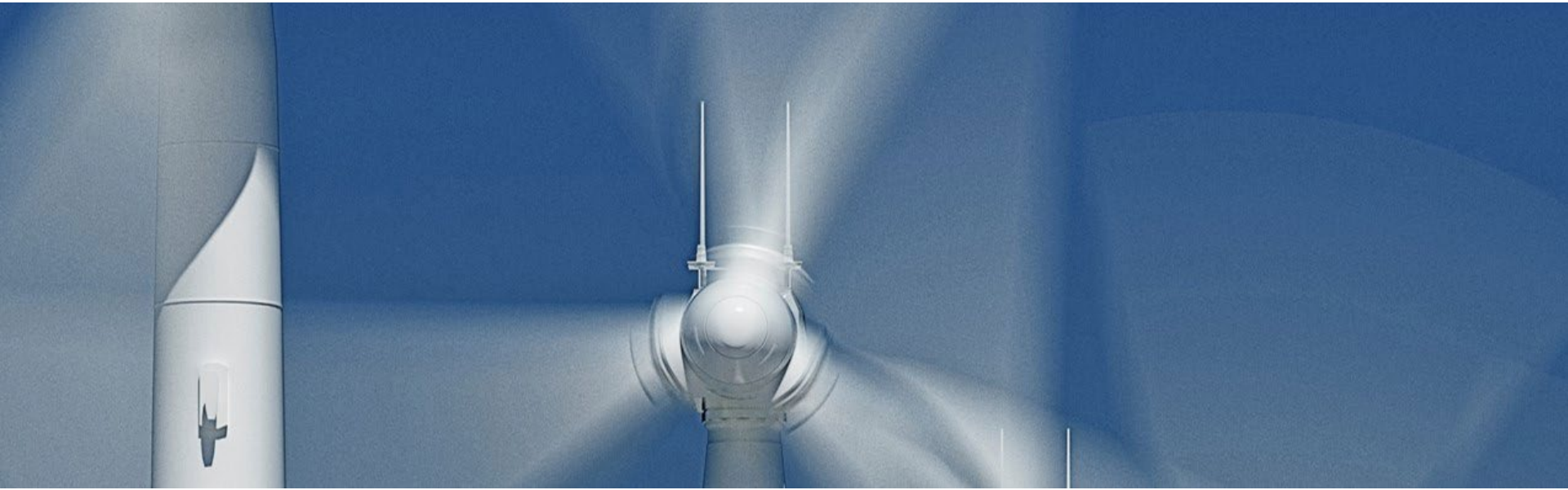


REsurety

Industry Needs for Wind Flow and Wake Modeling

Jennifer F. Newman

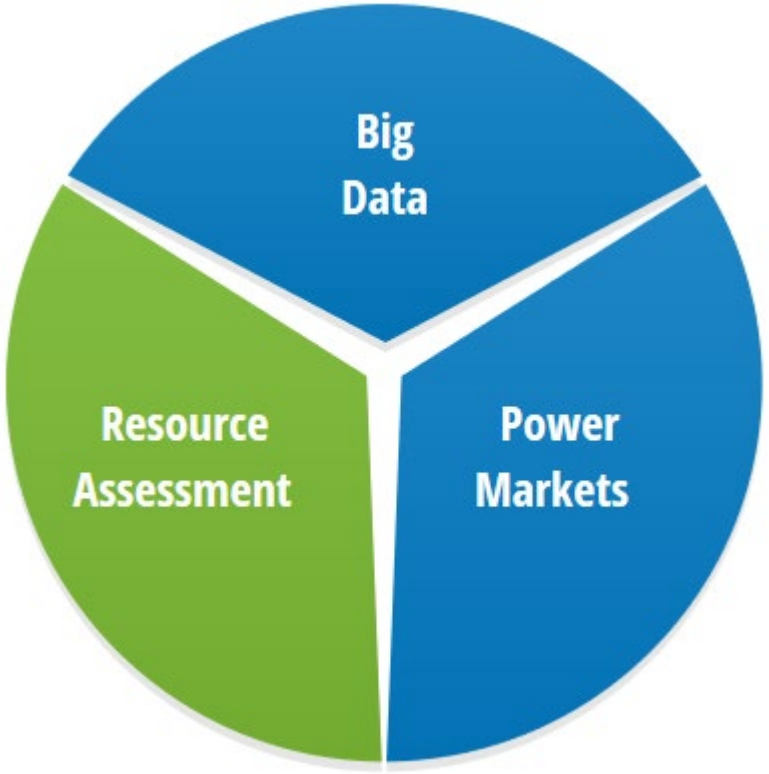
October 20, 2020

