New power bridges between Germany and Scandinavia

Interconnector projects in the 50Hertz area

Danish meets German Energy Transition

Copenhagen, 26/05/2016

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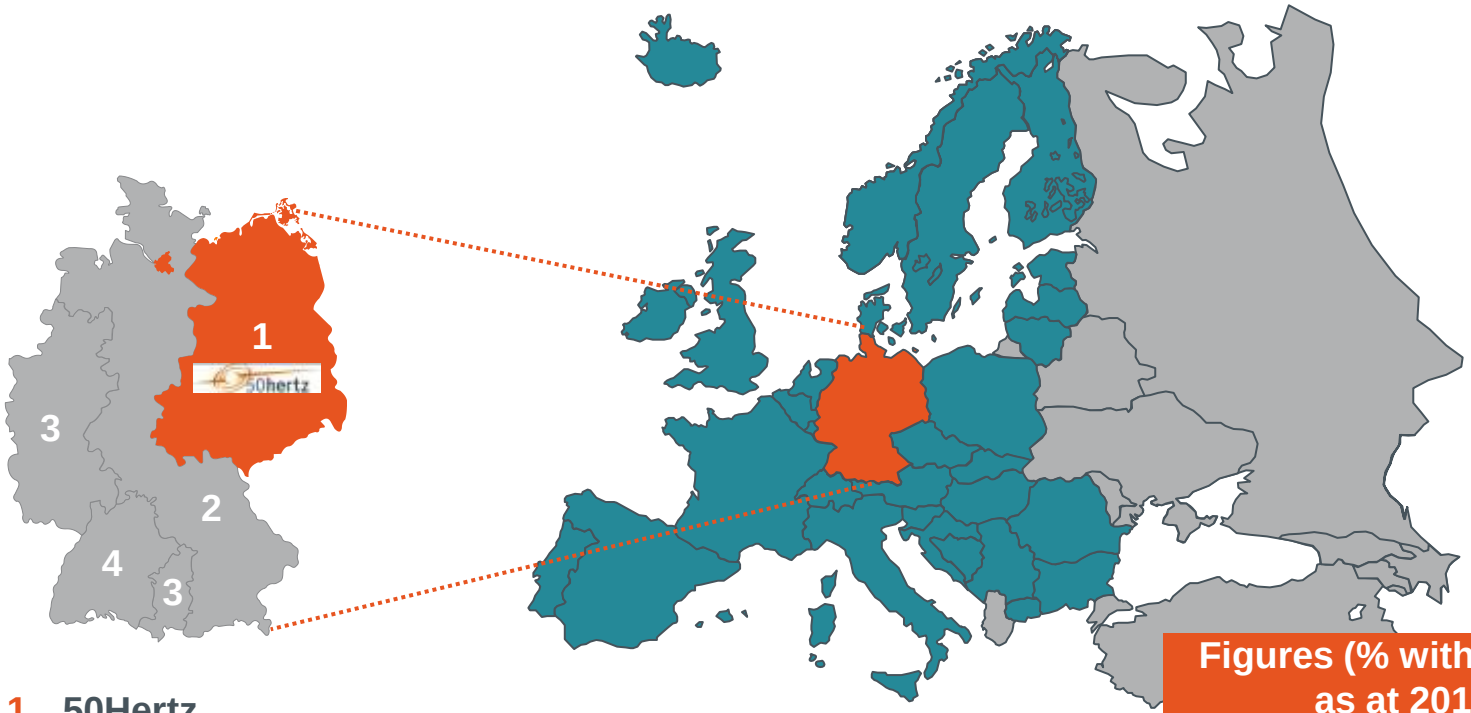
Agenda

1. Renewables in the 50Hertz area and the rationale for interconnectors
2. Kriegers Flak - Combined Grid Solution to Denmark
3. Hansa PowerBridge to Sweden

