NWX-NATIONAL RENEWABLE ENERGY

Moderator: Sandy Smith
October 21, 2009
11:00 am CT

Man: Hello. Good morning.

Coordinator: Welcome and thank you for standing by. At this time all participants are in a listen only mode. If you would like to ask a question during the - today's question and answer session please press star then 1 on your touchtone phone.

Today's conference is being recorded. If you have any objections you may disconnect at this time. Now I would like to turn the meeting over to Mr. Sandy Smith. You may begin.

Sandy Smith: Thank you very much. Good morning or afternoon as the case may be. My name is Sandy Smith and I'm with the Utility Wind Integration Group.

I would like to welcome all of you to the 10th in a series of webinars put on by (Inter ACA), APPA, Western Area Power Administration, the US Department of Energy, Wind and High (Pro) Technologies Program, (InRo), Utility Wind Integration Group, UWIG and the National Wind Coordinating Collaborative.

The subject of today's webinar is wind turbine maintenance programs. Today we'll be discussing turbine maintenance programs for utility owned wind projects. We're going to cover both in-house and contractor led efforts.

And the speakers will cover staffing requirements, training, planning consideration, budgets and O&M applications and techniques. I manage conference programs and communications initiatives for the Utility Wind Integration Group.

And I'll talk in a couple minutes very briefly about an operation for maintenance users groups that we offer that's a valuable resource to wind project owners and operators.

We have a distinguished panel of speakers today that includes Ryan Harry from BCS, Inc., (Buck Cutting) from the Sacramento Municipal Utility District, Chris Thomas from Enexco and finally, Chuck Carter from Sandia National Labs.

I encourage you to submit questions electronically at any time during the webinar and we will try to address them - address as many of them as we can at the conclusion of all the speaker presentations. We will work on posting answers to questions that we are unable to get to on the web, on the www.REPartners.org Web site.

That Web site will also allow you to go back and replay the audio recording and view the presentations from this as well as previous webinars from the current series.

The presentations and recordings from this and several other webinars can also be found on the UWIG Web site. And finally, I'd like to let you know that the next webinar in this series is scheduled for February 17, 2010 on rural economic development case studies.

So be sure to visit the www.REPartners.org Web site for future updates and registration information. With that I'm going to go ahead and give you a brief overview of the operations and maintenance group that our organization offers.

First off, a little bit of background about UWIG. It was established back in 1989 with a few utilities and support from (unintelligible) (InRo). We have members from the (Investrong) Utility, public power and rural electric cooperative sectors along with ISO RTOs.

We also have associate members from the wind development equipment and consulting community. It is a nonprofit corporation governed by a board of directors from our utility and ISO RTO members. We have (unintelligible) members which include representation from the sectors.

We have over 150 members from the US, Canada, Europe, as well as New Zealand and other countries. And then we focus primarily on technical issues. We originally started out focusing mostly on integration from the standpoint of the bulk and the bulk power system.

But it became clear several years ago that project plan availability was quickly becoming a driving issue. UWIG had established four user groups focusing on integration, interconnection technical issues.

We established an O&M user group in 2005 and reorganized it to reflect that of a successful turbine operations task force. And at this point it's the only existing forum for wind plant turbine owners operators to get together and talk about the issues that the face.

The scope of the group is to exchange experiences and explore issues related to turbine operations and maintenance which includes the turbine itself and other plant components, warranty and service contracts, liability, plant technician training and safety as well, condition monitoring predictive maintenance.

The key activity with this group is peer to peer information exchange with focus on best practices. And it's open to UWIG members who own, operate or maintain wind turbines. The user group meetings are held twice per year and consist of a plenary session in the morning focusing on a specific topic.

We just concluded our fall one which focused on condition based monitoring. It's followed by roundtables specific to a type of turbine. We have roundtables right now on GE, Vestas and Siemens machines.

We are looking at organizing forums and Clipper Windpower (unintelligible) in the future. The roundtables facilitate open, frank discussion between the owners and the operators. They are confidential discussions.

No notes are kept and the participants sign a nondisclosure agreement and vendors' consultants attend only upon invitation by the roundtable chair. Topics discussed include your boxes, blades, pitching (unintelligible), instrumentation, data, cooperation, safety, HazMat and lift systems.

And if you have additional - if you want additional information on this, if you have any questions, my contact information is on the slide here. It's also up on the UWIG Web site as well. And with that I'm going to go ahead and introduce our next speaker.

As I said, today's speakers include Ryan Harry, (Buck Cutting), Chris Thomas and Chuck Carter. And I'll go ahead and introduce Ryan Harry. Ryan is a technical research associate at BCS, Incorporated and has been working with BCS since 2008.

He's responsible for various energy efficiency and renewable energy projects for a number of clients including APPA and the US Department of Energy's Office of Energy Efficiency and Renewable Energy.

He has eight years of experience in the manufacturing, energy and utility industries. He holds a Masters Degree in energy and environmental policy and a Bachelors Degree in Physics both from the University of Delaware.

And with that I'm going to go ahead and turn the program over to Ryan Harry.

Ryan Harry: Hello everyone. As Sandy has introduced me, my name is Ryan Harry. I'm with BCS, Incorporated. And the first part of this webinar today will cover a case study prepared by BCS for APPA.

The case study focuses on the development of Los Angeles Department of Water and Power, more simply known as LADWP, their in-house wind maintenance program for their pine tree wind farm and that's located in the Tehachapi Mountains.

Unfortunately nobody from LADWP was able to speak today but I'm going to be covering some of the highlights of the case study. You can find the case study at www.APPAnet.org. And if you go to that site up at the top of the webpage you'll find a search box.

And if you just search for the title of the case study, "Establishing an In-House Wind Maintenance Program" it should be the first thing that pops up in the search. The case study was published in 2008.

And to briefly give a bit of credit where credit is due, Steve Fuller from LADWP was a significant contributor to this case study. Additional maintenance expertise was provided by Roger Hill and Valerie Peters from Sandia.

You'll hear their colleague, Chuck Carter, speak today. Larry Barr from Enexco and his colleague Chris Thomas will be speaking today. (Chris Sedrick) and (Chuck Troyo) and (Jay Charles Smith) as well.

The writers of this case study from BCS were Lindsay Bixby and (unintelligible). Funding was provided by EOE, Wind Powering America, Western Area Power Administration and APPA's Demonstration of Energy Efficiency Developments, more widely known as DEED.

All right, so to start off let's consider the project and its operator, LADWP. The project is located north of Los Angeles in the Tehachapi Mountains. And the project has the total capacity of 120 megawatts and consists of 80 1-1/2 megawatt GE turbines.

You know, and meanwhile as far as LADWP goes it has about a million and a half customers and it provides about 24 million megawatt hours of retail sales. And the wind farm will provide about 1.4% of LADWP's annual electricity and that's part of LADWP's goal to have 20% renewable by December 31, 2020.

When planning for an in-house - when planning for its wind maintenance, LADWP decided to develop an in-house maintenance program instead of contracting that maintenance out.

And this decision was brought on when LADWP had to specify its warranty contract with the turbine manufacturer, GE. Now typical warranties for turbines usually last two or five years.

And the two year warranty is included with - typically included with the cost of the turbine and is often the most chosen time period by utilities. Now the reason for this is that the five year warranty period often adds costs and also the failures typically happen within the first two years.

And so the two year warranty provides enough coverage for the operators to have enough time for a full shakedown typically. The GE warranty option being offered to LADWP was a two year parts and labor warranty.

However, the international brotherhood of electric workers wanted to insure that LADWP's possible maintenance jobs weren't outsourced outside of the utility. And so to meet that requirement LADWP decided to take the parts portion of GE's warranty but perform the maintenance in-house with LADWP staff.

Now despite the fact that LADWP and its staff have significant experience maintaining many types of electricity generators the utility had only little experience with wind turbine maintenance.

So to develop a sound program LADWP decided to turn to the US Department of Energy for assistance. And EOE put LADWP in touch with the Western Area Power Administration and Sandia National Labs for some help.

