Continuous Reliability Enhancement for Wind (CREW) Database

Wind Turbine Reliability Benchmark

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Outline

- Background: Sandia & CREW
- CREW Benchmark
  - Results
  - Data Challenges & Solutions
  - Data Value
- Closing

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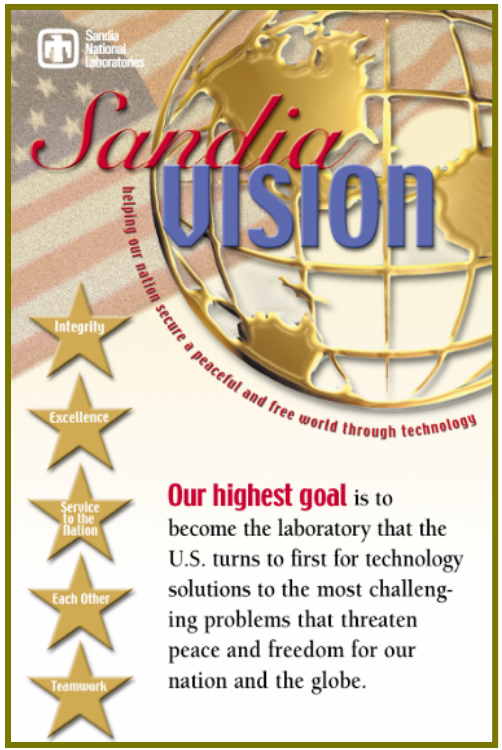


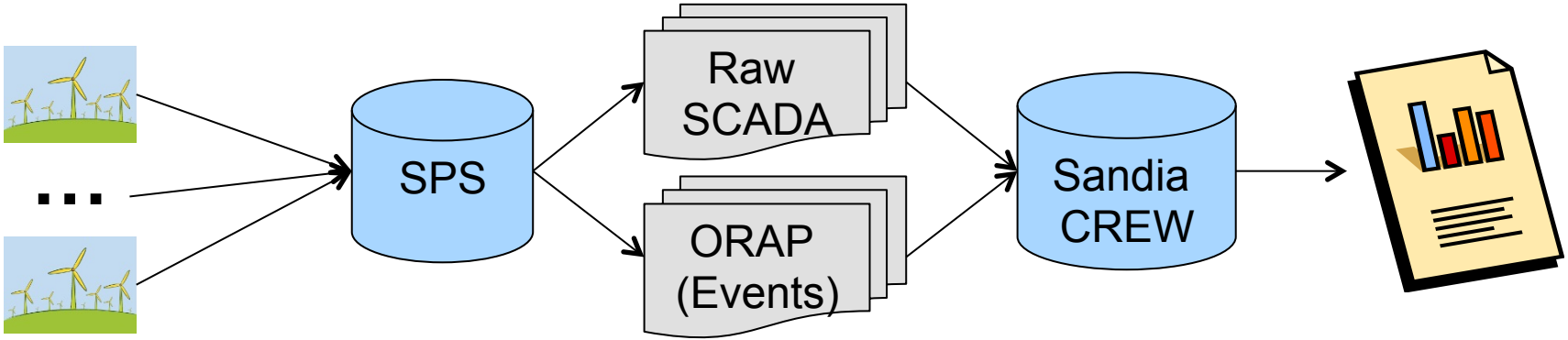
Wind Energy Technologies

Funded by Department of Energy (DOE)
Energy Efficiency & Renewable Energy (EERE)

- Wind Technology
  - Materials and Manufacturing
  - Structural, Aerodynamic, and Full System Modeling
  - Sensors and Structural Health Monitoring
  - Advanced Blade Concepts
  - Lab - Field Testing and Data Acquisition
- **System Reliability**
  - **Industry Data Collection**
  - **Improve reliability of the existing technology and future designs**
  - Blade Reliability Collaborative
- System Integration & Outreach
  - Wind/RADAR Interaction
  - Integration Assessment
  - SNL Wind Energy Test Facility

