X-Wakes

Modelling the future wind farm expansion - an application of X-Wakes results for area development planning

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on the basis of a decision by the German Bundestag

Monday, 26.06.2023 | Final Public Project Workshop

Fraunhofer IWES

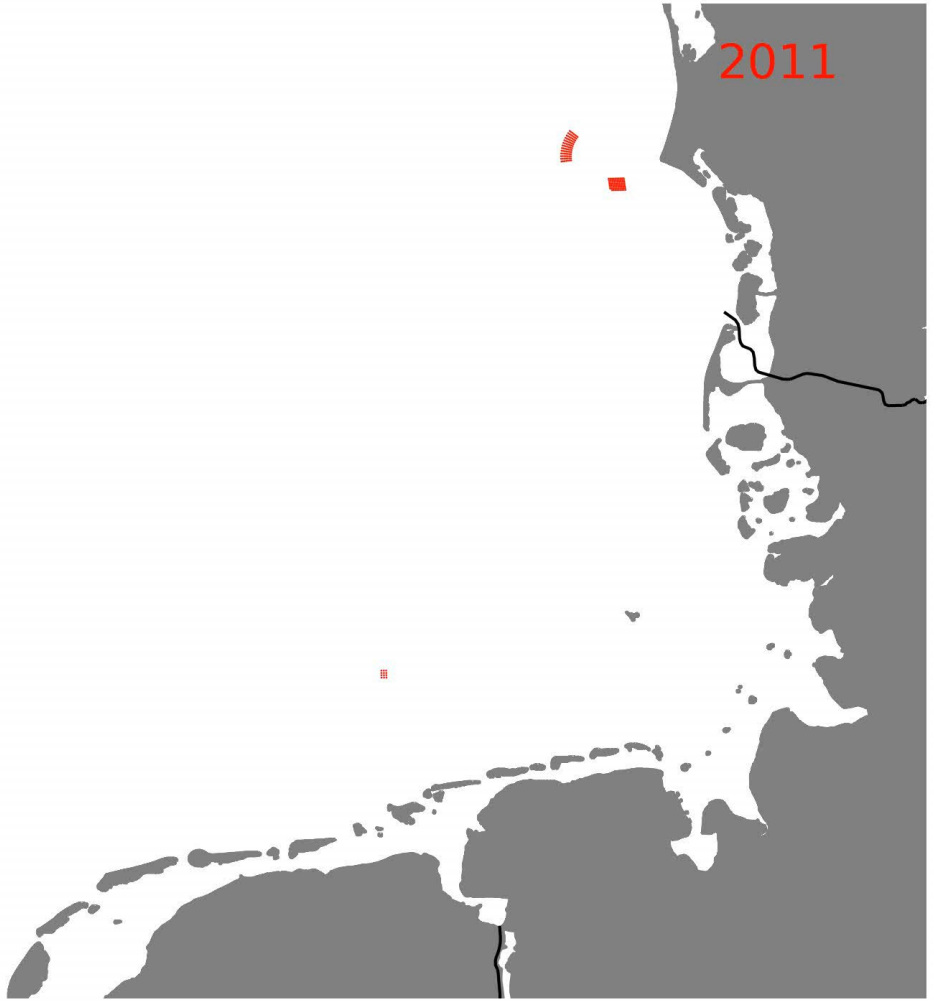
X-WAKES

Motivation

Offshore Wind Energy in the German Bight

- Germany currently has second largest capacity of offshore wind farms connected to the grid

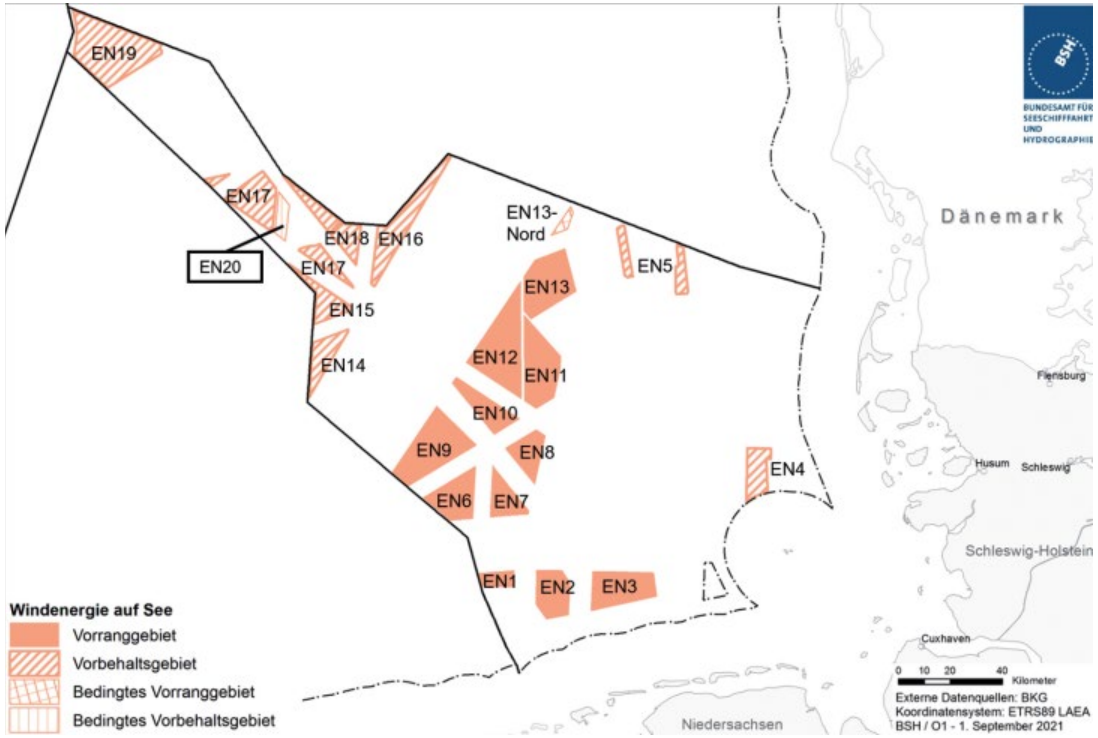
- Currently 7.7 GW out of which 6 GW are located in the German Bight