Renewables in the 50Hertz area and the rationale for interconnectors

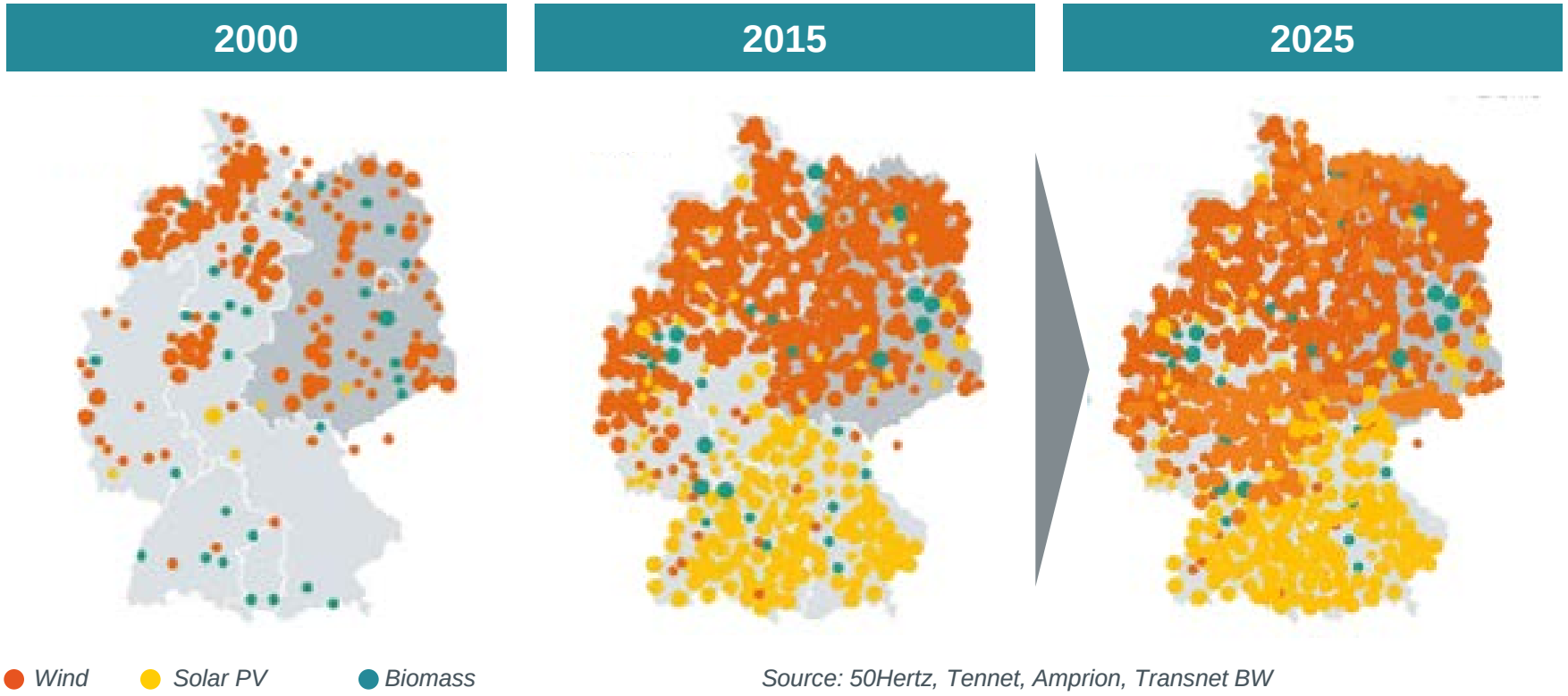
50Hertz as part of the European Electricity System



1. **50Hertz**
2. TenneT TSO
3. Amprion
4. TransnetBW

	Figures (% with respect to D) as at 2015/12/31
50Hertz installed capacity:	
- of which Renewables	50.500 MW (~27%)
- of which Wind	27.000 MW (~30%)
50Hertz peak load	16.100 MW (~39%)
	~16.000 MW (~20%)