CREW Benchmark Approach

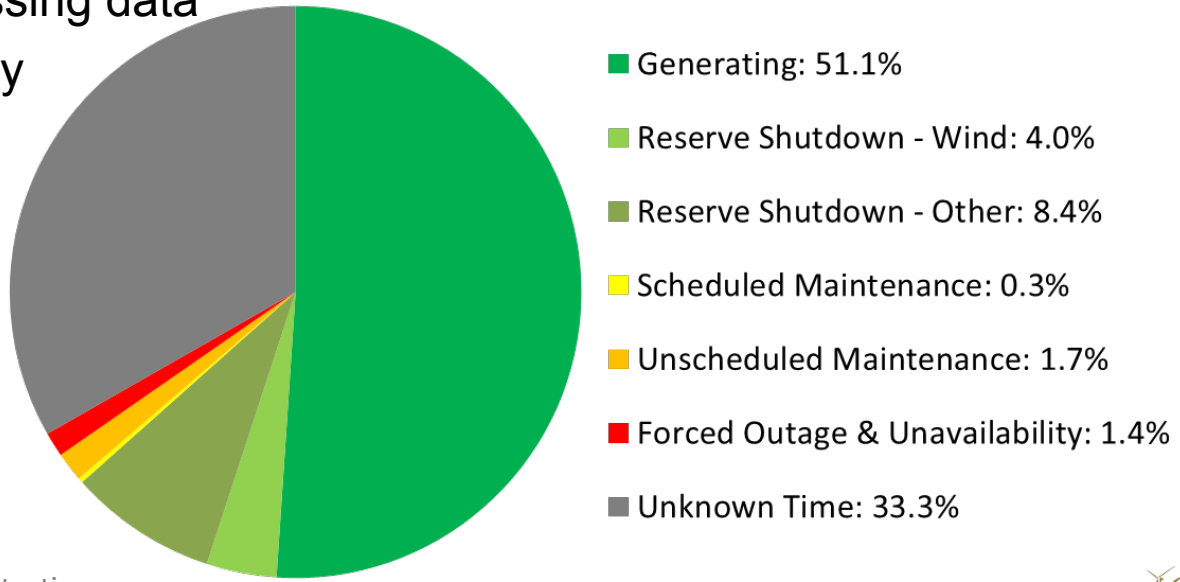
- Establish national reliability database
  - Benchmark U.S. wind turbine operations and maintenance (O&M) experience
- Provide regular public-domain reporting
  - Aggregate fleet reliability data metrics; enable comparison of a plant against the benchmark
  - Provide specific failure sources and frequencies
- Data from individual participants is proprietary



SPS: Strategic Power Systems; ORAP: Operational Reliability Analysis Program; SCADA: Supervisory Control & Data Acquisition

Availability Time Accounting

- SCADA and data transfer challenges lead to “Unknown Time”
  - Availability analysis needs to highlight the common communication and IT issues resulting in missing data*
  - CREW team is actively identifying these industry-wide issues & addressing them where possible



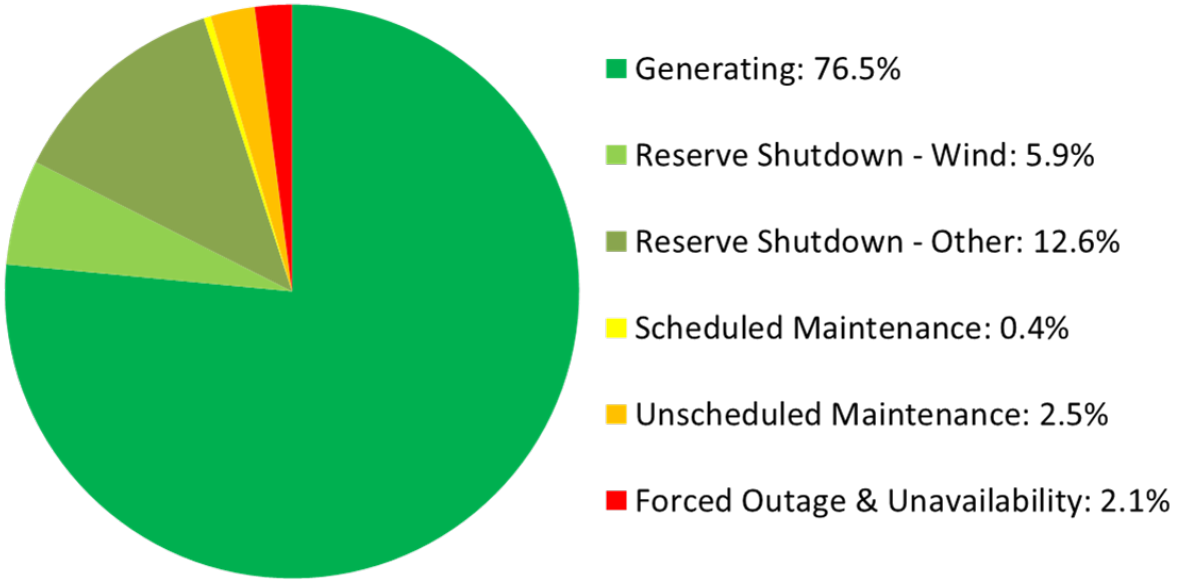
*Substantial portion of Unknown Time is attributable to pilot program & associated beta testing

