

04

# Historical Synthetic Realisations for Off-shore Wind Parks



# Enhancing PPA risk assessments with historical profiles

## PPA configurations requires power generation profile



### New wind off-shore park

Newly constructed projects are sold via PPA contracts for long-term security



### Pricing requires expected generation

Pricing of PPAs is based on expected generation profiles and market prices



### Often relies on historical realisations

Historical realisation can indicate the correlation to markets and own portfolios



## Making deals is challenging without a history

Benchmarking against local wind park power profiles is not always possible, making it challenging to obtain a **realistic power profile** aligned with the PPA

### Insufficient historical data

From already existing or similar projects

### Power generation profile

Not available for new projects

### Suboptimal risk assessment

Misestimations of risk and correlation

**Use Case developed for demo purposes (E-World, ...)**

# Price PPAs with modeled historical power profiles



## Synthetic Realisation

Simulates historical power generation using data from historical weather, location, and turbine specifications



### Historical Weather Data

Wind Speed, direction,  
surface roughness



### Technology Data

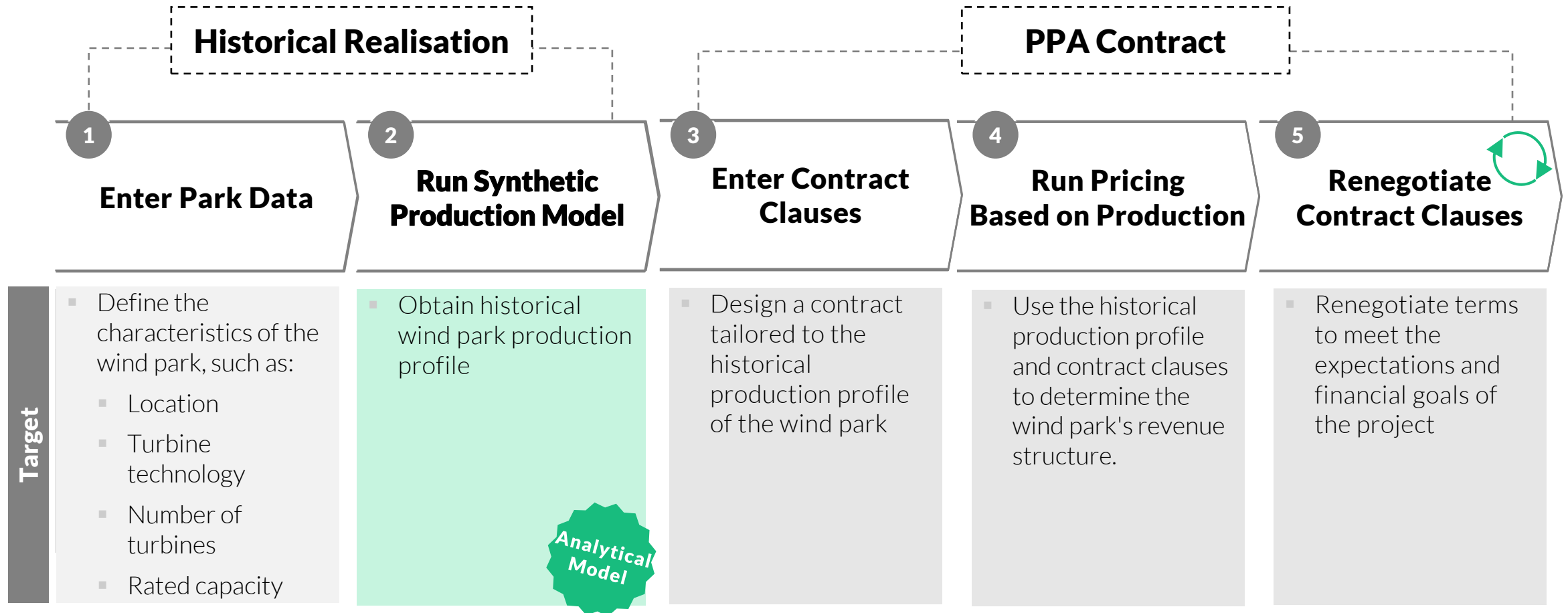
Height, capacity, power  
efficiency curve



