

WILL IT SPIN?

Predicting wind farm electricity output based on day ahead wind forecasts



The Voltcasters



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*Has worked as C#
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Previously worked in the field of agriculture combining farming with IOT



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Previously completed the Master's thesis in the field of seasonal climate predictability



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MSc Economics & Business Administration

Data set and stakeholder

2014 Global Energy
Forecasting Competition



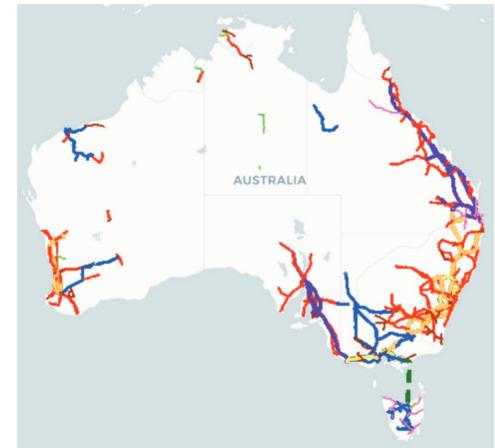
10 x 
Australian wind farms



hourly data

c.18k data
rows per wind
farm

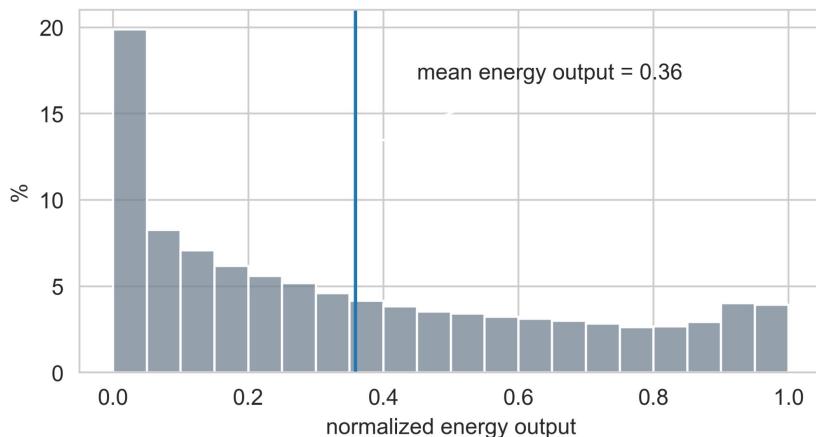
- **Electricity grid operators:** responsible for grid stability by balancing electricity demand and supply in the grid
- **Safe feed-in of intermittent** wind power into the electricity grid requires reliable forecasts



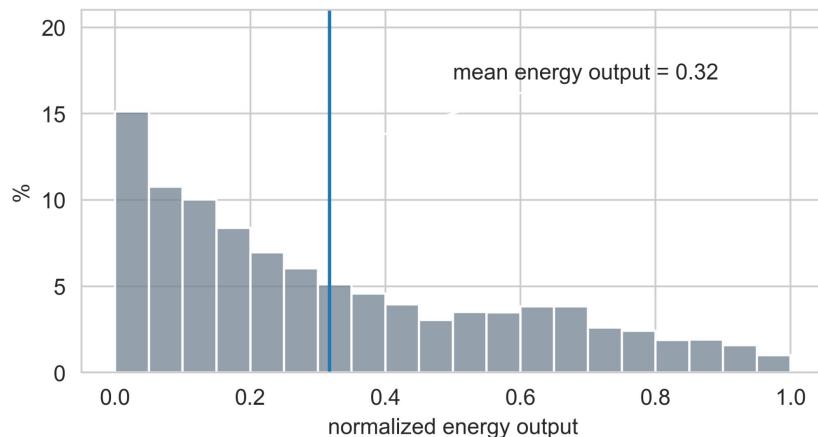
What do we predict?

Energy production of a wind farm for a given hour. The energy production was anonymized by scaling from 0 to 1.

All wind farms



Exemplary wind farm



Features

Horizontal wind is a **vector** which contains **wind speed** and **wind direction**. It is decomposable into **two components**:



U10 / U100: West-East wind forecast on 10m and 100m height



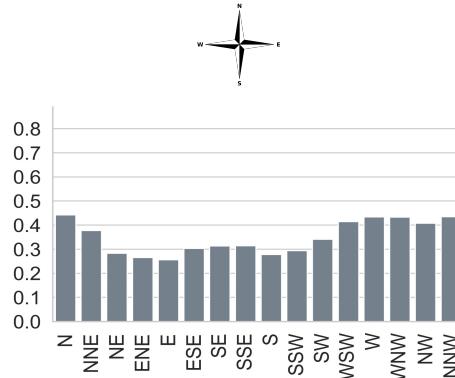
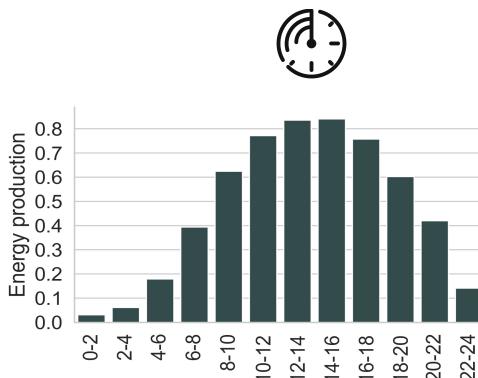
V10 / V100: South-North wind forecast on 10m and 100m height



The data set contains wind forecasts for the two components, issued everyday at **midnight** with an **hourly** resolution up to 24 hours ahead

Features

Wind speed and wind direction can be deduced from the wind components



Features were considered in different forms
e.g. cardinal wind direction / wind direction in degrees

