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Taking Advantage of Your Data to Increase Reliability

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CREW: Continuous Reliability Enhancement for Wind database

Program Focus:

- Create national reliability database of wind plant operating data
  - Sub-component level
  - Characterize performance of US wind fleet
  - Identification of issues and technology improvement opportunities
  - Improved quality of next-generation components
  - Industry RAM benchmarks

Industry Maturity Level

2010: 35GW

2030: 305GW

- *Still many **small** operators with little data expertise, running basic operations*

<u>Increasing Reliability</u>:

Fewer Failures = Increased Capital Utilization +
Decreased O&M Costs +
Increased Investor Confidence + …

- ***Larger** players with previous fossil experience growing*
- *Emerging supply chain: wide variance in **quality** and **availability***
- *Market instability > players come and go*

2010 → **2030**

Current operators care about capital utilization more than "new technology" –
Strong need to reduce O&M costs;
Protection of proprietary data

DOE goal: Pull-in earlier

Future operators will have stabilized operations and begin to focus on "new technology" –
Jump to the next level of performance;
More collaboration across industry

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CREW Database Program: Partner Maturity

LESS Mature Data & Analysis ----- *MORE Mature Data & Analysis*

Conversations with operators	Early Partners	ORAP Pilot Partners	ORAP Users & CREW Partners

2007 | 2008 | 2009 | 2010 | 2011 | 2012+

Maintenance Data Scheduled & Unscheduled	•No documentation (tribal knowledge) •“I’ve got my work orders up here” <taps head>	•Paper work orders •Scanning or typing paper forms	•CMMS with true electronic work orders
Failure Data	•Not captured from SCADA	•Data captured; large amounts of time unaccounted (10-15%)	•SCADA data reviewed, and errors addressed
Data Infrastructure	•Flat text files •FTP sites	•Data transfer processes •SCADA & Work Orders disconnected	•SCADA, CMMS, data historian linked •SCADA “events” drive work orders

Manual collection Hard copy → Data historian Automated

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Data-Based Decision-Making

What decisions do you need to make?

Data-Based Decisions

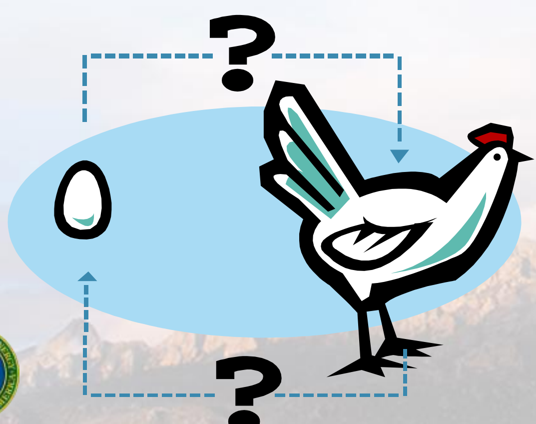
Data Analysis

Data Collection

1. Install/upgrade data collection systems
2. Collect and store data
   - SCADA (time series; faults)
   - Work Orders / CMMS
   - Other data (cost, inventory, etc.)
3. Integrate data (symptoms vs. resolutions)

4. Establish baseline performance
5. Identify (high-level) performance drivers
6. Determine root cause

7. Isolate possible improvements
8. Select improvement(s) with largest ROI
9. Implement and track improvement(s)



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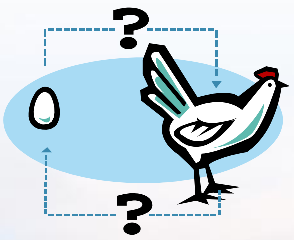
Data Collection

& Data Storage/Retrieval



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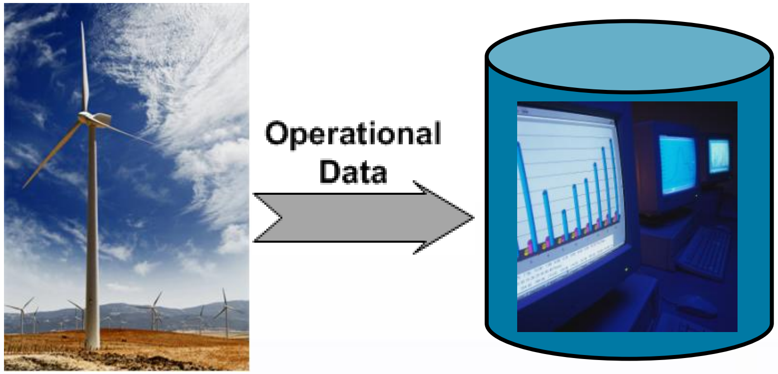
Collecting the Data

Translate Plant Knowledge To Corporate Knowledge!



