

IPRO 303

Operational Considerations in Wind Power Generation: Cost Impact of Equipment Failures, and Opportunities for Improved Performance

PROJECT PLAN

Instructor: Edmund C. Feldy PE
Sponsors: SmartSignal
IPRO Team: Olaoluwa Adeola, Christopher Catalina, Jesus Cervantes, Sara Claxton, Samad Erogbogbo, Earl Fairall, Richard Ike, Robert Keane, Kristina Lakiotis, Aaron Melko, Mithun Michael, Viral Patel, Donald Ruffatto
Date: Friday, September 19, 2008

1. Abstract

The Fall 2008 semester of IPRO 303 will investigate and analyze the economic and technical details of the wind-turbine electricity generation industry. The IPRO 303 team will be focusing on the impact of equipment failures that lead to downtime and maintenance associated with the failures. A comparison of current industry practices in dealing with these problems, along with a detailed economic analysis of the true costs involved, will be the major goal. A final report of the findings and conclusions of the IPRO 303 team will be provided to our sponsor, SmartSignal Inc. It is understood that this Project Plan will change as the term progresses and more information becomes available.

2. Background

- A. Sponsor Information:** SmartSignal Inc. offers software which models machine and equipment behavior, and can learn to distinguish between normal and abnormal conditions. This information is used by machine operators to proactively deal with potential problems before they cause faults and unplanned downtime. It can also be used to determine when preventive maintenance is actually needed, which can reduce costs by limiting unnecessary maintenance. SmartSignal has a long history of providing its products and services to many different industries. It does not currently deal with the wind power industry, but views this area as a potential future market for its products. Developing this market will require an in-depth understanding of the nature of equipment failures and industry maintenance practices, including all economic costs. An accurate awareness of the true costs of faults, planned and unplanned down-time, and maintenance and repair practices is therefore important to understanding the role SmartSignal's products can play in this industry. Equally important is an understanding of the accuracy of current industry perceptions of these costs. IPRO 303 will investigate these aspects of the wind turbine industry and attempt to develop some conclusions which will aid SmartSignal in determining its future role in this area.
- B. Addressed Problems:** As indicated in the paragraph above about SmartSignal the intention of IPRO 303 is not to solve an existing problem but to help our sponsor come up with an innovative solution that will be more effective than existing solutions. We will investigate if the current maintenance paradigm that exists in the wind-turbine power generation industry is sufficiently efficient.
- C. Technology Involved:** Technical report writing and computational analysis software will be employed in analyzing the data and information collected as well as reporting the analysis results.

- D. Other Attempts to Solve the Problem:** SmartSignal personnel are also working on alternative solutions. This is the first attempt by IPRO 303 at solving the problem.
- E. Ethical Issues:** SmartSignal operates in a competitive market and any classified or sensitive information or documents obtained from SmartSignal will be kept confidential and will not be disclosed to anyone outside the project team. SmartSignal has requested that we not mention their sponsorship of IPRO 303's project when gathering information. We recognize there may be important ethical consequences of this, and plan to examine these as they arise.
- F. Supporting Documents:** A document provided to us by our sponsor from our initial briefing for the project is attached as addenda A.

3. Objectives

- A.** Our project sponsor SmartSignal has provided us with the following objectives:
1. Explain faults that are occurring in wind turbines and why
 - Gain a general understanding of how wind turbines work
 - Identify turbine components and major failures
 - Determine turbine faults
 - Determine most costly/most common reasons for turbine downtime
 2. Provide detailed overview of current maintenance practices and procedures
 - Provide listings of maintenance procedures available
 - The advantages and disadvantages of current maintenance practices
 - Determine who is responsible for maintenance (i.e. manufacturers or 3rd parties)
 3. Technical Business Case
 - Describe the revenues and cost basis of wind power generation
 - Calculate costs of unplanned downtime due to failures

The team expects that these goals may change as the team acquires a better understanding of the project.

4. Methodology

A. Defining the problems

Identifying the cost of failures associated with wind turbine operations to aid in developing preventative turbine failure measures:

- Understand wind-turbine failure modes and their causes
- Understand the current paradigm for maintenance practices
- Cost analysis of wind-turbine power generation

B. Gathering research

Gather research and background information on turbine failures

- Use available wind data resources.
- Contact wind turbine manufacturers, operators, and 3rd party maintenance crews with questions regarding:
 - Turbine faults that occur
 - Staffing, expertise, organizational arrangements of maintenance programs
 - What maintenance is in-house? What's farmed out?