Further features

- Hour
- Weekday
- Month
- Public Holiday

Model evaluation metric & Baseline model

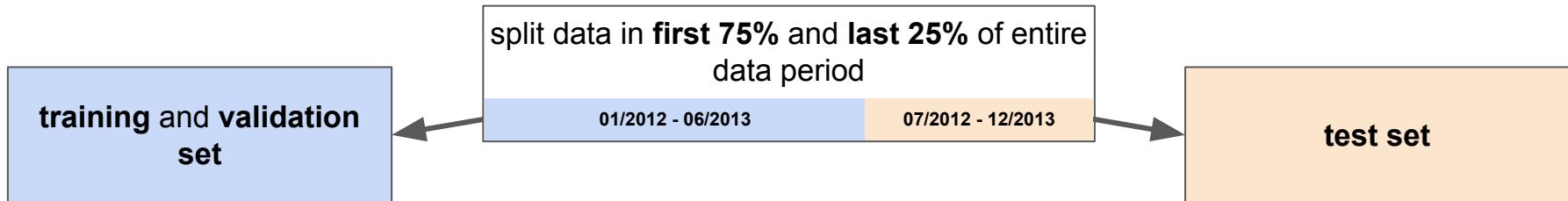
Root Mean Squared Error (RMSE)

- Measure of how much **predicted** and **actual energy production** differ from each other **on average**
- strongly penalizes **large forecast errors**, which can **endanger grid stability** and lead to **large costs**

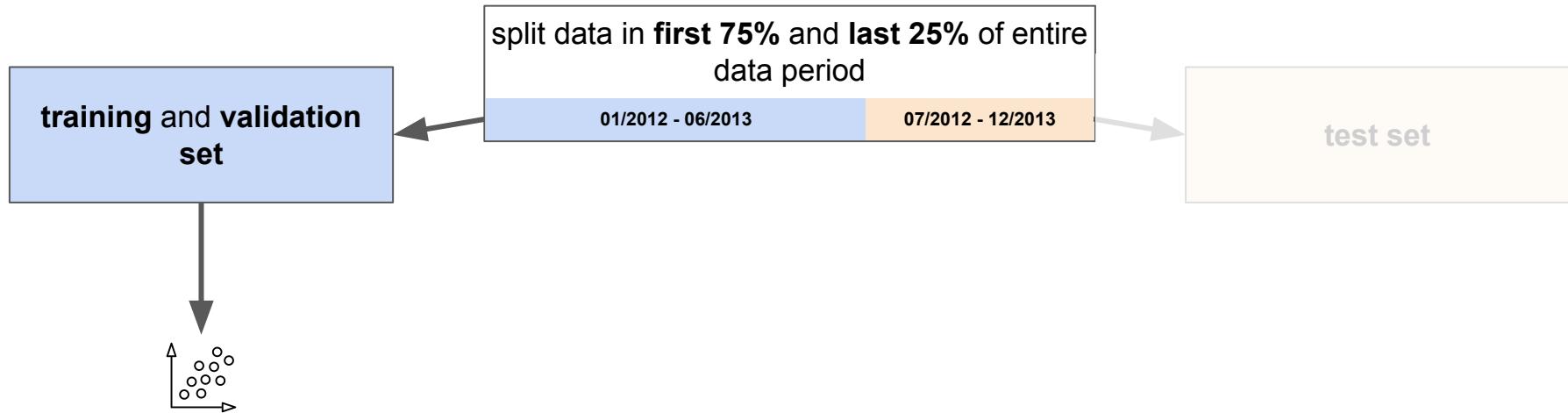
Baseline model

- always predict the **wind farm dependent average electricity production** and aggregate predictions over all wind farms

Modelling: Set-up and optimization procedure



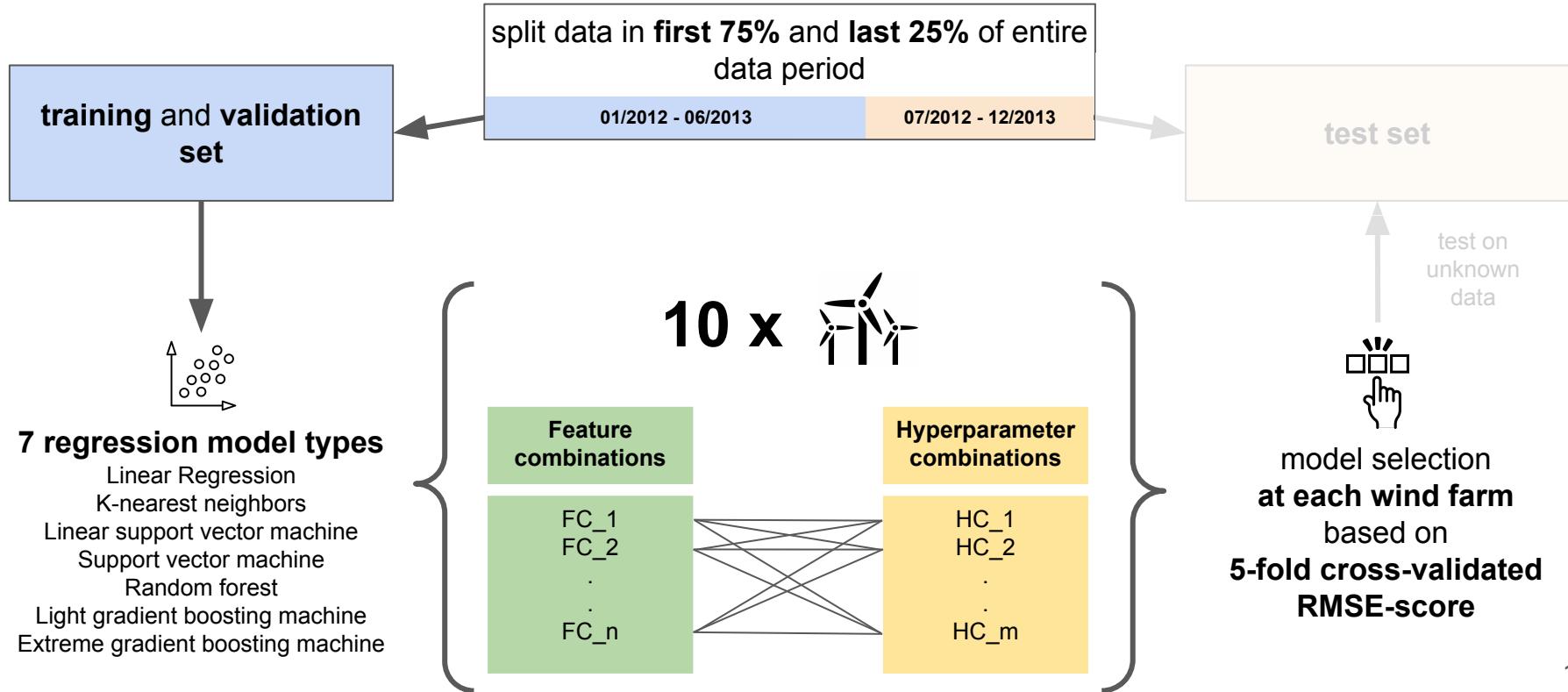
Modelling: Set-up and optimization procedure



