Challenges and drivers towards further offshore grid integration: A TSO perspective

Baltic InteGrid: Policy and legal conference

Espoo, 15/03/2018

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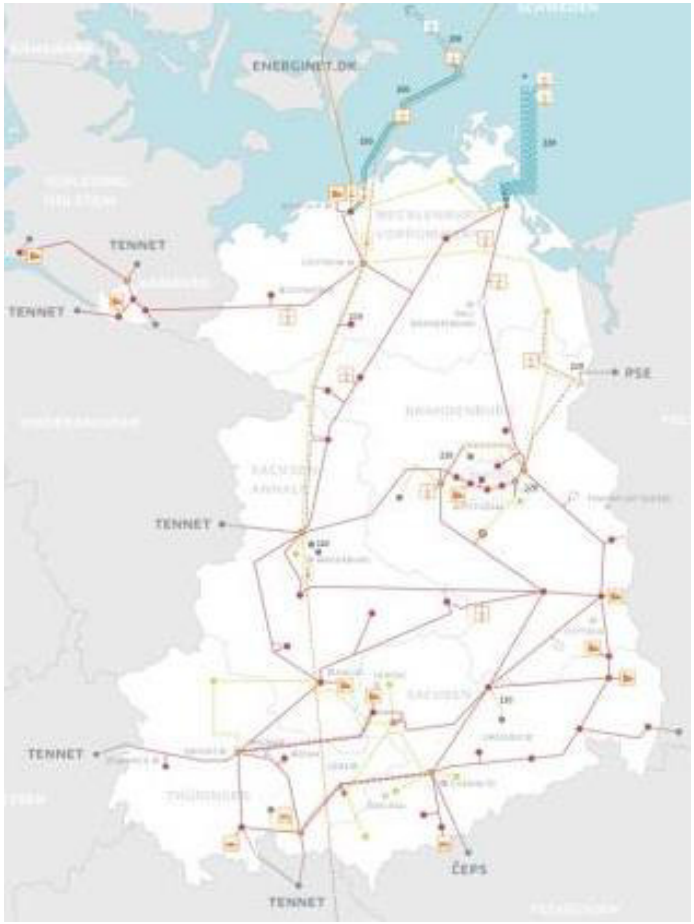
Agenda

1. 50Hertz offshore wind park connections
2. New 50Hertz offshore interconnectors
3. Drivers for interconnectors
4. Challenges for an offshore grid

