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# CMMS in the Wind Industry

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## Abstract

Through a wide variety of activities and interactions, Sandia has observed limited adoption of electronic work orders in the wind industry. To explore some of the contributing factors for this limited adoption, the CREW team looked to other industries to determine whether there are limitations in the tools sets available to the wind industry. To increase the insight into Computer Maintenance Management Systems (CMMS) or Enterprise Asset Management (EAM) systems, Sandia identified Management Resources Group, Inc. (MRG) to develop a report that will incorporate their many years of experience in industries like automotive, mining, gas and oil, and power generation. This report will review some of the software tools available for use in the wind industry. This report is one of the steps in driving a culture change toward the electronic collection of accurate work order data and the developing a “full data picture”.

## Foreword

To benchmark the current U.S. wind turbine fleet reliability performance and identify the major contributors to component-level failures and other downtime events, the Department of Energy (DOE) funded the development of the Continuous Reliability Enhancement for Wind (CREW) database by Sandia National Laboratories (Sandia). The CREW database uses high resolution Supervisory Control and Data Acquisition (SCADA) data. The SCADA data values come from the Strategic Power Systems, Inc. (SPS) automated data collection software tool, which gathers a variety of operating data from each turbine in its program. CREW also uses SPS' summarized ORAPWind® (Operational Reliability Analysis Program for Wind) data, which consists of downtime and reserve event records and daily summaries of operating time. This data is analyzed and used to guide DOE's research and development investment through identification of critical issues and technology improvement opportunities (TIOs). Additionally, through the Sandia's Wind Turbine Reliability Benchmark Report, published annually in the fall, the wind industry is able to assess their own reliability and performance against the US wind fleet and target their improvement activities to enhanced profitability.

In an effort to further understand the major contributors to failure and downtime, the CREW team began a wide variety of activities to gain access to work order data. This data should be recorded by the technician during the performance of inspections, maintenance and repairs. The work orders should detail the work performed during a period that the turbine is offline (a downtime event) and thereby provide additional data to the root cause that resulted in the downtime event. To make this data a powerful source of information for the plant operator, and to make it accessible to any larger analysis efforts, the work order data needs to be stored in an electronic format that can be gathered through automated collection tools. Through a wide variety of activities and interactions, Sandia has observed limited adoption of electronic work orders in the wind industry.

To explore some of the contributing factors for this limited adoption, the CREW team looked to other industries to determine whether there are limitations in the tools sets available to the wind industry. To increase the insight into Computer Maintenance Management Systems (CMMS) or Enterprise Asset Management (EAM) systems, Sandia identified Management Resources Group, Inc. (MRG) to develop a report that will incorporate their many years of experience in industries like automotive, mining, gas and oil, and power generation. This report will review some of the software tools available for use in the wind industry.

This report is one of the crucial steps in informing our industry and furthering the CREW team's goal to serve as "full picture" data champions to the wind industry, and thereby drive a culture change toward the electronic collection of accurate work order data.

Alistair Ogilvie and Valerie Peters

Continuous Reliability Enhancement for Wind (CREW) database  
Wind Technologies Department  
Sandia National Laboratories

# CMMS in the Wind Industry

## Exploring the Capabilities of Maintenance Management Systems in the Wind Industry

Submitted On: October 12, 2012  
Prepared For: Sandia National Laboratories  
Prepared By: Management Resources Group, Inc.



## Summary Report-

### *CMMS in the Wind Industry*



**Submission Date:** 10/12/2012

**Submitted To:** Sandia National Laboratories (SNL)

**Attention:** Alistair Ogilvie / SNL Wind Reliability Lead

**Submitted By:** Management Resources Group, Inc. (MRG)

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**Topical Area:** Computerized Maintenance Management System (CMMS) /  
Enterprise Asset Management (EAM) systems for Wind Energy Assets

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## Section One: Executive Summary



### The Wind Energy Industry

Despite declines in unit-level costs, the annual U.S. wind operations and maintenance (O&M) spending is estimated to double to nearly \$6 billion by 2025, according to a press release dated July 10, 2012 by IHS, a leading business analyst firm.

Many agree that the primary elements affecting O&M costs are the expenses associated with scheduled maintenance and the costs of unscheduled maintenance. There is a delicate balance between excessive scheduled maintenance that incurs unnecessary costs and too little maintenance that results in unscheduled downtime and lost revenue.

According to our research, many U.S. wind turbines are approaching the end of their warranty periods. This looming expiration is creating pressure for wind site owners to determine whether to use their own internal maintenance resources moving forward or to employ external assistance from either OEM organizations or third-party independent service providers (ISPs).

The overall lack of historical data available to accurately identify required maintenance task intervals is further complicating the decision. According to an article in *Windpower Monthly*, “mass production of wind turbines on an industrial scale is not yet a full decade old, and few turbine models have operated in large numbers for more than a handful of years. Robust operational data remains a relatively scarce commodity, and even expert technicians have been reliant on little more than anecdotal data regarding what component is likely to fail when on which turbine, or how trouble can be averted before it happens.”<sup>1</sup>

### The Importance of Maintenance

The impact that the maintenance organization has, whether positive or negative, can be enormous. Maintenance has a wide-reaching influence, affecting everything from profitability, safety, environmental compliance, asset life, and schedule commitments to the organization’s customers and associated reputation and good will.

In this competitive, global economy, many organizations have implemented a number of cost-effective measures in an attempt to protect eroding profit margins and declining market share. Now wise and proactive companies are turning to maintenance and evaluating the impact of improvements made in that area. The good news is that there are generally many viable benefits that the maintenance function can provide to bottom-line profitability.

Some areas of potential improvements include:

- Implementing a fully functioning CMMS/EAM system
- Obtaining and maintaining accurate equipment data
- Conducting equipment criticality ranking
- Adopting a sound reliability-centered maintenance strategy

<sup>1</sup> David Milborrow, *Breaking Down the Cost of Wind Turbine Maintenance*, *Windpower Monthly*, <http://www.windpowermonthly.com/news/1010136/Breaking-down-cost-wind-turbine-maintenance>, (15 June 2010).

- Developing a sound preventive and predictive maintenance program
- Creating and continuously improving informative job plans
- Implementing planning and scheduling
- Developing a secure and effective spare parts program
- Providing required and effective maintenance training
- Identifying and frequently measuring pertinent metrics and KPIs

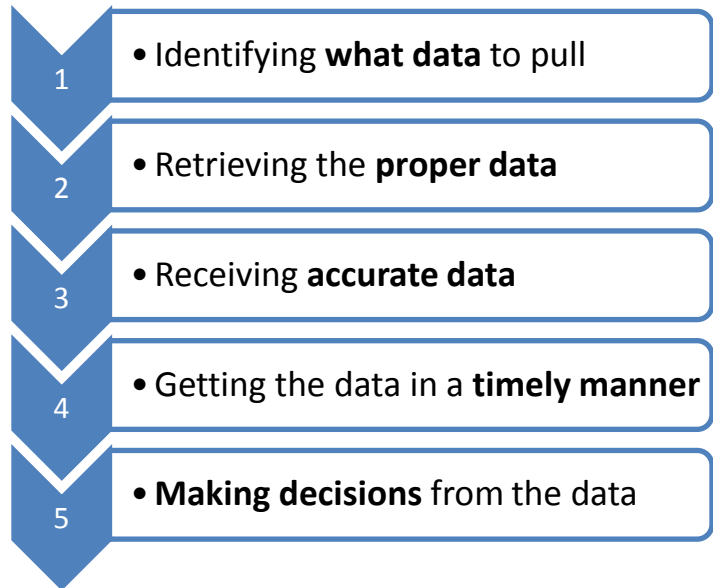
**The Importance of CMMS to Manage Maintenance**

It is well reported that the under utilization of maintenance software systems is very common. Although the estimated utilization rates vary among analysts, a reoccurring range of successful implementations averages between 20 to 60 percent. This dismal achievement level is anything but successful. One contributing factor is that there is often a lack of maintenance comments recorded on completed PMs and work orders, and when there are comments, they are not being properly reviewed to improve tasks the next time.

Documenting equipment history can have a significant and positive impact on an organization. According to David Berger, a recognized CMMS/EAM system expert, “Many senior management teams have come to the realization that, given the aging workforce being replaced across North America with younger, less experienced technical resources, modern knowledge management tools such as a CMMS/EAM are critical to help smooth the transition. These tools retain much of the knowledge lost when technicians and other maintenance staff retire or leave, for example, standard operating procedures and job plans, failure analysis data, diagnostic techniques and a complete asset history. Furthermore, younger technical resources have come to expect these tools, and are comfortable and proficient in their use.”

Other key areas where CMMS/EAM systems are being used effectively are associated with spare parts management, labor and cost tracking, identification of potential redesign or re-engineering opportunities, a repository for equipment manuals and drawings, etc.

When it comes to data management, this can be viewed as a progressive, five-step process:





### **Properly Selecting & Implementing CMMS/EAM in the Wind Industry**

There is a perfect storm brewing within the wind industry between the number of turbines expiring from their warranty programs and the minimal equipment history data available to implement optimal maintenance task frequencies. As a result, the CMMS/EAM system a wind energy site selects is extremely important. It has been our experience that the keys to being successful in such an initiative include:

- Establishing a sound, knowledgeable representative team
- Developing a detailed user requirements specification and vendor RFP
- Identifying any/all work processes that need to be improved prior to implementing the new system
- Conducting a thorough review of the final software candidate's system, including navigating through the test database/sandbox
- Closely reviewing the number of and type of canned reports and report writers
- Determining the amount and type of training required for site personnel to effectively use the system
- Ensuring the system implementation is fully functioning and that users are actually using the system in the manner designed
- Ensuring that the help desk support is meeting needs

While there are many other important attributes, this is a process and, as such, a successful outcome will require a great deal of time, energy, and attention to detail. This is not a silver-bullet solution. Unfortunately, over the years MRG has seen many organizations take a quick-fix approach only to fail miserably with this critical initiative. The CMMS/EAM system is the nucleus of the maintenance organization and requires a thoughtful and methodical approach to ensure that it is fully functioning and meeting management expectations.

Make using the CMMS/EAM part of the corporate culture. This component is critical to the system's success. Change is hard, and it is often met with great resistance, so it is important to address the cultural aspect of getting people to accept and follow the process. Employees need to accept and embrace the process, and that momentum stems from the sustained excitement of company leadership and an understanding of the value the system offers. When users perceive genuine enthusiasm from management and witness the many benefits the CMMS/EAM has to offer, they will be more likely to engage in the new process, and using the system will become habit. When users develop the habit of using the system, the company will benefit.

A properly selected, installed, and well utilized CMMS/EAM system can play a significant role in achieving critical goals at wind turbine generating sites.

### **An Encouraging Call to Action**

As a consulting firm with decades of experience in the maintenance community, we have tackled the challenges of effectively implementing maintenance software solutions across a broad range of industries, and we recognize the important opportunity that lies before your

organization. To aid Sandia National Laboratories (SNL) in this critical decision, we recommend your thoughtful consideration to the following key items:

- Continue to educate your internal team on sound best practices, and paint a clear picture that provides a vision and direction that the team can understand and support. Consider plugging the team into various industry-leading maintenance organizations and conferences. An educated team is a motivated body that can aggressively pursue realistic gains.
- Make a commitment to partnering with industry leaders in both the maintenance and wind arenas. Aligning your organization with the best vendors, service providers, trainers, and consulting organizations will pay large dividends in the long run, and the information your personnel will glean from those relationships will help you avoid costly mistakes.
- Select, implement, and utilize an integrated maintenance software system. Choose a champion who will select a team that will work tirelessly to ensure the best processes are mapped out and later used by the system that is selected and implemented.
- Adopt best maintenance practices, including reliability-centered maintenance, predictive maintenance, non-destructive testing, root-cause failure analysis, and continuous monitoring.

Identifying the optimal maintenance strategies and improving performance and equipment reliability are key elements to maximizing production and minimizing costs. A commitment to these best practices will ensure the blades will turn whenever the wind is blowing.

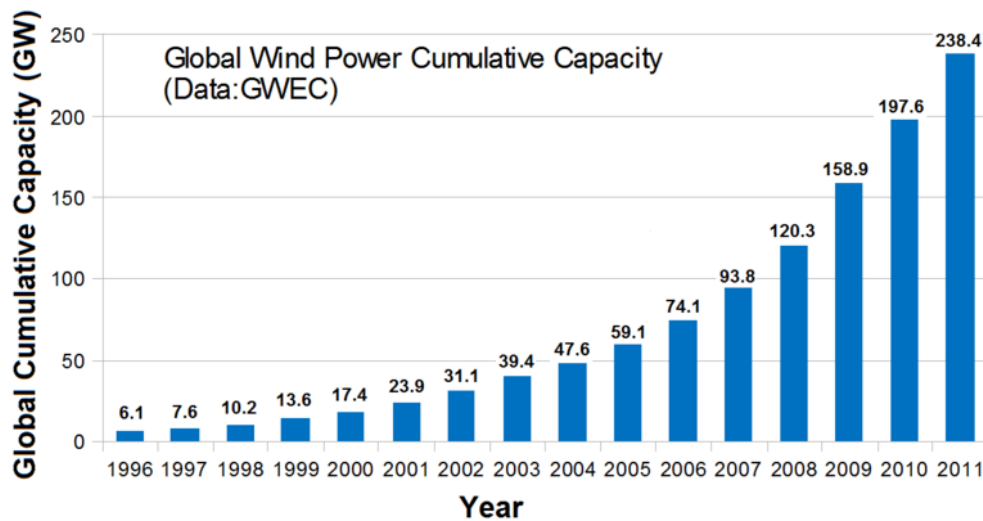
Section Two: Introduction



With an estimated \$40 billion worth of wind installations in the United States reaching the end of Original Equipment Manufacturer (OEM) warranty periods, operations and maintenance has become one of the most talked about issues in terms of maintaining profitability and reliability, while attempting to keep pace with increasing electrical generation demands. It has been stated that the U.S. wind industry has just reached a tipping point because last year more operational turbines came out of manufacturer warranties than remained under them.<sup>2</sup> This leaves operations management to make important decisions about how to best deal with the new, and potentially costly, responsibility of maintaining turbines.

The industry closed out last year with numbers that suggest a strong 2012, with approximately 50,000 megawatts (MW) of wind power capacity installed in the United States and another 8,300 MW of wind power under construction as the year began.<sup>3</sup> The need for best practices in safety, diagnosis, repairs, and the use of trained and knowledgeable technicians is becoming more important than ever. The trend for both U.S. and global wind power capacity is sharply rising as illustrated in the graph below.

Figure 1.1<sup>4</sup>



Operations and Maintenance (O&M) costs equate to 20-30% of the total annual costs of a wind turbine. Consequently, wind turbine manufacturers are attempting to reduce these costs by designing new turbines that require fewer service intervals and incur less turbine downtime. A Computerized Maintenance Management System (CMMS) or an Enterprise Asset

<sup>2</sup> Jesse Broehl, *Windpower Monthly Magazine*, <http://www.windpowermonthly.com/channel/plantoperations/news/994730/Operations---maintenance>, (01 April 2010).

<sup>3</sup> AWEA, *U.S. Wind Industry Annual Market Report-2011*, [http://www.awea.org/learnabout/industry\\_stats/upload/4Q-2011-AWEA-Public-Market-Report\\_1-31.pdf](http://www.awea.org/learnabout/industry_stats/upload/4Q-2011-AWEA-Public-Market-Report_1-31.pdf), (January, 2012).

<sup>4</sup> Wikipedia, *Global Wind Power Cumulative Capacity*, <http://en.wikipedia.org/wiki/File:GlobalWindPowerCumulativeCapacity.png>, (2 May 2011).

Management (EAM) system is the ideal electronic means to manage the planning, scheduling, and documentation of required maintenance activities.