- Turbine manufacturer warranty issues
- Use of technology, tools, and labor to combat unexpected downtime

C. Initial data compilation and analysis

Compilation of results gathered from research:

- Display failures and downtime results with graphs, tables, and spreadsheets
- Use the graphs, charts and (or) spreadsheets to determine which causes of unexpected downtime are most frequent, most costly, or both.

D. Prepare technical business case

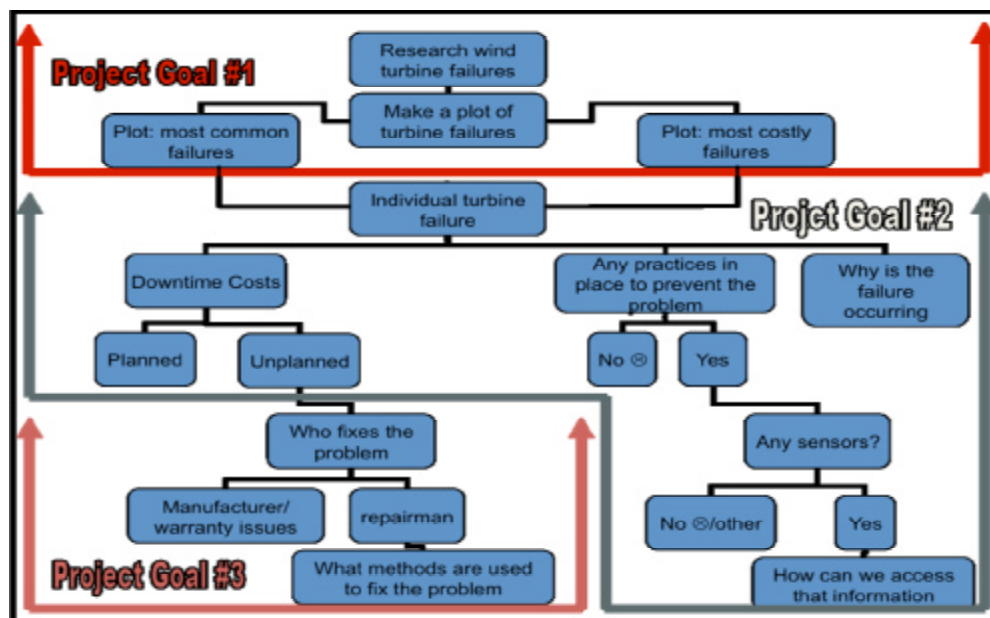
Use the previously compiled data to prepare technical business case

- Define data milestones, and direct focus to them
- Distribute subgroups to data milestones
- Subgroups should determine an answer to these questions (and more as we see fit) for their particular milestone:
 - Costs and comparison of unplanned downtime (due to failure) and planned down time (or in other words- scheduled maintenance)
 - Is a repairman required?
 - What methods are used to fix the problem?
 - Are there any practices in place to prevent the given problem? Can we have access to that information?
 - Why is the failure occurring?