50Hertz offshore wind park connections

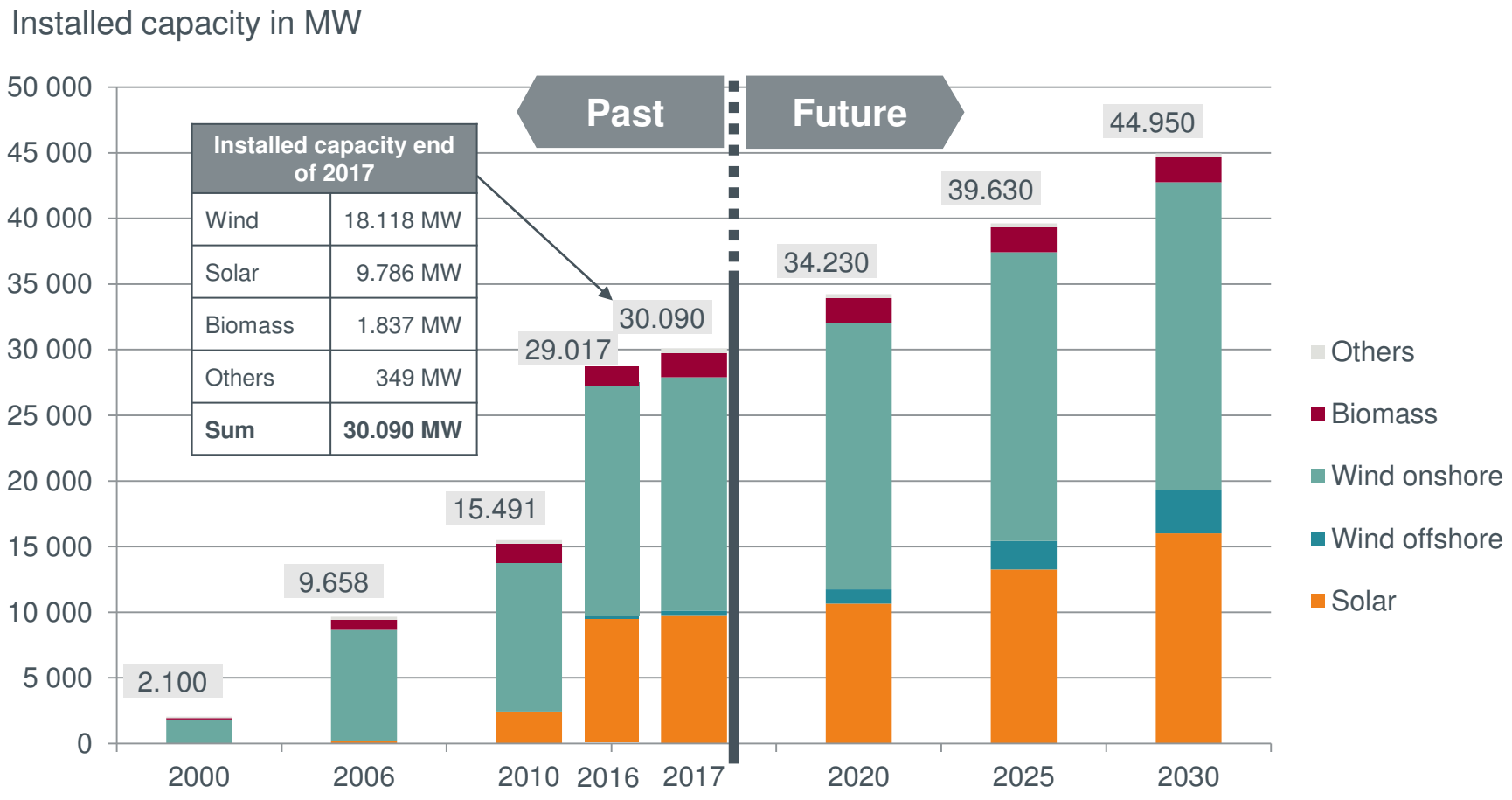
50Hertz at a glance



	Figures	
	2017	**2010**
Area	109.589 km²	109.589 km²
Total length of lines	10.150 km	9.800 km
Maximum load	~ 16 GW	~ 17 GW
Power consumption (based on electricity supplied to end-consumers in acc. with the EEG)	~ 96 TWh	~ 98 TWh
Installed capacity: - of which Renewables - of which Wind **- of which wind offshore**	51.686 MW* 30.090 MW 18.118 MW **336 MW**	38.354 MW 15.491 MW 11.318 MW **0 MW**
RES share in power consumption	53,4%	25,5%
Turnover - of which grid	9,5 bn. €* 1,3 bn. €*	5,6 bn. € 0,6 bn. €
Employees	1.043	643

