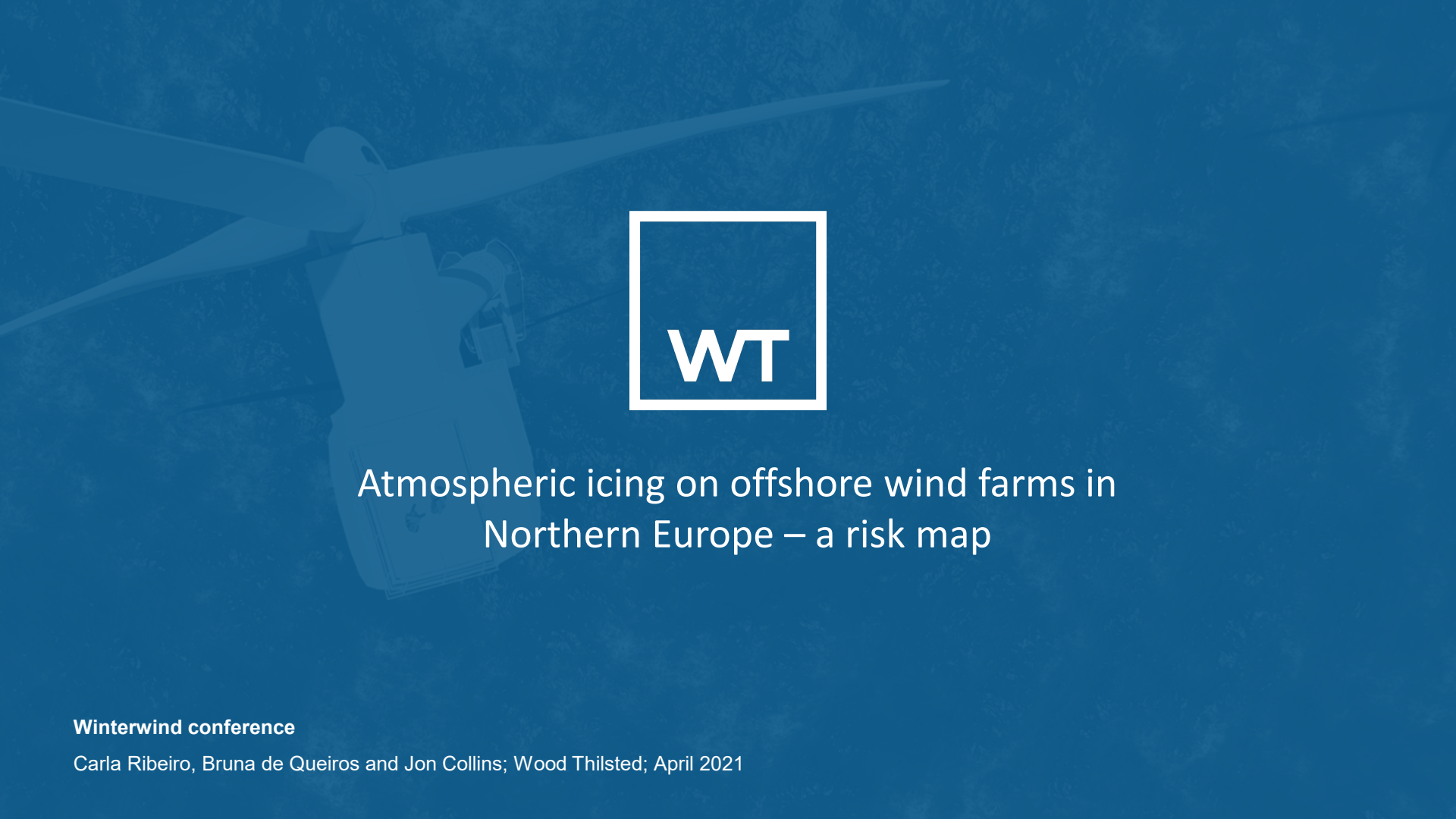

Atmospheric icing on offshore wind farms in Northern Europe – a risk map

Winterwind conference

Carla Ribeiro, Bruna de Queiros and Jon Collins; Wood Thilsted; April 2021

AGENDA

- Why – Why is atmospheric icing an issue for offshore wind
- How – How do we propose to understand this risk
  - Available data
  - Method
  - Other considerations when designing the map
- The WT proposed risk map