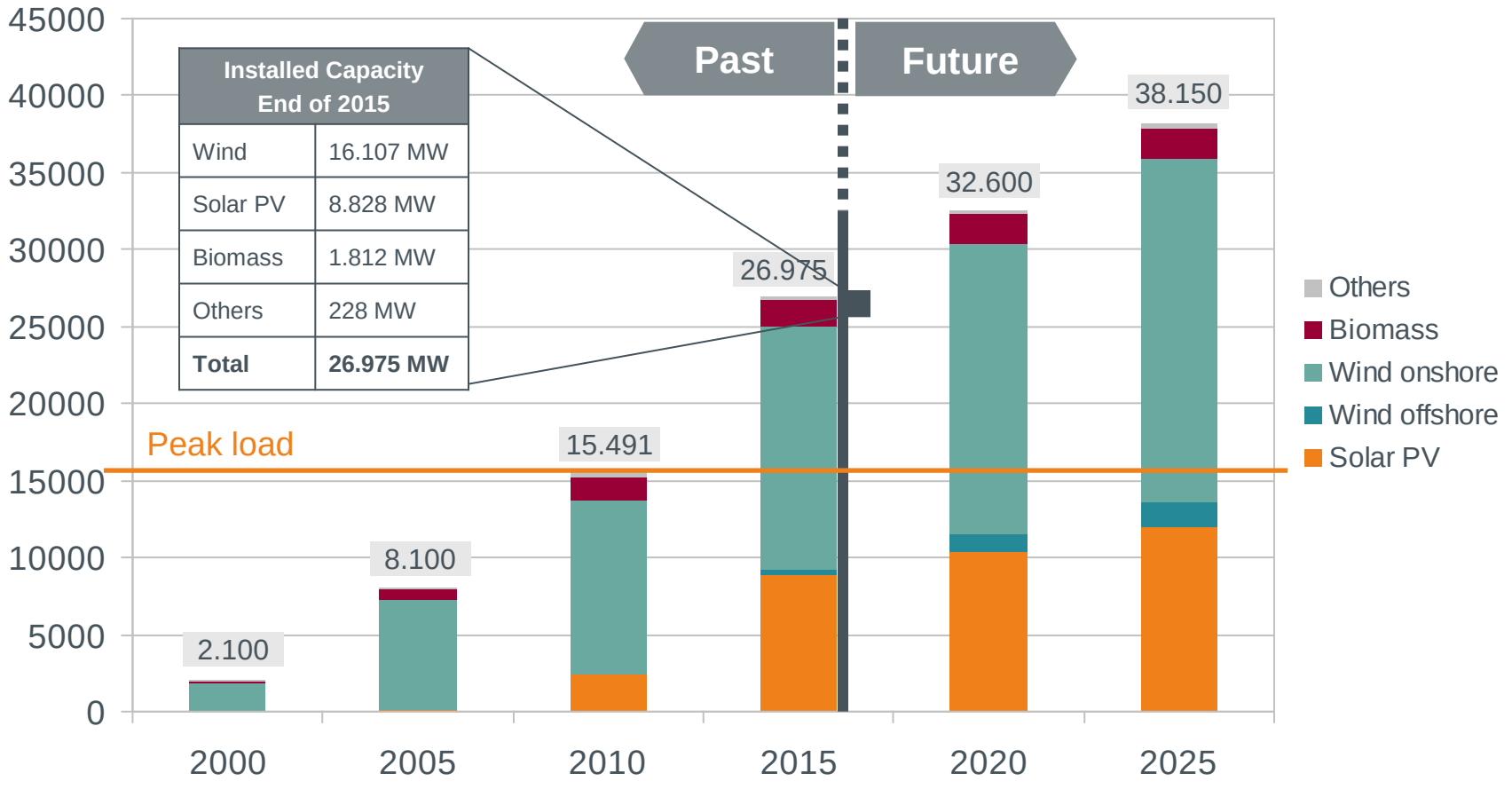
RES development in Germany as a highly visible aspect of the ‘Energiewende’



Over the next ten years the RES share in Germany will continue to grow – with further windfarms in the North and solar parks in the South.

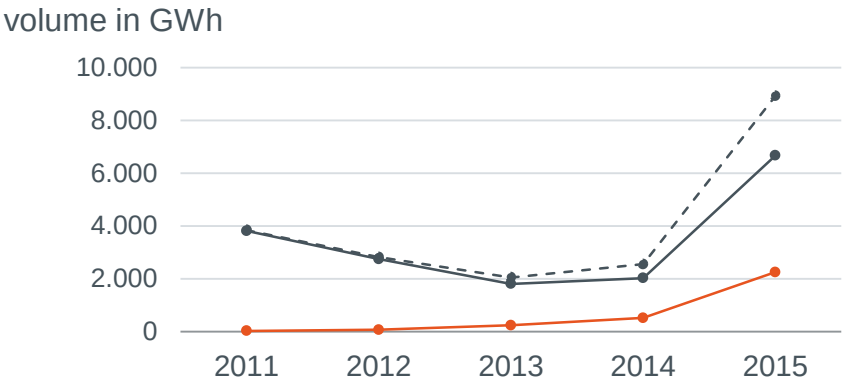
RES in the 50Hertz grid area:
Present situation and forecast of installed capacity