Motivation

Offshore Wind Energy in the German Bight

- Germany currently has second largest capacity of offshore wind farms connected to the grid
- Currently 7.7 GW out of which 6 GW are located in the German Bight
- Current long-term goals of the German government:
  - 2030 - 30 GW installed capacity
  - 2035 - 40 GW installed capacity
  - 2045 – 70 GW installed capacity
- One of the most densely areas of offshore wind globally

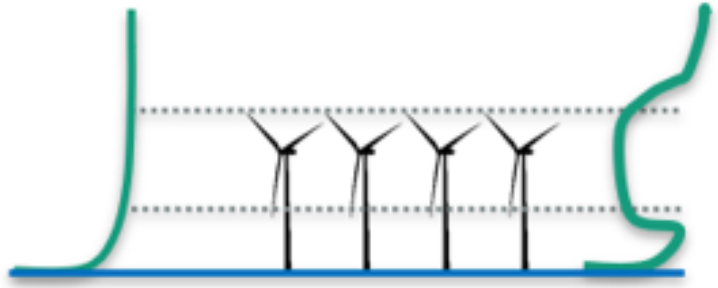


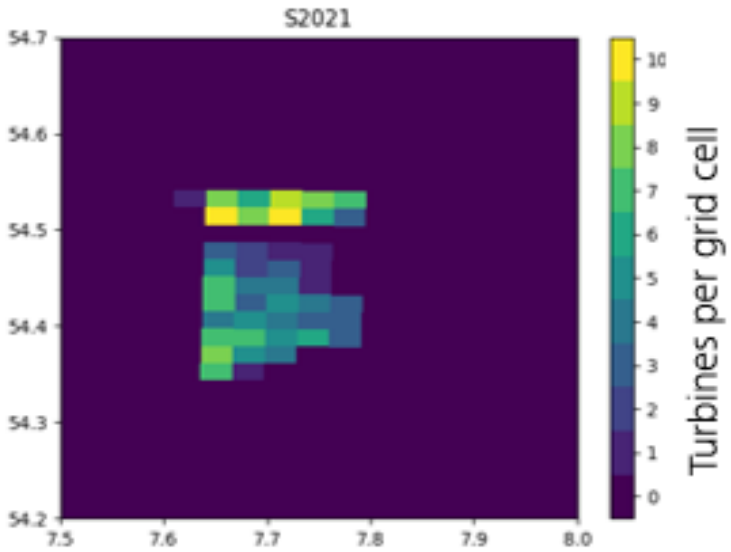
[source: BSH.de]

Methodology

Mesoscale Wake Modelling

- Weather Research and Forecasting Model (version 4.3.1)
- Driven by ERA5 + OSTIA reanalysis
- Model domain covering whole German Bight area at 2km resolution
- **Fitch wind farm parametrization:**
  - Wind farm effect modelled by **elevated sink of momentum** and **source of turbulence**
  - Older farms: several turbines per grid cell