Due to the infancy of the wind energy industry, relatively few turbines have reached their 20-year life expectancy. Capturing equipment history data and providing an electronic repository of machine condition, spare parts, and equipment failure data is extremely important at this early stage in the life cycle of these critical assets. Accurate and meaningful data leads to wise equipment care decisions, making it crucial for wind plant owners to implement an effective CMMS or EAM system in their operations.

As Sandia National Laboratories (SNL) has observed limited adoption of electronic work orders in the wind industry, they have been tasked by the Department of Energy (DOE) with championing the increased collection, storage, and analysis of electronic work orders to affect a shift in culture that incorporates meaningful use of work orders. In addition, SNL requires equipment failure history data to assist in Root Cause Failure Analysis (RCFA) activities. Having accurate and detailed asset information will enable SNL to make wise and informed operational and maintenance recommendations in the wind industry. As part of a strategy developed to achieve this task, SNL would like to assess the various CMMS or EAM systems available to the wind industry.

This paper will initially focus on providing good foundational information about CMMS and EAM systems in general and will later expound upon the wind energy market relative to maintenance information systems requirements and solutions. A sound understanding of both maintenance best practices within the wind industry and viable maintenance management software systems will lead to an effective approach for maintaining wind energy assets in this growing market.

**Section Three: Acronyms and Phrases****ac-ro-nym**

*noun* \ˈa-kre-  
,nim\

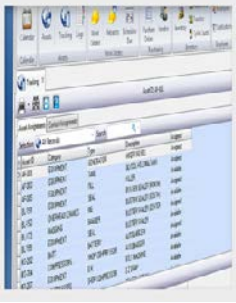
: a word formed  
from the initial  
letter or letters  
of each of the...;

*also* :  
an abbreviation

Some common maintenance industry and maintenance software terms and acronyms that may be used in this paper are:

1. ASP- Application Service Provider
2. BOM- Bill of Materials
3. CMMS- Computerized Maintenance Management System
4. EAM- Enterprise Asset Management
5. ECR- Equipment Criticality Ranking
6. ERP- Enterprise Resource Planning
7. FMEA- Failure Modes & Effects Analysis
8. MRO- Maintenance, Repair and Operations
9. MTBF- Mean Time Between Failure
10. MTTR- Mean Time To Repair
11. P&S- Planning and Scheduling
12. PM- Preventive Maintenance
13. PdM- Predictive Maintenance
14. RCFA- Root Cause Failure Analysis
15. RCM- Reliability Centered Maintenance
16. ROI- Return On Investment
17. SAAS- Software As A Service
18. SME-Subject Matter Expert
19. URS- User Requirement Specification
20. WO- Work Order
21. WR- Work Request

## Section Four: CMMS/EAM System Highlights



### CMMS/EAM Systems

A typical Computerized Maintenance Management System or Enterprise Asset Management system provides a number of different modules that allow users to capture data and perform work in a variety of ways. The difference in features offered by a particular CMMS/EAM system provider is generally found in three categories:

1. Out-of-the-box functionality
2. Functionality that is slightly configured
3. Customized functionality that is provided based on unique requirements

Many regard an EAM as a CMMS on steroids, but that is an oversimplification and does not paint the true picture. Typically, a CMMS deals strictly within the confines of the work order and preventive maintenance activity. Specific functions include:

- Scheduling preventive maintenance based on triggers (such as hours of operation) or timed events (for example, every three months)
- Ensuring probability-based availability repair and spare parts
- Serial number tracking and tracing
- Suggesting and originating the purchase of needed repair parts
- Warranty tracking
- Ensuring availability of manpower resources with required skills and training
- Maintaining an asset registry and repair parts database (i.e., nomenclature, hierarchy structure, where used, support descriptions, etc.)
- Tracking costs of maintaining individual pieces of equipment
- Differentiating and appropriately managing fixed, mobile, and continuous assets
- Recording unexpected events for further analysis
- Conducting a statistical analysis of equipment performance and reliability, and providing a variety of reports from static and dynamic sources (i.e., equipment utilization, equipment downtime, MTBF (equipment mean time between failure), MTTR (equipment mean time to repair), etc.)

EAM software encompasses these functions and, in most cases, extends their capabilities in these areas while offering certain features that can provide additional capabilities and value-added functionality. As seen above, a CMMS solution usually includes purchasing and procurement, inventory management, as well as equipment, parts, and asset tracking. However, CMMS applications typically do not have financial and accounting (other than mere cost recording) or human resource (HR) management capabilities (other than basic staffing needs recognition) and are typically purchased to integrate with the applications that support financial and HR management more deeply. These back-office applications are also typically designed to run at and for a single plant.

The CMMS functionality is thus typically extended to EAM by the addition of financial management modules and more advanced HR management, including creating and

monitoring rosters, and recording and monitoring necessary skills. Technically, EAM applications are also designed to accommodate more users and facilitate running at multiple sites from a single central database, thereby catering better to entire enterprises, rather than departmental or individual plant needs.<sup>5</sup>

The financial management aspects are not usually defined prior to purchasing an EAM, but require a tremendous effort to later define. This includes tie-in functionality or reporting (batch or otherwise) to the financial management software. If the EAM is intended to interact with the ERP or financial management system, it is worthwhile to determine if the EAM fully supports financial needs (cost center, cost codes, machine groupings, general ledger accounting, etc). Most EAMs today support some type of cost accounting, but consideration should be given to whether they tie into specific labor, material, contractor, or event-driven costs associated with maintenance.

Table 4.1 summarizes the typical features found in a CMMS compared with most EAM systems. Although there are certainly exceptions, this generalization depicts the many additional functions that are provided in most EAM solutions.

Table 4.1<sup>6</sup>

Functions and Features	Typically Found In	
	CMMS	EAM
Database structure and hierarchy	✓	✓
Repair parts availability	✓	✓
Manpower resource availability	✓	✓
Purchase requisition	✓	✓
Preventive maintenance scheduling	✓	✓
Cost accumulation and tracking	✓	✓
Inception recording and tracking	✓	✓
Standard and exception reporting	✓	✓
Whole life asset care		✓
Maintenance administration		✓
Predictive maintenance analysis		✓
Maintenance alternatives analysis		✓
Physical asset risk management		✓
Reliability-centered maintenance		✓
Root cause analysis		✓
Financial cost/life analysis		✓
Technical document change management		✓
Strategic usage analysis		✓
Strategic planning for asset management		✓

<sup>5</sup> CMMSCity, *EAM versus CMMS: What's Right for your Company?*, <http://www.cmmscopy.com/articles/eam-versus-cmms-whats-right-for-your-company>, (2012)

<sup>6</sup> Daryl Mather, CMMSCity, *The Total EAM Vision Strategic Advantages in Asset Management*, <http://www.cmmscopy.com/articles/eam-versus-cmms-whats-right-for-your-company>, (2011)

### CMMS/EAM System Functionality

Although a complete list of a system's capabilities may be quite lengthy, the most common CMMS/EAM functions include serving as an electronic repository for the following areas:

- Equipment history information
- Maintenance costs
- Work request and work order management (WO)
- Planning and scheduling functions (P/S)
- Preventive maintenance (PM)
- Predictive maintenance/condition monitoring (PdM)
- Materials management (MRO)
- Purchasing
- Resource management
- Failure analysis data (RCFA)
- Maintenance reports
- Metrics and KPIs
- Report writer or customized reports

The number of underutilized systems currently in use is overwhelming. The Aberdeen report revealed how maintenance software is used and what value these systems deliver to the users to improve effectiveness and efficiency. Consistent with the findings in Figure 4.2<sup>7</sup>, the CMMS Best Practices Study conducted by Reliabilityweb.com in July of 2011 show that work order management, reporting, and inventory functions are very important to users.

Figure 4.3<sup>8</sup> highlights the Top 50% of CMMS features while Figure 4.4<sup>9</sup> captures the Bottom 50% of features. With the proliferation of smart phones today, it is surprising that wireless functions were not more important to respondents. That number is expected to rise in coming years, especially as wireless functionality becomes more available in all systems. The low ranking of the wireless feature may be due to the lack of availability on some of the lesser-known systems. These tables can be found on the following pages, and the study may be downloaded at: <http://www.projetechnology.com/white-papers.html>.

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<sup>7</sup> Julie Rampello, *CMMS Best Practices Study- A Perspective*, [http://reliabilityweb.com/index.php/articles/CMMS\\_Best\\_Practices\\_Study\\_A\\_Perspective](http://reliabilityweb.com/index.php/articles/CMMS_Best_Practices_Study_A_Perspective), (July 2011).

<sup>8</sup> Ibid.

<sup>9</sup> Ibid.



Figure 4.2: Features of Importance- Top 50%

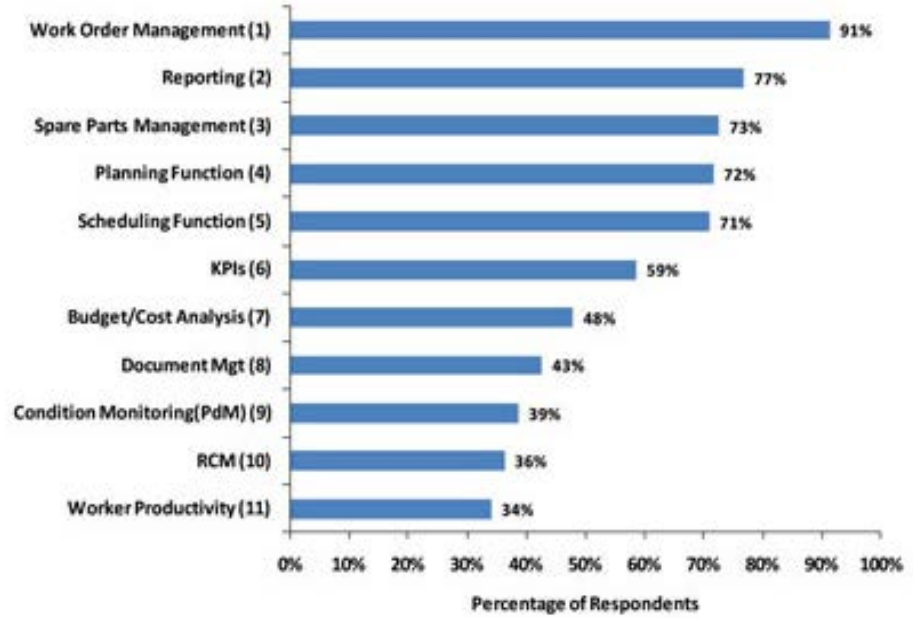


Figure 4.3: Excellent Performance Level- Top 50% of Features

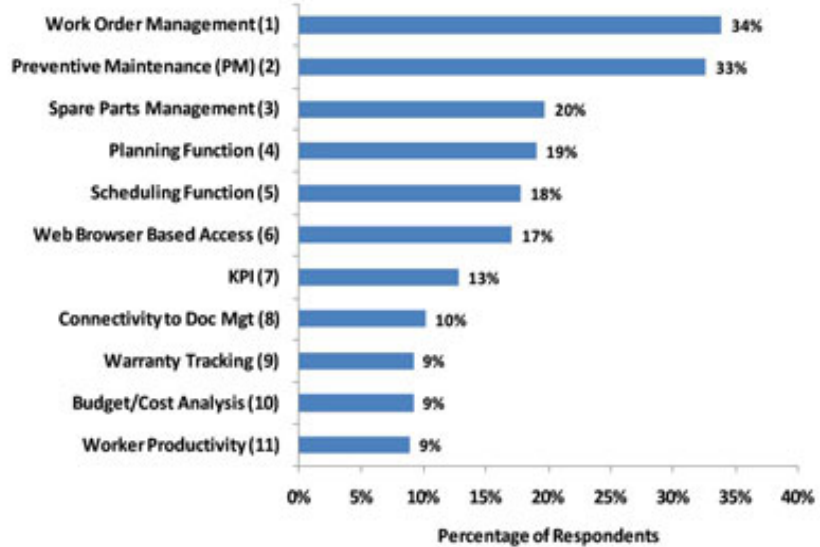


Figure 4.4: Excellent Performance Level= Bottom 50% of Features

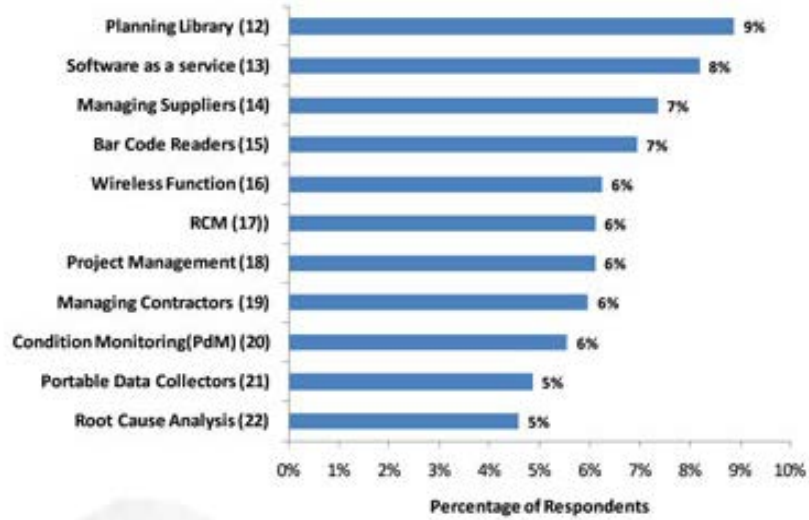
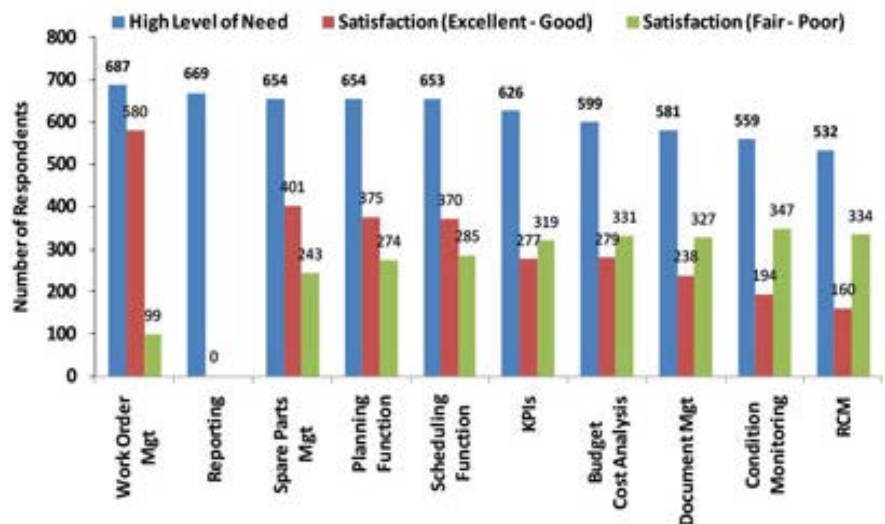


Figure 4.5<sup>10</sup> represents the comparison between the top ten features that survey participants reported as important compared with their satisfaction in those same areas. Only 23% of survey respondents claimed they are logging 100% of their work orders in the CMMS. Satisfaction levels increase when a CMMS is completely embraced and adopted, so it is not surprising that many users are dissatisfied with their software system.

Figure 4.5: Top 10 Features vs. Satisfaction Level of CMMS



<sup>10</sup> Julie Rampello, *CMMS Best Practices Study- A Perspective*, [http://reliabilityweb.com/index.php/articles/CMMS\\_Best\\_Practices\\_Study\\_A\\_Perspective](http://reliabilityweb.com/index.php/articles/CMMS_Best_Practices_Study_A_Perspective), (July 2011).