Data Collection Systems

- Reconfigure, upgrade, install
- Staff skills and abilities

Collect & Store Data

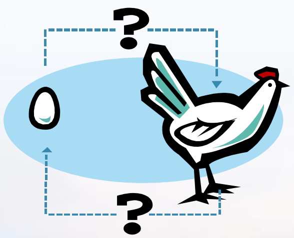
- **SCADA:**
  - Time Series: real-time, data points (~25 fault tags), granularity (1' averages)
  - Events and Alarms (Automatic Reset, Remote Reset, Technician Reset)
- **CMMS data:** centralized for linking with SCADA data and analysis
  - Paper Work Orders: At minimum enter them in an electronic format
  - Ultimate Goal – SCADA Faults Generate Work Orders
- **Environmental data** (failure context)
- **Centralized database/historian** – real-time and historical data, data integrity

Integrating Data

Operational data must be linked to maintenance and repair data in order to understand performance issues

- **Link SCADA summary, SCADA events/alarms, and work orders**
  - Relational database products: use relationships between data pieces to meet storage and access management requirements
  - Data historians: store time series data, using compression to manage storage of very large data streams
  - Knowledgeable staff to apply emerging automated tools for data linkage
- **Operations Command Center (OCC) approach**
  - Real-time SCADA data flowing from plant to centralized monitoring and control
  - Data stored in single large database
  - Robust, secure, reliable high-speed connection from plant to OCC
- **For smaller operators**
  - Site storage system to collect finite time-period SCADA data
  - Send subsets of data to central office for storage and analysis

Data Analysis



4. Establish baseline performance
5. Identify (high-level) performance drivers
6. Determine root cause

Baseline Performance

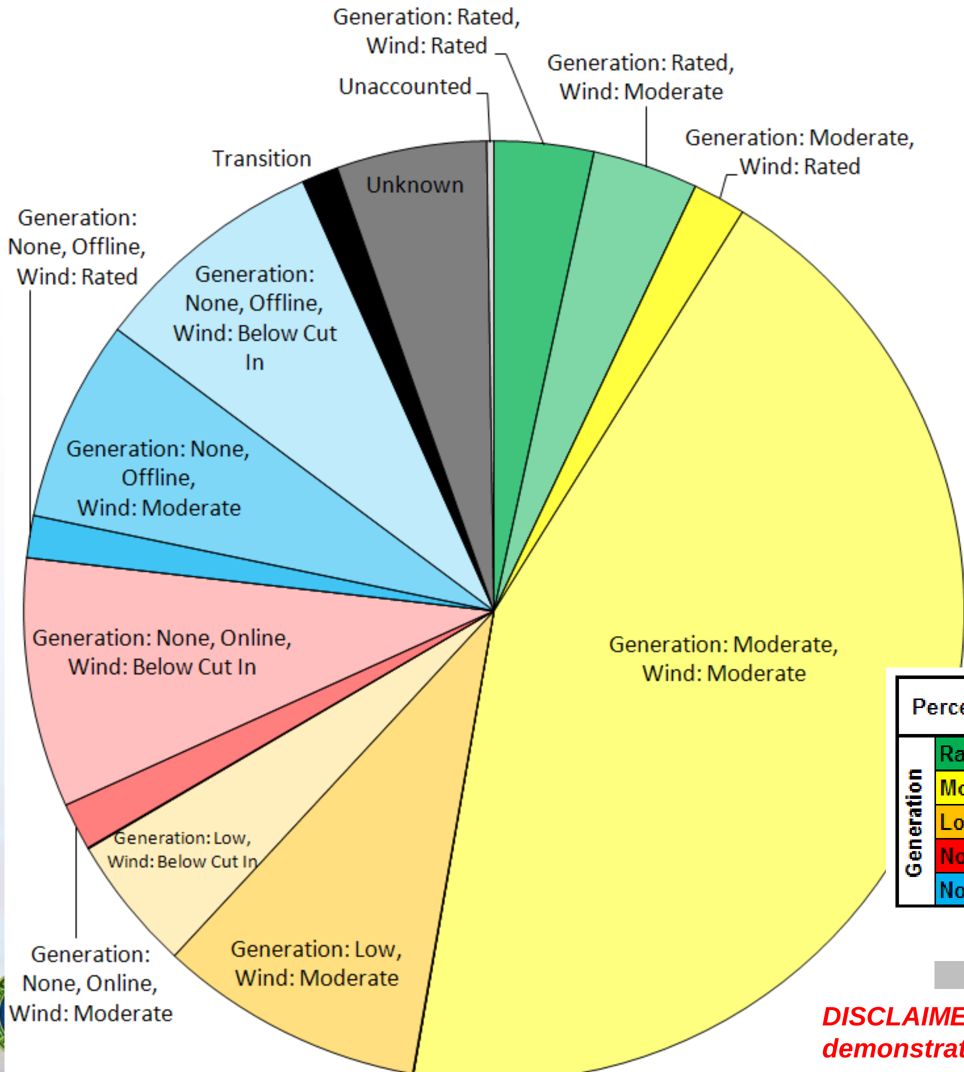
- **Establish baseline performance**
  - **Understand the current situation: What is it? How good is it?**
    - Calculate basic operations and reliability metrics (Availability, MTBE, Mean Downtime)