Model Validation

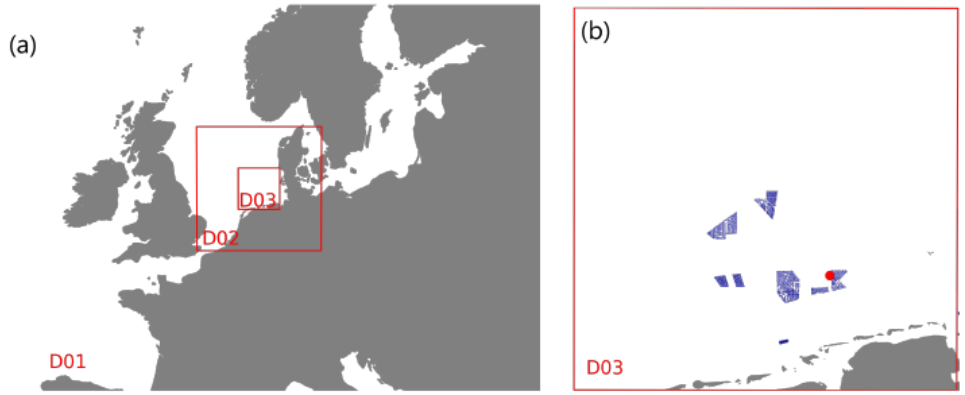
Scanning Lidar and Mesoscale Model

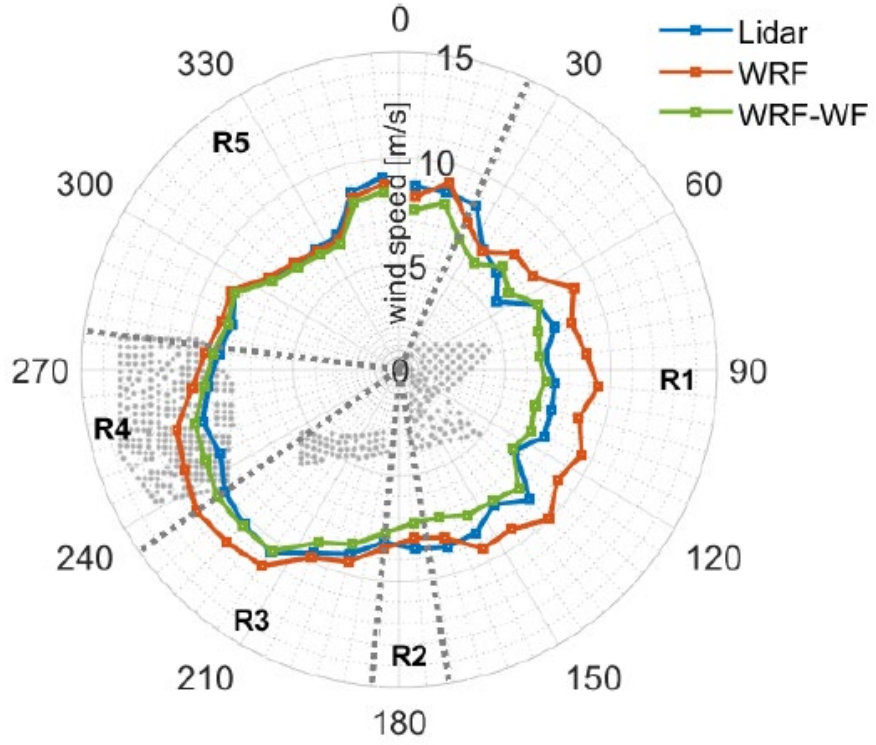
- Scanning lidar measurement campaign at GodeWind
- Duration: 5 months – spring to autumn 2020

- Mesoscale model simulations:
  - WRF (red): without wind farm parametrisation
  - WRF-WF (green): including wind farm parametriation

- Good agreement when using wind farm parametrisation
- Difference around 2% in wind speed on average