And to help I guess identify some of the areas where - a focus for the maintenance program, EOE provided the guidance. And for the following maintenance elements I'll highlight some of the case study content.

But for more information let's take a look at the case study itself. And also Chris Thomas form Enexco and Chuck Carter from Sandia will have some more information on turbine maintenance and some of the topics I'll touch on here.

A first bit of a maintenance program is establishing a maintenance schedule. A routine maintenance schedule must be established with maintenance intervals for the different components.

Now LADWP followed the GE maintenance schedule which breaks down maintenance in four, six, 12, 24 and 48 month intervals. Nebraska Public Power District also recommends that a wind turbine receive a cursory inspection its technician climbs the tower.

So that's in addition to the typical maintenance, just to make sure everything's going okay. The grouping of maintenance tasks is also important. Maintenance tasks grouped by type such as electrical tasks or mechanical tasks or structural tasks.

Grouping these tasks makes it easier for specialized technicians to accomplish multiple tasks while they are working on the turbines. The third part of is the (unintelligible) special needs of older wind turbines.

Despite the fact that manufacturers design wind turbines to last without an overhaul, for 20 years, older wind turbines may require an overhaul every five years. This is due to the failure of individual components within the turbine.

Nebraska Public Power again they actually installed two turbines for testing in 1998, to see how well those turbines would operate to determine whether it was a feasible for the state for their utility.

And so they did that to acquire knowledge that would help them determine the true cost of operation and maintenance, to develop a maintenance program. The fourth bit of it is incorporating predictive maintenance.

So even with the scheduled maintenance plan some turbine components will inevitably fail. Being able to predict the failures is important and - because if you catch the failure before they happen you can save a lot of downtime, save a lot of money by having parts on hand, etc.

And one way of doing this is through conditioned monitoring systems which constant monitor turbine components and notify operators if there are any problems with the turbine's function.

Typical conditions that are monitored include oil levels, blades, thermographic imaging of the turbine and its components and vibration and just overall performance of the turbine's output based on, you know, historical trend.

In addition to the conditions monitoring system there are also other ways to predict failures. And Chuck Carter from Sandia will be discussing a bit of this later on with his portion of the webinar and Sandia's Raptor software.

The fifth aspect is cleaning and cleaning is widely dependent on, you know, where the wind project is located depending on the climate, you know, whether you're in a dry climate or a wet climate and also just where the site's located relative to state highway or anything that could possibly contaminate turbines.

The sixth part is preparing for unscheduled maintenance. You know, in addition to the routine maintenance, unscheduled maintenance may also occur.

Some of this can be mitigated through the predictive maintenance program but there still are cases where unscheduled maintenance will inevitably occur. For example, weather events can damage wind turbines and lead to unscheduled maintenance.

The seventh part of it is implementing quality control maintenance. Unscheduled maintenance can also be minimized by monitoring maintenance history for quality control. ISOs planning, doing, checking and acting, quality assurance model is a good one to follow.

It's one typically followed. This quality control will insure that the maintenance is completed as is prescribed in the initial plan and, you know, going forward we have a record of what has been maintained, issues that have come up, etc.

And then the eighth part is incorporating a rescue plan for technicians. Rescue plans can help get technicians out of perilous situations whether they're caused by the turbine, the technician themselves or weather events that arise.

Rescuers should be present on all sites along with an emergency medical technician. A major component of any maintenance plan is safety and training.

It's of primary importance and the safety standards that are absolutely necessary when developing a wind site and the wind maintenance program. The wind maintenance program must conform to safety guidelines issued by OSHA by state and local governing bodies and by the utility itself.

The risk level for each maintenance task must be determined. The level of risk must be acceptable for the maintenance to be performed. As you can see in the lower right hand corner of the slide, some of the common causes of injuries are distractions, electroshock, misuse of tools, etc.

The risk level that's acceptable should be mitigated by requiring safety measures that help you reduce the risk of performing maintenance. For example, any technician climbing a tower in a ladder should be harnessed and properly attached to the ladder before climbing.

Other risk considerations and mitigation measures include lockout/tagout for electrical work and assigning the proper techs to the task at hand, to make sure that those techs have the knowledge and the training to perform the task that they're going to do.

Proper technician training is essential for wind turbine maintenance. Technicians must be trained and certified by programs and institutions which have the credentials to provide the training.

And with the increasing popularity of wind power there is an ever increasing number of wind maintenance programs being offered around the country, you know, at technical colleges, utilities, etc.

And utilities should work towards being able to provide in-house training and may be able to share the resources with other utilities. Training logs are also important to keep track of the training that technicians have received.

And these logs insure that the tech performing a job will be qualified to do so. And it'll make it easier for the supervisor to send the right techs to the job. The staff, equipment and parts requirements - not only having properly trained techs but having enough techs on staff is an important consideration.

MPPD recommends one tech to every six turbines. Kansas Wind Farm and Spearville recommends one tech to every eight turbines. Meanwhile, Enexco recommends eight to 12 techs for an entire wind farm depending on the size.

So 12 techs at the 80 turbine Pine Tree Wind Farm going by Enexco's high end would need a one to seven tech to turbine ratio which is right between what MPPD and the wind farm in Spearville recommend.

For performing the maintenance on one turbine the experts agree that tools can make a big difference in making maintenance a lot easier and less costly in the long run.

Some of those tools are recommended here and include electric and hydraulic torque tools for different types of fasteners on the turbine and the tower, etc., alignment tools for aligning the generator and tower lifts are big - another newer but bigger prat of things that make maintenance a lot easier.

Let's see. A piece of equipment that is rapidly gaining popularity as turbines get larger, is the service lift. The lift replaced the ladder. It allows technicians to more easily travel up and down the turbine's tower.

Although it can be expensive to retrofit on all their turbines the cost of incorporating new lifts on a new turbine can be relatively small compared to its value over the long run.

Another piece of equipment that is sometimes new for repairs is a crane which can be rented. Reducing crane time is a big piece of the puzzle in minimizing maintenance costs, set up and rental of the crane are time concussing and very expensive.

Some wind power product manufacturers have gone so far as installing onboard cranes, Clipper Windpower is one example of a company that has made an effort to do that.

In addition to the equipment required to make the repairs parts are also an important piece of the maintenance plan. A warehouse of common parts must be kept for maintenance to be most efficient.

To make a parts list for the warehouse the turbine operator can consult - should consult the manufacturer for recommended parts. And they should also take note of typical failures that occur over time on parts that aren't recommended by the manufacturer.

If these parts that commonly (unintelligible) are kept in stock the repairs can be done much more quickly and easily. The - another part of a maintenance program is reliability and being able to understand the probability of a turbine failure.

So having parts on hand is only a component of the maintenance program. The reliability program will allow the operator to prepare for failures and even determine which parts are the most important to have on hand.

Reliability is the probability of product and performance intended functions under the stated conditions for a given period of time. The four components of this are probability, intended functions, stated conditions and then the time period.

Tracking these four elements is essential in determining the expected reliability of a turbine or group of turbines and having a well designed and well written work orders can go a long way in tracking failures and maintenance performed over time.

The three important reliability equations in considering reliability issues are on this slide. The first is MTBF which is mean time between failures and it takes the total operational time of turbine and divides it by the total number of failures.

And the second is mean time to repair and that's the total repair time on a turbine divided by the total number of failures. And each of these equations are important in considering operational time and downtime and how it's due to failures and maintenance.

Preventive maintenance can also be taken into account in these equations and added to MTBF. Okay, so whenever a (repay) unit requires to go offline, you know, you can consider it a failure if it's taken offline.

The third equation is unit availability. And here I have it expressed as MTBF over MTTR. But you can also think of it and it might be easier to think of it as total up time divided by total time. So it's the total time that a turbine is available and is producing power.

And the maintenance program isn't possible without having a proper budget. Because determining a proper budget is essential for a success. Some typical rules of thumb that have been mentioned and are mentioned in the case study are 1% of total annual project budget or $1 million per installed megawatt.

