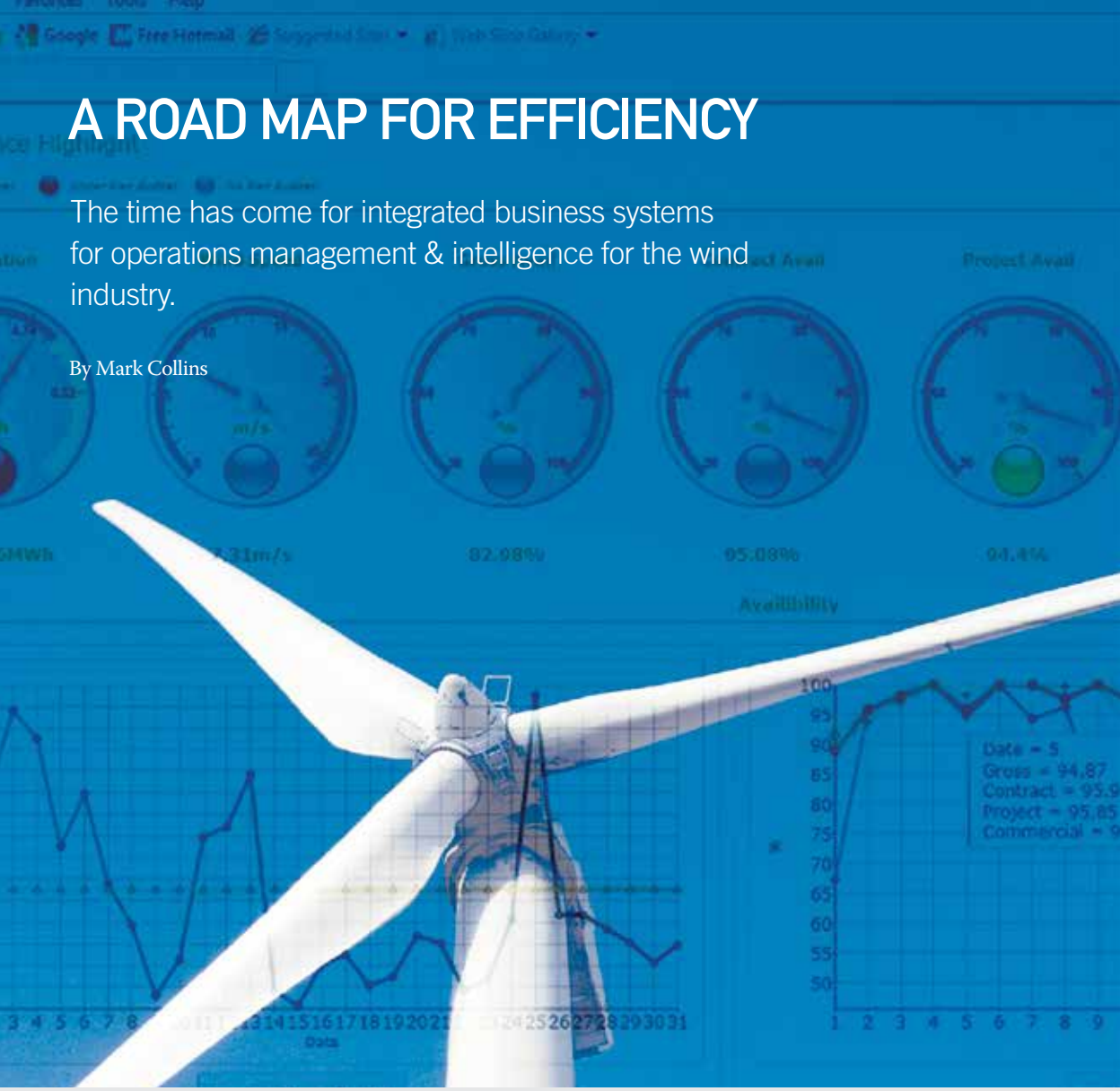
A ROAD MAP FOR EFFICIENCY

The time has come for integrated business systems for operations management & intelligence for the wind industry.

