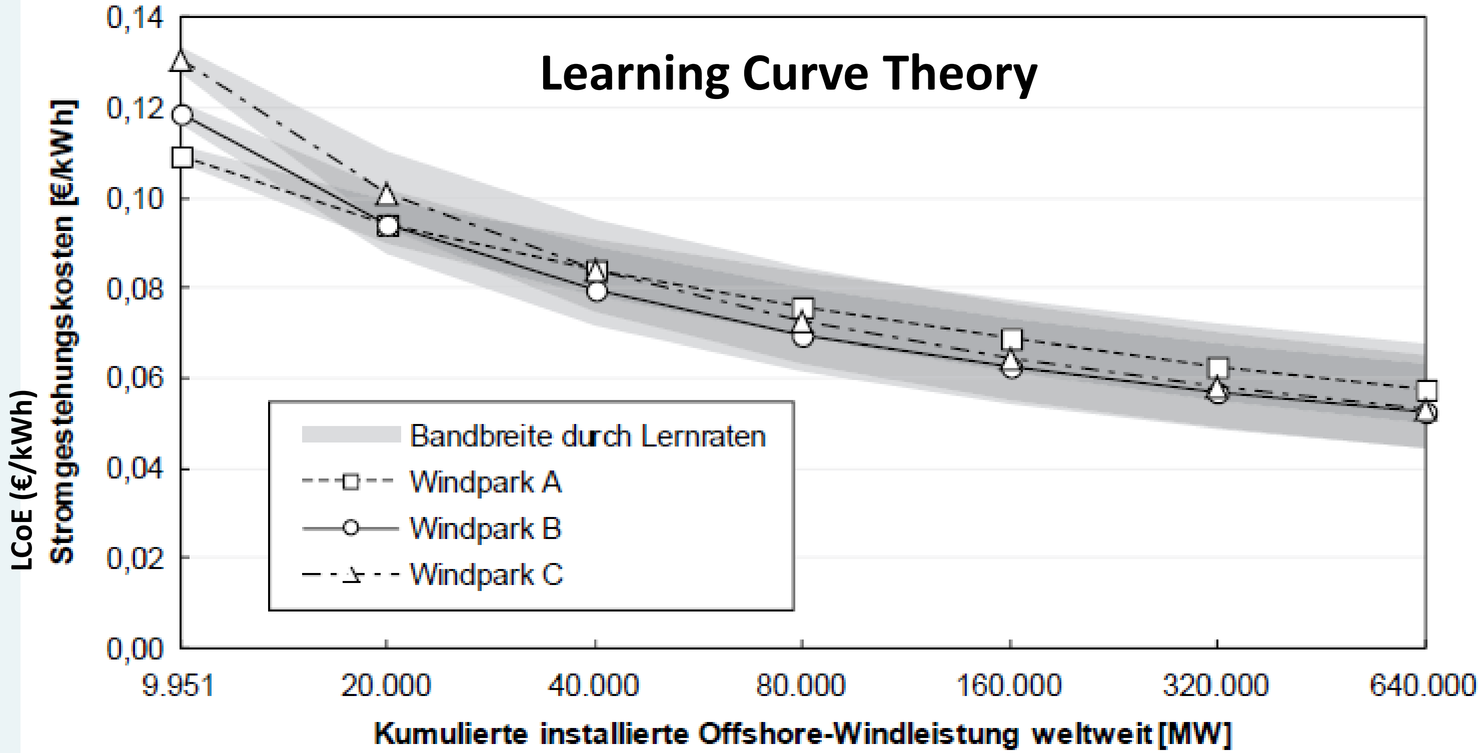
- Decommissioning
- OpEX
- Contingency
- Certificat./Approval
- Installation
- Substation
- Internal cable
- Support structure
- Turbine

© Prognos/Fichtner, 2013

Learning Curve Effect stimulated by ***constant market growth***

→ Economies of scale, increasing competiton and growing turbine size

Cost Reduction Roadmaps



Cumulated installed offshore wind capacity globally (MW)

