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Adapting ORAP® to Wind Plants: Industry Value and Functional Requirements

Salvatore A. DellaVilla
Strategic Power Systems®, Inc.
11016 Rushmore Dr.
Frenette Bldg., Suite 275
Charlotte, NC 28277

Prepared for the Sandia CREW Project Team:
Bridget L. McKenney, Alistair B. Ogilvie, Valerie A. Peters, Paul S. Veers
Sandia National Laboratories
P.O. Box 5800
Albuquerque, NM 87123

Prepared by
Sandia National Laboratories
Albuquerque, New Mexico 87185 and Livermore, California 94550

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CREW Project Team:
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Abstract

Strategic Power Systems (SPS) was contracted by Sandia National Laboratories to assess the feasibility of adapting their ORAP (Operational Reliability Analysis Program) tool for deployment to the wind industry. ORAP for Wind is proposed for use as the primary data source for the CREW (Continuous Reliability Enhancement for Wind) database which will be maintained by Sandia to enable reliability analysis of US wind fleet operations. The report primarily addresses the functional requirements of the wind-based system. The SPS ORAP reliability monitoring system has been used successfully for over twenty years to collect RAM (Reliability, Availability, Maintainability) and operations data for benchmarking and analysis of gas and steam turbine performance. This report documents the requirements to adapt the ORAP system for the wind industry. It specifies which existing ORAP design features should be retained, as well as key new requirements for wind. The latter includes alignment with existing and emerging wind industry standards (IEEE 762, ISO 3977 and IEC 61400). There is also a comprehensive list of thirty critical-to-quality (CTQ) functional requirements which must be considered and addressed to establish the optimum design for wind.

Contents

BACKGROUND

An assessment of the wind turbine industry today shows a gap exists between the growth in the installed base of wind turbines and the availability of current, factual, and detailed “reliability” performance metrics that can be used to characterize the operational performance of these assets. While owner/operators and Original Equipment Manufacturers (OEM’s) have access to their own operational, maintenance, and outage experience data at some level of detail, which is required for in-warranty administration, product service and support, and asset management, the market has limited or no access to current and relevant reliability performance information on the installed base. A data-poor environment can contribute to a sense of uncertainty as to the reliability of the equipment that has been installed. This leaves the market and the public in a position to question the technology, and perhaps to set inaccurate or false product performance expectations. It is clear that the market will insist on “best in class” performance, while the public interest will expect the lowest possible cost of power with the highest levels of product reliability.

The power generation industry fully appreciates the need for meaningful and current reliability performance metrics. For successful conventional thermal power stations, the rigor and value associated with collecting, analyzing, and reporting operational, failure, and maintenance data is ingrained in their business culture and operating practice. The data provides a basis for developing the key performance indicators (KPI’s) that are essential for profitably managing the plant(s). Today, various data capture and reporting systems are implemented to ensure that “critical to quality” (CTQ) data is available for assessment and action, plant improvement, effective communication with the OEM, required reporting to various industry or governmental organizations, as well as information sharing among product specific user groups. From Computerized Maintenance Management System(s) (CMMS) to remote monitoring (typically with the OEM), there is an emphasis on effective asset management and product improvement through information gathering and sharing, condition monitoring, and knowledge creation.

These power generation industry best practices must be extended to and implemented in the wind industry. Improved information sharing and knowledge is required to characterize the availability and reliability of these operating assets. The vast number of newly installed wind turbines and the associated increase in system capacity that they represent has no energy parallel. For the industry to sustain its continued growth, developers, owner/operators, insurers, banks, and others providing risk capital are requiring more meaningful data and information to establish realistic “pay-back” expectations. These financial pay-back requirements have placed a premium on effective asset management strategies to achieve operational excellence, to ensure that an accurate and meaningful pro forma is developed based on realistic equipment performance, to drive toward an acceptable return on equity, and to ensure a sustained level of profitability over the life cycle of the plant.

Each reliability issue that significantly impacts plant performance cannot be completely addressed within the operating environment. The equipment that is placed in the field must have the capability of high reliability operations designed into the system and specified at a component level. Component enhancement efforts need to be guided and prioritized by the information that comes from the operating plant. While turbine manufacturers and component suppliers may get quality feedback during the warranty period, information on the performance of their equipment even after the warranty is over will enable them to make the design and specification changes that continuously improve the reliability of their products. Reliability issues that are uncovered across the entire industry may warrant dedication of public resources to work with the industry to resolve those issues. An example of this is the Gearbox Reliability Collaborative project sponsored by the Department of Energy (DOE) Wind Program. It is also the purpose of this data gathering effort to inform these initiatives, both public and private, for the benefit of the industry as a whole.

A FOCUS ON RELIABILITY

The "20% Wind Energy by 2030: Overcoming the Challenges" report from the DOE identified six technical challenges that must be overcome to improve the likelihood that wind technology can be seen as a high penetration energy option. One challenge calls for performance improvement and reduced operating and maintenance cost, "through improved reliability." Reliability is recognized as a KPI that requires improvement, and continuous reliability enhancement is a program goal. Success will be determined by how effectively and transparently any gap in reliability is understood, verified, documented, and corrected.

In today's energy market, expectations for acceptable, sustainable, and reliable product performance are established on a pro forma basis, regardless of technology. For wind technology to effectively compete as a viable energy alternative, irrespective of the value of production tax credits or incentives, the reliability performance of manufactured components and full systems must improve. To achieve a substantial increase in total generating capacity, from approximately 2% in 2010 to 20% by 2030, the reliability issue must be addressed. It is important to recognize that the critical criteria for successfully executing this growth objective is determined by how reliably and cost effectively wind turbines actually perform.

To understand the performance of wind turbines in the United States, DOE has initiated a Reliability Collaboration and System Analysis activity to be executed and managed by Sandia National Laboratories (SNL). A major element of this program is the creation of a Continuous Reliability Enhancement for Wind (CREW) database that has on-going access to field data. One objective is to use the data to develop a factual assessment of the reliability of wind turbines at a plant, turbine, system, and component level, as well as across the several OEM's. Another DOE objective is to drive down operating and maintenance (O&M) costs by 35% by 2030. To achieve these objectives, reliability improvement must take place. Openness and information sharing should stimulate a competitive market, as it does in other related industries, driving down costs through manufacturing improvements, as well as implementing on-going process and performance improvements at the operating plants.