The National Wind Coordinated Collaborative breaks maintenance down further and they suggest that 21% of total project cost be dedicated to maintenance.

And notice the significantly larger portion that is due to unscheduled maintenance compared to preventive maintenance just because unscheduled maintenance will increase downtime and are typically more costly in repairs.

Increasing preventive maintenance and having good predictive maintenance is - goes a long way in reducing the unscheduled maintenance. Now some experts argue that trying to determine maintenance costs gets more difficult.

And every year because of technological improvements in turbine design and manufacturer's larger turbines and better materials mean a lower failure rate for turbines and some experts believe that turbine maintenance costs will only decrease in the coming years.

Now for more resources on turbine maintenance there's a list of organizations here. The Mature Wind (Data) Industry, you know, gives way to - more knowledge about maintenance and other wind power issues. And so today's webinar and other webinars in this series are just one example of that.

Now this list of resources shows some of the major players in the wind industry in terms of industry support. So take a look at their Web sites for more information on wind power.

And finally, the full length of the case study is shown here. It's a little long so if you can access this webinar later on www.REPartners.org you can click on that link and go right to it.

Or you can just go to www.APPAnet.org like I said, and go to the top of the webpage and search for "Establishing and In-house Maintenance Program. So with that this portion of the webinar is complete. And I'd like to thank you for taking the time to listen.

Sandy Smith: Okay. Thank you very much Ryan. I'll go ahead and get set up for our next speaker here, (John "Buck" Cutting), Buck as he likes to be called, has been a senior mechanical engineer with the Sacramento Municipal Utility District in the energy supply business unit power generation group for the past two years.

His current assignment is to provide ongoing operations and maintenance engineering support for SMUD's Solano wind project. He is a licensed mechanical engineer in the State of California.

His education includes a BS in aeronautical engineering from California Polytechnical State University and an MS from Humboldt State University. And he is a member of both the IEEE and ASME. And I'll go ahead and turn it on over to Buck.

(John Cutting): Good day everyone. Thanks for attending. Good day. Can everybody hear me? I wanted to first offer that most of this PowerPoint had come from another one that had developed by John Bertolino, our asset manager. So don't give me too much credit for it.

Basically I'm going to start with the background of the project and then conclude with some specific lessons we've learned. And I wanted to say this is probably 180 degree contrast to what LADWP. So without further ado we'll move on.

So SMUD is a municipal utility providing electric service (owner). It first provided service in 1946. It's got seven directors elected by our customer retailers. The service area is about 900 square miles, population served 1.4 million people, accounts served a little less than 600,000.

Our annual budget is about $1.5 billion. Our peak load is 330 megawatts and our own generation assets are 1,790 megawatts. And within that I got a note. Can you try speaking up? I'll try to talk louder.

Within that we have hydro, wind, thermal. We have a couple of co-gens we share with - I guess they're basically food processing or consumer goods manufacturing facilities. And then we have a base load thermal plan.

So our vision is to empower our customers with solutions and options that increase energy efficiency, protect the environment, reduce global warming and lower the cost to serve our region.

Environmental leadership is a core value of SMUD and we provide leadership in the reduction of greenhouse gases through proactive programs in support of national, state and regional climate change (unintelligible).

SMUD has established a goal to reduce long term greenhouse gas emissions from the generation of electricity to 10% of our 90 carbon dioxide emission level by 2050.

One of our near term goals is to provide dependable, renewable resources to meet 20% of our customers' load by 2010 and 33% by 2020. So you can see from this, this is why we're moving toward this wind.

So at this point our wind generation assets consist of the only facility we have is in the Solano. One is in the hills. It's actually - one is in the hills of Collinsville, the wind resource area of Solano County.

We have about 5,800 acres, excellent wind speeds. I mean we get - we run Class 1A machines and they run hard. I mean - and let's see within the project now we have four meteorological stations.

Two are permanent (lattice) towers and two are prospecting tilt up guide towers, a step up substation where we wheel the power into the Cal ISO grid collection system and one operations and maintenance building.

We currently have 102 megawatts of wind installed and we believe the site has 230, possibly 250 megawatts total. This is sort of a picture of the wind resource area. The - I don't know what you call it, the red solid line with the little dots on it is what Solano County has determined to be the wind resource there.

You can see our partners out here. We have (Idorola), Enexco, the (Shilo) 2 development since the slide was made has been completed after the Enexco project. And then you can see at the bottom the - let me get the laser pointer out, this is sort of our wind resource area that we own.

And our current project, our phase one is over in this area and our phase two project here. And our phase three project will be this area. We're unique compared to the other projects out there in that we actually own the land we're on.

So our phase one project started with a single Vestas V47 in 1999 for evaluation. I'm happy to say it's still running. It's been in service for I think it'll be 11 years this November. I think it was '98. Anyway, we've had very good luck with that, the V47s.

We added 15 more in 2003 with 50 meter hub hype machines and then we got seven more 65 meter hub hype machines in 2004. And our total capacity for phase one is 15 megawatts.

Then we did a phase two project in two phases which started - we were the launch customers in North America for the - not in North America, in the Americas for the Vestas V90. And we've got eight Mark 460 hertz V90s of which there are only eight in the world.

But they've been very - really good producing machines. We've had some issues and we'll discuss those in the future. So those were installed in May of 2006 and then we followed up with a second phase of 21 V90s installed December 2007 for a total phase two capacity of 87 megawatts.

Okay, this is where we substantially differ from LADWP what we have. Work with Vestas is a - what we call a full service operations and maintenance agreement and currently it's run through 2017.

And we pay a fixed cost for this full service operations and maintenance so we don't actually have to budget for unscheduled repairs, scheduled maintenance. We just pay and then we meet with Vestas and review, you know, how things are working.

We did include balance of plant for phase two and I should clarify that the demarcation point was where our collection system went above ground. We have roughly 3-1/2 miles of aerial collection system to our substation.

So we, within SMUD, kept the aerial portion but the underground is all maintained by the underground associated with the phase two (unintelligible). And then we have performance incentives and penalties based on availability.

So we really just track the one parameter - availability and if it goes above 95% there's a benefit. If it goes below there's a penalty associated with that. We do other site services sometimes with - we have various contractors. But we do use Vestas for some other site services.

For availability the V47s have been great. They're in the high - they're almost 99% almost every year. The V90s if we don't have gear box issues, generally have no problem getting the 95% availability.

The primary issue with the V90 has been gear box through the years. But I'll talk a little bit more about that later. The V90 gear box - currently their policy is to replace the (unintelligible) condition and they have been prompt and responsive to replace when failures occur.

Unfortunately the failures tend to occur when the production is the highest. And so we - it's a bad time so they'll dispatch the crew, they'll get a gear box, they'll get a crane and then it'll take weeks before - I mean I think we lost two or three weeks at one time.

The winds were just too high to perform any (risks). So we're trying to get much more proactive. And I think that we've come up with a pretty good plan to address proactively the gear box issue with Vestas. Let's see.

We've been - so our site doesn't even have a SMUD person, right? It is actually - we own the building. We own the property. Vestas, you know, occupies our building as part of their - part of the maintenance agreement.

And we've been very happy with their very low turnover in technicians, good experienced management staff. They've got good admin people. Because as you know, the logistic battle to get the parts there on time, find them, get them, get them shipped and processed is not a trivial one.

And I think that they have dedicated people to do that and it has worked out very well. Let's see earlier I didn't put in the slide the number of techs. We have roughly eight techs, two admin staff and one site manager on site.

Those are - and that works out to 6.5 techs per machine given that they're the 3 megawatt V90s I would think it seems reasonable that we're on the lower end because they're larger machines. I know the services on a V47 they can do, they have six month services and they take just about a day.

And the V90 takes two techs the better part of three days so that, you know, there is a difference in the size of the machine but it only gets an annual service.

One of the things - one of our hard lessons learned and this really helped us that we were under the full service maintenance agreement with balance of plant for phase two which we actually had - I don't know how to say it - what the right word is, bad collection system where we kept blowing up underground splices.

