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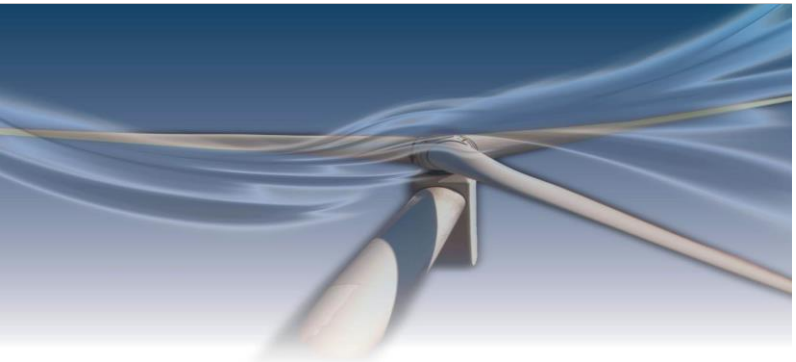

Availability and Reliability Standards

Standardizing Definitions for Wind Turbine Availability and Reliability for Operations & Maintenance Analyses

Ben Karlson

Sandia National Laboratories

U.S. DEPARTMENT OF ENERGY

NNSA National Nuclear Security Administration

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Presentation Overview

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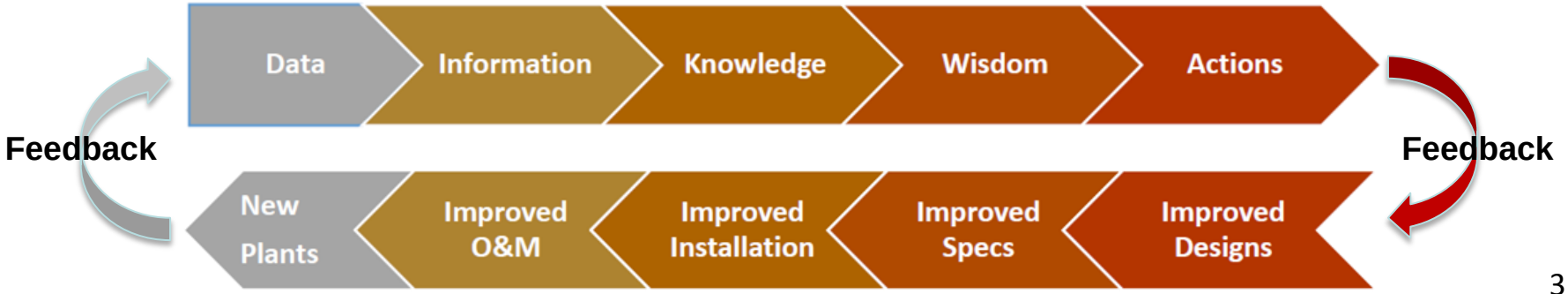
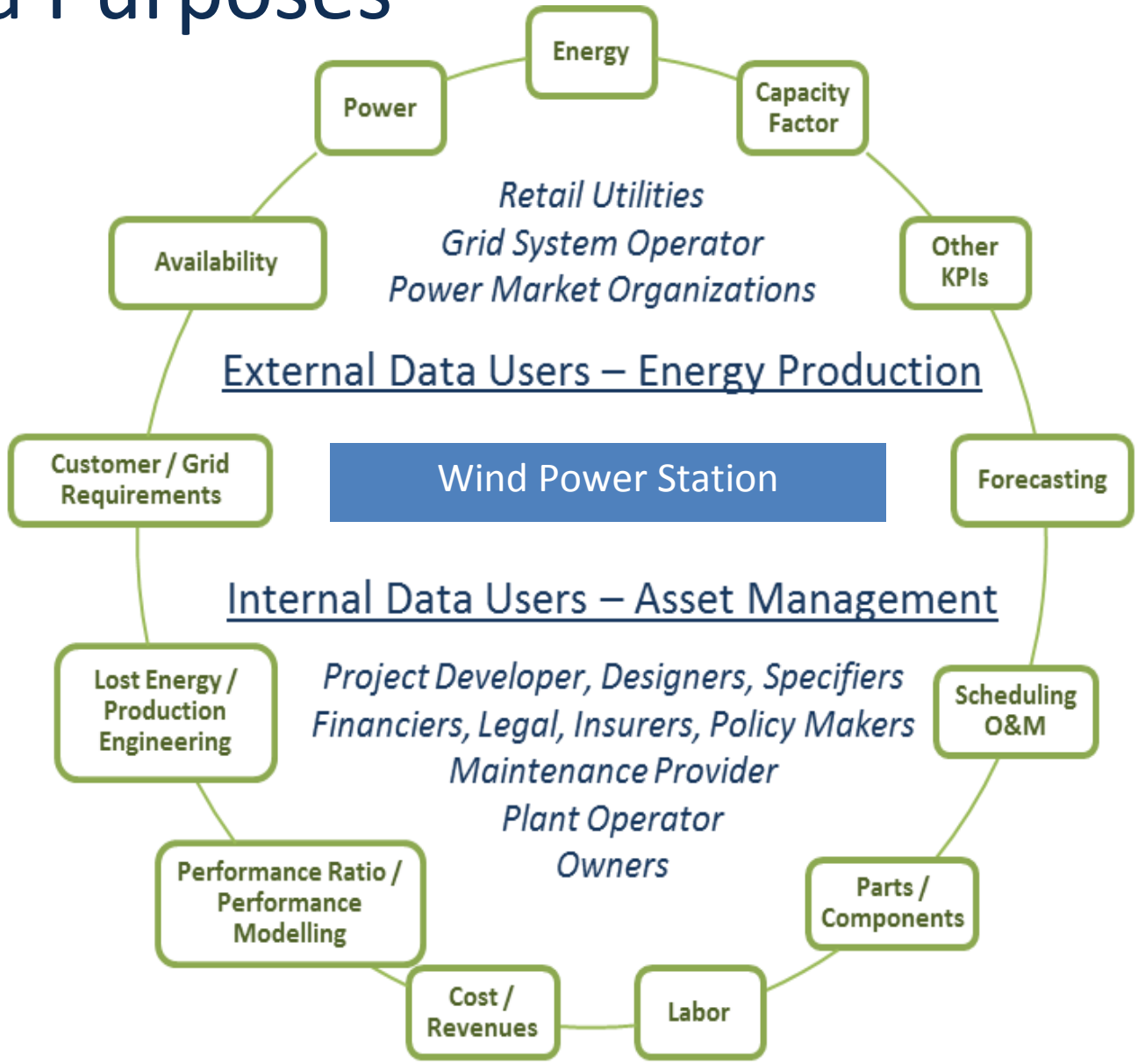
- Background
  - Why are we talking about Availability and Reliability standards?
  - What are the drivers?
- What standards exist?
  - IEC 61400-26
  - IEA Task 33
  - NERC GADS
- What's Next?
  - CREW database example

Concept of Wind Turbine Availability "not available" not well addressed by industry