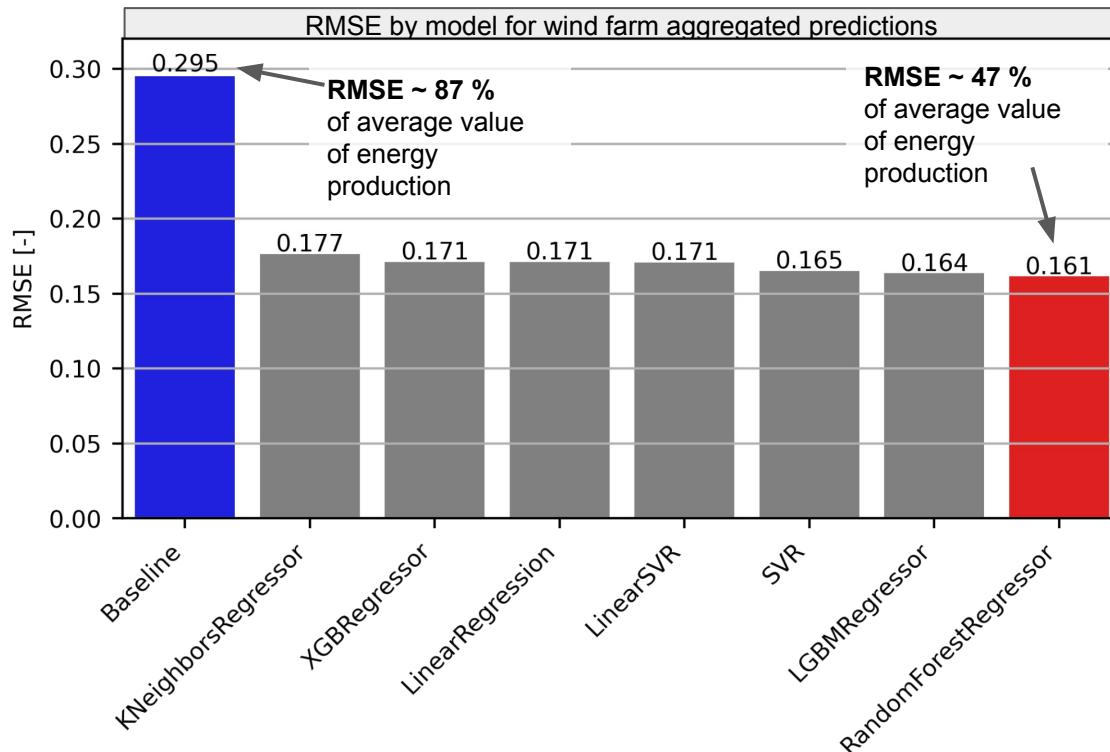
7 regression model types

- Linear Regression
- K-nearest neighbors
- Linear support vector machine
- Support vector machine
- Random forest
- Light gradient boosting machine
- Extreme gradient boosting machine