And we ended up having to replace it. Here are some pictures of the splices. And they were extremely disruptive and buried. You have to find it which means you have to go and try to find its location and then you have to dig it up.

And after a while they got encased in what we call an engineered thermal backfill leak which was basically a thermally engineered concrete that had to be jackhammered off and I mean immense disruption to service.

But the good news was that our full service maintenance agreement protected the district and it basically became a warranty issue and we did get the entire collection system replaced.

So one of the things I, you know, these are my lessons learned that I'm going to interject, is I'm very shy about underground splices. They're very hard to find and repair.

And if you have above ground with adequate services you can just put a new, you know, (Peabody) on the end of the conductor and get back in service and not lose a month to find it, fix it, repair it.

We did add cross bonding. They - we had failures to the cross bond locations. We tried to get the compaction of the backfill very high because we probably had too small of a cable and that was difficult.

So by going with a larger cable it made it much easier to backfill after the cable was replaced. Let's see. And the smoking gun in my mind and I'm trying to avoid any manufacturer names here, was with the cable for one phase of our projects didn't have a standard strand blocking water seal in it.

And it - I don't know if it necessarily - I mean it wasn't that it wouldn't work as effective as a water seal. It's that it made it very difficult to do a splice in it so that the splices tend to fail. You could view the pictures.

So we have a strand blocking standard within the district and the replacement cable clearly complied with that. So that's a recommendation. We have to be very careful and actually I would have a lab come out and sample all of your cable before you put it in the ground for building a new process.

Let's see. Lessons learned with (Skata) and fiber. We didn't put locator cables so it became very difficult when we're trying to dig this collection system back out to find our fiber and not damage it because the fiber loops have an impact far larger than the collection system being replaced.

The fiber loops did not coordinate with feeder so we kept having feeder outages with the - because of the splice failures and then we would lose the ability to well, communicate with a large swath of wind turbines because the fiber loops had no correlation with the feeder loops.

So I would definitely try to correlate feeder loops and fiber loops. Let's see. And the other thing we didn't do was have a dedicated homerun to the met tower so we would lose our met data. You'd be basically blind at the site when you had these collection system issues.

Fortunately we found a few spare fibers and were able to re-plumb it and now we have a homerun directly to one of our met towers so that it stays - continues to report during it. Let's see.

One of the other things is site services. I'm constantly grappling with - we have three site services contractors. We have SMUD staff. We have a large distribution services group that maintains all of our distribution system within the - basically the majority of the county of Sacramento.

We have dedicated resources with empower generation to maintain our hydro facilities. And they are all available. And it's always a challenge for me and I'm not offering any solutions here other than it's a challenge to find out what's the best group to use to take care of a site issue or another issue.

There are some issues like we have one metering contractor and kind of a unique metering system. And so they would have to do that. And then if there are any (Skata) related issues obviously the O&M contractor has to do that.

Anyway, it - as I stated earlier, considerable effort is expended managing and coordinating site work. It's a bigger process than I think we - anybody really anticipated.

We have lots of other full service operation maintenance agreements for - we commonly use them for our base load thermal plant and our cogeneration plants. And they work fine but then they're on a few acres, not 5,800 acres and that's kind of the lesson learned there.

That's pretty much all I had. I guess I'll get questions at the end. Thank you everybody for listening and I hope you found this informative.

Sandy Smith: Okay. Thank you very much Buck. There have been a few questions posted during the past couple of presentations and we'll...

(John Cutting): Okay.

Sandy Smith: ...field them at the end of the - of all of the presentations. We'll go ahead and begin the transition to the next presentation. Chris Thomas is the area operations manager with Enexco in Minnesota.

Prior to taking that position he was the operations manager at the Fenton Wind Project which is a 205 megawatt plant in Chandler, Minnesota. He did that for a couple of years.

And prior to that, he worked with Enexco quality control technical service and also, worked as a wind turbine technician with Enexco for a long - for an extensive period of time. I'm going to go ahead and turn it over to Chris to go ahead and make his presentation.

Chris Thomas: Okay. Thank you for the introduction. I'd like to begin with saying I feel pretty humbled speaking with this group of speakers so far. I have no formal education but I have done a lot of wind turbine maintenance. I've been doing it since 1990 so hopefully I can bring something to this group that's useful.

When doing maintenance obviously you need quite a few support systems to do this correctly because when you get into it there's quite a few considerations.

Of course number one being safety, two quality, technical services, training your people, purchasing all of your stuff, your inventory control of everything you've purchased and then dealing with the human resources end of it.

Safety, you know, is obviously the largest factor in this. You know, we strive to give the best quality work we can give to our customers. And the only way to maintain that is to do it safely. So the safety culture is the most important element of the program.

We educate all employees regarding to their roles and responsibilities for safety. Everyone from the top executive to first line employee impacts safety so we all have to do our part to provide a safe workplace.

So when the culture is laid out obviously we can't have managers out in the field not putting their hardhats on. The behavior is everyone's responsibility. So the important thing to try to do is to get all of these guys to want to do what needs to be done to be safe.

So I think once you've done that you're more than halfway there. It starts with employee orientation - laying out what's expected of them as far as safety from the very beginning, training them on it. In the technical training everything has to be documented down to the last period.

Even on the maintenance end you really have to sit down with the manufacturer's suggested maintenance, go through the checklist and then refer back to the manual step by step with the technicians making sure everyone is doing the same thing and then again making sure they're doing it safely.

And then as things change our manufacturers obviously have updates to their programs and those have to be integrated in there. So you have to reevaluate your maintenance from time to time. Again I have quite a few on safety here because again, to maintain and keep giving that quality of service you have to be safe.

And in order to do that we have to make sure that the more difficult tasks that are perfumed in the operations of the wind part that everyone is training for that specific operation.

Techs tend to come on the job and then they'll want to get into portions of the operations that they're not trained for and that has to be extremely discouraged. And training - formal training has to be documented for every difficult task of - especially the electrical end of it.

And then if it isn't documented of course it wasn't done. So the documentation of the training program and the safety program has to be kept pretty impeccable and at your fingertips.

Weekly safety meetings are essential. We conduct a safety meeting every two weeks and then we'll do a Monday safety meeting on the off weeks which will be less formal but still go over any safety experiences from that.

And not to mention, you know, the aspects of climbing and doing the maintenance but you're going to have things as forklifts, high voltage crane operation and I mentioned electricians. But it isn't just, you know, climbing and opening panels.

You're still going to have a fork truck driving around. You're going to have simple things like climbing stairs up to your parts room and carrying parts down. You know, all of these things can be dangerous if not taken seriously and done correctly.

And then you have to make sure that everyone is agreeing to this culture and it has to be conscientious regarding safety. So again that's the hard part, making sure everyone is conscientious with this and wants to be safe.

And then personal protective equipment - obviously there's a great variety of things and there is no shortage of people wanting to sell you this stuff. It takes a good bit of collaboration between everyone in your group to decide on which ones you want and are accepted and then implementing them all universally throughout your fleet.

Management involvement - supervisors monitor employees to insure proper procedures are followed. Again this is - comes down to the point where you have to make sure that you can get this across to your guys that their job is enjoyable to them and they want to do it.

And at the same time make sure that they're doing it safely. Having them follow the procedures is something that never ends and you have to constantly be on the lookout for any breaches in this procedure while at the same time making them feel comfortable and at home and enjoying their job.

Again, management's held to a higher standard so we have to be sure not to ask these guys to go out and just climb that thing by yourself real quick because it's something we both know is real simple. You have to wait and say no, it's not as important as your safety.

We'll get somebody else out here to go with you. Interact with employees and give them a pat on the back. It's really important to give positive reinforcement more than negative reinforcement.

You have to be sure to keep track of everything they did right and have those ready for reviews and such as well. And then discipline - that's something that you have to keep documented. Bring them in, document it, keep it on hand so you can start to see the pattern of behavior.

