CATAPULT
Offshore Renewable Energy

INTRODUCTION TO WEBINAR:

"Are governments waking up to wind wakes?"

Ken Kasriel

1 December 2023

Credit: Vestas

CONTENTS

- Wakes within farms, between farms
- Evolving science, evolving industry
- Contiguity
- International wakes
- What's the best use of the seabed?
- Are governments waking up to wind wakes?
- Takeaways (my humble pleas)

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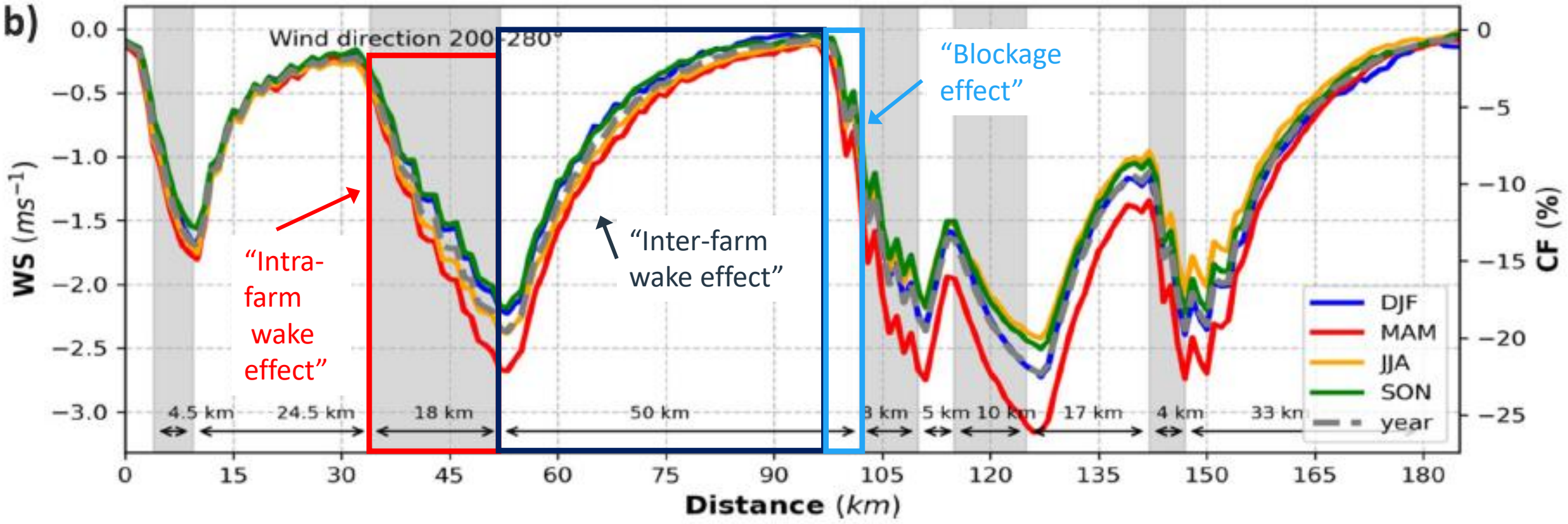
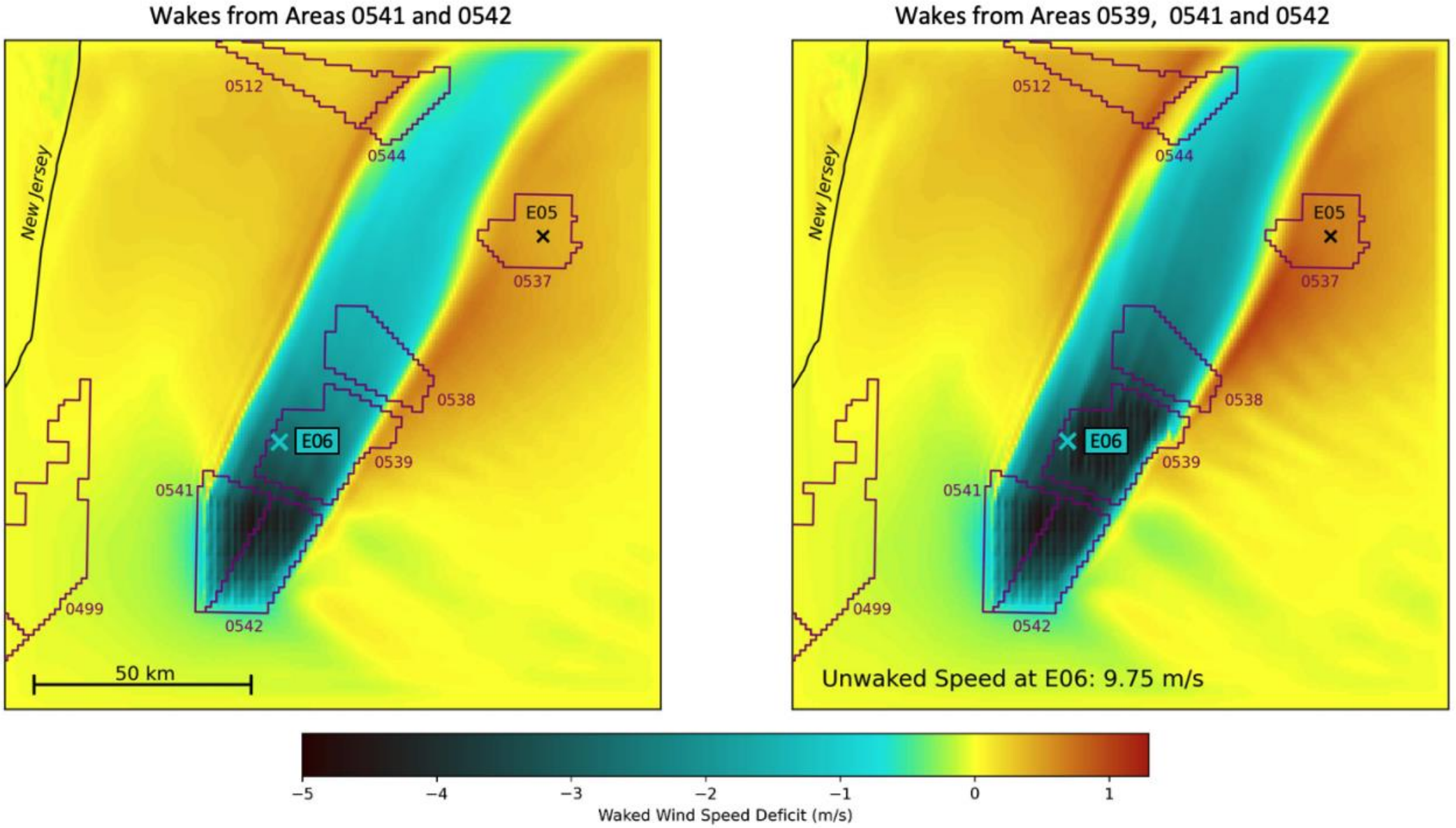
Wakes between farms

Simulated speed of wind blowing through five UK offshore wind farms (grey zones)



From Akhtar et. al , in *Nature*, June 2021 https://www.nature.com/articles/s41598-021-91283-3
Own boxes, lables and arrows



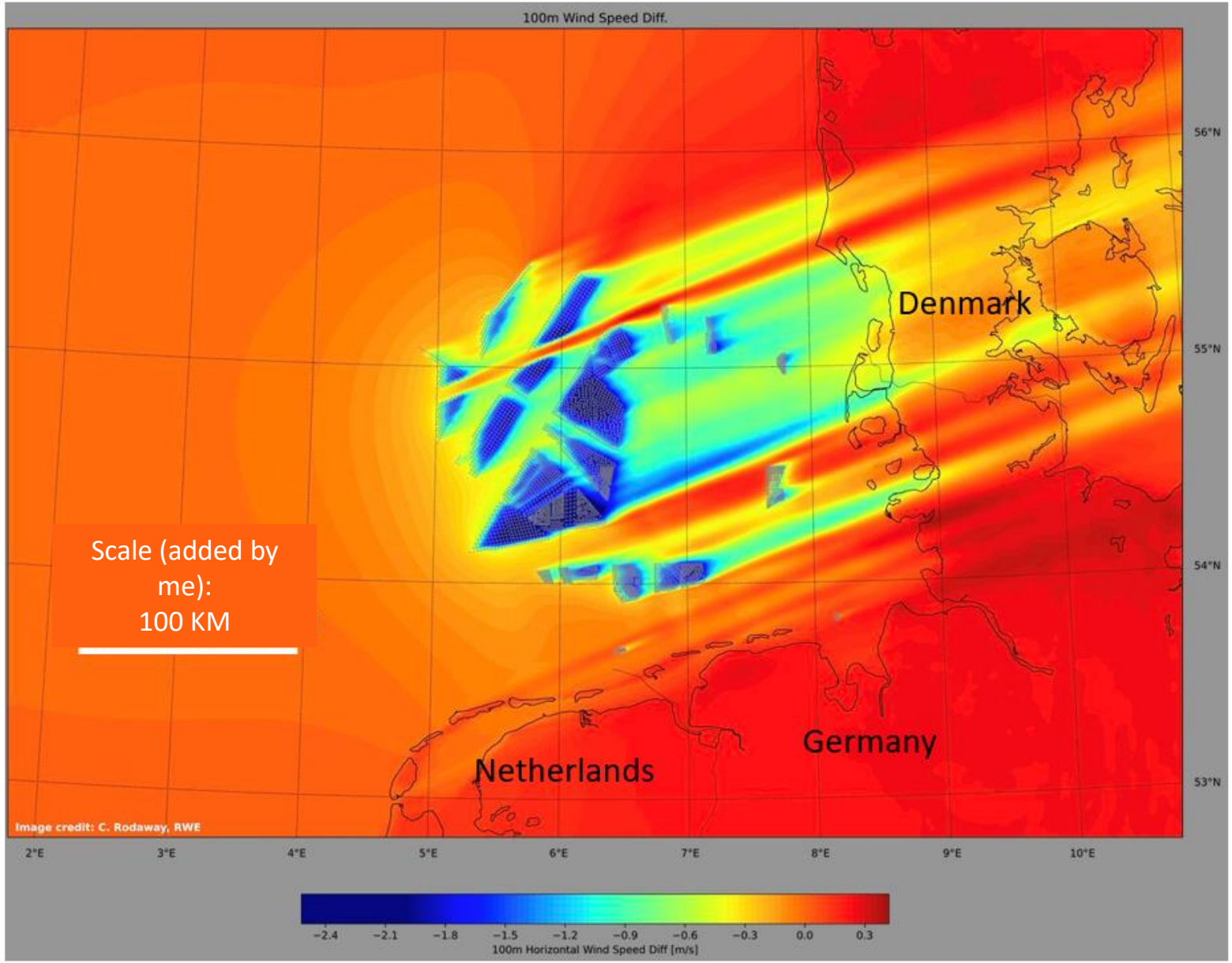
Mesoscale simulation of lease areas offshore New Jersey and New York, from Stoelinga et. al, "Estimating Long-Range External Wake Losses in Energy Yield and Operational Performance Assessments Using the WRF Wind Farm Parameterization," ArcVera Renewables, August 2022

Sven Utermöhlen • 1st
CEO, RWE Offshore Wind GmbH
7mo •

"We have identified this phenomenon as a challenge with regards to the energy yield of future offshore wind farms. They could be impacted heavily if they are in the long distance wind shadow of large clusters.

A physical effect with quite literal far-reaching implications, the models by RWE predict that these cluster wake effects can affect wind speed as far as 200 kilometers away, reducing the wind yield of future offshore farms by more than 10%."

-Sven Utermöhlen , CEO, RWE Offshore Wind GmbH, March 2023



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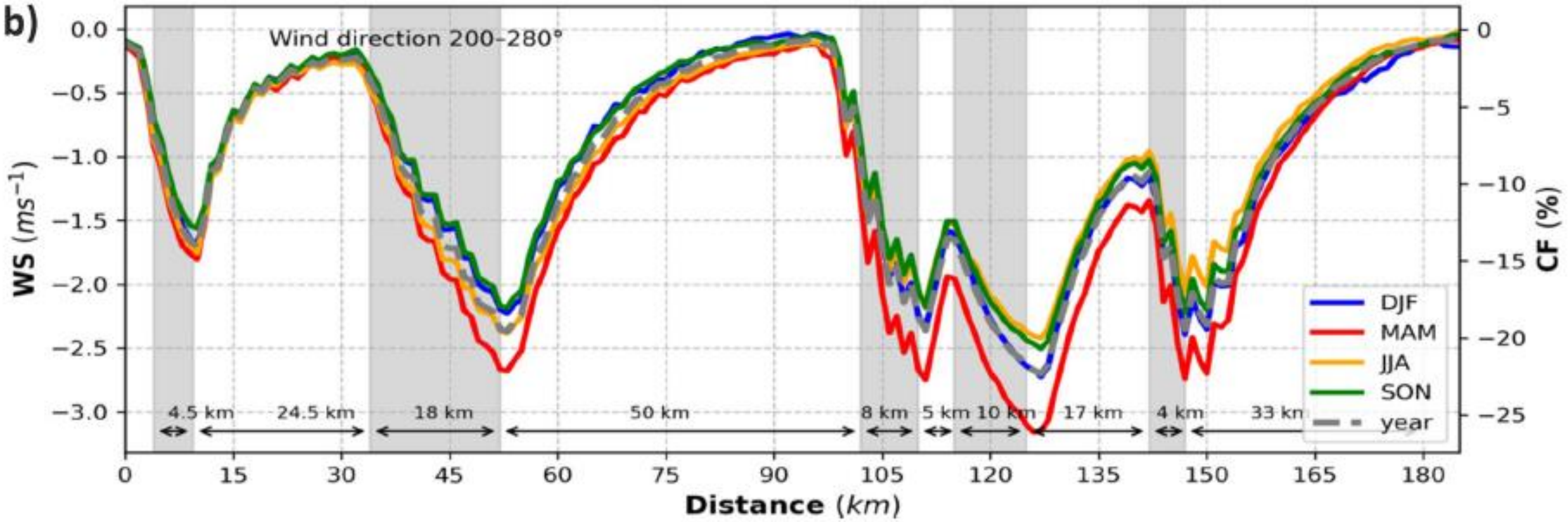