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WHY

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Offshore environment

SITE CONDITIONS ASSESSMENT

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1 INPUT DATA

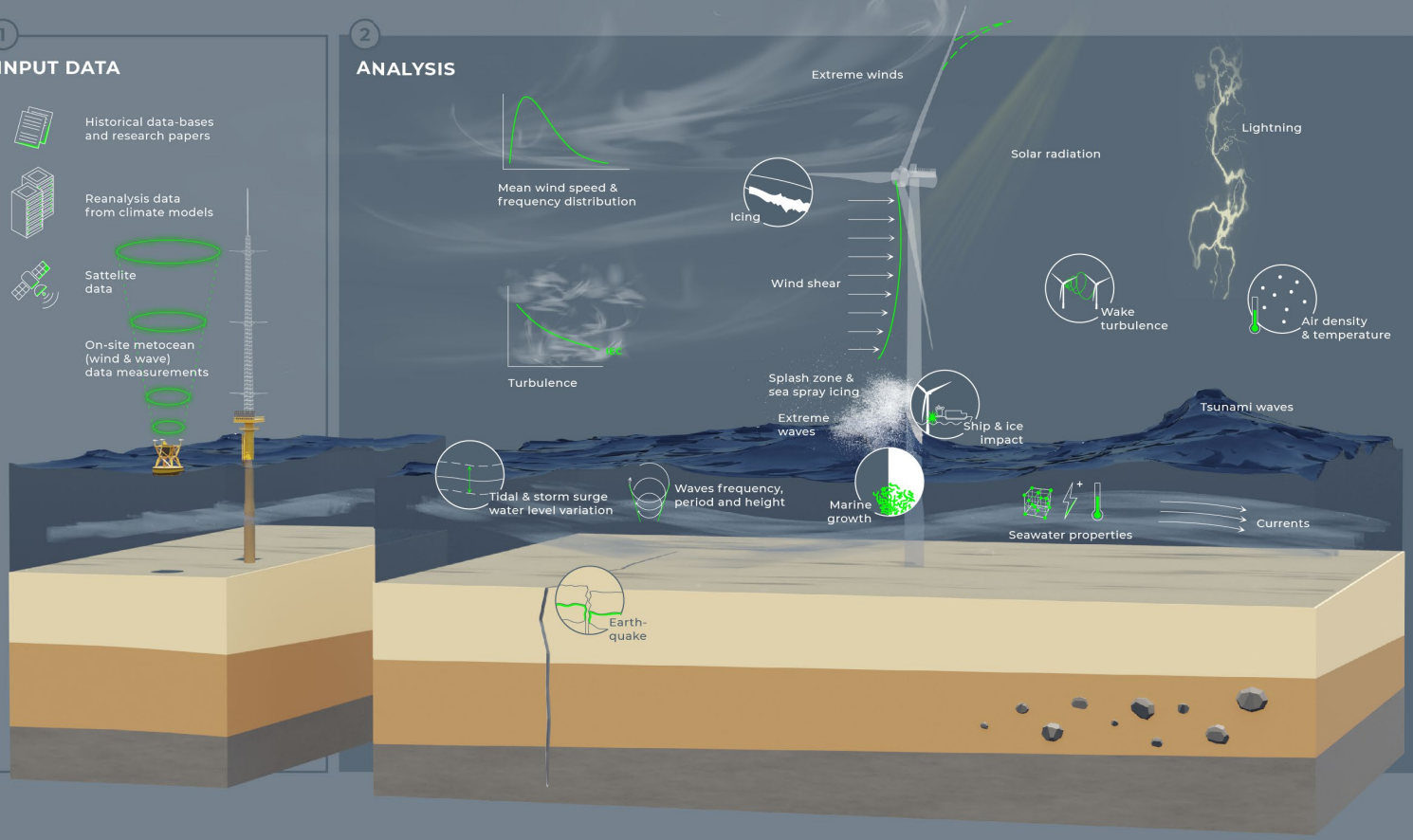
Historical data-bases and research papers