LCOE related to installed capacity

Learning ratio: Percentage of cost reduction when doubling capacity *C*

$$LCOE\ (C_1) = LCOE\ (C_0) * \left(\frac{C_1}{C_0}\right)^{-b}$$

Learning ratio = $1 - 2^{-b}$

Britta Reimers, Martin Kaltschmitt, Zeitschrift für Energiewirtschaft
Dec. 2014, Vol. 38, Issue 4, pp 217-234

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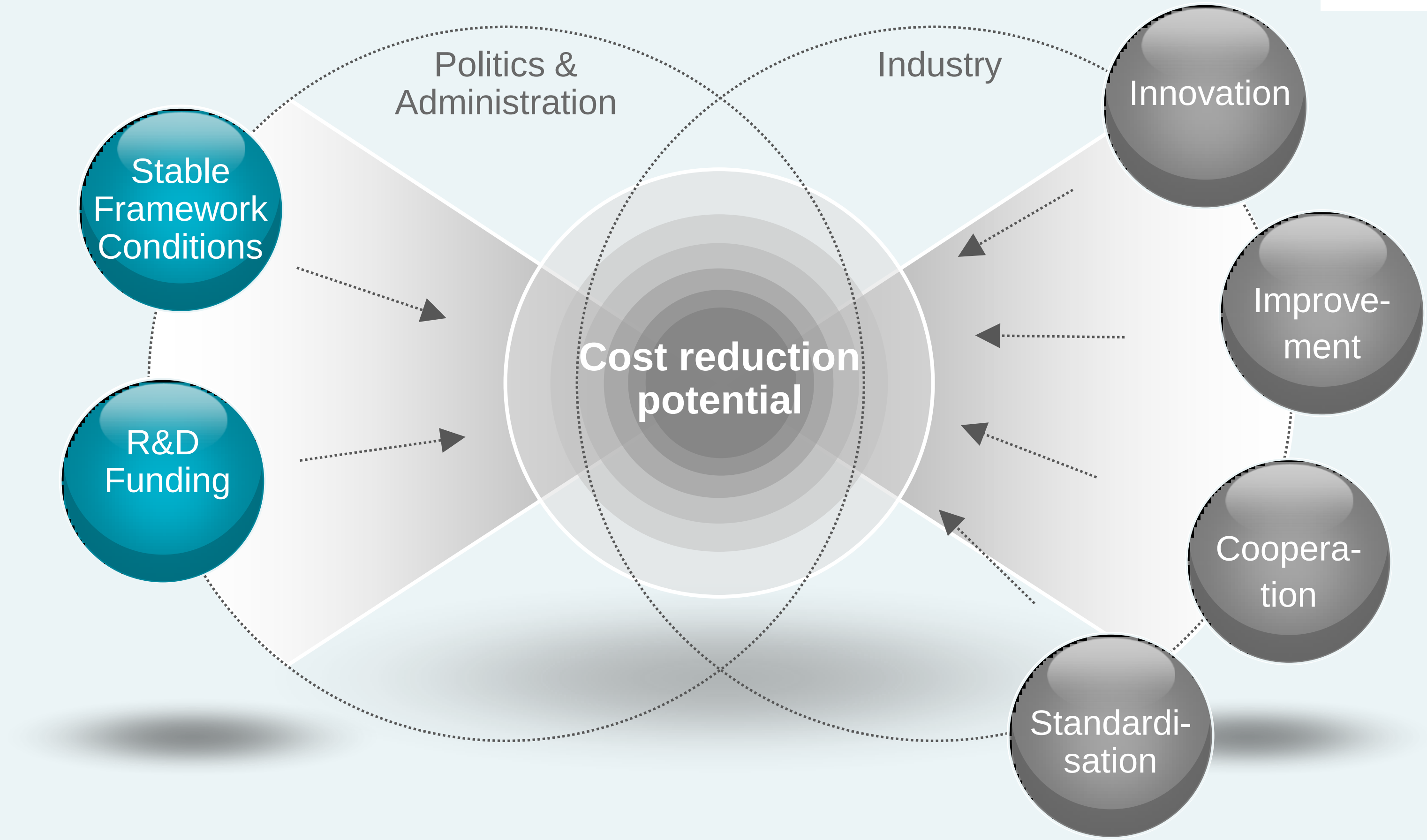
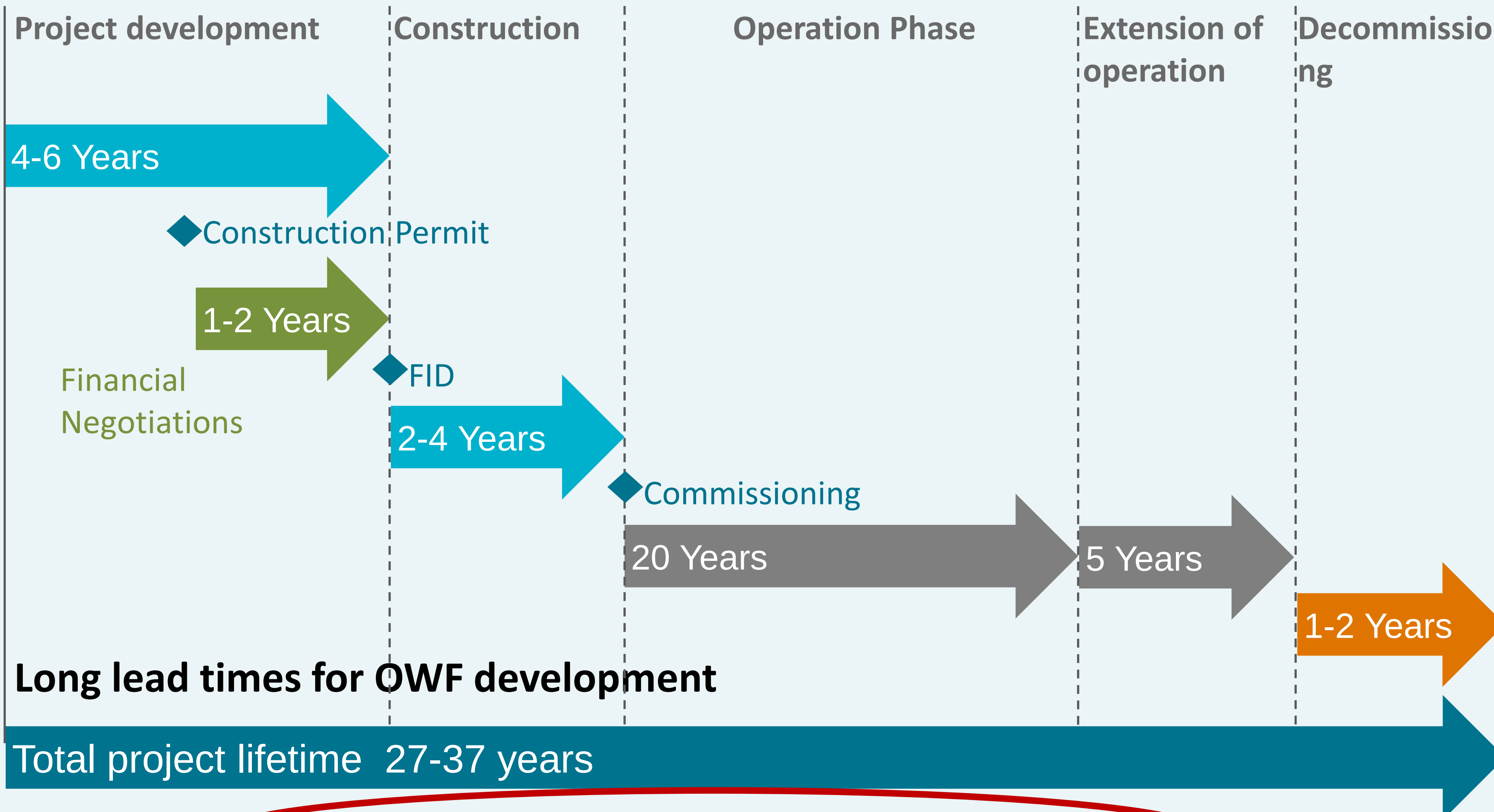
How to exploit the Cost Reduction Potential