**CMMS/EAM System Benefits:**

There are numerous advantages to properly selecting, implementing, and utilizing a CMMS/EAM. Some of the common benefits that organizations realize include:

- Improved maintenance efficiency
- Reduced maintenance and asset lifecycle costs
- Decreased equipment downtime
- Optimized spare parts management
- An accurate understanding of equipment health
- Improved equipment repair/replacement decisions
- Increased equipment life
- Informative management reports
- Assistance in performing greater maintenance budgeting accuracy
- Enhanced compliance with regulatory standards
- Improved plant personnel safety
- Reduced energy consumption

**CMMS/EAM System Providers**

Although there are currently more than an estimated 200 maintenance software product providers in the marketplace<sup>11</sup>, there are significantly fewer software companies being used by the majority of industrial and manufacturing end users on a regular basis. The players in this “space” represent Enterprise Resource Planning (ERP) packages such as JDE and SAP, Enterprise Asset Management (EAM) systems like Maximo and Infor, and numerous Computerized Maintenance Management Systems (CMMS).

The primary difference between these systems lies in the intent for which they serve. The ERP providers were born out of the manufacturing resource planning era, and their focus is on production analysis and planning. As an example, when it comes to “materials management,” the primary focus of an ERP system is on raw materials rather than maintenance spare parts. This is not to say that they do not possess strong maintenance management modules. It is simply to be noted that the focus of an ERP is on production management rather than maintenance management.

EAM systems trace their origins to extremely capital-intensive industries. It is common for EAM systems to reside in vertical markets such as chemical, petrochemical, and power generation. The primary difference between an EAM system and a stand-alone CMMS is that the EAM is designed to effectively document and support asset management across a number of sites; whereas, the CMMS was originally designed for single sites.

Table 4.6 captures the company and software names of ERP, EAM, and CMMS systems that are frequently used in the industrial marketplace. This directory does not include the numerous

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<sup>11</sup> Terry Wireman, *Successfully Utilizing CMMS/EAM Systems*, (Terrence O’Hanlon/Reliabilityweb.com, 2011) xiv.

systems that primarily focus on property management or facilities maintenance. Listed in alphabetical order, these common system providers include but are not limited to:

Table 4.6

#	CMMS/EAM System OEM's	System Name(s)
1	Ashcom Technologies	MantiMizer
2	Assetpoint	Tabware
3	Champs	Champs
4	DPSI	iMaint, PMC
5	eMaint	eMaint X3
6	IBM	Maximo
7	Infor	Infor10
8	Invensys	Avantis
9	Mainsaver	Mainsaver
10	Oracle	JD Edwards EAM
11	Oracle	Oracle EAM
12	Oracle	PeopleSoft EAM
13	Revere	IMMPOWER
14	SAP	SAP Plant Maintenance
15	Ventyx (ABB)	Ventyx (Mincom) EAM

**CMMS/EAM System Costs**

CMMS/EAM software packages vary greatly in cost because so much depends on user specifications and the amount of requested customization; therefore, it is important to recognize both initial and future expenses for the system. The following table lists some of the common system costs that users should be aware of when budgeting for software projects. It is important to note that the total cost of ownership can become quite expensive.

Table 4.7

#	Initial Costs	Future Costs
1	Software/Software Licensing	Help Desk Support
2	Any Required Additional Hardware	Maintenance Fees
3	Network Expenses	Customized Reports
4	Internal Resource Expenses (mapping out processes, developing users, scrubbing data, data entry, reviewing vendor demos & proposals, testing sandbox database, miscellaneous meetings, etc.)	Interfaces with SCADA & PdM Databases
5	External Resource Expenses (consulting, facilitation, data cleansing, etc.)	Updating Hardware
6	Any Configuration Services	Future Training (new employees, reinforcement for existing employees)
7	Any Customization Services	Likely User Group Conferences
8	Implementation Services	Potential Industry-related Conferences & Association Memberships
9	Internally-provided Training (New processes to all impacted employees)	
10	Externally-provided Training (system training for users, super-users, and administrators)	

**Additional CMMS/EAM System Considerations**

In addition to system functionality, system benefits, various software providers, and system costs, considerations include:

- Hosting- Application Service Providers (APS), Web Hosting, Software As A Service (SAAS)
- Interfacing and/or Provisions for:
  - Drawings, Manuals & Attachments
  - PdM Databases
  - Continuous Monitoring, SCADA Systems
  - Remote Monitoring
  - Root Cause Failure Analysis (RCFA) Exercises
  - Reliability Centered Maintenance (RCM) Exercises
  - Failure Modes & Effects Analysis (FMEA) Exercises
- Equipment Criticality Ranking (ECR) Exercises
- Data Standards:
  - ISO 14224:2006<sup>12</sup>
    - Guidelines for proper equipment data collection, equipment taxonomy, equipment attributes, maintenance consequence, etc.
    - Description of data-collection principles and associated terms and definitions that constitute a “reliability language”
    - Data quality control and assurance practices
    - Provisions for the minimum amount of required data to be collected and the required format of the data to ensure ease and accuracy of exchange of maintenance and reliability data between multiple parties
  - Standard Noun-Modifier Dictionary
  - Standardized Description Schemas & Numbering Conventions
- Bills of Materials (BOMs)
- Economic Order Quantities (EOQ), Automated Reorder Point Adjustments, etc.

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<sup>12</sup> ISO 14224:2006. ISO Standards Store,  
[http://www.iso.org/iso/home/store/catalogue\\_tc/catalogue\\_detail.htm?csnumber=36979](http://www.iso.org/iso/home/store/catalogue_tc/catalogue_detail.htm?csnumber=36979), (2006).

## Section Five: Industry CMMS/EAM Expertise



The following information has been gathered from a number of CMMS/EAM industry experts. As there is an abundance of information on this subject, we have attempted to provide input on topics relevant to learning more about maintenance software systems and how they may apply in the wind generation industry.

MRG searched and reviewed a host of industry articles, surveys, studies, and reviews by various subject matter experts, and we believe the following information to be representative of the maintenance management software industry as it pertains to the general industrial and manufacturing market. We believe this information will be beneficial for your consideration.

1. *The Gartner Reports*
2. *The Aberdeen Survey*
3. *CMMS Best Practices Study- Reliability Web*
4. *Society for Maintenance & Reliability Professionals Best Practices*
5. *Results of the 2010 Plant Services CMMS Review*
6. *SAP EAM / Plant Maintenance Best Practices Study*
7. *Insights from MRG project experiences*



1. The Gartner Reports:

The Gartner reports are perhaps one of the most recognized surveys conducted within the EAM systems field. As part of their research, they identify software systems in four quadrants: challengers, leaders, niche players, and visionaries. The software systems are measured by two large categories. The first is by their ability to execute as rated by their product/service; their market responsiveness; and their track record, experience, and viability. The second is by their completeness of vision as indicated by their understanding of the market; their innovation; and their marketing, sales, and vertical market strategies.

According to their web site<sup>13</sup>, positioning on the Magic Quadrants reflects the customer's view of the market. It also focuses on the solutions available; includes the suite offerings; and takes into consideration functionality, the experience available, and the fit to purpose. Maintenance software providers such as IBM Maximo, SAP, Oracle, Ventyx, Mainsaver, and others have commonly appeared on the magic quadrant.

Clients should bear in mind that the market for EAM products is very broad and populated with hundreds of vendors. Gartner has reviewed what they consider to be the most relevant products for clients and while the Magic Quadrant has widely distributed vendor positions, all those companies listed are active and successful in this market, and are the top echelon. The Magic Quadrant represents the top-right corner of a much larger "virtual" Magic Quadrant of vendors that are not considered therein.

Readers interested in seeing the specific results of the annual studies are encouraged to visit the Gartner website at [www.gartner.com](http://www.gartner.com). The Gartner reports for the power generation and utility markets will be of particular interest. The most recent study, which was just released in September of 2012, updates the November of 2011 and September of 2010 studies.

Note: It has been reported that The Gartner organization generally requires viewers to pay a membership subscription fee to gain access to this copyrighted material.

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<sup>13</sup> [http://www.gartner.com/technology/research/methodologies/research\\_mq.jsp](http://www.gartner.com/technology/research/methodologies/research_mq.jsp)



## 2. The Aberdeen Survey:

The Aberdeen report, titled *The Role of Software in Asset Performance Management*<sup>14</sup>, was written by Nuris Ismail and published in October of 2010 by the Aberdeen Group. It represents their fourth annual research study on reducing maintenance costs and minimizing asset downtime. This most recent report is comprised of twenty-one pages of feedback from more than 100 executives. The sections of the study include the following areas:

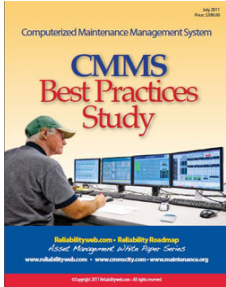
- Executive Summary
- Best-in-Class Performance
- Competitive Maturity Assessment
- Required Actions
- Chapter One: Benchmarking the Best-in-Class
- Business Context
- The Maturity Class Framework
- The Best-in-Class PACE Model
- Primary Drivers and Best-in-Class Strategies
- Chapter Two: Benchmarking Requirements for Success
- Competitive Assessment
- Capabilities and Enablers
- Chapter Three: Required Actions
- Laggard Steps to Success
- Industry Average Steps to Success
- Best-in-Class Steps to Success

Among many key points, the survey notes that “best-in-class companies are found to be more interested in software solutions to automate the business process, knowledge management and performance management capabilities.” It was also reported that 72% of best-in-class organizations were early adopters of CMMS/EAM systems while only 40% of industry laggards adopted maintenance software solutions.

To obtain access to the full report you may contact The Aberdeen Group at (617) 854-5200 or visit their web site at: [www.aberdeen.com](http://www.aberdeen.com).

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<sup>14</sup> The Aberdeen Group , *The Role of Software in Asset Performance Management*, <http://www.aberdeen.com/Aberdeen-Library/6741/RA-asset-performance-management.aspx>, (Oct.2010).



### 3. CMMS Best Practices Study- Reliability Web:

Reliabilityweb.com produced a CMMS Best Practices Study<sup>15</sup> in July 2011, demonstrating the value computerized maintenance management systems add and areas for future growth and improvement. The report was based on a survey of users conducted earlier that year that focused on implementation, use, and sustainability.

This approximately 50-page report, written by Steve Thomas with additional insights by Terrence O'Hanlon, provides an opportunity to better understand the user experience with CMMS in general and, for the Maximo brand specifically, the CMMS that Projotech provides. This report details CMMS changes and provides opportunities to address the evolving needs of CMMS customers.

Of particular interest was the low percentage (16%) of survey respondents that had integrated their CMMS with other asset health and performance management systems. Approximately 60% of respondents host their CMMS on a corporate server. Although vendor hosting only totaled 6% at the time of the survey, it is expected to rise as companies begin to view this approach as a more cost-effective solution to their CMMS issues and upgrades.

Another interesting finding was that out of 678 survey participants, 341 (or approximately half) stated that no return-on-investment (ROI) was created in their CMMS project. Of the remaining 337 survey participants, 190 (or 28%) stated that the ROI they had anticipated to receive did not occur while 147 survey participants responded that their ROI was achieved.

If you are interested in learning more about the CMMS Best Practices Survey, you may email Terrence O'Hanlon at the address below:

[tohanlon@reliabilityweb.com](mailto:tohanlon@reliabilityweb.com)

<sup>15</sup> Reliabilityweb.com, *CMMS Best Practices Study*, [http://reliabilityweb.com/index.php/articles/CMMS Best Practices Study A Perspective](http://reliabilityweb.com/index.php/articles/CMMS_Best_Practices_Study_A_Perspective), (July 2011).



4. Society for Maintenance & Reliability Professionals (SMRP) Best Practices:

SMRP Best Practices Report<sup>16</sup> is now available. Although this is not a paper solely focused on CMMS/EAM systems, it includes information supporting the importance of a fully functioning maintenance software system and managing by metrics, which should be obtained through the use of the CMMS/EAM system.

This comprehensive 254-page report developed by the SMRP Best Practices Committee for the purpose of standardizing how maintenance and reliability professionals measure and calculate common key performance indicators, provides the necessary tools for measuring and comparing performance using consistent measuring systems. This compendium of best practice metrics offers: 67 standard metrics (including 29 metrics that have been harmonized with the European Federation of National Maintenance Societies (EFNMS)), six guidelines that provide additional information or further clarification of component terms used in SMRP best practices, and a glossary that contains standard definitions for terms used in SMRP's metrics.

This informative report can be purchased on the Internet at the following SMRP link:  
[http://library.smrp.org/full\\_metrics/](http://library.smrp.org/full_metrics/)

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<sup>16</sup> SMRP Web-site, *SMRP Best Practices Report*,  
[http://library.smrp.org/full\\_metrics/](http://library.smrp.org/full_metrics/), (10 Oct. 2011).

5. Results of the 2010 Plant Services CMMS review<sup>17</sup>:

Despite uncertainty in the global economy and the maturing of the computerized maintenance management system/enterprise asset management (CMMS/EAM) software industry, companies from every sector continue to upgrade, replace, or buy new asset management software applications. This is especially true for asset-intensive industries because of the pressure to better manage ever-increasing asset lifecycle costs, while increasing the quantity and quality of production through greater asset reliability and performance. Another key driver appears to be the growing demands of regulatory bodies that seek tighter controls, greater accountability, and more detailed data capture and reporting.

There are 10 key trends in the industry, including important features and functions to consider if you're contemplating the purchase of any CMMS/EAM products or services. Many of these features and functions are excerpted from the online Plant Services CMMS/EAM Software Review (<http://cmms.plantservices.com>), where you can directly compare the capabilities of a wide range of software packages. According to David Berger, the 10 key trends are:

1. Industry specialization
2. Enterprise thinking
3. The Web
4. Operational excellence and best practices
5. Sustainability
6. Risk Management
7. Mobile technology
8. Condition-based maintenance
9. Scheduling
10. Pricing

This review claims that the "CMMS/EAM industry continues to mature as evidenced by the mergers and acquisitions of the past decade, although the level of this activity seems to have slowed in recent years. Industry consolidation has resulted in more streamlined costs because of economies of scale, and greater expenditure on research and development to produce a better software product. Additionally, CMMS/EAM vendors have an extensive network of partners that expand their product and service offerings. Many of these vendors have chosen niche markets in which to focus, such as a single asset class (e.g., fleet), a given industry (e.g., life sciences) or a product/service theme (e.g., reliability-centered maintenance). This is all good news for you, their potential customers, as you search for innovative ways to improve bottom-line performance."

To read the report in its entirety, visit the following plant services site:

<http://www.plantservices.com/articles/2010/04CMMSSoftwareReview.html?page=1>

<sup>17</sup> David Berger, *Plant Services CMMS/EAM Software Review*,  
<http://www.plantservices.com/articles/2010/04CMMSSoftwareReview.html?page=1>, (2010).



6. SAP EAM/Plant Maintenance Best Practices Study:

This study says:

Second only to energy, maintenance costs are a significant portion of every company's expense budget. Recognizing this fact, companies have implemented strategies to alter the perception that maintenance is a necessary evil to one where maintenance is considered a strong contributor to the company's profitability. One of these strategies is the integration of the computerized maintenance management system (CMMS) into the company's information and decision-making network utilizing tools such as SAP Plant Maintenance.

In order to gain a better and deeper understanding of the use of SAP PM as a profitability partner, Reliabilityweb.com surveyed 700 maintenance managers and reliability professionals. This report will provide insight into the use of SAP PM by those surveyed as well as provide suggestions for further improvement to increase value, not simply for the maintenance organization but for the company as a whole.

To obtain the report, contact the MRO-Bookstore at (239) 333-2500, or copy and paste the following address into your browser:

[http://books.mro-zone.com/product\\_p/sapreport2011.htm](http://books.mro-zone.com/product_p/sapreport2011.htm)



#### 7. Insights from MRG project experiences:

As a global leader in the Maintenance and Reliability consulting industry, Management Resources Group (MRG) specializes in providing industrial, manufacturing, and governmental clients a host of value-added professional consulting, engineering, and project management services. MRG subject matter experts combine their unique base of practical field experiences with a wealth of technology and tools to successfully assist clients in achieving a variety of best practices solutions.