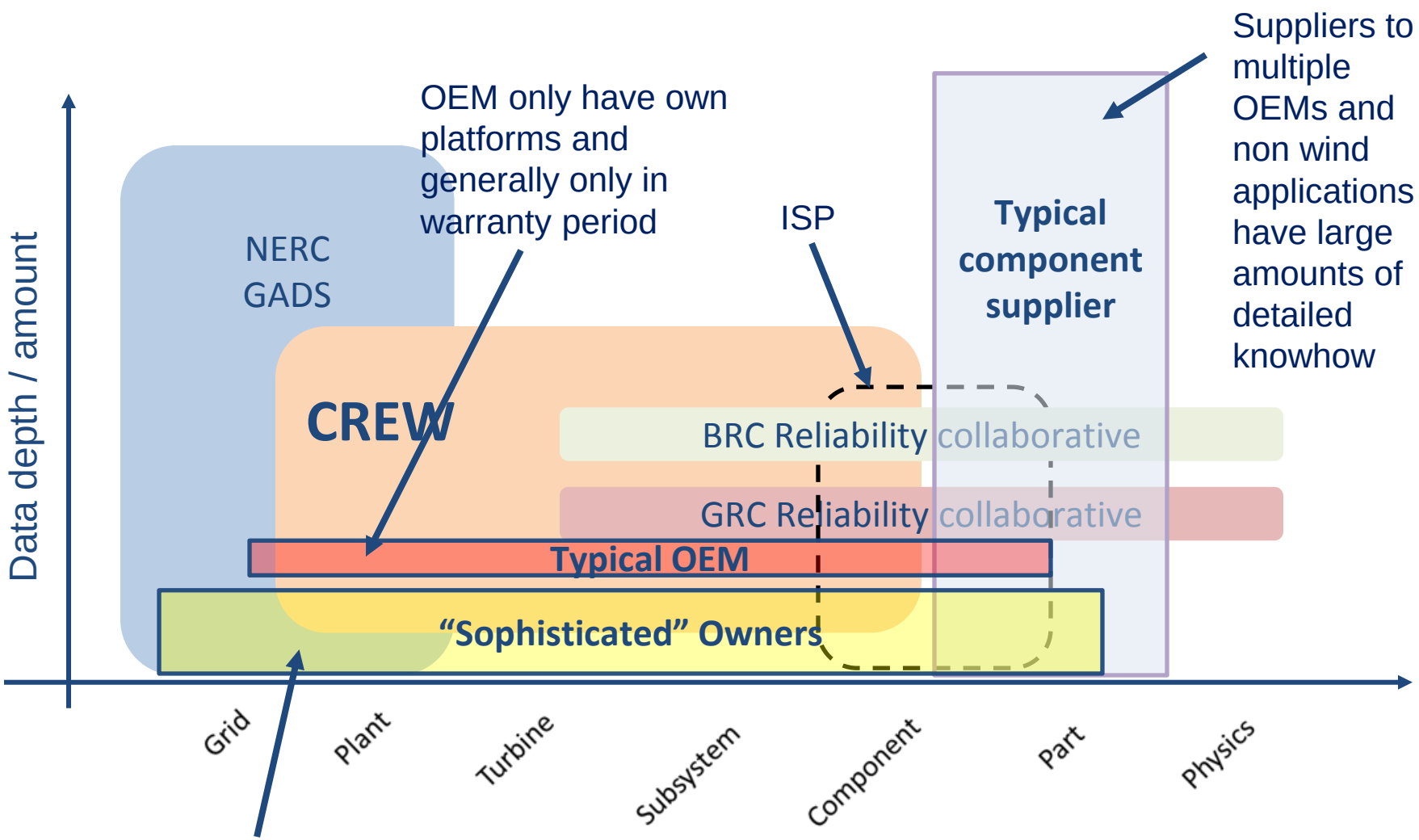
- History
  - Early disagreement for a definition of availability
  - Concept was left open for future discussion during the development of wind turbine design standard (IEC 61400-1)
  - In 2007, IEC TC-88 agreed to begin work towards a standard definition of wind turbine availability
- Drivers of Availability and Reliability Standards
  - Operational optimization
  - Maintenance optimization
  - Purchasing optimization
  - Investor confidence
  - Grid reliability
  - Technology Improvement Opportunities



Data Purposes



Insights of Different Stakeholders



Owners have multiple platforms from multiple OEMs. Interact with suppliers and service provides for the entire life of their wind farms

What Standards/Specs Exist?

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- IEC 61400-26: Availability for wind turbines and wind turbine plants

- NERC Generating Availability Data System (GADS)

- IEA Task 33: Reliability Data: Standardizing data collection for wind turbine reliability and O&M analyses

IEC 61400-26
Time based availability for wind turbines

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- *"The technical specification shall define generic terms of wind turbine systems and environmental constraints in describing system and component availability, lifetime expectancy, repairs and criteria for determining overhaul intervals. Furthermore the specification shall define terminology and generic terms for reporting wind power based generating unit reliability and availability measurement."*