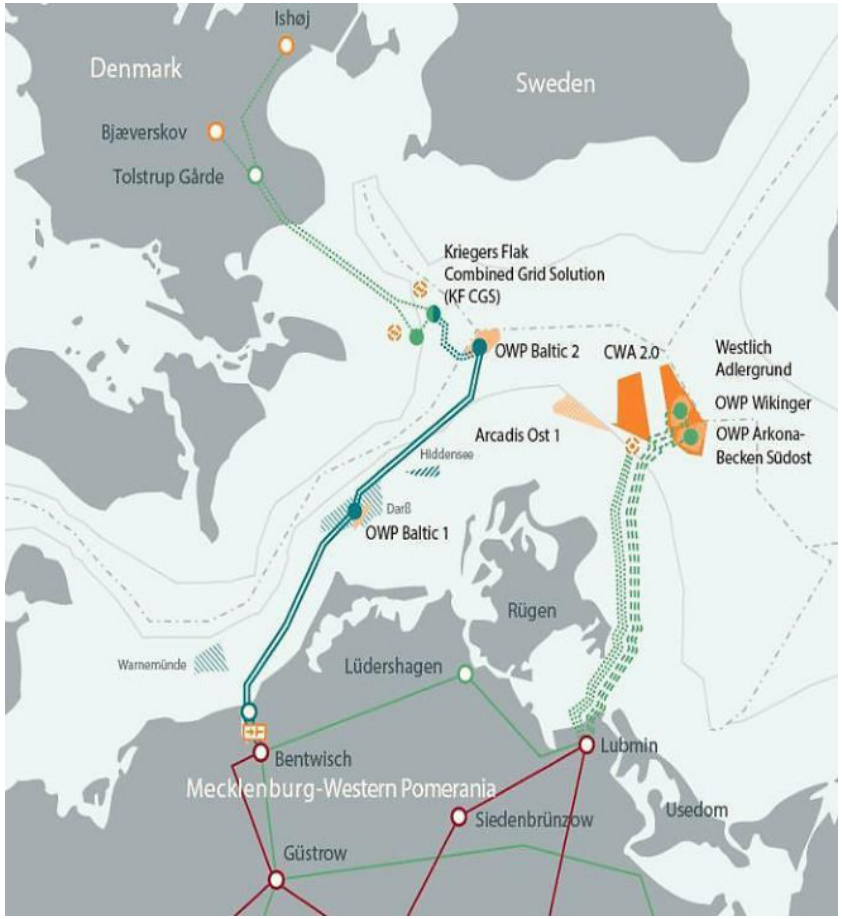
*Source: 50Hertz; 01.09.2017, *data from 31.12.2016*

Installed RES capacities will rise further over the next decade



Source: 50Hertz

Status of Offshore Grid Connections in the Baltic Sea



2011: Commissioning of Baltic 1

2012: Start of construction Baltic 2

2014: Connection granted to windfarm operators in the "Westlich Adlergrund" region; first cables ordered

2015: Allocation of grid connection capacity to the OWF Wikinger (350 MW) and Arkona-Becken Südost (385 MW) by the National Regulatory Authority (BNetzA)

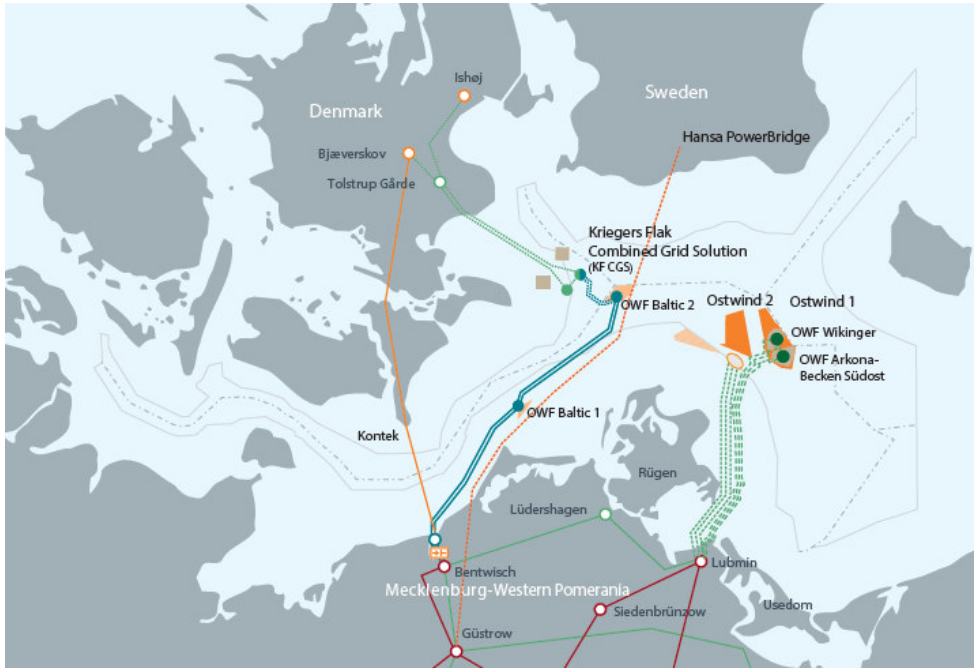
2015: Grid connection of Baltic 2

2015: Grid connection „Westlich Adlergrund": Receipt of all necessary approvals for the construction; start of preliminary works