SNL and Strategic Power Systems, Inc. (SPS**®)** are engaged in an effort to create a capability to gather operating data from a variety of sources and merge it into a database that fills the above needs. The specific purpose of this document is to summarize the value this capability will provide and to outline the functional requirements for developing and implementing this capability. This collaborative effort will result in a reliability tracking database large enough to characterize and benchmark the operation and maintenance experience of the US fleet; transforming plant data into Reliability, Availability, and Maintainability (RAM) metrics.

To achieve this objective, the project will leverage SPS' Operational Reliability Analysis Program (ORAP). ORAP is a reliability monitoring system, which collects RAM and operations data for benchmarking and analysis. ORAP is recognized as an independent and unbiased data collection, analysis, and reporting system for conventional gas and steam turbine technologies. A similar system, ORAP for Wind, will be deployed for the wind industry (see Figure 1). SPS' unbiased market presence ensures a repeatable process that is accurate, auditable, and verifiable.

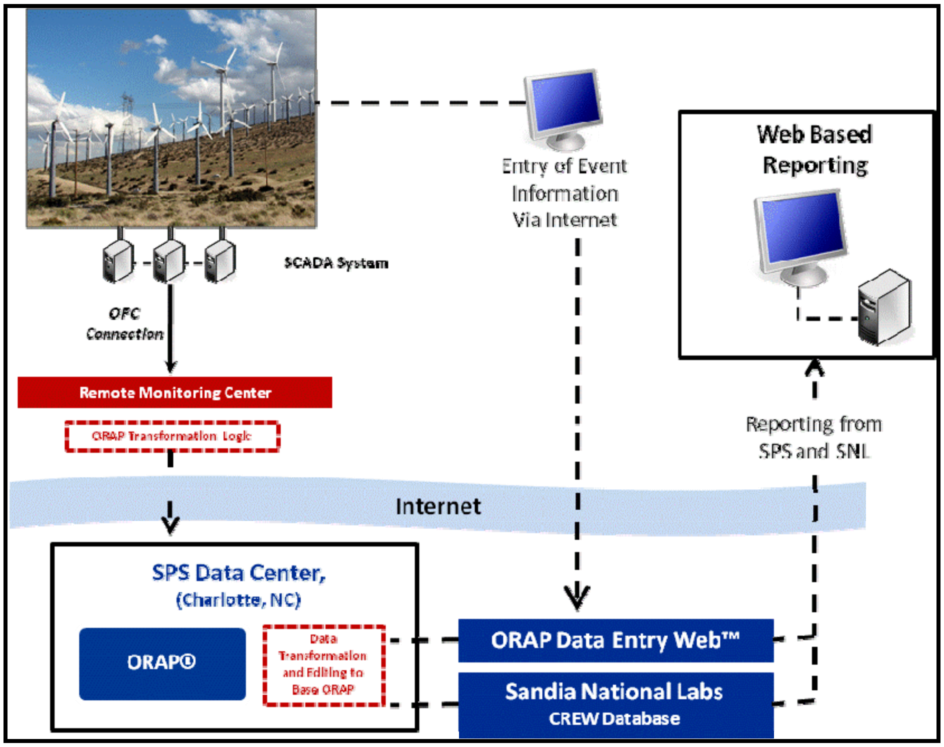

Figure 1: ORAP Data Collection & Reporting Process for Wind

To achieve this objective, the specific project plan will address the following seven (7) critical to quality (CTQ) requirements:

1. Leverage SPS's existing ORAP as the foundation for a wind plant database and information architecture, which can be a primary data source for CREW.

2. Build on the results of the North American Electric Reliability Corporation (NERC) Wind Turbine Working Group (WTWG) to ensure consistency and compatibility with appropriate reliability metrics deployed through the NERC GADS (Generating Availability Data System), while providing a more granular level of wind turbine operating data. This means that ORAP will be focused on each wind turbine in the plant to develop a perspective of each power producing element as well as the total plant.

3. Develop and implement an optimized data capturing process with maximum automation and minimum human (operator and maintenance staff) intervention to obtain the required operating, maintenance, and failure history at the right level of detail and with a high degree of accuracy and efficiency.

4. Provide value to plant operators by automating reporting requirements for various regulatory and business interests, including NERC GADS and specific ISO (Independent System Operator) reporting requirements.

5. Establish an effective, on-going, long-term data exchange at the right level of detail to meet the reporting requirements for the analytical assessments and reliability benchmarking goals of SNL, SPS, and other industry stakeholders.

6. Define the necessary data categories and elements required from each participating plant; pedigree data (plant configuration data – essential for establishing "peer groups"), operational data, outage event data, maintenance work order data, site ambient data, and met tower data.

7. Provide key stakeholders "real time" access to data and analysis to improve asset management and operations.

LEVERAGING ORAP® FOR WIND

SPS has the unique benefit of being able to look back over twenty-two (22) years of reliability engineering experience, with specific focus on electrical generation. SPS provides products and services that are focused on capturing plant operational and maintenance data, and transforming that data into standard industry performance metrics and benchmarks for use by some of the most recognized organizations in the global energy market today: EPRI (Electric Power Research Institute), ALSTOM, Chevron, Rolls-Royce, Iberdrola, GE, Direct Energy, E.on, BP, Mitsubishi... as well as hundreds of gas and steam turbine-driven plants all over the world.

SPS' industry recognition is based on reliability engineering and information technology strengths that are executed through the ORAP system. Fundamentally, ORAP provides a strong information infrastructure that has been developed and improved over time. The evolution of the ORAP infrastructure is based on three (3) criteria: first, the value of data gathering; second, implementing productivity processes to minimize manual input and time; and third, transforming the data into meaningful, unbiased information for reliability engineering assessment and action. SPS' brand and value is directly associated with how our customers see and use ORAP to their maximum benefit.

SPS' core competence and added value are based on:

- Collecting and analyzing operating, failure, and maintenance data from power plants all over the U.S and the world...
- Ensuring data completeness, accuracy, validity, and timeliness...
- Providing meaningful RAM benchmarks and identifying "best in class" performance...

