DESTINATION EARTH

Climate Digital Twin (DE340)

A New Tool To Obtain Relevant Indicators For The Energy Sectors

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INTRODUCTION

As the global push for **decarbonisation grows**, renewable energy is key towards achieving **net-zero** emissions. However, unlike fossil fuels, renewables are more vulnerable to **climate change** and **extreme weather**. Wind energy is especially sensitive to the effects of climate change, so accurate projections of wind speed are essential for optimizing output from existing wind farms and evaluating the potential of new sites [1]. **High-resolution** climate projections are essential for understanding **future wind resources** and supporting the renewable energy sector's adaptation to climate impacts.

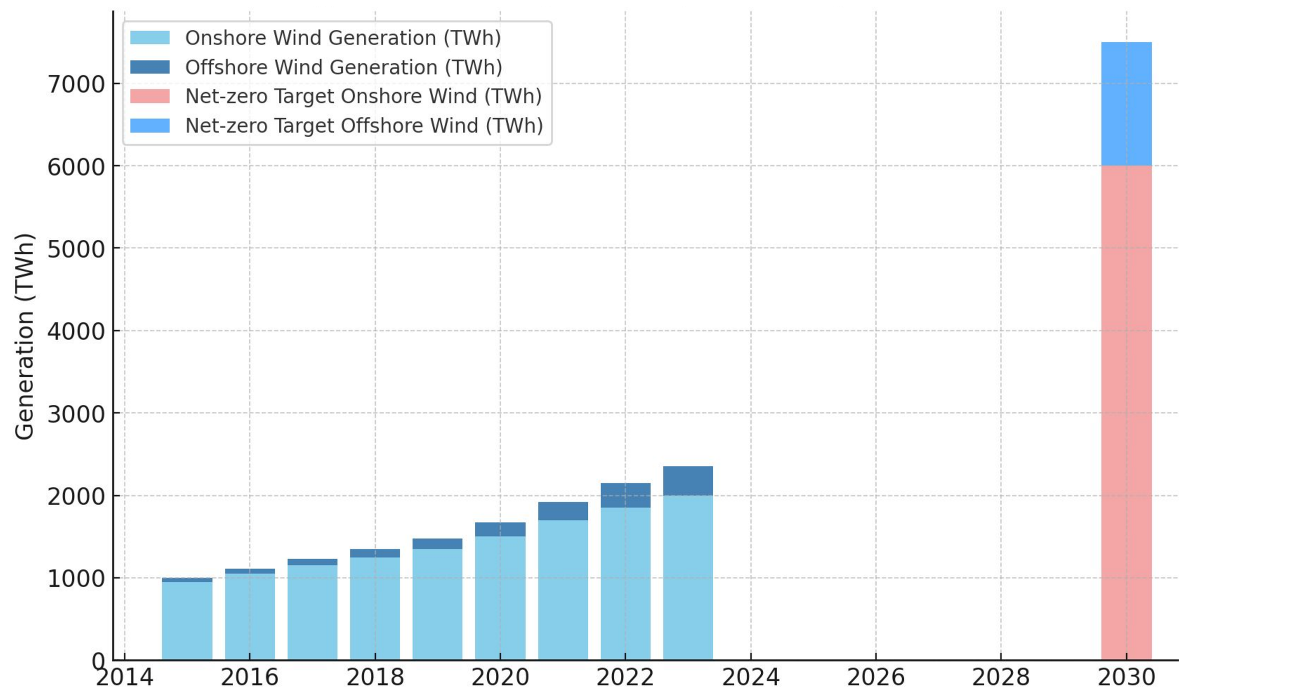

Figure 1: *Global wind power generation (onshore and offshore) for the period 2015-2023 and target for 2030 to achieve net zero emissions by 2050 (**NZE Scenario**) [2].*
Source: International Energy Agency (IEA) 2023; "Wind power generation in the Net Zero Scenario, 2015-2030", License: CC BY 4.0

The overall goal of the Energy use case is to **provide estimates of the changes in wind resources** under present and future climate conditions.