By Mark Collins



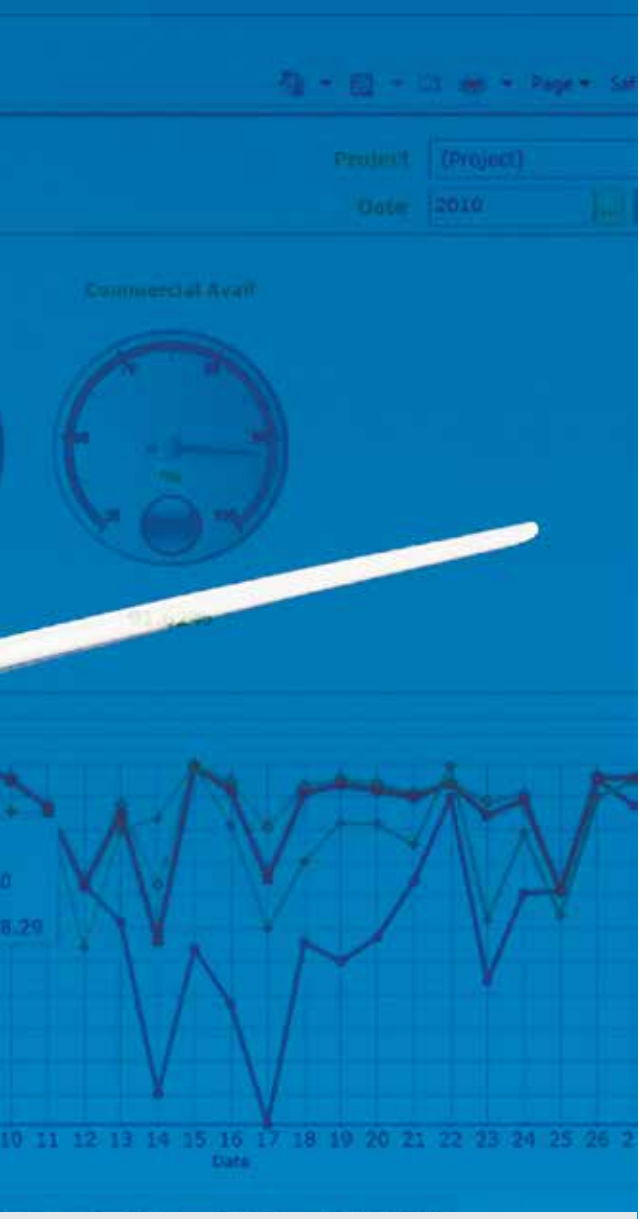
Mark Collins is the President of Ekhosoft. He can be reached at (425) 922-1900, or by email at mark.collins@ekhosoft.com. For more information about Ekhosoft and the Ekho for Wind software, call (450) 462-8105 Ext 111.

THERE HAVE BEEN MANY SIGNIFICANT advances in software for the wind energy industry over the past decade. A search of the Internet reveals hundreds of different software products for the wind industry, covering specific topics such as: site selection, wind forecasting, turbine design, wind data analysis, wind farm modeling and visualization, and flow modeling, among others. These are primarily engineering and design tools. While they are important in their own right, they do not help in the day-to-day operation of the business.

You can also find standalone products from other industries for applications such as: project management, maintenance & spares inventory, health and safety, land lease and royalty payments, and contract management, as well as standard enterprise resource planning (ERP) solutions for accounting and finance, which can be applied to any industry.

However, this same search does not return a single result for an integrated solution for the overall management of wind farm operations—a solution that would bundle together all of the required operations management and intelligence applications into a single, integrated solution for running the business.

This situation has also existed—and has been successfully addressed—in other industries. Initial solutions tended to be "point solutions," which were focused on a specific topic.



Over time, problems developed with duplication of data and processes, and there were difficulties in integrating the different "islands of automation."

Further solutions were later developed to address these problems, initially in discrete manufacturing, and subsequently in process industries. In those industries today, we see two very important developments which have resulted in the elimination of the problems:

- The creation of standards for deploying information systems
- The development of integrated solution maps for the required applications.

As a result, software companies started building integrated solutions, with industry-standard interfaces. In manufacturing today, there is a wide selection of integrated solutions available to the benefit of all prospective customers.

These same developments need to be brought into the Wind Industry.

DEVELOPMENT OF STANDARDS

A key example of standards for manufacturing systems is ISA 95, as seen in Figure 1.

These same levels of automation exists in the wind industry. While significant progress has been made at the lowest level by integrating sensors and SCADA systems, as well as standard ERP solutions for accounting and finance, little has been done in developing integrated solutions for the middle layer—operations management and intelligence.

SOLUTION MAP

The time has come to specify a similar solution map for the wind industry, in which:

- all of the functions required for operations management (running the business) are addressed;
- the solution provides the operational intelligence for performance management;
- the system is built around a common, shared database;
- the solution provides seamless integration of related systems and data from operations (SCADA, data historians), with the business systems (ERP, financials), as well as the Internet (forecasting and pricing).