What Does REsurety Do?

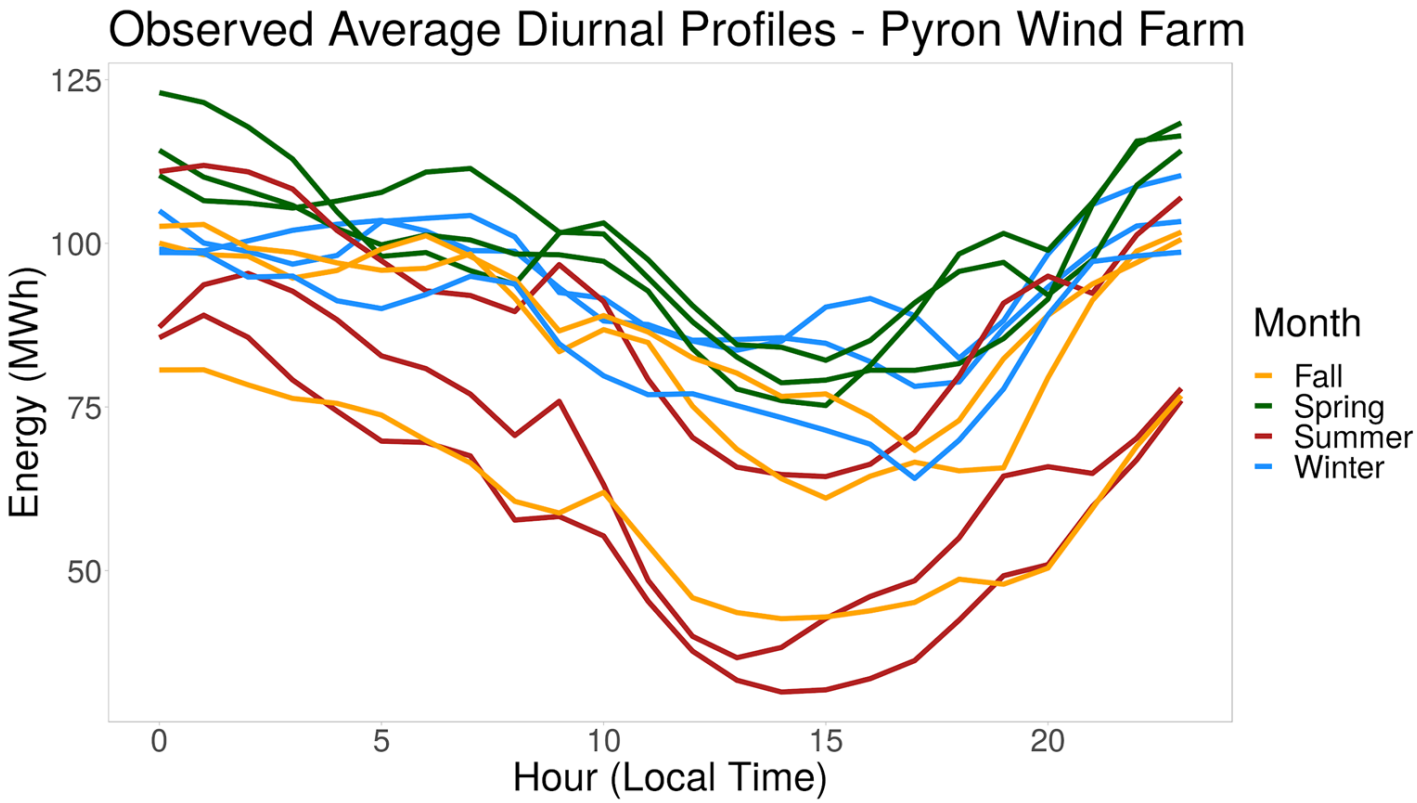
- REsurety structures and settles risk management contracts for buyers and sellers of renewable energy.