► Model setup is well suited for cluster wake modelling

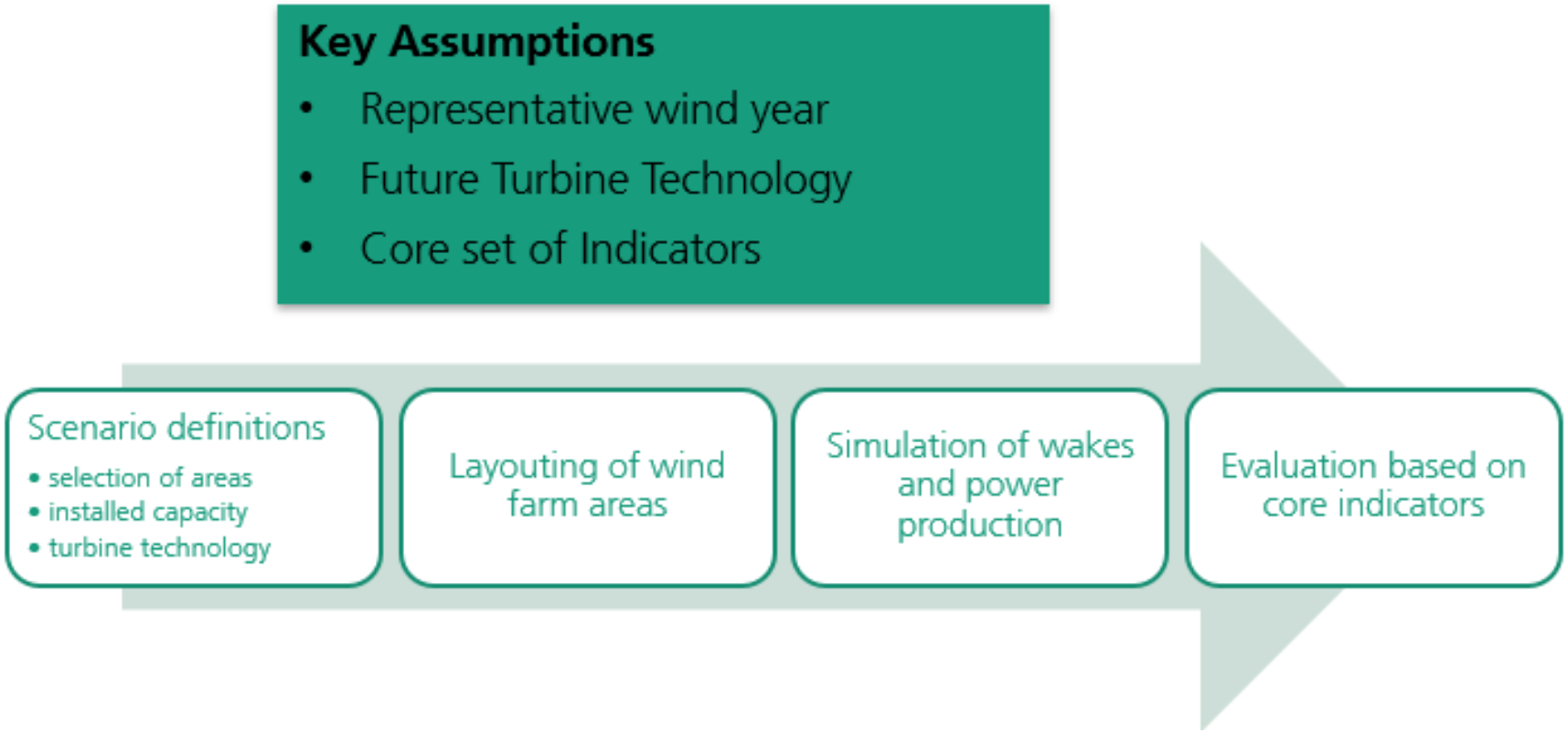




[Cañadillas, B et al. Wind Energ. Sci. 2022]

Modelling of the Future Energy Potential

Approach



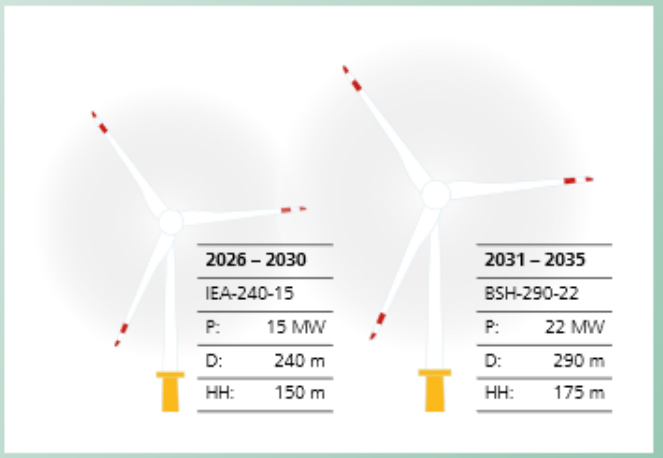
Modelling of the Future Energy Potential

Approach

Turbine Technology

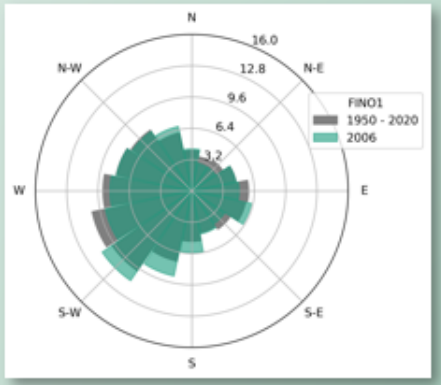
Two technology platforms in the next 15 years

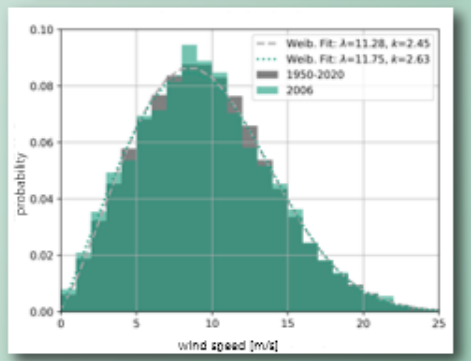
Years	P	D	HH
2026–2030	15 MW	240 m	150 m
2031-2035	22 MW	290 m	175 m



Wind Conditions

2006 approximates historical wind conditions





Expansion Phases

Comparison of scenarios for the North Sea (BSH consultation includes significantly more scenarios)

