



Linking calculation of wakes from offshore wind farm cluster to the Danish power integration system

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Linking calculation of wakes from offshore wind farm cluster to the Danish power integration system

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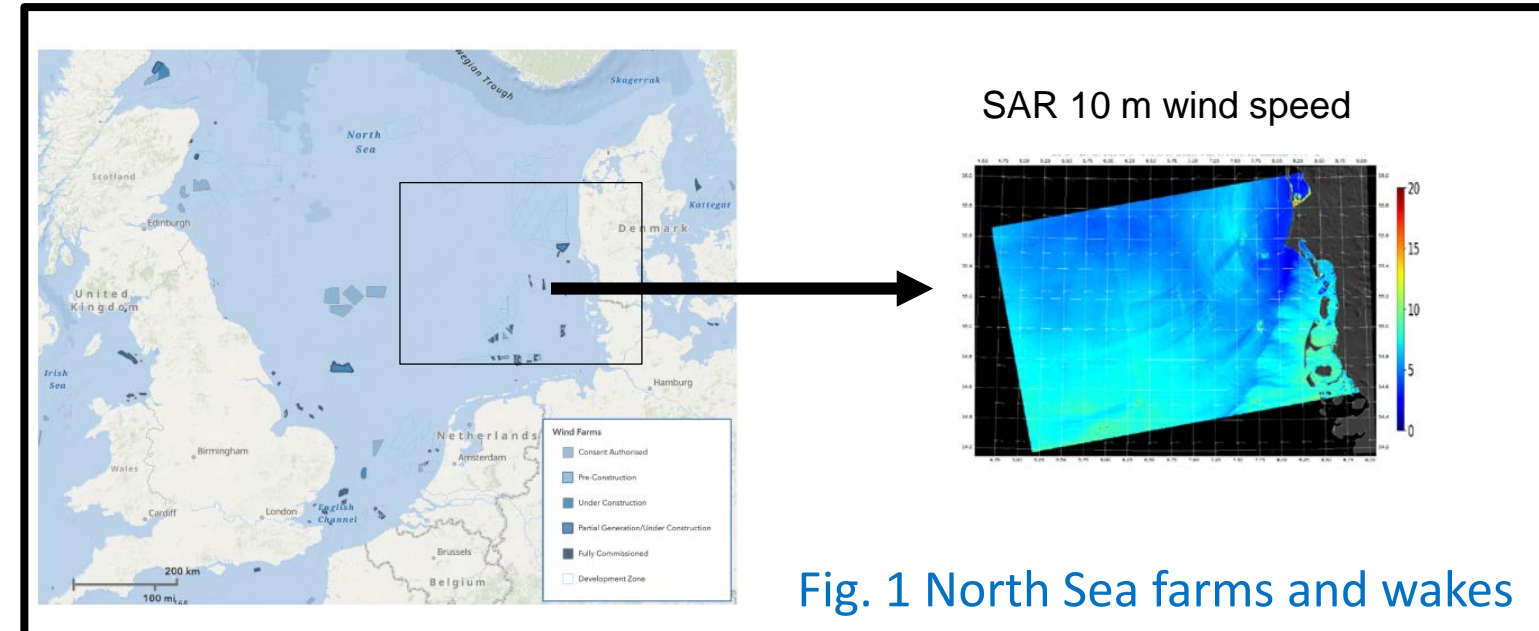
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1: DTU Wind Energy; 2: Vattenfall; 3: Wageningen University

Abstract

For the first time, the Danish power integration system takes into account of wake effects from large offshore wind farm clusters. The wake effect was calculated through an innovative, mesoscale wind-wave-wake coupled modeling system developed at DTU Wind Energy Department.

