METRICS TO OPTIMIZE BY
UNDERSTANDING WHAT’S NORMAL, WHAT’S RECOVERABLE
Plant Optimization Metrics

... How do you see your wind farm?

 Metrics for Identifying what’s Normal, what’s Recoverable

✓ **Windiness:** Applying a metric to translate average speed to energy
✓ **Downtime:** Translating how energetic the site was during downtime to an energy loss metric
✓ **Availability:** Effective metric to measure bottom line revenue, differences versus time weighted
✓ **Performance:** Taking SCADA data further, single-variate, multi-variate analysis
Windiness – Energy to Speed Ratio (EVR)

- **Power Curve Sensitivity**
  - Increases with % time in linear region

- **Site Speed Distribution**
  - Sample set of projects
  - Sensitivity in power output

**EVR:** A measure of a site's sensitivity to variations in wind speeds
Windiness – Energy to Speed Ratio (EVR)

High Wind Speed Regions have a lower EVR on average. Improper use of site specific EVR could cause significant bias in monthly energy budgets – potentially driving further analysis for energy that is not recoverable.

* Average EVR’s of sample set of sites in region shown
Lost Energy – Energy to Downtime ratio (EDT)

EDT: A measure of a site's power generation sensitivity to downtime
- Recoverable Losses: Prioritize with high EDT events
Lost Energy – Energy to Downtime ratio (EDT)

Look at events by EDT to prioritize which events are costing the most per time.

Investigate which turbines had the highest EDT and then further investigate which recoverable faults can help with this.

Understanding EDT can quickly translate into recoverable energy/revenue.
Availability – Time and Energy weighted

✓ Turbine Contractual Availability
   - Useful metric of performance against contractual requirements
   - Confusing and inadequate metric for performance against budgets

✓ Energy Weighted Availability
   - Useful Metric for capturing the energy lost for a given event
   - Useful metric of Performance against budgets, against other OEM’s

Contractual Availability – useful for contractual obligations, Independent check
Energy Weighted Availability – performance against budgets, other OEM’s
Availability – Time and Energy weighted

97% time weighted → 93.6% energy weighted ...
Performance Metrics – Leverage SCADA Further

Inlet conditions
(1) Inclement weather
(2) Excessive temperatures
(3) Altitude
(4) Turbulence
(5) Shear
(6) Veer
(7) Flow distortion

Farm Dynamics
(1) Off-Yaw operation
(2) Blade change (aero, mass)
(3) Component degradation
(4) Control System settings
(5) Permissive failures

Define single parameter metric or combine for multi-variate analysis
Performance Metric – Examples

✓ Single variate: Degradation over time of wind speed metric

✓ Multi variate: System state combining multiple parameters (state change %)

Failed Anemometer

Incorrect Pitch Setting

Yaw-Misalignment
Understand What’s Normal

- Establish a site specific energy to speed ratio
- Leverage SCADA to define Energy lost for given event
- Manage Availability with an Energy metric, not time
- Apply Performance Metrics (single &/or multi variate) to Identify and recover sub-optimal performance

... and then you can understand and address what’s recoverable