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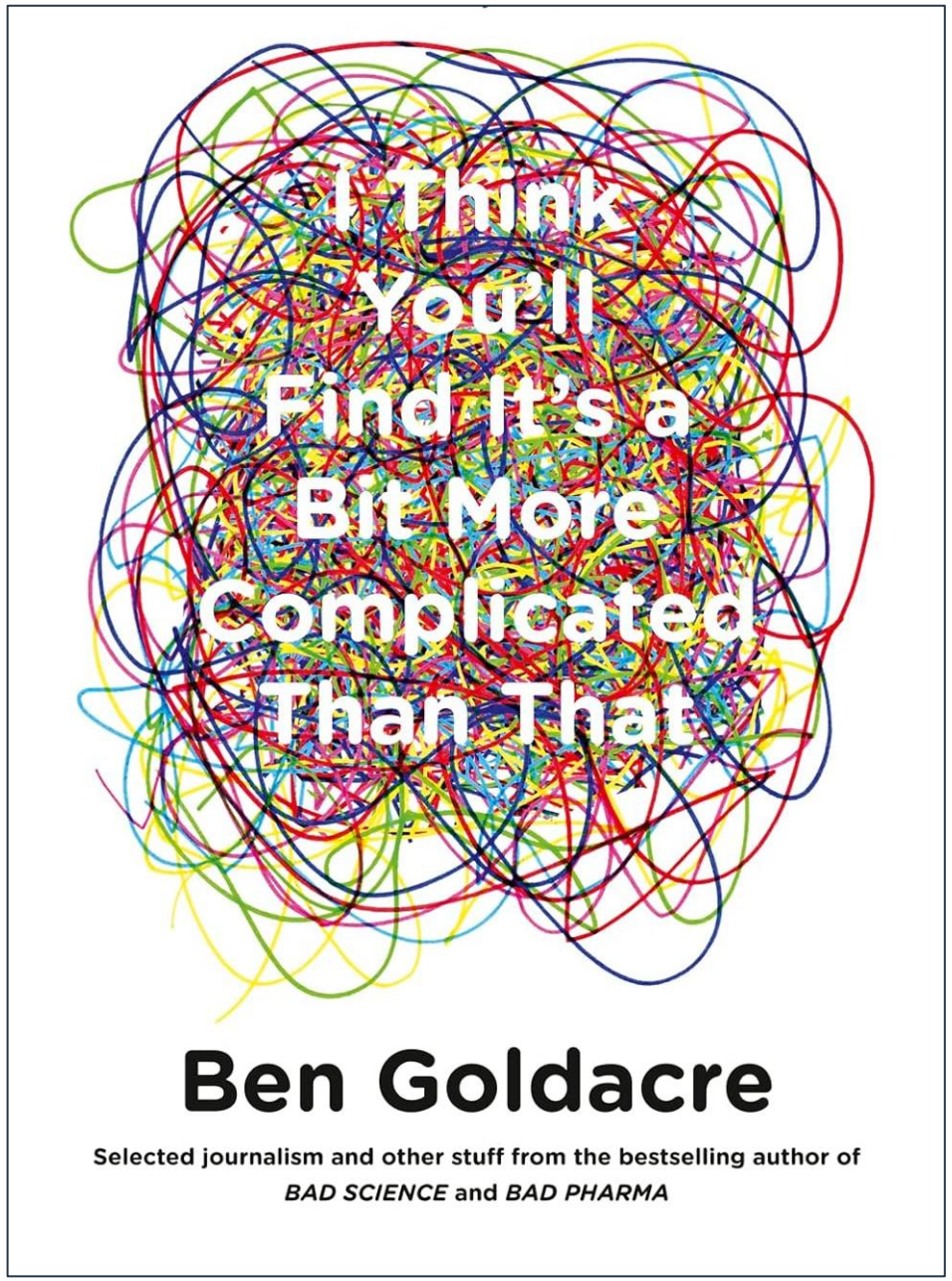
Wake length and “strength”: looking for some easy rules-of-thumb?



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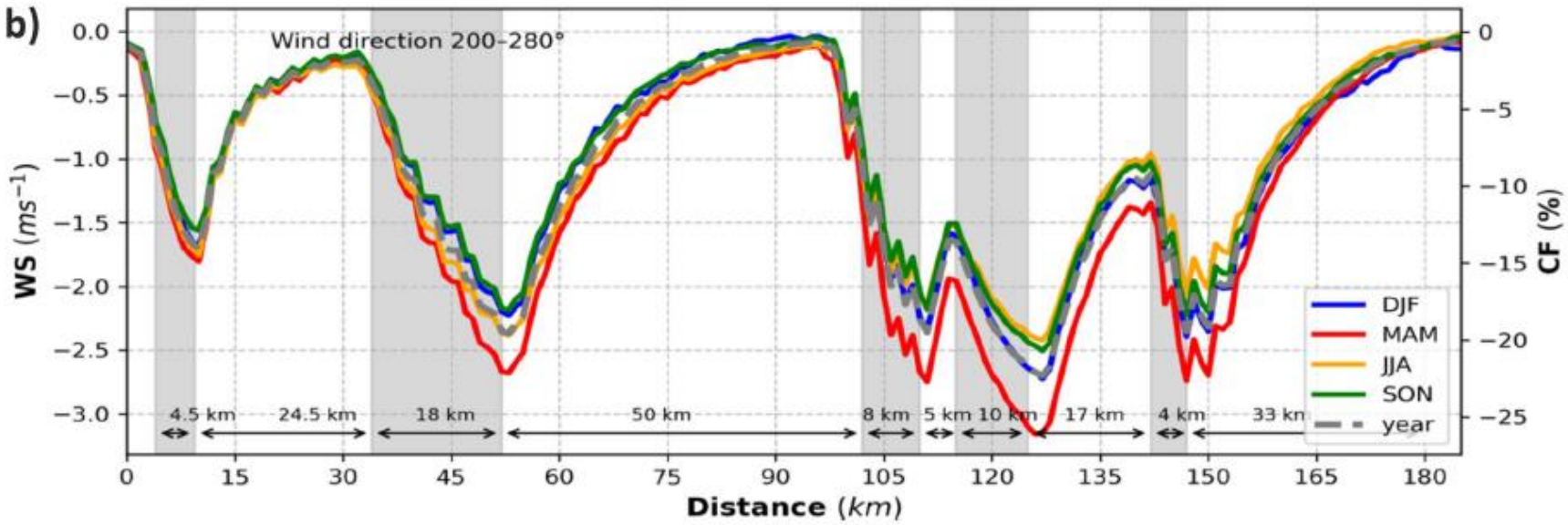

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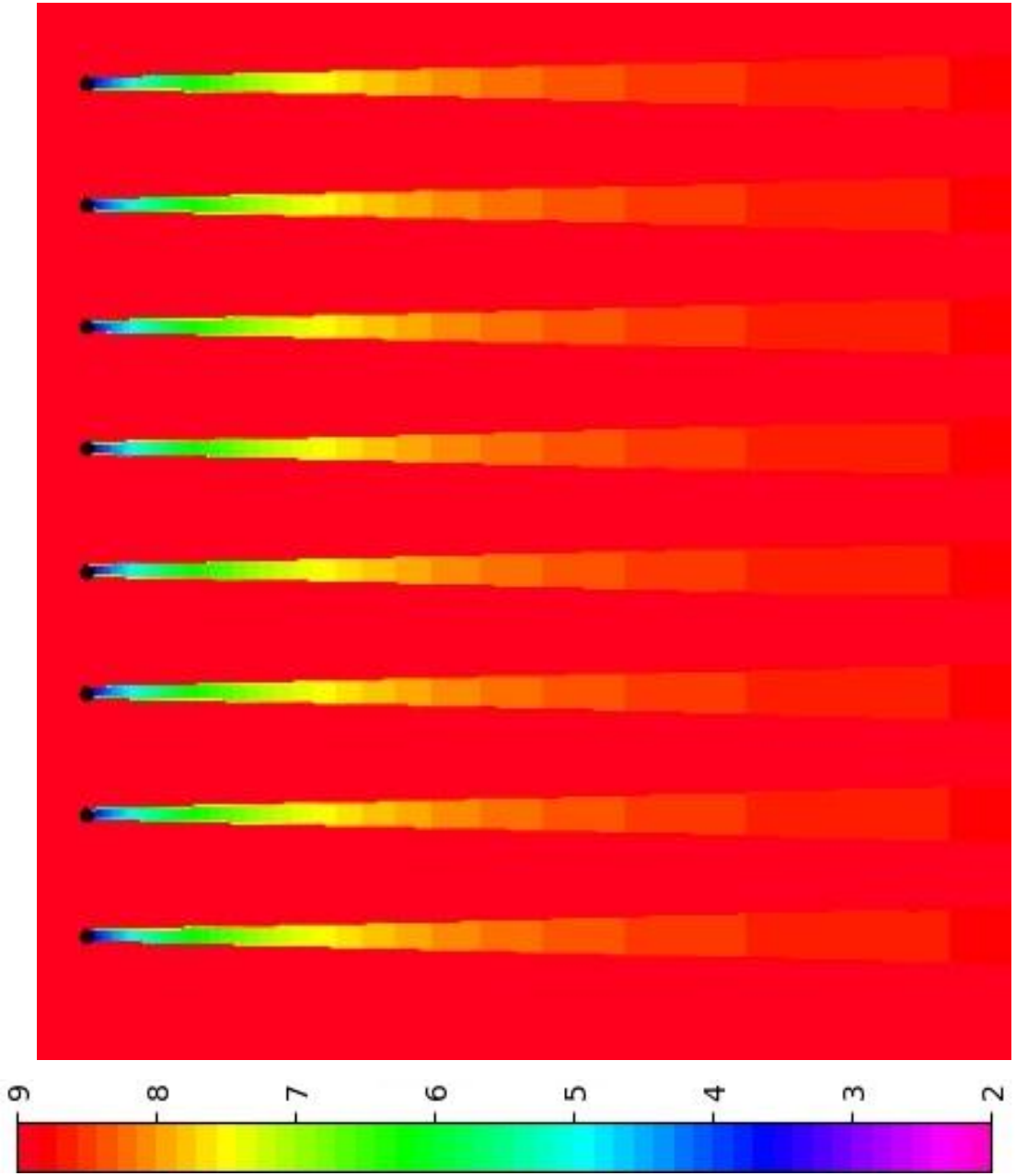
Some of the variables influencing wakes

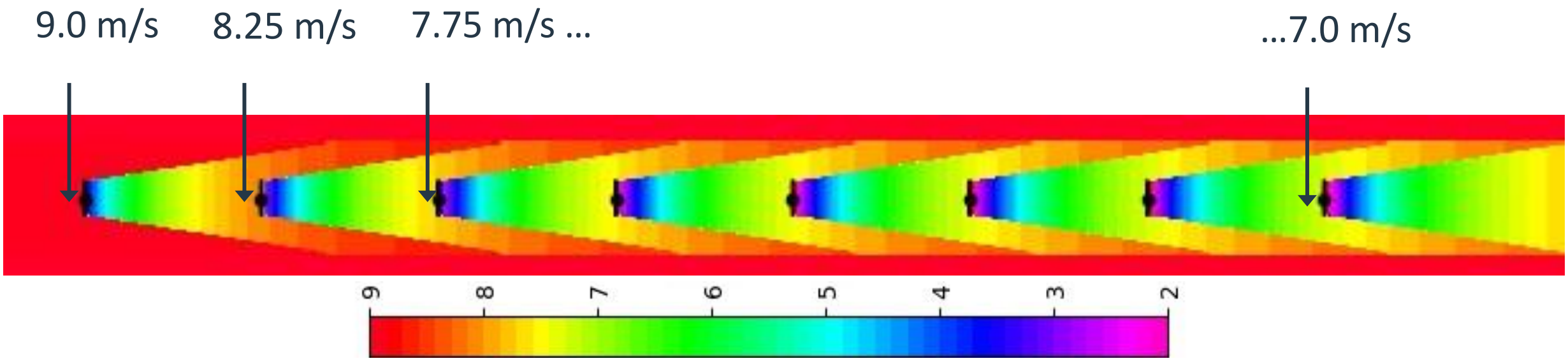
- the undisturbed wind speeds (i.e. before being “waked”)
- a site’s layout, including density (capacity per KM2)
- annual wind direction patterns

Notional layout I



Wind speed, metres/second (m/s)

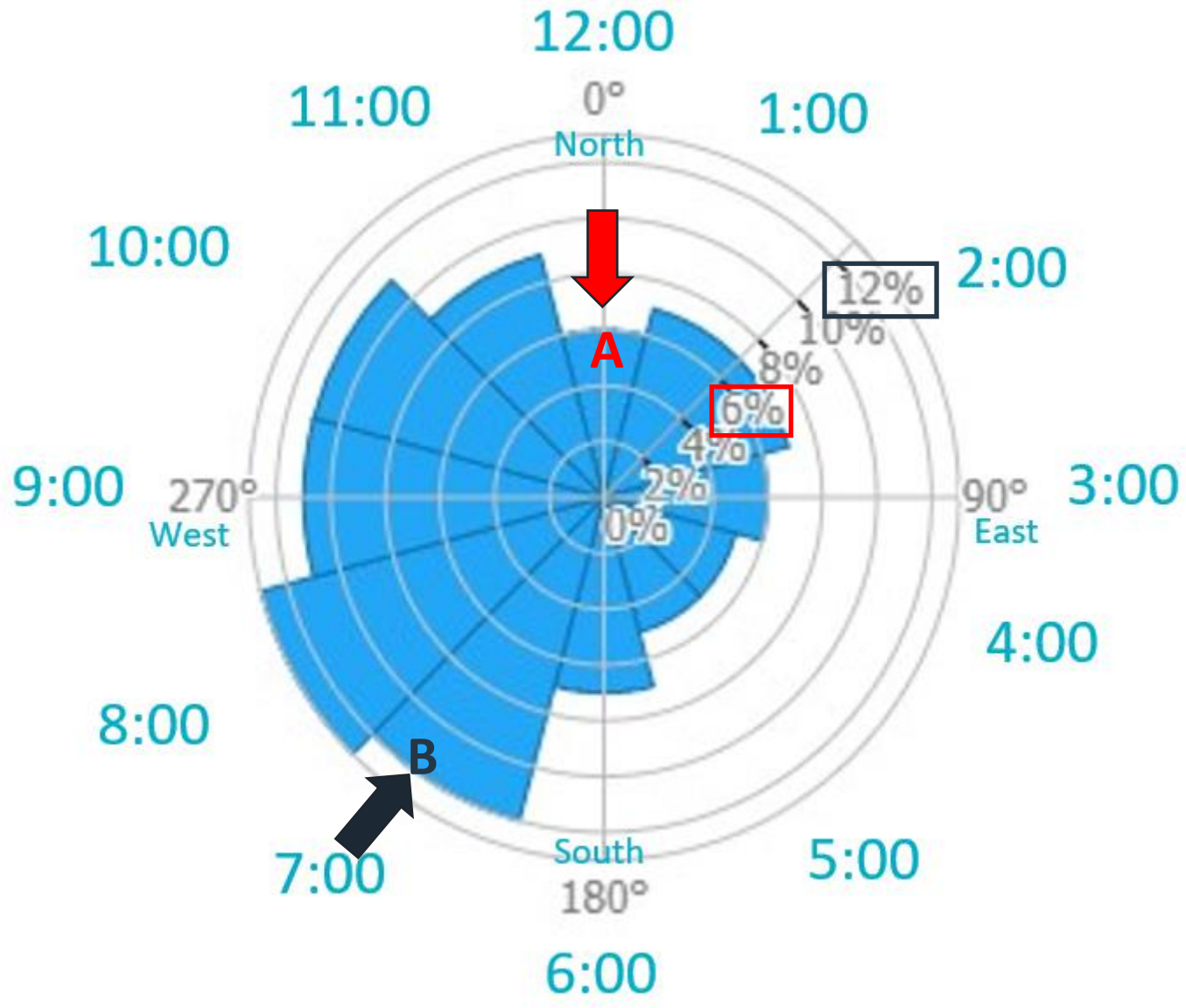
Notional layout II



"Compound wakes"
(my informal term)