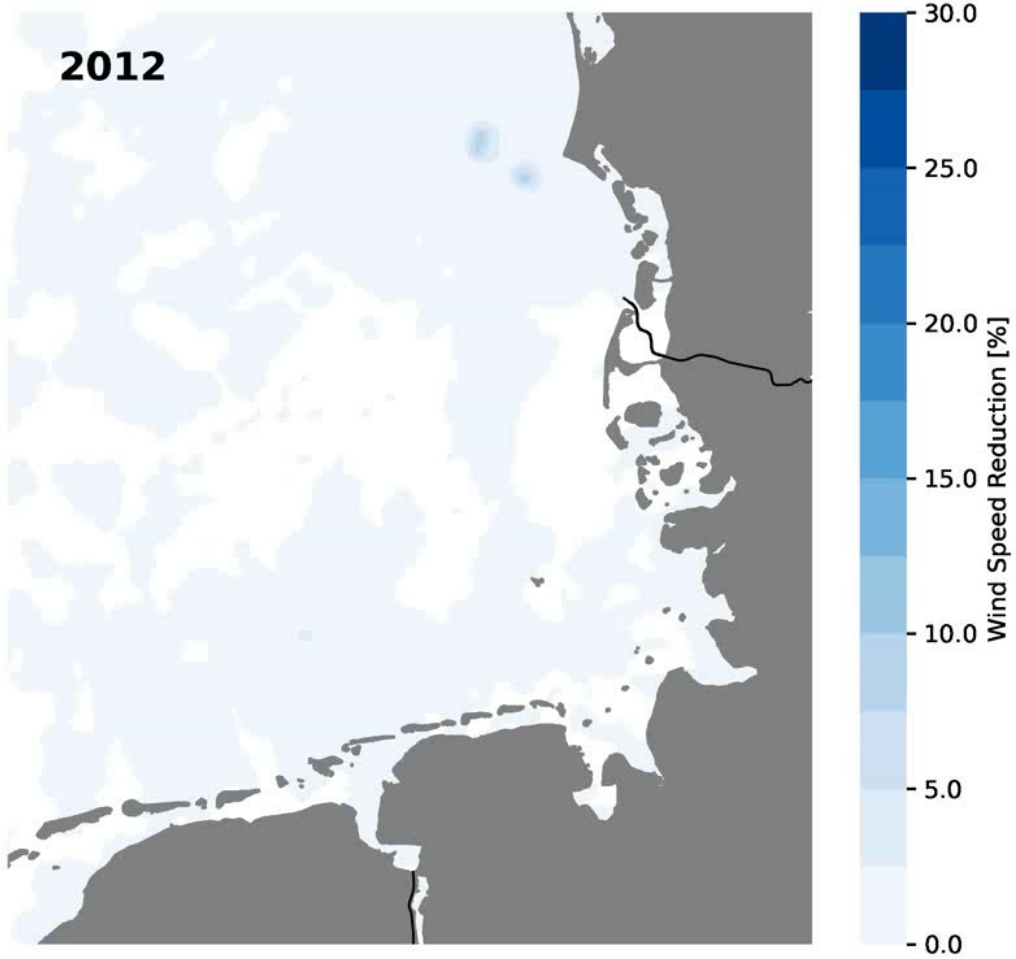
Source: Netzentwicklungsplan

Wind Farm Expansion

Past – 2011-2022

- Mesoscale model simulation **INCLUDING** wakes

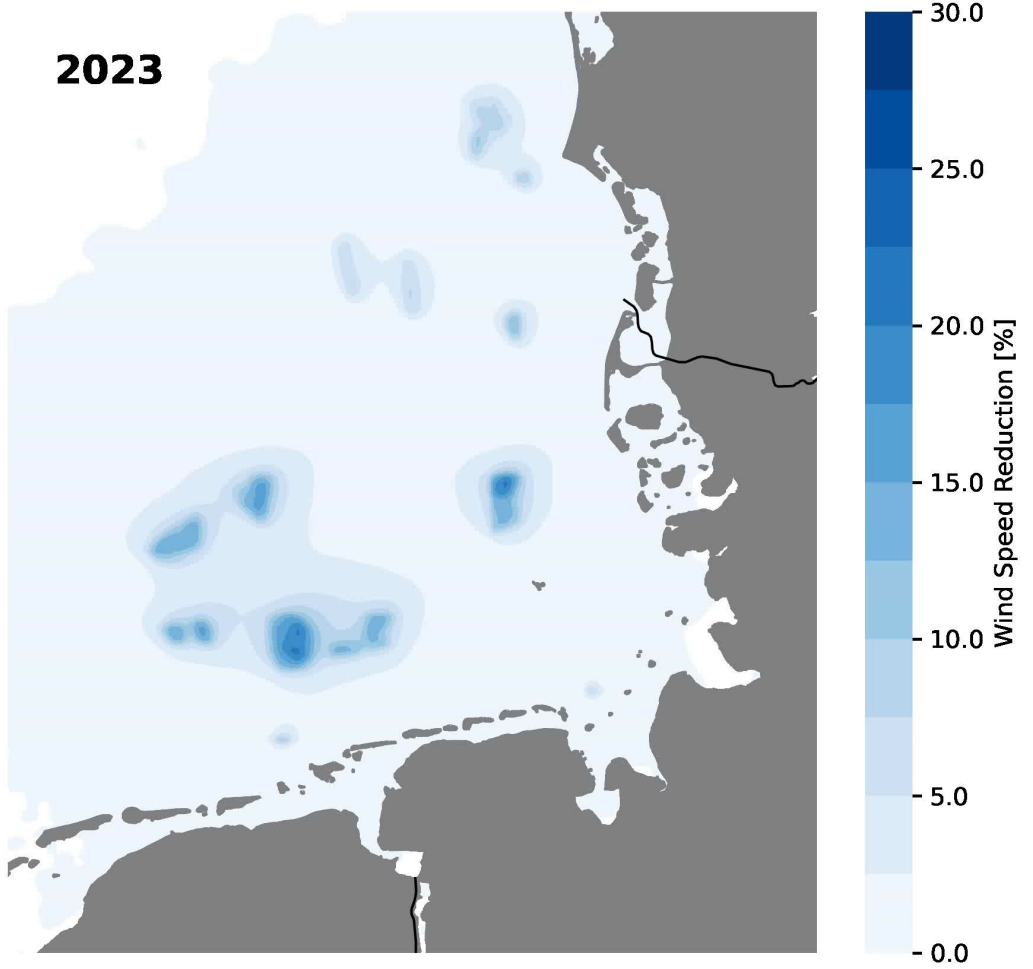
- Expansion leads to significant drop in wind conditions inside the wind farm cluster and the vincinity