- Technical specification is separated into three parts:
  - 61400-26-1 terms for time based availability of a wind turbine
  - 61400-26-2 terms for production based availability of a wind turbine
  - 62400-26-3 terms for time and production based availability of a wind power plant

Information Model for IEC 61400-26

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Information categories				
Mandatory Level 1	Mandatory Level 2	Mandatory Level 3	Mandatory Level 4	Optional - description see Annex A Level 5
INFORMATION AVAILABLE (IA)	OPERATIVE (IAO)	GENERATING (IAOG)	FULL PERFORMANCE (IAOGFP)	
			PARTIAL PERFORMANCE (IAOGPP)	Derated
				Degraded
		NON-GENERATING (IAONG)	TECHNICAL STANDBY (IAONGTS)	
			OUT OF ENVIRONMENTAL SPECIFICATION (IAONGEN)	Calm winds
				Other environmental
			REQUESTED SHUTDOWN (IAONGRS)	
			OUT OF ELECTRICAL SPECIFICATION (IAONGEL)	
	NON-OPERATIVE (IANO)	SCHEDULED MAINTENANCE (IANOSM)		
		PLANNED CORRECTIVE ACTION (IANOPCA)		Retrofit Upgrade Other corrective action
		FORCED OUTAGE (IANOFO)		Response Diagnostic Logistic Failure repair
		SUSPENDED (IANOS)		Scheduled maintenance Planned corrective action Forced outage
	FORCE MAJEURE (IAFM)			
INFORMATION UNAVAILABLE (IU)				

Condition State	Example
Full performance	Function with no limits or restrictions
Partial performance	Functioning with limitations and/or restrictions
Technical standby	Temporarily nonfunctioning due to controlled and/or predefined tasks required - e.g. self-testing, ramp-up
Out of environment spec	Operative but not functioning as the environment is out of design specs
Requested shutdown	Operative but stopped by an external request-i.e. curtailment
Out of electrical spec	Operative but not functioning as the electrical parameters are out of design specs - i.e. grid outage
Scheduled maintenance	Scheduled maintenance prevents system components for performing the intended functions
Planned corrective action	Actions required to retain, restore, or improve the intended functions that are not part of normal scheduled maintenance
Forced outage	Action taken as unforeseen damage, faults, failures or alarms are detected
Suspended	Activities in SCHEDULED MAINTENANCE, PLANNED CORRECTIVE ACTION and FORCED OUTAGE are interrupted or cannot be initiated due personal safety or equipment integrity - e.g. extreme weather
Force Majeure	Extraordinary event or circumstance beyond the control of the parties, prevents the parties from fulfilling their obligations.

NERC Generation Availability Data System (GADS)

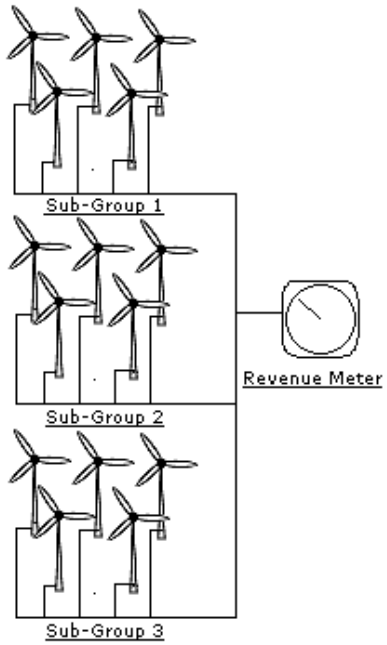
- The industry standard for reporting generator availability performance data
- Uses consistent formulas develop by industry to calculate key availability metrics
- Wind and Solar do not have mandatory reporting requirements
- Only ~4% of wind generation is reporting to GADS

- NERC provides free software to allow for easy reporting

Wind Turbine Group

Groups report the following site data:

- Associated Plant ID
- Turbine Group ID
- Turbine Group Name
- NERC Utility Code
- NERC Unit Code
- Installed Capacity in MW
- Auxiliary Capacity
- Commercial Date
- Nearest City, State
- Longitude and Latitude
- Elevation
- Wind Regime (topography)
- SCADA Type
- SCADA Manufacturer
- SCADA Model



http://www.nerc.com/page.php?cid=4|43|46

IEA Task 33

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Reliability Data: Standardizing data collection for wind turbine reliability and O&M analyses