- To date, we've structured over 6 GW of transactions across the U.S. and Australia.

- We model hourly plant generation and hourly power prices, as well as the covariance between the two.

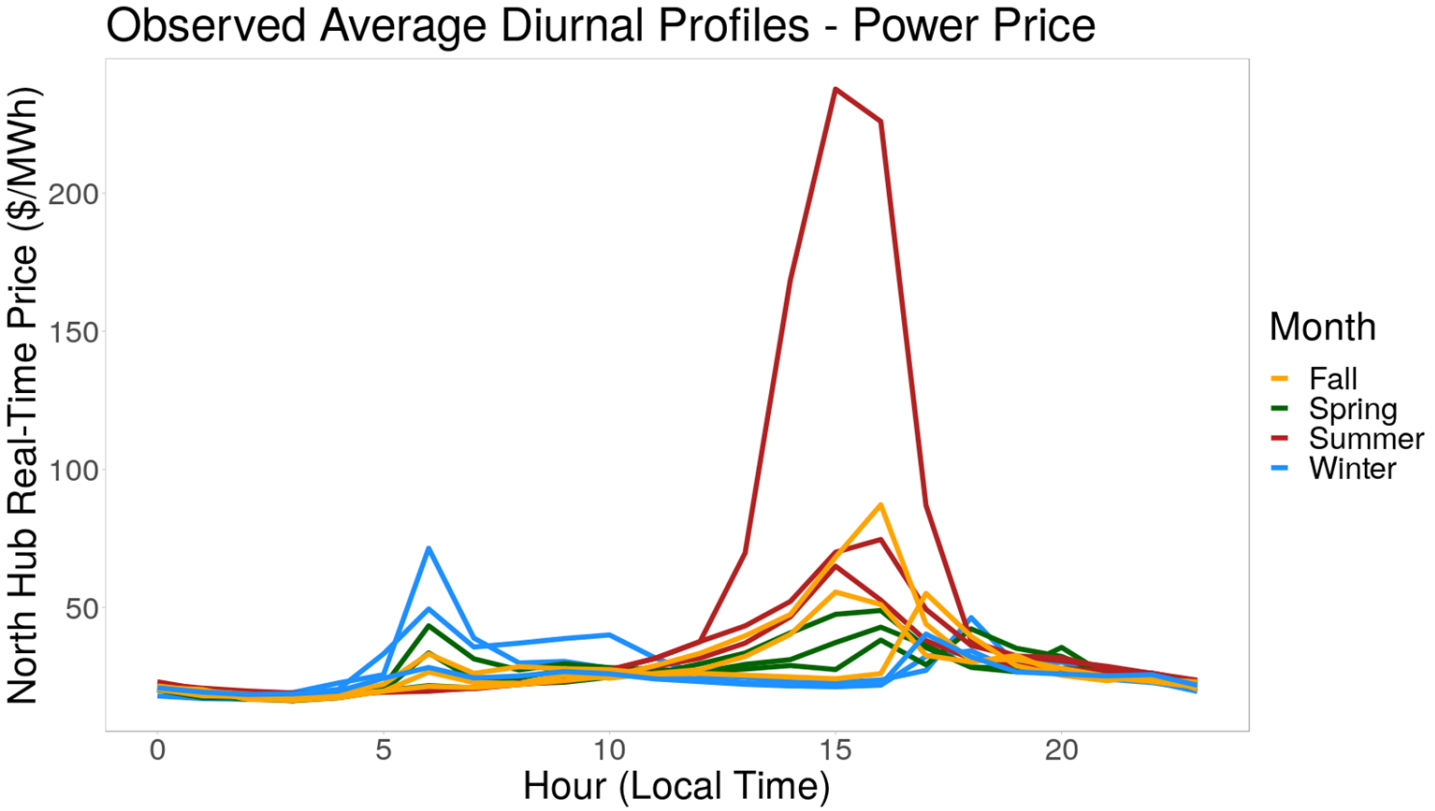


How Does Generation Vary Seasonally and Diurnally?