USERS & STAKEHOLDERS

Potential key user:

- **Joint Research Centre (JRC)**
Invited as the primary key user for the Energy Onshore use case of the ClimateDT, the JRC supplies policymakers with evidence-based facts to push European energy objectives forward.

- **Ocean Winds (OW)**
Oceans Winds (OW) is an international company dedicated to offshore wind energy and created as a 50-50 joint venture, owned by EDP Renewables and ENGIE.

- **Other key users**
Other users from the private sector and scientific community have been envisioned as beneficiaries of the climate information produced by the ClimateDT. Among them are wind farm owners, power grid operators, technical consultancy groups and R&D university departments focused on renewable energies.

How can the initiative help to improve the state of the art methods in this sector?

For this we can identify the user needs and requirements that the ClimateDT will be able to address:

Needs	Requirements
Ensure security of energy supply, price and power grid stability of the European energy system while improving data access and availability.	Provide climate information that shows how future climate will affect on-shore wind distribution and hence available wind energy resources on a global scale until 2050.
Obtain reliable data on how energy systems and turbine structural integrity can cope with the effects of extreme events.	Determine how changes in the multi-decadal 50-year return period of extreme winds and (compound) extreme events impact the renewable wind energy system.
Insight into future changes in climate variability to plan and manage the design of energy systems and the impact on energy demands and prices.	Provide information on the changes in heating and cooling degree days that are strongly linked to electricity demands and are valuable as input for energy models.

TECHNICAL DESIGN

The Energy Onshore application is being developed as a Python library (current version: 0.7.0), with a main script containing a set of indicators and supporting scripts containing auxiliary functions for data pre- and post-processing.

Table 1: *Summary of novel features introduced by the ClimateDT in GCMs [3].*

Feature	*State-of-the-art*	*ClimateDT*
Climate variable	10m wind components (u10, v10) Requires interpolation	**100m, 150m wind speed &** its components**.**
Temporal resolution	3 to 6 hourly	**1 hourly** to sub-hourly
Spatial resolution	100 km (CMIP) 12.5 - 50 km (CORDEX)	2.5 - **5 km**
Location	RCMs / downscaling required for regional climate information	**Regional climate information** available **globally**