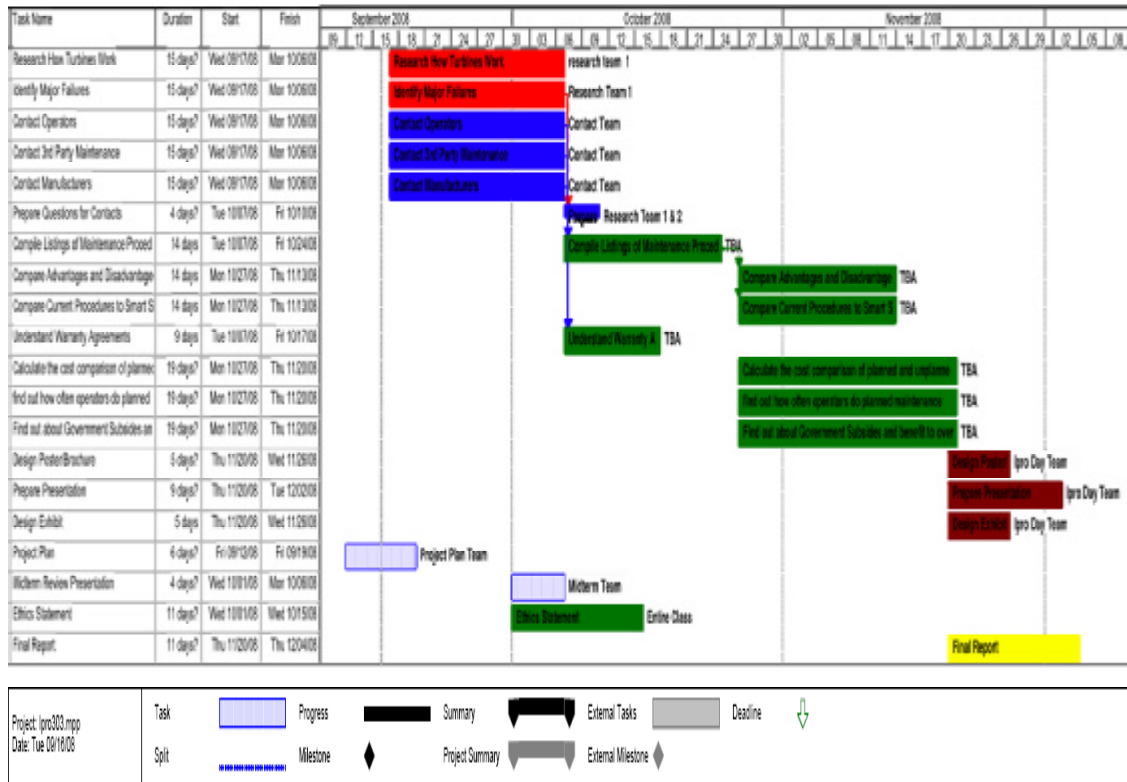
E. IPRO day preparations

Since our project will not be producing a prototype, we will be including in our final presentations and exhibit our results from our semester using the following: graphs/charts/spreadsheets, data milestones, project goals and conclusions.

F. Work breakdown structure



Gantt chart



5. Budget

IPRO Day	\$100 - Presentation board, handouts, visual supplies
Misc.	\$150 – Food for interviewees
Transportation	\$500 - Visiting Wind Farm

Total	\$750

6. Team structure and assignments

Name	Major and Year/level	Skills and Strengths	Experience and Academic Interests	Team
Chris Catalina	MSE - Materials Science and Engineering / ME - Mechanical Engineering 4 th year	Strengths: Thorough, Work well with others Computer skills: AutoCAD, Pro-Engineer, MATLAB, MS office, C++	-Familiar with mechanical testing of materials have knowledge of basic heat treating principals. -Have an interest in materials processing as well as alternative energy.	Contact
Laolu Adeola	MAE - Mechanical and Aerospace Engineering / Business Administration 3 rd year	Strengths: Working with people/working in teams Computer skills: Mac, PC, Linux Microsoft Office, Illustrator, MATLAB, Maple, C++, AutoCAD	-Entrepreneurship	Contact
Viral Patel	AE - Aerospace Engineering / ME - Mechanical Engineering 4 th year	Strengths: Punctual Computer skills: MS Office, MATLAB, Pro/Engineer	-Interested in aerodynamics of wind turbines	Research 2
Don Ruffatto	ME Mechanical Engineering 4 th year	Strengths: Data analysis/interpretation, problem solving Computer skills: MS Office, MATLAB, Pro/Engineer, Autodesk Inventor	-Researched wind turbines for a previous IPRO -Industry experience in automation -Interested in mechanical design and automation	Research 2
Sara Claxton	AE - Aerospace Engineering ME - Mechanical Engineering 4 th year	Strengths: Computer skills: MS Office, DA DISP, Pro/E,AUTOCAD	-Interned at a government company(Internal Ballistic Actuation) -Interested in aerodynamics and blended wing design	Research 2 Deliverables
Earl Fairall	AE - Aerospace Engineering 4 th year	Strengths: Technical project leader/coordinator Computer skills: Solidworks	-Interested in mechanical design -Technical Background in electric motors and mechanical systems	Research 2
Mithun Michael	EE - Electrical Engineering 4 th year	Strengths: creative, hard working, task oriented Computer skills: MS Office, MATLAB/SIMULINK, PowerSim, PSpice, C++/JAVA	-Interested in grid integration of wind turbines/intelligent control of power systems -Interested in renewable energy technology	Research 1
Jesus Cervantes	ME - Mechanical Engineering 4 th year	Strengths: Fixing/Drawing Computer skills:	-Interested in automobiles	Research 1
Samad Erogbogbo	ME - Mechanical Engineering 4 th year	Strengths: analytic, problem solving, team projects Computer skills:	-Previous IPRO, -Intern in automotive engineering industry	Research 1
Rob Keane	EE - Electrical Engineering 4 th year	Strengths: Computer skills: programming	-Electrical and Electronics Engineering	Research 1 Ethics
Kristina Lakiotis	CS - Computer Science 4 th year	Strengths: Computer skills: Programming, graphic programs	-Interested in alternative energy	Research 1 Deliverables Ethics
Richard Ike	ME - Mechanical Engineering 4 th year	Strengths: Organization, Problem solving Computer skills: AutoCAD, ProE, Matlab, MS office	-Metallurgical and Mechanical Testing	Contact Research
Aaron Melko	AM - Applied Mathematics / AE - Aerospace Engineering 4 th year	Strengths: Data analysis, organization Computer skills: Word, Excel, AutoCAD	-Mathematics -Teaching, Mentoring	Research 2