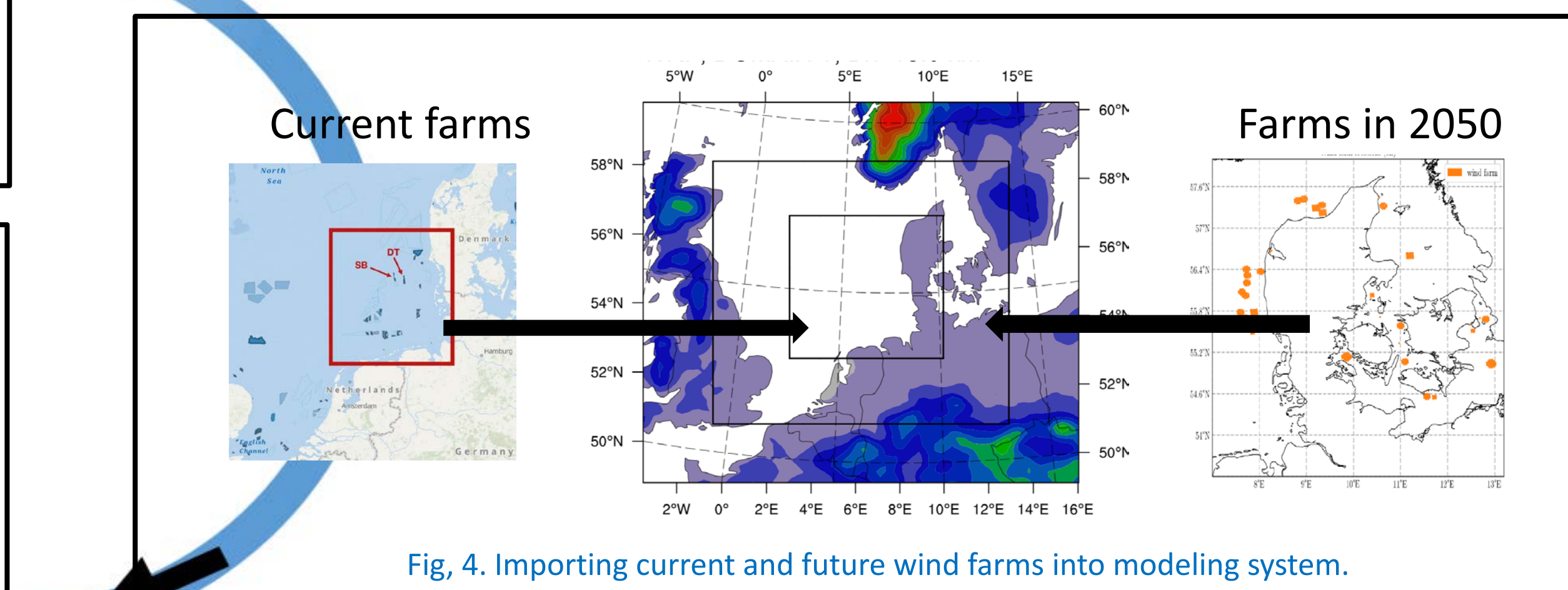
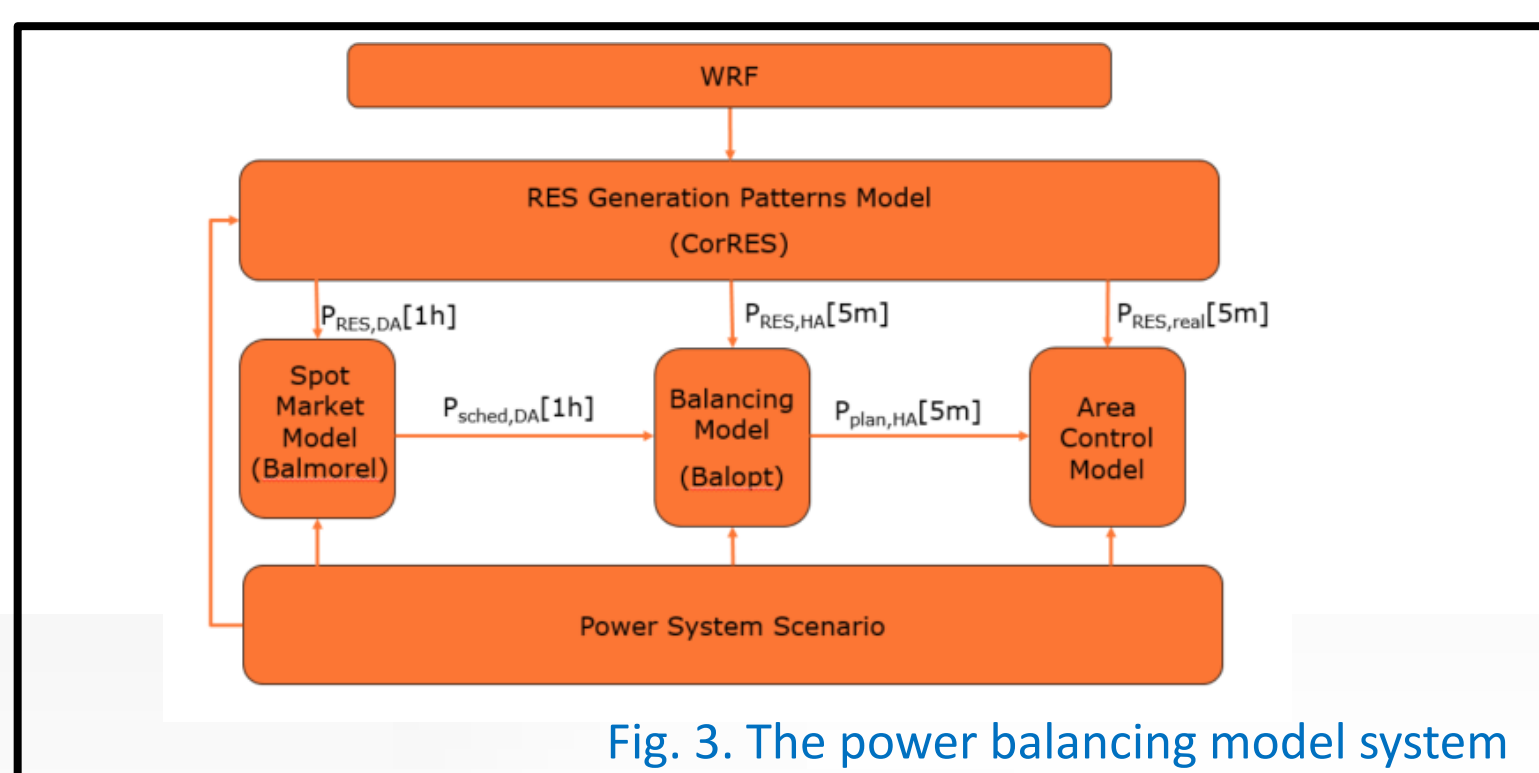