Modelling: Set-up and optimization procedure

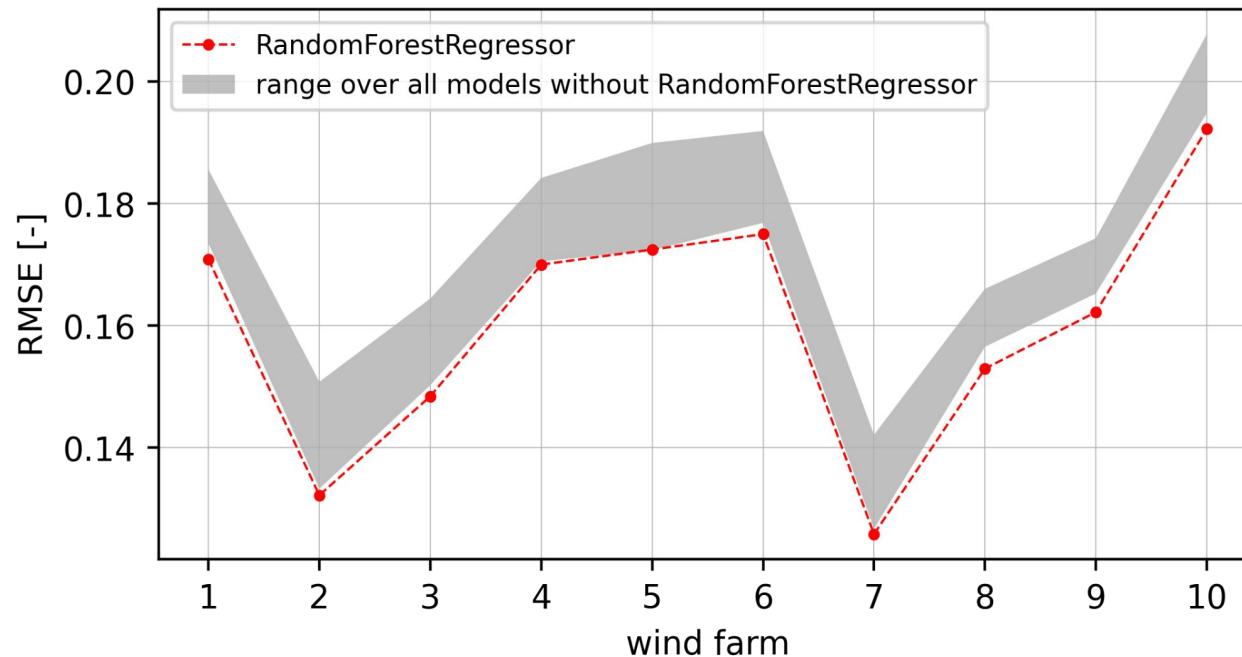


Model evaluation for predictions on the validation set



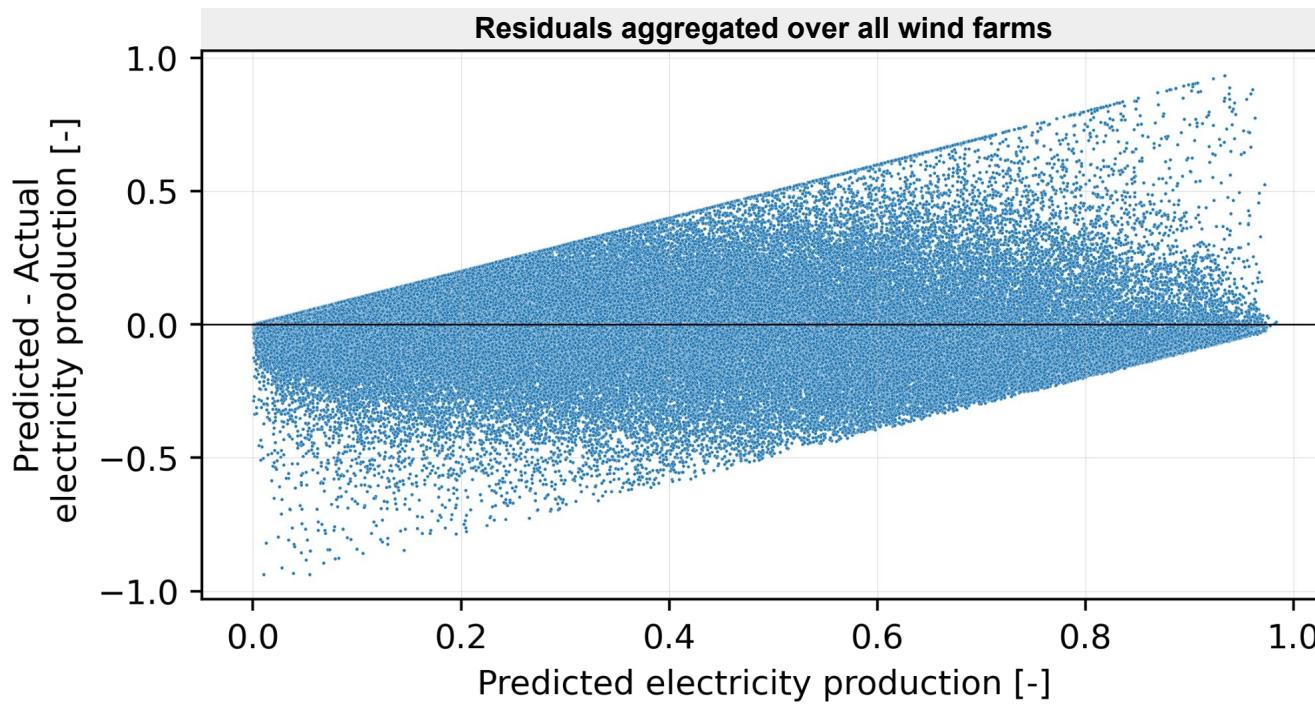
- Among the different model types, **Random Forest** provides the best **wind farm aggregated predictions**

Model evaluation for predictions on the validation set

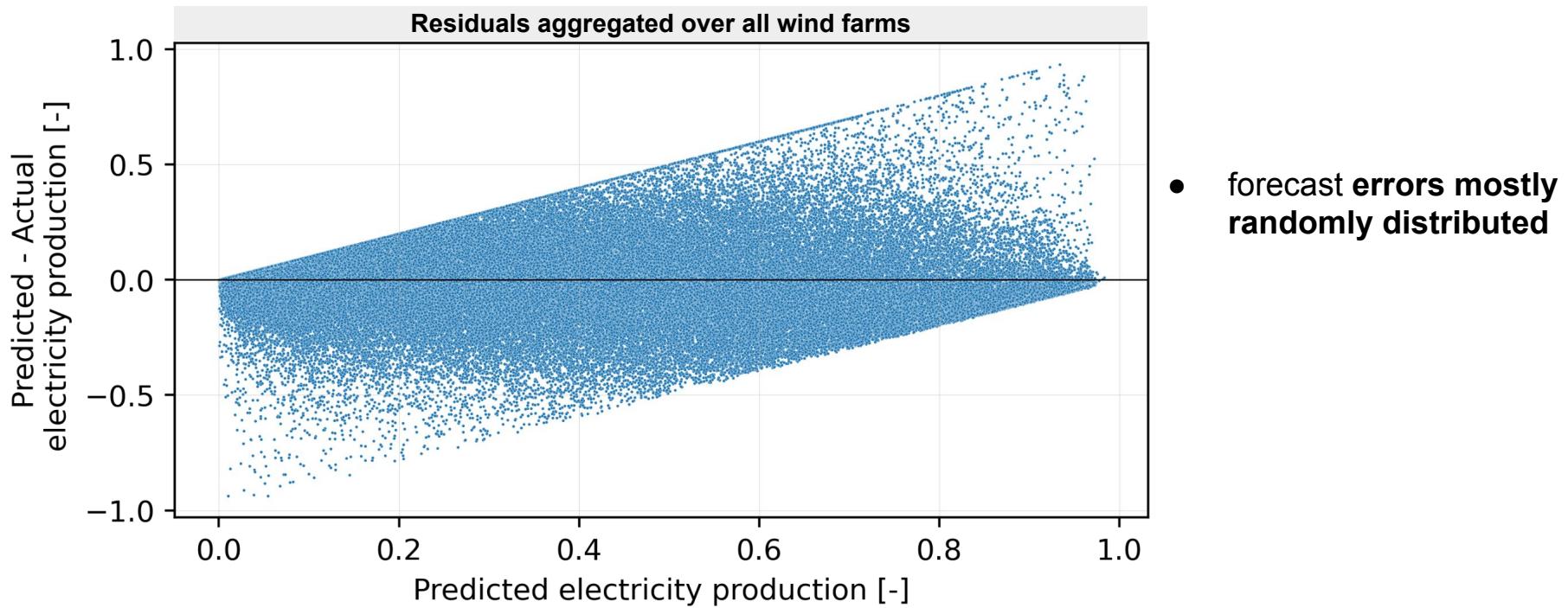


→ **Random Forest** is also the model type with the best predictions **at each individual wind farm**