MRG has developed a long and prestigious list of satisfied clients that are enjoying the benefits of our commitment to improving maintenance practices, equipment reliability, and business processes throughout the world. Over the past 25 years, MRG has worked with more than 140 industrial and manufacturing clients and successfully implemented CMMS/EAM systems at more than 560 sites worldwide.

Included in our experience, MRG has worked with close to fifty different power generation organizations to implement more than 180 CMMS/EAM system projects. Some of the companies we have worked with include AES, Alabama Power, Alliant Energy, Cajun Electric, Calpine, Constellation Energy, Detroit Edison, ENMAX, Florida Power & Light, Horizon Wind, Indianapolis Power & Light, NYPA, Luminant, Ocean States Power, Oglethorpe Power, Portland Gas & Electric, Reliant Energy, Sunflower Electric, TVA, Westar Energy, and many others. Some of the tasks we completed as part of these projects include:

- Conducting multiple data gap analysis reviews
- Walking down hundreds of plant sites
- Loading millions of inventory and asset records
- Standardizing master equipment lists and inventory data across numerous sites in multiple countries
- Improving master equipment list hierarchies
- Developing process maintenance and reliability workflows including Inventory and Purchasing
- Implementing a variety of different CMMS/EAM systems
- Providing technician and operator training

The following case studies are excerpts from actual MRG client engagements. These brief summaries highlight a few, select projects that are pertinent to achieving a successful CMMS/EAM system initiative. These project summaries communicate a variety of challenges that clients commonly experience and the correlating solutions that MRG provided as well as the benefits that were received as a result of implementing CMMS/EAM best practices solutions.



**Case Study #1:**

**Industry:** Power Generation

**Situation:** In response to financial reporting issues, the North American operations of a global energy company was facing an ERP-driven, time constrained, multi-wave SAP EAM implementation burden

**Solution:** Licensed MRG's Catapult™ and received training and mentoring on our delivery standards

Company performed equipment walk downs to populate the SAP locations and equipment list

Criticality ranking and failure-based reliability strategy development was performed utilizing MRG's Catapult™ and our delivery standards, thus coordinating plants operations and reporting

**Results:** EAM data model supports cross-plant asset performance optimization

100% data fit at go-live was achieved, and tight reporting needs were met against project milestones

Company was able to secure buy-in through MRG's involvement of site personnel in the development and implementation processes

Company has successfully applied these solutions at more than 14 North American plants with plans in place to expand to more sites and regions

This success enabled the planning of Phase II to focus on additional data enhancement in support of the corporation's goal of top quartile asset reliability performance

**Learning Point:** Asset data standardization across the corporation enables accurate standardized reporting, failure analysis, and maintenance strategy deployment.

The client ran the SAP Plant Maintenance (PM) data conversion in Catapult. The other SAP modules were converted using spreadsheets. Data quality issues plagued implementation of the other modules, leading to big delays. PM was implemented on time because of tight quality and project management controls afforded by Catapult.

**Case Study #2:**

**Industry:** Power Generation

**Situation:** An energy and technology company was converting to MAXIMO and needed a complete master data validation to ensure an accurate and efficient migration

**Solution:** MRG conducted an extensive analysis of the myriad of legacy data sources

Identified significant inconsistencies and facilitated the development of standards for all data in the new system

Collected all of the data, consolidated it in MRG's Catapult™ system, and then standardized new MRO descriptions for approximately 500,000 material masters

We also developed programs and scripts to facilitate the reconciliation, preparation, and data transfer of all asset-related data, work orders, PM procedures, and other foundational data. MRG managed the uploads of all data into MAXIMO

**Results:** 92,600,000 records were loaded, error-free, standardizing the master data across all plants

Consistent classification of assets and validation of all data loaded into the new system enabled the client to enhance their reliability processes through standardized reporting, metrics, and KPI generation

**Learning Point:** Accurate and detailed information enables accurate and trusted analysis of information, which in turn, enables accurate decision making. Inaccurate, missing, or incomplete data often results in excessive spending, such as excess inventory purchase which impacts the bottom line.





**Case Study #3:**

**Industry:** Power Generation

**Situation:** A large multi-fuel and technology energy company was losing money due to poor and inconsistent data quality and inconsistent technology platforms

**Solution:** MRG conducted an extensive legacy data analysis

- Created a data standardization rule set
- Standardized the asset, spare parts, and maintenance procedure data
- Established an MRO and asset dictionary and taxonomy throughout the enterprise
- Enhanced the legacy data to comply with the standardized taxonomies
- MRG uploaded the information into a new enterprise-wide standard technology and EAM platform

**Results:**

- The initiative quickly created a \$1.6 million net income increase
- A 6.4% inventory reduction was achieved
- An overall increase in equipment efficiency was realized
- The organization enjoyed increased productive maintenance personnel
- The standard information foundation established is providing the springboard for improved and standardized reliability practices across the enterprise

**Learning Point:** If a CMMS is installed without first enhancing the existing manual process, all you have accomplished is to automate a manual process, thereby only realizing small administrative efficiencies. In order to achieve equipment reliability and a best practices maintenance organization, the processes need to be enhanced as well.

Albert Einstein has been quoted as saying, “We can’t solve problems by using the same kind of thinking we used when we created them.” Under that same premise, we have learned

that organizations will benefit from using external subject matter experts to influence best practices improvements. Employing an external expert is key because internal resources don't know what they don't know.

Do not *financial engineer out* your data issues. You can design the world's best process, but if you have poor data, you will still encounter repeatable equipment issues. Be committed to improving the quality of the data within your system.

Do not financial engineer out the change management element as well. The behavioral aspect of implementing a new CMMS/EAM system is very real. There is a learning curve in the amount of time required to access records and obtain data from the system. Expect to see a productivity dip, and account for that in your project ROI estimates.

It's important to recognize that when it comes to measuring the success of the project, two sets of metrics may apply. The first is how well the project was implemented. The success of a project can depend on how well the initiative is accepted. This element can be influenced by factors as simple as who the project team members are. The team should be comprised of well-respected members who represent various business segments. It is also important to maintain a 3:1 ratio of employees to consultants, never engaging more than one external resource for every three internal resources.

Secondly, it is critical to measure the percentage of project completion each month for the site leadership team. This indicator will confirm or deny the level of support that exists from the leadership team at the facility. As with most large and critical projects, strong, positive, visible, and continual management support is required.



**Case Study #4:**

**Industry:** Chemical Processing

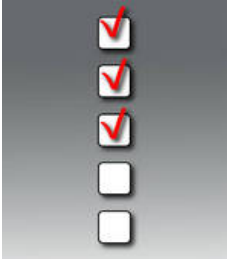
**Situation:** Inconsistently producing at 55% nameplate (unlimited market)  
Annual Maintenance Spend of 7% of RAV. (\$8+ million)

**Solution:** Site Assessment  
  
CMMS revitalization – data, process and analysis  
  
Work Management – planning & scheduling  
  
Criticality Ranking  
  
RCM/FMEA – maintenance strategy development  
  
RCFA – problem elimination  
  
Material Management – physical stores and management processes  
  
PM/PdM Optimization – procedure writing, PdM implementation

**Results:** 1st Year Annual Maintenance Spend < 4% RAV (\$4.5 million)  
  
3rd Year Annual Maintenance Spend = 3% RAV (\$3.4 million)  
  
Consistently producing at 130% nameplate (tens of millions of dollars)

**Learning Point:** Focus on fundamentals is what makes a system user friendly. This case study was for a green screen CMMS, and by focusing on good work management and reliability processes supported by accurate and complete data in the CMMS, the client was able to achieve excellent results. In the end, it is not so much the CMMS functionality that is important—most of them have sound functionality—it is how the system is used and managed that is important.

## Section Six: CMMS/EAM System Specification Considerations



One of the key elements to ensuring that the most suitable software system is selected and implemented is identifying specific user requirements to measure the prospective software packages against. As each site's requirements will vary, we will not provide a recommended User Requirement Specification (URS) in this report. However, common considerations for any URS include the following items for each module deemed necessary (asset management, work management, materials management, resource management, etc.):

- Module Overview
- Minimum Capabilities
- Functional Requirements
- Module Reports

In addition, you may want to consider the following attributes, based on how important they are to your site:

- Intuitive User Interface
- Integration Flexibility
- Web-based Solution
- Configurability
- Analysis Tools
- Configurable KPIs
- Multi-site Capabilities
- Industry Specialization
- Ease of Implementation
- ROI Calculations
- Practical Training
- Online Assistance
- Superior Help Desk Support

One of the most critical steps in planning for a new or replacement CMMS/EAM is to determine your needs. Procuring a CMMS/EAM system isn't about finding the best software package on the market. The key to a successful implementation is selecting a CMMS/EAM package that best meets your requirements. There are many good CMMS/EAM packages available today, but they each have different strengths and weaknesses. Your task is to determine user specifications based on the needs of stakeholders (e.g., maintenance, operations, engineering, IT, materials management, purchasing, finance), and then choose the combination of CMMS/EAM vendor and software package that can best deliver on those needs.

When developing User Requirements Specifications, it may be helpful to differentiate between need-to-have items and like-to-have capabilities. You could easily draft system specifications that request everything imaginable; however, there is obviously a cost associated with such a robust system. A worthwhile team exercise would be to have discussions and reach agreement on those two categories. Sometimes beginning these sessions by facilitating a

High-Medium-Low rating system will get everyone pointed in the right direction. Going into future demonstrations and reviewing proposals without covering this step will cause additional time and frustration later in the process.

Verify that the vendor being reviewed already has the requirement your team specified as being most important and is not in the process of releasing that additional functionality. Sometimes this distinction is not communicated very clearly, so it is a good practice to clarify that the software provider has, in fact, been successfully providing that particular capability for some time.

When crafting your URS, it is good practice to develop a spreadsheet from which to rate the prospective vendors. Many organizations find it beneficial to provide an area to rate the status of the functional item. An example of different status code descriptions are as follows:

- Status Code Descriptions:
  - Standard Feature (SF)
  - Available with Configuration (ACon)
  - Available through Customization (ACus)
  - Not Available (NA)
  - Not Practical based upon the cost (NP)

With the addition of columns for each vendor that submits a proposal, the vendor selection committee can use such a table to rate, score, and compare vendors. Note that the weighting and scoring of the evaluation criteria is a subjective process. Stakeholders have varying opinions about what is important, which is why it is critical to build consensus. Try to finalize the table before receiving any vendor responses to avoid prejudices.

Refer to Table 6.1 to view a sample of key areas within the system requirements rating exercise.

Table 6.1 Sample Requirements Rating Criteria (Source: MRG files)

Business Needs Priority Description		
<i>Assign a priority value to each requirement in accordance with the Business Requirements Specifications</i>		
Business Priority		Description
M	1	<b>MUST HAVES</b> - Non-negotiable, Immediate need, Objective is mandatory, has set limits, and is realistic
N	0.5	<b>NEEDS</b> - Fulfills a future business requirement
W	0.2	<b>WANTS</b> - Provides a demonstrated efficiency gain
U	0	<b>UNIMPORTANT</b> - Bells and Whistles that would be "Nice to have"

Weight-Score Description		
<i>Assign a points value to each requirement in accordance with the vendor performance (demonstrated and stated)</i>		
Points	Weight	Description
5	Out of the Box	Functionality is provided in the base product, No modification is required
4	Future Release	Functionality will be provided in a future release, No modification is required
3	Zero Cost Configuration	Functionality will be developed and placed into the base at no cost
2	Customization	Requires a customization that will most likely not be supported in future releases
1	Requires Programmatic Solution	Requires custom and/or 3rd party programming and support

It is critical to work with key stakeholders and invest about two to four months in the design of new processes and supporting system specifications. This must be done before the selection phase begins, so you can filter the sales pitch from each vendor and steer them to exactly what you need to see demonstrated to determine the best fit. The methodology you use to build process/system requirements should involve defining process flows that reflect the current state and the desired future state. The future state processes will be supported by best practices and enabling system specifications.

Section Seven: Wind Energy System Research Findings



**General Wind Industry Data**

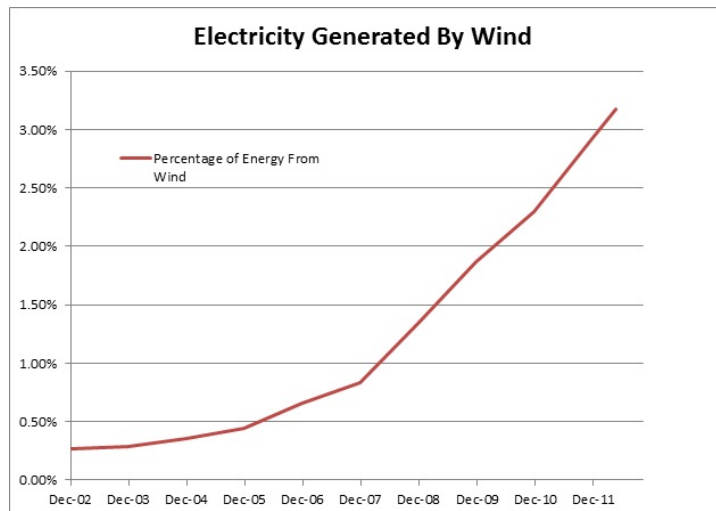
According to new research published by University of Delaware and Stanford University scientists in the Proceedings of the National Academy of Sciences, wind turbines could power half the world's future energy demands with minimal environmental impact. Researchers arrived at this determination by calculating the maximum theoretical potential of wind power worldwide, taking into account the effects that numerous wind turbines would have on surface temperatures, water vapor, atmospheric circulations, and other climatic considerations.

“Wind power is very safe from the climate point of view,” said Cristina Archer, associate professor of geography and physical ocean science and engineering at UD. Archer and Stanford’s Mark Jacobson identified the maximum wind power potential by finding the saturation point where adding more turbines would fail to increase energy output. As the number of wind turbines increases over large regions, the amount of power generated at first increases proportionately—but then reaches a point of diminishing returns and eventually flattens out.

Archer and Jacobson found that installing four million turbines could yield up to 7.5 TW, more than enough to power half the world’s power demand in 2030. They also showed that spreading wind farms out worldwide in windy locations would increase efficiency, as well as minimize costs and reduce overall impacts on the environment when compared to packing the same four million turbines in a few spots. “Everything comes at a price, but the price of wind power comes at a low cost in terms of climate impacts,” Archer said. The research was funded by the National Science Foundation, U.S. Environmental Protection Agency and NASA high-end computing.

According to Wikipedia, wind energy has grown exponentially over the last decade, with an average increase of 29.7% per year. If that rate continues, the United States will obtain 20% of its energy from wind by 2020.

The U.S. Department of Energy (DOE) is working with six leading wind turbine manufacturers towards achieving 20% wind power in the United States by 2030<sup>18</sup>. The DOE announced the Memorandum of



<sup>18</sup> Wikipedia, *Wind Power in the United States*, [http://en.wikipedia.org/wiki/Wind power in the United States](http://en.wikipedia.org/wiki/Wind_power_in_the_United_States), (2011).

Understanding (MOU) with GE Energy, Siemens Power Generation, Vestas Wind Systems, Clipper Windpower, Suzlon Energy, and Gamesa Corporation. Under the MOU, the DOE and the six manufacturers will collaborate to gather and exchange information relating to five major areas: research and development related to turbine reliability and operability; siting strategies for wind power facilities; standards development for turbine certification and universal interconnection of wind turbines; manufacturing advances in design, process automation, and fabrication techniques; and workforce development.

### **Wind Industry Maintenance Data**

One challenge that accompanies an emerging market is the lack of historical data. A recent wind farm maintenance survey results<sup>19</sup> shows there is much opportunity for improvement. With this in mind, Energías Renovables set out to make a first attempt to gather data that is not easy to come by, but which is of great interest to the sector, given that "maintenance work accounts for 20% of total project costs, including the initial capital investment," explains Alberto Ceña and Emilien Simonot, from AEE's Technical Department.

One of the most noteworthy findings is that the average score of independent maintenance service providers is better than that of turbine manufacturers. That said, however, even independent maintenance service providers score poorly on the issue of reporting to wind farm owners what work has been done and why.