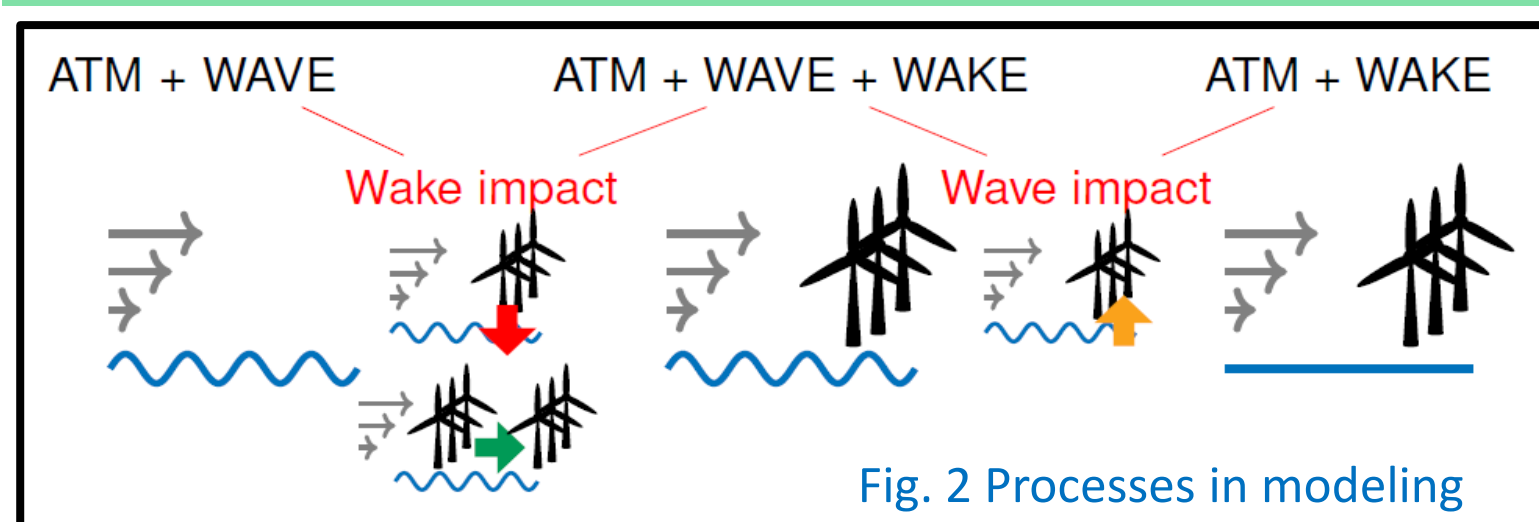
Objectives