Data source: ERCOT

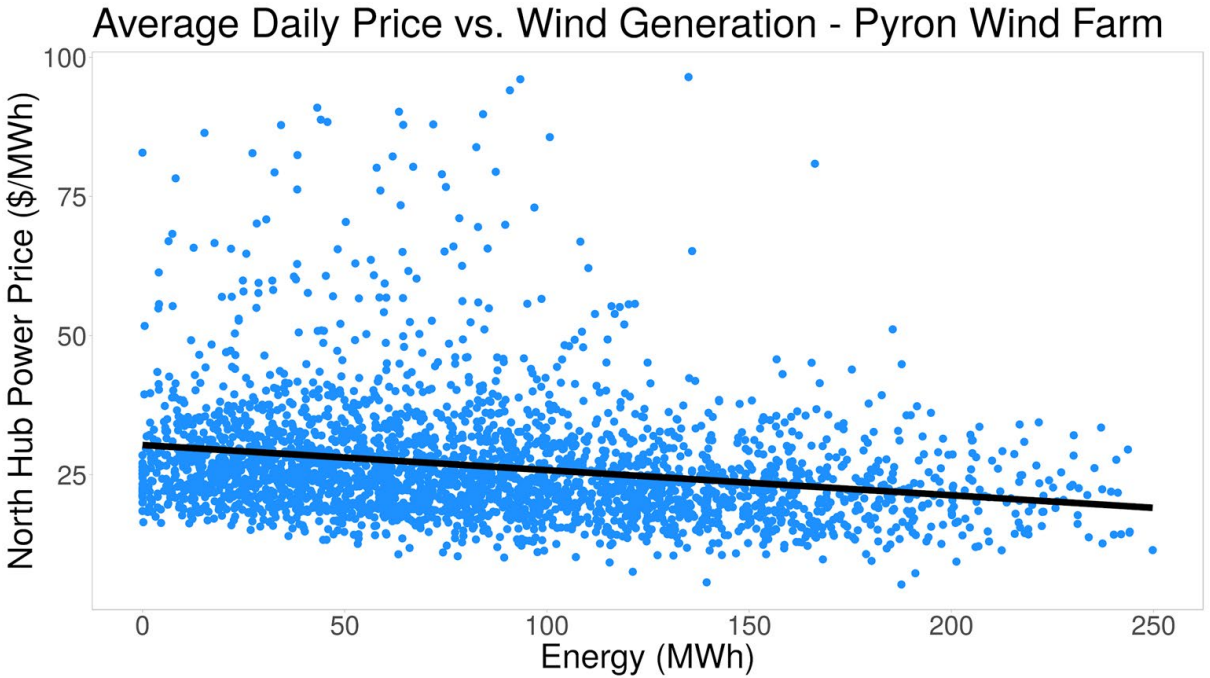
How Do Power Prices Vary Seasonally and Diurnally?



Data source: ERCOT

How Does Generation Impact Power Price?

There tends to be a negative correlation between renewable generation and the price of power due to the position of renewables as an inexpensive energy source.

