Holistic Classification of Wind Turbine Performance

The Problem

Problem Statement: *Design a system that compiles subsystem performance metrics into an overall turbine health score to allow for a holistic understanding of performance at the turbine- and site-level and to detect long-term issues.*

- Wind energy is a key tool in decarbonizing the energy sector and combating climate change, and installed wind capacity continues to grow in the US and around the world.
- Current wind energy capacity in the US is 118 GW, which is an increase of 14.2 GW from the previous year. Global wind energy capacity is 744 GW.
- With a rapidly growing capacity, there is a continued need to quantify and understand holistic, long-term wind turbine performance and health.

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The Procedure

1. Identify Data Signals and Priority Level

Subsystem	Data Signal	Priority
Power Grid	Active Power	Highest
	Reactive Power	Medium-Low
	Current	Medium
	Voltage	Medium
Pitch Control	Blade Pitch Angle	Medium-High
	Tip:Speed Ratio	High
Digital Signals	Digital State	High

2. Conduct Analyses

- Filter out known offline periods
- Calculate:
  - Ratio of measured active power to rated power
  - Distribution of reactive power
  - Standard deviation in blade pitch angles
  - Time spent in each digital state
  - Tip:speed ratio
- Plot as a function of time and as a function of wind speed

3. Synthesize Findings into Health Score

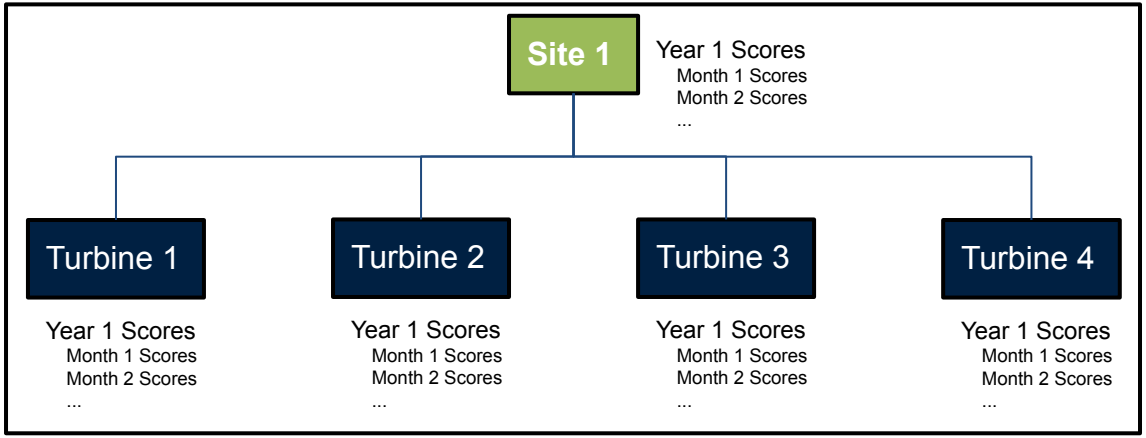
- Compare plots of tip:speed ratio, duration of offline periods, deviation in blade pitch angles, and active power ratio to discern trends
- Brainstorm which calculated values could be used represent others
- Determine how much understanding would be lost in synthesizing scores

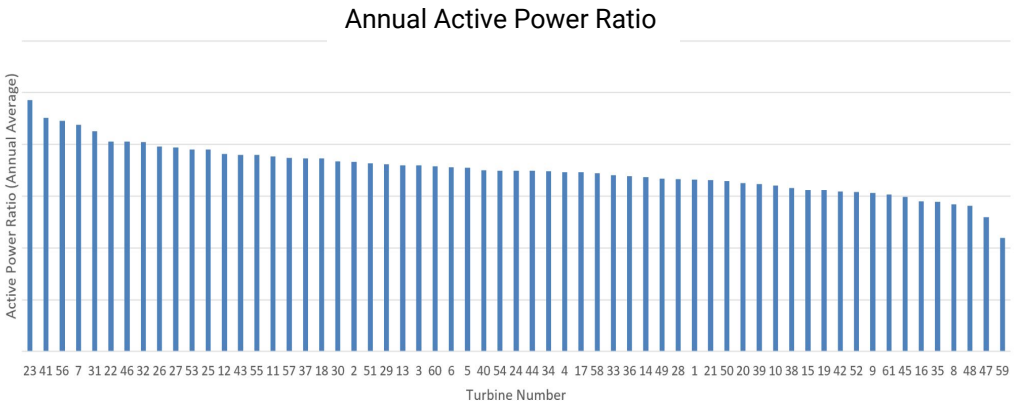
Existing Solutions:	*Deviation from Power Curve*	*Turbine Reliability*	*Mean Time-to-Failure & Time-to-Repair*	*Gearbox & Drivetrain Health*

The Solution

A turbine health dashboard that shows:

1. *The fraction of the year that the turbine is available to generate power, but does not generate power*
2. *The ratio of the measured active power to the rated active power*
3. *The standard deviation in blade pitch angle*





Next Steps:

- Modify the "Fraction of the year available but not generating" metric to the total amount of energy that could have been generated
- Expand analysis to include different sites and multiple years

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