Event & SCADA Data Source: ORAP ® for Wind

Availability Time Accounting

- Pie Chart approach allows comparisons with many different definitions of “Availability”

Utilization (aka Generating Factor)	76.5%
Operational Availability	95.0%

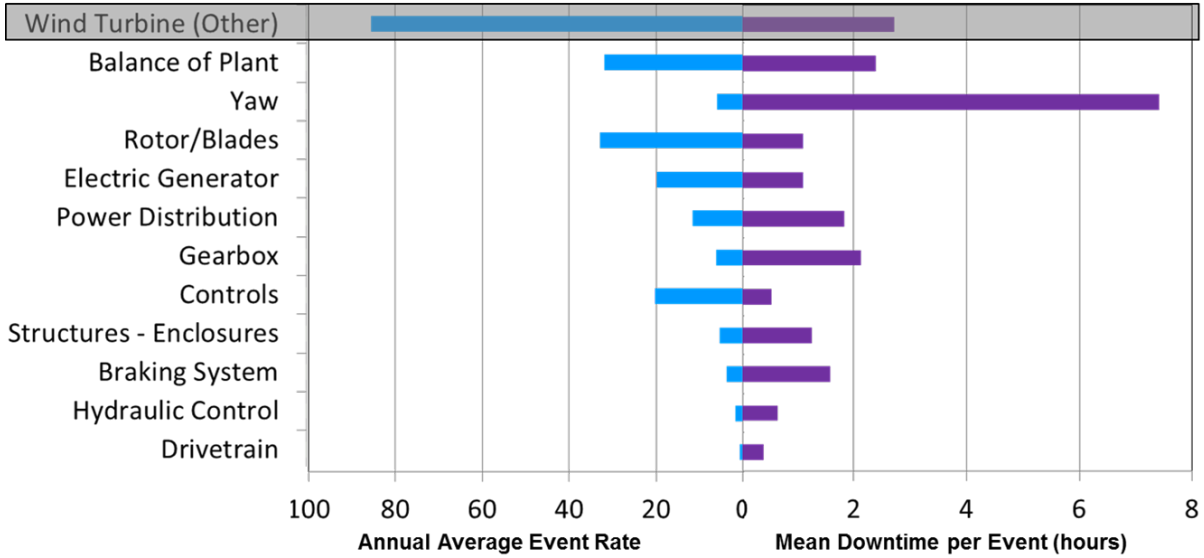


Event & SCADA Data Source: ORAP ® for Wind

ORAPWind SPS

Event Frequency vs. Downtime

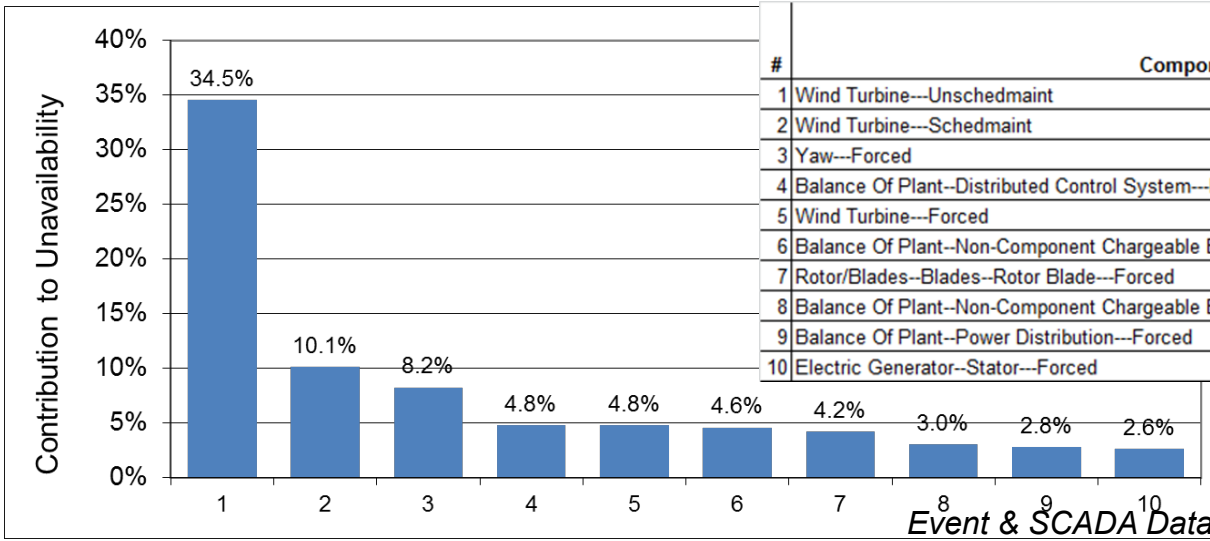
- Balance of Plant, Rotor/Blades have most frequent events
  - Aside from “Wind Turbine (Other)”
- Lengthy, but infrequent, Yaw events have largest mean downtime



Event & SCADA Data Source: ORAP ® for Wind

Top Unavailability Contributors
Component + Event Type

- Dominated by general events
  - Wind Turbine (Other): 3 of top 5; just under 50% of unavailability
  - Work Orders are critical for filling in these blanks about true root cause



#	Component + Event Type	Relative Contribution to Unavailability
1	Wind Turbine---Unschedmaint	34.5%
2	Wind Turbine---Schedmaint	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%

Event & SCADA Data Source: ORAP ® for Wind

ORAP Wind SPS

Data Challenges & Solutions

- **Capturing adequate detail**
  - Solution: Electronic WORK ORDERS! Capitalize on technician knowledge
    - Computerized Maintenance Management System (CMMS)
  - Solution: Encourage turbine and SCADA manufacturers to continue expanding detail in SCADA system and associated fault codes