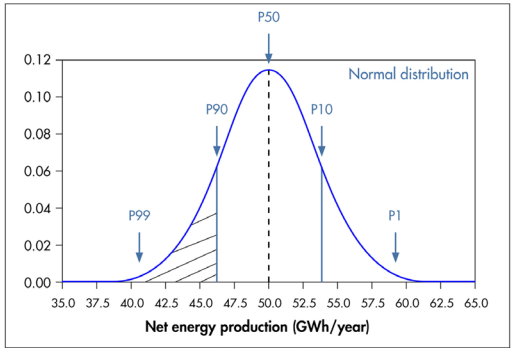


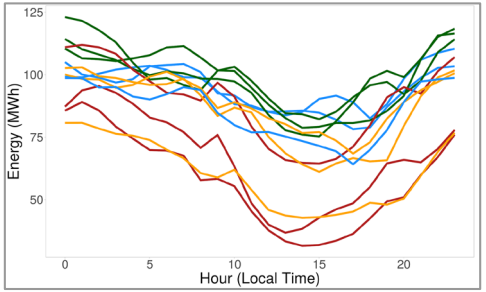
Data source: ERCOT

Wind Flow/Wake Modeling in Wind Resource Assessment

What We Have : Short-Term Meteorological Time Series

What We Need: Long-Term P50 *in addition to* expectations of seasonal and diurnal generation

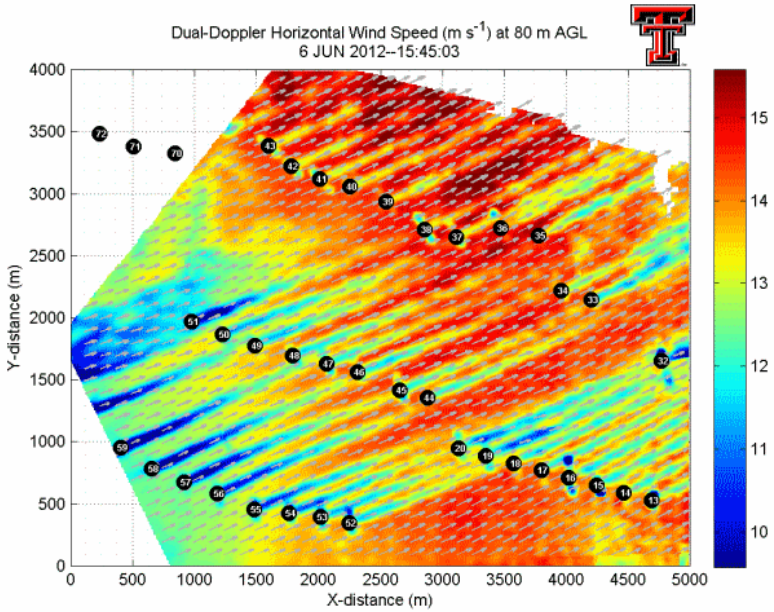




Source: UL

Wind Flow/Wake Modeling in Wind Resource Assessment

Two key components in wind resource assessment are **wind flow modeling** (modeling the spatial variation in wind speeds at different turbine locations) and **wake modeling** (traditionally, modeling the impact of turbines on downstream flow; recently, definition has expanded to include impacts of turbines on the upstream flow).



Key Wind Flow/Wake Modeling Challenges

- Simple linear wind flow models still outperform higher -fidelity models at some locations

- Wind farm blockage is difficult to quantify and model (with little consensus on the magnitude of impact)

- Incorporating the effects of stability into wind flow/wake modeling is difficult without going to a full time series approach

WAsP vs. Higher-Fidelity Models

Why do CFD models sometimes have higher RMSE than a simple linear wind flow model?