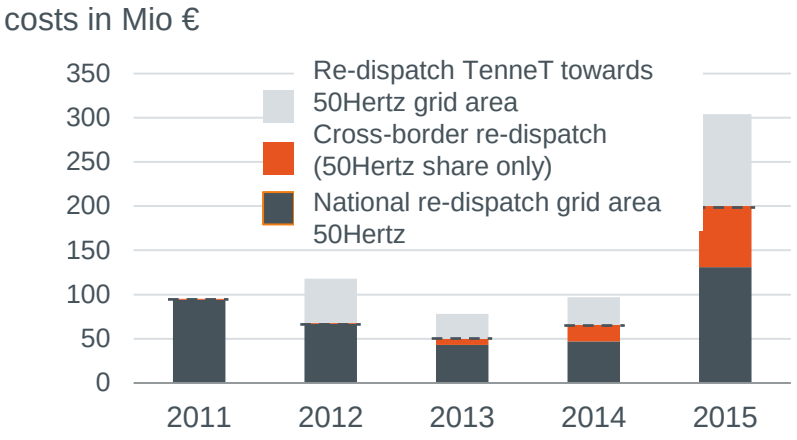
Installed capacities in MW



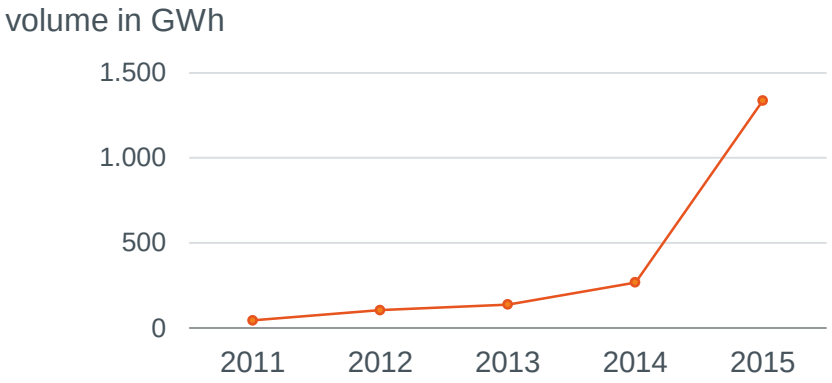
Congestion management: record high of interventions to stabilize grid in 2015

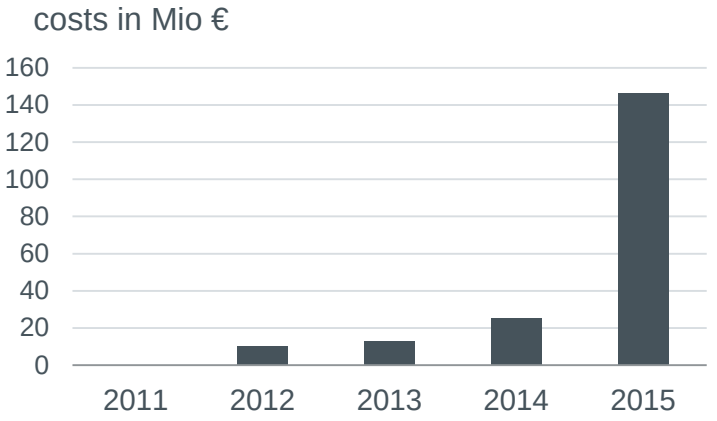
Electricity volume and costs for redispatch





Electricity volume and cost for curtailment of wind in-feed





Fast grid expansion is very beneficial for grid users as it would lower the costs for interventions in the grid, increase security of supply and enhance use of RES.

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

New “storage links“ under development

* Maximum available storage capacity of water reservoirs in 2011

- 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 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.

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 trigger 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.