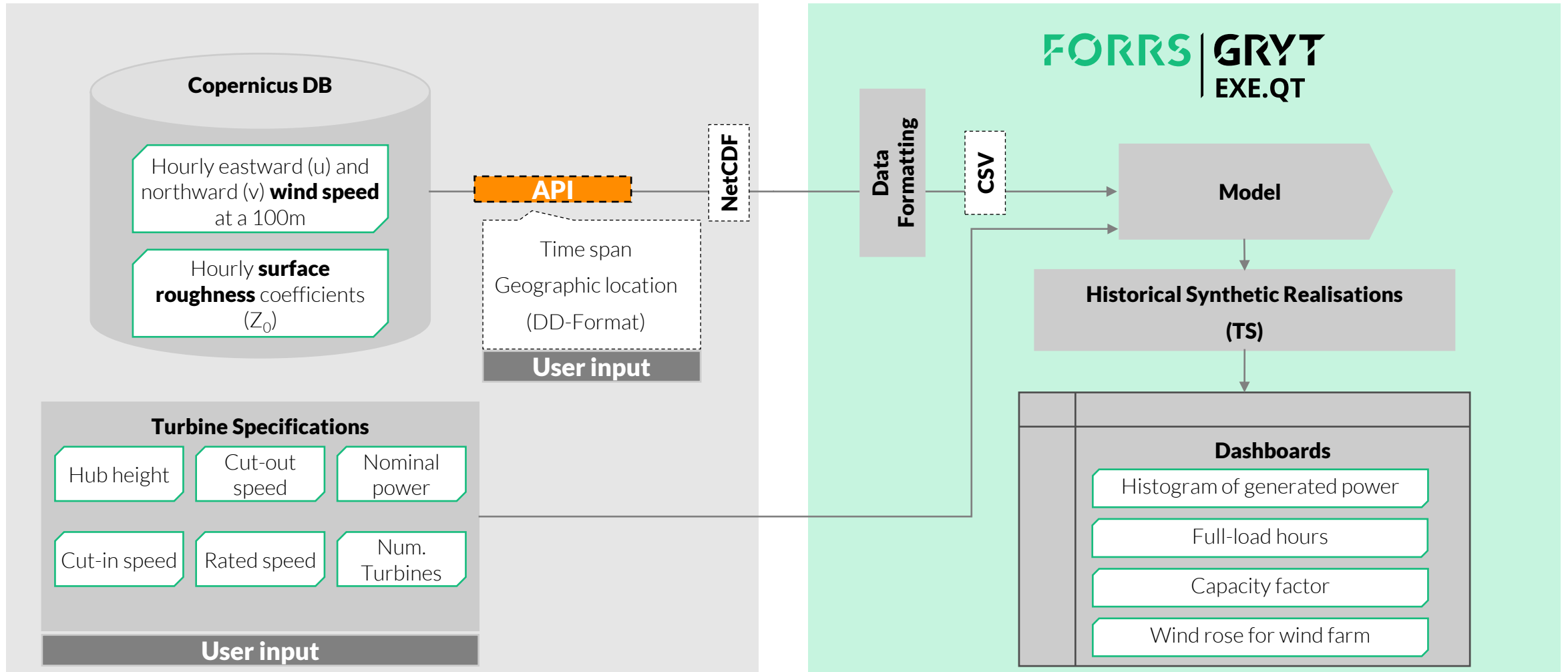
### “Historical” Power Profile

Times series on power  
output generation

# Historical realisation in the user's journey



# Data flow for the historical synthetic realisation



# Analytical model

Approach based on the study of Grothe et al. (2022)

1

**Absolute wind speed**

$$\text{speed}_{100} = \sqrt{u^2 + v^2}$$

2

**Escalated wind speed**

$$\text{speed}_{\text{hub}} = \text{speed}_{100} \cdot \left( \frac{\log(h_{\text{hub}}) - \log(z_0)}{\log(100) - \log(z_0)} \right)$$

3

**Turbine power output**

$$p(\text{speed}_{\text{hub}}) = \begin{cases} 0, & \text{if } \text{speed}_{\text{hub}} < \text{speed}_{\text{min}} \\ a_1 \text{speed}_{\text{hub}}^3 + b_1 \text{speed}_{\text{hub}}^2 + c_1 \text{speed}_{\text{hub}} + d_1, & \text{if } \text{speed}_{\text{min}} \leq \text{speed}_{\text{hub}} < \text{speed}_{\text{split}} \\ a_2 \text{speed}_{\text{hub}}^3 + b_2 \text{speed}_{\text{hub}}^2 + c_2 \text{speed}_{\text{hub}} + d_2, & \text{if } \text{speed}_{\text{split}} \leq \text{speed}_{\text{hub}} < \text{speed}_{\text{rated}} \\ \text{rated}_{\text{power}}, & \text{if } \text{speed}_{\text{rated}} \leq \text{speed}_{\text{hub}} < \text{speed}_{\text{max}} \\ 0, & \text{if } \text{speed}_{\text{max}} \leq \text{speed}_{\text{hub}} \end{cases}$$