WORKFLOW AND INDICATORS IN THE ENERGY ONSHORE APPLICATION

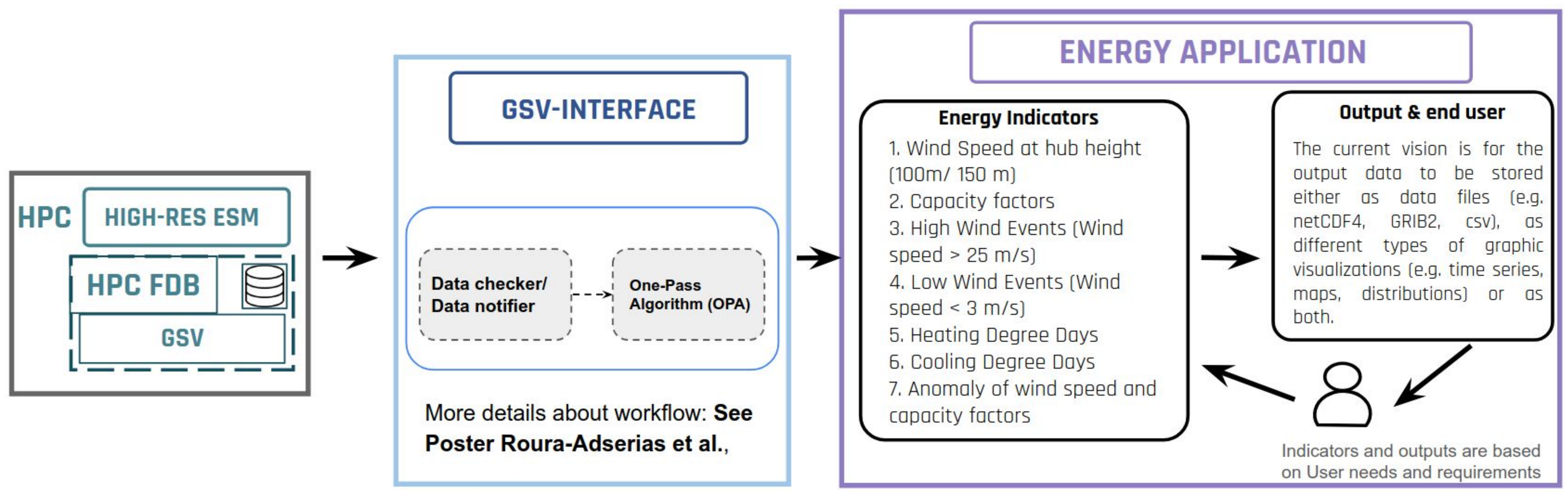

Figure 2: *Architecture of the Energy Onshore application and its implementation in the DestinE workflow [4-6].*

RESULTS

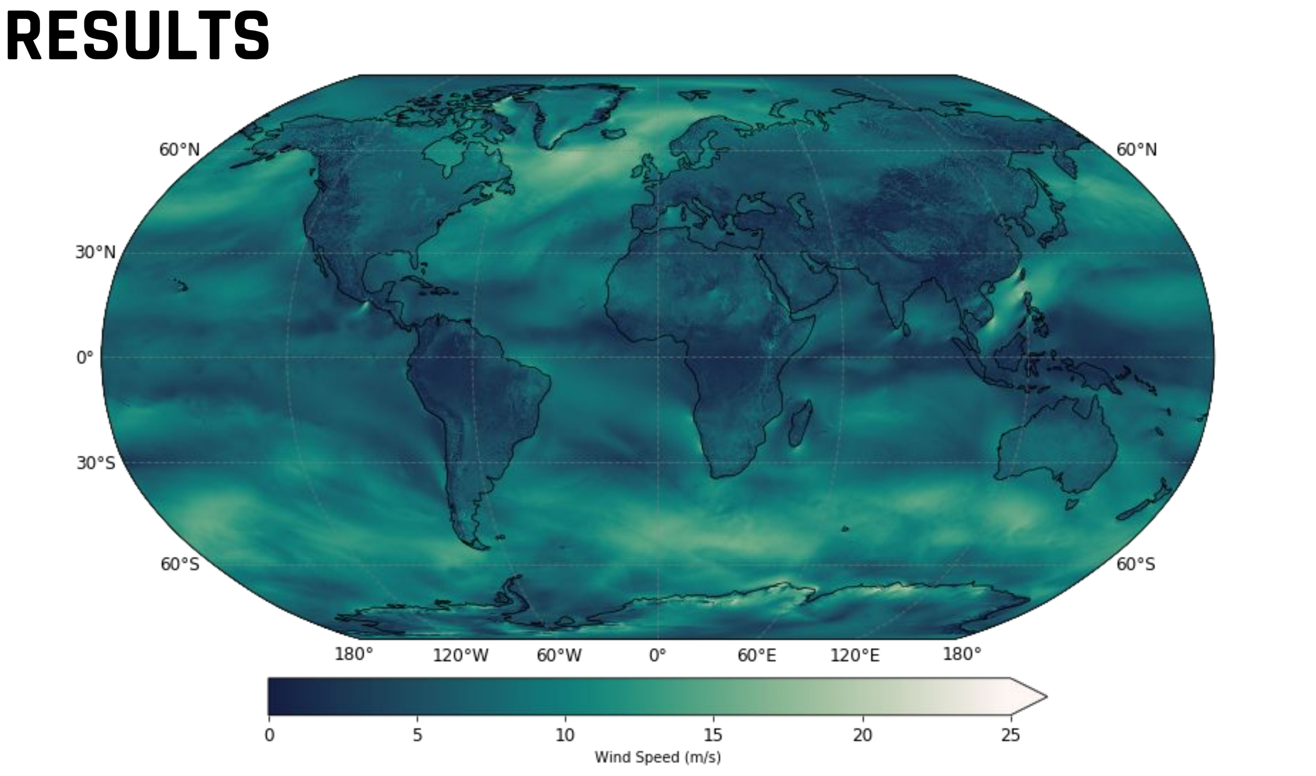

Figure 3: *Wind speed at 100m averaged over one week from 1-hourly wind components (100u, 100v). Data was obtained from the ClimateDT IFS-FESOM projection simulation.*

