SMALL WIND TURBINE STANDARDS SAFETY AND FUNCTION TESTING

March 13, 2012

Coordinator: Good morning and thank you for standing by. At this time all participants are in a listen-only mode. Today's conference is being recorded. If you have any objections, you may disconnect at this time.

I would now like to turn the call over to your host Mr. Tony Jimenez, the moderator from NREL.

Tony Jimenez: Hello everybody. This is Tony Jimenez and welcome to our webinar where we have two different topics related to Small Wind Turbine testing. The first one is about Small Wind Turbine test standards to be given by Jeroen van Dam.

And the second presentation will be one of the -- kind of the four standard tests that are done for small wind certification test and safety and function test which will be given by Ismael Mendoza.

And these webinars are part of the Small Wind Association of Testers Conference who will be held in Utica, New York in late April. And we decided to give kind of the introductory presentation as a webinar so that anybody could revi- or attend the webinars or review the webinar later on and get up to speed prior to attending the - prior to attending the conference. And then we don't have to put on these presentations during the conference.

So without any further ado, I'd like to introduce Jeroen van Dam. He is a Senior Engineer here at the National Renewable Energy Lab and he comes to us from the Netherlands.

And he is a test engineer at NREL has over 15 years of experience in testing, standards development and certification of wind turbines. He has performed field testing, dry-trained testing and blade testing.

And he is also heavily involved in the standard development committee for noise testing, blade testing, mechanical load testing and small and turbine designs.

So with that, Jeroen it's all yours.

Jeroen van Dam: All right, thank you Tony. So Tony asked me to - to give you a - a brief presentation of the - the small turbine standards both testing and design actually.

And so I'd like to - to kind of go through a couple of subjects here. I'd like to introduce to you the IEC which is where most of the international standards live. Kind of show how those standards fit together in and if you look at the certification standard it kind of shows where the different standards come in.

I'd like to give you some details about the 61400-2 which is the small turbine design standard. I'm assuming that in several of the other webinars that - that deal with power performance and noise testing you will hear about the details of those specific standards.

But I figured okay, let me at least give you an insight of what's being dealt with in the -2. And then last okay how do we - do we outfit in. So first of all, let's see if this wants to work.

There we go, why do we even have standards and it's - it's I think fairly easy. I mean we want to set a minimum level of safety and that's mainly related to the design standard.

So the IEC 61400-2 for small turbines in the IEC 61400-1 and -3 for large turbines and off shore turbines. For the testing standards the - the objectives is a little bit different there.

We want to produce repeatable consistent high quality test results and so we want to make sure that somebody doing a power curve on one end of the planet and get's similar results and comparable results for somebody doing the power work on the other side of the planet.

And so the overall goal here is to basically set a level playing field for all the players around the world. And - and my personal view -- and I think most people would agree -- is that this adds most value if this is done internationally.

Because then you'll only have to do the testing once, you'll only have to do the certification once. And you can take your products from country to country and so it basically would remove trade barriers.

That's said, anytime you have an international standard you will always be referring to your national standards such as building codes and of course electrical safety between Europe and the U.S. for instance is obviously different - different or just different frequencies.

But still international standards are our most valuable through the industry. So most of the testing and the certification standards are - are IEC standards. IEC stands for International Electrotechnical Commission. It's based out of

Switzerland, thus the website ends with CH. And these are widely accepted international wind turbine standards.

I mean that under the IEC there's basically two big branches. There's the Conformity and Assessment Board which deals with certification and conformity assessment.

And there's the Standard Management Board. Under the Standard Management Board there's a technical committee TC88 and TC88 is responsible for all wind turbines specific standard basically the 61400 series.

Now on the right you'll see that the TC88 actually has several countries participating and then several observing countries. And it's a pretty impressive list of countries that are actively participating and so, they're - they're well accepted.

In the U.S. we have a U.S. Technical Advisory Group which basically coordinates all the U.S. contributions to TC88 and we do that through ANC, the American -- what is it -- I'm actually forget what the acronym stands for, but it's a standard body and official one.

So TC88 then has several working groups each or maintenance teams depending on if it's a new document or a document that undergoes revision. And so these - these working groups then each work on the individual documents.

And the experts that are on those committees are nominated through our national committees which, which is ANC. And so if you want to be a member of these committees, you would be approaching the U.S. tag and then they'll ask for a vote in the U.S. tag which has all the industry participants in there.

And so on the right there is list of people that are currently active in some of the committees. Hopefully, the numbers will make a little bit more sense later on when I can show some of these.

But the NT22 is certification standard. The two is the small turbine design, 11 is acoustic noise, 12 is power performance, 13 is mechanical load measurements and 21 is power quality.

Now all these - these standards are almost continuously under - under revision. And so this is on the right-hand side is the official revision cycle as IEC sees it. It's not always how it happens in reality.

And as you can see on the right there's a cycle time that, that says, okay, 36 months from beginning to end for the technical work and more typical you'll see that, that's more of a - a five-year cycle.

Now I don't expect you to - to memorize or want to understand all the details in here but I want to point out a couple of the acronyms that - that are frequently used.