2016: Grid connection "Westlich Adlergrund: Pull-in of cable segment in OSS "Wikinger"

Steady development of wind offshore projects in the Baltic Sea – Grid connections for existing projects according to plan

Offshore Projects: Progress in 2017




Wikinger platform

Arkona platform

Ostwind 1:
- 1st feed-in of Wikinger Wind Farm (350 MW) in 12/2017
- platform of Arkona Wind Farm (385 MW) under construction

Ostwind 2:
- start of tender procedure for cable production and installation

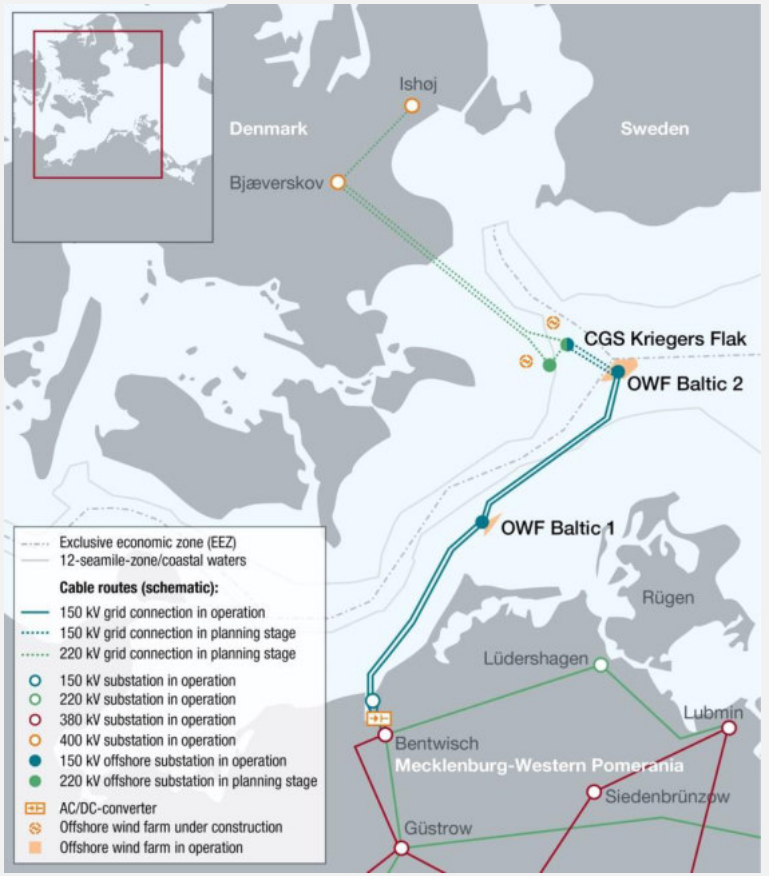
Kriegers Flak Combined Grid Solution:
- BtB-Converter and Offshore Platform under construction