ORAP is all about transforming data into actionable reliability information and knowledge. ORAP provides an understanding of RAM characteristics or KPI's that represent the performance of today's mature and advanced gas and steam turbine technologies. These KPI's provide reliability and availability trends, the sources of and the reasons for plant downtime at the component level, as well as relevant industry benchmarks. As such, ORAP provides up-to-date KPI's for each participating customer, especially owner/operators and OEM's. For the owner/operator, how the equipment performs on a service hour per start basis impacts maintenance schedules and outage durations, influences parts' lives and spare part requirements, and ultimately determines whether pro forma profitability goals are achievable. For the OEM, availability and reliability performance are a reflection of both product and service quality. Consequently, the owner/operators and equipment manufacturers have a shared objective: to ensure that the actual availability and reliability performance of the operating asset is measured, is acceptable, and is sustainable. SPS, through ORAP, provides an understanding of what is required to attain "best in class" performance.

The critical issue is to determine what is required to adapt the ORAP system for wind. The issue relates to whether the foundational building blocks for developing time and energy based measures can be easily determined and retrieved from operating wind turbines. These foundational building blocks include: equipment taxonomy, pedigree data, operating data, outage data, and counter data (or aging characteristics). And industry standards, like IEEE (Institute of Electrical and Electronic Engineers) 762 (IEEE Standard Definitions for Use in Reporting Electric Generating Unit Reliability, Availability, and Productivity) and ISO (International Organization for Standardization) 3977 (Part 11 – Reliability, Availability, Maintainability and Safety) must be considered as well. They provide important guidance and insight for addressing any operational or performance differences between thermal and wind turbine plants. Any gap in the data that is required to track and develop meaningful time and energy based RAM metrics must be identified, addressed, and closed. Ultimately, the feasibility of developing, implementing, and deploying ORAP for wind will be determined by how effectively and productively the data collection, validation, analysis, and benchmark reporting can be defined and executed.

BUILDING BLOCKS FOR VALUE

Availability and reliability metrics as key power plant performance metrics rely on an accurate understanding of four fundamental informational elements: time, capacity (production or energy), events, and pedigree (configuration detail including taxonomy). It is absolutely essential that any proposed system initiated for capturing and reporting the reliability performance of wind turbines across a variety of designs, manufacturers, Megawatt (MW) sizes, O&M practices, or any other important technology characteristics, explicitly address these four elements. From this perspective, the ORAP system provides a sophisticated architecture that captures each of these CTQ elements and establishes a process that is uniform and consistent. Moreover, ORAP follows existing industry standards (IEEE 762 and ISO 3977) to ensure that both the collection of data and the reporting of reliability metrics follow these industry standards and are meaningful, accurate, verifiable, and repeatable. And while the ORAP system has been designed and implemented for the conventional gas and steam turbine power plants, the extension to wind technology should be relatively straight forward and deployable to the market for validation and full implementation. It should be noted that reviewing and being compliant with IEC (International Electrotechnical Committee) standards for wind turbines is a CTQ requirement as well. It is expected that the IEC will issue standards relating to both reliability metrics (time and energy based) as well as standardizing data points/tags. As ORAP is consistent with industry standards (IEEE 762 and ISO 3977), using the IEC standard will have a positive influence on establishing ORAP for wind.

It is important to point out that the electric power industry recognizes NERC as the de facto standard for monitoring and reporting the reliability of electric generating assets in the United States. The NERC reporting standards and guidelines are based on IEEE 762, providing the industry with uniform reliability metrics and formulae for application across the various generating technologies available in the market. NERC’s processes and database architecture GADS adequately address the four fundamental elements of time, capacity, events, and pedigree. With the support of the Independent System Operators (ISO’s) at the state level, NERC provides a valuable resource for understanding the reliability performance of the various generating options, providing meaningful comparisons of the different technologies on a consistent basis, and ensuring a uniform process for capturing the required reliability performance data from participating plants. NERC is currently in the process of addressing the addition of wind turbine technology to the generating mix, and understanding what the implications are from a data capturing and reporting perspective. With the advice and technical direction of their WTWG (a group of industry owner/operators, ISO’s, and other industry stakeholders) NERC has made significant progress in defining additional reliability metrics specific to the wind industry. This includes identifying specific additional data that is required from participating plants to calculate these RAM metrics. However, it is important to note that with guidance from the WTWG, NERC has focused data collection and reporting efforts at the revenue meter level, not at the individual turbine level. This means that NERC will have very limited granularity. This will not provide sufficient information to determine system and component issues, and their impact on individual turbine capability and performance. This is counter to the approach that will be taken with ORAP. ORAP will be focused on each wind turbine in the plant, and will utilize data down to the component level, to develop a perspective of each power producing element as well as the total plant.

It should be noted that SPS and NERC have a long standing relationship based on data exchange and information sharing. The primary distinction between NERC GADS and ORAP is the level of reporting granularity. A key requirement of ORAP is to provide system and component outage experience detail (whether forced outages or scheduled maintenance) to support improvement in component reliability. Since improvement in system and component reliability can be achieved through reduction in forced outages (on both a frequency and duration basis) or by verifying that maintenance outages are performed in an optimum manner (i.e. following manufacturer recommendations), it is important to track these events to the lowest level of detail possible. It is an absolute requirement of this project that the ORAP system provide a basis for capturing the wind turbine reliability data at the right level of detail (system and component data). With ORAP capturing work order or maintenance events at the component level, the ability to roll up the detailed outage data to the level required by NERC GADS becomes a routine task. This will provide a productivity benefit for the wind plant, as data capture at the component level will only be performed once with direct input to ORAP, then automated translation for NERC GADS will create data at the higher level and for the wind plant. Conversely however, because the NERC GADS data is not at the turbine level or at the component level of detail, there is no opportunity to create the reporting detail required by ORAP.