Objectives

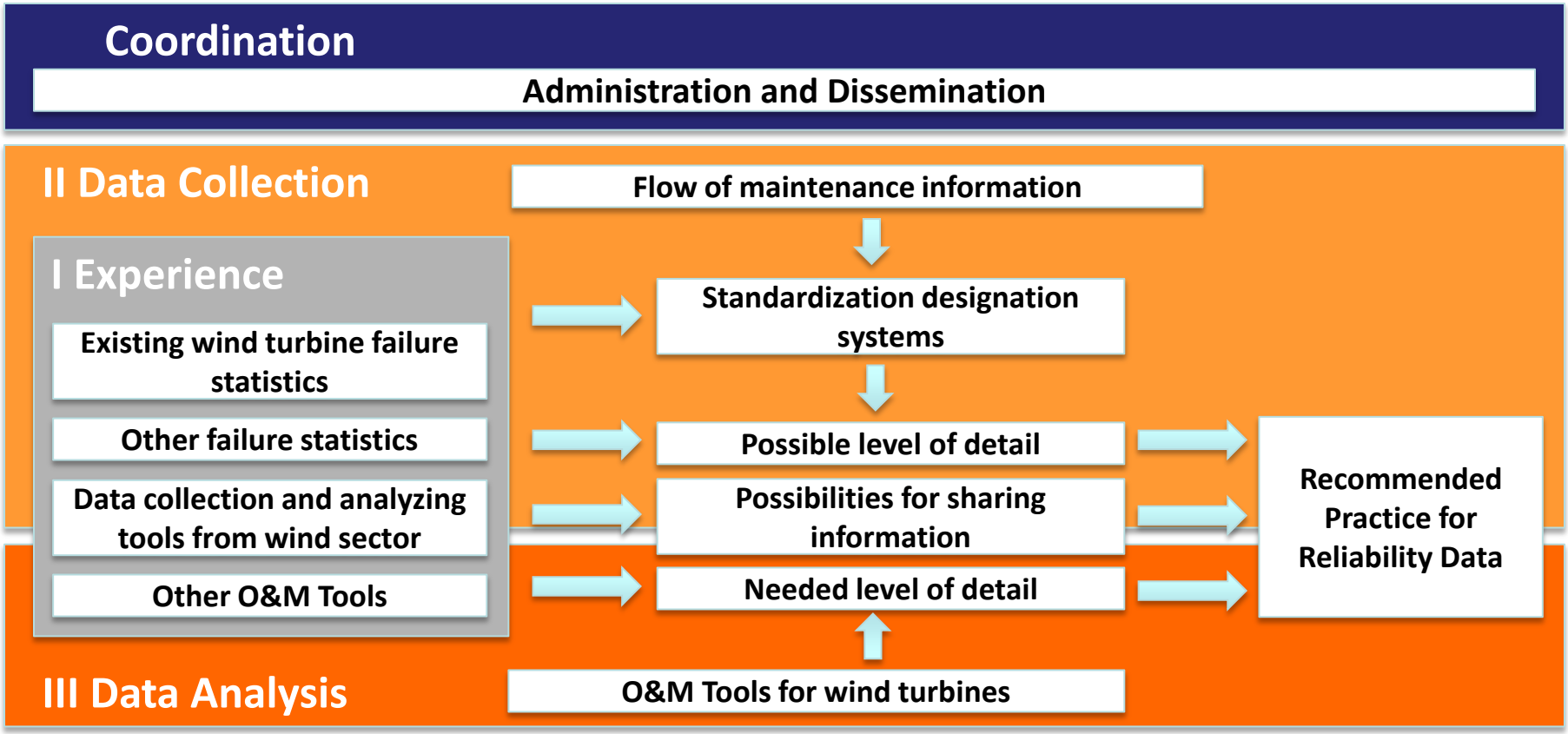
- Provide an international open platform for regular and continuous exchange of experience and progress from research activities and measurement projects on failure statistics on wind turbines.
- Develop "***Recommended Practices for Reliability Data***" during the Task.
- Identify areas for further research and development as well as standardization needs