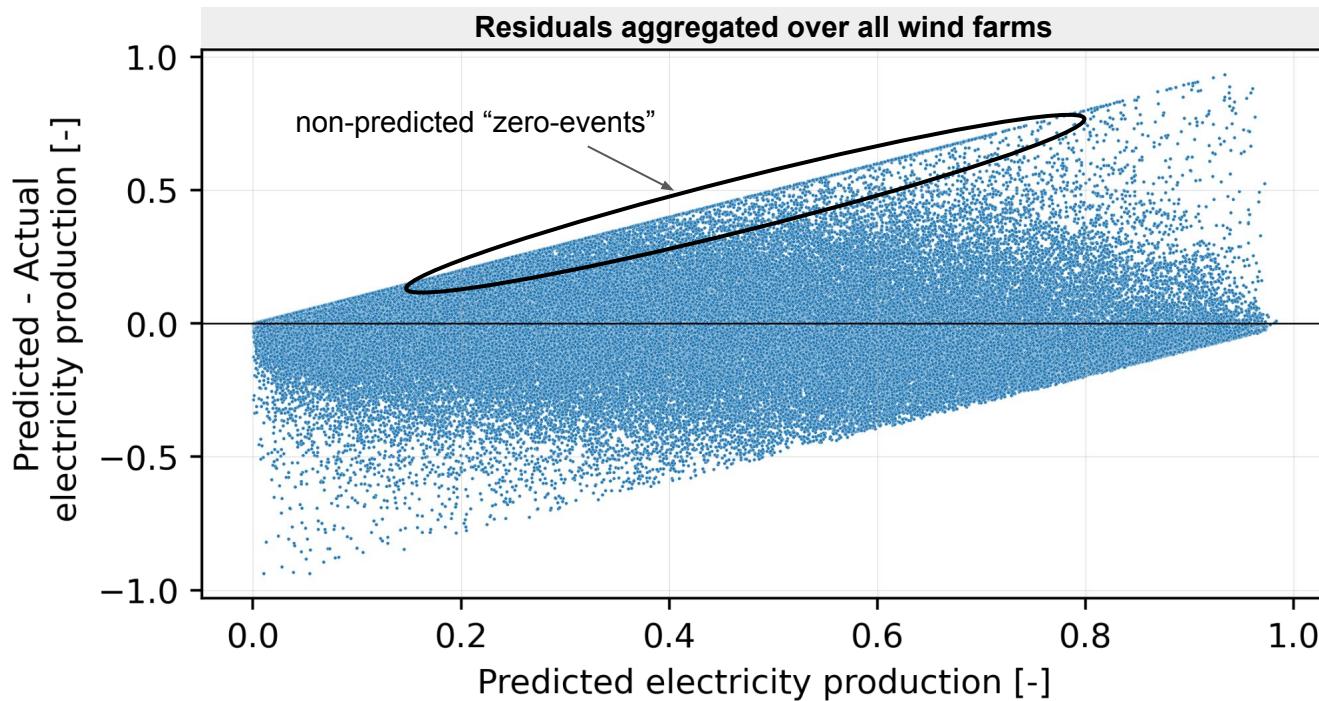
Error analysis for Random Forest Regressor



Error analysis for Random Forest Regressor



Error analysis for Random Forest Regressor



- forecast errors mostly randomly distributed
- however, systematic **overprediction** during **downtime** periods

Dashboard

Energy Output Forecast for the Next 24 Hours

Choose date and zone for forecast

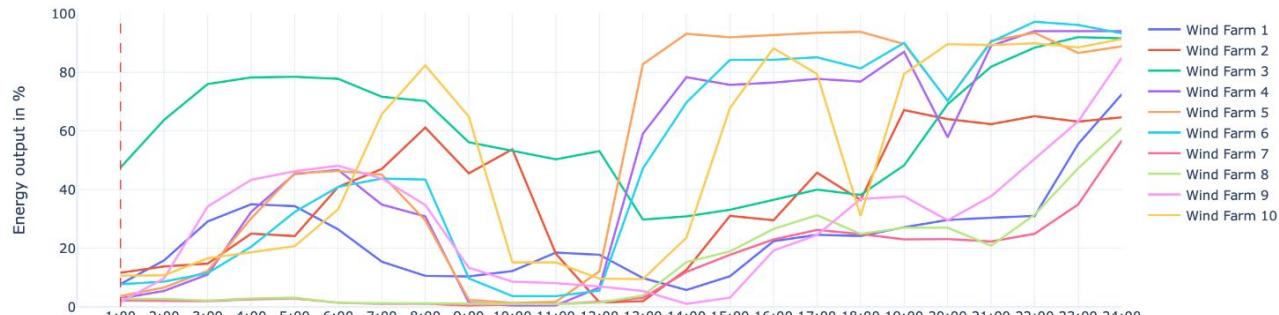
08/28/2013

- Wind Farm 1
- Wind Farm 2
- Wind Farm 3
- Wind Farm 4
- Wind Farm 5
- Wind Farm 6
- Wind Farm 7
- Wind Farm 8
- Wind Farm 9
- Wind Farm 10