Tasks

Teams					
Project Plan	Research 1	Contact	Research 2	Deliverables	Ethics
Chris	Kristina	Chris	Aaron	Sara	Kristina
Laolu	Jesus	Richard	Earl	Kristina	Rob
Samad	Rob	Laolu	Sara		
Richard	Samad		Viral		
Sara	Michael		Don		

Project Plan:

This sub group will be responsible for compiling the sections of this document. They are ultimately responsible for the final appearance and format of this document.

Research 1:

This sub group will be involved in researching how wind turbines work and identifying the major failures that this IPRO team will be focusing on.

Research 2:

This sub group will be in charge of preparing questionnaires for the contact team.

Contact:

The contact team will be responsible for contacting operators, 3rd party maintenance, and manufacturers to schedule interviews.

Ethics:

The ethics team will be considering and analyzing the important ethical consequences of the request by our sponsor to

Designation of Roles

Meeting Roles:

Minute taker:Entire Team (Via Schedule)
 The schedule for minute takers is attached as Addenda B.

Agenda Maker:.....Team

Timekeeper:None will be assigned

Status Roles

Time sheet collector/SummarizerTo be determined

Master Schedule Maker:Sara Claxton

iGroups coordinator:.....Samad Erogbogbo – Managing files

.....Sara Claxton – Managing e-mails

A team leader has not yet been designated but the need for that formal assignment will be addressed in the next couple of weeks.

Not Available (white)
 Available
 Availability Varies
 IPRO Class Time - 3:15 pm to 4:30 pm

	8:00 AM	9:00 AM	10:00 AM	11:00 AM	12:00 PM	1:00 PM	2:00 PM	3:00 PM	4:00 PM	5:00 PM	6:00 PM	7:00 PM	8:00 PM	9:00 PM	10:00 PM	11:00 PM	12:00 AM	1:00 AM
Monday																		
Lochu Adesola																		
Chris Catalina																		
Jessie Cervantes																		
Sara Clouton																		
Sanaad Erogluoglu																		
Earl Fairall																		
Richard Ito																		
Rob Keane																		
Kristina Lakotic																		
Aaron Melko																		
Hihus Michael																		
Vital Patel																		
Don Ruffalo																		
Tuesday																		
Lochu Adesola																		
Chris Catalina																		
Jessie Cervantes																		
Sara Clouton																		
Sanaad Erogluoglu																		
Earl Fairall																		
Richard Ito																		
Rob Keane																		
Kristina Lakotic																		
Aaron Melko																		
Hihus Michael																		
Vital Patel																		
Don Ruffalo																		
Wednesday																		
Lochu Adesola																		
Chris Catalina																		
Jessie Cervantes																		
Sara Clouton																		
Sanaad Erogluoglu																		
Earl Fairall																		
Richard Ito																		
Rob Keane																		
Kristina Lakotic																		
Aaron Melko																		
Hihus Michael																		
Vital Patel																		
Don Ruffalo																		
Thursday																		
Lochu Adesola																		
Chris Catalina																		
Jessie Cervantes																		
Sara Clouton																		
Sanaad Erogluoglu																		
Earl Fairall																		
Richard Ito																		
Rob Keane																		
Kristina Lakotic																		
Aaron Melko																		
Hihus Michael																		
Vital Patel																		
Don Ruffalo																		
Friday																		
Lochu Adesola																		
Chris Catalina																		
Jessie Cervantes																		
Sara Clouton																		
Sanaad Erogluoglu																		
Earl Fairall																		
Richard Ito																		
Rob Keane																		
Kristina Lakotic																		
Aaron Melko																		
Hihus Michael																		
Vital Patel																		
Don Ruffalo																		
Saturday																		
Lochu Adesola																		
Chris Catalina																		
Jessie Cervantes																		
Sara Clouton																		
Sanaad Erogluoglu																		
Earl Fairall																		
Richard Ito																		
Rob Keane																		
Kristina Lakotic																		
Aaron Melko																		
Hihus Michael																		
Vital Patel																		
Don Ruffalo																		
Sunday																		
Lochu Adesola																		
Chris Catalina																		
Jessie Cervantes																		
Sara Clouton																		
Sanaad Erogluoglu																		
Earl Fairall																		
Richard Ito																		
Rob Keane																		
Kristina Lakotic																		
Aaron Melko																		
Hihus Michael																		
Vital Patel																		
Don Ruffalo																		