"Cost reduction comes through volume!
Volume needs confidence,
Confidence needs consistent policies".
(Andrew Garrad, former EWEA President, Windkracht 2014)

Offshore Wind is different …

Idealized Project Schedule



Reliable & stable legal framework crucial

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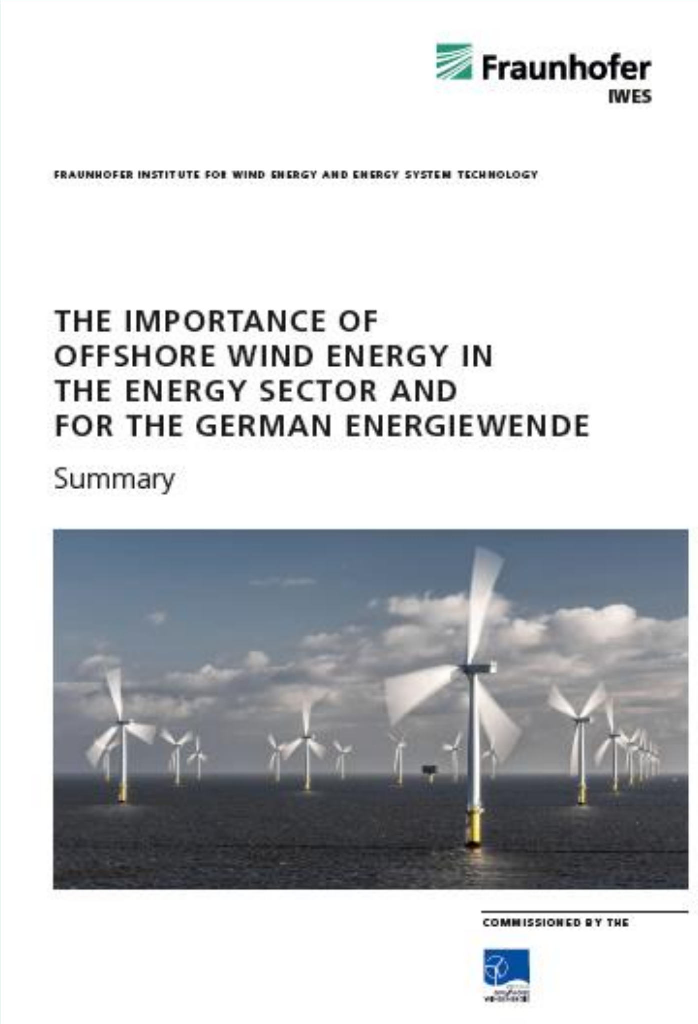
Energy System Benefits of Offshore Wind

Key Assumptions/Study Results

1. By 2050, German Energiewende requires 800 TWh coming from wind and solar – *can only be realized with large offshore wind capacities!*
2. Offshore wind leads to ***reduced cost for flexibility measures*** → least-cost option
3. Offshore wind has considerable ***power plant characteristics –*** important for security of supply (provision of balancing power, high schedule reliability, etc.)
4. ***Stable and continuous expansion*** of offshore wind capacities ***required*** to harvest energy system benefits and cost reduction potentials


Fraunhofer IWES

FRAUNHOFER INSTITUTE FOR WIND ENERGY AND ENERGY SYSTEM TECHNOLOGY

THE IMPORTANCE OF OFFSHORE WIND ENERGY IN THE ENERGY SECTOR AND FOR THE GERMAN ENERGIEWENDE

Summary

COMMISSIONED BY THE

Study launched in Nov. 2013,
at EWEA Offshore 2013, Frankfurt

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Main challenges for offshore wind development, as defined by the European Wind Initiative in 2009

- **Resource**
    - The resource needs to be better understood
    - Detailed measurements and a high resolution European offshore wind atlas are needed to identify best resource → spatial planning
- **Technology – not only turbines!**
    - Reliability, efficiency, accessibility is the main focus
    - Innovative breakthrough concepts
    - Upgrading of existing technologies
- **Deployment**
    - Optimising manufacturing capabilities throughout supply chain (turbines, components, substructures, grids)
    - Developing logistical support infrastructures (vessels, harbours)
    - Developing standards, replicable installation and O&M processes
    - Getting sufficient numbers of qualified people involved (education & training)

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Policy Priorities/Actions to realize the potential of offshore wind in Europe → **23.5 GW by 2020,**up to **65 GW by 2030***

- **Industry‘s committed to cost reduction,** supported & facilitated by:
- Long-term Vision and Targets
- ***Stable Regulatory Framework*** with adequate support schemes and Electricity Market Design
- Improved ***Access to Finance***
- Cost-effective and timely ***Grid Investment and Connection***
- Addressing ***Planning/Permitting*** System issues (incl. MSP)
- Develop ***Supply Chain and Logistics***
- Support ***Innovation (RDD) and Training*** - Enhance (cross-border) synergies
- ***Awareness Raising*** and Public Information Activities

* Source: Ernst & Young, 2015

Thank you for your attention!

