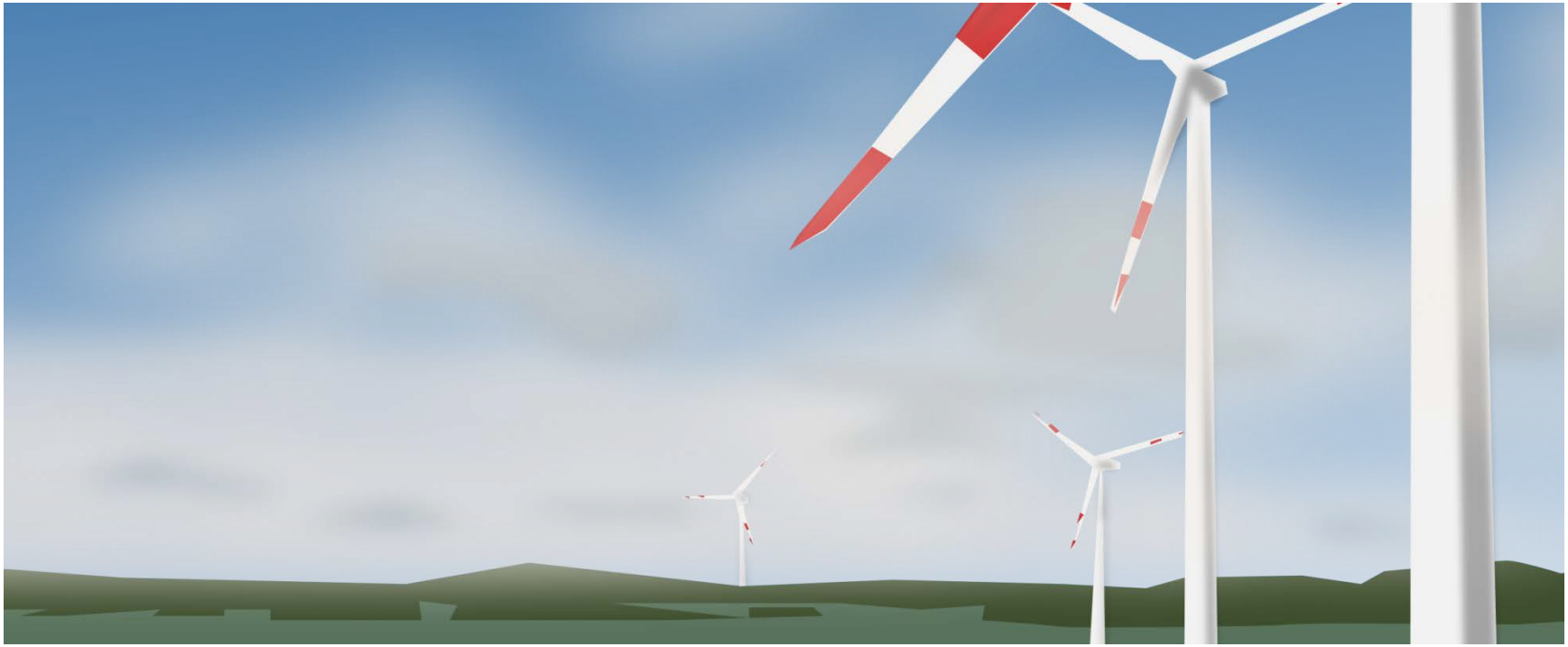
Intraday Forecasts of the Wind Energy Production for Transmission System Grid Nodes