The following represents an initial proposal for the desired content of a solution map for an operations management and intelligence system for the wind energy industry.

Just like the ISA 95 standard for the manufacturing industry, the standard model for the wind industry should consist of five layers, as outlined in Figure 4. Here, the solutions in Levels 1, 2 & 4 are well developed. The balance of this section will focus on the application needs for Level 3 – Operations Management & Intelligence. The individual modules are grouped into subsystems under the headings of "Generation," "Maintenance," "Health & Safety," "Accounting & Reporting," "Performance Management," and "Technology." The proposed solution map calls for a common data structure, and for integration between all of the modules. This is accomplished through the use of a common set of foundation modules.

FOUNDATION MODULES

The foundation modules include the basic building blocks to configure the system for use, and include: Asset Hierarchy; Event Manager; Performance Criteria; Electronic Logs; Alarms and Notifications; and KPI (key performance indicator) Manager.

- Asset Hierarchy—This module allows the user to manage overall asset hierarchy, from organizational units

(company, geographical unit, division, plant, etc.) down to equipment, sub-assemblies, and components. There is no limit to the number of levels the user can create in the hierarchy. The asset hierarchy module is the backbone of the software solution—against which all performance criteria, events, and activities are structured. This solution seamlessly integrates with other standard industry solutions [ERP, computerized maintenance management systems (CMMS) and data historians] to provide the information on asset availability to all foundation modules and application modules

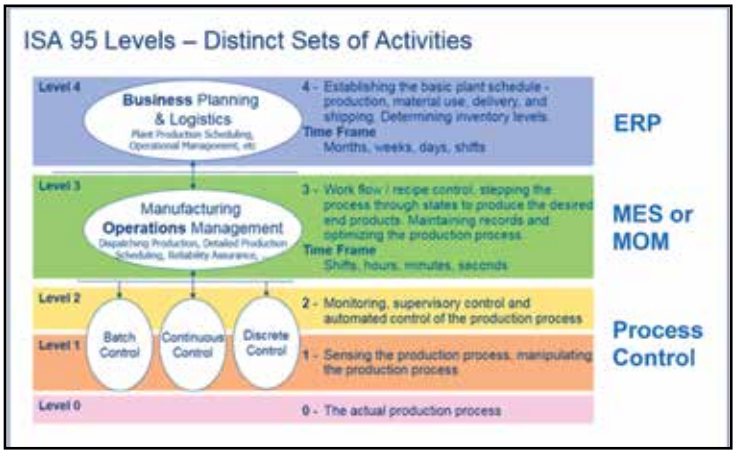


Figure 1: ISA 95 manufacturing standards.

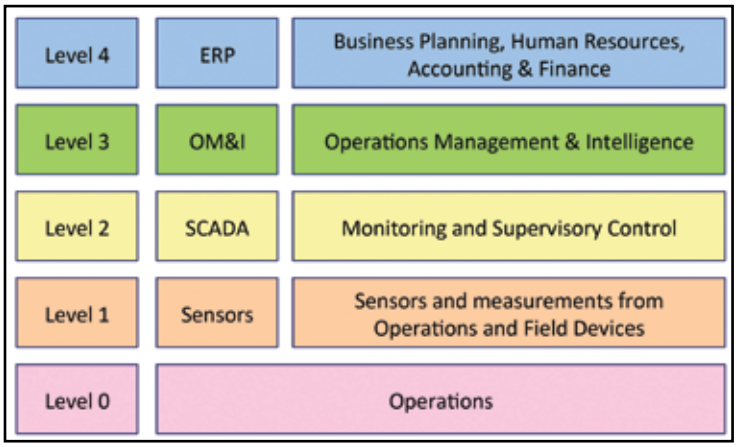


Figure 2: Layered structure of proposed wind energy solution map.

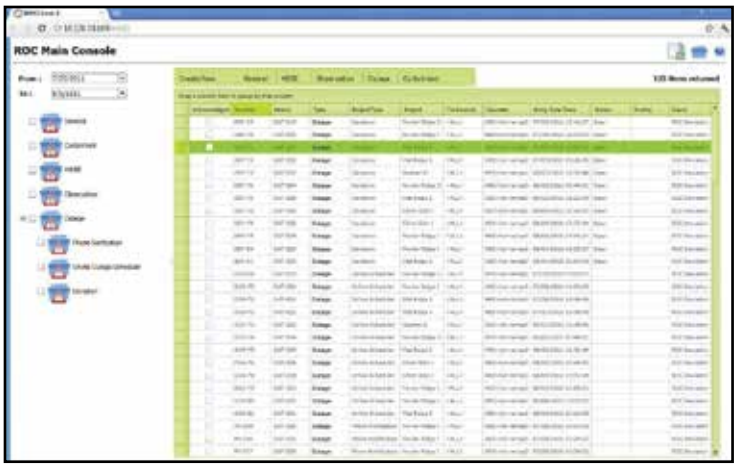


Figure 3: Screenshot–Electronic Logs.