ORAP, as a reliability reporting system and database, has grown and evolved since it was first designed, developed, and introduced by SPS for commercial use in the power generation and industrial process markets in 1987. ORAP has a state-of-the-art relational database architecture based on Microsoft SQL Server technology. Today, ORAP has been migrated to Microsoft's most current software release; MS SQL Server 2005/2008. With MS SQL Server 2005/2008 as the backbone, ORAP is fully Web enabled through a .NET framework, with state-of-the-art reporting and analysis services, inherent in the current release of Microsoft's family of database and development products. The ORAP information architecture provides a strong infrastructure that effectively handles and supports the information flow of data from participating plants; from data retrieval, to information processing and storage, through report generation and analysis. Data confidentiality is required, enforced and maintained through designed-in security features. For optimum reliability, with a secure 24/7 access capability, the ORAP database and Web based reporting services is hosted at an off-site, fully redundant and secure data center.

APPLYING ORAP® DESIGN FEATURES FOR WIND

The ORAP system has a robust database architecture that has evolved and expanded over time. Technology changes that have taken place in the power industry have driven improvement and flexibility in the design of the ORAP database. This has favorably positioned ORAP to accommodate wind turbine and plant technology differences, when compared with existing ORAP capability in place for thermal power plants.

Existing design and operational features of the ORAP system must be reviewed to determine any necessary changes or additions to support wind technology. Existing ORAP design features that are in place for thermal plants include the following: (They are the foundation for expanding to wind).

1. The ORAP database schema (relational structure) provides a design framework for capturing and storing operational data, outage events, counter readings, and plant configuration (pedigree) information from participating generating plants. These data elements are fully consistent with the industry standards: IEEE 762 and ISO 3977, (in the future, the IEC standards). This data structure is fully consistent and goes beyond the NERC GADS reporting requirements:

   - Configuration (Pedigree) Data –

     Company, Site, Plant, Unit
     OEM (main equipment supplier)
     Model
     MW Rating (ISO Conditions) (International Organization for Standardization)
     Site Conditions
     Others...

   Note: The configuration or pedigree data are essential for defining units of like model, design, or operation. The configuration data tracks the engineering design to meaningful equipment levels. This is important for defining "peer groups" for benchmark comparison of operational performance.

   - Operating Data –

     Service Hours
     Reserve Standby Hours
     Starts (successful, attempted, testing)
     Megawatts
     Site Ambient
     Others...

   Note: To the largest degree possible, process data from either the plant SCADA (Supervisory Control and Data Acquisition) or a central remote monitoring facility on a turbine by turbine basis will be required. This will provide the optimum automated approach for collecting data that can be transformed into time, capacity, and energy values.

The objective is to capture the appropriate and most complete set of data tags, or process points, and equipment faults available from the SCADA, without imposing any requirement for additional sensors. The objective is to define and develop logical transformations of the points into time, capacity, and energy values. These transformations will define service hours, standby hours, megawatt hours, wind speed and other relevant site ambient conditions, start-up and shutdown, lockouts, and other important operational and process parameters.

- Event (outage) Data –

  Planned, Unplanned, and Forced outages (based on the outage classification)
  Major Inspection Activity (time to perform and interval)
  Concurrent Maintenance, Non-curtailing Events, and Deratings
  Outage Cause, Symptoms, and Corrective Actions (narrative/description)
  Others...

  Note: The outage classifications will be consistent with the existing SPS structure, and will be made compatible with the NERC GADS requirements. However, it is expected that required changes or additions to the outage classification will be required to address faults and automatic resets.

  Data from CMMS and lock-out/tag-out systems will provide useful information pertaining to outage events. In addition, outage descriptions may be supplemented by various attachments (pictures, drawings, plant outage reports) for comprehensive assessment of symptom, corrective action, and root cause of outage events.

- Counter Readings –

  Service Hours
  Stops/Starts
  Equivalent Operating Hours/Maintenance Factors
  Others...

  Note: Counter readings are taken to track the aging characteristics of the turbine. The issue of age for a wind turbine and/or other key equipment will require tracking by serial number of critical components like the gearbox. This will require parts tracking capability to a serialized part number level.

- Other Data Reporting –

  Part Replacements
  Major Equipment Removals
  Compliance with Manufacturer Service Bulletins

Testing Details
Others...

2. The ORAP database contains a standard equipment coding "taxonomy", based on EPRI's "Equipment Breakdown Structure" (EBS), developed and maintained by SPS. This breakdown structure is based on a hierarchical structure: major system, system, component group, and component. This provides the opportunity to develop an equipment taxonomy that is modifiable and expandable based on introduction of new technology. These equipment codes are also fully compliant with the European Kraftwerk-Kennzeichensystem (KKS) standard and can accommodate multiple coding structures.

   The fundamental design structure of the EBS allows field data to be reported at the necessary level to characterize the cause of plant downtime; usually defined based on a symptom or corrective action. The impact of outage events, on a frequency and duration basis, can be easily grouped at any level based on this hierarchical structure.

   These standard codes are at a significant level of detail. The codes provide an approach for organizing and categorizing outage events (both maintenance and forced outages) for detailed statistical and engineering analyses. Sufficient data is obtained to identify design and/or operating and maintenance issues at a component level. This level of detail will be essential to meet the goals of identifying reliability issues and constraints that must be resolved through product development and improvement.

   <u>Note</u>: The equipment taxonomy EBS must be developed to meet the overall project objectives. Independent work already performed by SNL, NERC, and SPS will provide a strong basis for developing a standard architecture. The various wind turbine models (based on OEM, size, and other technical differences) will be used to develop the existing technology matrix. This will then provide the basis for developing the standard taxonomy (see Figure 2).