Offshore wind farm clusters are growing, see Fig. 1 for the crowdedness over part of the North Sea. Farms downwind of other farms suffer from reduced wind resource, namely the wake effect (e.g. Fig. 1). This farm-farm wake effect has never been taken into consideration in a power integration system.

In an offshore environment, winds interact with waves. This project also aims to answer how the interaction is between winds, waves, currents and wakes (Fig. 2, [1]), and how it will affect the power integration system. Eventually an optimized modeling system will be recommended for the offshore application.

Methods



- Couple wind-wave-current-wake modeling (WRF-SWAN(WBLM)-ROMS-EWP/FITCH)[2,3]
- Power balancing model with coupled model input
- Long term modeling, using both climatologically representative year method [4] and statistical-dynamical downscaling method [1]
- For current, as well as future scenarios (2050)
- Calibration, verification and validation using measurements (SCADA at DanTysk (DT) and Sandbank (SB), numerous stations and SAR data)

Results

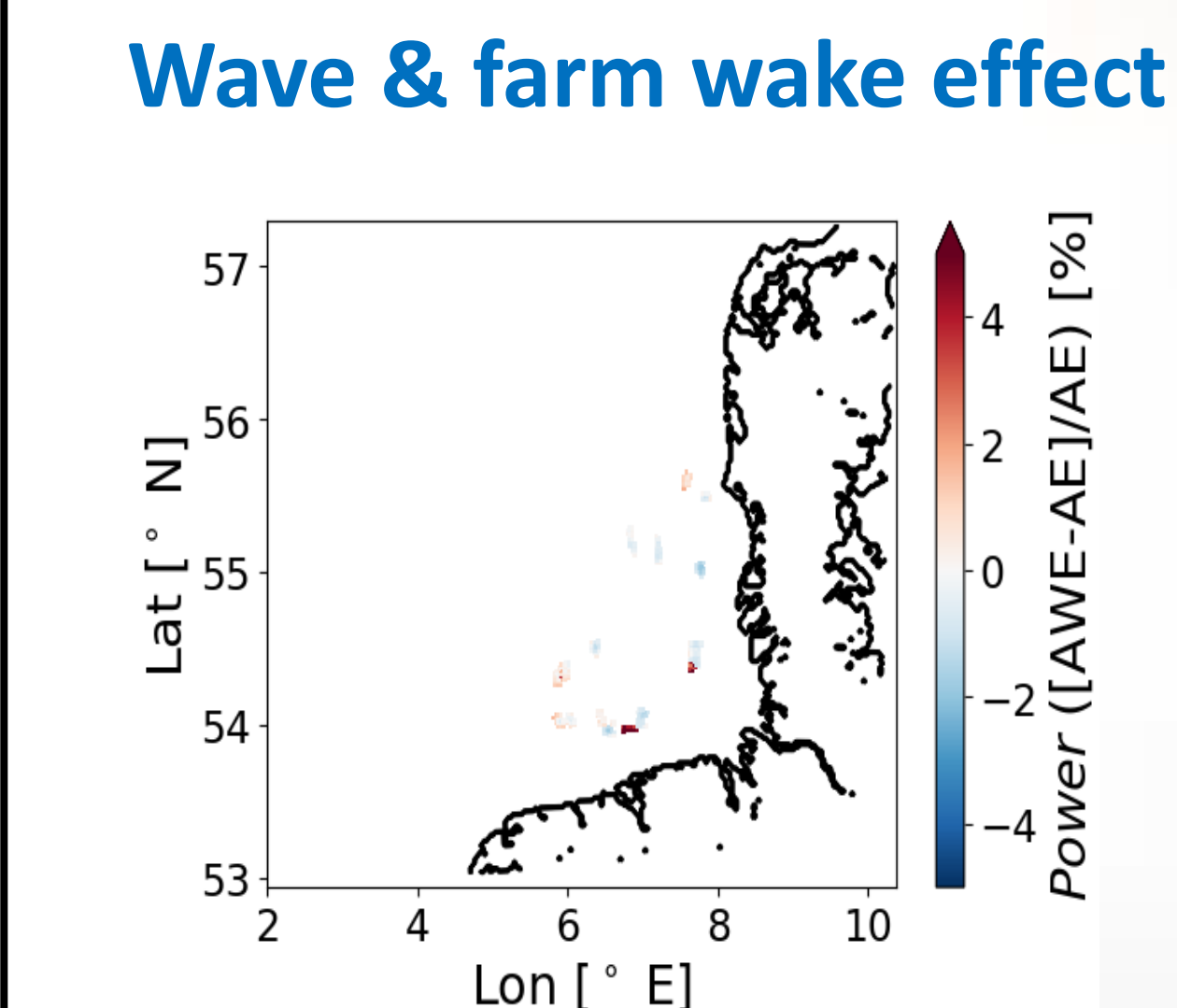
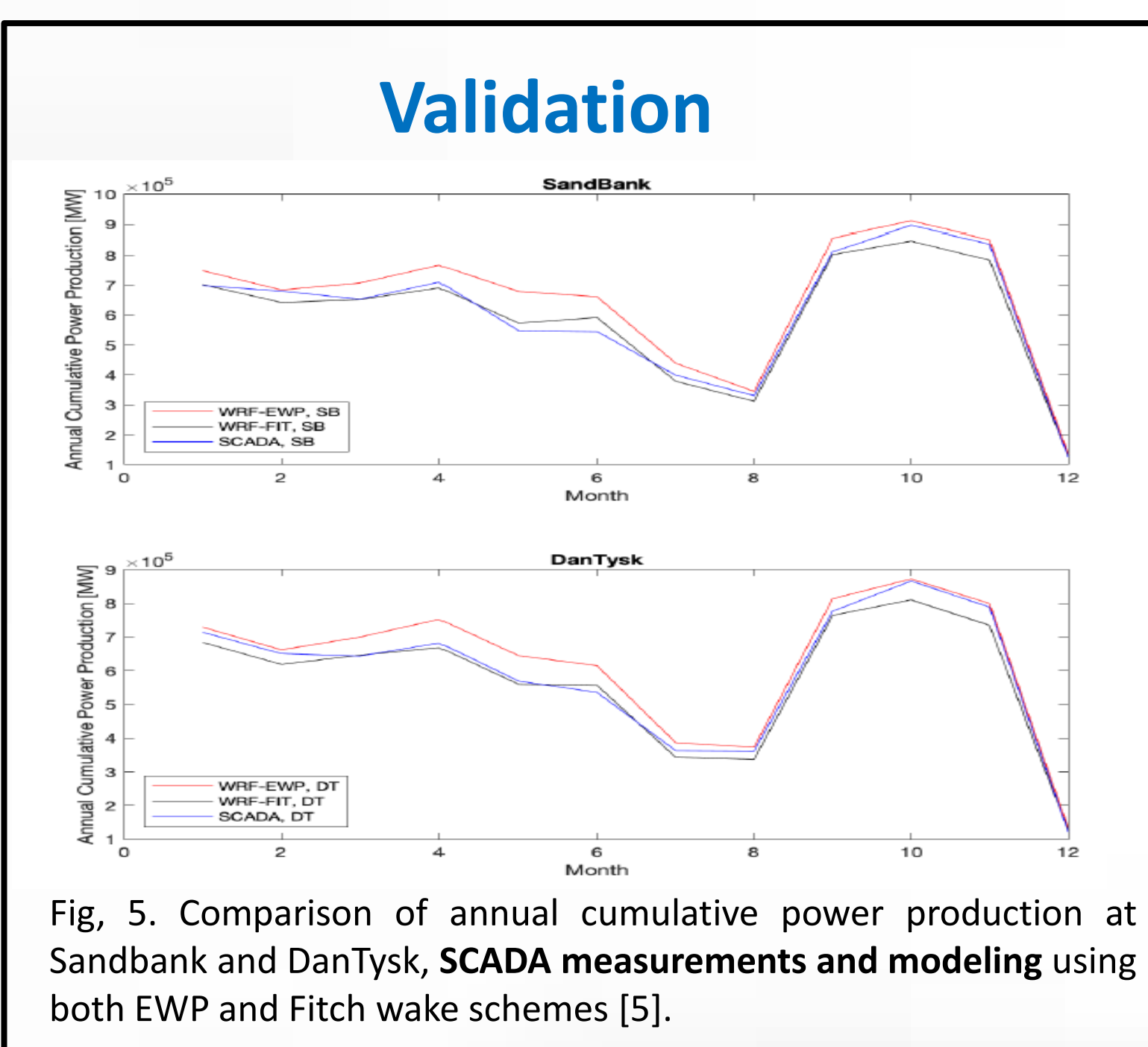


Fig. 6a. Long term wave effect on mean power production at wind farms using coupled model WRF-SWAN (WBLM)-EWP[1].