Hansa PowerBridge:
- start of cable route engineering and environmental studies

New 50Hertz offshore interconnectors

Combined Grid Solution – wind park integration

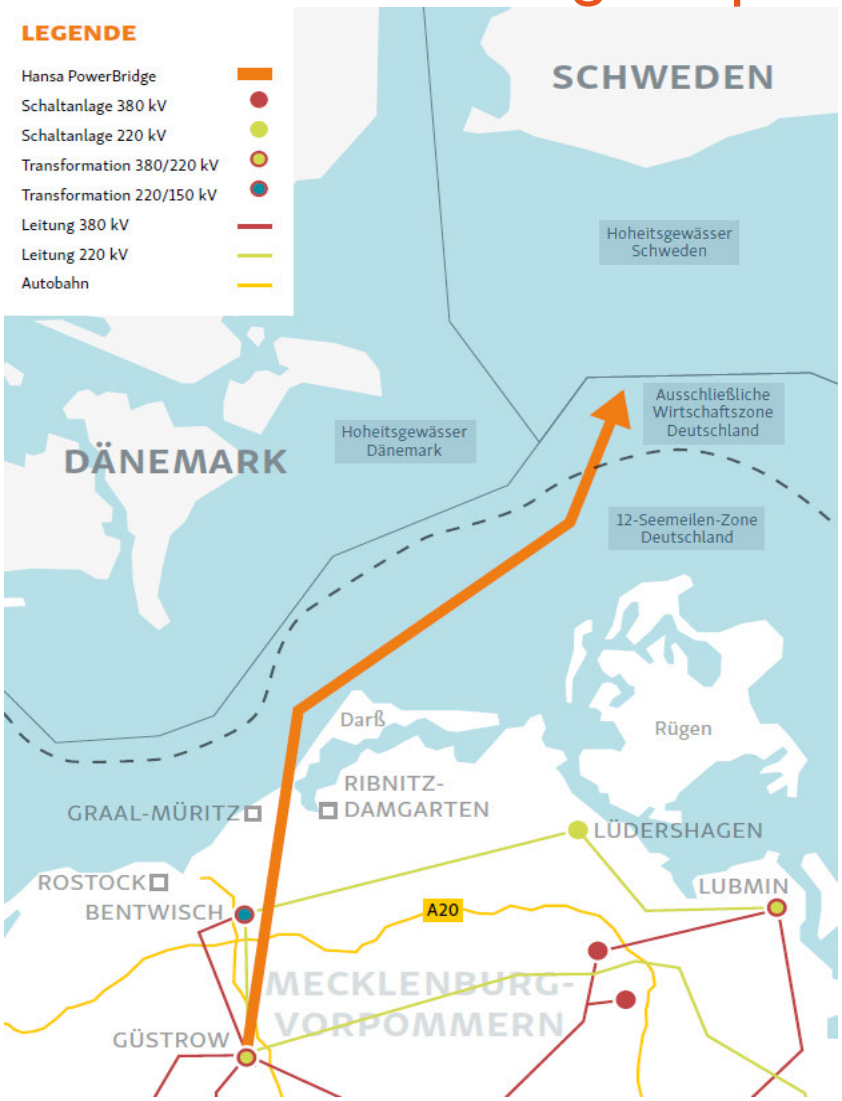
- The Kriegers Flak Combined Grid Solution is the world's first hybrid system of grid connections of offshore wind farms (OWF) and a cross-border interconnector combining:
  - the radial grid connections of the German OWF Baltic 1 & 2 and the newly built Danish OWF Kriegers Flak and
  - a cross-border interconnector between Denmark and Germany, connecting the high voltage alternating current (HVAC) grid of the German north-eastern region with the Danish area of Sjaelland
- The project is co-financed by the European Energy Program for Recovery (EU).



Project overview/ © 50Hertz

Co-financed by the European Union
European Energy Programme for Recovery

Hansa PowerBridge – point-to-point interconnector



- 700 MW interconnection between Sweden and Germany
- Cooperation Agreement signed January 2017
- Operational in 2025/26
- Taps into Scandinavian hydro storage potential while German volatile RES infeed grows rapidly

- Choice for DC point-to-point connection
  - Strategic importance for energy
  - Permanent and reliable availability of trading capacity
  - No additional complexitiy from linkage with other grid projects
  - Experience from operation of CGS required
  - Necessary DC breakers not yet in use
  - Currently uncertainty about Swedish offshore wind policy

Drivers for interconnectors

Wind integration triggers interconnectors

- A rising share of renewables in Germany requires internal grid extension, operational and market-based measures and interconnectors.
- Drivers for interconnectors:
  - Comparison of **spot price levels** (yearly average of spot prices) between two markets has been a good indicator for promising interconnector projects and triggering investment.
  - With a growing share of **volatile energy sources**, **flexibility** (hourly price differences) becomes more and more important. Interconnectors to regions with sufficient storage capacities may play an important role for systems with high shares of fluctuating RES generation.
  - Other drivers such as **energy trade in shorter time frames** (hours and shorter), use of interconnectors for **balancing purposes,** the consideration of interconnectors for cross-border **capacity markets** and **security of supply** are likely to gain importance.