VIEWING WIND DIRECTION PATTERNS WITH A WIND FREQUENCY "ROSE"

Percentages sum to 100%



Source: Global Wind Atlas

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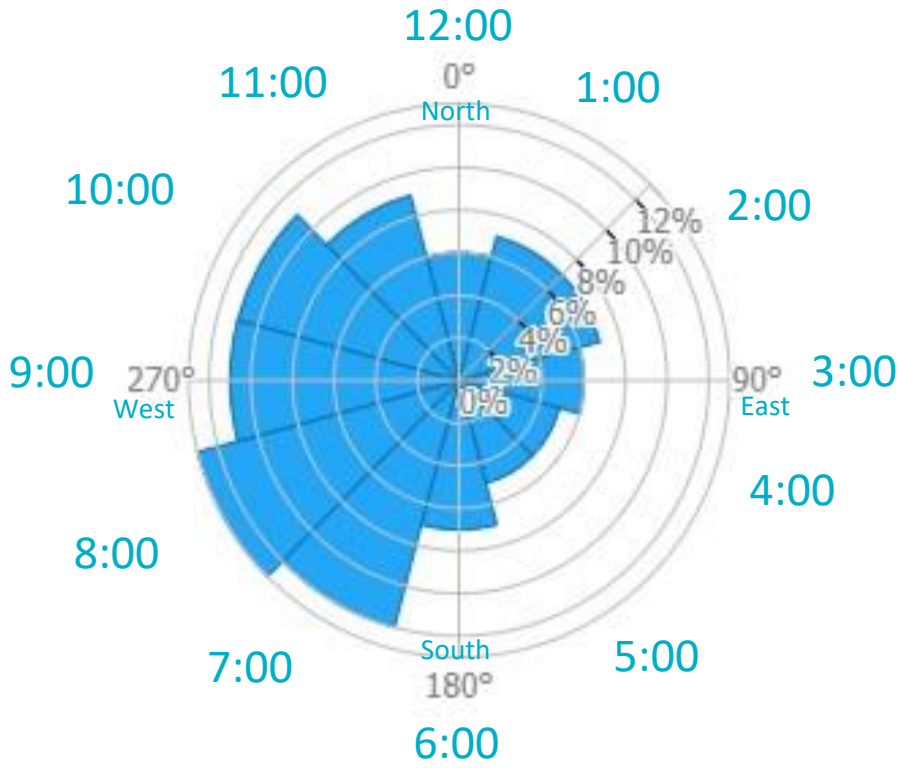
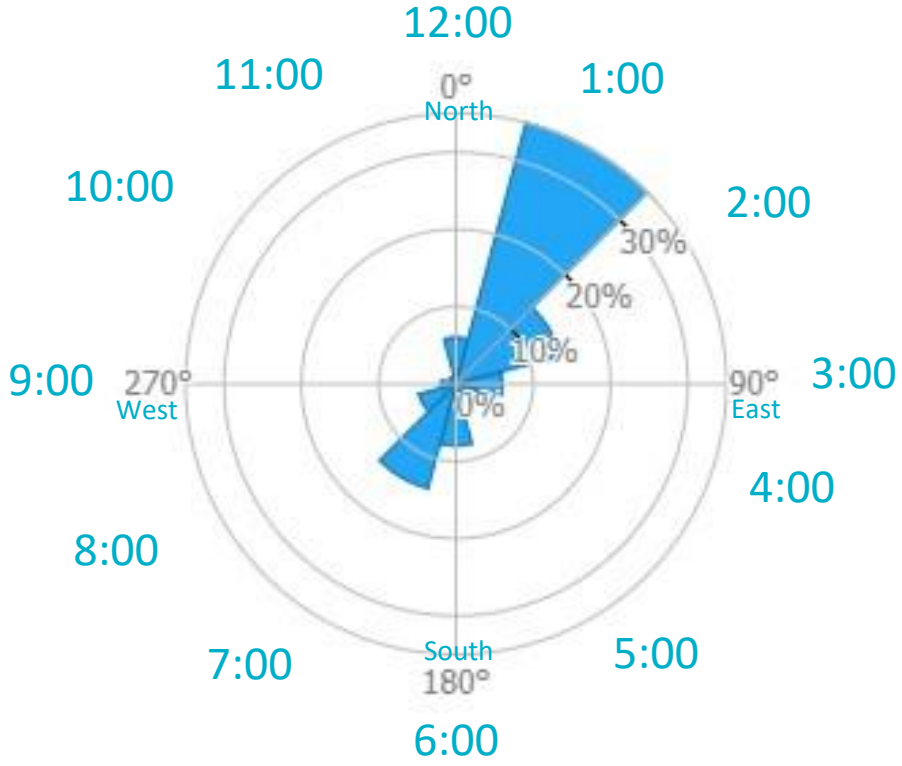
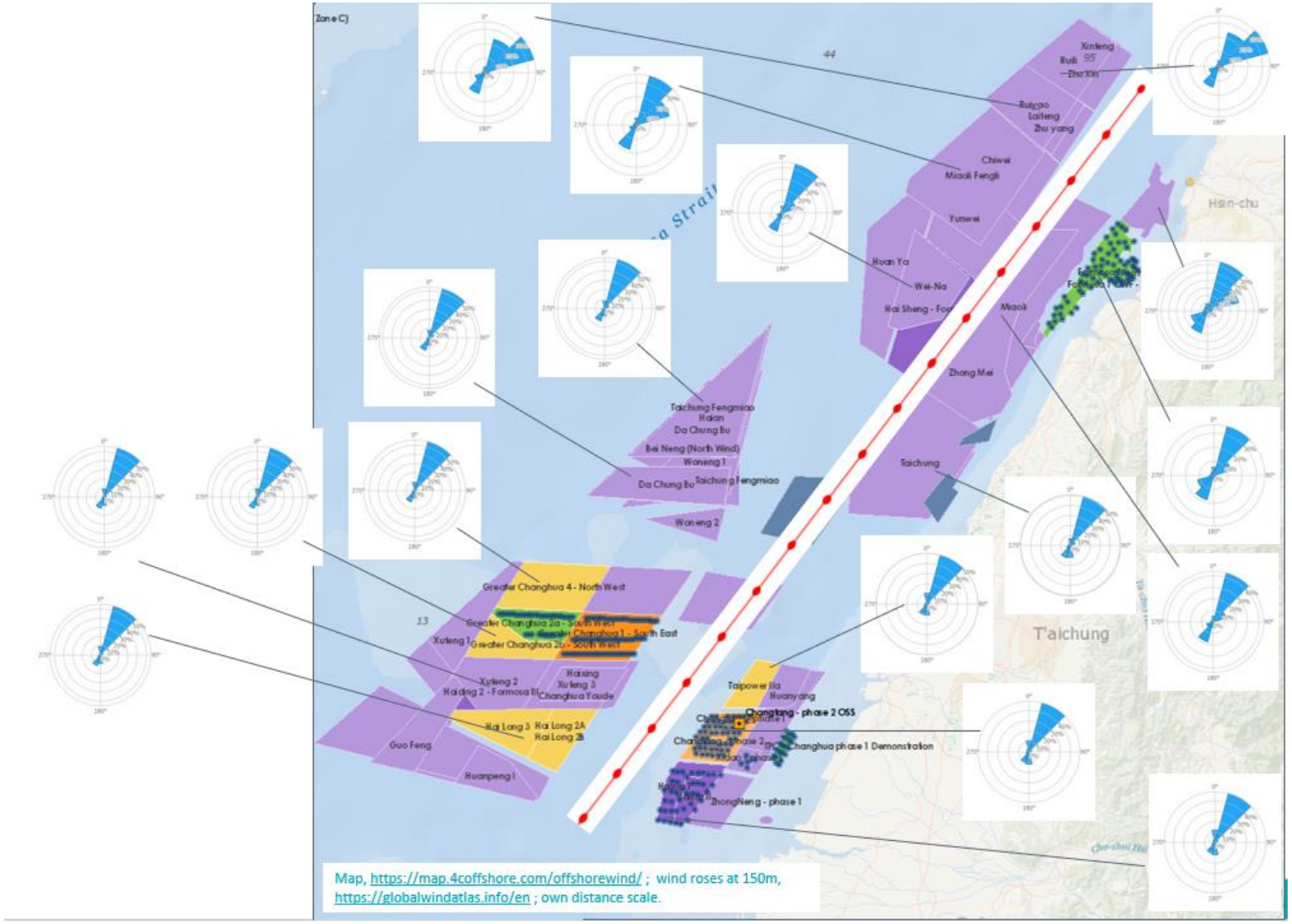




Source: Global Wind Atlas

Wind roses for selected areas, Taiwan.

Distance between red dots is 10 km.



- Fully Commissioned
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https://map.4coffshore.com/offshorewind/; Global Wind Atlas

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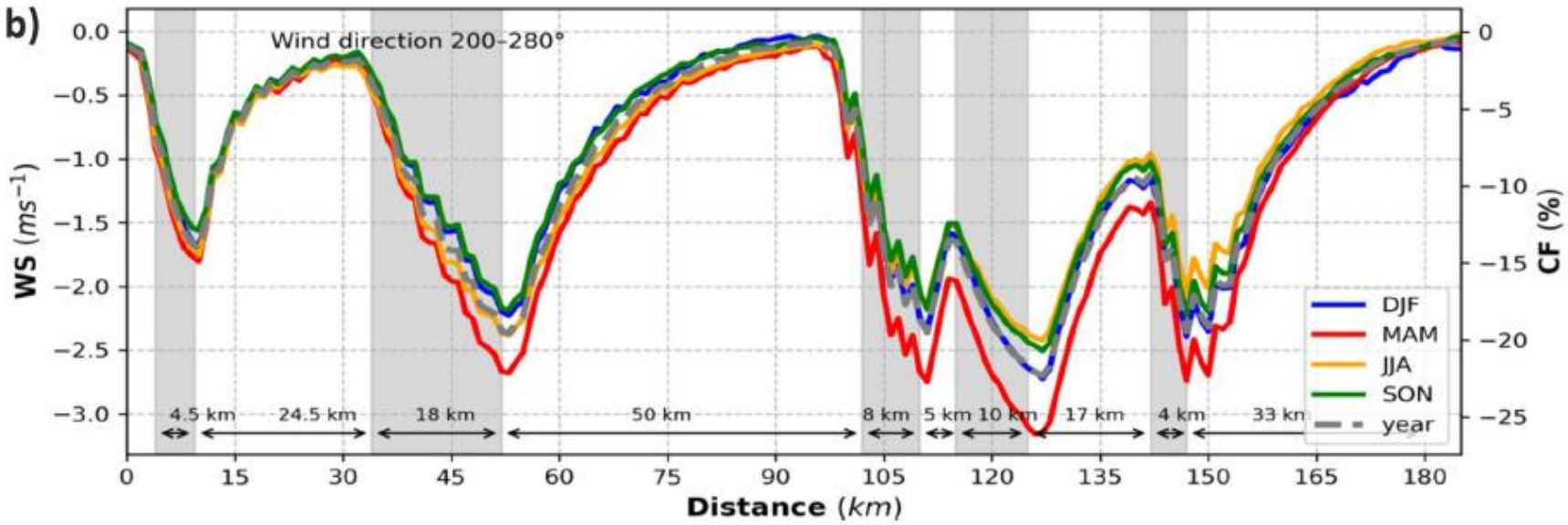

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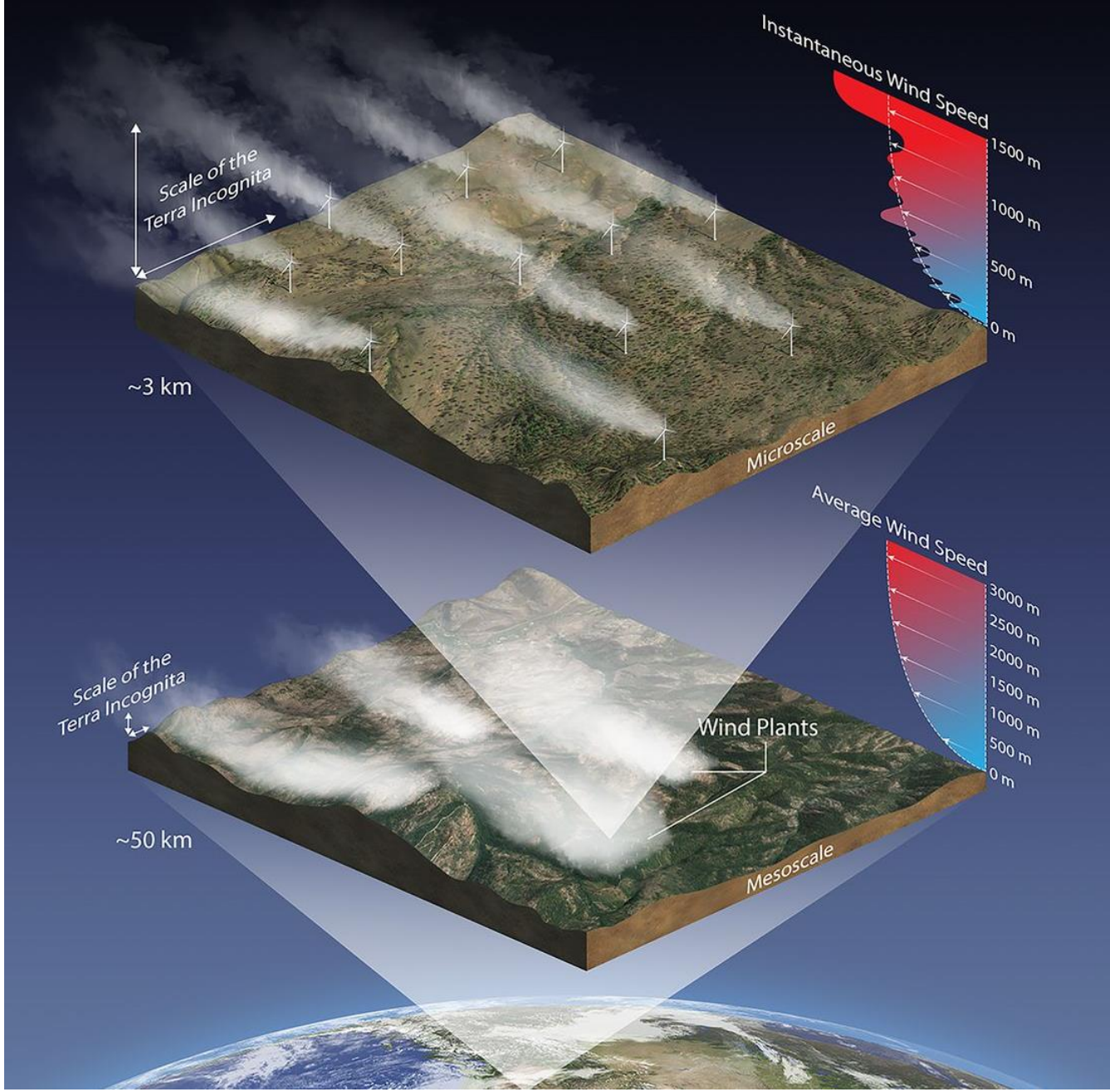
Some of the variables influencing wakes