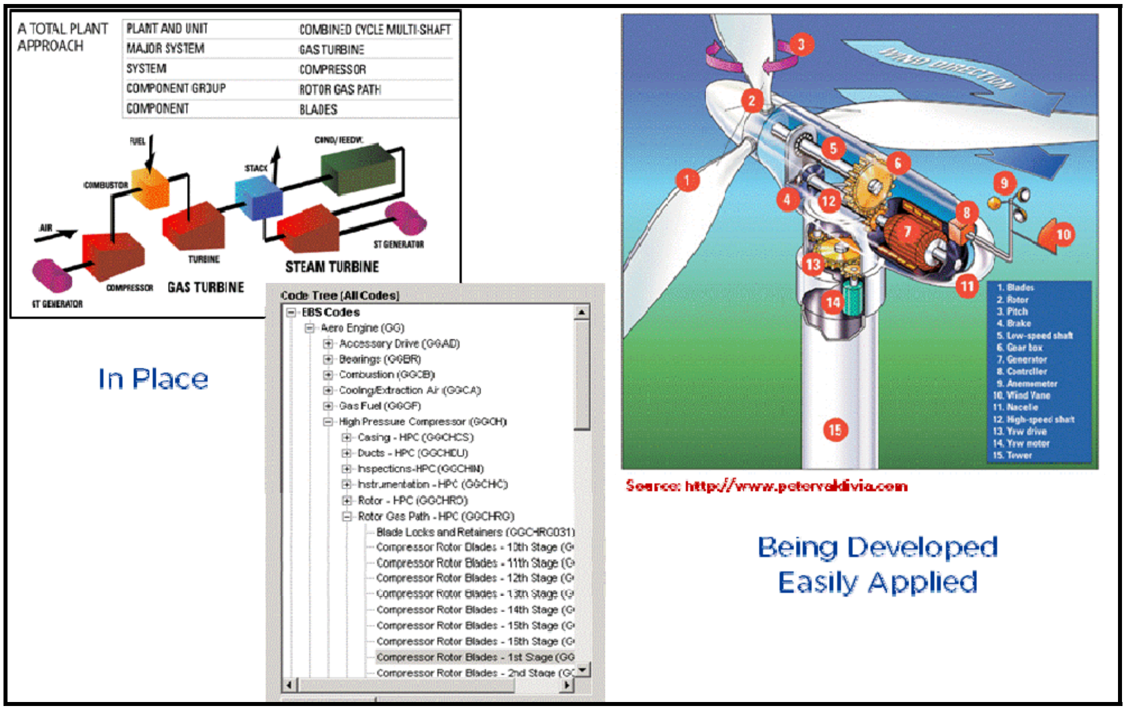

Figure 2: Deriving Wind Plant Taxonomy – Equipment Breakdown Structure

3. ORAP data is received on a monthly basis (at minimum) for timely assessment of operational reliability and availability at the unit level. ORAP is capable of dealing with near "real time" control system data using patented data transformation logic developed by SPS. SPS processes require timely, comprehensive, and accurate feedback from participating plants on a scheduled basis.

   The database has a flexible design to quickly modify or add new data fields as required and to support anticipated differences required with wind technology without having to significantly change the underlying design.

4. Engineering review, edit, and validation of all reported data (automated and manual) is conducted to ensure the completeness and accuracy of reported data.

   Note: Data validation is a CTQ requirement. The data validation begins at the various operating plants, as well as being an essential process for adding data to the ORAP database. To the largest degree possible, validation of the data must be automated, with sufficient and comprehensive checks put in place to ensure data quality.

5. ORAP has full data input reporting capability using both local and distributed personal computer (PC) or Internet based reporting. A specific design objective relative to the collection of data from the operating plants is simplicity, minimum human effort, maximum automation, and scalability. It is a CTQ requirement that the data flow to the ORAP database

for processing and direct flow to the SNL CREW database, and to the degree required, NERC GADS and various ISO's (Independent System Operators).

6. A reporting data warehouse for quarterly and on-demand statistical reporting is also part of the ORAP system. The reporting database structure covers both individual turbine generators and the total plant with data ready for reporting on both a "unit year" and "pooled statistics basis". With ORAP as the fundamental building block, SPS has developed a family of robust, interactive decision support tools that significantly enhance the process of capturing field data at the unit and plant level. Through an on-line Web based process called ORAP Interactive, direct access to the ORAP database provides an effective means for reporting and analysis of the data and transformed information (see Figure 3). SPS developed these tools to provide owner/operators, OEM's, and those with a vested interest in the energy industry the ability to achieve operational excellence through effective asset management. These same processes, procedures, and core competencies will be applied as ORAP is expanded for wind.

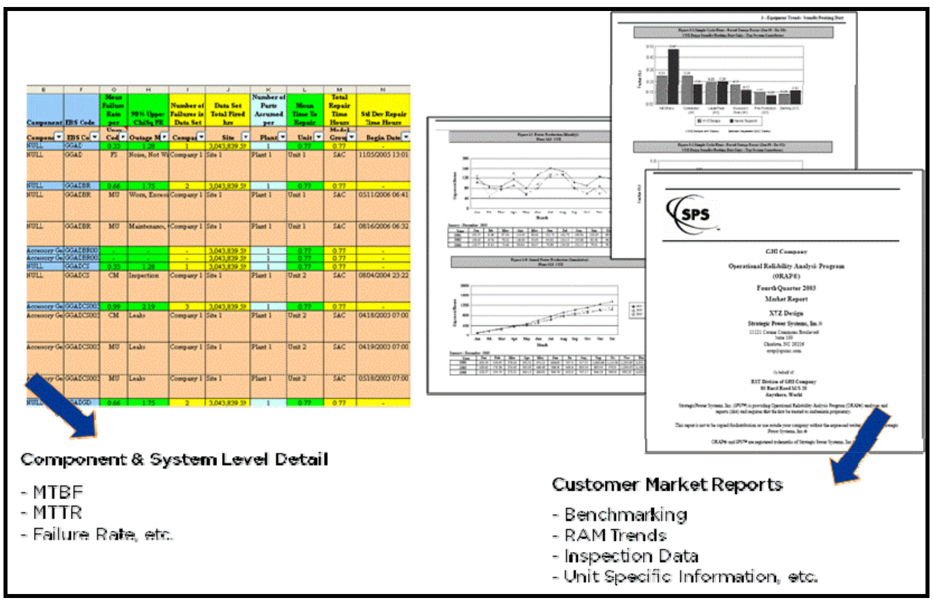

Figure 3: Reporting – Value to Stakeholders

Clearly, leveraging ORAP for wind is feasible. The infrastructure is in place to ensure a successful design and development effort for deployment of ORAP for wind.

CRITICAL-TO-QUALITY FUNCTIONAL REQUIREMENTS

The following specific critical to quality (CTQ) functional requirements must be considered and fully addressed to establish the optimum design; ORAP for Wind:

1. Must be at the individual turbine level (including groups and subgroups) with roll-up to the total plant.

2. Must understand plant arrangement and operational issues from an engineering perspective (influences on data capture).