4

**Wind park output**

$$\text{Historical Synthetic Realisation} = p(\text{speed}_{\text{hub}}) * n_{\text{Turbines}}$$

**Model Assumptions**



**Standard Weather Conditions**



**No Maintenance**



**Single Turbine Aggregation**

# User interface

## EXE.QT environment

The screenshot displays the EXE.QT user interface, which is organized into three main sections, each with a toggle switch and a collapse/expand arrow:

- Date & Project Area:** Contains fields for "Historic Begin Date:" (2020-01-01) and "Historic End Date:" (2023-12-31). Below this is the "Project Area Coordinates:" section with "Latitude:" (53.45) and "Longitude:" (-3.58).
- Turbine Specifications:** This section is highlighted with an orange border. It includes "Object Parameter:" with a dropdown for "Turbine Model:" (SWT-3.6-120), "Hub Height:" (84.4), and "N° Of Turbines:" (160). Below this is the "Turbine Characteristics:" section with "Cut-In Speed:" (3), "Rated Speed:" (14), and "Nominal Power:" (3.6). An "Add Item" button is located at the bottom right of this section.
- Settings:** Contains an "Identifier:" field with the text "Windpark\_StormFront\_Synthetic\_Power\_Generation".

At the bottom of the interface, there are "Back" and "Run Now" buttons.