- the undisturbed wind speeds (i.e. before being “waked”)
- a site’s layout, including density (capacity per KM2)
- annual wind direction patterns turbine
- turbine hub height and swept area of the blades
- **atmospheric conditions:** local **micro-scale** and surrounding **meso-scale** (medium distance/ a few kilometers up)

MICRO-SCALE & MESO-SCALE

Micro-scale

Meso-scale



From "Grand challenges in the science of wind energy," illustration by Besiki Kazaishvili, US National Renewable Energy Laboratory, in Science, 10 October 2019

REVIEW

Grand challenges in the science of wind energy

PAUL VEERS, KATHERINE DYKES, ERIC LANTZ, STEPHAN BARTH, CARLO L. BOTTASSO, OLA CARLSON, ANDREW CLIFTON, JOHNEY GREEN, PETER GREEN, [...], AND RYAN WISER +19 authors Authors Info & Affiliations

SCIENCE · 10 Oct 2019 · Vol 366, Issue 6464 · DOI: 10.1126/science.aau2027

https://www.science.org/doi/10.1126/science.aau2027

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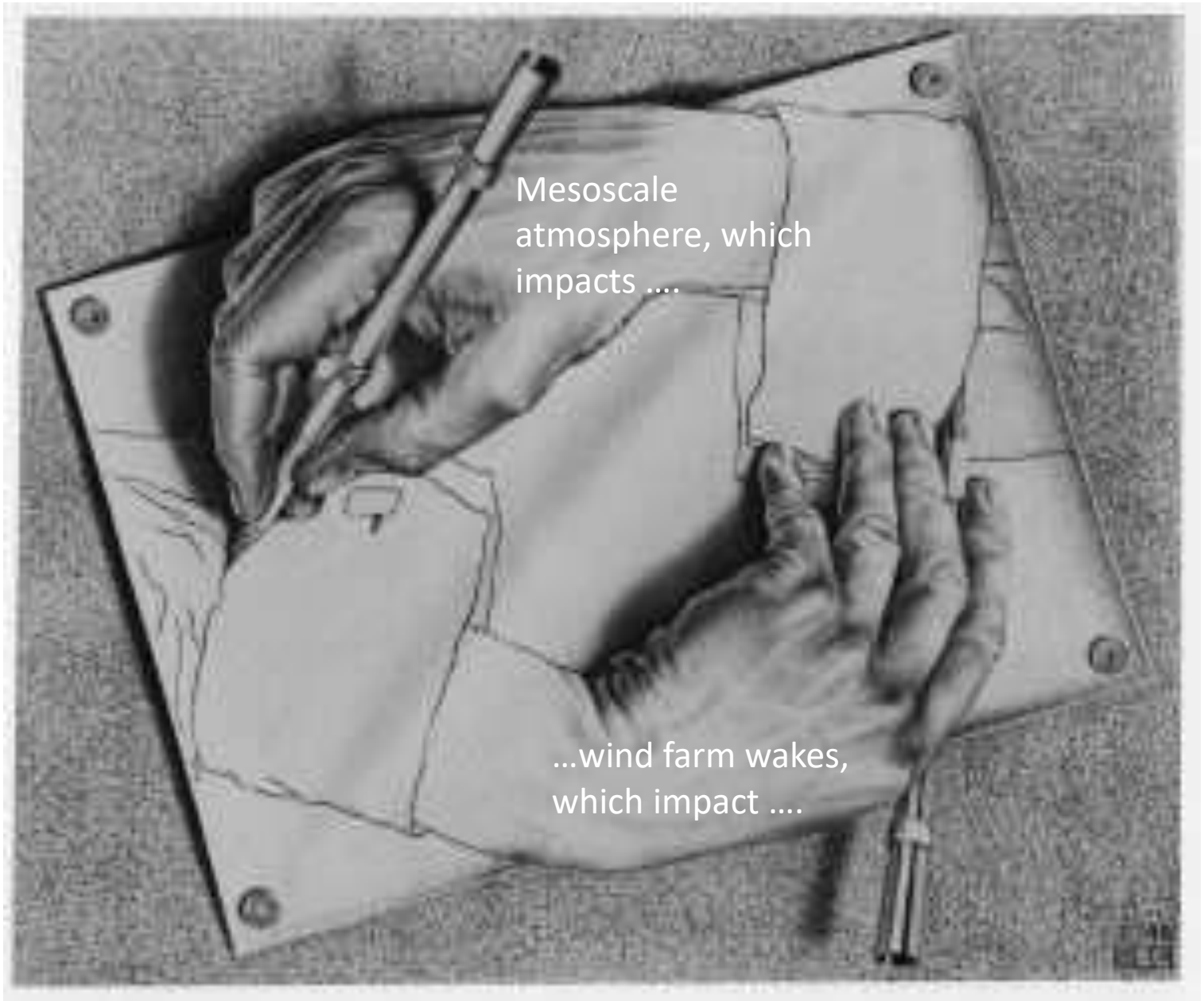
https://moa.byu.edu/m-c-eschers-drawing-hands/



Add to this the circularity, some moving parts:

The science of how offshore farm wakes and the atmosphere interact is new and evolving

The object of study, the farms themselves, are evolving, getting unprecedently

- larger
- more numerous
- more "neighbourly"

eawe european academy of wind energy
Wind Energy Science

Investigating energy production and wake losses of multi-gigawatt offshore wind farms with atmospheric large-eddy simulation

Peter Baas ✉, Remco Verzijlbergh, Pim van Dorp, and Harm Jonker

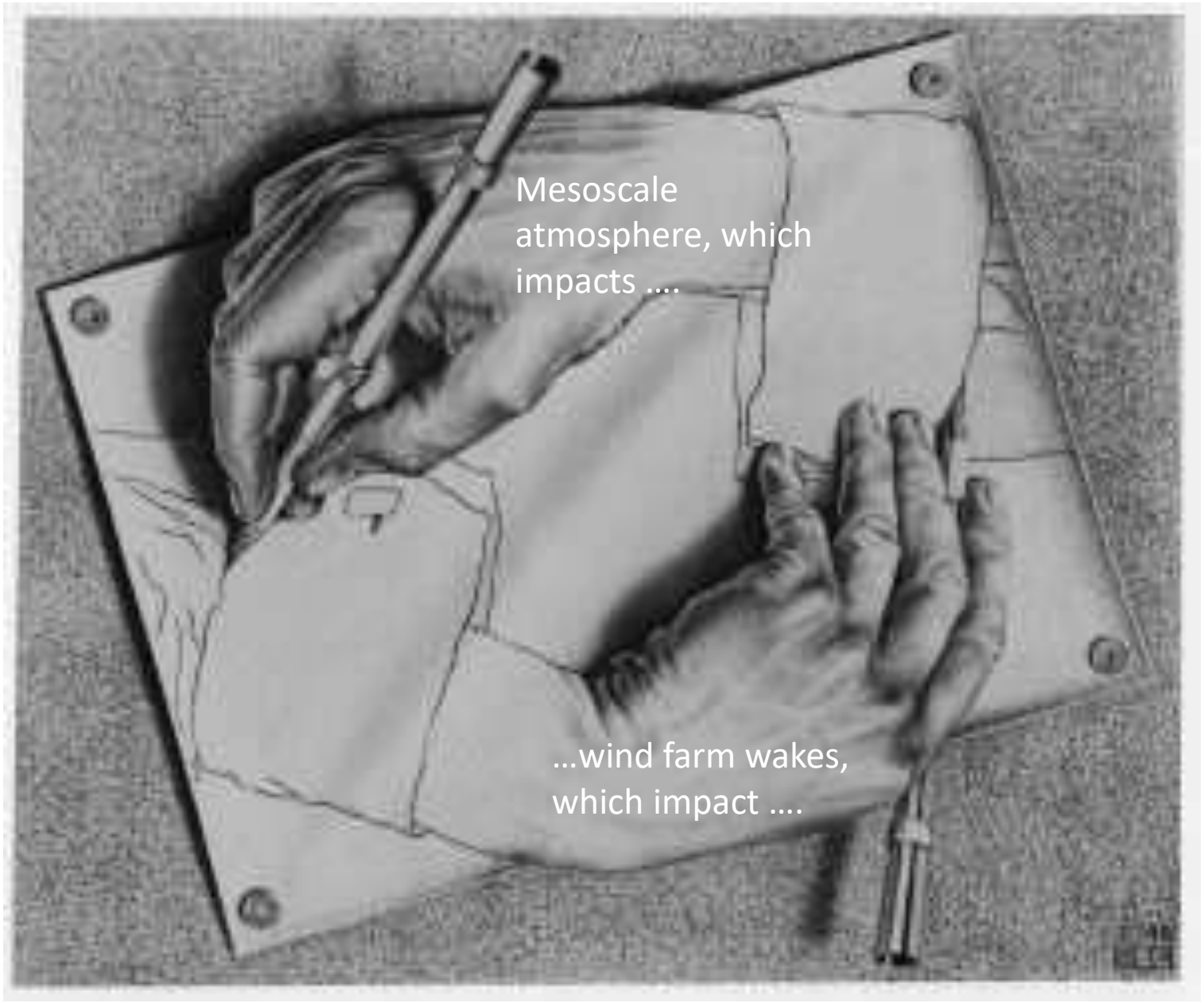
Baas et. al. May 2023:

"The current generation of wake models has been extensively validated on wind farms in the 100-to-500MW range.

Using these models to make predictions for the future generation of multi-gigawatt wind farms forces them to operate well outside their validation range.

This could at least add significant uncertainty to their predictions."

https://moa.byu.edu/m-c-eschers-drawing-hands/



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European Commission
“Notional” 2024-2038 construction schedule
(20 November 2023)

For North Seas Energy Cooperation countries:

- Belgium,
- Denmark,
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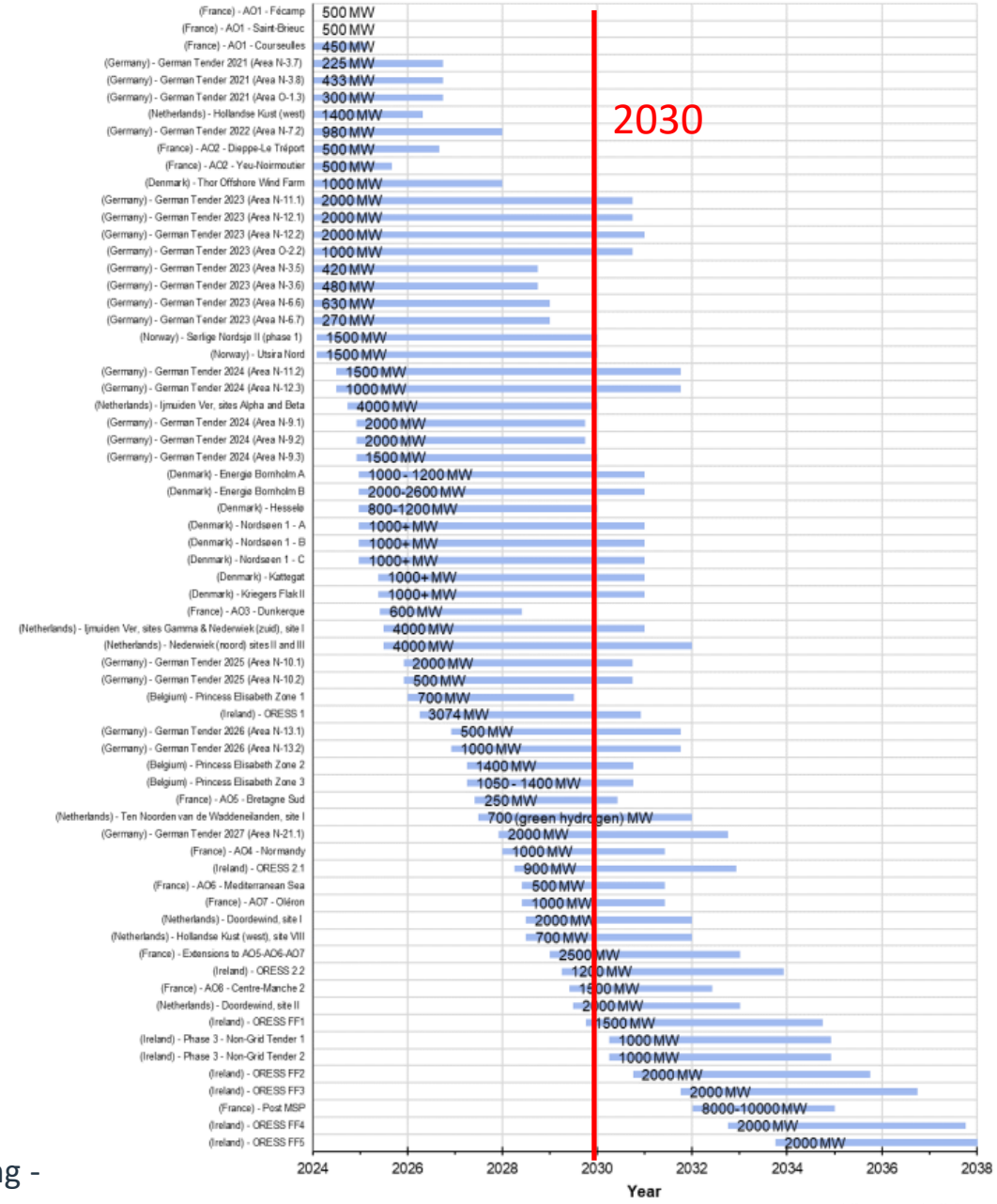
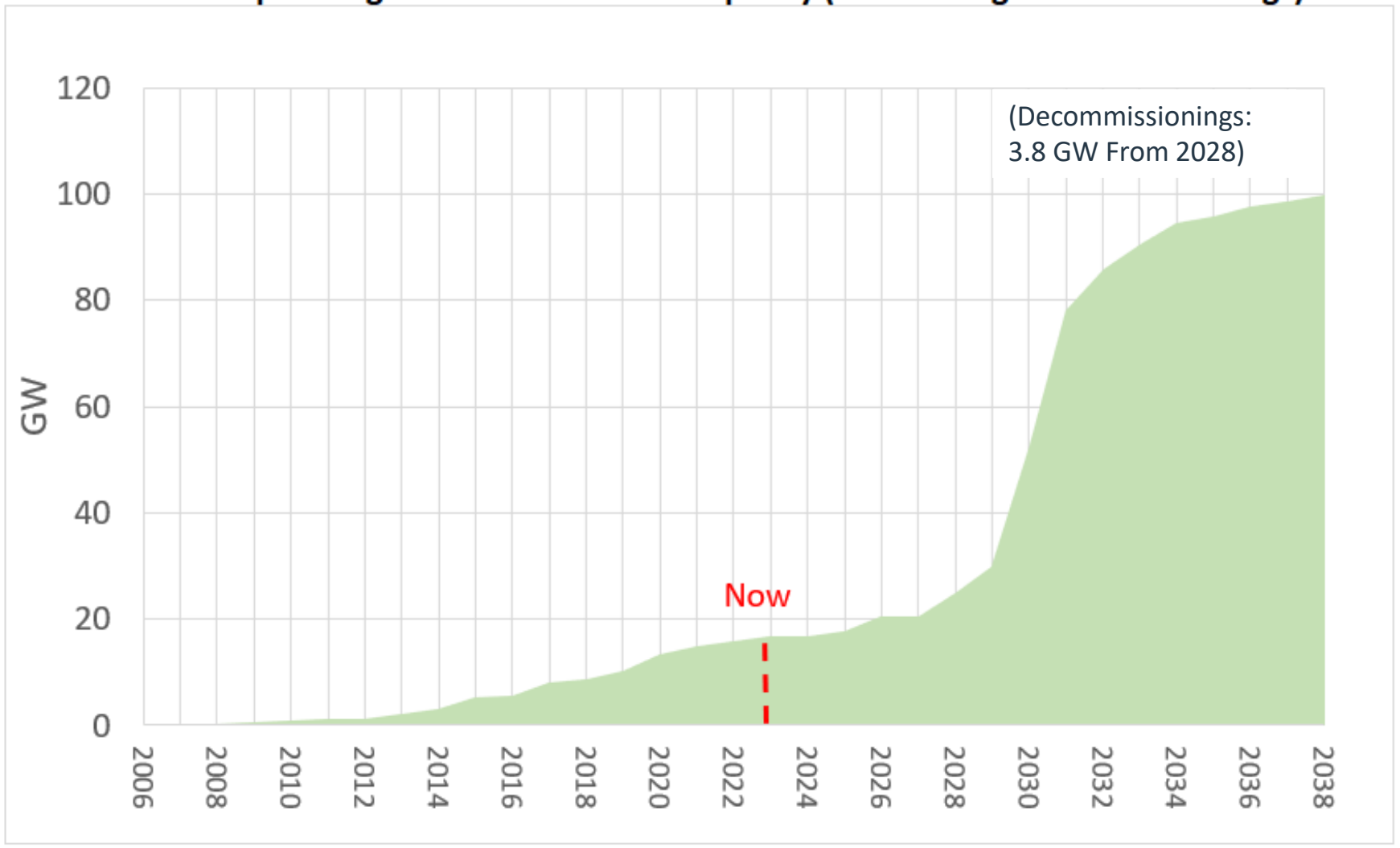
67 new farms / 88 GW, of which