Wind farm operators saw some value in the preventive maintenance provided by turbine manufacturers, giving them a score of 2.5. This score improved to 2.8 for unscheduled repairs, while independent providers received an average of 2.6 and 3, respectively, on these questions.

A report by business intelligence company, GBI Research, indicates that technological advancements in wind power mechanisms will allow wind farms to run far more efficiently and reap more profits as older wind turbines are upgraded. They say the immediate increased demand for global wind energy operations and maintenance may eventually cause a reduction in revenue, but for now, business is booming.

Wind farm owners may focus on performance and reliability of the turbine and its components to understand why projects underperform or fail and what can be done to keep the wind project operating as expected. They must also consider safety standards, estimating costs, predictive maintenance, and data analysis to improve performance and extend the life of the entire system.

Among some of the recent industry announcements, turbine OEMs, component manufacturers, service providers, and other specialists in operations and maintenance are offering customers options for maintaining their assets. One such option may be production-

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<sup>19</sup> Energías Renovables, *Much to Improve, Wind Farm Maintenance Survey Finds*, <http://www.enerbias-renovables.com/articulo/much-to-improve-wind-farm-maintenance-survey>, (14, May 2012).



based contracts. Production-based O&M agreements use a fixed and variable fee structure instead of a time-based availability with the goal of maximizing production for customers.

General Electric (GE) is one company that is gaining experience with this model. The variable portion of the agreement is based directly on wind farm production relative to megawatt hour with GE and its customer. The total cost of the O&M agreement, not just the availability bonus to reduce upfront costs, balance risks, and promote a run-it-like-we-own-it approach to service, is one way GE is helping customers.

According to a GE spokesperson, by focusing on production, they are adding value for their customers and are better aligning their goals with those of their customers, which equates to sharing the risk between GE and their customers. "Production-based O&M brings us another step closer to running the turbines like we own them." The contracts with GE give customers access to wind turbine upgrades, service facilities, and a network of skilled, highly trained local technicians who are connected to GE's engineering organization.

Like GE, other manufacturers and suppliers are offering specialized service or contracts for customers with O&M needs for their turbines. Moventas, one of the world's leading wind gear manufacturers, is expanding its up-tower repair service globally to offer its customers better cost-savings and less downtime in repairs, maintenance, and monitoring.

Steve Casey, general manager of Moventas<sup>20</sup>, Inc. says the company is providing up-tower repair service in North America to replace the high-speed, intermediate, and low-speed assemblies on site, thus eliminating the need to ship the gearbox to the manufacturing facility.

"This began last year when we performed the first full helical up-tower gearbox repair," he said. "We have since performed numerous full helical repairs, including one in Germany. The real credit goes to our Field Service Manager, James Macik, and his team of technicians for making the concept a reality. This service eliminates the need for the large boom and secondary cranes normally required to take the entire gearbox down tower. This is a significant cost savings for our customers."

By using a mobile service and small hydraulic crane, field service technicians can bring the complete gearbox down from the nacelle. In addition, Moventas' up-tower repair service makes it possible to perform end-of-warranty inspections, condition monitoring, standard high-speed pinion and bearing change-outs, and pitch tube repairs.

The CMaS unit, which is unique in that it was designed specifically for wind gears, monitors the condition of the oil in addition to providing 24/7 vibration feedback. "Since we cannot dyno-test our up-tower helical repairs, we install our CMaS system on each repair to ensure that the gearbox is operating on the same standards as it would if it were repaired in our facility."

Casey says Moventas also started a mobile workshop that is deployed to the site to provide

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<sup>20</sup> Wind Systems, *Keeping the Turbines Turning*, <http://windssystemsmag.com/article/detail/403/keeping-the-turbines-turning>, (August, 2012)

customers with immediate response time and reduced travel costs. Moventas is also adding more mobile units throughout the United States and Europe with expansion planned in India, Australia, Brazil and China. “Our goal is to significantly shorten response time, reduce customer costs, and to continue to lead the industry in repairs that can be done on-site rather than in a workshop,” says Olli Valimaki, Senior Vice President of Service with Moventas. “This is a significant cost-saver for the industry, making it even more competitive compared to traditional energy forms than before.”

Another specialty provider is Gearbox Express<sup>21</sup>. This company targets a very narrow section of the market focusing on down-tower services, technical advice, and field support. “We don’t compete with any channel partners, including O&M providers. We are completely independent in the market, and we know that repairing gearboxes will become a necessity for OEMs and operators,” said Bruce Neumiller, CEO of Gearbox Express.

Since Gearbox Express (GBX) doesn’t perform up-tower work on the turbines, they can maintain a good working relationship with O&M providers, and since they don’t manufacture gearboxes, OEMs and turbine owners are also open to working together. Many owners have multiple makes of gearboxes in their fleet, and with GBX, they can have one supplier for all of them, he said. “We know replacing the gearbox quickly is better for our customers.”

Renewable Concepts (RCI) is a division of RTP, Inc.<sup>22</sup> that provides a wide range of general contracting services with more than 50 years experience in construction, operation, and maintenance. RCI performs on-site and off-site tower source inspections and carries out repairs on components in the pre- and post-construction stages. Services include special projects personnel, owner’s representatives, construction and commissioning manager, and instrumentation and controls (I&C) technicians. RCI can work with owners in power generation from initial development and planning to final turnover.

The founder and CEO, Rob Tinsley, started Renewable Concepts to address the unique needs of the wind industry. “The wind industry now needs an “Angie’s List” to help wind farm owners choose between all the O&M service providers on the market,” he said. “We have service providers who are more about quantity than quality. This hurts the industry.”

Wind turbine operations and maintenance (O&M) is a growing business segment in the U.S. wind energy market. Wind farm owners must now decide whether they will handle O&M service with their own staff or contract with OEMs or private service providers to keep the wind turbines turning.

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<sup>21</sup> Wind Systems, *Keeping the Turbines Turning*, <http://windssystemsmag.com/article/detail/403/keeping-the-turbines-turning>, (August, 2012)

<sup>22</sup> Ibid.

**Wind Turbine OEMs**

According to Wikipedia, there are currently over fifty wind generation equipment manufacturers throughout the world. The top wind turbine manufacturers by installed U.S. market share based on 2010 & 2011 estimates are:

Table 7.1

#	Company Name	2010 Reported Market Share	2011 Estimated Market Share
1	GE Energy	41.3%	~41%
2	Vestas	17.3%	~20%
3	Siemens	11.6%	~12.5%
4	Mitsubishi	7.6%	~4%
5	Suzlon	5.2%	~5%

**Wind Turbine Maintenance/Service Providers**

In terms of maintaining wind generation assets, there are three primary entities providing these services:

1. The wind turbine Original Equipment Manufacturers (OEMs)
2. The end-user wind farm owners
3. Independent Service Providers (ISPs)

The following table illustrates the pros and cons that each maintenance services provider is believed to offer.

Table 7.2

Maintenance Provider	Pros	Cons
OEMs	Familiarity with equipment, Meets specifications, Experienced, Has parts	Often the most expensive
Internal Wind Farm Employees	This is the least costly option	Need to develop competence (training, SOPs, management), To supply parts
ISPs	Reduced cost and no internal training/oversight is required	Involves procurement process and contract set-up, May supply parts

In the past, wind turbine developers were the only firms capable of looking after the operations and maintenance (O&M) on their machines. But as the wind market has grown in Europe, so has the number of companies moving into this service area. Although wind turbine developers remain the dominant players in this field, independent service providers (ISPs) and third parties have taken a small but growing share of the business, and many utilities are increasingly keen to manage their own O&M contracts, according to Windpower Monthly.

There appears to be an ever-increasing number of ISPs entering this market. As the manufacturer's warranties are expiring, there are many service organizations as well as OEMs jockeying to provide maintenance on the wind turbines and subsequent equipment at wind generation sites.

The following table illustrates some of the organizations that we identified as having a strong focus on providing maintenance services to wind generation owners.

Table 7.3

Wind Generation OEMs Providing Maintenance Services	Wind Generation ISPs
Acciona	Availon
Clipper	B9 Energy
DeWind	BHE Environmental
Gamesa	Broadwind Energy
GE Energy	enXco
Mitsubishi	Gemini
Nordex	Global Energy Services
Siemens	Outland Energy Services
Suzlon	PEM
Vestas	Renewable Concepts, Inc.
	Run Energy
	Upwind Solutions
	Wind Energy Services Company

There is considerable interest in identifying the larger onshore U.S. Wind Farm Owners. According to Wikipedia, the following list represents the top 10 owners based on rated nameplate capacity. Many of these wind farms have been built in stages, and construction of a further stage may be continuing at some of these sites.

Table 7.4<sup>23</sup>

#	Project	Capacity (MW)	State
1	Alta Wind Energy Center	1020	California
2	Shepherds Flat Wind Farm	845	Oregon
3	Roscoe Wind Farm	781	Texas
4	Horse Hollow Wind Energy Center	736	Texas
5	Tehachapi Pass Wind Farm	705	California
6	Capricorn Ridge Wind Farm	662	Texas
7	San Geronio Pass Wind Farm	619	California
8	Fowler Ridge Wind Farm	600	Indiana
9	Sweetwater Wind Farm	585	Texas
10	Altamont Pass Wind Farm	576	California

**Wind Industry Maintenance Strategies**

Although maintaining equipment at a wind farm has some unique challenges, the wind industry can certainly pursue some of the best practices preventive (PM) and predictive maintenance (PdM) approaches that their peers in the industrial and general manufacturing sector are utilizing. By adopting continuous monitoring or frequent monitoring of machinery health conditions, wind techs are able to schedule required maintenance activities at the proper intervals. By utilizing a host of pertinent PdM technologies, wind industry personnel responsible for caring for these critical assets are in a better position to identify when an impending failure may be approaching, providing valuable time to plan, schedule, and execute the required corrective tasks before the condition becomes an emergency.



In a webinar sponsored by ReliabilityWeb.com on September 14, 2012, Jason Tranter shared some of his experiences with one of the foundational PdM disciplines in his presentation titled *Vibration Monitoring of Wind Turbines*. Jason explained that some of the unique challenges of using vibration technology in wind applications included:

<sup>23</sup> Wikipedia, *Wind Power in the United States*, [http://en.wikipedia.org/wiki/Wind\\_power\\_in\\_the\\_United\\_States](http://en.wikipedia.org/wiki/Wind_power_in_the_United_States), (2011).

- The variability of speed and load when collecting data from one site visit to the next
- The fact that a lot of what is being measured is very slow speed bearings
- The resonance that is present
- The number of complex planetary gear boxes
- The nature of the remote locations
- The expense of acquiring data

Due to the variability and the slow speed, Jason pointed out that it is important to select an accelerometer that is sensitive enough to read down to 0.1 Hz. Jason also said that his experience has been that roughly one-third of the defects are in the gear boxes and over 20% are in the generators. Therefore, he encouraged the group to consider using vibration and oil analysis testing on the wind farm gear reducers while in operation and using a visual bore scope inspection on the gears during shutdown. Jason recommended checking the generator with vibration analysis.

As manually collecting the data is not considered the ideal option due to safety considerations, accessibility, and changing conditions, Jason pointed out that collecting data with the use of on-line instruments is the optimum choice. He recommended installing one sensor on the main unit, three on the gear box, and two on the tower and cell.

### **Wind Industry Spare Parts Strategy**

Another key equipment reliability strategy rests in undertaking a best-practices approach to managing spare parts. The need to properly manage MRO parts in general manufacturing and industrial sites is an important task. It is extremely critical to properly manage this key activity in the wind industry.

In addition to committing to capturing all necessary spares in the Bills of Materials (BOMs) and within the inventory module of your CMMS/EAM system, it is important to select a sound approach to housing these spares. Some models call for a small inventory at each farm while others choose to store them in large, regional warehouses. A third approach is to pull from the OEM's inventory. Regardless of your approach, a few items to consider when establishing a sound maintenance spare parts program include:

- Ensuring that a stocking list of spares is developed, reviewed, and agreed upon
- Populating the inventory database with these items noting their properly formatted described name, part number, manufacturer part number, storage location description, stocking quantity, reorder point, vendor, price, etc.
- Implementing a security program to ensure parts are not walking off unaccounted for
- Implementing a periodic cycle counting program
- Employing proper design, organization, shelving, lighting, and signage practices in storing spare parts
- Establishing a kitting program with the Work Orders
- Implementing a bar coding program
- Utilizing the reservation feature as well as the return feature on your system
- Identifying select KPIs to measure the effectiveness of your spare parts program
- Utilizing automated reorder and min/max stocking adjustment features in your system

### Wind Industry CMMS/EAM System Requirements

There are very few systems that specify that they provide unique solutions to the wind turbine industry. Australian-based WTGservice is currently the only maintenance software system that has been developed specifically for the wind industry. Unlike certain industry-specific solutions that have been developed over the years, such as in the pharmaceutical and life sciences fields, at this point only a few software providers are considering providing a market-specific module for this industry. Consequently, some wind O&M providers are using their own, in-house software solutions.

Regardless of whether you consider an off-the-shelf solution, an industry-specific solution, or develop an internal system, there are certain functional requirements that should be considered when qualifying software capabilities for a wind energy site.

1. Asset hierarchy copy and paste functionality
2. Paperless WO system process
3. Remote system monitoring
4. Predictive maintenance (PdM) database interfacing
5. Mobile devices
6. Root Cause Analysis data capture
7. BOM, materials management interface
8. Bar Coding/RFID
9. Reservations/Kitting features
10. Emergency notification (email and/or phone alerts)

Although the majority of these capabilities are provided in most reputable systems, it is important to clearly confirm that these provisions are included in any system you may consider purchasing.

### Additional Industry Research Findings

According to a presentation developed by Lucintel in 2011<sup>24</sup>, gear box, generator, and turbine blades represent the three primary components in a wind turbine generating site that requires regular servicing. They estimate these items alone represent 80% of the total turbine maintenance cost.

According to the findings<sup>25</sup>, many wind farm operations and maintenance teams are so resource-constrained that they are barely able to keep up with the unscheduled maintenance repairs that their wind turbines require to continue generating electricity. Even regular, scheduled preventative-maintenance like oil changes and gearbox lubrication (services that are often still under warranty) are falling behind as manufacturers face similar resource struggles related to the shortage of qualified technicians.

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<sup>24</sup> Lucintel Brief, *Opportunity in Global Onshore and Offshore Operation & Maintenance Market*, (March, 2011).

<sup>25</sup> WindPower Conf., *Survey of Attendees*, <http://www.renewableenergyworld.com/rea/news/article/2008/09/survey-says-60-of-us-wind-turbines-may-be-behind-in-maintenance-53502>, (2008).