Industry Value:

- Increased implementation of appropriate, standardized, data-based decision making techniques and tools to optimize wind plant O&M and thereby increase turbine reliability and plant availability while decreasing O&M costs

IEA Task 33

- Addresses the data collection and failure statistics in the wind energy sector to standardize reliability data will facilitate effective analysis and the wide applicability of results.
- Aims to use reliability data to support improving reliability and optimizing O&M procedures of wind turbines through the use of reliability data.

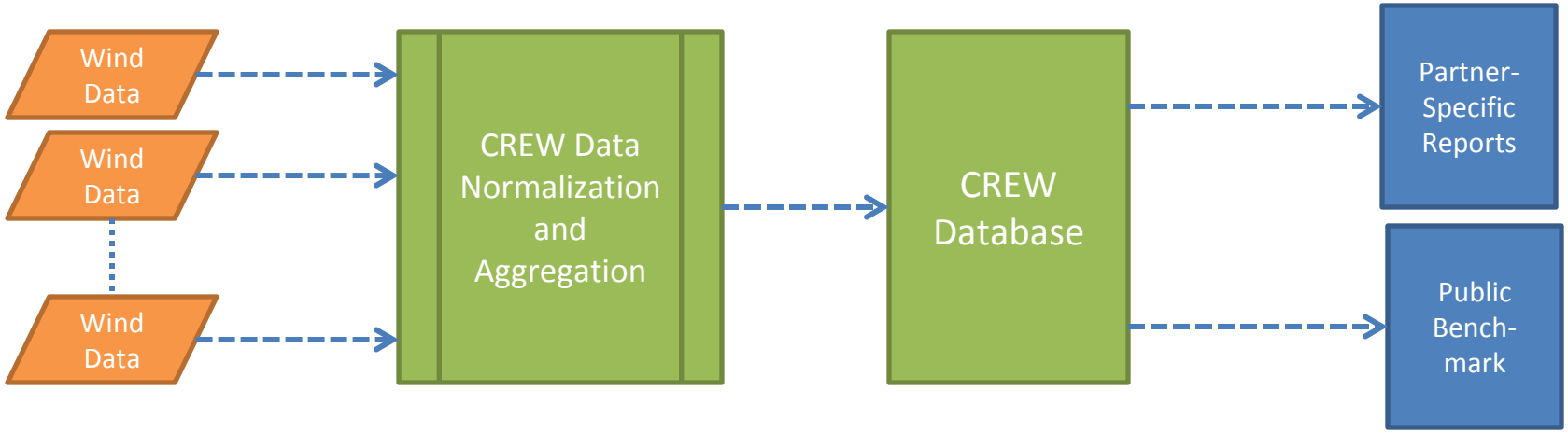


Sandia's CREW Project

Continuous Reliability Enhancement for Wind (CREW)

- Improve US wind fleet reliability
- Strategic technology improvements are accomplished by:
  - ***Establishing a US Wind Fleet Benchmark*** that can be used to drive DOE Technology Investments and as a baseline to which owner/operators can identify improvement opportunities.
  - ***Deep technical analysis of a few wind farms*** to provide performance and reliability tools and model validation, root cause analysis of failures and research on operations.
- Past CREW approach
  - SCADA feeds from individual plants to SNL database. Data was aggregated into fleet-level model for reliability benchmarking and analysis
- New approach shifts from low-level SCADA feeds to high-level summarized availability and reliability data dumps