- 42% by end of 2030,
- 52% thereafter



Source:
European Commission, North Seas Energy Cooperation, "NSEC tender planning - November 2023", 20 November 2023

North Seas Energy Cooperation countries*:
Cumulative operating offshore wind farm capacity (considering decommissionings)



*Belgium, Denmark, N.France, Germany, Ireland, Netherlands, Norway, Sweden

2006-23 new farm and 2006-38 forecast decommissioning data: Westwood Global Energy Windlogix

2024-38 forecast new farm construction data: European Commission, "Notional" schedule from "NSEC tender planning - November 2023", 20 Nov. 2023

ORE Catapult analysis. For 2024-38, assumes that the forecast year of construction completion = the full commissioning year.

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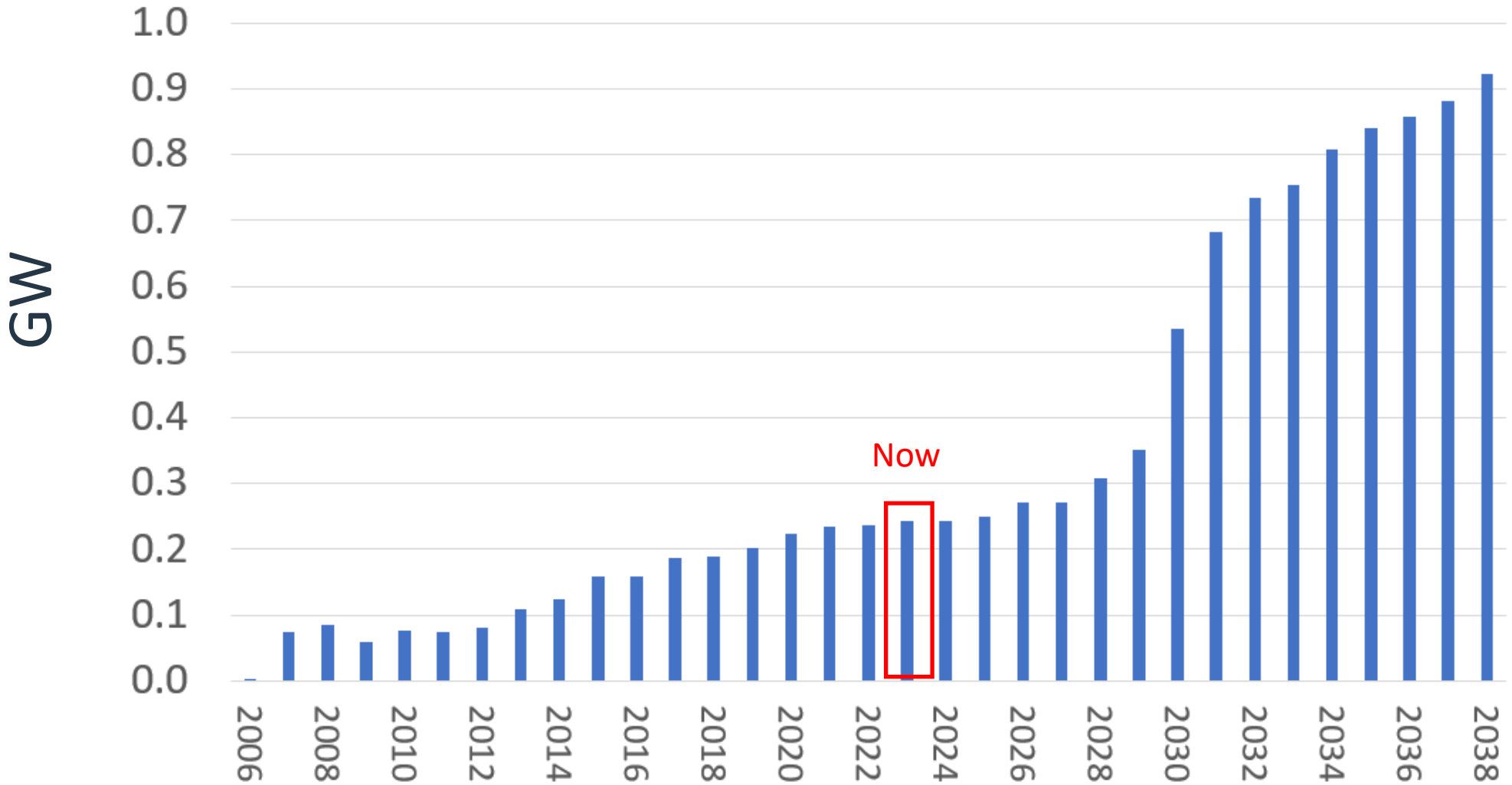
Average size of operating offshore wind farms (considering decommissionings)



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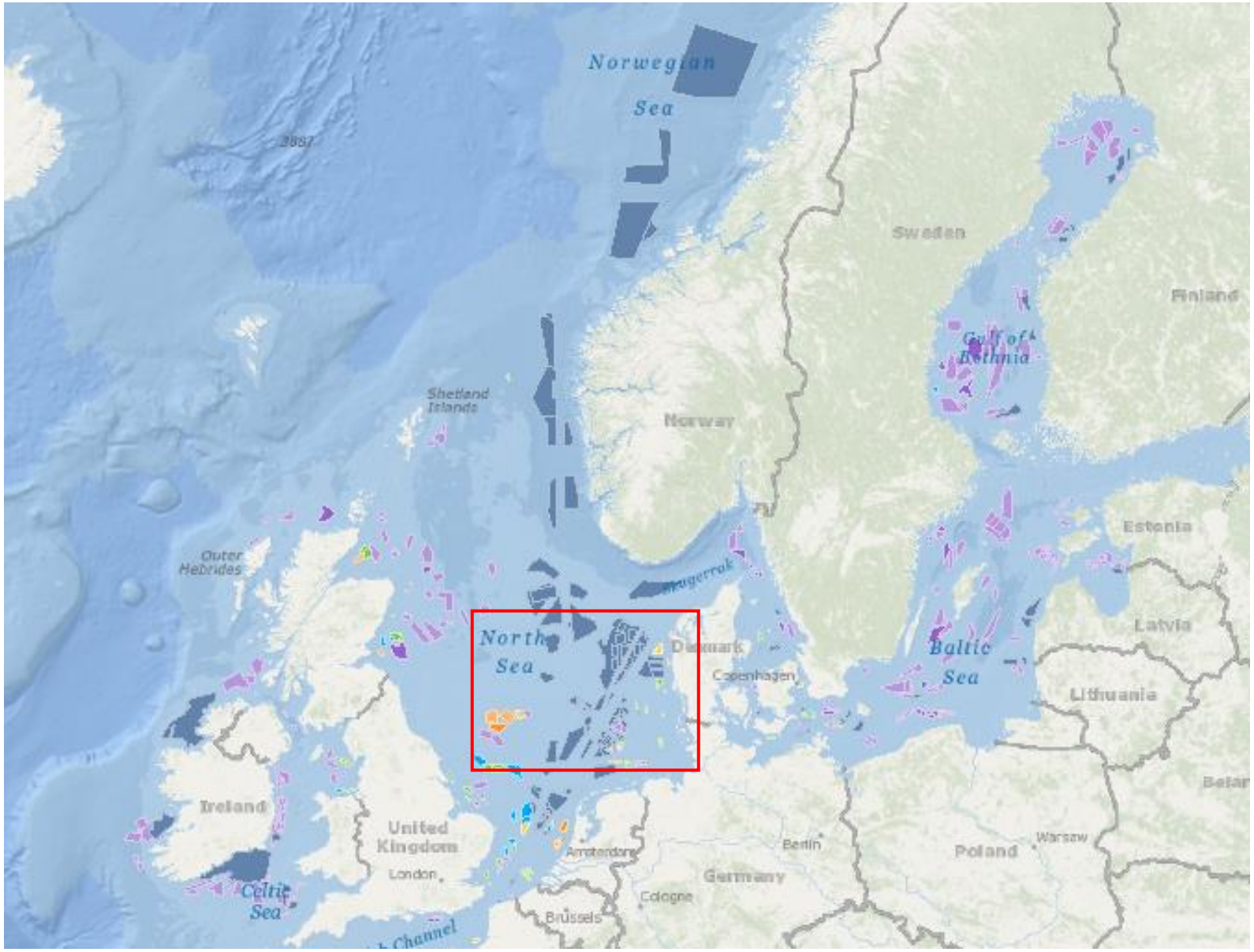

https://map.4coffshore.com/offshorewind/

Contiguity

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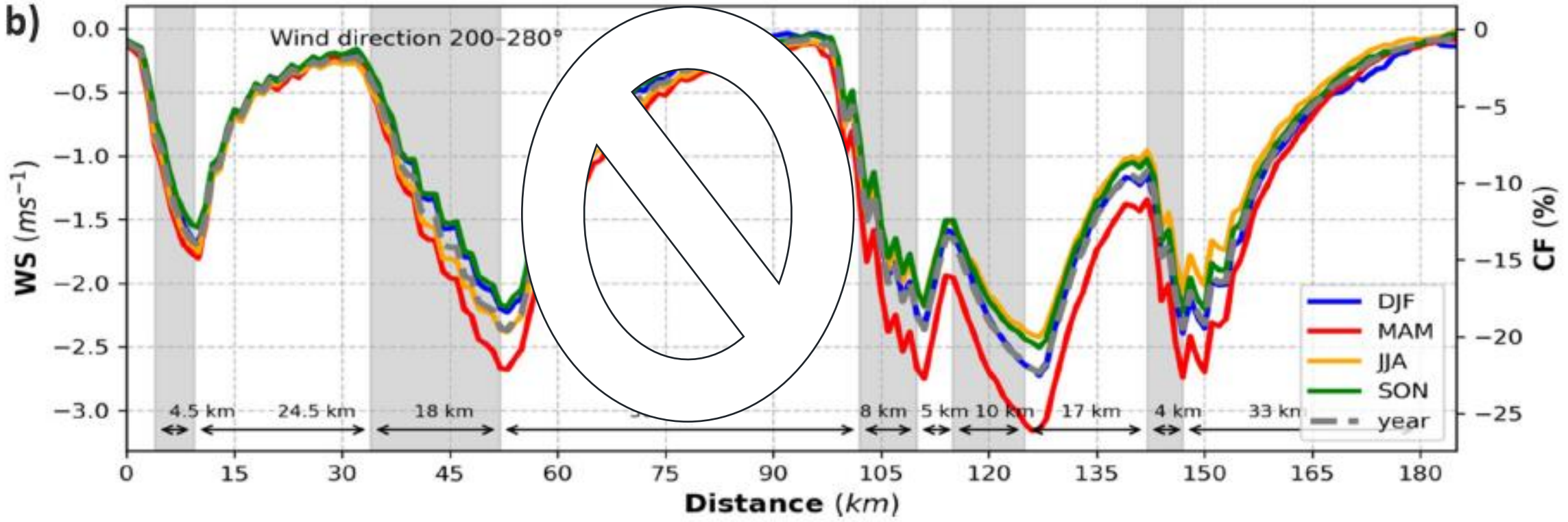

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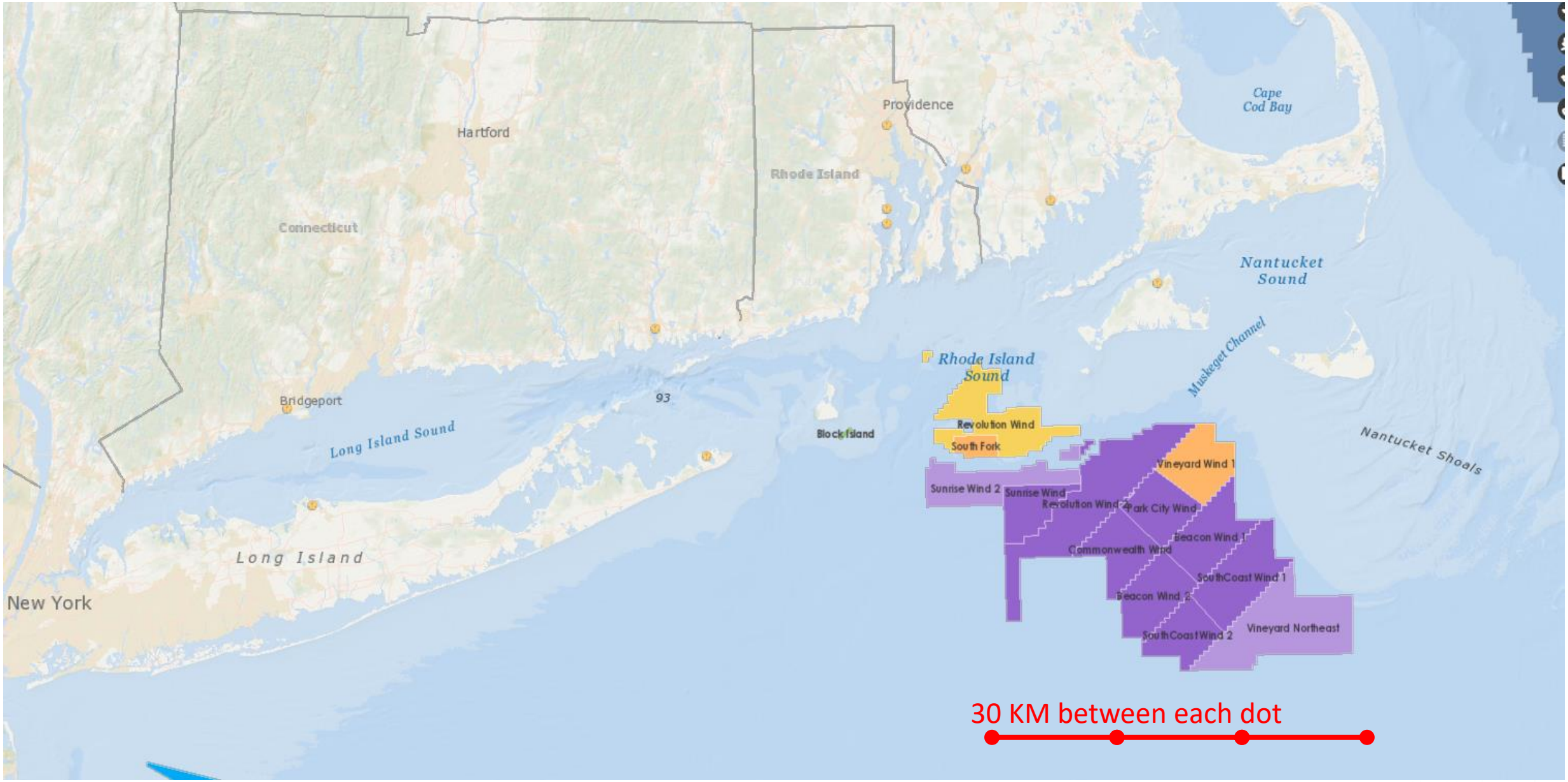