- Event Manager—Operating and non-operating events within the organization are detected, recorded, and communicated through the Event Manager Module. This module (Figure 10) is suited for monitoring operating events that cannot be tracked manually or with traditional system alarms. It can also capture events either electronically or manually. This module automates and highlights unusual conditions, and notifies the user when these events occur. As a result, the user is able to reduce operating costs and improve yields with fast, effective follow-up, while improving regulatory compliance, reducing incidents, and analyzing events.
- Performance Criteria—Once the Asset Hierarchy has been established and attention switches to collecting data for analyzing performance, the targets, standards, or metrics for the different events (performance criteria), must be established. Examples include: the rated output of the wind turbine for different wind speeds; expected operating temperature for wind turbine gearbox oil; and the schedule for preventive maintenance tasks. Performance Criteria can also be established for the business—for expected daily generation; target for real-time energy prices; and other daily, weekly, monthly, or annual statistics.
- Electronic Logs—This module provides an electronic log framework (Figure 3) to allow users to make log entries under predefined categories such as safety, environment, and operating procedures, among others. The log entries should be supportable with any digital media (voice, pictures, videos).
- Alarms and Notifications—The Alarms and Notifications engine is intended to notify users that any predefined situation may be developing or occurring. Notifications can be sent via email or text message. The

Figure 4: Screenshot–Generation.

software includes an escalation function should there be no response within a predefined time frame.

- KPI Manager—This module provides a real-time solution framework for the collection, analysis, and calculation of key performance indicators. The KPI Manager delivers accurate and timely information the user needs in order to enhance visibility into operations and increase the efficiency and effectiveness of resources. It provides accurate key performance indicator data throughout the organization, allowing everyone to drive performance improvement initiatives. The KPI Manager rolls up low-level performance indicators (such as unit-specific production generation) to high-level business objectives (e.g. site productivity or asset utilization). Users can quickly drill down to view actual performance measures and respond appropriately.

GENERATION MANAGEMENT MODULES

The modules in Generation Management are related to tracking electricity generation and downtime and include: Generation, Downtime, Outage Management, Generation Forecast, and Lost Generation Analysis.

- Generation—Generation data—collected from SCADA systems through the data historian or other central collective—is tracked by individual asset, summarized, and presented in real-time display (Figure 4). This data can be used for comparisons to specifications, or comparisons between equivalent units.
- Downtime—This module pro-

vides tracks all downtime events—planned or unplanned, imposed or self-induced. These events are captured either manually or automatically, and include the capability to code events by different fault codes (e.g. manufacturer, O&M, NERC, PPM). The user should be able to review and modify all events captured in the system. Displays (Figure 5) to review event logs, as well as charts to analyze downtime by turbine, component, fault code, etc., should be included.

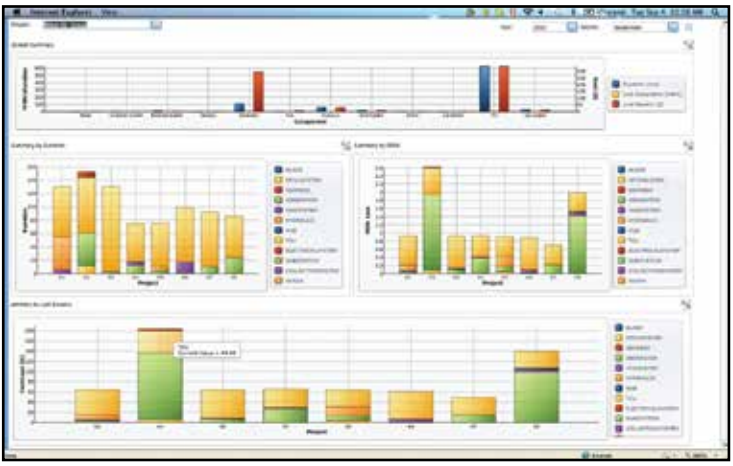


Figure 5: Screenshot–Downtime Analysis.