Kriegers Flak – Combined Grid Solution to Denmark

Kriegers Flak Combined Grid Solution (Interconnection to Denmark)

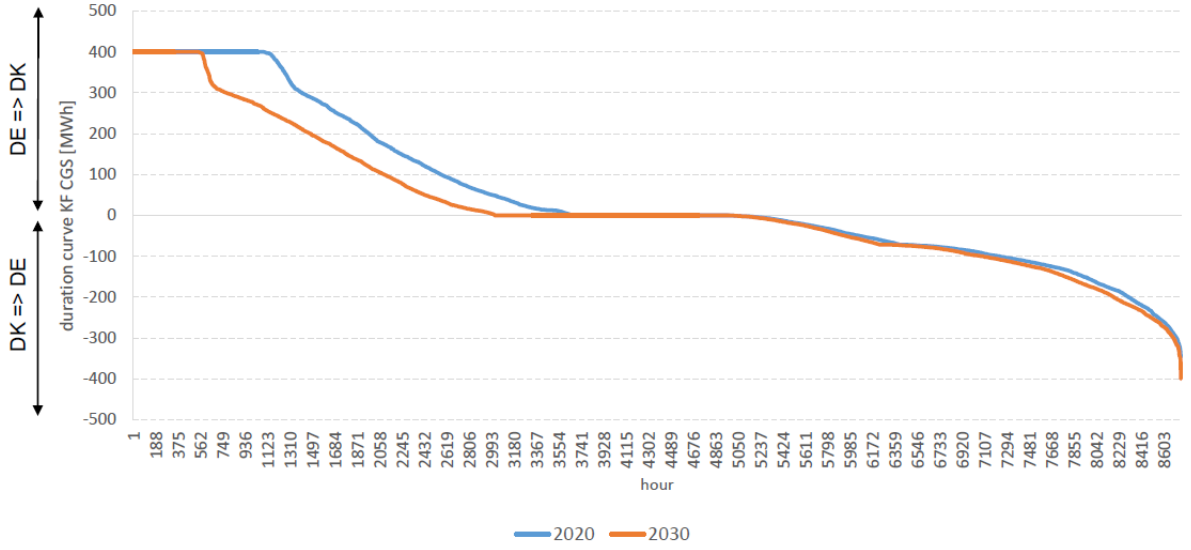
Project	Interconnection DK - GER
Installed capacity	400 MW HVDC (B2B converter) 400 MW HVAC (cable)
Length	≈54 km HVAC subsea cable (2 x 27 km)
Substation onshore: Substation offshore:	Substation Bentwisch (GER), B2B converter station Substation Bjæverskov (DK), filter OSS Baltic 2 (extension) (GER) OSS Kriegers Flak E (DK)
Envisaged commissioning	2018
Pecularities	▪ Unique combination of offshore wind farm connection and interconnector ▪ Status as European Project of Common Interest ▪ Partly funded by European Union
Social Economic Welfare (modelled for 2020)	Ca. 10 Mio € per year

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

Simulated flows indicate that trade from Germany to Denmark will decrease slighty in the longer run

- Market simulations for CGS show
  - German market prices more and more influenced by offshore wind production
  - Higher impact of wind production in neighbouring areas makes spot prices converge in DK and DE which slightly decreases price spreads

The importance of CGS for system adequacy rises, impact of volatility will relatively become more important than an annual average price level.