Reanalysis data from climate models

Sattelite data

On-site metocean (wind & wave) data measurements

2 ANALYSIS



3 DELIVERABLES

The deliverables consist of the following reports:

Site conditions assessment: Design Basis part A1

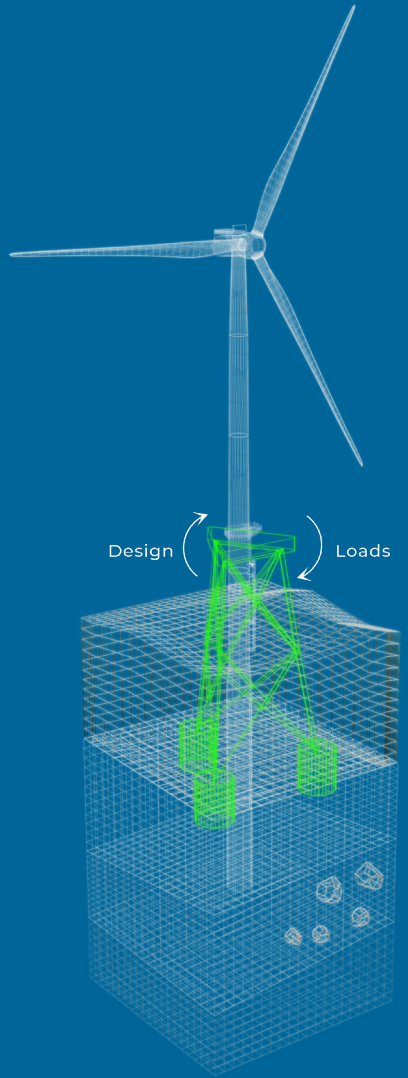
Light site conditions assessment

Site hazard assessment

P50

Energy production assessment and layout design

WHY



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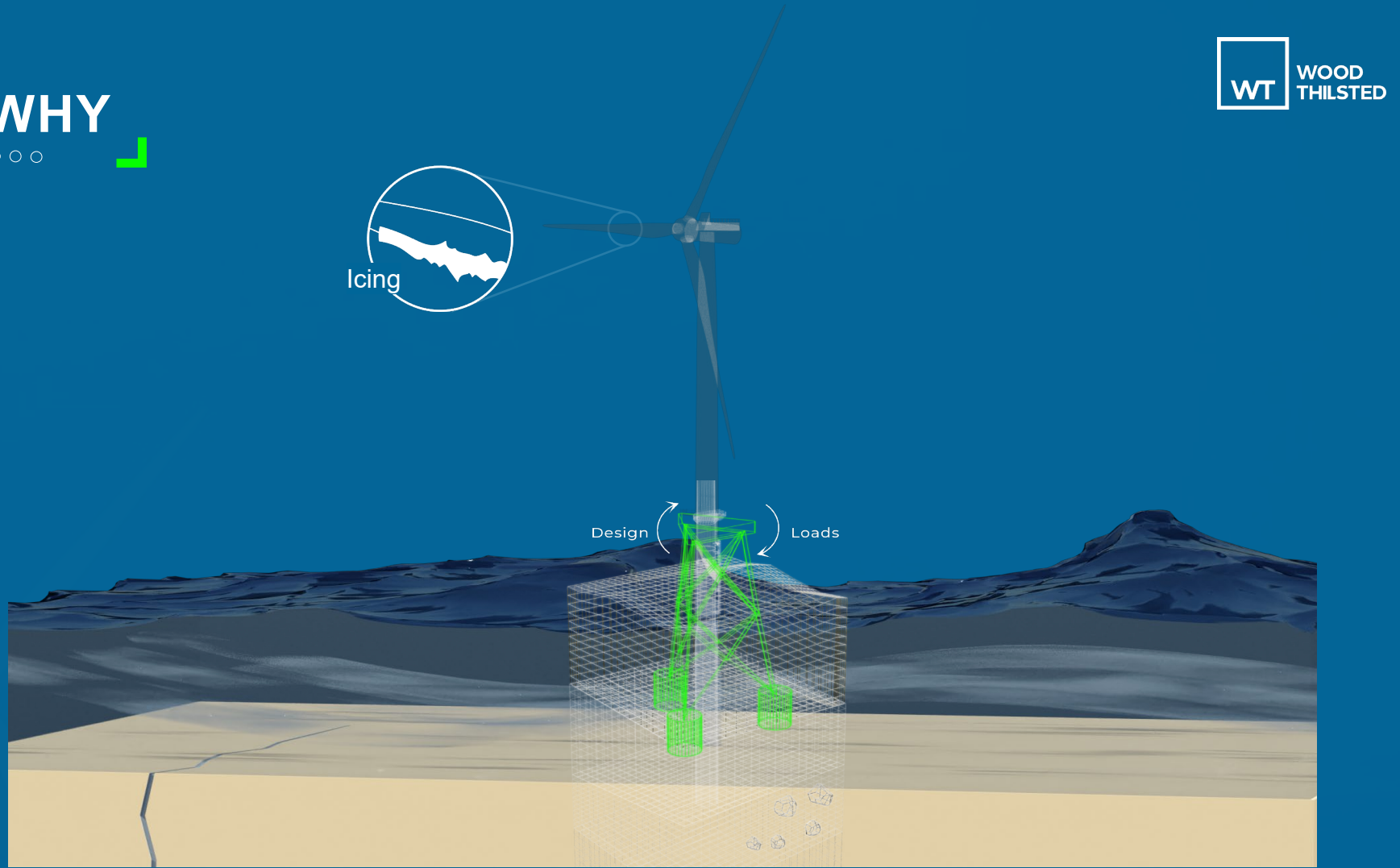
WHY



HOW

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HOW

Data used: (long-term data from 8 offshore met masts at around 100 m height a.s.l.)

- Publicly available data from the Crown Estate for masts around in the UK waters (North sea, Irish sea, Scottish coast).
- Publicly available data from the FINO masts in German waters (North and Baltic sea).
- Data from private developers in the North sea and Norwegian sea.

Method:

- We selected a row of masts around the same latitude to test for longitude influence. This row crosses the Irish sea, North sea and Baltic sea.
- We selected additional masts in the Scottish Coast and Norwegian sea to test for the influence of latitude.
- At least 5 concurrent winters have been compared for all masts.
- Anemometer data has been inspected for icing and partial icing, and the average number of hours of icing per year have been determined.
- A kriging interpolation method, between the existing points, has been used to create a map.
- Results of the map have been compared with the expected latitudinal and longitudinal ratios obtained, and against expectations according to the considerations detailed below.

Other considerations when designing the map:

- There is a deficit of data in the Gulf of Bothnia and Gulf of Finland. We have used the ratios developed and other information such as average sea temperature, Gulf Stream path, cloud base height across Scandinavia and onshore icing experience, to inform some adjustments on the kriging results.
- The influence of the Gulf Stream has been considered both due to the longitudinal ratio determined above and in informing the icing on the west coast of Ireland, Celtic sea and English Channel.