Select all

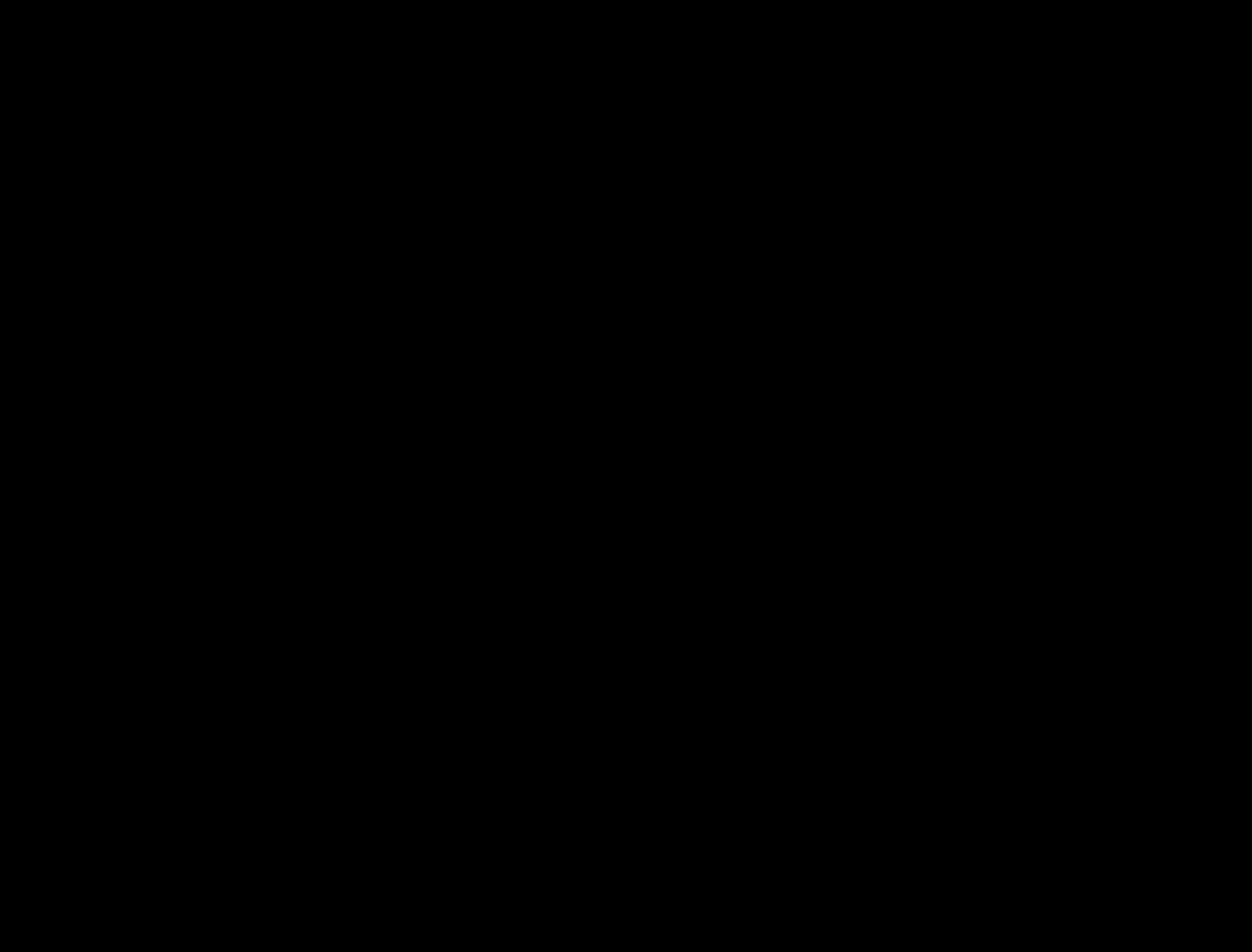
Forecast Energy Output Mean Daily Energy Output Wind speed (in m/s) and Direction Daily Mean Energy Production About this Dashboard

Forecast Power Output over 24 hours



Choose to view hourly forecast in detail:





Dashboard depicts
predictions and analyses of
the test data

Outlook

- Rolling update of model training when new observations were made
- Stakeholder-specific cost related metric
- Consider data with regards to wind farm downtime to improve prediction of zero production

WILL IT SPIN?

An aerial photograph of a vast wind farm situated in a desert valley. The foreground is filled with numerous wind turbines, their blades catching the light. A winding road cuts through the center of the farm. In the distance, a major highway with multiple lanes is visible, along with several small settlements and industrial structures. The surrounding terrain is arid and rocky, with mountains rising in the background under a clear blue sky.

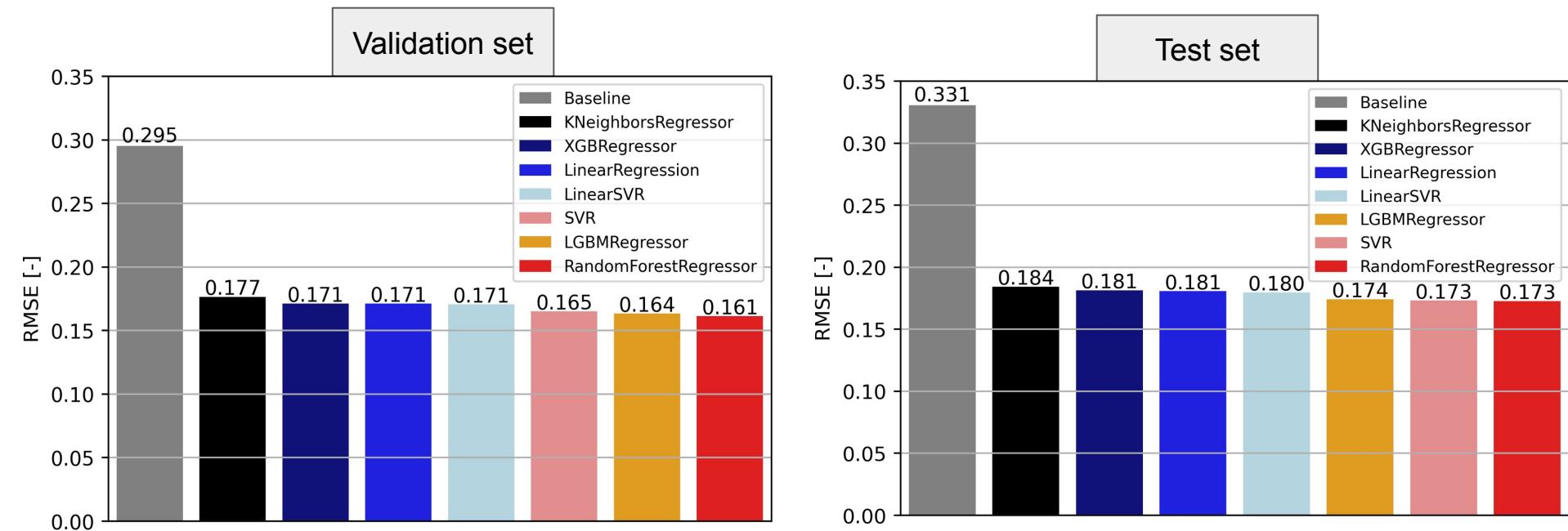
Capstone Project of the “Voltcasters”: Christine, Ferdinand, Moritz, Jerome