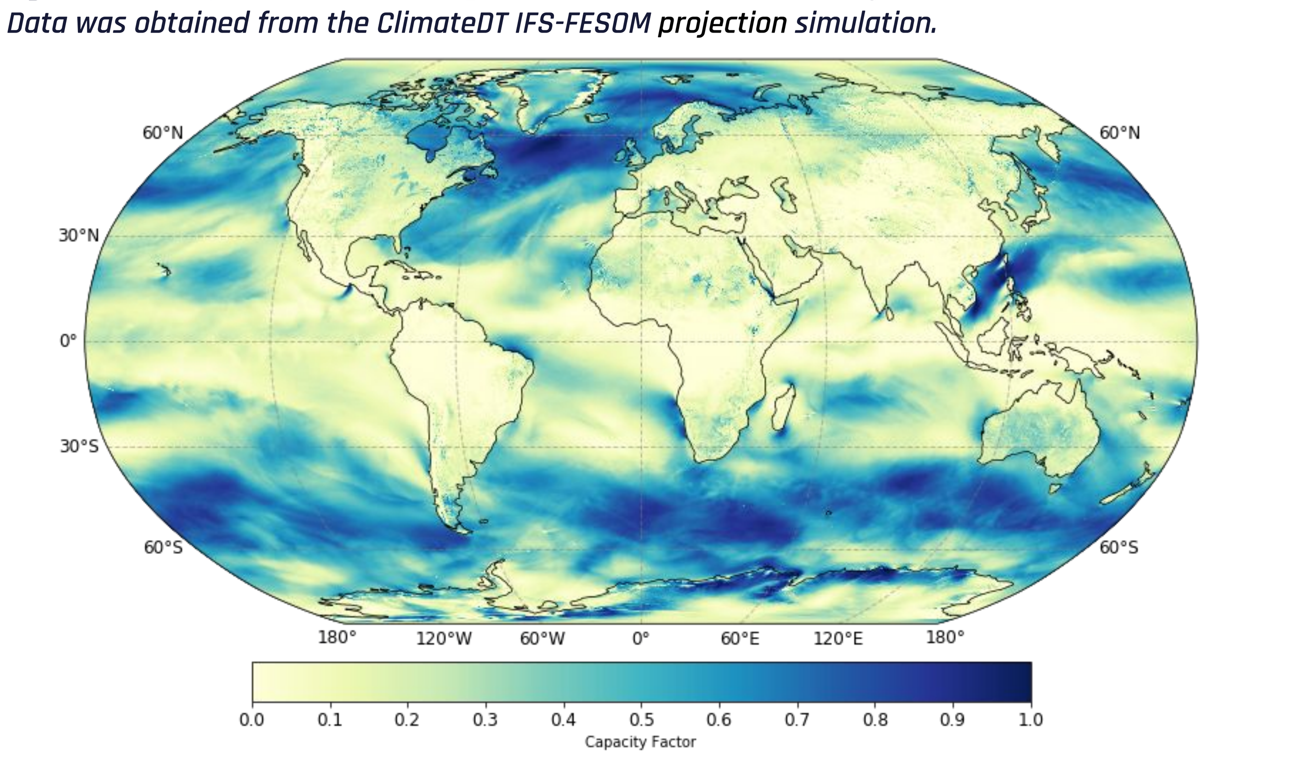

Figure 4: *Capacity factor at 100m hub height for a class S Vestas V164 wind turbine, averaged over one week iand computed from 1-hourly wind components (100u, 100v). Data was obtained from the ClimateDT IFS-FESOM projection simulation.*