  - **How does performance compare to OEM expectations?**
    - Power curve (wind speed vs. power output), including outliers
    - How does a typical turbine spend its time:
      - Non-generating (no wind, down for scheduled maintenance, curtailed, etc.)
      - Generating (power rating vs. wind speed)
      - Transitional/Unaccounted (no data)/Illogical (positive generation with no wind)
    - What data is missing: e.g., identify when turbine state cannot be determined

  - **Document assumptions** (if 5% of SCADA records are not usable, was the turbine up or down during that time?)

Time Allocation

- **How does a "typical" turbine spend its time?**



• **Transition**: Turbine changes from running to not running (or vice versa) during Measurement Period

• **Unknown**: Either turbine's status or environmental conditions are not captured; OR they are captured, but are illogical

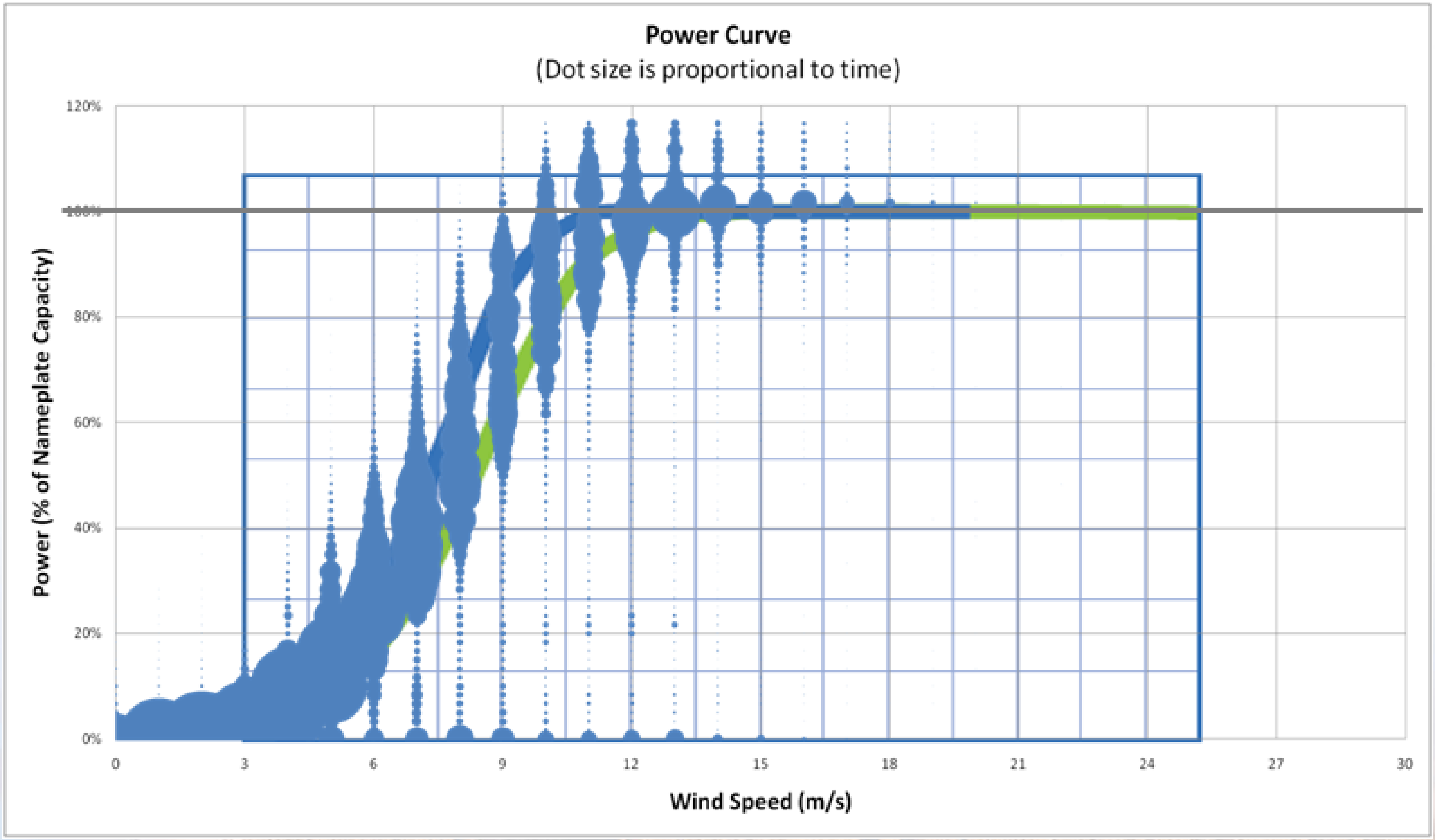
• **Unaccounted**: Missing records and/or time lost due to rounding of small Measurement Period lengths