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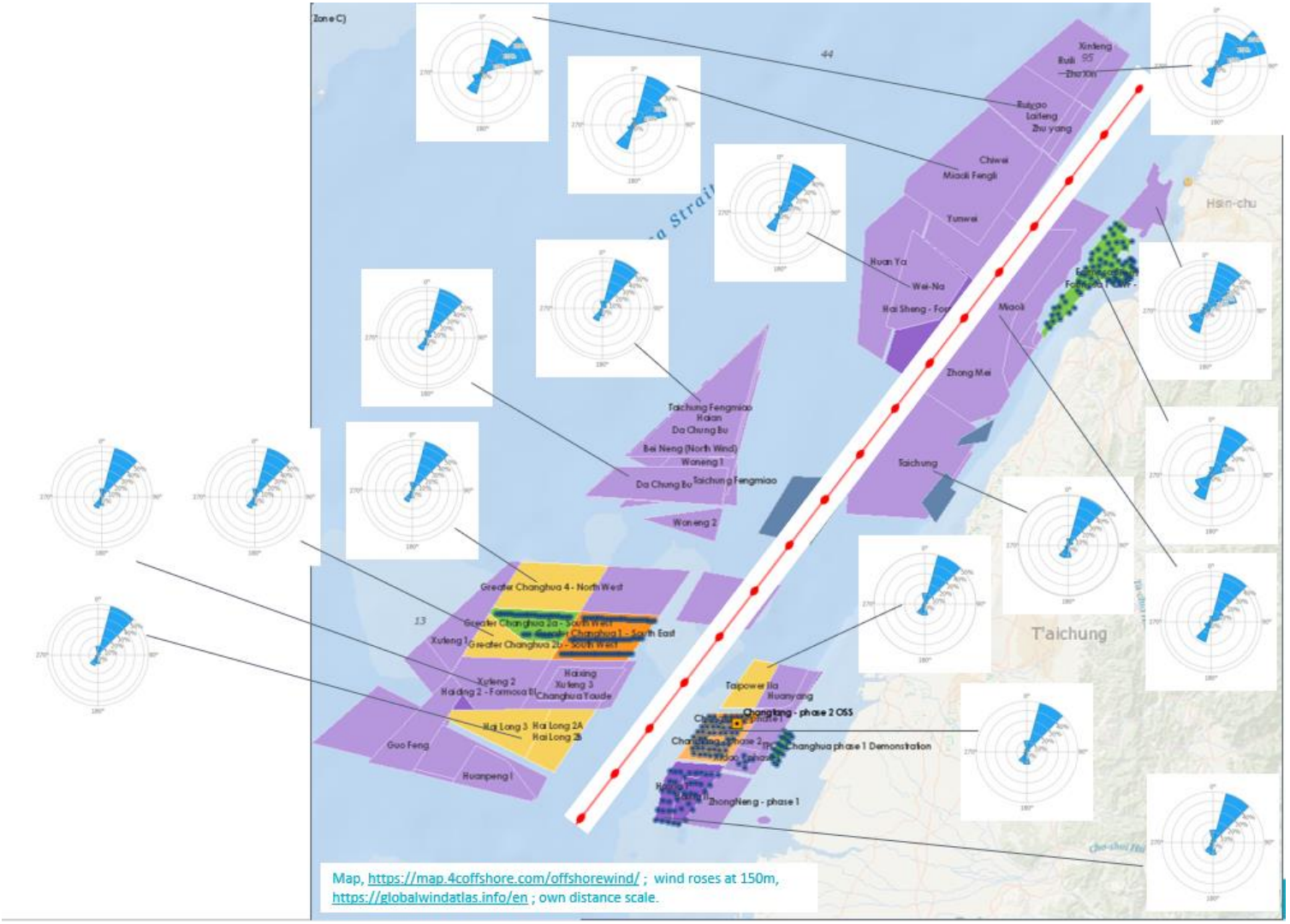

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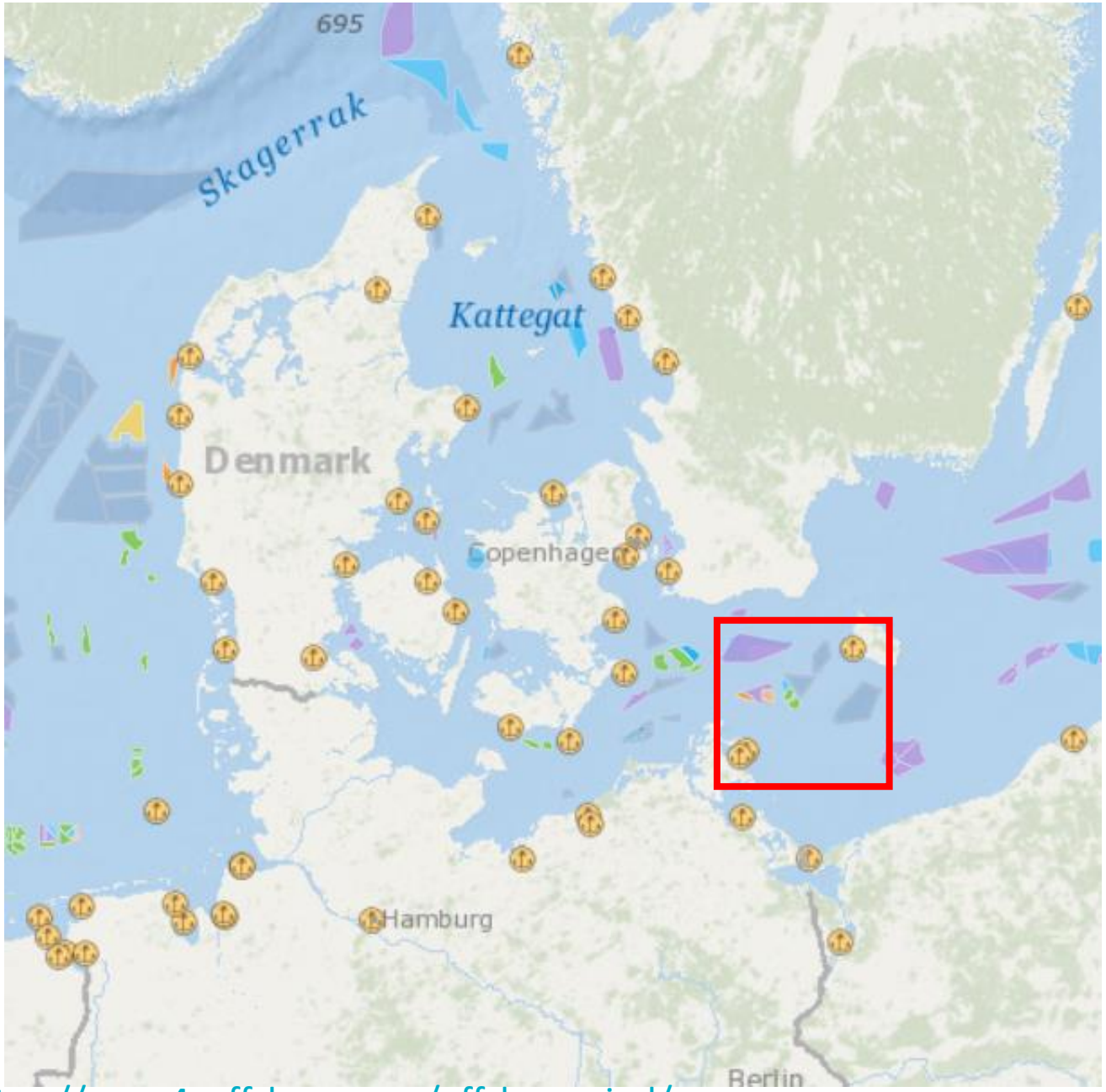

International waking : Baltic Sea example

Technical strengths:

- Nice annual mean wind speed @150 M: 9.9- 10.1 m/s
- Shallow enough for bottom-fixed development

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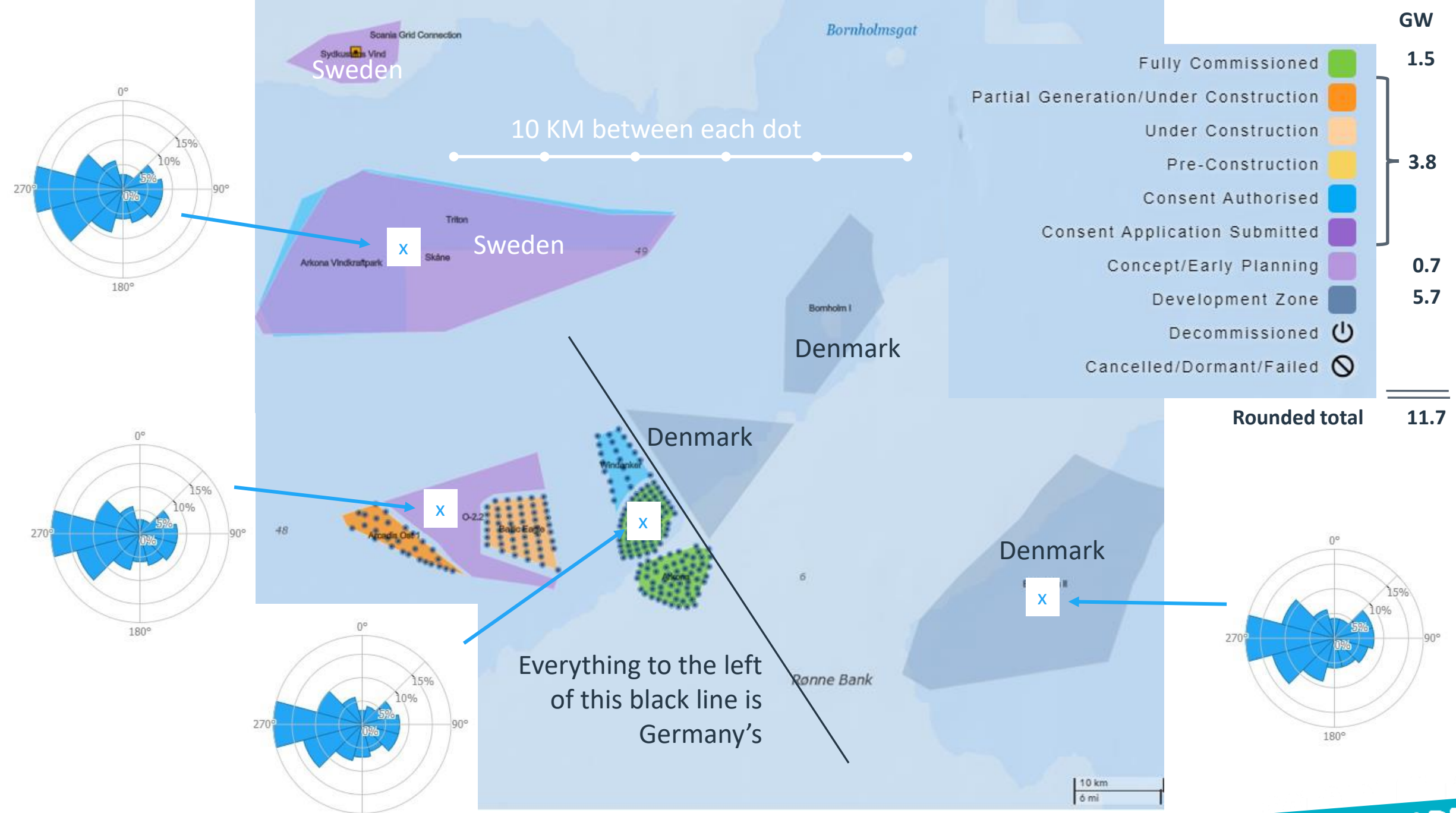