YES, it will!

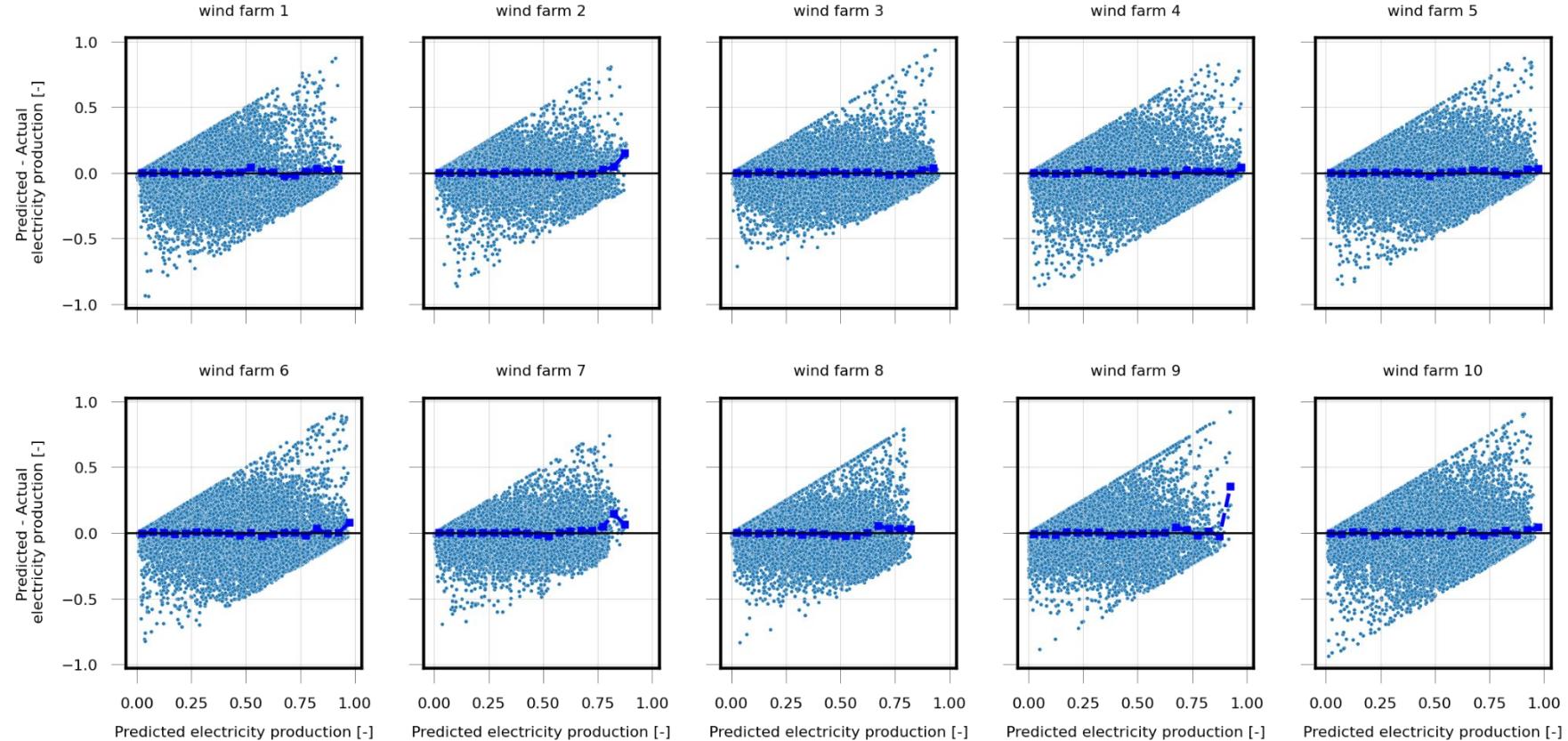


Capstone Project of the “Voltcasters”: Christine, Ferdinand, Moritz, Jerome