Stephan Vogt, 9 June 2016



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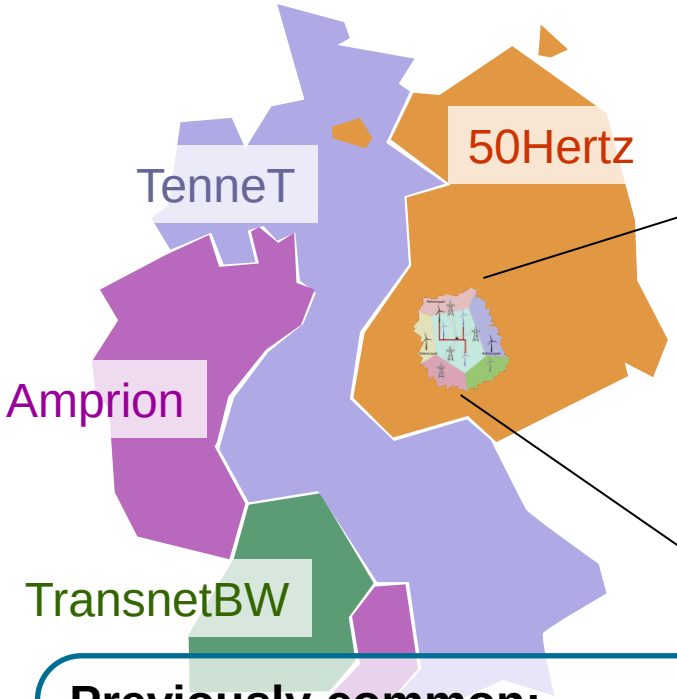
Agenda

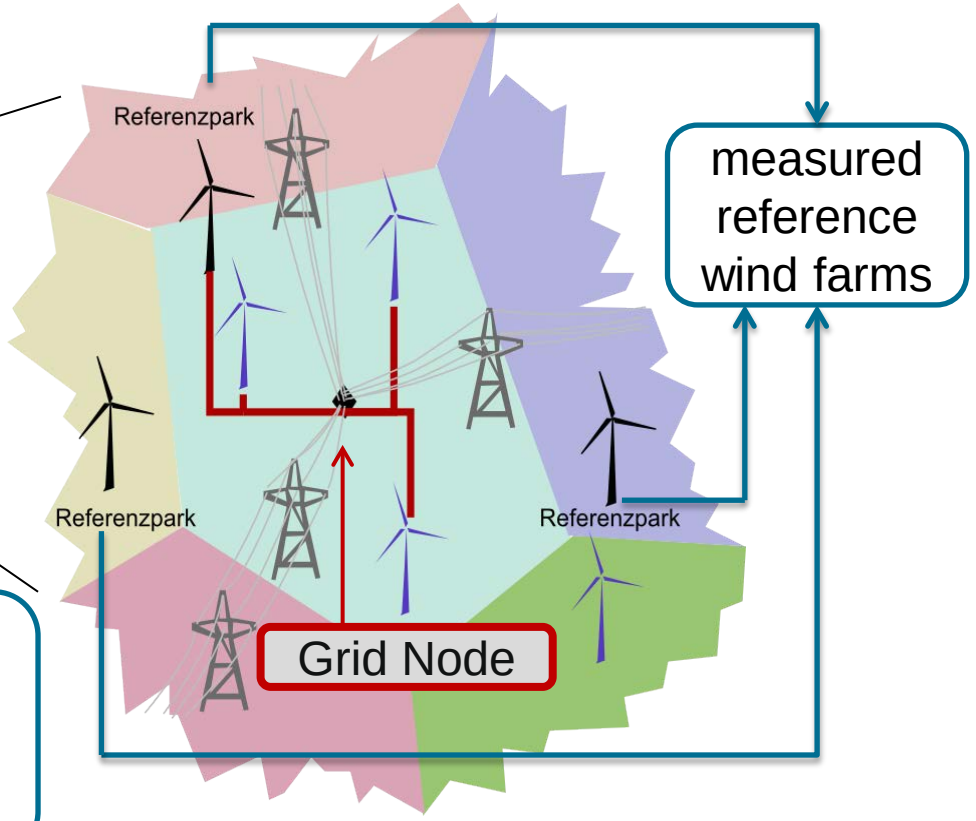
- Introduction
- Methods
  - Approximation with Reference Wind Farms
  - Generic Power Curve
  - Combination with Spatial Weights
- Results
  - Experiment Setup
  - Farm Errors
  - Significance
- Conclusion

Introduction

German transmission system operators (TSO)