## Section Eight: Selection and Implementation Considerations



### Outline of a CMMS/EAM Selection & Implementation Process

Although system selections and implementations may vary slightly, the following steps outline this complex process. Key steps must be performed properly to ensure that successful system utilization is achieved. The main elements of this comprehensive process are:

1. Initial investigation
  - a. Appoint a project champion(s)
  - b. Form a system requirements & selection team
  - c. Identify high-level system requirements
  - d. Identify required number of concurrent users/user licenses
  - e. Identify computer hardware requirements
  - f. Identify system connectivity and interface capabilities
  - g. Identify IT support/role
  - h. Develop data migration requirements
  - i. Develop data cleansing requirements
  - j. Identify preliminary sourcing
  - k. Identify required funding
2. Funding
  - a. Justify feasibility
  - b. Request funding
  - c. Approve funding
3. Project Preparation
  - a. Establish a Project Manager
  - b. Develop a project plan
  - c. Prepare data
  - d. Develop data standards
  - e. Conduct data collection
  - f. Perform data verification
  - g. Identify process integration opportunities
  - h. Address change management opportunities
4. Specifications
  - a. Develop detailed current & future system user requirements
  - b. Develop canned and customized reports requirements
  - c. Develop a weighted system rating template
  - d. Develop an implementation plan
  - e. Develop help desk support requirements
  - f. Develop a training plan
  - g. Develop a system provider qualifications matrix
  - h. Develop a request for proposal
  - i. Develop rating selection criteria
5. Selection
  - a. Obtain any required non-disclosure agreements
  - b. Conduct vendor screening



- c. Participate in qualified vendor demos
  - d. Participate in qualified vendor sandboxes
  - e. Receive the system and implementation proposals
  - f. Review the system and implementation proposals
  - g. Conduct system and implementation vendor reference checks
  - h. Rate the participating vendors
  - i. Ensure computer hardware requirements are met
  - j. Perform the analysis and selection for the system and implementation plan
  - k. Request and receive internal purchase order information
  - l. Notify all participating vendors
6. Implementation
- a. Review and appointment an internal selection team
  - b. Verify work processes
  - c. Implement system
  - d. Conduct system training
  - e. Close out and evaluate project management
  - f. Evaluate system effectiveness

### **Considerations for a CMMS/EAM System Review and Selection Team**

There are a number of steps involved in properly selecting and implementing a CMMS/EAM system. This is not a quick and simple process. It is important to remember that the end goal is to enjoy a fully functioning system and not to simply meet a “go-live” deadline. It is also important to recognize that this is a team effort. A successful initiative requires participation from representatives in a number of key areas. Some of the departments that should be involved in this project include, but are not limited to, the following functional areas:

1. Project Management
2. Maintenance
3. Engineering
4. Equipment Reliability
5. Operations
6. Information Technologies
7. Planning/Scheduling
8. Storeroom
9. Purchasing
10. Safety
11. Site Leadership
12. Human Resources

### **Selection Procedures Example**

As an example, MRG utilizes a methodical and structured approach to facilitate the selection of an organization’s EAM/CMMS software package. From the onset of the engagement, the MRG team works with the client to understand their specific needs and to develop a tailored client specific selection process. Each step in the process involves and/or considers the client,

relevant subject matter experts, and end-users. The resulting output is a definitive verifiable software recommendation based on quantitative and qualitative findings.

MRG works with the client to develop a detailed project plan and timeline to govern project deliverables and schedules. As appropriate, the team considers the client's current EAM/CMMS software use or experience to facilitate the selection process. A comprehensive selection engagement includes all or most of the following tasks:

- Verifying use of client's current EAM/CMMS
- Authenticating client's EAM requirements
- Setting up MRG's selection tool
- Utilizing MRG's selection tool
- Assisting with RFP preparation
- Providing guidance for vendor shortlist selection
- Developing demonstration scripts for the vendors to follow while giving their presentations
- Facilitating vendor demonstrations
- Aggregating and presenting the results of the process
- Delivering the recommendation

### **Resource Considerations**

We are not making a system software recommendation for Sandia National Laboratories in this report, but there are several key elements to consider when approaching this important decision. Some very good industry resources to help with this decision include:

- *The 10 Pitfalls to Avoid when Selecting a CMMS/EAM Solution*- David Berger
- *50 Questions to Help your CMMS Search*- Joel Levitt
- *The 10 Keys to a Successful Implementation*- Kris Bagadia
- *How to Avoid CMMS/EAM System Failures*- Terry Wireman
- *The 10 Best Maintenance Practices for your CMMS*- Dennis Belanger
- *Connecting Reliability to EAM*- Ricky Smith
- *Successfully Implementing Best Practices and EAM*- Jim Davis

## 1. *The 10 Pitfalls to Avoid when Selecting a CMMS/EAM Solution*<sup>26</sup>

Some of the typical blunders made when selecting a CMMS/EAM are described in a recent white paper titled, *The 10 Pitfalls to Avoid When Selecting a CMMS/EAM Solution*. This white paper, based on a reader survey *Plant Services* conducted in December 2008, details the top 10 selection mistakes:

1. You're far too focused on the software's "look and feel."
2. You're purchasing software based on functional fit only.
3. You think your CMMS/EAM is just a static data and reporting system.
4. You're hung up on the slicing and dicing of CMMS/EAM data.
5. You believe that "green" functionality is just today's "flavor of the month."
6. You're focused solely on how the CMMS/EAM will satisfy your current needs.
7. You tend to focus on how the CMMS/EAM benefits your location, instead of what benefits the organization overall.
8. You think implementing a single-vendor ERP/EAM solution translates into the most "fully integrated" solution.
9. You think it's always better to own and control your hardware, software, and support services.
10. You celebrate the day the CMMS/EAM system goes live.

Do any of these mistakes sound familiar? Your best defense is to allocate adequate time for the right resources in the early planning and selection stages. This can save years of aggravation during and after implementation. Follow a solid step-by-step methodology for designing new processes, developing the system requirements that support them, and selecting the right combination of CMMS/EAM package and vendor. To increase the odds that your CMMS/EAM software implementation will be a success, consider following these steps:

1. Build process/system requirements
2. Develop a request for proposal (RFP)
3. Establish a vendor selection committee
4. Determine short-list evaluation criteria
5. Read through the proposals
6. Rate the proposals
7. Final rating of vendors by the vendor selection committee
8. Short-list vendors
9. Follow-up to short-listed vendors
10. Committee member evaluation

Following this 10-step process will improve your chances of selecting and implementing the CMMS/EAM software that best fits your needs. The key is maximizing the work done initially, i.e., to define new processes and supporting system requirements. Furthermore, build consensus across multiple stakeholders throughout the design and selection phases

<sup>26</sup> David Berger- Western Mgmt. Consultants, *The 10 Pitfalls to Avoid When Selecting a CMMS/EAM Solution*, <http://go.infor.com/EAMpitfalls>, Courtesy of INFOR, (2009)

to ensure buy-in. Finally, develop a balanced set of evaluation criteria, and use a methodology that enables you to rigorously evaluate each vendors package against those criteria.

Download the complete report at: <http://go.infor.com/EAMPitfalls/>

## 2. *50 Questions to Help your CMMS Search*<sup>27</sup> - Joel Levitt

In his book, *Managing Factory Maintenance*, author Joel Levitt outlines fifty questions to assist organizations on their journey to identify the right CMMS for their site(s). In order to avoid some of the most common pitfalls of choosing, purchasing, and installing computer systems, Joel encourages organizations to ask themselves and vendors a number of pertinent questions about the system.

In his paper, Joel poses the fifty questions in five different categories. They are:

- Work Order- 11 Questions
- Stock Room- 4 Questions
- Maintenance History and Reporting- 12 Questions
- PM System- 9 Questions
- General- 14 Questions

Review the actual list of Joel's 50 questions at the following web address:

<http://www.maintenanceresources.com/referencelibrary/cmms/50questions.htm>

## 3. *The 10 Keys to Successful CMMS Implementation*<sup>28</sup>

The statistics are startling — from 50 to 80 percent of all computerized maintenance management system (CMMS) implementations fail. When considering the costs associated with a CMMS project, a 50-80 percent failure rate is a tough number for any company to overcome, but with simple steps for a well-thought-out implementation plan, anyone can harness the full potential that a CMMS can bring to an organization. The following is an introduction to the steps you can take to ensure your CMMS implementation is a success.

1. Determining the Scope of Your Project
2. Getting Management Commitment
3. Planning Your Project
4. Preparing for Change
5. Training
6. Data Gathering
7. Data Entry
8. Reports and Analysis
9. Follow-up and Continuous Improvement
10. Links and Attachments

<sup>27</sup> Joel Levitt, *50 Questions to Help your CMMS Search*, <http://www.maintenanceresources.com/referencelibrary/cmms/50questions.htm>, (2004).

<sup>28</sup> Kris Bagadia, *The 10 Keys to Successful CMMS Implementation*, <http://www.reliableplant.com/Read/28838/CMMS-implementation-keys>, (04/06/2012).

#### **4. How to Avoid CMMS/EAM System Failures- Terry Wireman**

With the success rate of CMMS/EAM System implementations at approximately 50%, the following ten reasons for failures are provided as maintenance tips to highlight the most common selection, implementation, and utilization problems. If companies can pay attention to these pitfalls, the number of success stories will increase dramatically.

- Failure 1: Incorrect assessment of needs
- Failure 2: Improper documenting of needs
- Failure 3: Neglecting to obtain management support
- Failure 4: Incomplete marketplace search
- Failure 5: Developing an in-house system
- Failure 6: Inadequate assessment of vendors
- Failure 7: Insufficient testing of software
- Failure 8: Deficient implementation planning
- Failure 9: Inadequate training/documentation
- Failure 10: Misjudging data collection time

To request a copy of this article, and see details of these ten key failures, contact Terry at: [www.twireman@mindspring.com](mailto:www.twireman@mindspring.com)

#### **5. The 10 Best Maintenance Practices for your CMMS- Dennis Belanger**

A computerized maintenance management system (CMMS) stores crucial information about a company's assets and is the primary tool for managing an organization's maintenance and reliability practices. Just as it is critical for craftsmen to have the proper tools and the know-how to use those tools, it is critical for management to fully understand the functionality and potential benefits of the company's CMMS.

Quite often the organization does not really know how to use its primary toolset in the most effective manner. In the world of maintenance and reliability, there are literally hundreds of things that an organization can do to improve its performance. Some of the most frequently asked questions about a CMMS are:

- What should we do first?
- What will provide the best bang for our buck?
- How do we make sure changes will be sustainable?

Management Resources Group (MRG) answers these questions and provides a guide for making fundamental improvements to your organization's maintenance and reliability practices. This list of the ten best maintenance practices for your CMMS is based on MRG's 25 years of experience working with clients across a broad range of industries and provides an overview of what MRG considers to be the non-negotiable practices required to achieve success and improve performance.

Dennis lists the following ten best maintenance practices for your CMMS from #10 down to #1:

- 10: Put someone in charge
- 9: Paper reduction admin reduction
- 8: Build a long term plan
- 7: System training vs. software training
- 6: Use spiral learning
- 5: Don't take short cuts
- 4: Don't forget culture change
- 3: Build high quality accurate data
- 2: Define your processes in detail
- 1: Improve your practices

*“Organizations often build a plan to support the implementation of a CMMS that begins with the selection of the software and ends with Go Live of the system. In reality the Go Live is only the beginning of the effort”.*

Ensure you have a long-term plan in place that addresses the following:

- Master data development and long-term data management
  - Data standards, quality, level of detail
  - Control of data entry in system
  - Management of new and obsolete data
  - Resources to build and validate data
- Metrics and KPI management
- Business process compliance measurement
- New-hire training (new employees and new to role employees)
- Advanced system training
- Upgrade management
- Report development, management, and distribution

Dennis says: “Accuracy and consistency of data is the foundation of the system. If this isn't done correctly and to the proper level of detail, the system will not be able to deliver its designed value. Commit to building and maintaining foundational data, and you will have a valuable and sustainable system.” He believes good system data looks like this:

- Location Hierarchy – Clearly defines the system
- Master Equipment List – The core of the system
  - Class, subclass, attributes, descriptions (see examples)
  - Drives: reporting, analysis, cost tracking, failure tracking, reliability strategy deployment, asset comparison, RCFA
- Item Master – contains stock and non-stock item records
  - Stock and non-stock items
  - Classification, attributes, consistent descriptions, technical detail
- Bill of Materials – the most valuable data component

- Increases planner productivity, improves quality of repair, key info for inventory management, critical to emergency response
- Failure Hierarchies – class/subclass specific
  - Problem, cause, remedy (FMEA based)
  - Advanced starting point for RCFA

Dennis encourages companies to build this data from day one. In his experience, companies that try to build data later almost always fail. He also tells organizations to validate data before it's imported. If you are unsure about accuracy, don't load it.

If you are interested in obtaining a copy of the presentation or white paper titled *Top 10 Best Maintenance Practices for your CMMS*, contact Dennis Belanger at: [belangerd@mrgsolutions.com](mailto:belangerd@mrgsolutions.com)

## 6. **Connecting Reliability to EAM<sup>29</sup> - Ricky Smith**

Ricky believes that most plant maintenance and operations groups have the opportunity to make a much bigger contribution to the bottom line by linking their reliability efforts with their EAM system.

The importance between linking equipment reliability and CMMS/EAM systems cannot be overlooked. EAM and the other systems that we use should play a supporting role in ensuring the execution of the process and increasing plant performance. Ricky states that improving plant performance by managing the reliability of the assets leads to significant business benefits by:

1. Increasing production output
2. Decreasing cost
3. Reducing need for capital replacement
4. Maximizing competitiveness and protecting jobs

Ricky goes on to say that "... connecting reliability to your EAM is key to truly managing your assets. EAMs are very helpful in managing the execution of work, but tools are needed to manage the determination of the right work at the right time. With the right tools, you can drive maintenance activity from your asset health data. And the best way to get started is one system at a time, which will result in significant and rapid financial rewards to your company".

To read the article in its entirety, you may access it at:

<http://www.cmmscopy.com/articles/connecting-reliability-to-eam/>

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<sup>29</sup> Ricky Smith, *Connecting Reliability to EAM*, <http://www.cmmscopy.com/articles/connecting-reliability-to-eam/>, (2006).

## 7. **Successfully Implementing Best Practices and EAM**<sup>30</sup> - Jim Davis

In this informative article, Jim Davis shares the “Top-7” Critical Pitfalls to Avoid in implementing best practices and EAM systems. Jim states that “each year companies spend thousands to sometimes millions of dollars on a new EAM system only to find that one to two years down the road after implementation, they have no better data than what they previously had and find themselves using less than twenty-five percent of the capabilities of the new software.”

So what went wrong? Why didn't the investment pan out as anticipated? How then could other companies avoid the same mistakes in the future? There can obviously be many different factors that contribute to an unsuccessful EAM implementation. However, the most common ones can be summarized below:

- IT drove the project, with little to no real user input.
- The company failed to do a thorough review of its business practices.
- Little thought and effort was put into developing the right “codes & tables” within the system.
- User Levels were not well identified and honored.
- Software training was not aligned with process training.
- Critical KPI's and reports were not well thought through.
- There was not a software super-user/administrator clearly defined.

Use the following address to access the entire article:

<http://www.cmmscopy.com/articles/successfully-implementing-best-practices-and-eam/>

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<sup>30</sup> Jim Davis- Performance Consulting Associates, *Successfully Implementing Best Practices and EAM*, <http://www.cmmscopy.com/articles/successfully-implementing-best-practices-and-eam/>, (2009).



Section Nine: Vendor Questionnaire Summary & Client Satisfaction Survey Template



**CMMS/EAM Vendor Questionnaire**

In an effort to objectively and accurately identify attributes and capabilities of the top CMMS/EAM system providers in the industry today, MRG developed the attached vendor questionnaire. Comprised of six sections and 45 questions, this informal survey encompasses:

Table 9.1

Section #	Section Description	# of Questions
1	Company Background	10
2	Basic Modules Provided	20
3	Pricing Structure	4
4	Implementation & Support	4
5	Industry Specialization	5
6	Miscellaneous	2
		45

A blank portion of the Vendor Questionnaire that was distributed is attached as Table 9.2.

Table 9.2: CMMS/EAM System Vendor Questionnaire, Page 1

**CMMS/EAM System Vendor Questionnaire**

Created: 09/01/2012



Survey Completion Date:	
Company Name:	
Company Website:	
U.S. Headquarter Location:	

**Survey Instructions:**  
 Please answer the following questions with an accurate and honest response or with a simple "Yes/No" answer in the space provided. If you feel additional comments are required, please provide them in the space titled "Miscellaneous Comments".