Image Source: http://resortdata.com

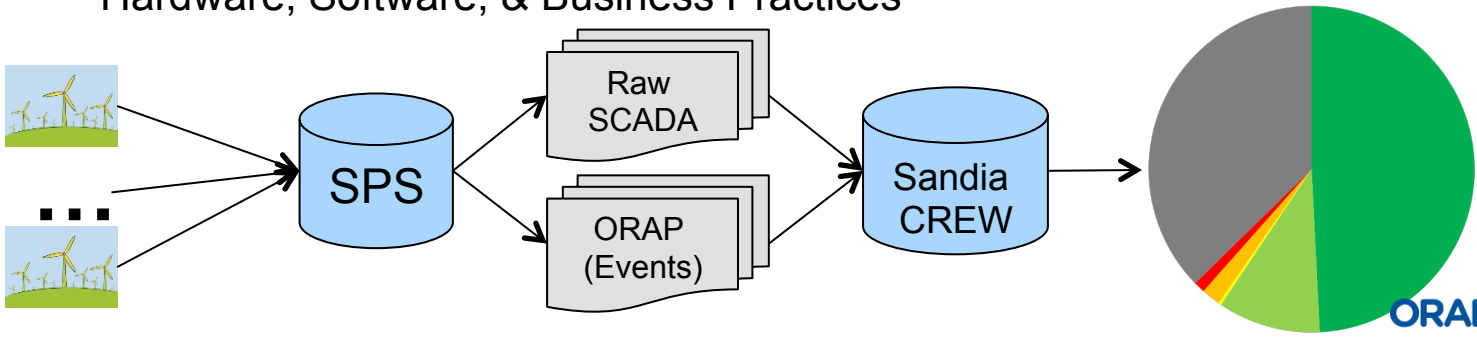
Data Challenges & Solutions

- **Data Volume**
  - Solution: Invest in architecture (a little) ahead of time
    - Hardware, software, DESIGN
    - Analysis plan
      - Goals, data needs, analysis/reporting approach
  - Solution: Work at multiple levels of detail
    - Raw data (as fast as possible)
    - Summaries (1 minute, 10 minute, daily)
    - Events (detail on downtimes)

Image Source:
http://courses.essex.ac.uk/ce/ce802/

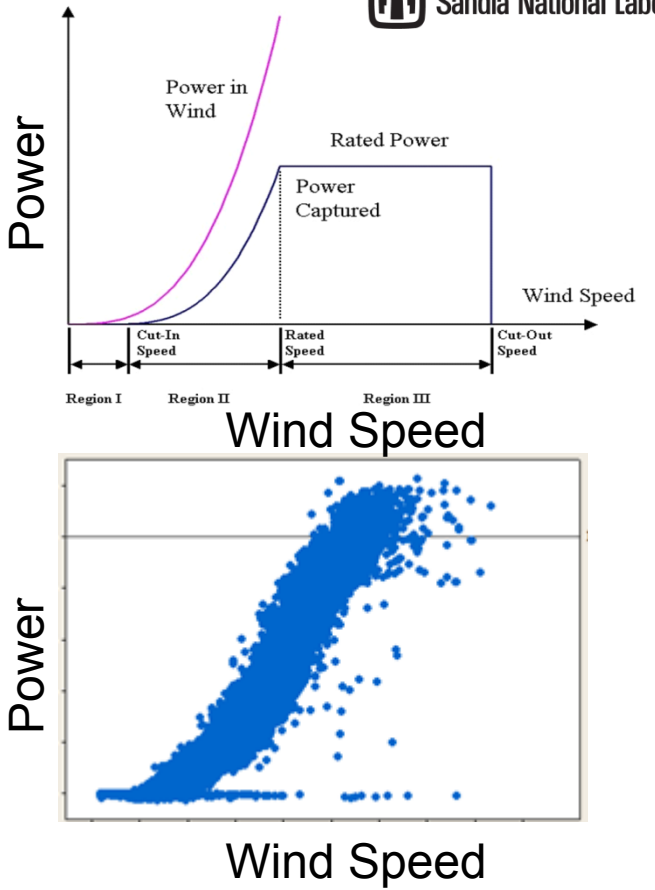
Data Challenges & Solutions

- **Fully accounting for all time**
  - When sharing data across various enterprises, there can be a lot of links & opportunities to miss data
  - Solution: Admit some data will be missing, incomplete, or illogical
    - Address how to handle this in analysis plan
  - Solution: Develop more robust data transfer pathways
    - Hardware, Software, & Business Practices



CREW Data Value

- High Resolution SCADA Data ("Raw" data)
  - Gathered every 2-6 seconds
  - Value: Identify unexpected patterns; quantify how common they are
- Summarized SCADA Data
  - Statistical summaries of SCADA data
  - Value: Easier to employ for quick analysis
- Events
  - Quick summaries of non-operating time
  - Value: Identify common downtime drivers & summarize overall turbine performance



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Benchmark Report

- Full benchmark: energy.sandia.gov/?page_id=6682
  - Archive of Wind Turbine Reliability publications energy.sandia.gov/?page_id=3057#WPR
- Fall 2012 benchmark: increased depth & breadth
  - Longer time periods, more plants, more variety
  - Larger section of fleet
    - More and varied operating data will help accurately represent U.S. fleet
    - All U.S. wind plant owners, operators, and OEMs are invited to participate
    - Please contact:

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