Example of a Transmission Grid Node

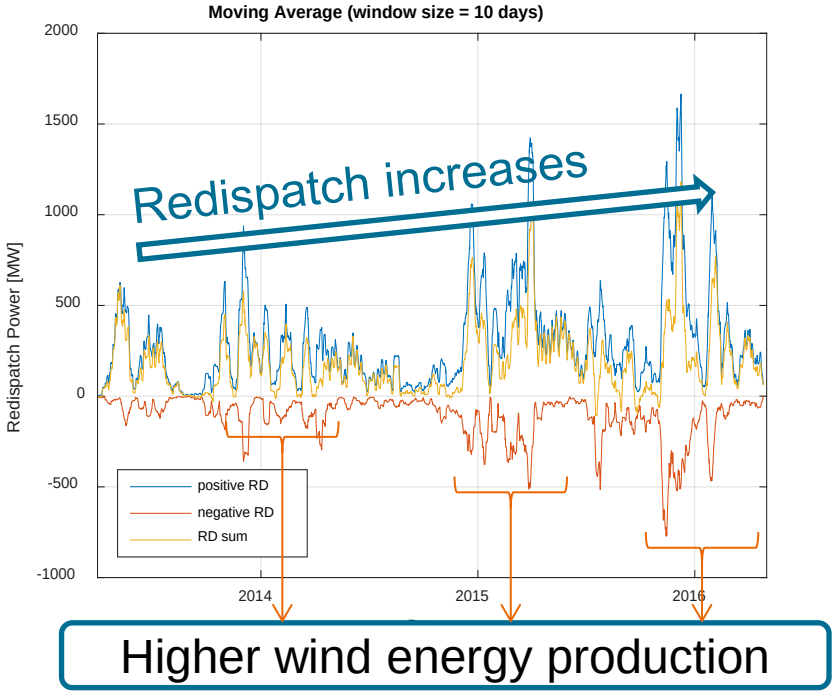


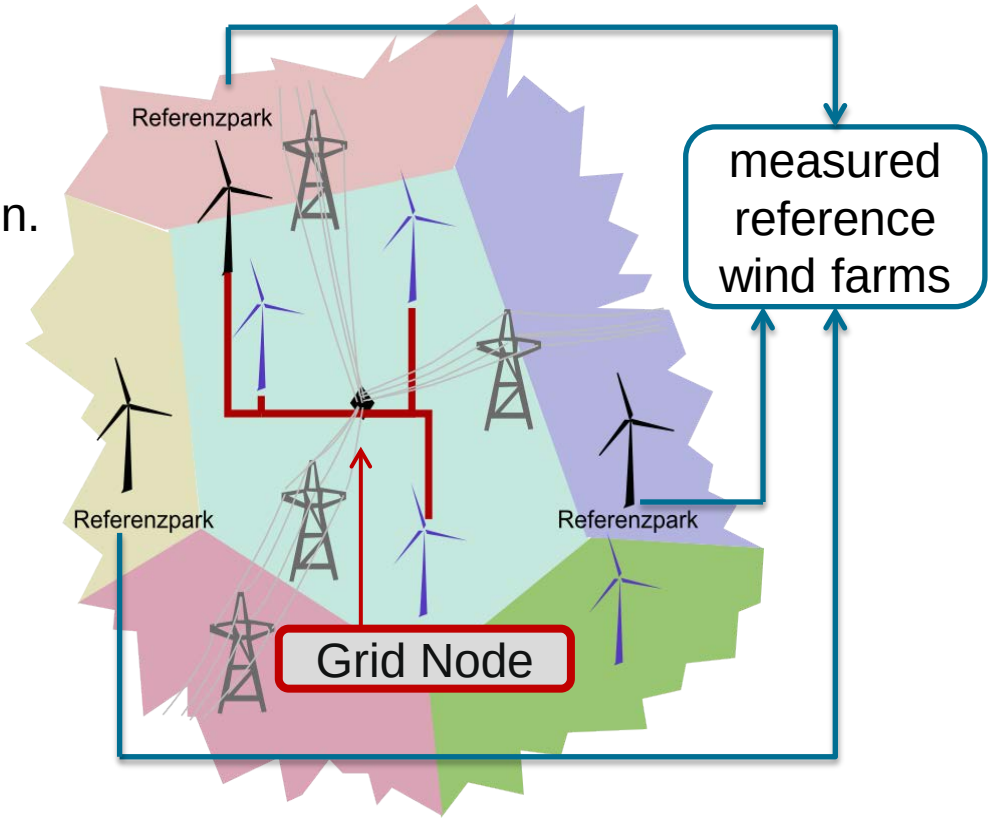
Previously common:
future grid node wind power production as constant proportion of the control zone forecast