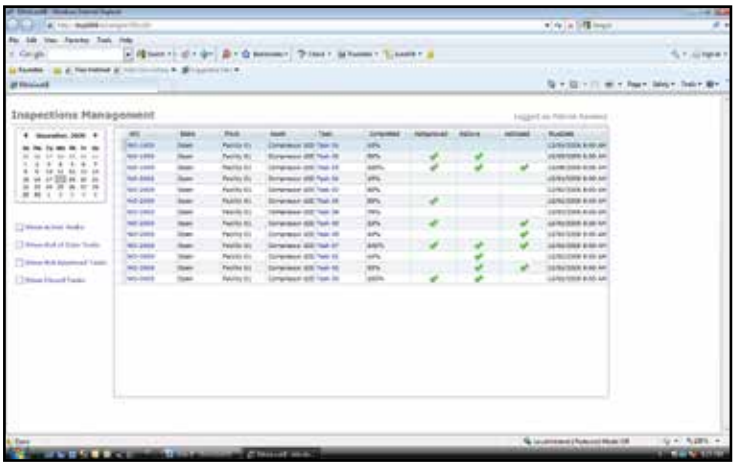


Figure 6: Screenshot–Inspection Tours.

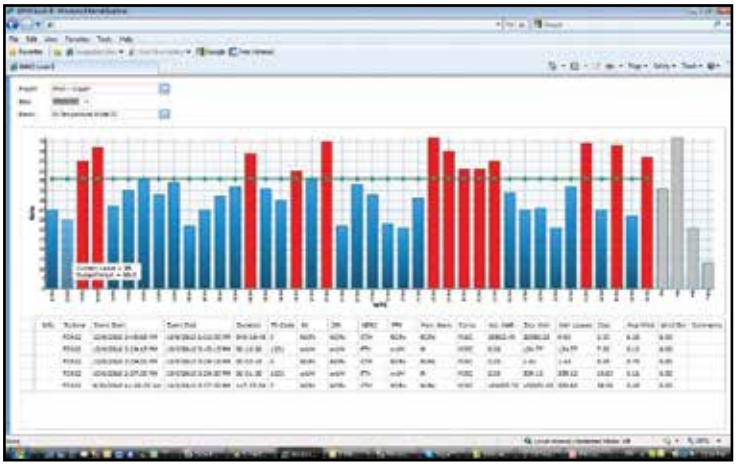


Figure 7: Screenshot–Condition Monitoring.

- Outage Management—This application supports logging and tracking of site outages—planned and unplanned—and captures generation and resource availability at the time of the outage, while triggering required notifications or work orders. This increases visibility of outage information across the organization; ensures that key personnel are notified of outages; captures critical information associated with an outage; and ensures the required procedures are followed for bringing a unit back online.
- Generation Forecast—An environmental forecast is brought into the system from a third-party provider. This information is used to calculate the expected generation from each asset, considering known outages for maintenance or curtailment. The generation forecast can also be converted to a financial forecast based on market or contact prices.
- Lost Generation Analysis—This module allows the user to analyze and categorize all lost generation, both in terms of lost production and lost revenue. Standard reporting categories in the industry are: generation, gross availability, contract availability, project availability, and commercial availability. The solution must also consider downtime related to curtailment or maintenance. The loss analysis should use pricing from contract actual agreements, or real-time pricing from the Web. (Figure 9)

MAINTENANCE MODULES

The modules for maintenance functionality are those related to planning, coordinating, and tracking maintenance activity, and include: Equipment Records, Maintenance Information, Work Orders, Inspection Tours, Condition Monitoring, and Spares Inventory.

- Equipment Records—This module allows the user to maintain a

complete hierarchical record of all operating equipment. There should be no limit to the number of levels in the hierarchy, and the asset hierarchy should include all subcomponents (e.g. sub-assemblies and parts). Ideally, the Equipment Records module also points to digital records of the equipment such as engineering drawings, pictures, and operating manuals.

- Maintenance Information—Detailed information should be associated with the equipment records, specifying the maintenance work to be done, the interval between service, the job skill requirements, and the spare parts and tooling required for the work.
- Work Orders—The system should support work orders for different types of activity, such as inspection tours, corrective maintenance, and preventive maintenance. The work orders should clearly identify the following: equipment involved; safety procedures to be followed; repairs to be made; parts and tools required; and the expected start and completion date of the work.
- Inspection Tours—This function (Figure 6) allows the user to use printed reports or mobile devices to specify safety or maintenance inspection requirements to field personnel. With mobile devices, the user can easily communicate maintenance tasks (safety procedures, job steps, drawings, etc) to field personnel, who in turn can use the device to indicate task completion, record verbal comments, or take photographs and videos of the situation.
- Condition Monitoring—This mod-