European goals on interconnector capacity

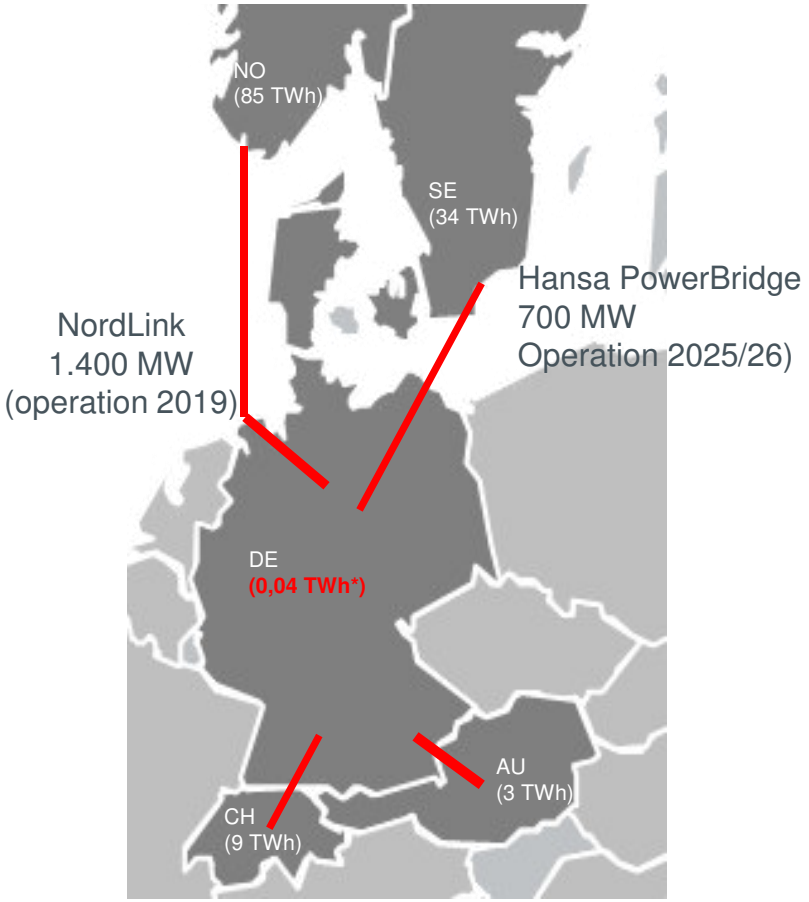
- Currently 10% (2020) and 15% (2030) EU goal in ratio of interconnector capacity to total installed capacity
- Goals strengthen TSO position when interconnectors face approval from regulatory and spatial permission authorities

- Target value reform proposal by Expert Group to European Commission in November 2017:
  - Hourly wholesale electriciy price difference on annual average > 2 €/MWh
  - Ratio of capacity to peak load > 30%
  - Ratio of installed RES > 30%

Member States by interconnection level as measured in relation to the installed renewable generation capacity in TYNDP vision 3: orange <= 30%, yellow 30-60%, green > 60%

The interconnector potential between Germany and Scandinavia is not yet fully exploited

New “storage links“ under development



- Increasing volatile surpluses in Germany due to renewables in-feed require flexible and abundant storage capacities
- World Energy Council (2012) study showed potential of 7 to 12 GW of additional interconnections between Germany and the Nordic countries.
- Capacity for Alpine hydro storage and potential for new technologies like power-to-gas and batteries likely to remain at a much lower level.

Challgenges for an offshore grid

Different incentive schemes for interconnectors and offshore wind park connections in Germany

Connections for offshore wind parks

- Legal obligation for TSOs to connect offshore wind parks
- Planning in Offshore Network Development Plan
- Limited penalty payments for delayed connection
- Cost-based renumeration for investment the same as for other asset investments

Interconnectors

- Investment depends on detection of social economic welfare in cost-benefit analysis
- Agreement of partner TSO needed
- Inclusion in National Grid Development Plan (onshore) and European TYNDP necessary for regulatory approval
- Cost-based renumeration the same as for other investments
- No special regulatory incentive for offshore interconnectors and/or links integrating wind parks

Offshore wind park connections and interconnectors are set up in different incentive and permission schemes. There are no specific incentives for setting up an offshore meshed grid.