Motivation

TSOs ensure secure network operation.
Therefore necessary:

- Load flow calculations
- Consider volatile power production (wind & PV)





Highly suspected redispatch causes:

- Errors in control zone intraday forecasts (15min to 8h)
- Spatially variable wind power production → missing grid node forecast

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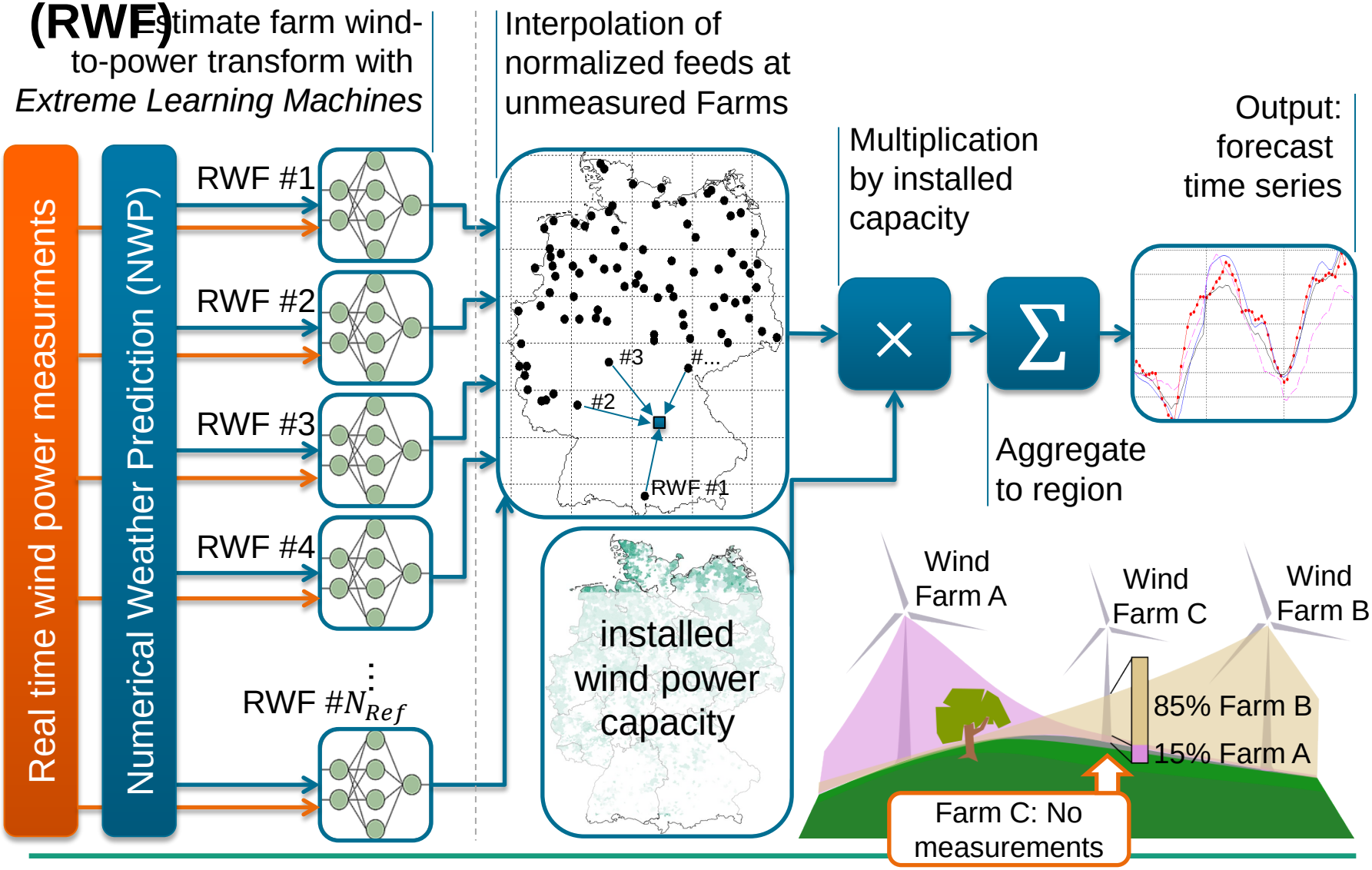
Method #1 – Approximation with Reference Wind Farms (RWE)