It has to be documented like any other maintenance or tool or anything. They're resources just like anything else and you have to keep records on it. Now safety officers - those need to be non-management.

They need to be colleagues of theirs that are not on the same level of management but in picking the safety specialist it's - you almost have to look at the human behavior more than anything.

And they have to really be a conscientious person who wants to make sure everyone is safe. At the same time isn't a doormat for lack of a better term. They have to be a part of the group. And so choosing your safety specialist is not always the easiest thing.

They're located at the facility, they perform in-house training which not everyone is cut out for training. They have to present to safety meetings so they have to be able to speak in front of everybody comfortably.

They have to monitor the health and safety of the employees, keep an eye on them, report anything that looks out of the ordinary. They have to investigate incidences so they have to be thorough in they have to - everything has to be documented of course. If it didn't get documented of course it didn't happen.

And then they have to attend their quarterly safety supervisor officer's meeting by the safety manager. Monitor mostly using North American Incident Calculation, I guess TRIR.

Obviously as wind power gets bigger and there are bigger players you're not going to get the contracts with the big utilities and the big owners if your TRIR is not in line.

When there's incidences at the site and a lot of times you'll have a manufacturer and the O&M provider which is either the owner or the third party, it's very important to share all safety incidences with every entity. The safety isn't something that should be proprietary.

I think when it comes to everyone going home at night it need to be very transparent. And then of course all this as I mentioned, has to be documented so you can keep this all in one place and not have it in multiple spreadsheets.

Do not have it in multiple formats but keep one easy to read spreadsheet with all of your incidences at your fingertips so it can be shared with all involved in the wind park.

And quality control - this is where I spent about eight years of my time. And what I tried to get across is when quality control came onto the site it wasn't like you were a police officer coming to investigate a crime.

You come to the site, you do inspections and then you have a meeting with the technical group, the techs, and you show them where things are lacking and you improve on that so it doesn't happen again.

The quality control should be a tool not a - it should be a tool for bettering the technicians, not a disciplinary task so to speak. And technical support is something quality control can also do but you can have it in separate departments.

But there has to be your top techs available to the different sites if you have more than one. But you need a top tech available to the rest of the techs that can work with them and support them in learning how to correct the turbine.

And sometimes this technical support can conduct classes in a certain area as they get more knowledge and feel like this is something that we can do on a bigger scale with lots of technicians.

I spoke on turbine maintenance inspections. Those should be a tool to help technicians. You can, you know, correct them without making them feel like they're poor technicians.

What you want to do is create confident technicians out of ones that perhaps are a little intimidated by this turbine (unintelligible). When it comes to turbine acceptance inspections like at the beginning of a project, it's important that when you have the punch list that you only have one punch list.

Because sometimes you tend to have the manufacturer, the main contractor who's putting up the part and then the owner or the third party O&M. And they all have different spreads or punch lists. Someone has to own it.

So usually in your meetings, your construction meetings, you make sure that you're all working off of one list because I've seen that where you all tend to have different lists and you're doubling up and no one knows who's correcting what and when.

So that's something to keep an eye on. And then end of work inspections - usually throughout the working period the O&M provider will have a single list as I spoke for - spoke about a (port) where everything is in one place and you've already issued all of your warranty claims.

And there shouldn't be too much lagging behind. So your end of work inspection really is a collaborative of all of your maintenance inspections you've done through the warranty period if you've done it correctly.

And then internal audits - review of all completed maintenance checklists. This is a function of quality control where you just come in and make sure the documentation is up to snuff.

What you want - and I keep telling the techs and you want to make sure to mention this to your techs in all of your meetings because they tend to forget it, is write everything down. Everything has to be documented.

They'll come to you and say oh, I saw this. This gear box was a little leaky around the shaft. Don't tell me. Write it down. Everything needs to be documented down to the last little thought in their mind. Anything. It's like a journal. Write it down.

Document it so later when something comes up and the turbine looks like it's going to stand down or something you can go back to the record and you have the notes on the technician so you can see what it was like before.

What you don't want is to get to maintenance sheet and you get there and it's just all check, check, all good news like a Russian newspaper. Review of world sample analysis reports and gear box inspections.

Again with the gear box inspections you want to make sure that everybody is taking their time and doing this right. This is your biggest asset in the turbine. This is where most of the time all of your money is.

You want to make sure they're all pulling their oil samples at the same time which is usually right after you shut the turbine off as soon as you get up there. They're all pulling it from the same place because what you get is you get samples that people pulled after the maintenance, some pulled it before.

Some pulled it from the bottom of the gear box. Some pulled it from the pump. And when you try to get trends, when you get all of these samples together they're all over the place. And you wonder why. Because consistency is very important when you're looking at oil.

You all have to be looking at the same thing. Something totally different is going to give you something totally different. Now procedures are a big part of quality and what you want to make sure is you have one person owning that one so everything stays in one place so you can make sure that they're revised.

So any revision that suggests it needs to go through some kind of quality control. It's distributed throughout the different sites you may take care of the different entities that are working on the turbines.

So everyone gets to weigh in on it because after it's approved for updates you don't want people coming back and say hey, I have, you know, this isn't right. I think this should be in there. Everyone needs a chance to make the best procedure they can make it.

And then distribution of manufacturer service bulletins is another place where one person needs to own that and keep track of what needs to be done according to the manufacturer and document the repairs and check them off as they go.

I think calibration just - so mainly you've got to make sure that that of course is documented and you don't want someone just typing in on a spreadsheet that it was calibrated.

You need to print out sheets every time and if the technicians are going to calibrate their own torque wrenches and gauges they sign off on it and date it quarterly or monthly, whatever you do. And then that is kept as the sign back up.

And then you update a spreadsheet and make another print, get it to the site so the next cycle they handwrite in their initials and their date and their torque range. Every cycle.

So you don't have, you know, just a spreadsheet because it's not a good way to keep track of your - you want to be able to show your auditing firm or whoever, that you got every cycle's handwritten calibrations noted.

Technical support regarding troubleshooting work procedures, specifications and deviations is of course another aspect of it that I spoke on, you know, troubleshooting.

You need to have your technicians available, your top technicians available for the rest of the group to call on because they're going to come across items they don't understand or know how to fix.

Procedures of course as I spoke, everybody needs to - someone needs to own it, send it out, make sure everyone's got their input and then bring it back to a central location, update it and send it out as a revision. The same with the specifications.

And deviations - that's - maybe you want to deal with that with your spare parts. I've seen it a lot where you'll get a lot of parts in and one will tell you they'll come bad or the technicians will break them, you know, on the way up to the tower.

And they won't get used and they just end up lost in the space. So you need to have a procedure ready to deal with this deviated stock of inventory so you can either get it taken out, write it off or get it fixed and put it back in.

Continued trading is important because you'll have these technicians who are like me, don't have formal training. So they need to - as they get higher up in their skill set they can figure out what the standard is for gear box failures.

They can learn about multiple synchronous generators that are out there now. They could learn about oil analysis and different types of oil analysis, different types of oils.

These are all places where as these guys learn these different skill sets that they become better technicians. Manufacturers offer training and suggest that you don't send technicians into that right as you get them.

Much more is maintained and used and they get to see the turbines. Get up there, look at them, see what defaults are, work with someone else who's been trained, then go to the class.

Then they're much more in tune to the turbine and it's the license to learn. And then they just soak it up like a sponge. In-house training obviously you're - as an O&M provider you get to see what exactly you have to deal with day after day and the techs you're dealing with day after day.

So you tend to know what you want to put in your training program so that they become a useful resource as you do more maintenance. You train on what, you know, you've learned and you transfer that knowledge onto your employees.

As far as the hands on there's no better learning tool than just getting out there and doing it. However, again you have to make sure you're safe. More decisions and considerations behind the scenes.

In addition, two things that are evident on the site, there are a number of additional things that require the same level of due diligence that are not a definite such as HR function.

The O&M is very much a people intensive business and requires focused efforts on recruiting, benefits and retention. There are times in the industry that we've seen where it's difficult to keep technicians happy.