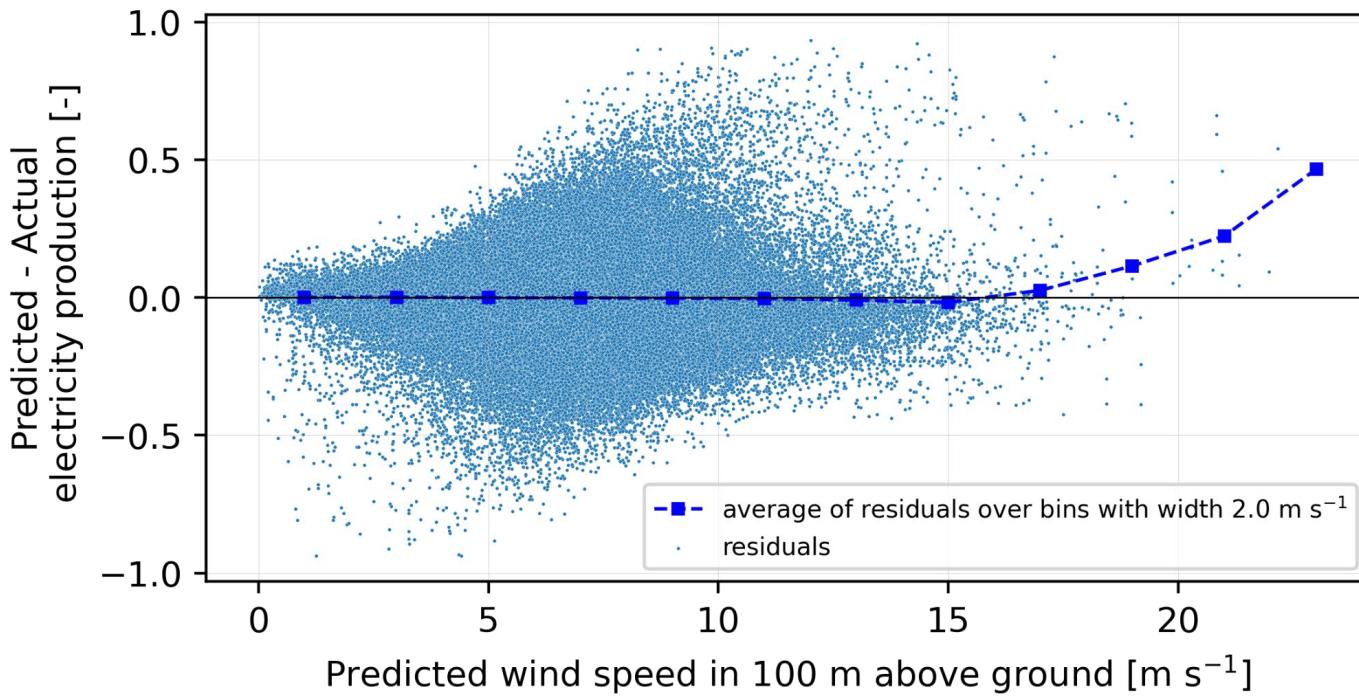
Appendix



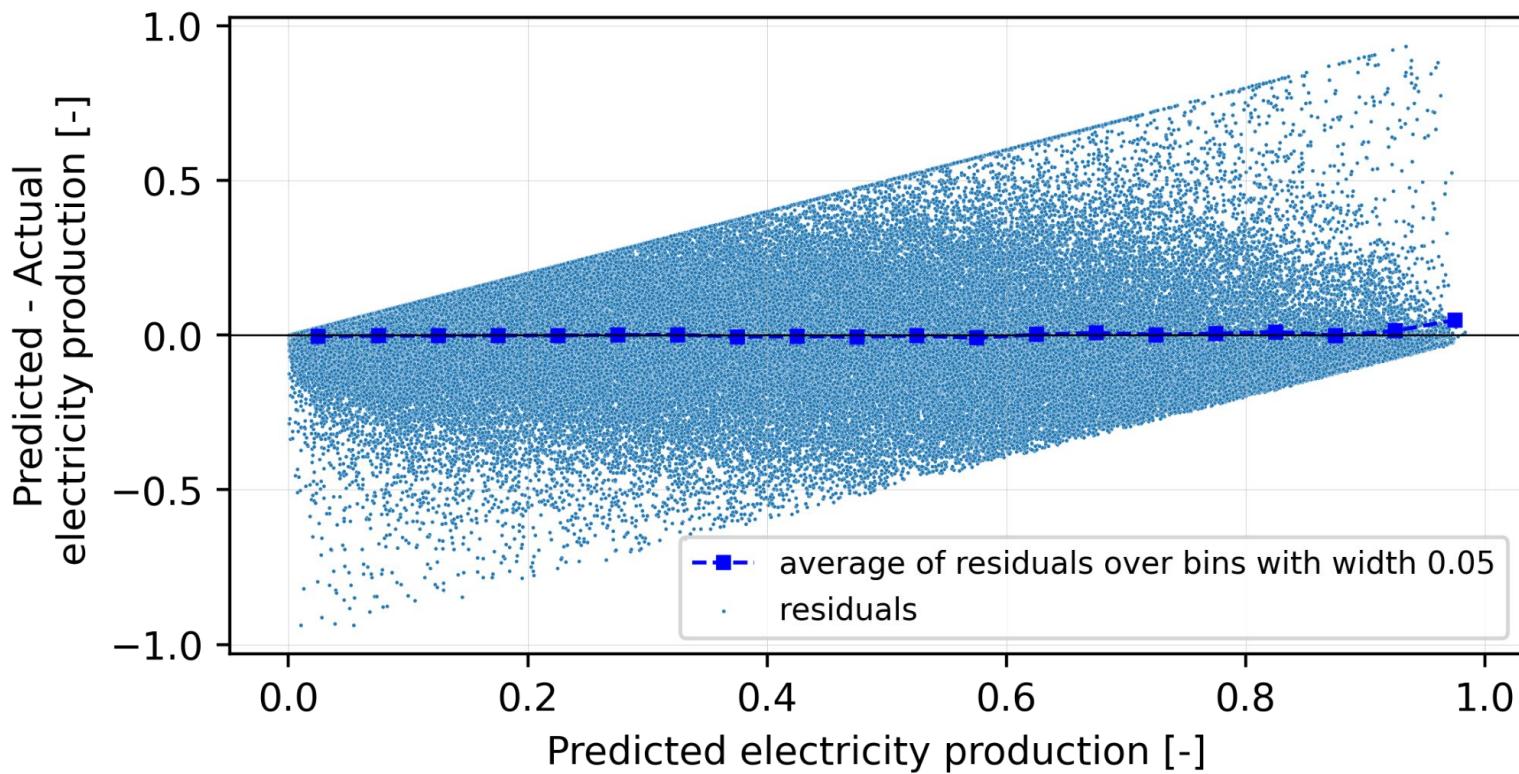
Appendix



Appendix



Appendix



Appendix: Feature Importance