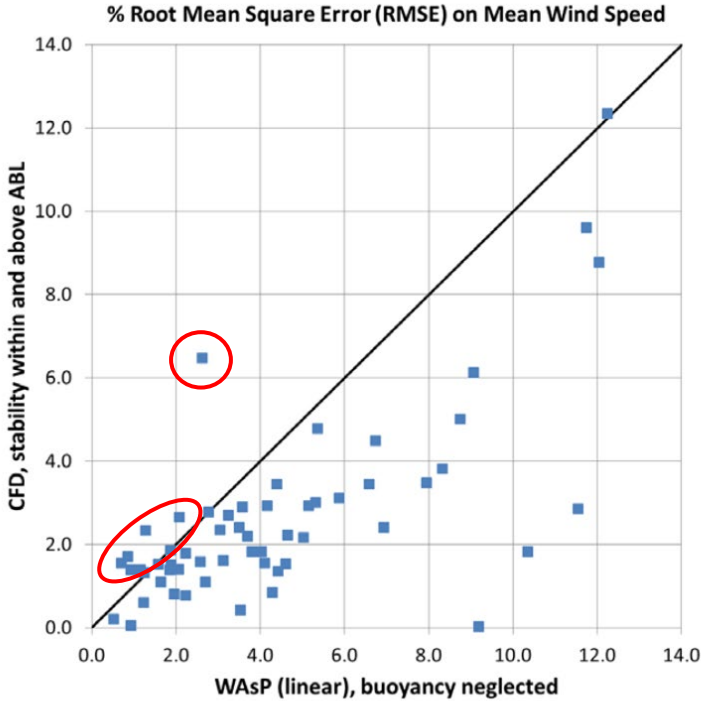


Figure 8 – %RMS error on MWS predictions at each of 57 wind sites, CFD vs. WAsP.

From Bleeg et al. (2015).

Reference: Bleeg, J., Digraskar, D., Horn, U. and Corbett, J.F., 2015. Modelling stability at microscale, both within and above the atmospheric boundary layer, substantially improves wind speed predictions. In *Proceedings of the EWEA Conference, Paris, France*.

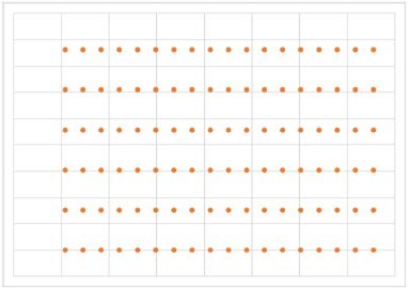
Estimating Blockage Losses

In an exercise during the 2019 AWEA WRA Conference, 4 IEs were given the same wind farm configuration and came up with very different views on blockage losses