They - as the industry grows there's a lot more options out there. So how do you keep people happy? Obviously by paying them but sometimes, you know, that doesn't fit your business model. If you want to have sustainable growth you can't just start throwing money at them.

The best thing I've seen so far is the pat on the back. Making sure the technicians are happy where they're at. You make them feel like they're a part of something and they belong and they're important.

Procurement - this is where the spare parts come into play. As you get bigger the turbine gets to be more of a function. To find these parts, purchase them, get them into inventory tends to be a bigger and bigger process as you get bigger.

It's important to make sure that you've got this end place and you have a good way of keeping track of it all. The more you buy of course, the better the pricing is.

So you want to make sure your O&M provider has enough purchasing power to keep the costs down when it comes to procuring all of these supplies because, you know, as the turbines get bigger everything gets more expensive. This is one place that Buck hit on and I'm going to touch on it again.

This is where your experience comes down to procurement. I've noticed before sometimes you'll get purchasing agents who will get you splices that aren't that great of splices. And you really have to do a lot of Q&A and researching what splices are good.

One of the things you have to make sure of when it comes to your balance of plan is when these things happen, you know, before they happen you need to go to the (unintelligible), find out what your resource is for finding out what the fault parent was be it splicers or your square D meters or whatever you've got.

And make sure that you have a good fault current analysis so you know when that thing tells you what the problem was, how much current you had. You get a good idea of how far away it was because if it's just a number to you you're just guessing.

Underground can be a pain but in the Midwest it's actually a little better than the overhead because of the extreme conditions we have. When the park is put in if you're going to have splices - well you're going to have splices in your underground.

One of the things you've got to watch is that they do it - that they're - that they have a clean splice pit. That they're not - they don't have trucks running around on a dry day with dust just pouring into their splice pit. The main thing I've seen is keeping these things clean while you do them.

And another thing I would suggest is all of these larger cables and this one is 34 5, they have concentrics on them to keep that inductive load grounded. And they'll take the concentrics out and ground them every so often and they'll want to do it right at the splice.

I suggest you don't do it where the splice is because a lot of times where that concentric comes out that splice is where it leaks and then they get water in them. Do the concentric down the pit a little bit and leave the splice alone.

Keep the concentric away from the splice. Another place that you have to think about also are the pad mount oil samples. You need to do that regularly because these pad mounts tend to collect acetylene and of course you don't want to be switching a pad mount that's full of acetylene.

And so you want to keep track of those because when you have a problem with your main breaker you have to shutoff the pad mount so you can work on your main breaker you want to know if it's full of acetylene.

Another thing you can do to keep your balance of plan is thermal imaging. Something to consider is a scheduled thermal imaging of your balance of plan on a, you know, annually usually is what's suggested along with the pad mount oil samples.

So you can see where things are getting hot before they blow up. Insurance coverage - this is probably what I know about the least but I know that of course that's important to make sure you have the right level of coverage.

And then know who your representative is to deal with the insurance and when you have any kind of large component failure that you have a contact person to talk to at the site level so you can find out if you have a claim or not.

So you don't want it to be a mystery who your insurance coordinator is. You want to make sure that your site managers have that readily available so they can contact their insurance administrator to deal with claims.

They tend to forget it when you have an underground splice or you have a blade failure, you have a gear box failure. They're so - these days so busy dealing with scheduling cranes and is it going to be windy and, you know, where am I going to get the new boxes, they don't talk to the insurance administrators.

You may have a claim on that. There's a company that you have (unintelligible) have the resources to stay on the job and stay behind things like warranties.

We want to make sure that, you know, your O&M provider has the time to stay on the job and make sure the turbines are up when the wind's blowing. You want to instill in your technicians the joy and the happiness of fixing a turbine that's off the line with the winds blowing and they want to get that turbine back on the grid.

This little thing in here on tools of the trade. Up here now is a shaft tog that we use for alignment. Shaft tog offers one now that will record your alignments and you can take it back to your PC and print out the alignment.

It's a really nice option. The problem is it's twice as much as the standard that we're using now. But that's something to look for as prices come down or as you procure these tools.

It's a good option to have because obviously it comes right out of the computer. Here's what the alignment was. Your techs can initial it and it's just a little more of a solid document when the tool can print out what you've got there as far as alignments go.

Great picture of them performing alignments. You can see the lasers at each end, measuring the distances. Back in the day we used to use dial indicators on each end and have to watch the dial that go around. These tools can take a lot of the guesswork out of it. So it's actually a nice addition.

This is an alphatronic for doing torqueing. These are very expensive assets and I suggest that you keep track of these just like you would a wind turbine. As they break you want to keep document what happened to them and send them in.

And then document what they did to them and the dates that they went back into service. Very expensive tool that you want to make sure you know what's going on with it. I suggest that, you know, as you hand these tools out of course you have a training class with your technicians on how you're going to use these tools.

And then after you've been using these tools for a couple of weeks you get the techs back together and discuss how the users are using these things and establish, you know, best practice because everyone will tend to talk amongst two or three technicians.

But you want to get this amongst your whole group and discuss the shortcomings and what works and the best way to do this to keep the tool in service.

You tend to buy - you want to buy these tools and then you use them and you don't keep them going. You want to make sure that you have someone that's also scheduling these tools if you have more than one site.

So as someone else needs one you can transfer that tool over and keep these tools going. This is a picture of the high torque in the back of the truck. Again, you know, I suggest you guys get together, get your technicians together every so often and say what's working, what's not working.

What do you see as the biggest problem here using these tools? You know, where are you reacting off of - what, you know, make sure everyone knows what works best so you don't end up with broken tools.

You know, the fastest way to break these tools is to use them wrong or not, you know, not take seriousness of, you know, how expensive they are and don't just be treating them like they were not expensive.

Just threw in a picture of the crane here. Obviously the biggest expense for your main component replacement is a crane these days. Turbines have gotten to the point where cranes have to be so gigantic to get to these high levels.

And then of course, take the rotors down you can see them rising, so you need another crane to tail the rotor. The cranes are getting harder to find as the turbines - we get more turbines in the area.

And I just want to make sure that you maybe talk to your crane companies ahead of time and make sure they've got what you need and can respond when you need them.

All right, in conclusion, O&Ms specialists make it look easy doing them right, keeping costs low and (unintelligible) high is anything but easy. Well I thank you for the opportunity to do this. I need this kind of practice.

I again feel very humbled by the speakers, their qualifications thus far and I hope this has been helpful and thank you very much for the opportunity. Okay.

Sandy Smith: All right. Thank you very much Chris. And we're humbled by all of the work that you have to do there to keep the plants up and running. Our next speaker is going to be Chuck Carter. Chuck is a senior member of the technical staff at Sandia National Labs.

He joined Sandia this year but he's worked in the field of reliability, maintainability and availability for the last 15 years. As an Air Force officer he worked as a payload engineer on Titan 4 Rockets.

He worked as a reliability analyst at the Air Force operational test and evolution center and as a systems engineer for the space and missiles system center. As a civilian reliability analyst he performs reliability assessments of numerous aircraft and petrochemical systems.

He is the developer of the simulation engine for the commercial reliability tool Raptor. Chuck earned a BS in aeronautical and astronautical engineering from the University of Illinois at Urbana Champaign and an MS in systems engineering from the Air Force Institute of Technology.

And without further ado I would like to introduce our final speaker for this webinar, Chuck Carter.

Chuck Carter: Great. Good morning. Hopefully you can hear me. And good afternoon to those of you on the East Coast. I'm going to be talking about a couple of tools today that are used for reliability analysis.

And specifically I'm going to talk about how prognostics and help management kind of fits into these tools. And before I get into talking about them though I just want to say that these types of tools are something that you can use very early in a project.

You can use them before you even have begun any type of construction. Or you can use them on a system that's been in place for many years and build an as is model and then use that as a baseline to do some what if analysis. Analyze some potential alternatives for upgrades and things.