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THE WT RISK MAP

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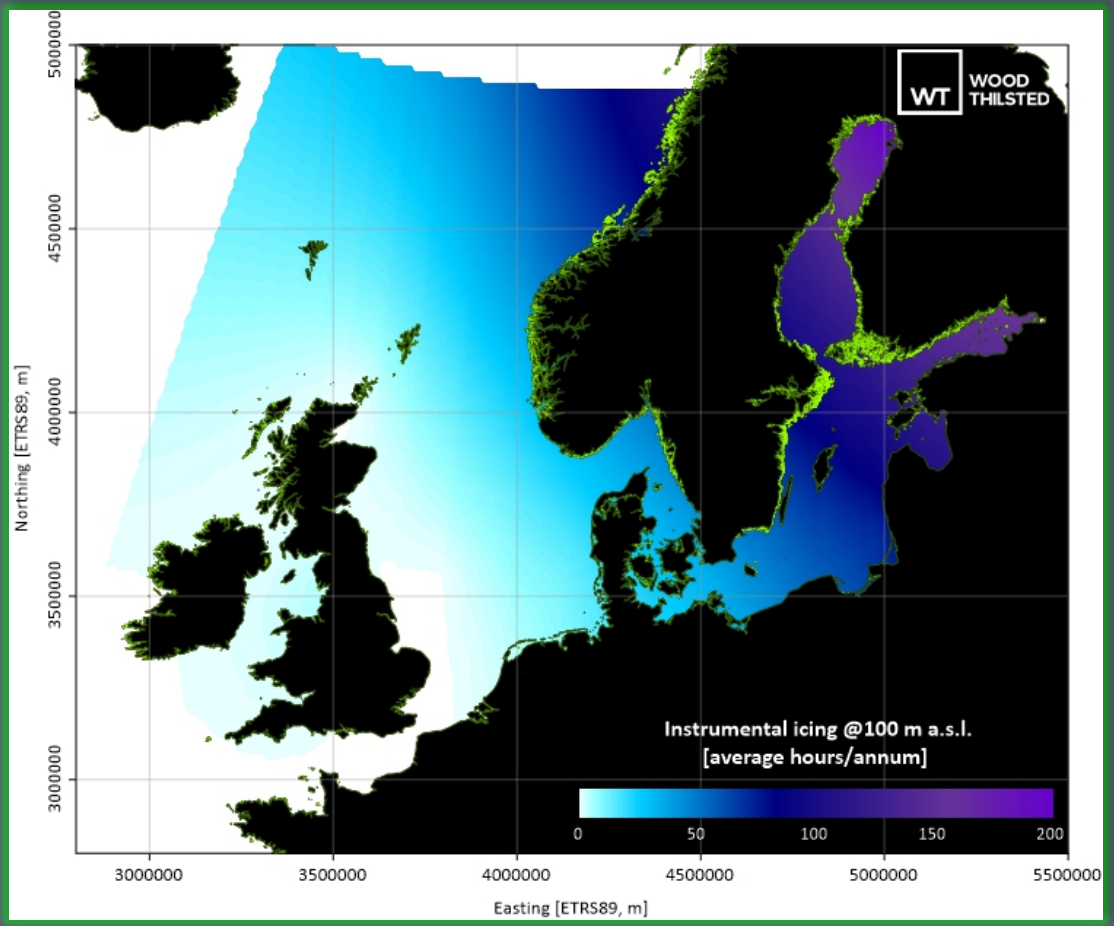
MAP



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FINAL REMARKS

/ UNCERTAINTY

- Deficit of data in some areas of the map and assumptions made
- Correlation between anemometer icing and ice load in turbines
- Long-term representativeness of the data assessed
- Effect of climate change in future conditions

/ RISK REDUCTION

Despite uncertainty, the map offers an initial benchmark against which developers can inform expectations of atmospheric icing at their proposed site

/ REDUCTION IN LCoE

The map allows for an establishment of expectations both for energy losses caused by ice accumulation in turbine blades, but also in what concern ice loads affecting the structure. Early understanding of both these aspects can lead to reductions in the LCoE

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“WE BELIEVE THAT IN TEN YEARS’ TIME, OFFSHORE WIND WILL BE POWERING EVERY HOME IN THE COUNTRY, WITH OUR TARGET RISING FROM 30 GIGAWATTS TO 40 GIGAWATTS,” BORIS JOHNSON, OCTOBER 2020