Potential barriers for a Baltic offshore grid

- **Planning and decision-making**
  - How to handle the risk for highly increased complexity of projects with several transmission system operators, regulatory schemes, wind park stakeholders and national interests?
  - Stable political, economic, system-related drivers for partner-TSOs?
  - Do interconnections of wind parks allow for sufficiently beneficial trading capacities?
  - Which additional incentives are available?
- **Technical**
  - Coherent decisions for AC/DC solutions and connections of asynchronous Scandinavian, Baltic and Continental grid?
  - Compatibility of converters?
  - Availability of DC breakers?
  - Correct choice of substation and platform locations?
- **Operation**
  - How to coordinate the operation in a meshed transnational grid?
  - How to coordinate transmission capacity trading with offshore wind park infeeds?

Conclusions

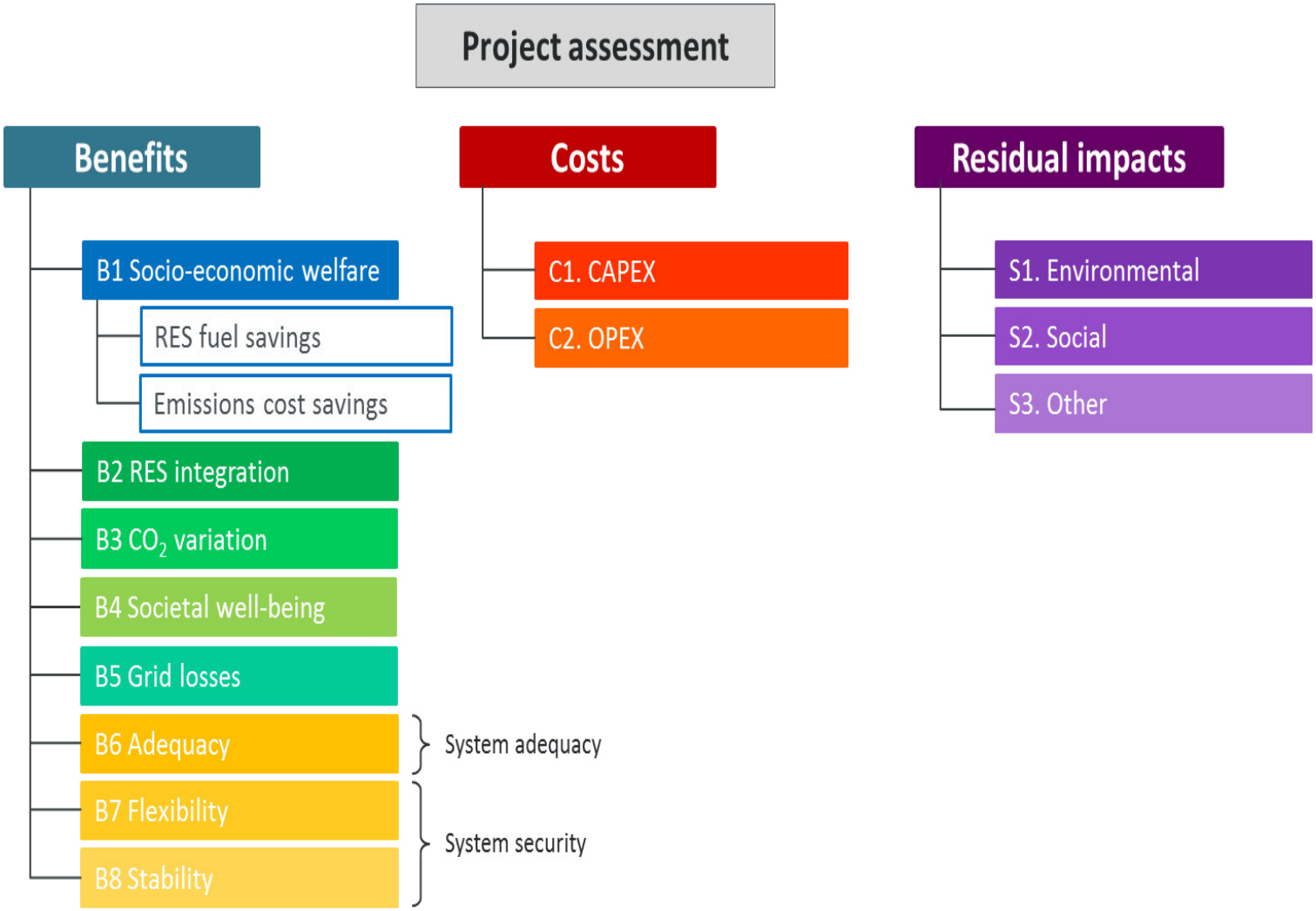
- **A Baltic offshore grid is an interesting long-term development option:** 50Hertz tests its operational implications in the Combined Grid Solution project.