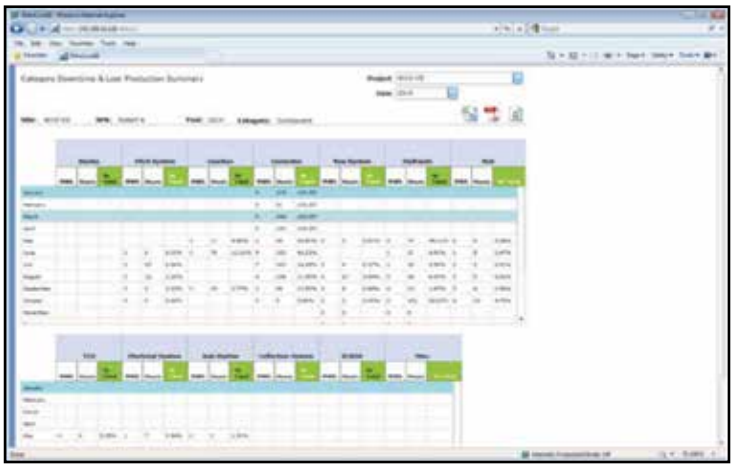


Figure 8: Screenshot–NERC GADS Reporting.

ule (Figure 7) allows the user to collect condition data from the operating units, comparing this data standard or expected values. It also triggers any necessary alarms, alerts, notifications, or work orders. The system should handle any type of condition measures, including vibration analysis, oil sample analysis, bore hole photography, and dynamic loads, while coordinating this information with other system data (e.g. weather conditions, generation data).

- Spares Inventory—Here, the user can track the quantity and location of all spare parts, subassemblies, or tools, along with the associated information for procurement. The module should also allow for tracking equivalent parts or allowable substitutions. In the case of repairable or re-usable parts, the module should also allow for tracking usage history of such parts.

Figure 9: Lost Generation Analysis.

Figure 10: Screenshot– Event Viewer.

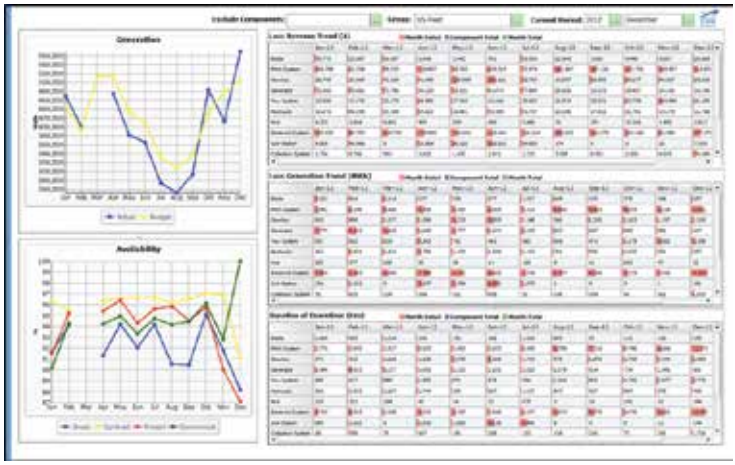


Figure 11: Screenshot–Management Dashboard.

HEALTH AND SAFETY MODULES

- Incident Tracking—Our incident tracking application allows you to enter new incidents and assign them to the right personnel for investigation and resolution. It classifies incidents in a variety of categories enabling powerful search capabilities and flexible reporting.
- Work Place Hazards—This application assists workplace safety professionals in documenting workplace and material hazards, and in recording a complete history of the hazard investigations and assessments. It covers job safety analysis, ergonomic analysis, lockout/tagout, and risk assessment. It also allows the user to record any events and analyze them using the root cause analysis application.
- Compliance Management—Provides the user the ability to make compliance programs repeatable, sustainable, and cost-effective. Compliance Management provides a common framework and an integrated approach to manage all compliance requirements faced by an organization. It enables companies to manage cross-industry mandates and regulations such as SOX, OSHA, EH&S, and FCPA, as well as industry-focused regulatory guidelines from FDA, FERC, FAA, HACCP, AML, Basel II, and Data Retention laws.
- OSHA Reporting—This application allows the user to track all health and safety issues, material and workplace hazards, and risk assessments, and has the capability to generate all OSHA standard

reports. The module can easily track safety investigations and audits, while also providing the ability to record the costs associated with safety incidents. In addition to standard reports, this module lets the user create personalized dashboards and analytical reports to optimize reporting.