### Historical Weather Data

Wind Speed, direction, surface roughness



### Technology Data

Height, capacity, power efficiency curve



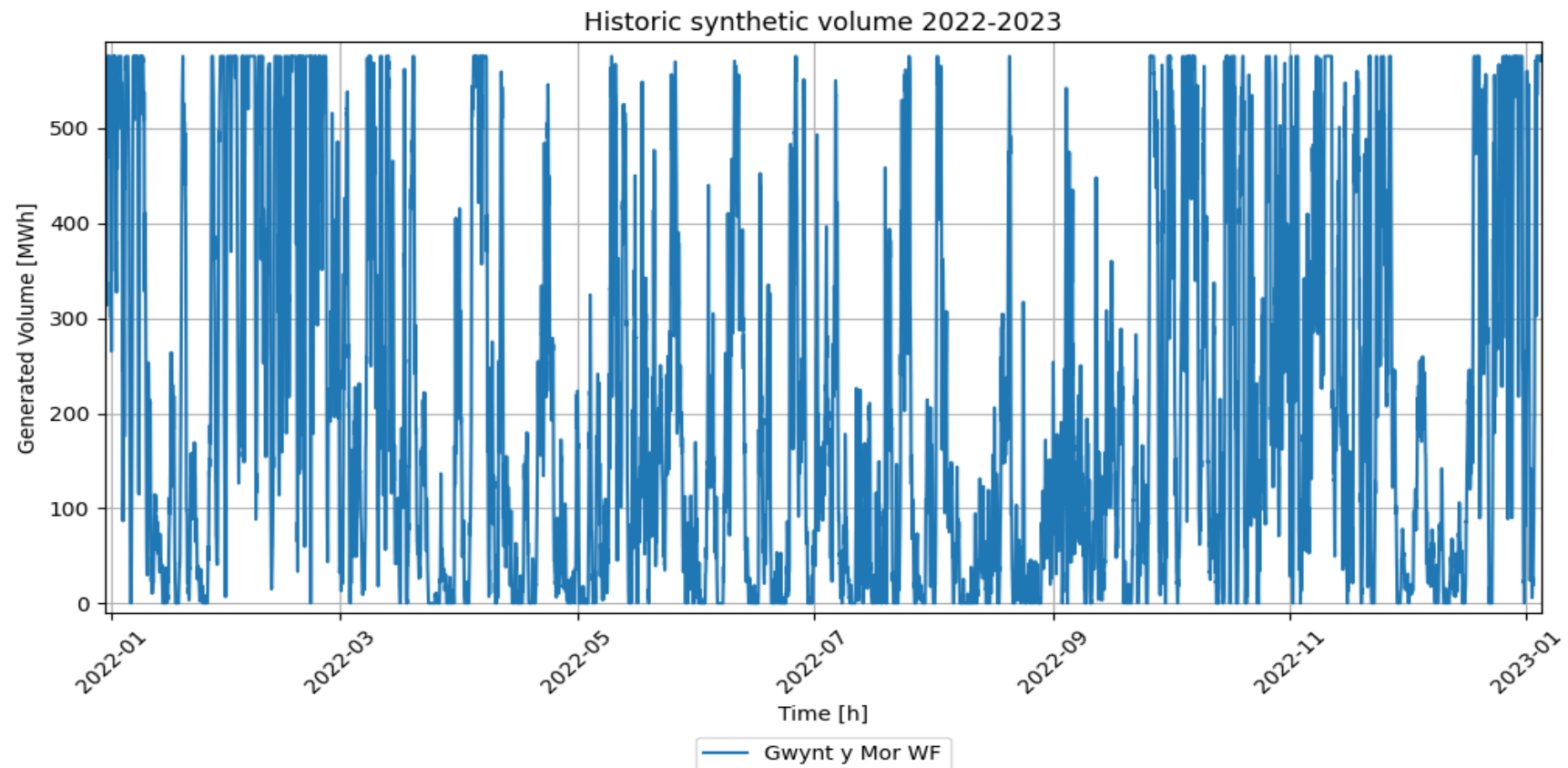
### "Historical" Power Profile

Times series on power output generation

# Main output

Example for the “Gwynt y Mor” wind park in the UK

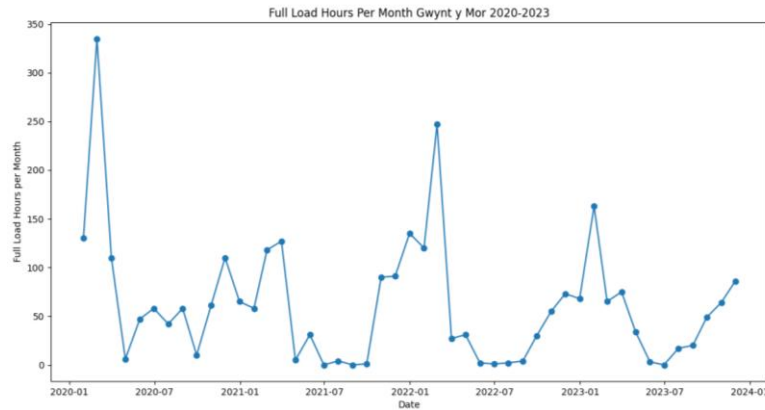
## Historical synthetic realisations



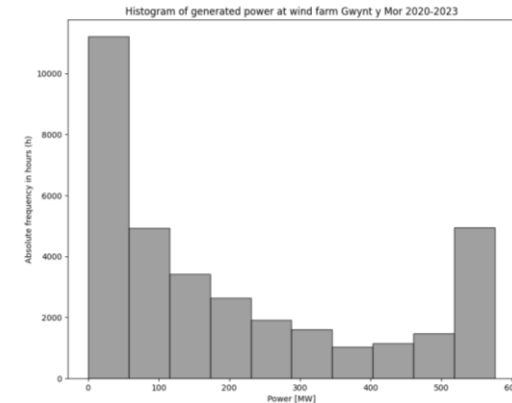
# Other outputs

Example of the "Gwynt y Mor" wind park in the UK

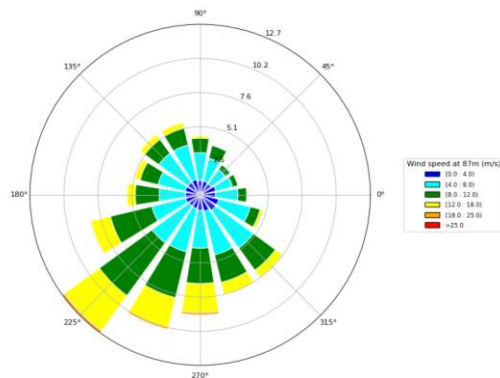
## Full-load hours



## Histogram of generated power



## Wind rose of the park



## Capacity factor

Installed wind power capacity: 576.0 MWh  
Capacity Factor: 0.3559 or 35.59%

$$\text{Capacity Factor} = \frac{\text{Total Energy Produced}}{\text{Rated Capacity} \times \text{Number of Hours}}$$

# Model improvements

Deterministic model