- **The current incentive scheme for wind park connections and interconnectors seems sufficient to achieve renewables integration and trade capacities**. However, special incentives could boost a meshed offshore grid.

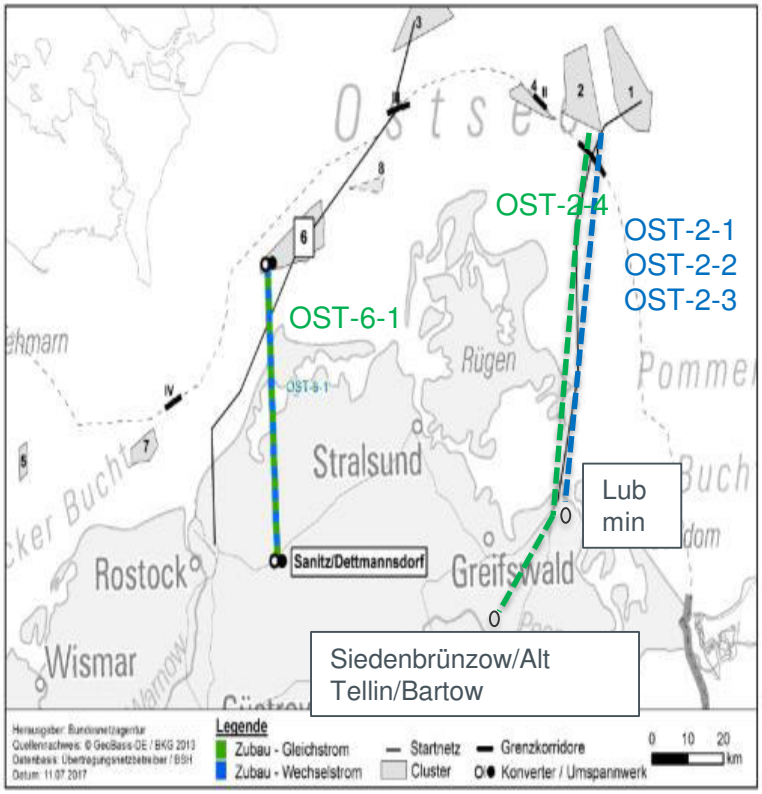
- **Benefits of a meshed offshore grid must clearly outweigh the current preference for pont-to-point connections.** They have to address economic, technical, regulatory and operational challenges.

Back-up

2nd CBA guideline currenlty developed at Entso-e level



German Offshore Grid Development Plan
Confirmed grid connections – Baltic Sea



AC-grid connection
DC-grid connection

– Necessary grid connections for 2030:

- 3 x AC-grid connections (750 MW)
  - 3 x AC-connections with a capacity of 250 MW (OST-2-1; OST-2-2; OST-2-3)
- 1 x DC-connection with a capacity of 900 MW (OST-2-4)* – estimated realisation time in 2027
- 1 x DC-connection with a capacity of 900 MW (OST-6-1)* or 3 x AC-connection with a capacity of 750 MW – estimated realisation time in 2029
- Two new grid connection points required

* The estimated realisation time are changed by the BNetzA.