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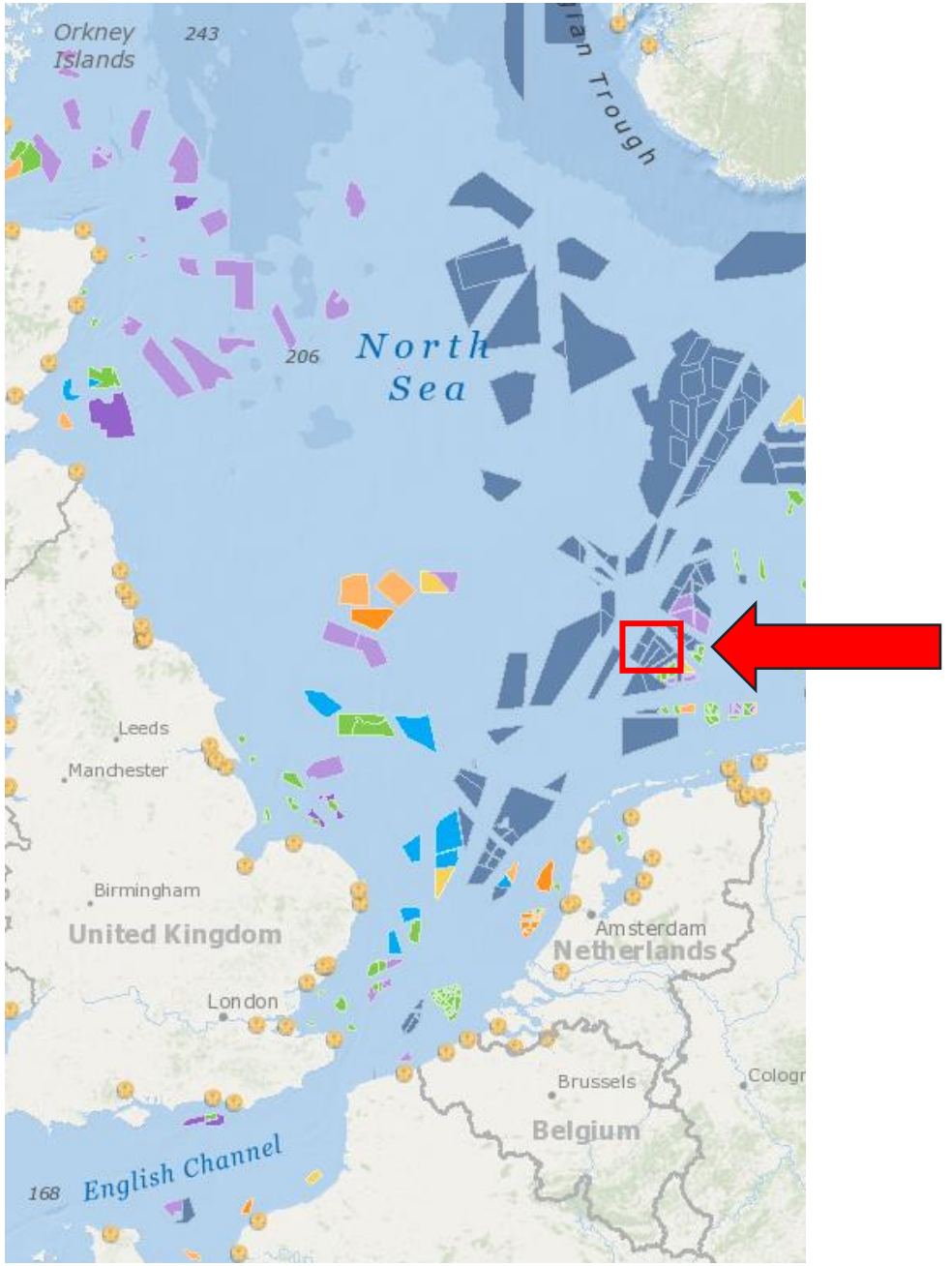
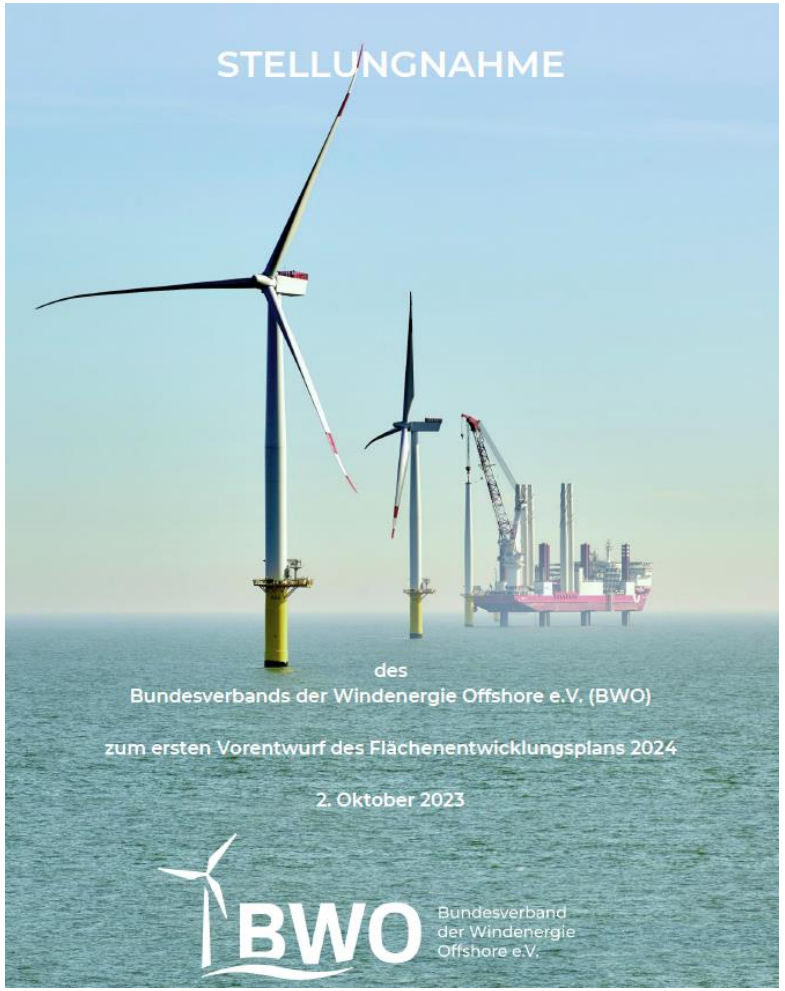
What is the most efficient use of the seabed?

A recent German case





From “Opinion of the Federal Association of Offshore Wind Energy (BWO) on the first preliminary draft of the 2024 area development plan,” October 2, 2023
Machine Translated by Google

"[F]or areas N-9.1, N-9.2 and N-9.3, a reduction in full-load hours of around 5 percent was calculated if the two areas [N-9.4 & N-9.5] were built with an output of 2,000 MW.

The yields of the parks in the areas in the wake would fall significantly."

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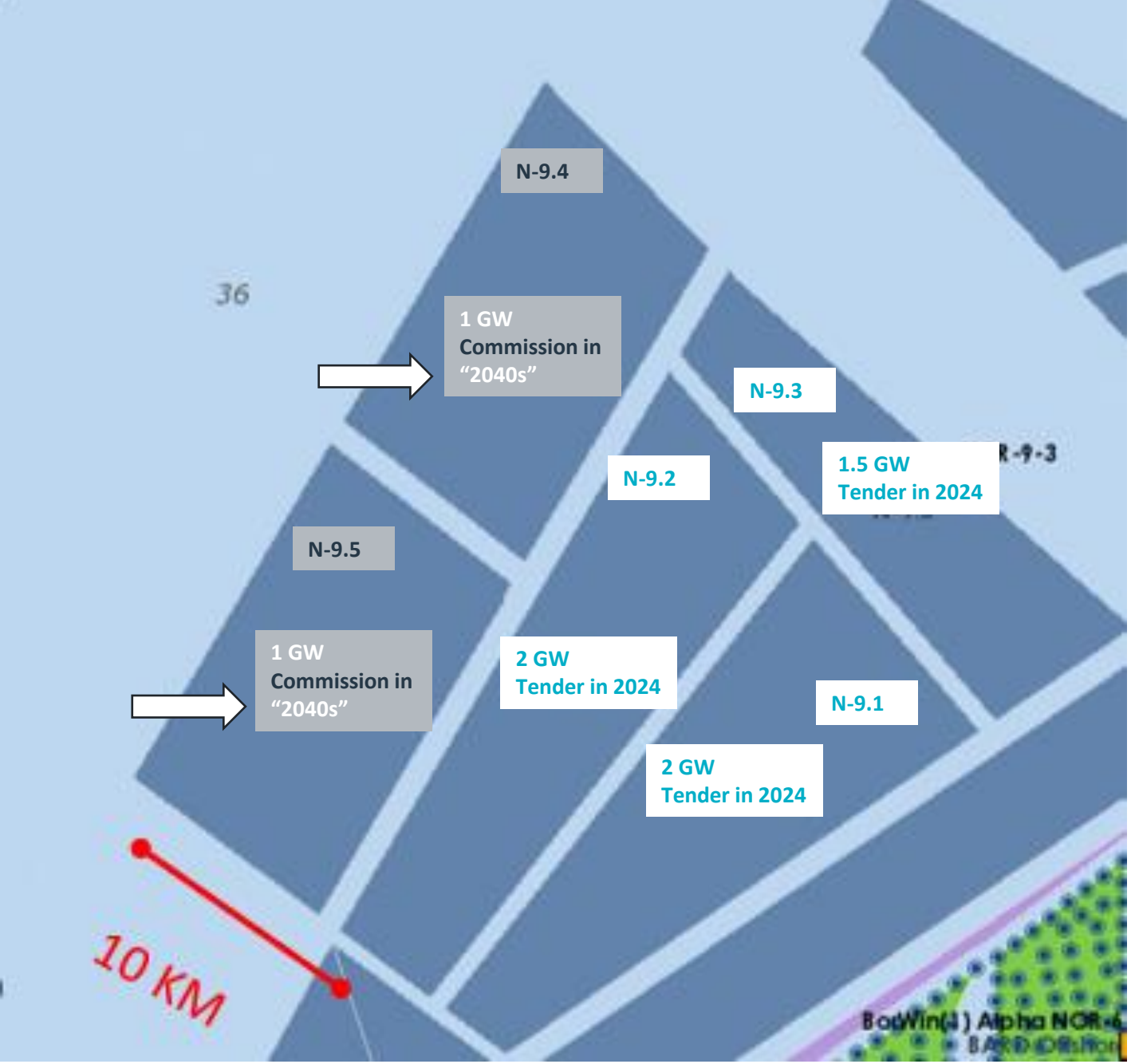
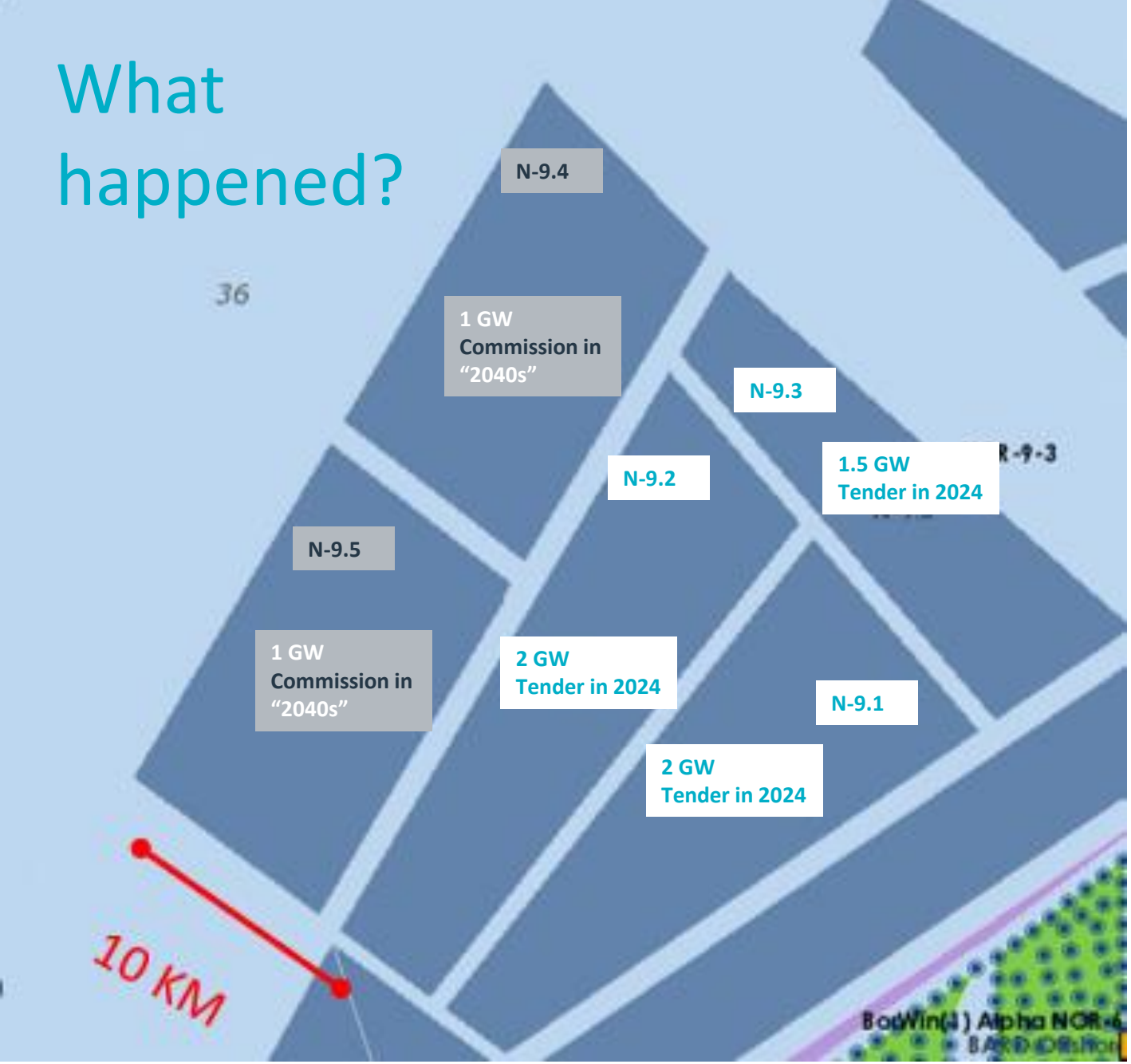


"[I]n the interest of cost-efficient development of offshore wind energy in the North Sea, a change in the order of development should be considered....

In order to reduce the significant shading effects over the timeline, we propose postponing the commissioning of N-9.4 and N-9.5 until after 2040."

What happened?