Stiftung OFFSHORE-WINDENERGIE

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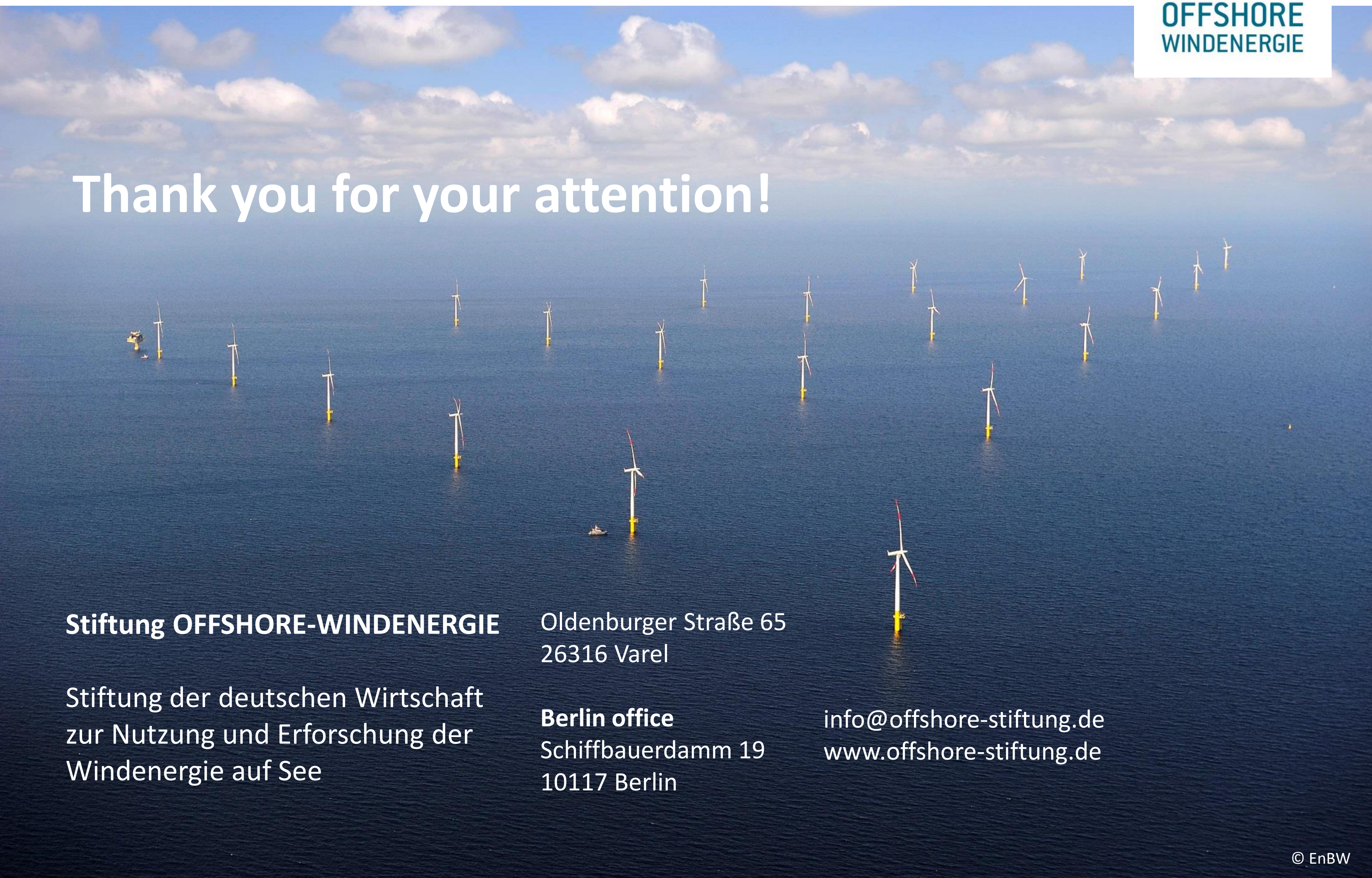