CREW Data Flow & Process



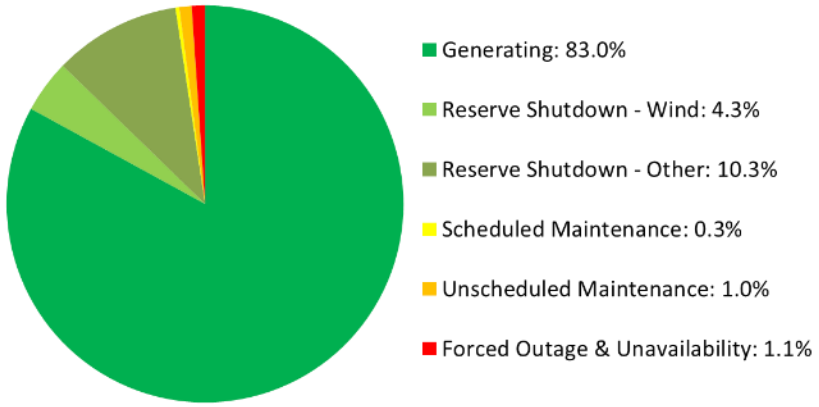
- Wind farm owners provide summarized performance and reliability data in monthly reports
- NDAs define terms for data sharing

- Standardization of data reporting aligned with IEC 61400-26 and IEA Task 33 recommendations
- Data will be scrubbed to remove and protect proprietary information

- Aggregated CREW database will be made available to researchers for analysis
- No proprietary information will be included

- Annual public benchmark will be performed to identify and quantify DOE technology improvement opportunities
- Data partners receive a partner-specific report

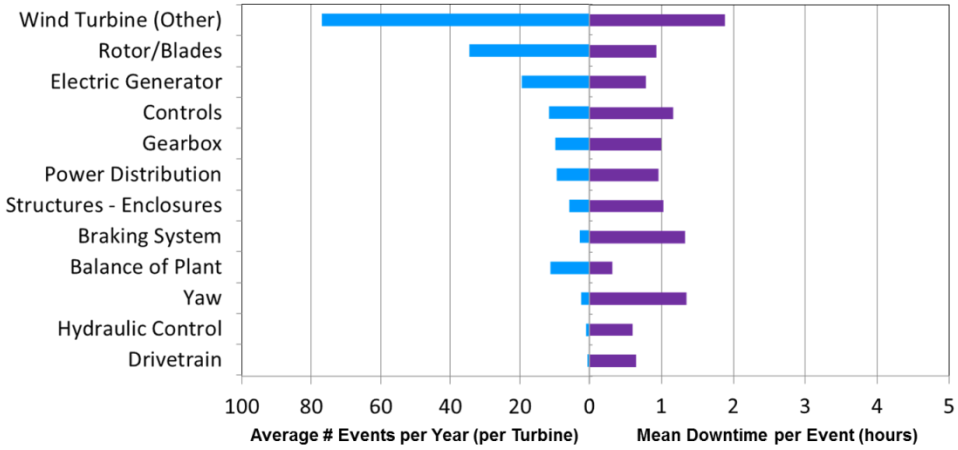
2013 CREW Benchmark



- Data represents 327,000 turbine-days
- Key metrics all slightly improved, compared to 2012

	2013 Benchmark	2012 Benchmark
Operational Availability	97.6%	97.0%
Utilization	83.0%	82.7%
Capacity Factor	36.1%	36.0%
MTBE (hrs)	39	36
Mean Downtime (hrs)	1.3	1.6

- Average: 1.6 days of generating before each downtime event
  - Some events automatically reset, others need intervention



- Gearbox not in top 5 systems
  - Benchmarking faults and symptoms, at this point
  - Current emphasis on electronic work orders for wind industry

http://energy.sandia.gov/crewbenchmark

Conclusion

- Availability and reliability data are needed to create a continuous picture of the power plant's performance over its lifetime.
- Uniform tagging across different datasets is critical
  - IEC and IEA have made great strides towards achieving this
- Meaningful technical benchmarking requires normalization with respect to physical processes (technology, location etc.)
- SCADA data analysis could enhance the relationships and give accurate lifetime performance (power and reliability) estimates
- Data sharing is an important piece to understanding the health of the wind industry and will lead to a lower COE

Thank you!

Ben Karlson

Benjamin.Karlson@sandia.gov
(505) 377-3774

http://energy.sandia.gov/energy/renewable-energy/wind-power/