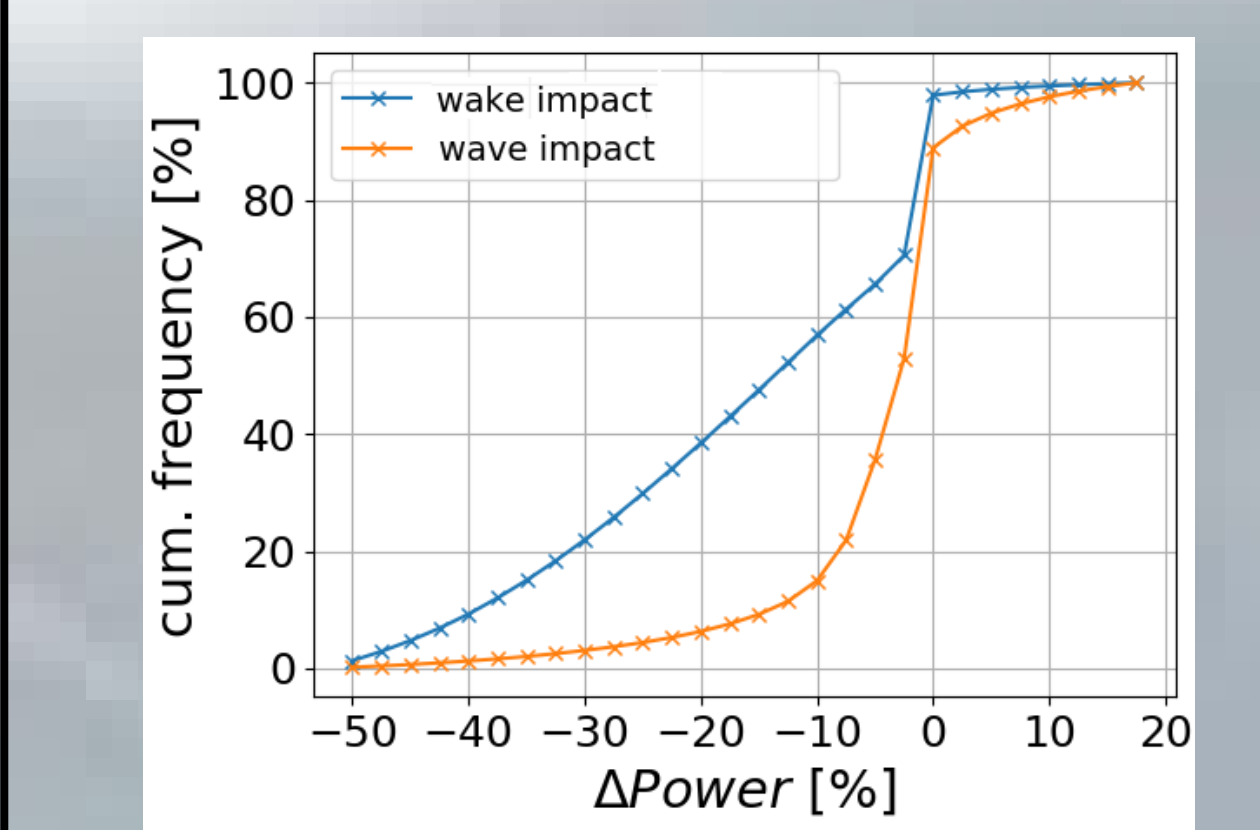


Fig. 6b. Cumulative frequency for changed power production due to wave and wake effect, respectively, using coupled model WRF-SWAN (WBLM)-EWP for current climate over domain in Fig6a[1].