Okay, the two tools I'm going to be talking about are Raptor which is a commercially available tool. It's made by a company called ARINC, A-R-I-

N-C. And then another tool called SEM, System Enterprise Model which is a tool that's developed here at Sandia.

Okay, Raptor conceptually is a pretty easy tool. It's called a discreet event Monte Carlo simulator. And what it does is it takes component level information such as MTBFs and statistical distributions that describe the time to failure of various parts and also describe the repair of those parts.

And then logistics information regarding how many spares you have and how long it takes to get ready to do repairs, cost information, anything else you have.

And then it simulates that system operating over a period of time and it spits out system (over) results, your reliability, availability, capacity if that's what you're trying to get, and other parameters.

Okay. Hopefully you're not lagging with the graphics but you should be looking at a screen capture of Raptor. It's a reliability block diagram of a wind turbine. And the things that are squares on there, the blocks, those represent pieces of hardware. Those are components.

And for each one of those there's a failure distribution defined and repair distribution defined along with some other information. The round circles in this diagram - those are just there for logic purposes. They control what's called the (unintelligible) where you have redundancy.

And on a wind turbine typically you don't have much redundancy and if you look at this block diagram it might look like there's redundancy in there but if you look on the nodes most of them are (unintelligible). Like for example, under the gearing area it says five out of five.

And the other ones are in (unintelligible) as well. So essentially this is a series - reliability block diagram which means if any of the parts has failed then you're going to get some downtime associated with it.

The reason it was drawn that way is because with this particular tool you can get not only system availability but it will give you localized availabilities. And if you have these nodes in there and have it drawn the way it's drawn here you can find out the availability of say your gearing subsystem or maybe your pitch control subsystem and things like that.

So essentially it is a block diagram. And when you feed it with all of this component level information what the tool does is it allows you to say okay, now I just want to simulate this system running for ten years.

And you start a simulation and you can run it with graphics on or off. But if the graphics are on you'll see these blocks on the screen occasionally turning red. And when it turns red that indicates a failure has come up on that particular part.

And it'll draw a random number to determine how long that repair is and it'll stay red on the screen until that repair is complete and then come back to green.

Actually if you watch it closely though you'll actually see it goes to like a dark red initially and then a bright red and then another dark red and then back to green.

And what that downtime period represents is that the initial dark red is a pre-repair logistics delay which means that you're down but you're not actively repairing it yet.

When you see it turn bright red then you're into an active repair. And when you're into the - you could have a post repair logistic delay also. And all those account as downtime for that part. And if you're in series it's downtime on the system.

And eventually it comes back up and your system comes back up. The whole time your - this tool keeps track of if the system's up or not and so it's able to determine at the end of the simulation system availability and it can track costs and things like that.

So on the next - let's advance the slide. On the next one it shows sort of what it looks like. This is a summary of the - somebody's blocks. When I say blocks I'm referring to parts of the wind turbine. And there are distributions - it says failure distro. That's their failure statistical distribution.

And (unintelligible) is a pretty common statistical distribution to describe the time to failure of a component depending on the shape, brand it kind of looks like a normal but tends to get - allow for good modeling components that have a wear out type function.

And there are some exponentials in there. And then to the right I'm looking at the table at the upper right, is repair distribution. And for now they're just entered in as fixed repair times.

But it's generally better to use log normal because log normal is - tends to very well describe the repair time associated with pretty much anything. In the lower left there's some input for system settings.

And in particular I want to look at the one that says cost of red time per hour. And there's a 160 number entered in there. What that number is it's the - sort of the cost per hour that is incurred basically due to lost business.

And there are some assumptions in there that may or may not be too good. But it's not that relevant I guess how accurate it is. It's really the technique. What I said here was that the sale price of electricity was $100 per megawatt hour.

And (unintelligible) turbine has an average output of 1.6 megawatts. So for this particular turbine every hour that it's down it's costing you $160 in lost revenue.

We'll move onto the next slide and these are some additional model inputs. And at this time if you look at the one on the left there's a pre-repair logistics delay time showing and most of them are eight hours.

So what that's saying, there's an eight hour delay from the time you first realized that something has to be repaired to the time there's actually a person out there turning a wrench and fixing it.

But there are a few of them that have 168 hour pre-repair logistic delay which is a week. And those are those items that have a - some type of significant preparation required to do that operation such as getting a crane out to the site.

Or if it's some type of component that's not maintained on the - the spare part is not maintained on the site and you have to get it out there. So we have a bunch on that week long hit.

And what I'm trying to do in this particular example is see what could be gained if we had some kind of knowledge in advance that there was going to be a failure on some of these parts through condition monitoring program and we're able to - instead of waiting until a thing fails then we could kind of take it down on our own terms and pre-stage the crane or whatever else we need.

And then take it down. And with that assumption what I'm able - I went back and took those pre-logistics delays, the ones that were a week long and I reduced them to the same as the other components. I just put an eight hour pre-repair logistics delay.

And for all of them there was a two hour post repair logistics delay. So I took those two examples there and ran each one of them for ten years. And all the other costs (unintelligible) - you can enter all kinds of cost fields in the model but just for this example I zeroed out everything except for that cost of red time.

And if you look at the one on the left it says $317,000 and that that represents the total lost revenue due to downtime to the case where I had those long logistics delays. And then on the right it was down to $214,000.

So about $100,000 over the ten year period or a little over $10,000 a year, that's for one turbine, that you would save if you were able to reduce that logistics delay time with some type of condition monitoring.

If you have a farm then you'd see probably a linear increase in revenue if you had ten of them. It would basically be ten times that number. But the cost implemented would probably not be linear and you would get some benefit from the economy of scale.

Whatever effort you put in to determining what you're going to monitor and what method you're going to use to monitor would apply to all of them so it's really a matter of just putting on the - whatever pieces of equipment are necessary to do that monitoring.

We talked a little bit about that cycle that you see like in a model anyway that you see a block go through where it's operating for a while and then it goes into this pre-repair logistics delay and then after repair and the post repair.

With PHM they actually may get some benefit in other sections of that lifecycle. You might extend that green time or operating time in particular if you have preventive maintenance on items.

If you have an active PHM program you might realize that the item doesn't need to be replaced at that time. You can let it go beyond your previously determined PM time until you can actually see some type of signs that it's about to fail and then replace it.

You can also get some reduction in your repair time. And that - when you do an orderly shutdown sometimes there are fewer tasks that actually have to be done. An example of that might be some type of seal that blows and it's going to get hydraulic fluid or oil all over everything.

And, you know, that's what happens if it actually fails. But if you're able to take it down before that you can eliminate some of that effort that's involved in the repair. Okay, the next tool I'm going to talk about is SEM and SEM is another tool for doing a reliability analysis.

It's done at a little bit higher level. It's what's called the enterprise level model which means that it models the whole enterprise from failures up through your supply chain and how long it takes to get parts from OEMs which is original equipment manufacturers, you know to the supplies - you have an interim supply location and from supply out to the site.

So all that stuff is involved in this type of model. It's another simulation type tool. But at the base of this tool it still comes down to parts and failure distributions and repair distributions. In this particular case it uses - it breaks down the failure distribution into two parts.

A random part which is along with the exponential distribution. And the wear outs which is models with the normal distribution. And it focuses on that normal distribution which is the wear out part.

That's where PHM has implemented and there are a couple of different techniques that are involved in what that's - what I want to show you with this tool.

Okay, on this slide what you see is sort of what would happen if you have no PHM at all. That curve at the top represents a normal distribution. It's your time to failure. And at some point in - within that normal distribution you get an actual failure.

If you have no PHM and no parts stored on site at the time that item fails you have some sort of delay and part order lead time. Eventually the part arrives and then you start that repair action.

The ideal situation would be on the one in the bottom where sometime prior to that actual failure you get an indication you're able to make a prediction of when the failure is going to occur.

Hopefully that lead time is greater than your part order lead time. So you can order that part, have it sitting there when the item breaks and it's already ready to go.