Section	Question #	Survey Question	Survey Response	Yes	No	Miscellaneous Comments
1. Company Background	1.1	Primary Product Offered (ERP, CMMS or EAM):				
	1.2	Primary Product Name:				
	1.3	Product Version #:				
	1.4	Last Product Release Date:				
	1.5	Language or Code Software is Written In:				
	1.6	Years in Business:				
	1.7	Annual Sales (Of Primary Product Noted Above):				
	1.8	# of Employees (Dedicated to Primary Product):				
	1.9	# of Customers (Of Primary Product):				
	1.10	Market or Industry Specialization:				
2. Basic Modules Provided	2.1	Equipment History				
	2.2	Work Requests				
	2.3	Work Orders				
	2.4	Preventive Maintenance				
	2.5	Predictive Maintenance Database Interface				
	2.6	Planning & Scheduling				
	2.7	Inventory/Spare Parts Management				
	2.8	Bar Coding				
	2.9	Purchasing				
	2.10	Warranty Tracking				
	2.11	Canned Reports				
	2.12	Report Writer				
	2.13	Human Resources Management				
	2.14	Tool Management				

### Questionnaire Results

In an effort to receive information from a representative number of CMMS/EAM system providers, 30 companies were invited to participate in completing and submitting the questionnaire. It should be noted that organizations known to provide primarily facility-based maintenance systems, specializing in hospitals, property management complexes, etc. were not invited to complete and submit the system vendor questionnaire. We focused on system providers that specialized in serving larger, asset-intensive industries.

Of the 30 organizations contacted, 24 expressed an interest in participating in the questionnaire. At the time of this report submittal, only 17 of the 24 CMMS/EAM software manufacturers have submitted their survey forms.

It should be noted that, in addition to contacting the software OEMs, effort was made to speak with many of the ISPs to determine which maintenance software they were using to aid in managing their O&M contracts. Although some of the ISPs failed to respond to our inquiries, we did receive responses back from seven or eight service providers. A few of them claimed to be using SAP while a couple said they use Maximo, but many of them stated they were either using their own, proprietary system or whatever system their wind farm customers had purchased.

Ian Greig, Group Technical Manager for Run Energy stated they have been using the eMaint software for the past six to seven years and are extremely happy with the detailed planning, scheduling, monitoring and reporting that eMaint's X3 CMMS provides.

The survey results from the software OEMs are as follows in Table 9.3.

Table 9.3

#	Survey Question	# of Responses	Summary of Survey Responses
1.1	Primary Product Offered	16	CMMS Only: 9, EAM Only: 3, Multiple Products: 4
1.6	Years in Business	16	Average of 25.5 years
1.8	# of Employees	13	Average of 103 employees
1.9	# of Customers	14	Average of 2,557 customers
2.1	Equipment History	17	Yes: 17 No: 0
2.2	Work Requests	17	Yes: 17 No: 0
2.3	Work Orders	17	Yes: 17 No: 0
2.4	Preventive Maintenance	17	Yes: 17 No: 0
2.5	Predictive Maintenance Database Interface	17	Yes: 13 No: 4
2.6	Planning & Scheduling	17	Yes: 17 No: 0
2.7	Inventory/Spare Parts Management	17	Yes: 17 No: 0
2.8	Bar Coding	17	Yes: 16 No: 1
2.9	Purchasing	17	Yes: 17 No: 0
2.10	Warranty Tracking	17	Yes: 15 No: 2
2.11	Canned Reports	17	Yes: 17 No: 0
2.12	Report Writer	17	Yes: 14 No: 3
2.13	Human Resources Management	17	Yes: 13 No: 4
2.14	Tool Management	17	Yes: 16 No: 1
2.15	Contractor Management	17	Yes: 16 No: 1
2.16	Root Cause Failure Analysis	17	Yes: 14 No: 3
2.17	Mobile Devices	17	Yes: 17 No: 0
2.18	Automated Alerts	17	Yes: 16 No: 1
2.19	On-line Monitoring (SCADA, Meters, etc.)	17	Yes: 13 No: 4
2.20	Remote WO Module	17	Yes: 16 No: 1
4.1	Do you Provide Implementation Services:	17	Yes: 17 No: 0

4.3	Do you Provide On-site Training:	17	Yes: 16 No: 1
4.4	Do you Staff In-country Help Desk Support:	17	Yes: 16 No: 1
5.1	Estimated # of Wind Energy Customers:	17	7 responded with "0" 5 respondents were unsure Remaining 5 responses totaled <70
5.2	Provide Equipment Register Copy/Paste Features	17	Yes: 16 No: 1
5.3	Provide Paperless WO System Process	17	Yes: 17 No: 0
5.4	Capable of Remote System Monitoring	17	Yes: 13 No: 4
5.5	Provide a Customer Website Allowing Networking Within the Industry	17	Yes: 12 No: 5
6.1	Number of Canned Reports Provided:	15	Average of 189 canned reports avail.
6.2	Provide Customized Dashboards	16	Yes: 13 No: 3

**Questionnaire Summary**

It should be noted that the answers provided by the software manufacturers have not been challenged. For the purposes of this survey, the submittals were based on the honor system, and therefore the responses are assumed to be accurate. The findings from the questionnaire responses that were considered items of interest include:

- The majority of the questionnaire respondents considered their primary offering to be categorized as a CMMS vs. an EAM system or ERP. (Question 1.1)
- With 14 respondents, one firm estimated that they employed into the thousands on their core product offering, with only one other organization estimating over 100 employees at 1,000. The remaining twelve respondents totaled 336 employees between them, or an average of 28 employees per software OEM. The top employer was SAP followed by IBM. There was quite a distance between the first and second company and between the second and third company. TMA, Champs, and Mainsaver rounded out the top five positions. (Question 1.8)
- With 15 survey respondents, SAP reported the most customers followed by IBM and Qqest (Manager Plus) at 10,000 each. Mainsaver and Micromain completed the top five positions with an estimated number of customers at over 5,000 and 3,500 respectively. (Question 1.9)
- Four of sixteen software packages replied as not having interfaces with Predictive Maintenance databases. They are eWork Orders, Micromain, ManagerPlus, and WTGservices. (Question 2.5)
- Only one company replied as not offering bar coding capabilities. This was fsc Limited (4site). (Question 2.8)

- Three software providers stated they do not offer report writer capabilities. They were eWork Orders, MicroMain, and WTGservices. (Question 2.12)
- Four systems reported they do not provide online monitoring capabilities. They were Assetpoint (Tabware), eWork Orders, MicroMain, and WTGservices. (Question 2.12)
- While all 17 respondents confirmed they provide implementation services (Question 4.1), one company—eWork Orders—replied they do not provide on-site training. (Question 4.3)
- Of particular interest was the response to the question about the estimated number of wind industry customers each software company possessed, (Question 5.1). Of the 17 respondents, seven stated zero, five were not sure, and the remaining five companies had a combined total of just fewer than 70 wind energy customers. SAP claims to have more than 275 power generation companies, but went on to say that “it should be noted, however, that not all power companies have wind generation capabilities.” Of the remaining companies that stated they have specific wind industry clients, WTGservices touts 28, Mainsaver reported to have 20, Maintimizer claims 10, ManagerPlus reported <10, and Maximo responded with three.
- Systems that were reported to be incapable of remote system monitoring include eWork Orders, MicroMain, Bigfoot, and WTGservices. (Question 5.4)
- The quantity of canned reports that each software provided was quite varied. Three were unsure, while the fewest numbers ranged from 19 with WTGservices and 20 with Bigfoot to 500 or more with TMA and MicroMain. (Question 6.1)
- The three companies that replied they do not offer customized dashboards were Ashcom (Maintimizer), MicroMain, and WTGservices. (Question 6.2)



### Client Satisfaction Survey Template

We created a client satisfaction survey to gauge how satisfied various maintenance software end users are with their CMMS/EAM systems. The questionnaire is comprised of 47 questions from three categories. The survey areas include *Review and Selection*, *Implementation*, and *Utilization and Satisfaction*. The goal is to provide a communication feedback tool to gain insight into CMMS/EAM system end-user customer experiences.

Although conducting a survey of CMMS/EAM end users was not part of this report, the intent is to use the document to gather feedback from future wind energy maintenance providers—such as wind farm owners, turbine OEMs that provide maintenance services, or independent service providers—to identify the specific system they are using and to capture their satisfaction with that system.

A portion of the MRG *CMMS Satisfaction Survey* is attached in the following table.

Table 9.4: CMMS Satisfaction Survey, Page 1

**CMMS Satisfaction Survey**

Created: 08/15/2012



Date:	09/ /2012	CMMS Version Currently Using:	
CMMS End User Customer:		# of Years Using this CMMS:	
Customer Location:		# of Sites Using this CMMS:	
CMMS Brand Currently Using:		# of Users or Concurrent Licenses:	

Survey Section	Question #	Survey Question	Survey Answer		Survey Rating (1: Very Poor/Dissatisfied, 2: Poor/Dissatisfied, 3: Average, 4: Well Satisfied, 5: Very Well Satisfied)					Miscellaneous Comments
			Yes	No	1	2	3	4	5	
<i>Survey Instructions:</i> Answer the following questions with the appropriate "Yes/No" response or a 1-5 rating. Use a ✓ to indicate your answers.										
1. CMMS Review & Selection	1.1	Did your company form a CMMS review & selection team?								
	1.2	To what degree was this team comprised of a variety of different pertinent groups?								
	1.3	Did your organization create User Requirements Specifications (URS)?								
	1.4	How thorough and how well was your URS written?								
	1.5	Did your company create a Request For Proposal (RFP)?								
	1.6	How specific and well-written was your CMMS RFP?								
	1.7	Did you conduct CMMS vendor demos of their software?								
	1.8	How well organized and informative were the vendor demos?								
	1.9	Did you establish CMMS sandboxes from which to navigate in and test the functionality of the various systems?								
	1.10	To what degree was feedback from the team members experiences in the sandboxes collected and a factor in the system selection?								
	1.11	Did 75% or more of the review and selection team log in and navigate through the various systems?								
	1.12	To what extent were CMMS vendor references checked prior to purchasing the selected system?								
	1.13	Was a CMMS budget established prior to requesting RFP's?								
	1.14	To what degree was the budget adhered to with the selection of the awarded system?								
2. CMMS Implementation	2.1	Was your selected system an "out-of-the-box" solution?								
	2.2	Was your selected system a "configured" solution with minimal to no customization?								
	2.3	Was your selected system a highly "customized" solution?								
	2.4	Did you use the software manufacturer to implement the CMMS?								
	2.5	If not, did you use a 3rd party implementer?								
	2.6	How well did the data scrubbing go?								
	2.7	Has your CMMS been integrated with your sites Enterprise Resource Planning (ERP) system?								



## Section Ten: Conclusion



According to the American Wind Energy Association (AWEA), 1,200 megawatts (MW) of wind power capacity was installed during the second quarter of 2012, bringing installations for the first half of 2012 to 2,896 total MW. By the end of the first half of 2012, the U.S. wind industry totaled 49,802 MW of cumulative wind capacity, with over 10,300 more MW currently under construction in 30 states and Puerto Rico. The U.S. wind industry has added over 35% of all new generating capacity over the past five years, second only to natural gas, and more than both nuclear and coal combined. Today, U.S. wind power capacity represents more than 20% of the world's installed wind power.

In recent years, wind turbine OEMs have been enjoying strong activity, and have been particularly busy filling orders for projects in Canada, Mexico, and Central and South America. However, according to Andrew Longeteig, a spokesman for Vestas at company headquarters in Oregon, "the U.S. wind industry has slowed, largely due to the uncertainty of the federal Production Tax Credit extension at the end of 2012, which has led to a significant reduction in turbine orders for 2013, and the market slowdown is affecting Vestas' manufacturing facilities in Colorado."

The wind production tax credit, which is set to expire at the end of 2012, extends to those using wind energy and equates to 2.2 cents per kilowatt-hour for the production of electricity from turbines during the first 10 years of electricity production.

According to the AWEA, the U.S. wind industry represents both a large market for wind power capacity installations and a growing market for American manufacturing. Over 470 manufacturing facilities across the United States make components for wind turbines, and dedicated wind facilities that manufacture major components such as towers, blades, and assembled nacelles can be found in every region.

Mass production of wind turbines on an industrial scale is not yet a decade old, and few turbine models have operated in large numbers for more than a handful of years. Robust operational data remains a relatively scarce commodity, and even expert technicians have been reliant on little more than anecdotal data to try to predict when a component is likely to fail, and how to avert an impending failure.

### **Becoming Proactive**

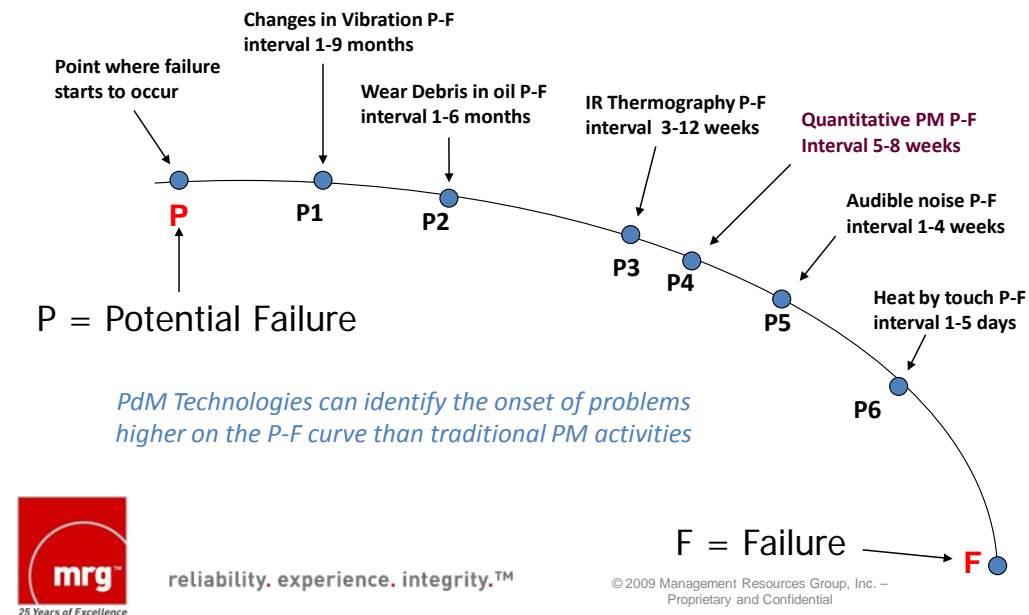
Cutting costs by preventing failures instead of running wind turbines until they break lies at the heart of a new approach to operations and maintenance. Analysis of condition-monitoring data can alert the maintenance team before damage is done. Owners, operators, and developers are recognizing the significant value of getting ahead of problems and preventing failures rather than running turbines until they break.

The period between when equipment begins to fail and when it completely fails provides an opportunity for proactive maintenance organizations to identify, schedule, and execute

corrective actions. A visual representation of this timeline is what those within the maintenance community have come to refer to as the Potential to Failure diagram or the “P to F Curve.” This phenomenon, as illustrated below, depicts the various condition-monitoring techniques and the associated longer lead times (in general terms) that are afforded to equipment caregivers compared to the much shorter time afforded to traditional sensory lead times. By using various predictive testing disciplines, the opportunity for maintenance and reliability specialists to detect and correct equipment anomalies prior to complete failure is greatly increased.