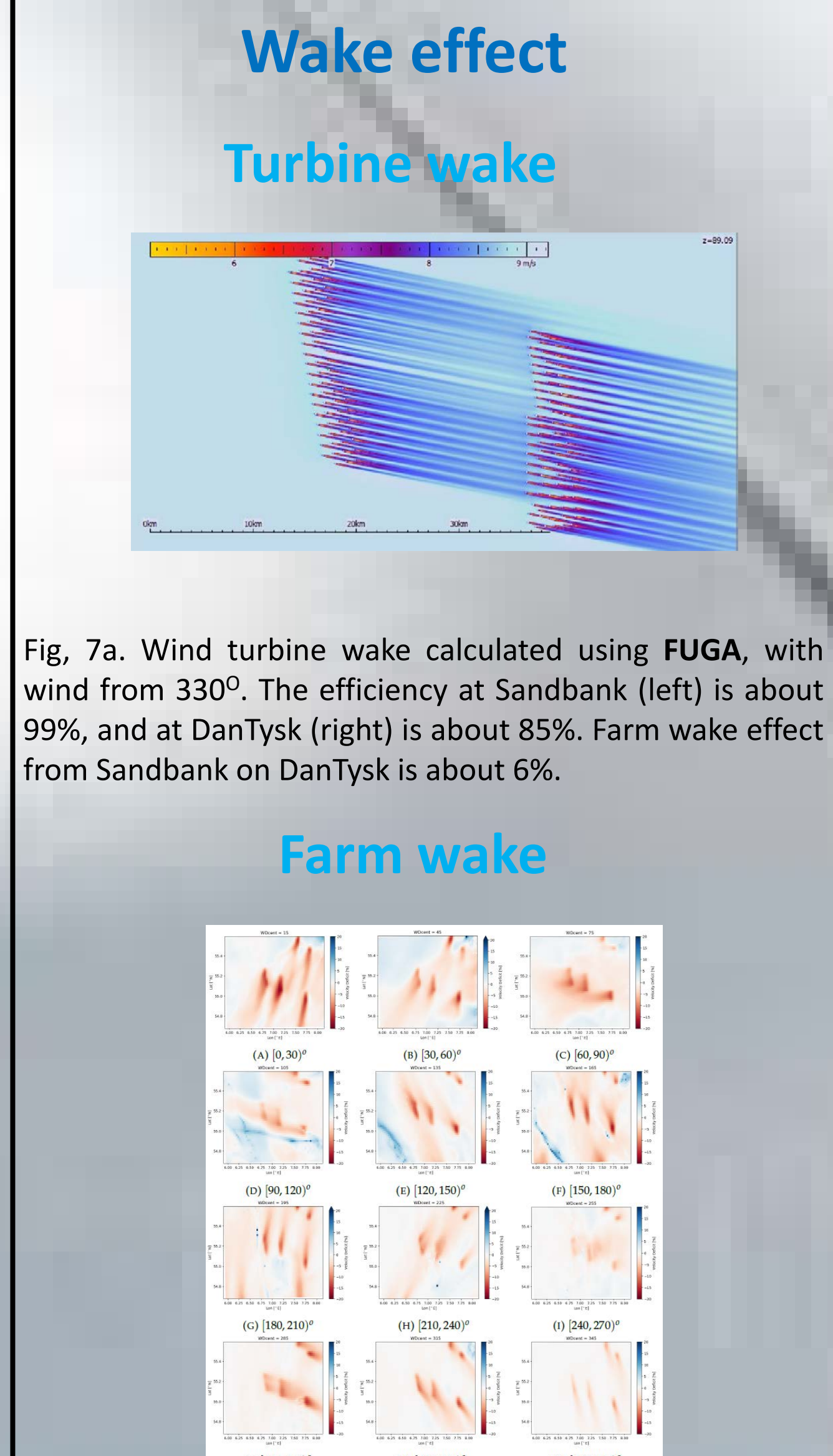


Fig. 7a. Wind turbine wake calculated using FUGA, with wind from 330°. The efficiency at Sandbank (left) is about 99%, and at DanTysk (right) is about 85%. Farm wake effect from Sandbank on DanTysk is about 6%.