Wind Farm Expansion

Future – 2023-2030

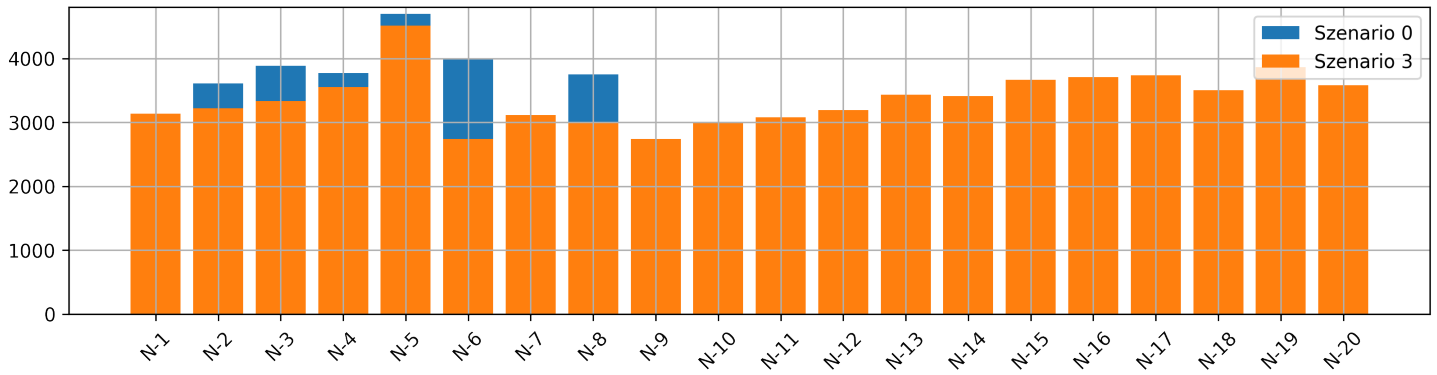
- Mesoscale model simulation **INCLUDING** wakes
- Reference year: 2006 – representative for the climatology
- Future turbine technology (2025-2030): 15 MW – IEA turbine
- Underlying time series data available upon request!



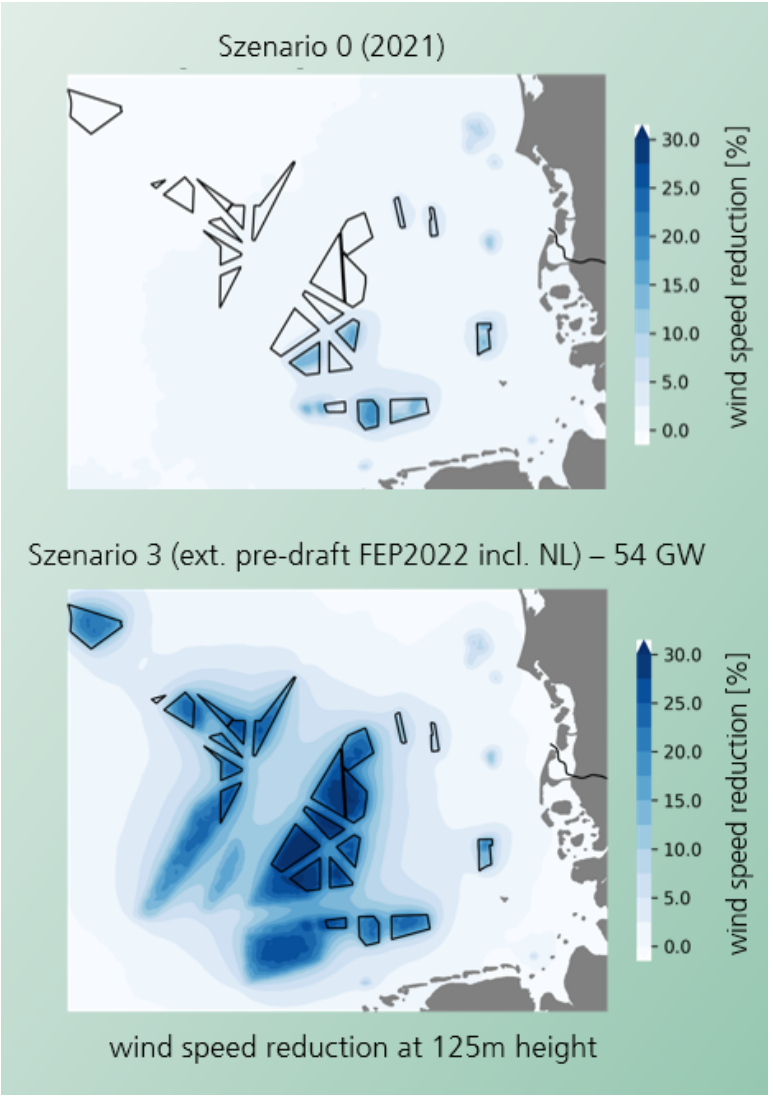
Scenario Results

2021 vs. pre-draft area development plan

- Between 2800 and 4000 full load hours depending on cluster and distance to further expansion areas
- approx. 184 TWh average annual energy yield