Of course real life doesn't work that way so what this tool then does is try to make a more realistic modeling of how PHM will work. And so what it does is it creates a prediction time for the - creates a - within the model you get an actual failure time will come up.

But also you'll get a predicted failure time based on research and things that you've done to determine what type of lead time you typically get. But that distribution of the prediction lead time is itself a normal distribution that occasionally will result in a prediction that's too late.

So I went ahead and included the equation at the bottom. I'm not really going to talk about it much but I just want to include it in case anybody is involved in modeling directly and they can see how Sandia did it within this model.

But if I move onto the next slide you'll sort of see what happens if you get a late prediction. You still might get some idea before the actual failure occurs but your prediction time for when it's going to fail in this case, came after the actual failure so you would get some downtime associated with waiting for that spare or support equipment.

And the next slide is just sort of a screen capture of what it looks like within this SEM tool. And those variables - the ones that are actually going into the model there's order lead time, prediction lead time. The big one in there is the prediction time standard deviation.

The probability of late prediction and then there's another one, that run to failure. Even if you do get a prediction and if it turns out that your prediction time is early some cases you go ahead and swap it out and in other cases you just let it run until it fails.

And what this is there to do is just allow you to make your model more represent how things are actually done. That way it makes for a better baseline model and then you can do what if analysis at that point using your baseline model.

Once we implemented this PHM feature into this tool we built an example that was pretty complex with regard to the logistics of it, all of the different repair sites.

It hit a large number of - this is actually initially built for aircraft so we had aircraft in the model and we computed our mission capable rate which is essentially in availability.

And when we did this the only thing not realistic about this example is we didn't have a large number of parts. But we took the parts that were on there and half of them we implemented our PHM philosophy on it.

And we were able to increase their mission capable rate from 77 up to 82. So I don't know, I might not be realistic and in fact I'm sure it's not realistic that you would be able to implement PHM on 50% of your parts.

But you could still sort of get a feel for it from this that PHM when it works, will help you with your overall availability. So capabilities exist to model the benefits of PHM. It's something you can do if you're planning a new facility or you can do it right now on your current facility.

You can build a model of it. Look at those things that are potentially - you could recover some revenue by reducing the downtime and then get an idea using these models what that benefit would be.

And you can do it either indirectly by focusing on the PHM effects which is what I did with the first model. The first model didn't even have PHM as an advertised feature but I still know the effect of PHM is that it reduces your logistics delay time.

And so I was able to do someone else's with it. Or you can, you know, have models that directly have PHM variables in it. a little more accurate probably but they're also harder to feed because you need to get an idea of what the prediction lead time and prediction lead time standard deviation.

So if you're attempting to consider whether you should put condition monitor or PHM on your plant you might start with the baseline model but then look at which of those parts do I even have the potential to modify and where the technology exists to get some kind of heads up on an impending failure.

You also want to look at those parts that are going to have the most impact on system performance. Those that have significant delays that are there before you start your repair.

And then some other cost considerations - in addition to the equipment that goes on the turbine itself there may be some off system monitoring equipment and personnel costs.

So the last question there - is PHM cost effective? It's a rhetorical question. It's just it really depends. You know, it depends on a lot of factors. How much downtime you're getting and what you can recover.

But the point of what I'm trying to say is that simulation actually offers a pretty good method of sort of up front getting a feel for whether or not it's going to be good for you by seeing what could be recovered, what's the available revenue we should say, that could be recovered if you can reduce those logistics delay times.

So we blew through that pretty fast but I guess that'll leave more time for questions then. That's all I have.

Sandy Smith: Okay. Thank you Chuck and I appreciate your giving that presentation and everybody else given their presentation. I am going to go ahead and open the floor up to questions. I have been monitoring questions during the course of the meeting.

Some of these have been targeted to specific speakers but in other cases it might be also beneficial for other people to weigh in if they have input. This first question that came in was specifically - I guess it came in during the course of Ryan's presentation.

Are there any federal environmental regulations for wind turbines such as SPPC, that's spill prevention regulation or other state anti-spill measures when injecting lubricants? What types of lubricants are used? Are they petroleum or synthetic based? And if Ryan or Buck or Chris wants to weigh in on that, that would be good.

Ryan Harry: I'll let either Buck or Chris weigh in on this one.

(John Cutting): This is Buck. There's lots of lubricants. We've got hydraulic fluid in gear oil and I'll be honest, our O&M contractor Vestas, primarily deals with that. And they take great pains to not spill it and properly handle it.

I don't know if I can offer anymore details than that but I hope that helps.

Sandy Smith: Chris do you have anything to weigh in on that?

Chris Thomas: Just that yes, they're both synthetic and petroleum based and it's always been throughout my career, standard to not pollute the ground. And when we do we have to dig it up and process the dirt. As far as I know, no lubricants are allowed to get into the surrounding area.

(John Cutting): Yes. That's our process too. We dig a lot - well we don't very often but we've had to.

Chris Thomas: Right. Yes.

(John Cutting): We work really hard to avoid it.

Chris Thomas: Exactly.

(John Cutting): Yes.

Sandy Smith: Okay. This next question was specifically for Ryan. To what degree has LADWP assumed O&M responsibilities on the project to date? What has been the experience in terms of the effectiveness of using their personnel trained on turbine O&M?

And after they've been easily able to make the transition to dealing with wind turbines?

Ryan Harry: Oh. We haven't gotten much feedback from Steve Fuller at LADWP or others from LADWP since the case (failure) was written. So I can't give a definite answer (unintelligible). However, I will contact Steve with these questions and see if he can answer them.

And then I can post those to the www.REPartners.org or e-mail them to this group. So and if anybody wants to contact me directly regarding these. My e-mail address is RHarry@BCS-HQ.com. But that's as good as I can do at this moment, at this point.

Sandy Smith: Okay. And I know I've had a couple of people inquire about a direct link to the case study and we're going to go ahead and post that on the www.REPartners.org Web site as well as on the UWIG Web site too.

It doesn't make a whole lot of sense to throw out a web link over a phone call. The next question was for Buck. And I guess it was just in particular to one slide. Was the cost on the Vestas O&M agreement an annual number?

(John Cutting): No. That's for the entire - until the 2017 and I think we awarded it mid last year. I'll look it up here real quick. So (unintelligible). Yes. It was July last year. So it's from July last year until the end of 2017.

Sandy Smith: Okay.

(John Cutting): And that's 23 V47s and 29 V90s.

Sandy Smith: Okay. And that did answer my question which was, you know, did it cover both...

(John Cutting): Yes.

Sandy Smith: ...(unintelligible). Okay, great. What was my next question? There wasn't really any other questions. I did want to point out to folks that in addition to the resources that Ryan pointed out there are some good resources on turbine reliability on Sandia's Web site.

And that URL is pretty simple. It's www.Sandia.gov/wind. They hold a series of wind turbine reliability workshops that had some good resources on wind turbine reliability and wind plant O&M. And I encourage you to check that out.

And I might also go ahead and post that with some other links for your information. It looks like I don't really have any other questions posted. I'm checking on this. Do any of the other speakers have any closing comments they'd like to make?

(John Cutting): This is Buck. I did want to comment that like Ryan we have installed lists in all our V90s that are working and we're doing it in our V47s too. IT basically gives the techs a better working environment and insure their longevity and commitment to our project.

Sandy Smith: I think that and coming up with climbing assists is becoming a standard practice throughout the industry. Anybody else have anything else to ask or to comment on?

Well if not I'm going to go ahead and conclude this webinar. I'd like to thank everybody for your attendance. Once again, a recording and a transcript of the proceedings along with the presentations will be made available on the www.REPartners.org Web site as well as on the Utility Wind Integration Web site. That's www.UWIG.org.

I look forward to seeing you at the next webinar which will be held in February of 2010 and that will cover rural economic development case studies. And with that I'll go ahead and conclude these proceedings. Thank you very much and thank you very much to our speakers.

Coordinator: This concludes today's conference. You may disconnect at this time.

END