Addenda A

The following are viewgraphs from the initial project presentation given to our team by our sponsor:

SmartSignal IPRO:
Wind Project Overview

David Farrell
SmartSignal Product Manager
9/3/08

© 2008 SmartSignal Corp. Confidential

Agenda

- Some Wind Energy Basics
- SmartSignal's Wind Proposition
- Goals for IPRO Project

© 2008 SmartSignal Corp. Confidential

Wind Power Market Drivers

- Various markets have Incentives (Carrots) and Penalties (Sticks) to help utility/energy companies develop renewable resources
 - In the US market, there are both Carrots and Sticks:
 - Carrots -
 - 10 year US Federal Production Tax Credit (PTC) of 1.8¢/kWh escalating
 - 5 Year Accelerated MACRS depreciation schedule
 - State Incentives (e.g. CEC Grants, Sales Tax Exemptions)
 - Local Incentives (e.g. Property Tax Exemptions)
 - Sticks -
 - Renewable Portfolio Standards (RPS) and other Mandates - 18 States so far, plus discussion about a Federal RPS
 - California 20% Renewable Energy by 2017
 - New York 24% Renewable Energy by 2013
 - Emissions/Carbon Reduction Programs
 - US is non-participant, however other markets are heavily focused on Carbon programs, where wind is a zero-emission resource

© 2008 SmartSignal Corp. Confidential

Wind Power Market Drivers

- Elsewhere the methodology is primarily Carrots via attractive "Feed-In" Tariff rates and non-discriminatory utility integration policies
- The result is countries with attractive Carrots, have seen the highest growth and largest markets (e.g. Germany, Spain)

Country	Incentive	Comments
Austria	7.00	Guaranteed for 13 years
Australia	4.00	Divided almost half & half between electricity and environmental bonus
Belgium	7.00	The tariff consists 6.0 cents (fixed for 10 years) + 2.5 cents (green certificate). Consists of price from NordPool spot market plus a 1.2 cent CO2 premium. Projects established by end 2002 benefiting from government-subsidized prices for the first 12,000 MWh fixed tariffs.
Denmark	5.00	Prices established by end 2002 benefiting from government-subsidized prices for the first 12,000 MWh fixed tariffs.
France	8.00	Rates for the initial 8 years, thereafter a reduction to 5.00 cents per kWh in high wind regions and the 5.00¢/kWh in 2008. Fixed in law as of 2002. Modified slightly in 2005. The rates will apply for the initial 8 years of operation and thereafter the market level-in rate will be adjusted to reference "reference" for the respective location.
Germany	9.10	Rates are different by location. Multinational wind energy producers get 80% of the consumer price. Wind farms without grid access to markets get 7.31 cents per kWh. A 40% grant of capital costs possible.
Greece	0.10 - 7.91	Projects larger than 3 MW get 4.8 cents and smaller installations get 5.3 cents. Competitive bidding process have been used under the AER 9 (Alternative Energy Requirement).
Ireland	4.0 - 10	Price depends on year of installation. The system undergoes charges from a "fixed price" scheme to "RPS Quota" scheme with green certificate.
Italy	3.10 - 6.00	