BACK-UP Slides

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Germany – first commercial OWFs (08-2013)

EnBW Baltic 1 (Inauguration May 2011)
Within the 12-nm-zone **(Baltic Sea)**

- 21 Siemens turbines (à 2,3 MW) → 48,3 MW
- 16-19 m water depth
- Monopile foundations,
- AC grid connection
- Construction during 2010-2011

BARD Offshore 1
(inaugurated 27 Aug. 2013)

- EEZ **(North Sea)** - 90 km from shore
- 80 wind turbines (à 5 MW) → 400 MW
- Electricity for 400,000 households
- 40 m water depth
- Tripile foundations
- DC grid connection (120 sm sea cable)
- Construction from 2010-2013

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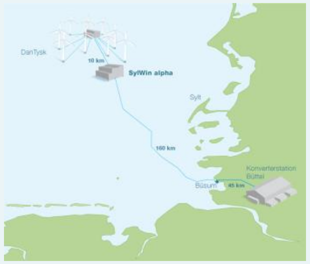
Commercial OWF completed and/or under construction

Borkum Riffgat – OWF completed (EWE)
30 turbines (3,6 MW) – 108 MW, Construction 2012-13
BUT Grid connection delayed until Feb. 2014

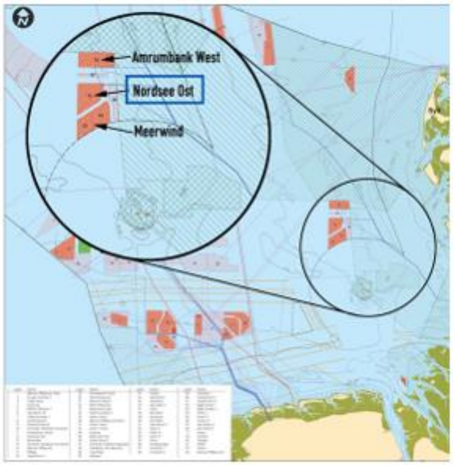
Borkum West 2 (Trianel)
Phase 1: 40 turbines (5 MW) – 200 MW
Construction 2012-15, grid connection delays

Borkum Riffgrund (DONG)
77 turbines (3.6 MW) – 277 MW, Construction 2013-15

Dan Tysk (Vattenfall/SWM)
80 turbines (3,6 MW) – 288 MW, Construction 2012-15



Commercial OWF completed and/or under construction (10-2013)



Helgoland Cluster

Meerwind Süd/Ost - WindMW (Blackstone)
80 turbines (3.6 MW) - 288 MW, Construction 2012-14

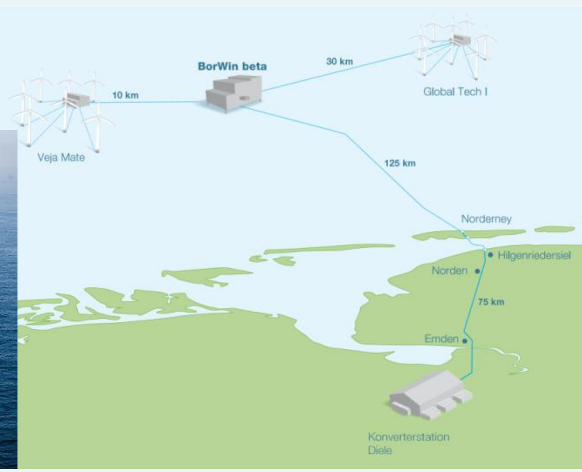
Nordsee Ost – RWE Innogy
48 turbines (6.15 MW) – 295 MW, Construction 2012-14

- **Amrumbank West** – E.ON Climate & Renewables

  80 turbines (3.6 MW) . 288 MW,
  Construction 2013-15

Commercial OWF completed and/or under construction (10-2013)

Global Tech 1 – investor consortium led by SWM
80 turbines (5 MW) – 400 MW, Construction 2012-15



Baltic 2 - EnBW (Baltic Sea)

80 turbines (3,6 MW) – 288 MW,

Construction 2013-15