3. Must recognize and protect the proprietary nature of specific owner/operator data.

4. Must be fully compliant with IEEE 762 and ISO 3977 for time and capacity/energy based data requirements (i.e. pedigree, operational, event, counter, capacity, energy, ambient) and measurements (i.e. metrics). Also, the design efforts made by the NERC WTWG must also be considered to ensure that data requirements will be met.

5. Must consider and be compliant with the IEC reliability standard (time and energy) when released to the industry for application.

6. Must obtain SCADA (and/or control system) data points/tags and faults/alarms automatically at a desired scan rate/frequency (no manual effort (push vs. pull) – and no invasion/intrusion on SCADA). This data must cover both the complete plant and substation(s).

7. Must consider and be compliant with the IEC standard that will address standardizing SCADA data points/tags and faults/alarms.

8. Must develop a scalable approach for archiving the SCADA data points/tags and faults/alarms as required and for some acceptable period of time for future review and reference.

9. Must develop and utilize transformation logic to process the data point/tags and faults/alarms to develop accumulators of time, capacity/energy, and events.

10. Must obtain outage event data from available CMMS and/or lock-out/tag-out systems at a desired rate/frequency (manual effort should be minimized). It is recognized that some manual effort will be required. This data must cover both the complete plant and substation(s).

11. Must consider streamlining a CMMS version for owner/operators not using an off-the-shelf product. This would be required to provide manual input capability to capture meaningful outage event details.

12. Must develop a scalable approach for archiving the CMMS and/or lock-out/tag-out data as required and for some acceptable period of time for future review and reference.

13. Must develop and utilize transformation logic to process the CMMS and/or lock-out/tag-out data to determine the beginning and ending of events (outage duration), as well as the symptom, corrective action, and the root cause of the event.

14. Must develop an equipment breakdown structure (taxonomy) consistent with SPS' standard (major system, system, component group, and component). The ability to add, edit, modify, and delete codes must be provided. It is expected that EBS codes for specific wind turbine models will be developed to then derive a generic taxonomy. Must include KKS translation (input and reporting).

15. Must consider ReliaWind project efforts and results, including taxonomy and benchmark reporting.

16. Must revise current ORAP data collection process for symptom, corrective action, and root cause. Input process should define whether the outage description provided represents symptom, corrective action, and root cause (all can be reported). The equipment breakdown structure code must be captured for each.

17. Must consider impact of capturing the symptom, corrective action, and root cause on reporting.

18. Must assess and determine the value of capturing and/or making changes to the Outage Mechanism Code (OMC). The OMC code is used in the existing ORAP system in a limited manner. The OMC is used specifically for sorting data and reporting specific failure modes. Additional OMC codes and possibly other uses will be required for wind.

19. Must develop (unite) data on a turbine/plant month basis (at a maximum – hourly/ daily/weekly also available) to develop/roll-up unit year data.

20. Must develop automated and manual data validation routines to identify issues, data errors, and ensure data quality.

21. Must provide ability to add, delete, and modify data to ensure validity of all types/classes of transformed data.

22. Must ensure full security of data transfer and database access.

23. Must ensure strong internet based communications for high speed and secure data transfers from plant/central monitoring center and SPS.

24. Must minimize the need for additional hardware (servers) at the plant or at a central monitoring center.

25. Must develop the process for aggregating data for meaningful reporting (at the right level of detail and metrics), including benchmark reports for owner/operators. This must support "data partners" with information consistent with their specific level of data provided.

26. Must develop the approach for access to reports through ORAP Interactive (internet based). This must support "data partners" with information consistent with their specific level of data provided.

27. Must develop the data transfer requirements for the SNL CREW database. It is expected that this will include, but not be limited to: performance history of each turbine, power output, wind speed, wind direction, wind conditions and a complete set of downtime events, including associated symptoms, root cause and corrective actions.

28. Must consider the NERC WTWG efforts to ensure capability of providing required data to NERC and to various ISO's (Independent System Operators).

29. Must consider off-shore issues and logistical concerns.

30. Must consider the unavailability types to be consistent with the existing SPS structure, and with the NERC GADS requirements. It is expected that required changes or additions to the outage classification will be required to address faults and automatic resets specific to wind plants.

These critical to quality functional requirements must be executed in an efficient manner to provide value and to ensure scalability. The specific requirements will be organized into the following major categories so that the specification and the work performed can be further developed in an efficient manner (see Table 1).

Table 1: Functional Requirements – Major Categories

Topic	Specific Issue Number
Taxonomy Definition	14, 15
Review All Standard(s) – RAM Metrics	4, 5, 7, 22, 23, 30
Automated Data Collection (ADC) & Transformation Logic	1, 2, 3, 6, 8, 9, 10, 12, 13, 19, 22, 23, 24, 29
Modification to ORAP Data Entry Tools	11, 16, 18, 30
NERC Export	22, 23, 26, 28
CREW Export	22, 23, 26, 28
Data Validation & Populating Reporting Database	20, 21, 23, 24
Reporting	15, 17, 19,22, 23, 25, 26
Documentation Plan	User & System Doc. Begins in Detailed Design
Hardware & Security	22, 23, 24

DISTRIBUTION

Kurt Anderson
Upwind Solutions
3555 Lear Way
Medford, OR 97504

Mark Anderson
Centennial Power, Inc.
1150 West Century Avenue
PO Box 5558
Bismarck, ND 58506

Warren Ault
LM Glasfiber ND Inc.
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Larry Barr
enXco
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Tracy, CA 95377

Phillip O. Barry
NAWRTC at Mesalands Community College
911 South Tenth Street
Tucumcari, NM 88401

Rashi Bates
Shell Wind Energy
150 N. Dairy Ashford
Bldg C, Room 334C
Houston, TX 77079

Fred “Doc” Beasom
NextEra Energy
7021 Oak Creek Road
Mojave, CA 93501

William Beecher
AES Wind Generation, Inc.
P.O. Box 581010
North Palm Springs, CA 92258-1010

Benjamin Bell
Garrad Hassan America, Inc.
45 Main Street, Suite 302
Peterporough, NH 03458

Harvey Benes
Nebraska Public Power District
PO Box 310
402 East State Farm Road
North Platte, NE 69103-0310