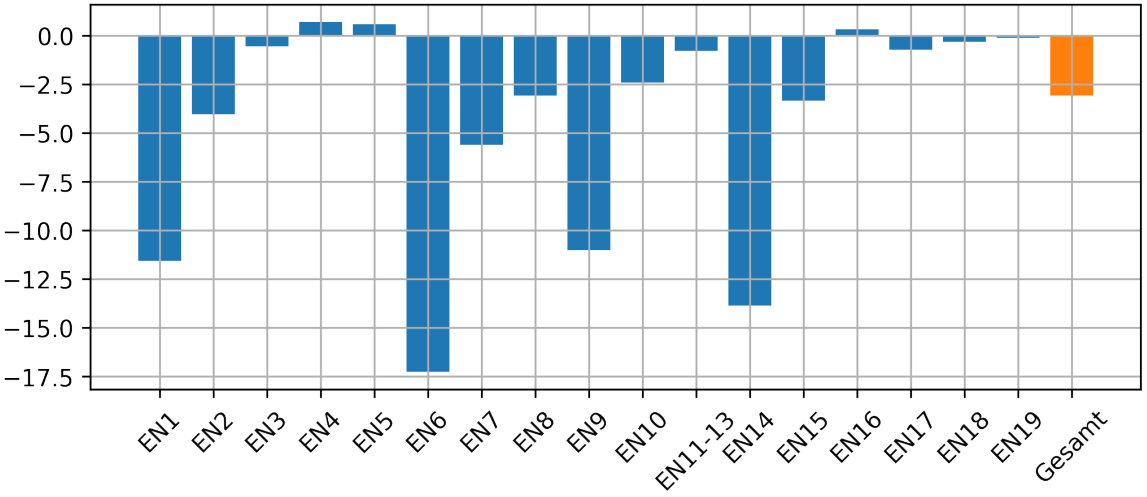
* All yield figures **excluding** electrical losses and other technical losses

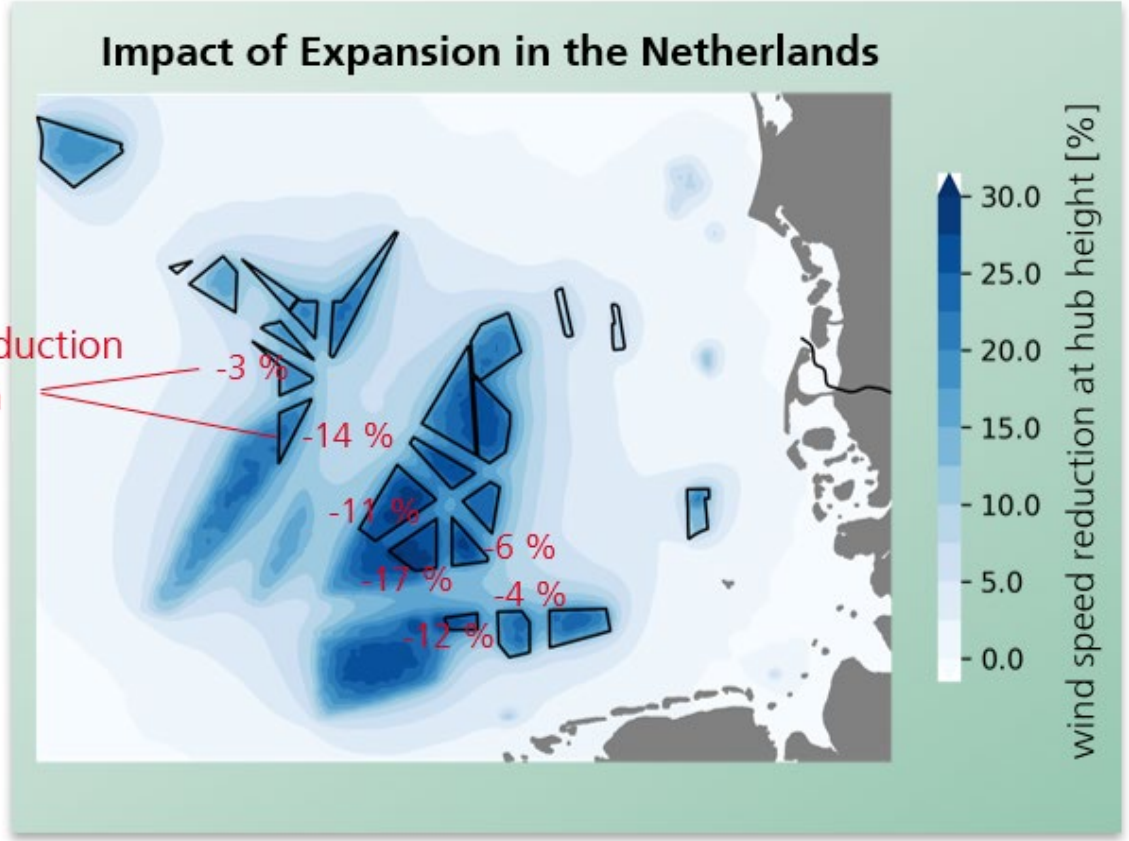


Scenario Results

Impact of the Expansion in the Netherlands

- Based on Dutch *Draft North Sea Programme*: expansion of **26 GW installed capacity in prevailing wind direction** close to EEZ borders
- Strong impact on clusters EN1, EN6, EN9 and EN14