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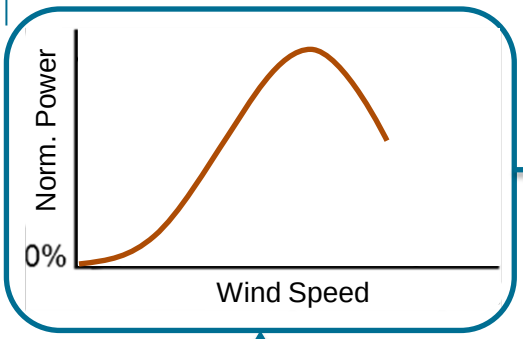
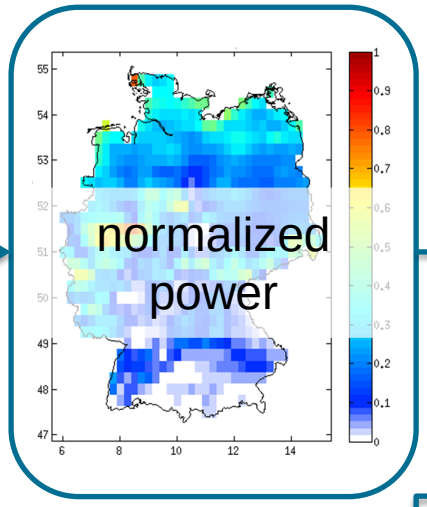
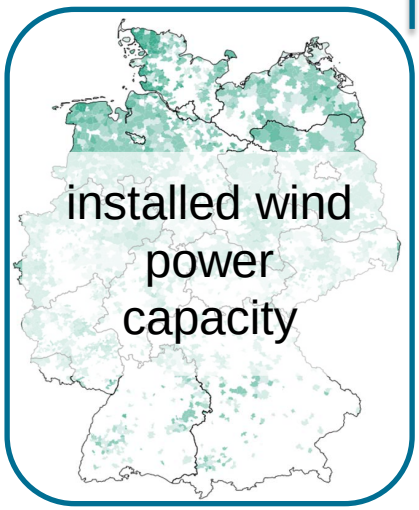
Method #2 – Generic Power Curve (PC)

Speed to power transformation with a “physical” power curve



Wind speeds from numerical weather prediction (NWP)

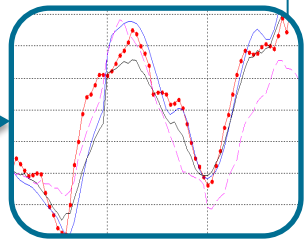




Multiplication by installed capacity

Aggregate to region

Output: forecast time series



Considers local NWP data

- **But:** Does not use any real time measurements

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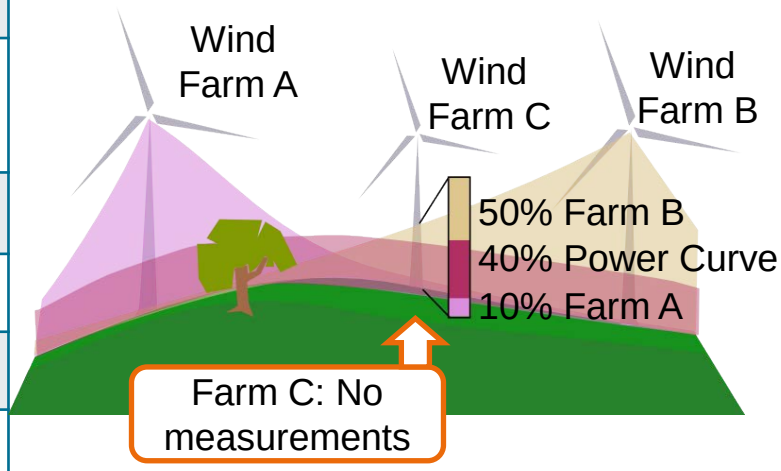
Method #3: Combination with Spatial Weights