Layout 1: 50 MW; 3 RD

Layout 2: 150 MW; 4 x 8 RD

Layout 3: 300 MW; 6 x 12 RD

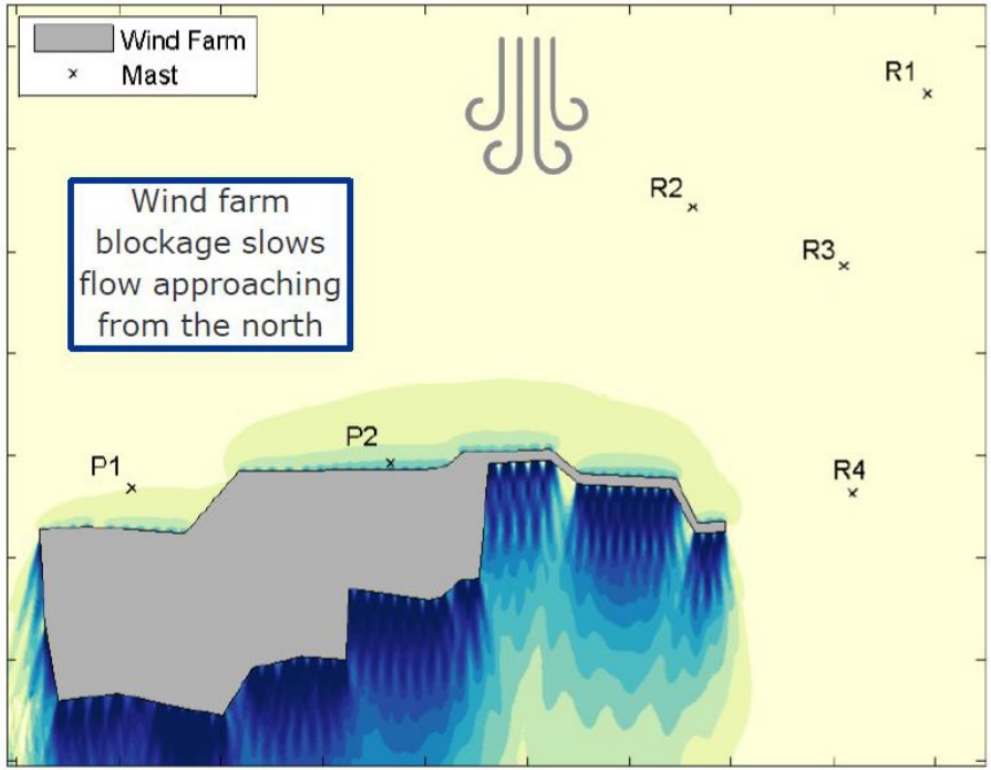


Expert		Blockage loss [% energy]	Blockage loss [% energy]	Blockage loss [% energy]
ArcVera	(Eron)	-	-	-
DNV GL	(Jessica)	0.94	1.76	0.37
Natural Power	(Taurin)	0.21	0.53	0.47
UL	(Nick)	0.0	2.0	2.4

Quantifying Wind Farm Blockage

Quantifying blockage losses from observed data is difficult, as most pre-construction met towers are decommissioned prior to the start of operations for the wind farm.

Thus, most of our estimates of blockage impacts come from CFD models (figure at right) or wind tunnel experiments.



James Bleeg, "Accounting for Blockage Effects In Energy Production Assessments, " 12 Sep 2019, WRA 2018

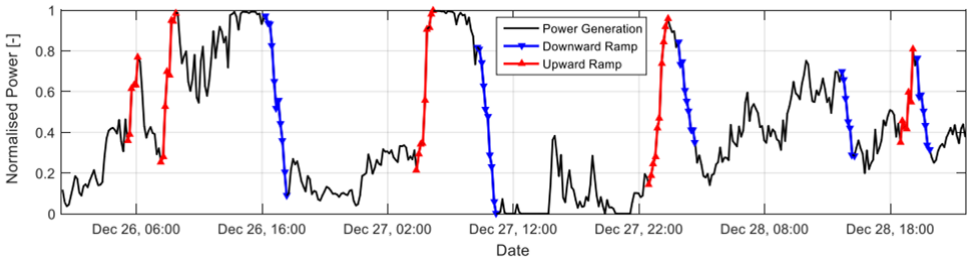
Power Matrix vs. Time Series Approach

Power Matrix Approach

	0°	30°	60°	90°	...
2 m/s	0.05 kW	0.07 kW			
2.5 m/s	0.1 kW	0.12 kW			
3 m/s	0.3 kW	0.4 kW			
...					

- Create a look-up table of plant generation by wind speed and direction bin (represents average atmospheric conditions)
- Cross look-up table with hourly wind speed/direction data from trained re-analysis dataset

Time Series Approach



From Würth et al. (2019)

- Use WRF to simulate a long-term time series of wind speed, wind direction, and stability at the site
- Pass WRF time series through a stability-dependent wake model

Reference: Würth, Ines, L. Valldecabres, E. Simon, C. Moehrlen, and B. Uzunoglu, 2019. Minute-Scale Forecasting of Wind Power - Results from the Collaborative Workshop of IEA Wind Task 32 and 36. *Energies*.

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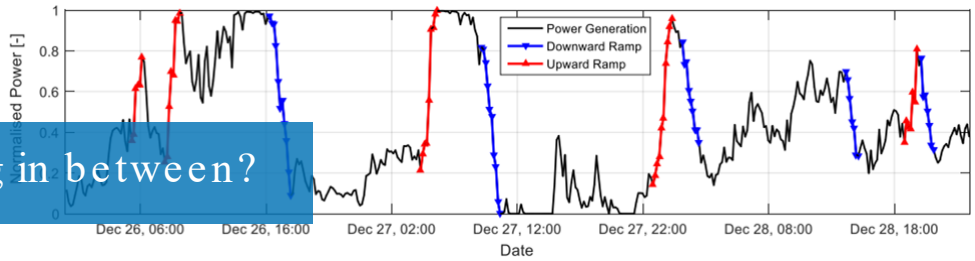
...					

Is there something in between?

Time Series Approach



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Key Questions

- Are there specific regions/types of terrain where NWP/CFD approaches struggle?
- Is there a way to accurately estimate blockage effects without taking a full CFD approach?
- Is a full time series approach necessary for accurately modeling diurnal variation in plant production?

Thank You!

Contact: jnewman@resurety.com