Glen Benson
AWS Truewind LLC
463 New Karner Road
Albany, NY 12205

Daniel W. Bernadett
AWS Truewind LLC
463 New Karner Road
Albany, NY 12205

Roy Blackshear
AEP, Desert Sky Wind Farm Lp
PO Box 518
Iraan, TX 79744

Eckart Bodenbach
Winergy Drive Systems Corporation
950 Tollgate Road
Elgin, IL 60123

Ken Bolin
XCEL Energy
1225 17th Street, #483
Denver, CO 80202-5534

Dan Brake
NextEra Energy
700 Universe Blvd
Juno Beach, FL 33408

Geoffrey Bratton
JP Morgan Capital Corporation
10 South Dearborn Street
Chicago, IL 60603

Sandy Butterfield
Boulder WindPower
209 Boulder View lane
Boulder, CO 80304

Luis Cerezo
EPRI
1300 West WT Harris Blvd
Charlotte, NC 28262

Jon N. Chafin
Wind Hunter
821 East Dove Loop Road, Suite 2425
Grapevine, TX 76051

Craig Christensen
Clipper Windpower Technology, Inc.
6305 Carpinteria Ave., Suite 300
Carpinteria, CA 93013

Michael Courville
Shell Wind Energy
150 N. Dairy Ashford
Bldg C, Room 334C
Houston, TX 77079

Martin C. Crotty
Upwind Solutions
3555 Lear Way
Medford, OR 97504

Mike Curley
NERC
116-390 Village Blvd.
Princeton, NJ 08540

Ted De Rocher
Caithness Operating Company, LLC
9790 Gateway Dr., Suite 220
Reno, NV 89521

Tracy Deadman
AES Wind Generation
4300 Wilson Boulevard
Arlington, VA 22203

Salvatore A. DellaVilla
Strategic Power Systems, Inc.
11016 Rushmore Drive
Frenette Building Suite 275
Charlotte, NC 28277

Edgar DeMeo
Renewable Energy Consulting Services
2791 Emerson St.
Palo Alto, CA 94306

Chris E. Derickson
Nebraska Public Power District
PO Box 310, 402 East State Farm Road
North Platte, NE 69103-0310

Carlos J. Diaz
Edison Mission Energy-Midwest
Generation EME, LLC
440 South LaSalle Street, Suite 3500
Chicago, IL 60605

John R. Dunlop
American Wind Energy Association
448 Morgan Avenue South, Suite 300
Minneapolis, MN 55405

Philip K. Dutton
206 Reveille Road
Austin, TX 78746

Marc Dworkin
Reunion Power LLC
PO Box 2049
Manchester Center, VT 05255

Scott Eatherton
AES Wind Generation
14740 Altamont Pass Road
Tracy, CA 95391

Ahmed Elgamal
University of California-San Diego
9500 Gilman Drive #0085
San Diego, CA 92093-0085

Neal Emmerton
Bluarc Management Group LLC
777 Tahquitz Canyon Way, Suite 200-13
Palm Springs, CA 92262

Energy Research Centre of the Netherlands
T.S. Obdam
PO Box 1
1755 ZG Petten
The Netherlands

Miguel Ezpeleta
Acciona Wind Energy USA, LLC
101 North Wacker Drive, Suite 610
Chicago, IL 60606

Margaret M. Ganczak
Vestas Americas
1881 SW Naito Parkway, Suite 100
Portland, OR 97201

Jeff Gibbons
AES Wind Generation, Inc.
P.O. Box 581010
North Palm Springs, CA 92258-1010

Ben M. Givens
American Electric Power
1423 CR 131, Trent Wind Farm, L.P.
Trent, TX 79561-3029

Miguel Angel Gonzalez-Posada
Gamesa
2050 Cabot Blvd. West
Langhorne, PA 19047

AnneMarie Graves
Garrad Hassan America, Inc.
11770 Bernardo Plaza Court, Suite 209
San Diego, CA 92128

Randall Grayson
enXco
215 111th Street
Lake Wilson, MN 56151

Gary Hackett
Portland General Electric Company
121 SW Salmon Street
Portland, OR 97204-2908

Bruce Hamilton
PPM Energy, Inc.-A Scottish Power Company
1125 NW Couch, Suite 700
Portland, OR 97209-4129

Bruce Hammett
WECS Electric Supply, Inc.
Box 580276, 19465-3A N. Indian Avenue
North Palm Springs, CA 92258-0276

David A. Healy
MidAmerican Energy
666 Grand Avenue, PO Box 657
Des Moines, IA 50309-2506

James Heenan
GE Energy
2 Central Quay, 89 Hydepark Street
Glasgow, G3 8 BW
Great Britain

Bill Holley
GE Wind
GTTC, 200-D
300 Garlington Road
Greenville, SC 29615

James Holly
BP Alternative Energy North America Inc.
501 Westlake Park Boulevard
Houston, TX 77079

Peter Hjuler Jensen
Riso National Laboratory
Station for Wind Turbines, Box 49
DK-4000, Denmark

Desiree Johnson
Iberdrola Renewables
1125 NW Couch St, Suite 700
Portland, OR 97209

Thomas Jonsson
iQwind LLC
8208 NW 30th Terrace
Miami, FL 33122

Gary Kanaby
Knight & Carver Yacht Center
2423 Hoover Avenue
National City, CA 91950

Morten Karulf
ABB Danish Wind Team
Meterbuen 33
8382 Skovlunde
Denmark

Carl Knowlan
Horizon Wind Energy
808 Travis Street, Suite 700
Houston, TX 77002

Clifford Lange
Structural Integrity Associates, Inc.
5215 Hellyer Ave. Suite 210
San Jose CA, 95138

Benjamin Lanz
IMCORP
179 Middle Turnpike
Storrs, CT 06268

Scott Larwood
1120 N. Stockton St.
Stockton, CA 95203

S. Doug Levitt
CalWind Resources Inc.
2659 Townsgate Rd. #122
Westlake Village, CA 91361

Steve Lockard
TPI Composites, Inc.
373 Market Street
Warren, RI 02885-0367

James Locke
AIRBUS North America Engineering, Inc.
213 Mead Street
Wichita, KS 67202

James Lyons
Novus Energy Partners
201 North Union St., Suite 350
Alexandria, VA 22314