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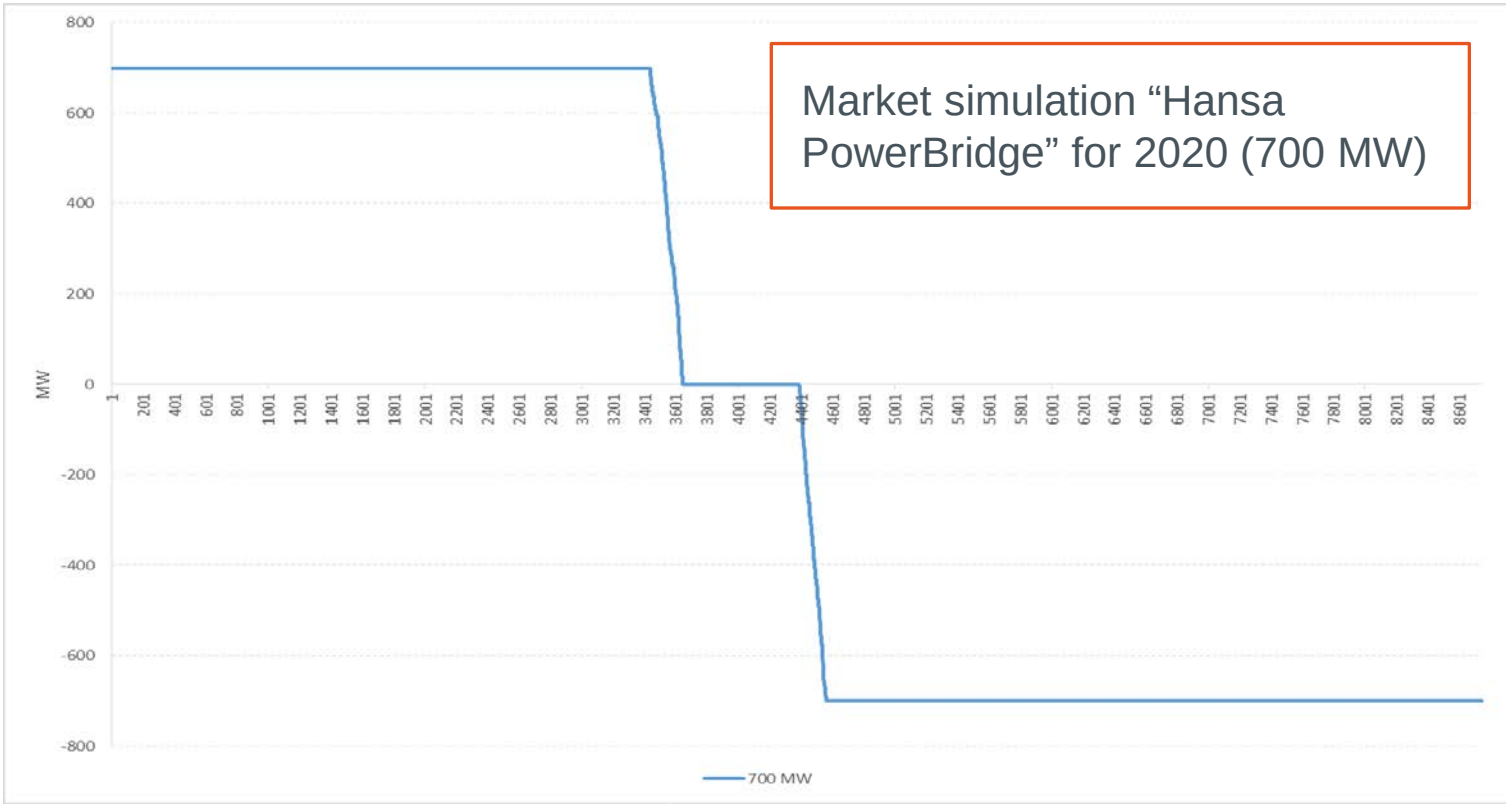
Hansa PowerBridge to Sweden

Hansa PowerBridge (Interconnection to Sweden)

Project	Interconnection SE- GER
Installed capacity	700 MW HVDC Potential of increase in the future
Length	≈300 km, incl. HVDC subsea cable
Routing	SE4 - Güstrow
Social Economic welfare (modelled for 2030)	Ca. 30-80 Mio € per year
Envisaged commissioning	2023-2025
Next steps	▪ Verification of routing and technical details ▪ Signing of cooperation agreement on the implementation phase early 2017

Market simulation indicates an almost even trade balance due to the complementary generation mix



Volatility of hourly price differences makes Hansa PowerBridge a profitable project although the annual average price difference is low.

Source: Hansa PowerBridge Feasibility Study 2014

German – Scandinavian interconnectors foster wind integration in Europe

- Wind integration requires grid expansion – on national and international level
- Drivers for interconnectors are diverse:
  - RES integration
  - welfare gains
  - avoidance of redispatch and curtailment of RES in-feed
  - fostering of the European Internal Electricity Market (aim of 15% interconnector capacity for each country)
  - security of supply

  - The importance of each driver varies among regions

  - 50Hertz develops new interconnector projects in the Batlic Sea with strong commitment