$$p_{combined,j} = w_{PC}(\vec{x}_j) \cdot p_{PC,j} + \sum_{i=1}^{N_{RWF}} w_{RWF,i}(r_{i,j}) \cdot p_{RWF,i}$$

$$w_{PC}(\vec{x}_j) = \frac{\alpha}{\alpha + \sum_{i=1}^{N_{RWF}} \varphi_s(r_{i,j})}$$

$$w_{RWF,i}(r_{i,j}) = \frac{\varphi_s(r_{i,j})}{\alpha + \sum_{k=1}^{N_{RWF}} \varphi_s(r_{k,j})}$$

$p_{PC,j}$	Power curve (PC) forecast of unmeasured wind farm j
$p_{RWF,i}$	i-th ref. wind farm (RWF) forecast
$p_{combined,j}$	Combined power
w	Weight of the Methods
α	Influence factor of the PC
$\varphi_s(r_{i,j})$	Radial basis function where $r_{i,j} = \lVert \overrightarrow{x_i} - \overrightarrow{x_j} \rVert$



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Experiment Setup

12 previous 15min real time measurements of 58 wind farms, 96 x per day

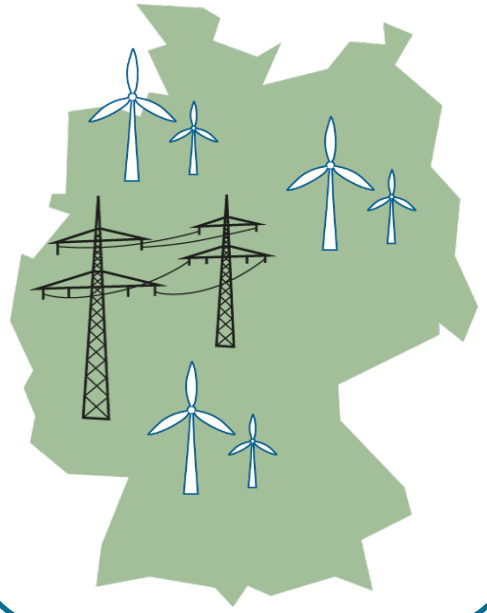
Last IFS (ECMWF) weather forecast 3h resolution, 6.25h delay, 2 x per day

Approximation with reference farms (Method #1)

Generic Power Curve (Method #2)

Combination with spatial weights

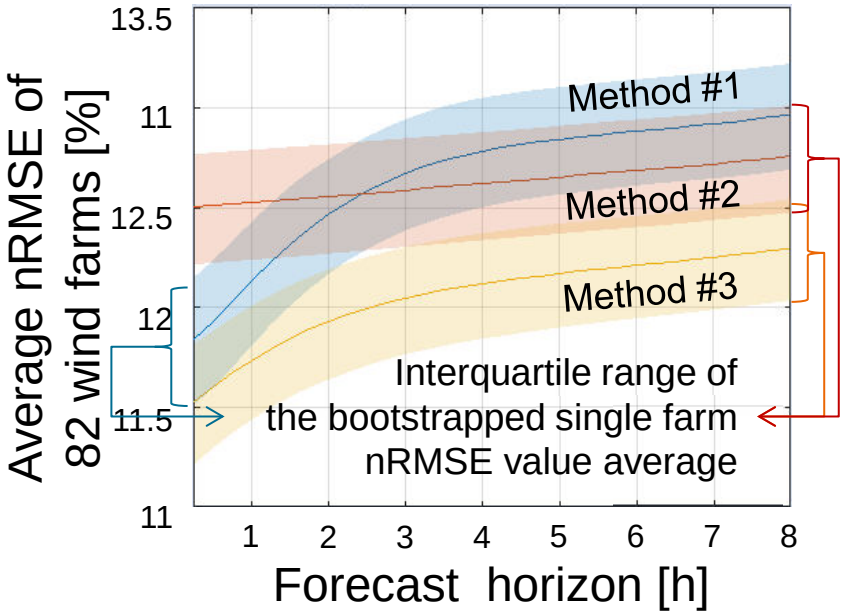
Comparison based on 82 reference farm measurements (Forecast Horizons: 15min, 30min, … 8h)