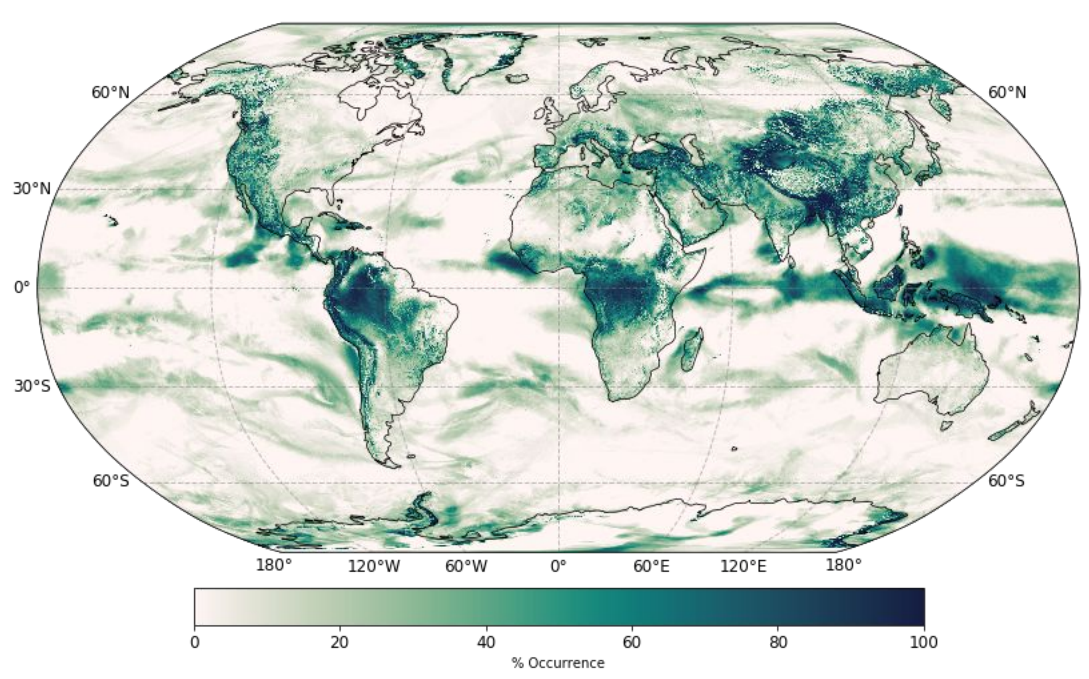

Figure 6: *Percentage occurrence of **Low Wind Events** (LWE) at 100m accumulated over one week irom 1-hourly wind components (100u, 100v). Data was obtained from the ClimateDT IFS-FESOM projection simulation. The threshold for LWE: Wind Speed below 3m/s.*