© 2008 SmartSignal Corp. Confidential

The Growth of the Market -
>20% annual, sustained

- Global capacity grew 24% in 2005 to 59,100MWs
- Average annual growth rate over last 10 years is 29% - fastest growing generation source
- Europe continues to lead the world in total installed capacity with over 40,500 MW, or two-thirds of the global total. These wind installations supply nearly 3% of Europe's electricity and produce enough power to meet the needs of over 40 million people
- The European Wind Energy Association (EWEA) has set a target to satisfy 23% of European electricity needs with wind by 2030
- Chinese Renewable Energy Law = 17% of all generation to come from renewable resources by 2020 = roughly 120GW of renewables (mostly wind), 30,000MWs by 2010

© 2008 SmartSignal Corp. Confidential

The Growth of the Market -
>20% annual, sustained

- North American Market driven by State/Provincial Renewable Portfolio Standards - e.g. California 20% RPS, CEC now discussing 33% by 2030. Western Governors now planning supporting policies for 30,000MWs by 2025 in Western US.
- Canada's installed wind capacity of 680 MW at the end of 2005 is expected to increase to 1,200 MW by the end of 2006. While Canada's federal government targets the installation of 4,000 MW of wind energy by 2010, its more ambitious provincial governments plan to install a combined 9,200 MW by 2015.
- Ontario Energy Minister Dwight Duncan has directed the Ontario Power Authority to double the amount of electricity the province draws from renewable sources as it implements its 20-year supply mix plan, bringing the total to 15,700 MW by 2025

© 2008 SmartSignal Corp. Confidential

A Typical Modern Wind Turbine

smartsignal

- There are four main categories/classes of wind turbines supplied today, generally considered 4th or 5th generation technology
- The "Mainstream" and "MW-Class" turbines are primarily installed in on-shore environments
- The "Multi-MW Class" are targeted for offshore environments
- From a data perspective, they are nearly identical, just different scale

© 2008 SmartSignal Corp. Confidential

Scale Examples

smartsignal

© 2008 SmartSignal Corp. Confidential

Example Wind Turbine

smartsignal

- Vestas V80 – 2MW Wind Turbine
- Rotor Diameter – 80 meters
- Hub Height – 70 meters
- Weights – Blades 6.5 Tons, Nacelle 79 Tons
- Wind Speeds:
 - Cut-in = 4 meters/second (8.95mph/Class 3 "Beaufort" Gentle Breeze)
 - Rated Output = 13 meters/second (29.08mph/Class 6 "Beaufort" Strong Breeze)
 - Cut-out = 25 meters/second (55.923mph/Class 10 "Beaufort" Whole Gale)

© 2008 SmartSignal Corp. Confidential

Data Overview

smartsignal

- Turbine Controller/PLC provides between 350-1200 tags, dependent upon what manufacturer "publishes" in protocol.
 - Mostly digital, typically approximately 50-60 Analog values
- Some manufacturers publish controller protocols (e.g. Mitsubishi). Others consider highly proprietary (GE, Suzlon, Vestas, Siemens, Gamesa)
- Most Manufacturers require their SCADA for warranty:
 - GE, Bonus/Siemens, Vestas, Gamesa, Suzlon. Mitsubishi is the exception
 - Typically provide customers access to post-processed 10-minute records in SQL/Access.
 - Some offer subset of data in OPC-Server capabilities (for additional cost) for customers that want real-time high-res data (e.g. GE, Vestas, Bonus)

© 2008 SmartSignal Corp. Confidential

SmartSignal Wind Availability & Performance Solution

smartsignal

Increase Profitability and Simplify Operations with the Predictive Analytics Leader

Predict...
Diagnose...
Prioritize...

ELIMINATE FAILURE

© 2008 SmartSignal Corp. Confidential

Wind Industry Operating Challenges: A Whole Different Set of Economics

smartsignal

Assets Difficult & Expensive to Access

Large Number of Physically Disperse Assets
Relatively Low Generation from Individual Assets

For Viable Wind Power Economics: Availability is King!!!