Percent of Time		Wind				
		Above Cut Out	Rated	Moderate	Below Cut In	
Generation	Rated	0.0%	3.4%	3.6%	0.0%	7.0%
	Moderate	0.0%	1.8%	43.9%	0.0%	45.7%
	Low	0.0%	0.0%	9.1%	4.7%	13.8%
	None (Online)	0.0%	0.0%	1.6%	8.6%	10.3%
	None (Offline)	0.0%	1.4%	7.0%	8.1%	16.5%
		0.0%	6.7%	65.2%	21.4%	93.3%

Transition = 1.3% Unknown = 5.2% Unaccounted = 0.2%

DISCLAIMER: This chart contains only notional (fictional) data to demonstrate the type of results which reliability analysis may provide.

Power Curve



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Determining the issues

Identify high-level performance drivers

- Explore trends, outliers, good performance and surprising results
- Which are the good turbines? Which are problematic and why?
- Which types of downtime events are driving poor performance
  - Pareto analysis is simple but powerful
- Compare multiple metrics
  - Event frequency vs. event duration
  - Generation vs. turbine's recorded wind speed
  - Outliers are very revealing
  - Where is performance roughly the same? Where is there great variability?

Determine root causes

- Why are good turbines good, and vice versa?
- Why are certain aspects of operations having such a negative impact? (investigate de-rates, unexplained performance, unexpected patterns)
- What are root causes of the top problems? (fishbone chart, etc.)

Determining the issues

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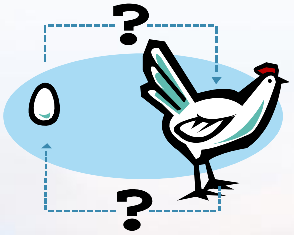
Data-Based Decisions



7. Isolate possible improvements
8. Select improvements with largest ROI
9. Implement and track improvements

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Data–Based Decision Making

Time → **Functioning** | **Degrading** | **Failing** →

Functioning → **$$$**

Prescriptive replacement of functioning item

Degrading → **$**

Replace item with maximum usage before failure

Failing → **$$$$$**

Loss of availability due to failure

↓

Reduce COE

Business Decisions

Improving in areas you know you should be looking into -
Discovering areas you didn't think to look at.

- **Minimizing O&M Costs (Isolate possible improvements)**
  - Maintenance schedules: Decrease component failure and early replacement
  - Schedule downtimes to minimize impact to generation and grid
- **Maximizing Capital Investment (Select improvements with largest ROI)**
  - Funding improvement efforts
  - Equipment purchase selections (performance to spec)
  - Reduce cost of financing and insurance
- **Policy & Public Sector**
  - Increase pace of development
  - Grow public support (drives policies)
  - Influence developing standards
- **Implement <u>and Track</u> Improvements**

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Other Value

- **Doing a good job with reliability data collection, analysis, and decision-making sets the foundation for all kinds of other analysis & decision-making**
  - Grid integration (ex: impact of curtailment)
  - Labor analysis
  - Understanding weather & seasonal impacts
  - Supply chain analysis
  - Data-based input to investment decisions (your own & others)
    - Insurance
    - Tax-payers, rate-payers
  - Policy-making

Path Forward

- **Improve your capability to collect, store and analyze your operational data. Decrease COE through reduced O&M cost and higher availability.**

- **SNL report to be published October, 2010**

- **Participate as a pilot site in the CREW database project**
    - Courtesy reliability analysis
    - Early use of ORAP for Wind tool to collect and link SCADA to CMMS data

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