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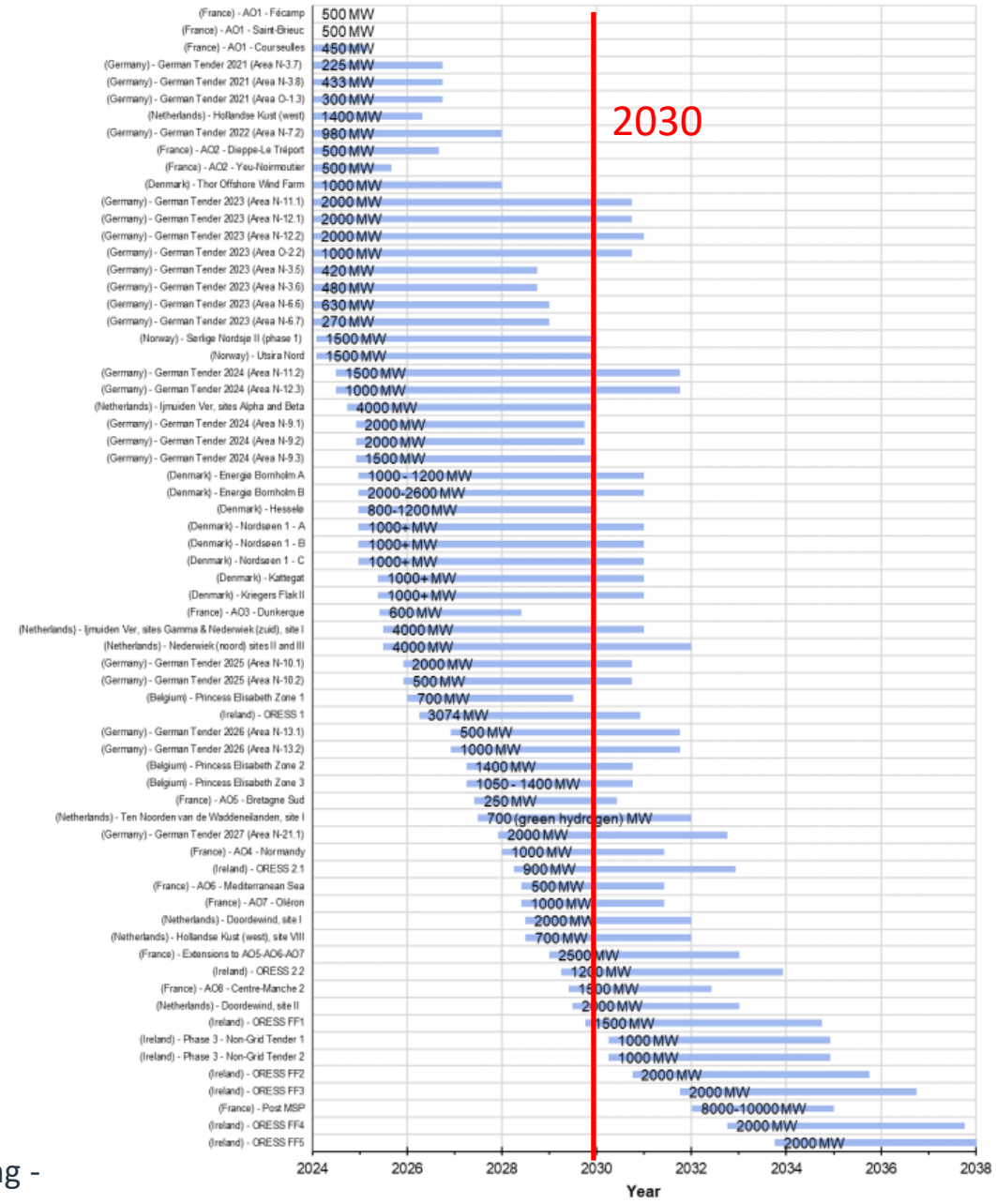

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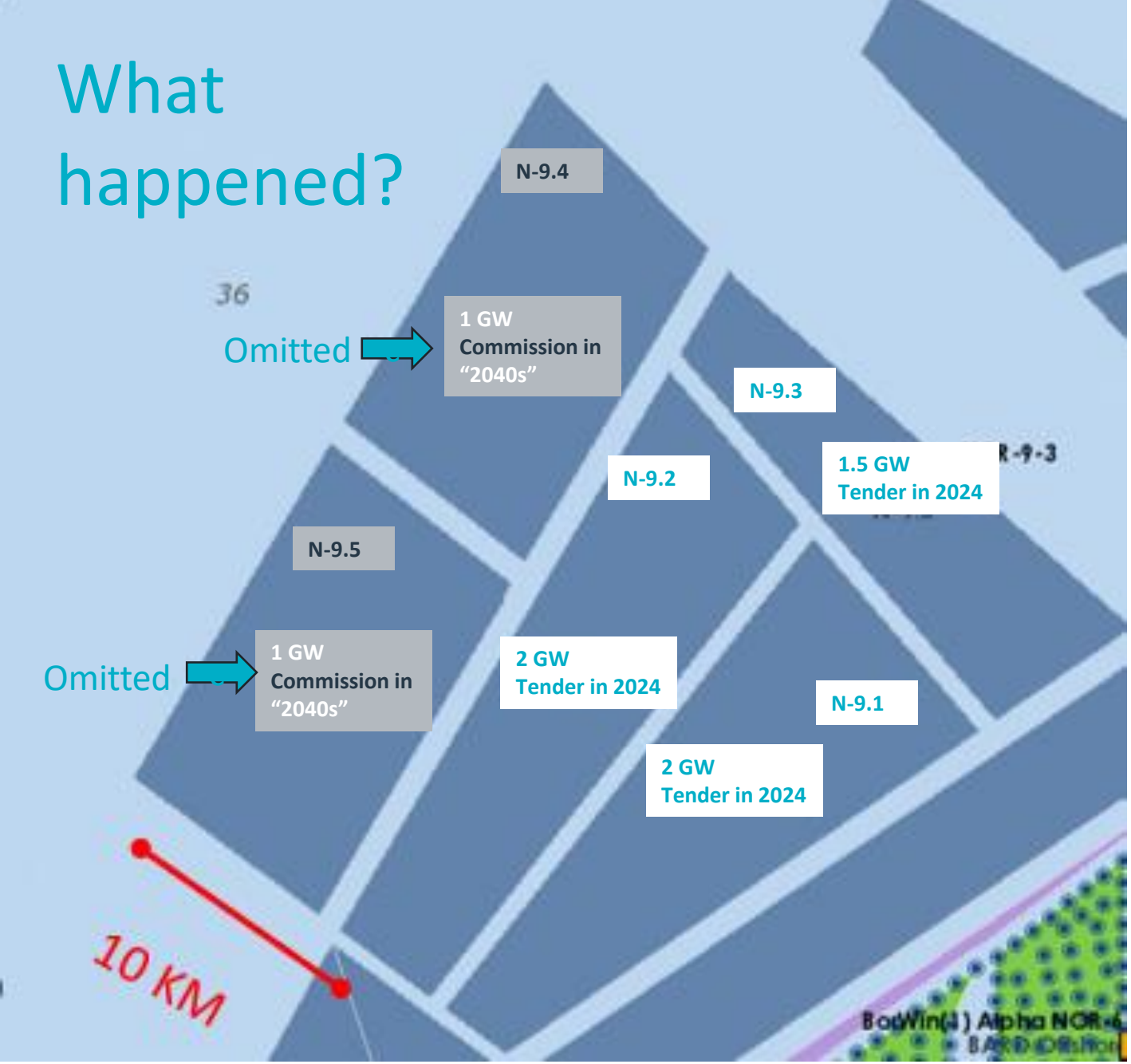

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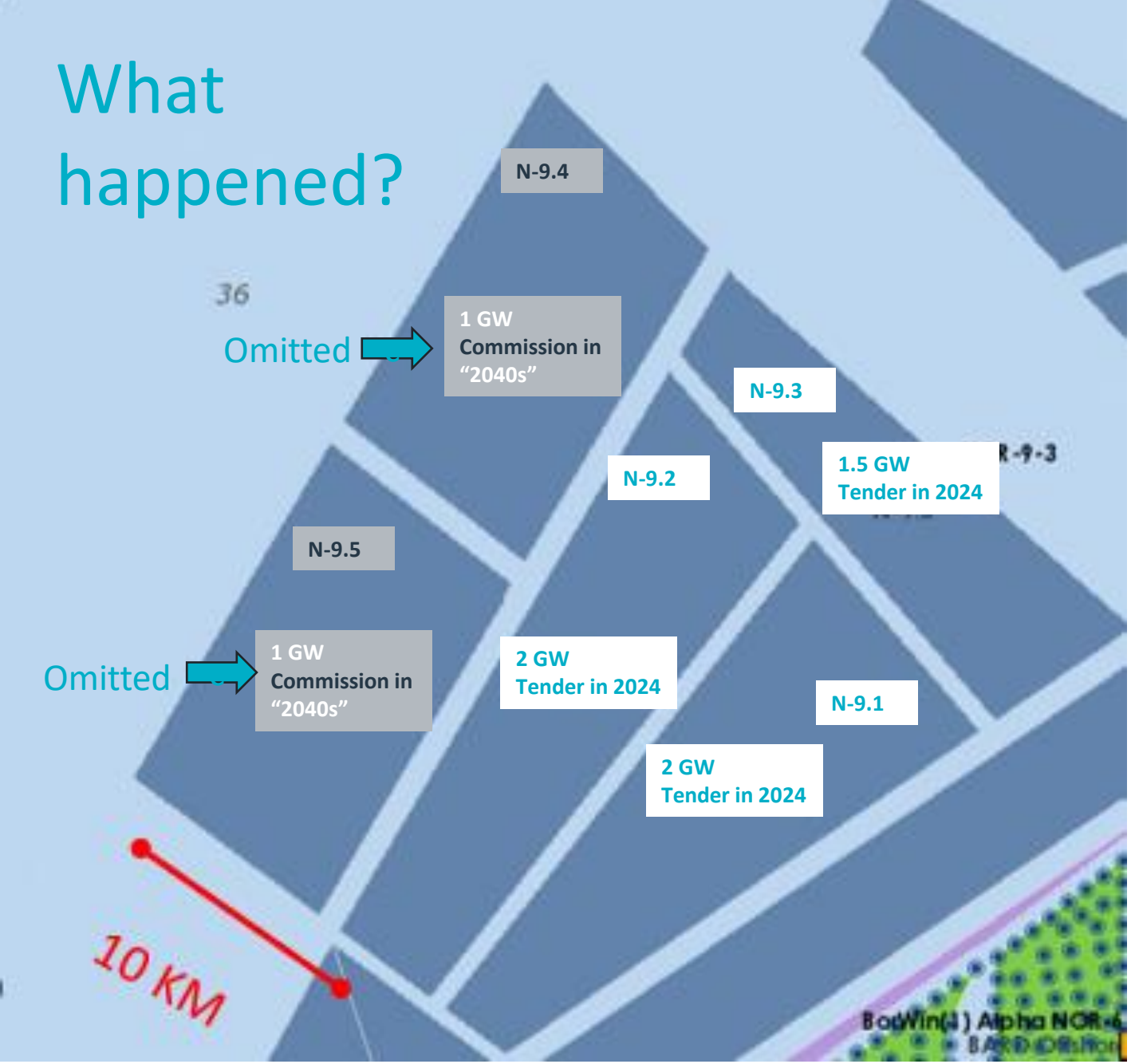

Raises fundamental question: **what is the best of use of the seabed**?

Maximising concurrent capacity online (GW) ?

or

Maximising ultimate, economically viable generation, considering wakes? (GWh)

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Offshore Renewable Energy

INTRODUCTION TO WEBINAR:

"Are governments waking up to wind wakes?"

Some are starting to.
The more the merrier!
The sooner the better!

Ken Kasriel

1 December 2023

Credit: Vestas

North Seas Energy Cooperation

(European Commission)

REPORT

Spatial study North Seas 2030 – offshore wind development

Client: North Seas Energy Cooperation/ Rijkswaterstaat

Reference: RHDHV-BI4271

Status: Final

Date: 03 November 2022

Royal HaskoningDHV
Enhancing Society Together

First in a list of 16 recommendations:

"1. Explore wake effects and options for solutions in more depth and put it on the agenda within regional MSP [marine spatial planning] collaboration for new developments of OWF after 2030 in the Southern North Seas "

X-Wakes

Fraunhofer IWES

Fraunhofer Institute for Wind Energy Systems

X-Wakes – Interaction between the Wakes of Large Offshore Wind Farms and Wind Farm Clusters with the Marine Atmospheric Boundary Layer

Funding:	Federal Ministry for Economic Affairs and Climate Action (BMWK)
Total funding:	EUR 1,303,341
Partners:	Technical University of Braunschweig, Karlsruhe Institute of Technology (KIT), University of Oldenburg (Center for Wind Energy Research, ForWind), University of Tübingen, Helmholtz-Zentrum Geesthacht, UL International GmbH
Duration:	11/2019 - 04/2023

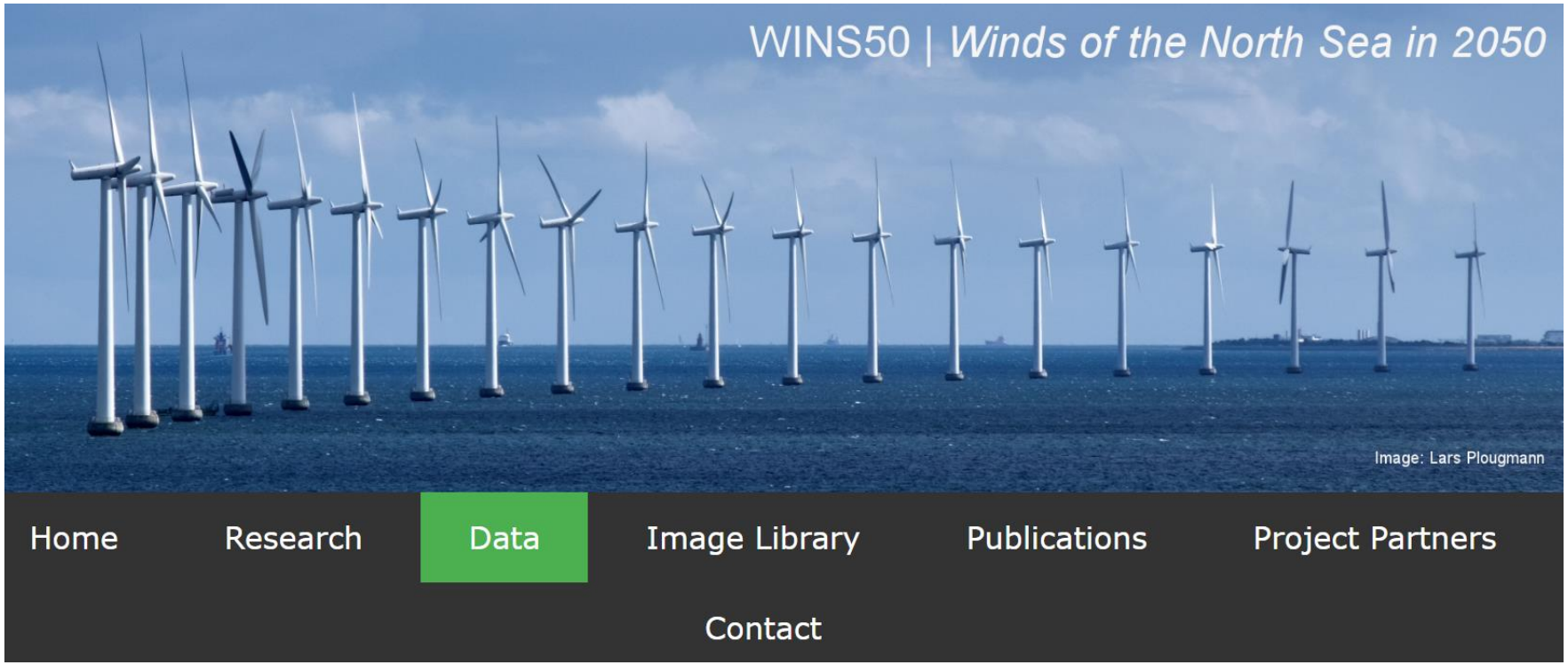
November 2023 publication of initial; hypothetical study of wake effects commissioned by the Crown Estate

THE CROWN ESTATE

Royal Netherlands Meteorological Institute
Ministry of Infrastructure and Water Management

TU Delft

whiffle



https://wins50.nl/

Early 2024:

Will release a public data from modelling a hypothetical 2050 energy capacity scenario for the North Sea which “can be used for detailed wake analysis studies and/or assessing requirements for the electricity grid of the future”

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Takeaways:

- "No wind farm is (necessarily) an island" – consider the potential wakes from neighbouring farms

- Get in the habit of viewing assets through wind rose-coloured glasses (with the free Global Wind Atlas)

- Planners and regulators should set offshore wind targets,
  -NOT in terms of nameplate capacity (gigawatts),
  but rather
  -in terms of actual generation (gigawatt hours), considering wake/blockage effects

- For the offshore wind build out, there are no do-overs. To fail to prepare is to prepare to fail

Thank you, audience and panelists!

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