© 2008 SmartSignal Corp. Confidential

Current Maintenance Paradigm Inadequate for the Long Term

Efficient Asset Management?
Efficient Asset Management of data.
Need to Internalize Support

© 2008 SmartSignal Corp. Confidential

Predictive Analytics: A Proven Power Industry Solution

*Can you spot a pattern shift in these data trends?
 Is there a developing fault?
 Or have operating/ambient conditions changed?*

Now consider doing this analysis across all your wind turbines, and all their sensor data...

Trending data samples alone is inadequate

© 2008 SmartSignal Corp. Confidential

Predictive Analytics: A Proven Power Industry Solution

- Modeling detects very subtle shifts in operating behavior
 - Tells you where operation should be
 - Cuts through clutter, brings needed incidents to your attention

Deviations develop between actual value & model estimate

Software detects small drift from expected behavior, flags as problem

Mathematical Combination of Sensors "Sees" Patterns Even Experienced Engineers Can't

SmartSignal: The Predictive Analytics Industry Standard

- Every asset is modeled uniquely, based on actual historical data
- Diagnostic advice tells you specifically where to look
- Solution perfectly suited to mechanical failure modes in wind turbines

Leading Power Industry Experience Base

SmartSignal Wind APS: Comprehensive Solution of People, Processes, and Technology

Notify → Verify → Plan → Act

Online Analytical Tools offer Context for Verification, Planning

Email Notifications Provide Developing Fault Diagnoses

Efficient New Asset Management Paradigm: Easy Maintenance Planning, Improved Financial Outcomes

© 2008 SmartSignal Corp. Confidential

Speed To Value, and Personalized Ongoing Support from an Experienced Team

- Solution Brought Online Within Weeks
 - Layers on & complements your Instrumentation and Historian Investments

Information Infrastructure

Operating Infrastructure

© 2008 SmartSignal Corp. Confidential

Speed To Value, and Personalized Ongoing Support from an Experienced Team

smartsignal

SmartSignal Staff Augments Your Team

Equipment Performance Intelligence Integrates Seamlessly Into Your Workflow

- Email, Direct Calls → Incident Management Outage Decisions
- SmartTracking Portal & Log → Mitigation Workflow Learning Archive
- Summary Reports → Maintenance Planning Periodic Meetings
- Weekly Calls → Process Optimization Review

SmartSignal Wind APS Summary

smartsignal

- Move from Reactive to Proactive Maintenance
 - Have key issues of importance brought directly to your attention
 - Receive diagnostic advice
 - Receive analytical support from our staff and online tools
 - Receive Equipment Performance Intelligence through processes that integrate seamlessly into your workflow

Adding Insight to Raw Data, Addressing Core Wind Asset Management Challenges

© 2008 SmartSignal Corp. Confidential

SmartSignal Wind APS Summary

Move from Suboptimal Planning and Performance to Improved Availability and Profitability

© 2008 SmartSignal Corp. Confidential

SmartSignal IPRO Wind Project Overview

David Farrell
SmartSignal Product Manager
93793

Wind Industry Players & Resources

- Owner/Operators
 - Florida Power & Light is biggest in US
- Manufacturers
 - GE, Vestas
- Information Infrastructure
 - OSIsoft
- Service Companies
 - enXco
- Trade Magazines
 - Wind Power Monthly, North American Wind Power
- Advocacy Groups
 - AWEA, American Wind Energy Association
 - Danish Wind Energy Association
 - <http://www.windpower.org/en/denloc/wde/index.htm>
- Ancillary players
 - Trucking companies, component manufacturers, site developers...


© 2008 SmartSignal Corp. Confidential

Project Input Information Sources

- Contact industry players
- Literature & web resources
- Wind Stats data report

© 2008 SmartSignal Corp. Confidential


Three Project Goals



1. Provide clear explanation of what faults are occurring, where & why
 - Use diagrams, examples, etc.
2. Provide detailed overview of current maintenance practices and challenges
 - Staffing, expertise, organizational arrangements
 - What's in-house, what's farmed out
 - Warranty paradigm; what then?
 - Use of technology, tools, labor
 - Any common threads? *"Bigger players are like this, small ones operate differently...etc."*