Partition	From	To
Training	01/01/2013	30/05/2014
Validation	30/05/2014	15/12/2014
Test	15/12/2014	30/06/2015

Results – Farm Errors

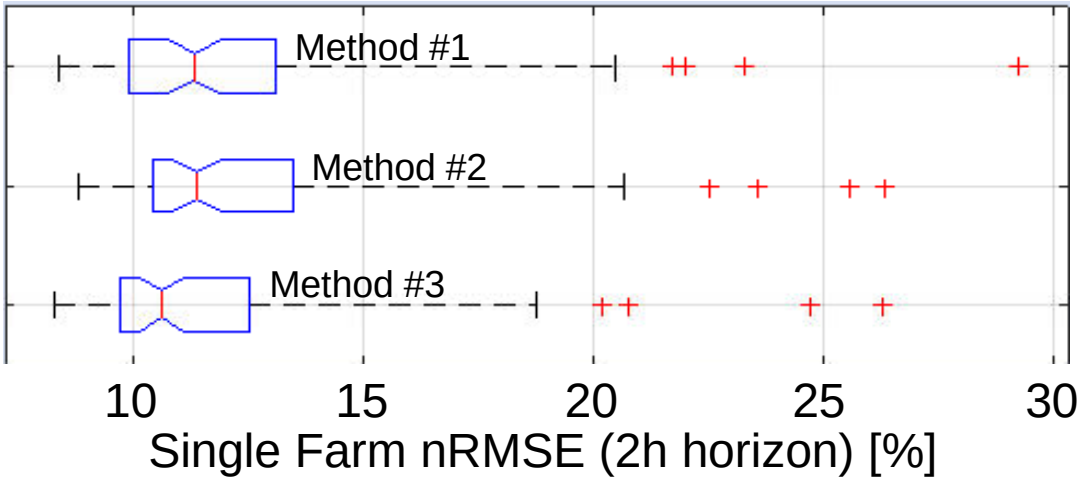
- **Real time measurements** → improve unmeasured farms in the first 3 to 4 hours
- Generic power curve does a surprisingly good job
- Best to combine real time supported reference farm forecasts with power curve, but **is it significantly** better?



