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WIND TURBINE RELIABILITY BENCHMARK

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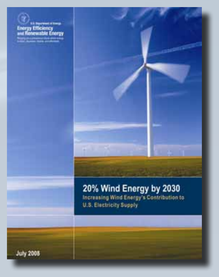
INTRODUCTION

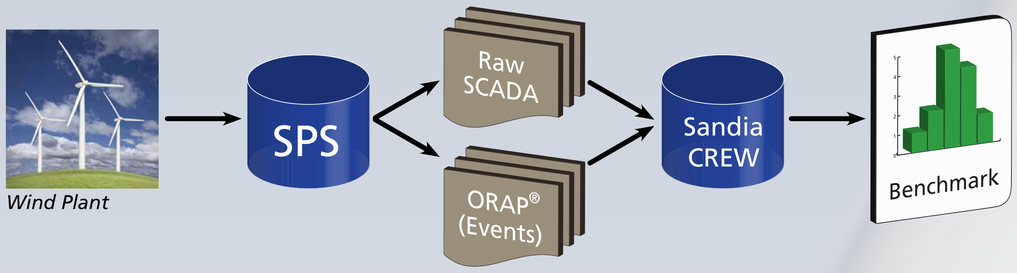
The *20% Wind Energy by 2030* report (Department of Energy, 2008) specifically discusses financial risks from increasing Operations and Management (O&M) costs and the impact of lower-than-expected reliability. With Department of Energy sponsorship, Sandia National Laboratories established the CREW (Continuous Reliability Enhancement for Wind) database, to benchmark the U.S. wind turbine fleet's reliability, operations, and maintenance experience. CREW's Wind Turbine Reliability Benchmark report analyzes U.S. fleet performance based on aggregated reliability data for a cross-section of U.S. wind plants.



METHODS

Data Collection

Sandia partnered with Strategic Power Systems (SPS), whose ORAP® for Wind (Operational Reliability Analysis Program) software collects real-time data from wind plant partners, including information from their Supervisory Control and Data Acquisition (SCADA) systems.



Data Aggregation Steps

1. Gather sufficient data (duration, breadth) to aggregate without violating anonymity.
2. Create individual plant models, by summarizing ORAP® for Wind events into event frequency & duration for each component + event type. Also, perform time accounting, based on summing hours across turbines.
3. Create aggregate event frequencies and durations, by weighing individual plant models by their number of turbine-days. Also, create aggregate time accounting by summing turbines hours across plants.

Data Reporting

- Goal: Provide regular public-domain reporting
  - Calculate aggregated fleet reliability data metrics
  - Provide specific failure sources and frequencies
  - Enable comparison of a plant or fleet against the benchmark
- Guiding Principles
  - Data from individual participants is proprietary. Data only used in reporting when it can be sufficiently aggregated or masked to protect individual participants.
  - Document data issues, including unknown and unspecific data. Also provide best estimates without these issues.

CONCLUSIONS

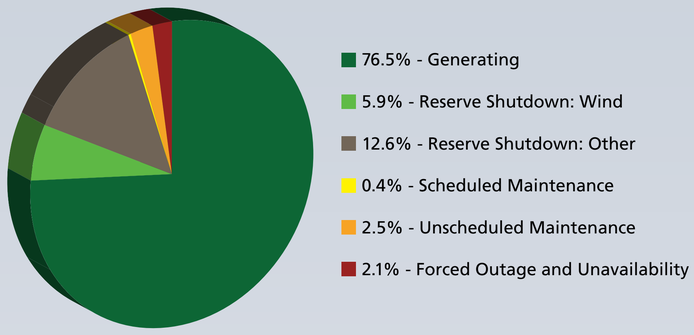
- Overall performance in line with expectations

Generating Factor (aka Utilization)	78.5%
Operational Availabiltiy	94.8%
Capacity Factor	33.4%

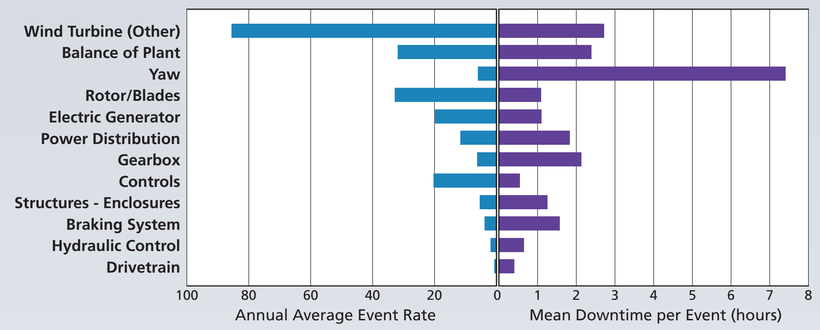
- Turbine Unavailability is dominated by "Wind Turbine (Other)" events
  - These events are whole turbine maintenance, generic or unexplained trips, etc.
  - Unspecified events dominate system and component assessments of availability
  - In addition to SCADA data, work order information is critical to fill in these gaps
- Gearbox not in top 5 systems
  - Have not collected data long enough to estimate impact of major repairs
  - Benchmarking day-to-day performance, at this point
- Although details are not provided in the public benchmark, reliability performance varies tremendously from plant to plant

RESULTS

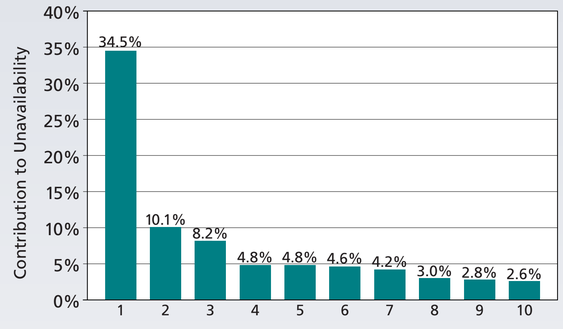
Availability Time Accounting



Downtime Event Characteristics, by System



Top Unavailability Drivers, by Component + Event Type



#	Downtime Event Type	Relative Contribution to Unavailability
1	Wind Turbine---Unscheduled maintenance	34.5%
2	Wind Turbine---Scheduled maintenance	10.1%
3	Yaw---Forced	8.2%
4	Balance Of Plant--Distributed Control System---Forced	4.8%
5	Wind Turbine---Forced	4.8%
6	Balance Of Plant--Non-Component Chargeable Event--External Circumstances--Grid Instability---Forced	4.6%
7	Rotor/Blades--Blades--Rotor Blade---Forced	4.2%
8	Balance Of Plant--Non-Component Chargeable Event--Natural Perils--Wind---Forced	3.0%
9	Balance Of Plant--Power Distribution---Forced	2.8%
10	Electric Generator--Stator---Forced	2.6%

The full benchmark can be accessed at http://energy.sandia.gov/?page_id=6682
Event and SCADA Data Source: ORAP® for Wind

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