- Environmental Issues—This module provides users a means to track all issues related to the environment in one central system. It allows you issues related to land use, track oil spills and waste disposal, and track issues related to wildlife and birdlife. The software can also track the noise created by wind turbines operating in different wind conditions.

ACCOUNTING AND REPORTING MODULES

The modules in Accounting and Reporting are those related to executing accounting tasks, as well as providing in-house and statutory reporting about operations, above and beyond the functionality ERP solutions provide, and include: Energy Settlements, Lease and Royalty Payments, NERC GADS Reporting, Revenue Forecasting, Day Ahead Training, and Warranty Management.

- Energy Settlements—All Generation and downtime information is paired with metered data and pricing information to calculate Energy Settlements. Pricing data can be taken from contracts or from real-time pricing on the Web, and can also be used to value losses from downtime events.
- Land Lease & Royalty Payments—This application tracks all of the agreements for the user's operating assets. It manages contracts for land lease and royalty payments, automatically triggering payments for any period and/or frequency. It also allows the user to preview the complete output to ensure accuracy and completeness prior to transferring the data into an accounting system.
- NERC GADS Reporting—The application should be programmed to generate the reporting requirements specified by the North American Electric Reliability Corporation (NERC) Generating Availability Data System (GADS). It allows users to gather and verify event and performance data, as well as analyze (Figure 8) current and historical event and performance data, including energy availability, outages, and demand factors.
- Revenue Forecasting—The revenue forecast application allows the user to import weather condition forecasts, and then calculate a generation forecast

using the historical performance of each asset (taking into consideration all planned maintenance outages, curtailment, or other planned outages). It also translates data into revenue forecast by accessing contract pricing stored in the system, or by accessing real-time pricing data on the web.

- Day-Ahead Trading—Comparing forecasting module information with customer power commitments, the software can predict anticipated surplus generation for a future time period. This surplus can then be offered on the day-ahead trading market at asking price.
- Warranty Management—This module allows the user to monitor all assets under warranty, tracking work performed and replacements made during the warranty period. This includes tracking parts or sub-assemblies that have been removed, repaired and put back into service as warrantied parts on other turbines. This system should be put in place well before the equipment comes out of warranty, so equipment records are established and the maintenance tracking procedures are in place.

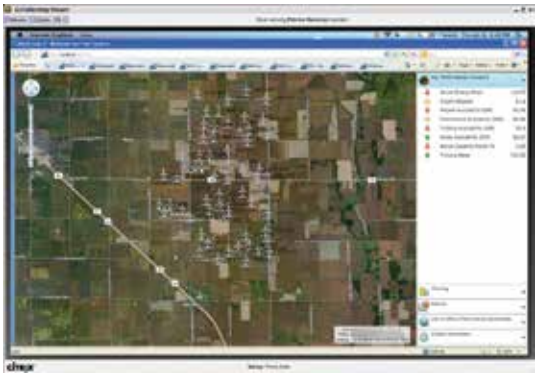


Figure 12: Screenshot–Visualization.

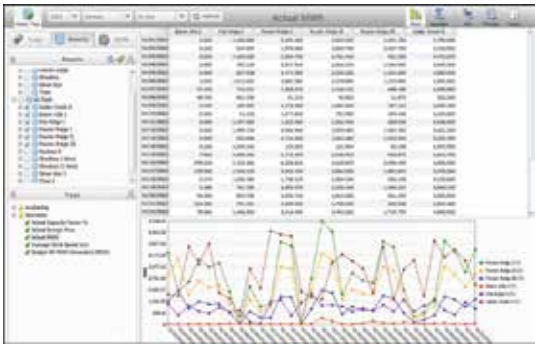


Figure 13: Screenshot–Data Mining and Analysis.

PERFORMANCE MANAGEMENT

The modules for Performance Management are those related to collecting, analyzing, and reporting on all data across the organization, and include: Operational Planning, Capacity Analysis, Performance Analytics, Comparative Reporting, Root Cause Analysis, and Activity Tracking.

- Operational Planning—This enables improvement of operational planning capability through increased visibility of key site-related data. It consolidates critical operations data into a single, centralized location for visualization and analysis. Planned and unplanned downtime events, scheduled and unscheduled outages, and weather forecast data are all centralized into a single, consolidated system that can provide the insight needed to enhance operational planning.
- Capacity Analysis—Gaining insight into project capacity can dramatically increase the profitability of renewable asset(s). Whether it is individual wind turbine power curve or an entire wind farm's peak power, the capacity analysis application provides the operator with the ability to understand how well assets are performing in relation to their rated capacity.
- Performance Analytics—Allows the user to create performance summaries for all operating assets, including measures such as gross, contract, and commercial availability, performance to manufacturer's standards,