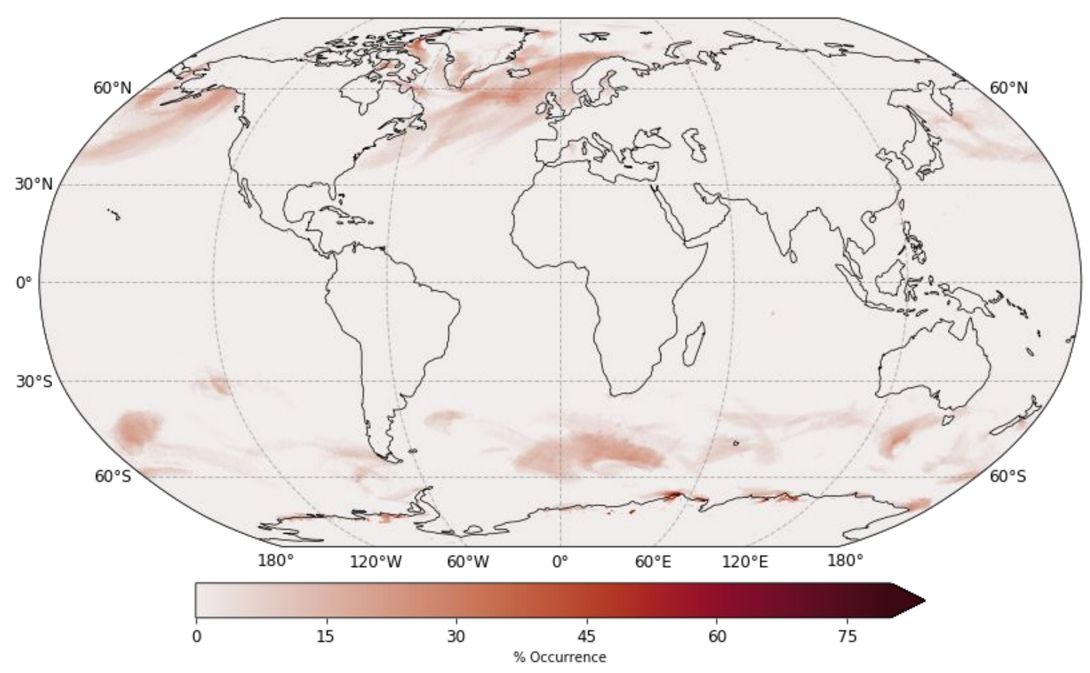

Figure 7: *Percentage occurrence of **High Wind Events** (HWE) at 100m accumulated over one week from 1-hourly wind components (100u, 100v). Data was obtained from the ClimateDT IFS-FESOM projection simulation. The threshold for HWE: Wind Speed above 25m/s.*

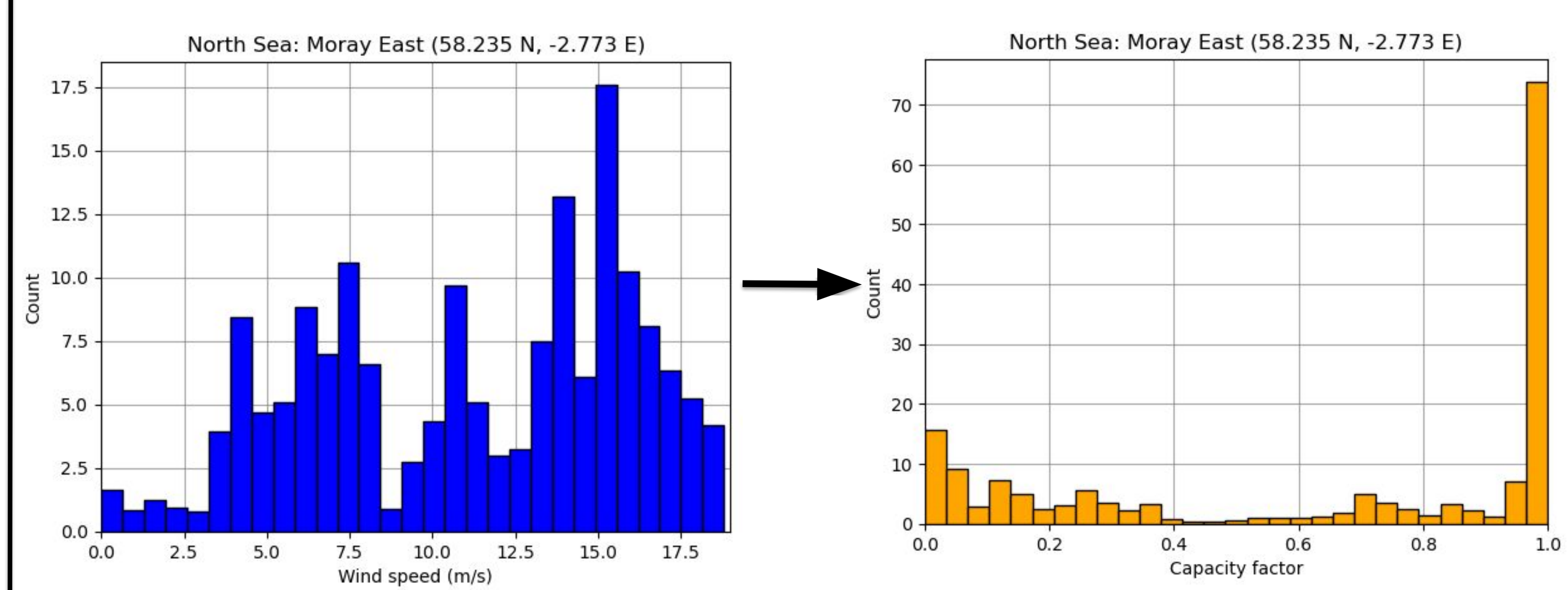

Figure 5: ***Wind speed** (left) and **capacity factor** (right) distributions for a class S Vestas V164 wind turbine over one week and computed from 1-hourly wind components (100u, 100v). Data was obtained from the ClimateDT IFS-FESOM projection simulation.*

References

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