Figure 10.1

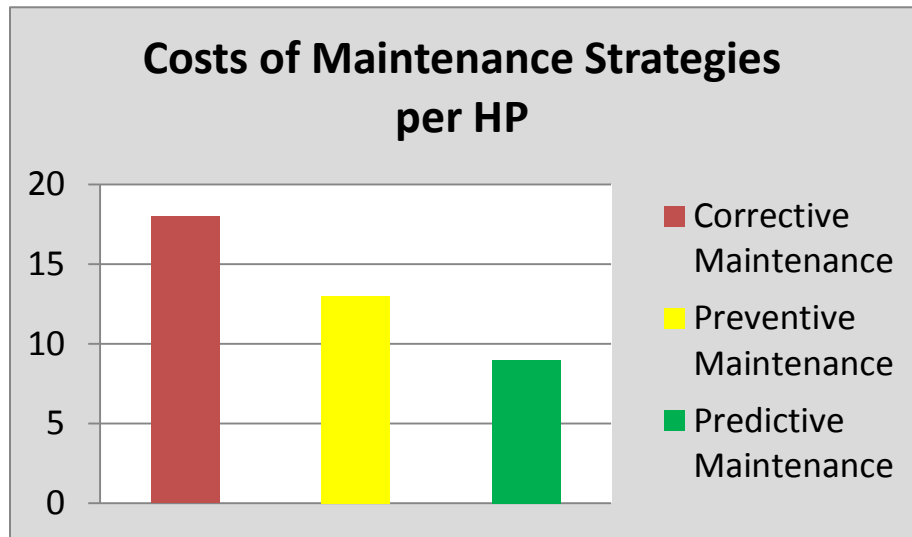
## The P to F Curve



### The Reduced Cost of Being Proactive

Although there is an initial cost involved in implementing predictive testing at a site, in the long run, it is a much more cost-effective strategy than operating in a reactive, “firefighting” mode. A study conducted within the power generation industry by the Electric Power Research Institute (EPRI) in 1986 illustrates this fact. The study documented that the annual maintenance cost of repairing machinery when it breaks down (corrective maintenance) is \$17 to \$18 per horsepower. Comparatively, the annual maintenance cost per horsepower using preventive maintenance is between \$11 and \$13, and the lowest cost shows that predictive maintenance reduces manual maintenance costs to between \$7 and \$9 per horsepower. The study by EPRI showed that an overall maintenance cost reduction of 47% is generally obtained by using predictive maintenance techniques, in comparison to the basic reactive approach.

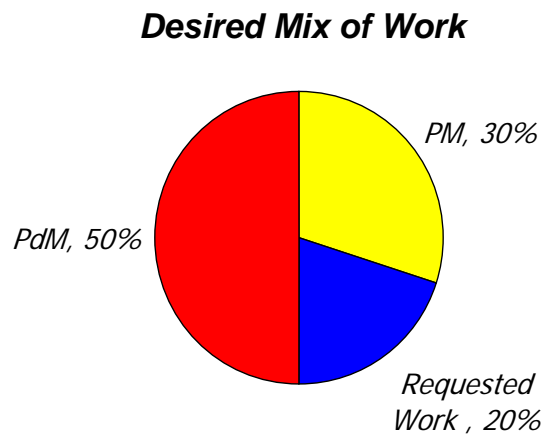
Figure 10.2



More recently, the National Wind Coordinating Committee (NWCC) estimated that 75% of the total wind industry maintenance costs are attributed to unscheduled maintenance, 20% is preventive maintenance tasks, and the remaining 5% is associated with major planned overhauls. The opportunity, therefore, resides in the potential to reduce the larger, reactive category from 75% to 25% by implementing sound predictive maintenance (PdM) practices.

Proactive organizations don't wait for equipment to fail. They place a high priority on preventive and predictive activities that preserve equipment health and detect deteriorating conditions early in the failure process. Typically 15% of craft labor is dedicated to time-based PM tasks, with another 15% used to correct problems discovered during these tasks. An additional 15% is used to perform predictive tasks such as route-based vibration analysis, thermography, oil analysis, etc. These tasks generate another 35% of work that can be planned and scheduled for execution at a time most convenient to Operations. Only about 20% of work is generated outside the PM/PdM program.

Figure 10.3: Excerpt from MRG Reliability Awareness Training



Our experience in best practices is reflected by a series of studies that were conducted over a six-year timeframe by 10 objective and reputable organizations whereby they identified the pacesetters in a host of different vertical markets. The gradient measurements reflect how companies within each market segment compare by quartile. For example, organizations

considered to be in the top quartile of the power generation market use vibration analysis on 87% to 95% of their applicable asset base, while companies in the second quartile use vibration technology on applicable assets between 62.5% and 79% of the time. Refer to the table below to measure in which quartile your organization is ranked.

Table 10.4: Excerpt from MRG Reliability Awareness Training

QUARTILE	% VIB	% IR MECH	% IR ELEC	% OIL ANAL	% OTHER NDT	% ON PM	% ON BOM
<b>Power Generation</b>							
Top 1st	95.0%	73.0%	100.0%	42.0	47.8%	20.0%	79.0%
Middle 1st	87.0%	62.5%	92.0%	38.0	39.3%	22.0%	72.0%
Top 2nd	79.0%	54.0%	88.1%	32.7	33.9%	24.0%	68.0%
Middle 2nd	62.5%	43.9%	85.1%	26.2	27.9%	26.0%	65.0%
Top 3rd	59.8%	36.6%	79.8%	22.8	21.6%	28.0%	61.0%
Middle 3rd	41.7%	24.9%	74.5%	16.7	17.3%	31.0%	57.0%
Top 4th	29.8%	18.1%	68.7%	11.2	13.9%	33.0%	53.0%
Middle 4th	12.8%	5.5%	60.9%	7.6%	9.1%	34.0%	47.0%
Bottom 4th	3.8%	0.0%	52.1%	1.0%	6.1%	38.0%	36.0%

Note: The following information is intended to clarify the meaning of the column titles above:

- **QUARTILE-** The overall placement of an organization based on its performance in a number of key areas such as low maintenance costs and high equipment reliability.
- **% VIB-** The amount of vibration analysis being performed on equipment compared to all of the applicable equipment on which it could be performed, expressed as a percentage. (Rotating machinery such as motors, blowers, gear reducers, etc.)
- **% IR MECH-** The amount of infrared thermography being performed on the mechanical equipment compared to all of the applicable mechanical applications it on which it could be performed, expressed as a percentage. (Checking for hot spots on bearings, couplings, etc.)
- **% IR ELEC-** The amount of infrared thermography being performed on the electrical distribution system compared to all the applicable electrical distribution systems on which it could be performed, expressed as a percentage. (Scanning for temperature rises on breakers, switchgear, motor control centers, bus bar, etc.)
- **% OIL ANAL-** The amount of oil analysis being performed on the equipment compared to all of the applicable equipment on which it could be performed, expressed as a percentage. (Gear boxes, hydraulic systems, etc. To include testing for the presence of contaminants, wear particles and metals as well as the presence of water.)
- **% OTHER NDT-** The amount of other non-destructive testing being performed on the equipment compared to all of the applicable equipment on which it could be performed, expressed as a percentage. (Ultrasound detection, motor circuit analysis, Eddy current analysis, magnetic particle counting, radiography, etc.)

### **Periodically Review Processes**

Maintenance software is only as good as the business processes it supports. Be sure to periodically review, analyze, and improve your current work-flow processes, taking advantage of the CMMS's built-in functionality for best practices.

The CMMS is typically not used to its fullest potential. In many cases, organizations are only utilizing a small piece of the CMMS and not even coming close to realizing the full benefits of the system. Take time to think about how the tool could be used to support improved practices. Consider whether your organization is driven by data. Is data used to make decisions, or do decisions tend to stem from gut feelings? Reactive companies are always playing catch-up. Establish good maintenance and reliability procedures and get educated about industry best practices.

By understanding the electronic work order systems available and their abilities to execute standard and industry-specific maintenance functionality, Sandia National Laboratories will be in a strong position to help wind industry members select the best system. Additionally, being aware of the common pitfalls associated with implementing these systems will help orchestrate successful implementations.

### **Future Enhancements**

It is impossible to predict how maintenance software systems may improve in the future. However, by recognizing the importance of effectively capturing, storing, retrieving, and using accurate maintenance data today, it's easy to envision how critical it will be to effectively manage data in these same areas in the future.

Anticipated use of condition monitoring applications and Supervisory Controls And Data Acquisition (SCADA) systems are expected to continue to rise, providing enhanced understanding of the entire wind turbine system health. Proactively gathering information about impending failures or changes in the equipment operating parameters will enable wind park asset maintainers to better plan, schedule, and execute maintenance activities prior to the condition becoming an emergency. Leadership will be in a better position to make intelligent, equipment-condition, business-based asset care decisions by utilizing PdM data—combined with commercially available products from companies such as GE, InSight, Ludeca, National Instruments, WindRisk, WindSL, and many others—and data from select turbine OEM monitoring software, operations, and maintenance.

As important as it is today to integrate maintenance data with other cells of enterprise information, it will likely be more crucial to leverage comprehensive and accurate operational, maintenance, and financial data into a common platform tomorrow. Possessing the ability to easily and quickly view and act upon real-time, accurate “dashboard” information at the fingertips of a number of variant functional perspectives within the enterprise will serve to positively impact decisions. These organizations will be positioned to make quick, informed decisions that will contribute to meeting production schedules ensuring quality, safety, and environmental standards are in compliance; satisfying customer demands; extending

equipment life; optimizing worker productivity; and reducing costs. Companies that seek to be wise stewards over their key business data drivers and intellectual property are the organizations that are anticipated to achieve a competitive advantage in the future.

Another area in which future software enhancements are expected to occur is within the exchange of data between equipment OEMs and the end-user client. By possessing much more data than what the consumer typically receives now, the end-user site responsible for properly caring for the long-term health of these newly acquired assets will be better equipped. Additional data that the owners of critical equipment hope to enjoy in the future relate to better bills of materials (BOMs), pre-packaged equipment and job plans, accurate preventive maintenance interval frequencies, diagnostic and troubleshooting guides, etc.

Warranty tracking, equipment repair/replace algorithms, and Root Cause Failure Analysis (RCFA) are other features that we anticipate will be improved upon in wind industry maintenance software in the coming years. In addition to many of the technical and functional improvements that are likely to occur within future releases of maintenance management software, perhaps one of the most important areas in which advances will be made is not within the software at all, but within the culture of the companies putting this software to use.

Maintenance leaders typically possess a good technical background and are generally very proficient in addressing technical issues. Unfortunately, they tend to struggle when it comes to resolving the behavioral, people-side of the equation, which can be problematic because a strong focus on changing the cultural side of business is critical to success. Companies can review, select, purchase, implement, and train on using the best designed systems on the market, but if they fail to educate the technicians on the value of using the system and put in place accountability measures to ensure the system is being used according to agreed upon work processes, they have failed.

A colleague once said, without pursuing an improvement strategy in which the framework is focused on developing processes and people, you are bound to fail. It is believed that the organizations that recognize the need to address the “soft” side of the maintenance world will be the leaders in tomorrow’s businesses.

For additional considerations regarding the possible future of maintenance software systems as well as the maintenance organization in general, consider reading “*A Vision of Enterprise Reliability*” by Dennis Belanger of MRG. You may access this article at: [http://reliabilityweb.com/index.php/articles/list/category/cmms\\_and\\_eam](http://reliabilityweb.com/index.php/articles/list/category/cmms_and_eam)

Section Eleven: Appendix

Appendices

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## Appendix A: Plant Services CMMS/EAM Software Review Comparison



The Plant Services CMMS/EAM Software Review is designed to allow you to compare packages across a comprehensive range of capabilities. It offers the option of weighting capabilities to reflect their importance in your application and receiving a calculated ranking of the software offerings according to your specifications.

As the “Introduction” screen explains, you can use the Review to simply browse the results of our verified vendor survey data, compare products, and find further information on particular packages and vendors. Or, you can have the system rank packages according your customized and advanced criteria. Clicking on “Software Aspects” lets you weight them individually, so the comparison engine can calculate scores and present packages according to how well their strengths match your weightings.

Clicking on an individual software aspect in the “Introduction” screen brings you to a “Priorities” screen, which shows the exact survey questions used to establish the package score for that aspect. Exercising your option to rank a question less than “very important” factors its score so it has less weight in the calculated comparison.

You can hand-pick packages and compare them for various aspects or enter weightings and priorities and click “calculate” to bring you to the comparison screen. Here, you’ll see a side-by-side comparison detailing the level of functionality for each capability. You can access the site by visiting: <http://cmms.plantservices.com>.



**Appendix B:** Related MRG Research

Related MRG research that forms a companion or reference to this report was not limited to but includes:

- American Wind Energy Association (AWEA): [www.awea.org](http://www.awea.org)
- CMMS City: [www.cmmscity.com](http://www.cmmscity.com)
- Management Resources Group (MRG): [www.mrgsolutions.com](http://www.mrgsolutions.com)
- Plant Services CMMS/EAM Software Review: [www.PlantServices.com/CMMS\\_Review](http://www.PlantServices.com/CMMS_Review)
- Reliability Web.com CMMS Articles: [www.reliabilityweb.com/index.php/articles/list](http://www.reliabilityweb.com/index.php/articles/list)
- Society of Maintenance & Reliability Professionals: [www.smrp.org](http://www.smrp.org)
- Terry Wireman, *Successfully Utilizing CMMS/EAM Systems* (Ft. Myers: Reliabilityweb.com, 2011)
- Wikipedia: [www.wikipedia.org](http://www.wikipedia.org)
- Wind Energy Update: [www.windenergyupdate.com](http://www.windenergyupdate.com)
- Windpower Monthly Magazine: [www.windpowermonthly.com](http://www.windpowermonthly.com)

## Appendix C: Industry Resources

Additional CMMS/EAM system, reliability, and wind industry resources are not limited to but include:

- Alternative Energy Wind Power News: <http://www.alternative-energy-news.info/headlines/wind/>
- Association for Maintenance Professionals (AMP)– Online community with over 9,000 maintenance reliability professionals: [www.maintenance.org](http://www.maintenance.org)
- CMMSCity.com – Website includes articles, tips, tutorials, and news on Computerized Maintenance Management. [www.cmmscopy.com](http://www.cmmscopy.com)
- Global Wind Energy Council (GWEC): [www.gwec.net](http://www.gwec.net)
- MaintenanceConference.com– Calendar of maintenance reliability focused events: [www.maintenanceconference.com](http://www.maintenanceconference.com)
- MaintenanceForums.com – Online message boards with over 20,000 maintenance reliability professionals: [www.maintenanceforums.com](http://www.maintenanceforums.com)
- Maintenance Resources- An index of various CMMS/EAM-related sources: [www.maintenanceresources.com/cmms/index.htm](http://www.maintenanceresources.com/cmms/index.htm)
- Maintenance Technology Magazine: [www.mt-online.com](http://www.mt-online.com)
- MRO-Zone.com Bookstore– Online bookstore with CMMS books and DVD's: <http://books.mro-zone.com>
- National Renewable Energy Laboratory (NREL): [www.nrel.gov](http://www.nrel.gov)
- National Wind Coordinating Collaborative: [www.nationalwind.org](http://www.nationalwind.org)
- PA Wind Energy Symposium: [www.wind.psu.edu/resources](http://www.wind.psu.edu/resources)
- RECHARGE- The global source for renewable energy news: [www.rechargenews.com](http://www.rechargenews.com)
- Reliabilityweb.com – Maintenance reliability focused website includes articles, tips, videos, tutorials, news, etc. [www.reliabilityweb.com](http://www.reliabilityweb.com)
- Renewable Energy Magazine: [www.renewableenergyworld.com](http://www.renewableenergyworld.com)
- Renewable Energy Policy Project: [www.repp.org](http://www.repp.org)
- Society of Maintenance & Reliability Professionals (SMRP): [www.smrp.org](http://www.smrp.org)
- Software comparison site: [www.cmms-eam.com/compare.cfm](http://www.cmms-eam.com/compare.cfm)
- Think Energy Management: [www.think-energy.net](http://www.think-energy.net)
- Uptime Magazine – Bi-monthly magazine for maintenance reliability professionals. [www.uptimemagazine.com](http://www.uptimemagazine.com)
- Wind Power Engineering & Development: [www.windpowerengineering.com](http://www.windpowerengineering.com)
- Wind Power Monthly: [www.windpowermonthly.com](http://www.windpowermonthly.com)
- WindRisk: [www.windrisksolutions.com](http://www.windrisksolutions.com)

- Wind Systems Magazine: [www.windsystemsmag.com](http://www.windsystemsmag.com)
- Windustry: [www.windustry.org](http://www.windustry.org)

Note: MRG does not necessarily endorse any specific entity mentioned here, but offers these resources in the spirit of sharing potentially valuable support in your maintenance software, equipment and process reliability, and wind energy needs.