© 2006 SmartSignal Corp. Confidential


Three Project Goals, Continued



3. Detailed Technical Business Case: costs of equipment failure, and opportunities for improvement
 1. Describe the revenue and cost basis of wind power generation
 1. Revenues
 2. Government Incentives
 3. Any fluctuations or inconsistencies
 4. Estimate comprehensive operational costs
 1. Any available comparison with traditional coal power generation
 2. Calculate costs of unplanned downtime
 1. Maintenance/Repairs
 1. Parts, labor, crane rental (\$\$\$!!!)
 2. How long is payback for a given failure (from generation revenues)?
 2. Any Regulatory Penalties
 3. Costs of replacing needed generation with other sources, either internally generated (penalty if using fossil fuels?) or on open market (more expensive than internally generated)

© 2006 SmartSignal Corp. Confidential


Some Capstone Questions



- ☞ Can you tie your downtime cost estimates to operators perceptions?
- ☞ How do they view the costs? What elements are they highly cognizant of, which have less visibility?
 - Penalties
 - Repair & payback
 - Substitute generation costs
- ☞ Do they have heads-in-sand from the current warranty coverage?

© 2006 SmartSignal Corp. Confidential

Business Case Summary



- ☞ Use Wind Stats reports
- ☞ Use team research data
- ☞ Provide best, most accurate detail possible
- ☞ Make & state assumptions where needed – ranges rather than point estimates may be appropriate in cases
- ☞ Multiple scenarios may be appropriate to summarize
- ☞ Provide template, such as spreadsheet, and instructions for SmartSignal to make similar calculations using future Wind Stats reports

A business case need not have complete accounting and knowledge of all variables that can affect the outcome.

It does need to have credibility of coverage, and realistic assumptions made and clearly stated.

© 2006 SmartSignal Corp. Confidential

Addenda B

This following is a tabular representation of the schedule of minute takers:

IPRO 303 Fall 2008**Power Generation: Cost Impact of
Equipment Failures, and**sponsor: **SmartSignal**meets: **Mon & Wed from 15:15 to 16:30**meets at: **IGTC 3424 S State, rm 4C4-1**l'm at: **3424 S State, Suite 4001 South**

				Class	MEETING MINUTE OWNER	
8/27/08	Wednesday	Wed	We	1	none	
9/1/08	Monday	Mon	Mo	2	none	
9/3/08	Wednesday	Wed	We	3	none	
9/8/08	Monday	Mon	Mo	4	Ed Feldy	
9/10/08	Wednesday	Wed	We	5	Laolu Adeola	
9/15/08	Monday	Mon	Mo	6	Chris Catalina	
9/17/08	Wednesday	Wed	We	7	Jesus Cervantes	
9/22/08	Monday	Mon	Mo	8	Sara Claxton	
9/24/08	Wednesday	Wed	We	9	Samad Erogbogbo	
9/29/08	Monday	Mon	Mo	10	Earl Fairall	
10/1/08	Wednesday	Wed	We	11	Richard Ike	
10/6/08	Monday	Mon	Mo	12	Rob Keane	
10/8/08	Wednesday	Wed	We	13	Kristina Lakiotis	
10/13/08	Monday	Mon	Mo	14	Aaron Melko	
10/15/08	Wednesday	Wed	We	15	Michael Michael	
10/20/08	Monday	Mon	Mo	16	Viral Patel	
10/22/08	Wednesday	Wed	We	17	Don Ruffatto	Don, you lucked out dur
10/27/08	Monday	Mon	Mo	18	Laolu Adeola	But you then become
10/29/08	Wednesday	Wed	We	19	Chris Catalina	If somebody who is st
11/3/08	Monday	Mon	Mo	20	Jesus Cervantes	This may happen mor
11/5/08	Wednesday	Wed	We	21	Sara Claxton	
11/10/08	Monday	Mon	Mo	22	Samad Erogbogbo	
11/12/08	Wednesday	Wed	We	23	Earl Fairall	
11/17/08	Monday	Mon	Mo	24	Richard Ike	
11/19/08	Wednesday	Wed	We	25	Rob Keane	
11/24/08	Monday	Mon	Mo	26	Kristina Lakiotis	
11/26/08	Wednesday	Wed	We	27	Aaron Melko	Actually, some of these
12/1/08	Monday	Mon	Mo	28	Michael Michael	So you like Don abou
12/3/08	Wednesday	Wed	We	29	Viral Patel	Last person first, i.e.
12/5/08	Friday	Fri	Fr		IPRO DAY	
12/8/08	Monday	Mon	Mo	30		
12/10/08	Wednesday	Wed	We	31		