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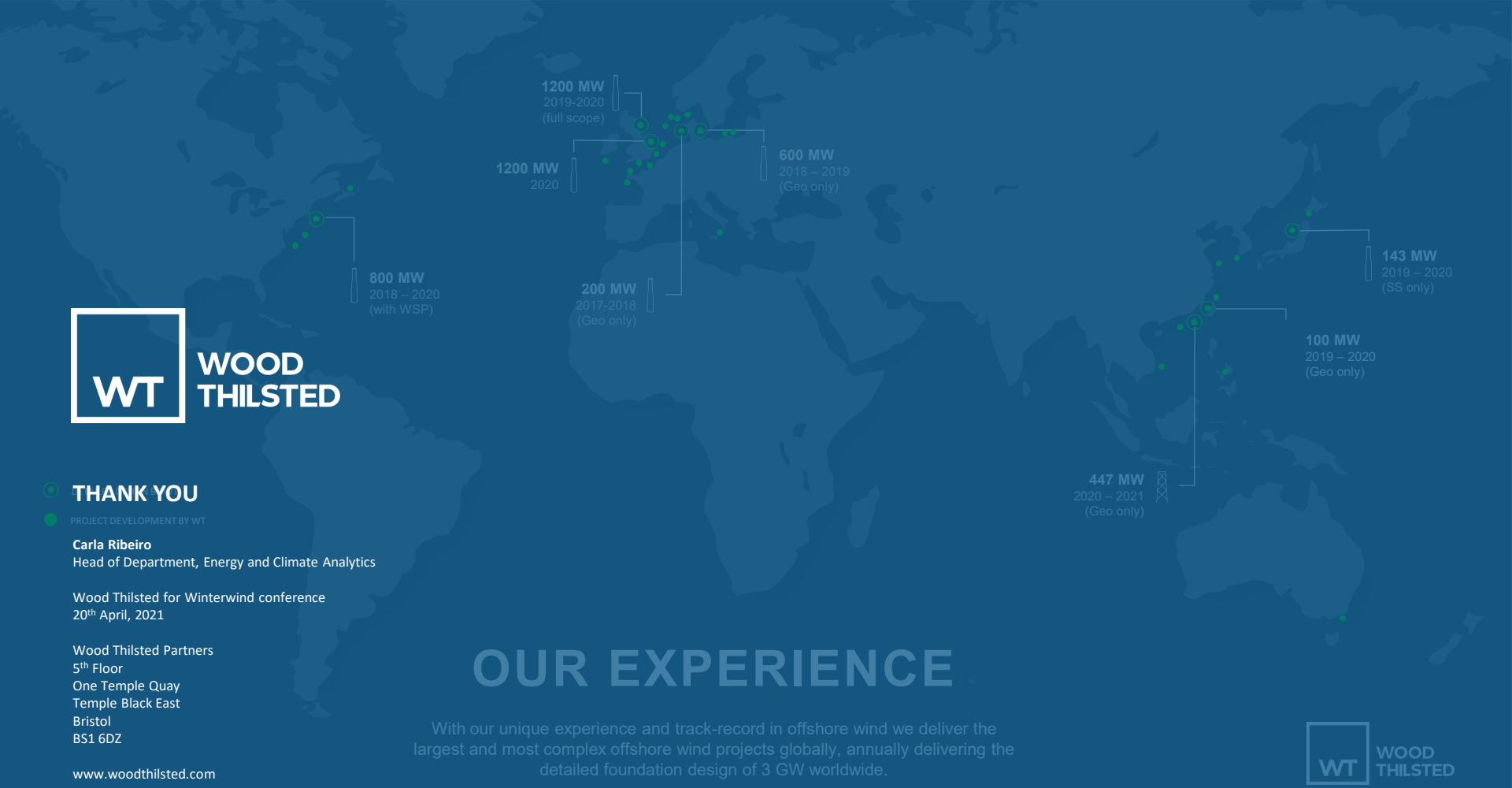

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THANK YOU

PROJECT DEVELOPMENT BY WT

Carla Ribeiro
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Wood Thilsted for Winterwind conference
20th April, 2021

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