Reference Farm Approximation

Generic Power Curve

Combination



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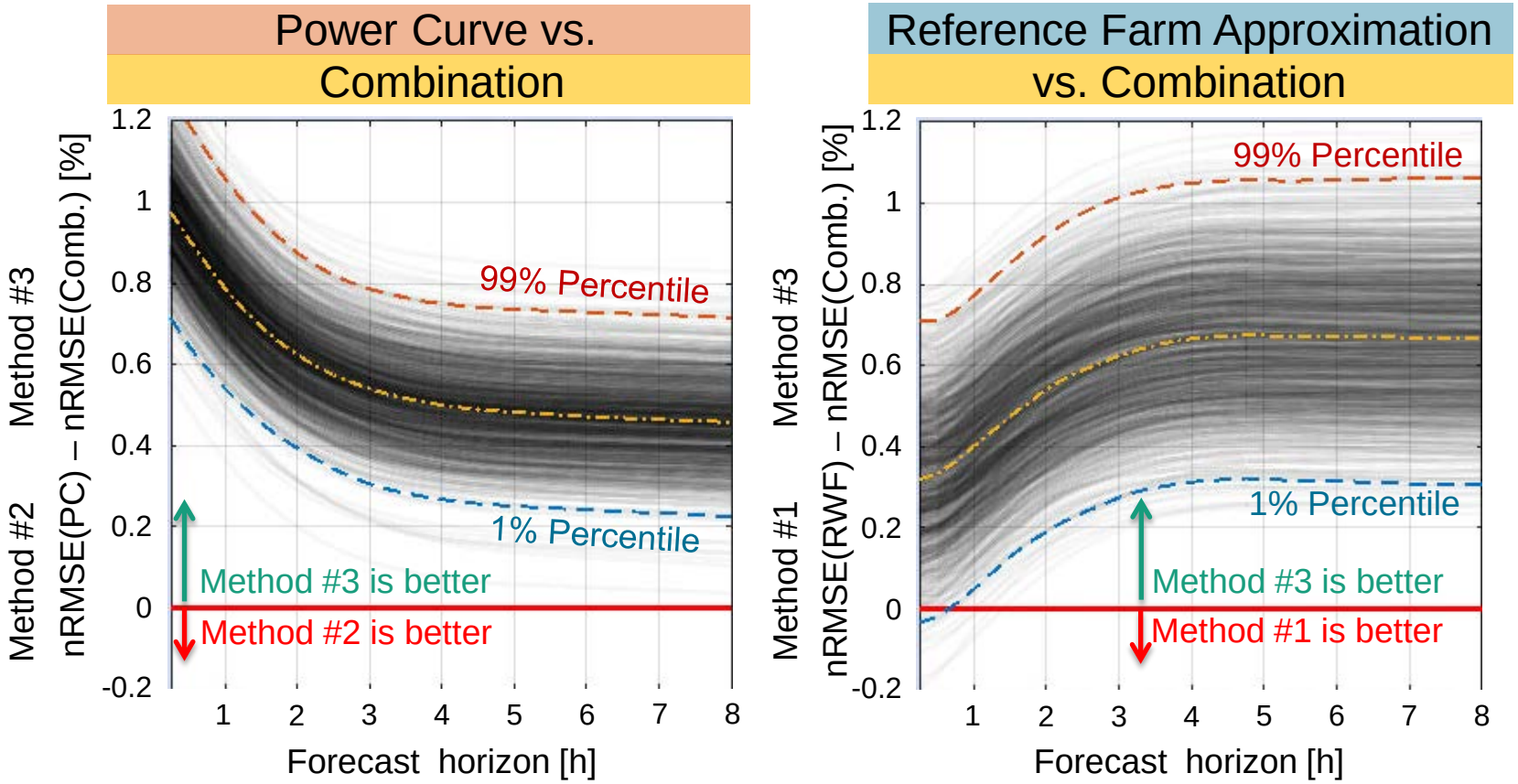
Significance of the Improvement

Improvement over all single Wind Farms with the average error of 1000 bootstrap sets with 82 single wind farm errors:



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Conclusion

- 3 Methods forecast the production of unmeasured wind :
  - Reference farm method: Extrapolation of single farm forecasts to region
  - Generic Power Curve
  - Combination
- Methods compared: 2.5 years of NWP and 15min power measurements
- Generic power curve ≈ reference farms
- Combination (method #3) results in significant improvement

Acknowledgements

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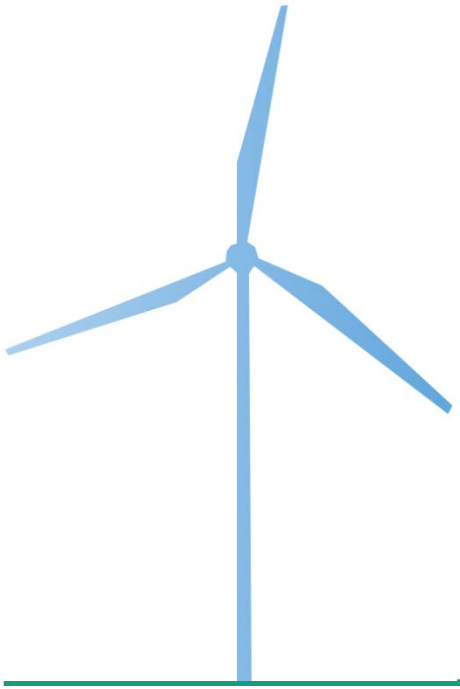

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