Shaw Makaremi
Clipper Windpower
6305 Carpinteria Ave.
Carpinteria, CA 93013

Ninochska Maldonado
enXco
3896 Begonia Street
Palm Beach Gardens, FL 33410-5608

Lance Manuel
University of Texas at Austin
1 University Station, C1748
Austin, TX 78712

Shane Mawhinney
B9 Energy (O&M) Ltd.
Willowbank Road
Milbrook Industrial Estate
Larne, Co. Antrim
N. Ireland, BT402SF
United Kingdom

Brian McNiff
McNiff Light Industry
43 Dog Island Road
Harborside, ME 04642

Glenn Melski
Enel North America, Inc.
One Tech Drive, Suite 220
Andover, MA 01810

Jim Mikel
Energy Maintenance Service, LLC
PO Box 158
Gary, SD 57237-0158

Steve Mikel
Suzlon Wind Energy Corporation
620 3RD Avenue
Pipestone, MN 56164

Amir Mikhail
Clipper Windpower Technology, Inc.
6305 Carpinteria Ave., Suite 300
Carpinteria, CA 93013

Laura Miner
Invenergy LLC
One South Wacker Drive
Suite 1900
Chicago, IL 60606

Jim Morgan, LCDR, USN
Mesalands Community College
911 South Tenth Street
Tucumcari, NM 88401

Larry Mumper
SKF USA Inc.
1510 Gehman Road, PO Box 332
Kulpsville, PA 19443-0332

Walt Musial
NREL/NWTC
1617 Cole Boulevard MS 3811
Golden, CO 80401

Juan Nasiff
NextEra Energy
700 Universe Blvd
Juno Beach, FL 33408

Ross Newlin
enXco
3818 Aspenwood Drive
Richmond, TX 77469

NWTC Library (5)
NREL/NWTC
1617 Cole Boulevard
Golden, CO 80401

Tim Olsen
Tim Olsen Consulting
1428 S. Humboldt St.
Denver, CO 80210

Terry Oswald
Horizon Wind Energy
808 Travis St., Suite 700
Houston, TX 77002

Francicso Oyague
National Renewable Energy Laboratory
1617 Cole Bldv. MS 3811
Golden, CO 80401

Venkata Subbaiah Pasupulati
Oak Creek Energy Systems, Inc.
14633 Willow Springs Rd.
Mojave, CA 93501

Robert Z. Poore
DNV-Global Energy Concepts
1809 7th Ave., Suite 900
Seattle, WA 98101

Jon Powers
CalWind Resources, Inc.
2659 Townsgate Road #122
Westlake Village, CA 91361-2738

Pep Prats
Ecotecnia
Roc Boronat 78
8005 Barcelona
Spain

Kenda Ransom
Strategic Power Systems, Inc.
11016 Rushmore Drive
Frenette Building Suite 275
Charlotte, NC 28277

Dave Roberts
OSI Soft
777 Davis Street, Suite 300
San Leandro, CA 94577

Dan Rottler
Puget Sound Energy
PO Box 97034, PSE-09S
Bellevue, WA 98009-9734

Paul Rowan
MLS Electrosystem
9333 Timber Trail
Pittsburgh, PA 15237

Rene Rysbergen
B9 Energy O&M Ltd
Millbrook Industrial Estate
Larne, Northern Ireland
BT40 2SF, United Kingdom

Jeanfils Saint-Cyr
Strategic Power Systems, Inc.
11016 Rushmore Drive
Frenette Building Suite 275
Charlotte, NC 28277

Matt Sakurada
BP Wind Energy
130 N. Steele St., Suite A
Sanford, NC 27330

Manny Sanchez
NextEra Energy
700 Universe Blvd
Juno Beach, FL 33408

Michael Schmidt
Iowa Lakes Community College
19 South 7 Street
Estherville, IA 51334-2234

Kevin Schroeder
Invenergy LLC
One South Wacker Drive
Suite 1900
Chicago, IL 60606

Shawn Sheng
National Renewable Energy Laboratory
1617 Cole Bldv. MS 3811
Golden, CO 80401

Brian Smith
NREL/NWTC
1617 Cole Boulevard MS 3811
Golden, CO 80401

Sandy Smith
Utility Wind Integration Group
PO Box 2787
Reston, VA 20195

Robert F. Steele Jr.
Strategic Power Systems, Inc.
11016 Rushmore Drive
Frenette Building Suite 275
Charlotte, NC 28277

Cece Sterling (10)
Office of Wind and Hydropower Technologies
EE-2B Forrestal Building
U.S. Department of Energy
1000 Independence Ave. SW
Washington, DC 20585

Phil Stiles
Acciona Energy North America Corporatiion
333 West Wacker Drive, Suite 1500
Chicago, IL 60606

Bahvahnie Suppiah
OGE Energy Corp.
P.O. Box 321, M/C 504
Oklahoma City, OK 73101-0321

Andrew Swift
Texas Tech University
Civil Engineering
PO Box 41023
Lubbock, TX 79409-1023

Bob Szymanski
enXco
17298 Commerce Way
Tracy, CA 95377

Kedian Taborn
Strategic Power Systems, Inc.
11016 Rushmore Drive
Frenette Building Suite 275
Charlotte, NC 28277

Britt Theismann
American Wind Energy Association
1101 14th Street, NW, 12th Floor
Washington, DC 20005-5601

Michael Tyson
Suzlon Wind Energy Corp.
8750 W. Bryn Mawr Ave., Suite 720
Chicago, IL 60631

William A. Vachon
W. A. Vachon & Associates
PO Box 149
Manchester, MA 01944

Case P. van Dam
Dept. of Mechanical & Aerospace Eng.
University of California at Davis
One Shields Avenue
Davis, CA 95616-5294

Paul Veers
National Renewable Energy Laboratory
1617 Cole Bldv. MS 3811
Golden, CO 80401

Chris Walford
Puget Sound Energy
PO Box 97034, PSE-09S
Bellevue, WA 98009-9734

Carsten Westergaard
Vestas Technology
440 Louisiana St., Suite 400
Houston, TX 77002

Charles White
B9 Energy (O&M) Ltd.
Willowbank Road
Milbrook Industrial Estate
Larne, Co. Antrim,
N. Ireland, BT402SF
United Kingdom

Eric White
AWS Truewind LLC
463 New Karner Road
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