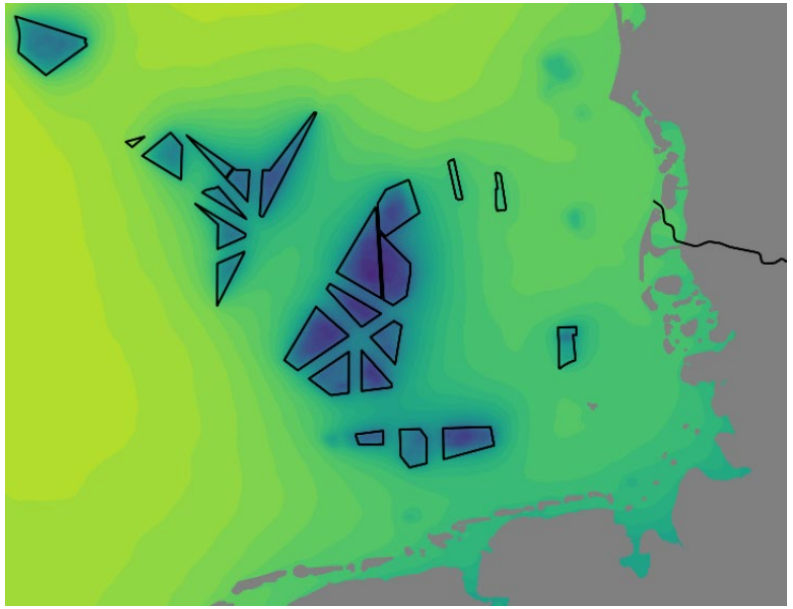


Total Yield Loss – German Bight: ~ 3 %

Summary & Outlook

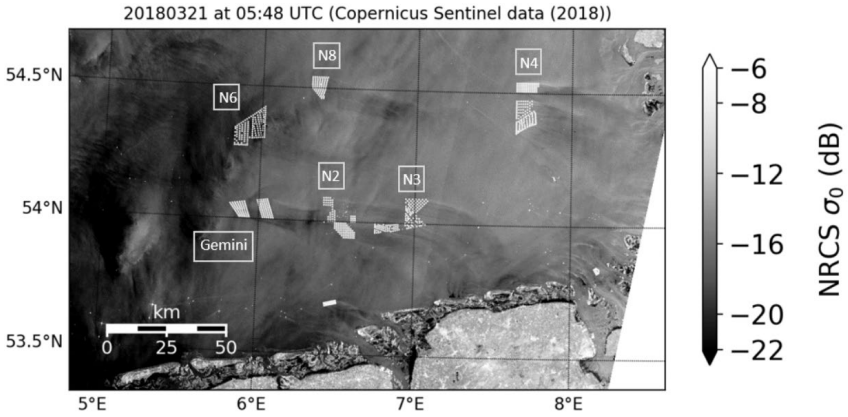
Offshore Wakes and Wind Resource Research

- Developed a workflow to investigate expansion scenarios by means of mesoscale wake modelling
- Yields can be evaluated on individual wind farm sites
- Further scenarios currently being investigated, also with variation of turbine parameters
- X-Wakes delivered the basis in terms of model development and validation

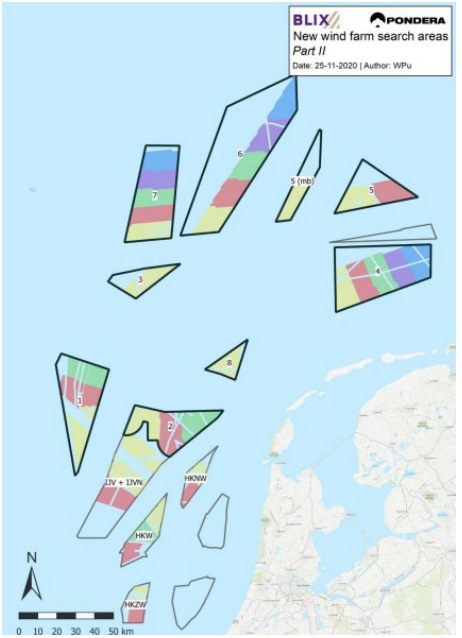


Conclusions

X-Wakes



- Germany has ambitious plans for offshore wind farm expansion, but areas are very limited – need to plan wisely already now
- X-Wakes project focused on improving and validating models and transferring knowledge towards more efficient wind farm operation and planning
- Cross-border planning and joint research between North Sea / Baltic Sea states is extremely important
- Many X-Wakes results are publicly available, several publications in preparation



Acknowledgements

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Questions?