Fig. 7b. Monthly mean wind speed deficit at hub height for May 2018 using Fitch scheme based on prevailing direction around Sandbank and DanTysk [5]

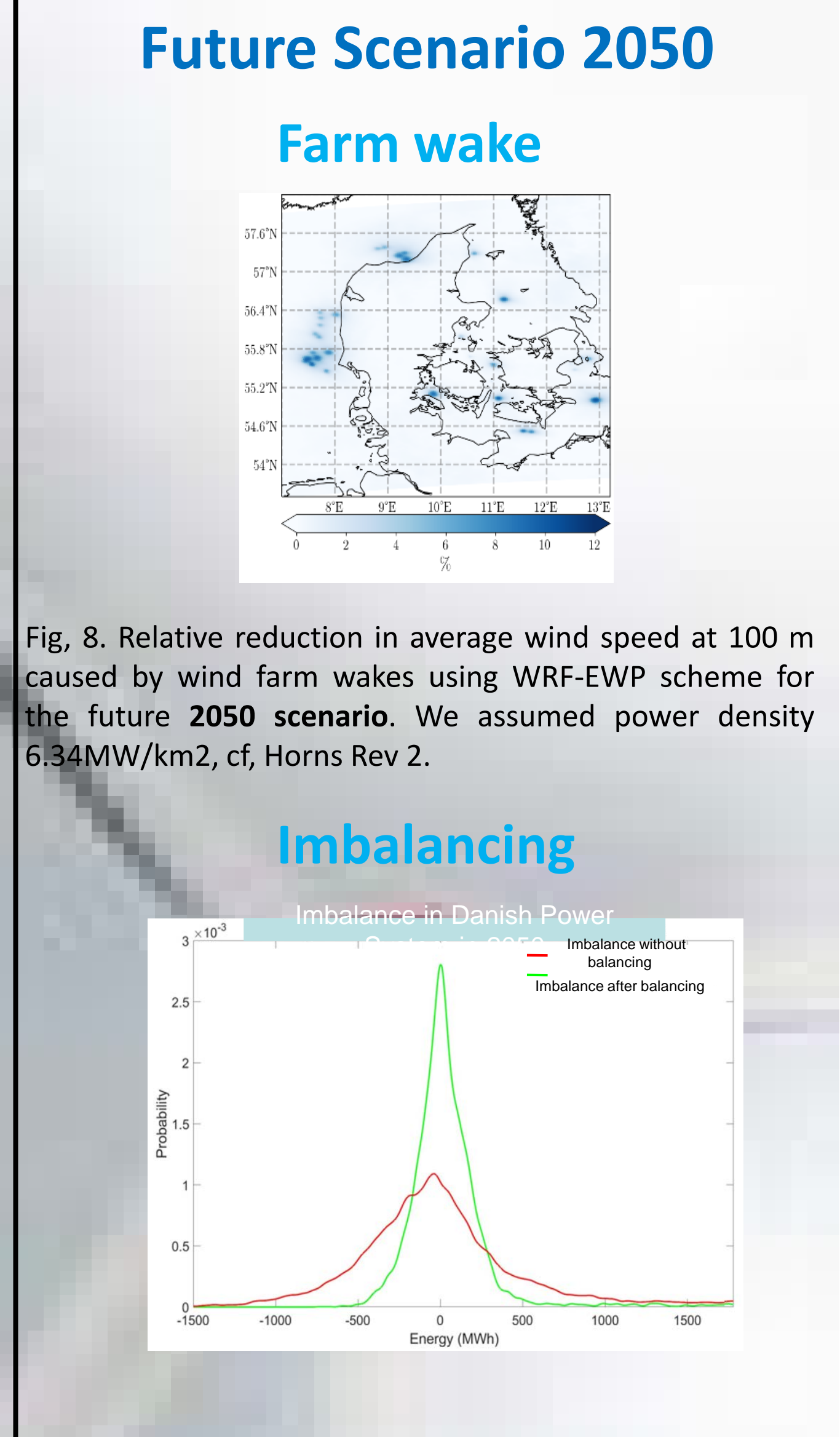


Fig. 8. Relative reduction in average wind speed at 100 m caused by wind farm wakes using WRF-EWP scheme for the future 2050 scenario. We assumed power density 6.34MW/km2, cf. Horns Rev 2.

Fig. 9. Probability distribution function of the Real Time imbalance induced in the Danish power system in the year 2050. Red curve is in case of no Intra-Hour balancing optimization. Intra-farm wakes are considered so far.

Conclusions

- A Robust wind-wave-ocean-wake coupled modeling system developed at DTU Wind Energy, providing real time meteorological, wave and ocean, and wake parameters.
- A first time model ready for input to power integration system, for current and future scenario. The model is of general use.
- The offshore wind farm cluster wake effect is considerable.

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