SOFTWARE FUNCTIONALITY FOR OPERATIONS MANAGEMENT & INTELLIGENCE FOR WIND FAMRS						
Performance Management	Operational Planning	Capacity Analysis	Performance Analysis	Comparative Reporting	Root Cause Analysis	Activity Tracking
Accounting & Reporting	Energy Settlements	Land Lease & Royalty Payments	NERC GADS Reporting	Revenue Forecasting	Day Ahead Trading	Warranty Management
Health & Safety	Incident Tracking	Work Place Hazards	Compliance Management	OSHA reporting	Safety Inspections	Environmental Issues
Maintenance	Equipment Records	Maintenance Information	Work Orders	Inspection Tours	Condition Monitoring	Spares Inventory
Generation	Generation Data Capture	Downtime	Power Curve Analysis	Outage Management	Lost Generation Analysis	Generation Forecast

Table 1: Completed solution map for Operations Management.

UNDERLYING TOOLS AND TECHNOLOGY						
Visualization	Design Studio	Map Overlays	Summary KPI's	Drill Down Capability	Configurable Dashboards & Reports	Mobile Support
Foundation Modules	Asset Hierarchy	Attribute Definition	Event Manager	Performance Criteria	Electronic Logs	KPI Manager
Underlying Technology	Interface to SCADA	Interface to Data Historian	Interface to Business Systems	Interface to the Web	Messaging Network	Mobile Technology

Table 2: Intelligence for wind farm management.

and comparative performance. The software should support hundreds of thousands of data calculations, generating actionable intelligence to support performance improvement initiatives and the pursuit of increased ROI.

- Comparative Reporting—One of the key benefits of an information system independent from a particular vendor's SCADA system is that it allows the user to consolidate and compare data from different units. This can be accomplished by establishing codes for normalizing data from different sources. Examples include using fault codes from multiple vendors, and comparing performance of similar turbines in different areas versus the prevailing wind speeds in those areas.
- Root Cause Analysis—The root cause application should serve an accountability function. It enables the user to analyze structures, prioritize corrective actions, and track progress. This ensures that resources are focused, to avoid performance losses. Root Cause Analysis improves problem resolution with automatic and precise downtime logging, tracks implementation of recommendations, and allows the user to assesses effectiveness of recommendations.
- Activity Tracking—Projects are defined and broken down into specific tasks, including responsibility, start/end dates, priority, targeted results, and risk evaluation. Daily updates can be viewed both on a per project basis as well as in schedule performance charts. Hierarchical management of data allows authorized viewing up the organizational ladder. Impact of change activities can be measured over time.

Software supports drill down to source data.

ADDITIONAL FEATURES

- Design Studio—The Design Studio allows for creation and/or modification of displays and reports within the system. The user can also configure customized KPI's, as well as create custom modules within the software.
- Visualization—The software should provide tools for visualization (Figure 12), including map overlays, a dashboard object library, dashboard/report templates, and a library of pre-defined KPI's.
- Import/Export—The software should allow the user to import data from external systems (e.g. bulk loading specific turbine fault codes, or importing regional wind forecasts). The software should also allow exporting of data to related systems, as well as the export of on-screen content to Excel or PDF formats.
- Interfaces—This includes the software required for interfacing with other related business systems, SCADA systems, data historians, or the Web.
- Mobile Technology—With the exponential growth of mobility and due to the distributed nature of the wind energy assets, it is imperative that the system solution utilize mobile technology. Alerts and notifications should be transmitted to mobile devices. Dashboards, performance summaries, and KPI's should be visible on smartphones and tablet computers.
- Messaging Network—This module allows users to have better interaction with the platform's data flow. By providing a push-and-pull mechanism, users are able to experience enhanced interaction with module applications and faster notifications from any computer, or device connected to the Messaging Network.
- Data Mining & Analysis—The software should allow for ad hoc data mining and querying of the data, making selections by asset, event type, tag status, or tag information. Results should be presentable in tabular form or in charts (Figure 13), and the user should be able to perform "what if" analyses or causal analyses on the resultant data.

THE END PRODUCT

If we summarize all of the preceding information into a single model, we end up with the solution map for Operations Management and Intelligence for wind farm management, outlined in Tables 1 and 2.

Hopefully this will be viewed as a viable first step in the creation of an overall model for Wind Farm Information Systems. Ekho for Wind, from Ekhosoft, has been developed in accordance with this proposed standard model. The author welcomes feedback and suggestions on the proposed model, and is open to inquiries about Ekho for Wind.