And so on the top here like this pointer wants to work there -- you'll see a new work item proposal or a new work proposal. Once that gets approved there will be a committee that - that meets and that basically starts meeting and starts coming up with a - a working draft which is the WD.

After the committee thinks that, that working draft is acceptable in good enough shape to be circulated it then basically releases a Committee Draft or a CD.

And that Committee draft goes to - to all the national committees, all the countries and we are expected to - to provide comments. And these could be typos; these could be technical comments or other general comments.

Once the committee basically thinks they've been able to address all of those comments suitably then they would release what's called a CDV, a Committee Draft for Vote.

And this then would go out to all the national committees again and the national committees are expected to basically get a yes or a no, a vote on the approval of this standard so it can then be released.

And then finally, you know, you'll see the term FDIS, Final Draft International Standard which basically then it's frozen. There might be some editorial things going on, minor things that have no technical impact and - then there's also the option I think to get this standard translated into French and perhaps even in Russian.

So those are the kind of the terms CD, CDV and FDIS are the important ones to - to keep in mind. All right, so here is an overview of the type certification flow chart out of the -22.

The -22 deals with the certification of wind turbines and the types certification is probably the most important certificate in there where if you achieve it that, that basically proves you have succeeded obtaining certification for that type of wind turbine.

And so basically on the top you'll see that there's a design evaluation then there's the manufacturing evaluation, type testing, type characteristic measurements and then the final evaluation.

And then I'm wondering why my other things are not showing up here. Okay, let me see if that's -- there it is. So the design evaluation here - here's where you will obtain your design load for the wind turbine.

This is where you will do your stress analysis, your limit state analysis. You will have electrical evaluations, controlled protection system evaluations. And then that's - that's basically your design evaluation.

And basically you'll be using the -2 and the -13 in there, mostly the -2 but if you have -- if you want to take the option of measuring your design loads directly, you would then basically end up using the -13.

In the type testing and the type characteristic, I'll break out on the next slide. And I have a little bit of a lost connection going on right now. But hopefully, we can get that resolved quick here.

Woman: You want to go to the next slide?

Jeroen van Dam: Yes, please. Slide #8, there it is. Okay. So the type testing itself consists of several tests once again and these are the mandatory tests. And so basically you have the safety function test, the power performance test, load measurements, blade tests and other tests.

And for small turbines the safety and the function test are described in the -2 will now explain power performance then refers to basically the -12, -1 on load measurements, for model validation are not really applicable.

They would be applicable if you want to use it for the derivation of the loads. And then for blade testing it refers to - to the -23. Now for small turbine those load measurements and the blade T get replaced by the duration test which is also described in the -2.

Now there's a little bit confusion as we just recently found out that the -22 says okay blade testing and gets replaced by duration testing. And that - that's incorrect and we're hoping to get that clarified pretty soon. It should only be the blade fatigue test that gets replaced by the duration test.

Now we also have the type characterization tests and these are actually optional test. And so these are the power quality test, acoustic noise test and the (lobal) but right through tests.

And these flow charts are built for large turbines and so power quality only deals with three phase machines and a lot of the small turbines you'll realize that they are single phase machines or they could even be battery charging.

And then similarly the (lobal) goes right through test, those are important for utility skilled machines but for small wind turbines the utilities could probably care less.

All right, slide, there we go. So what is all in the IEC 61400-2? Basically it starts out with defining the external conditions such as wind temperature, etc. would steps into structural design, so durational of the design modes, safety factors limits state analysis, and then basically it has descriptions on productions and shut down systems.

And then it's got testing descriptions in there, electrical system requirements, support structure and documentation. So for the external conditions basically -- besides the wind conditions there's other conditions.

The wind conditions are split into normal wind conditions, basically a - a wind speed distribution with a turbulence model and those are linked also to wind turbine classes.

And so when you design a wind turbine, you'll have to pick a design class and the design class will define the winds condition. You'll be designing this wind turbine too?

It also had extreme wind conditions and those extreme wind conditions basically consist out of (unintelligible) gusts and so these could be extreme gusts. These could be extreme direction changes. This could be gusts with a direction changes.

And then there's a whole bunch of other external condition, such as temperature, lightening, highs, but also something like electrical conditions. I mean the regret we'll have though it will be impacting your turbine as well and then so the requirements on the range of parameters that you have to consider for that.

So on the structural design side there is further three ways to - to basically derive your design loads. There are some simple equations and I'll go into that later.

And then there's the ability to use computer simulation such as aerolastic codes and stats, adams, bladed and then there's the optional direct measurement by basically instrumenting the turbine and then strain gauging, measuring all your - measuring all your loads.

I've not heard of anybody having an awful lot of confidence in being able to do the third option reliably. You'll always have to take the data that you measure under the conditions that you happen to walk into during your test. And then you'll have to extrapolate them to all the wind conditions and turbine conditions that your turbine might see in its 20-year design life.

And there's a lot of uncertainty in the measurements themselves and then there's even more uncertainty in extrapolation to those did the full 20 years. Once you have your - the design loads you'll - you'll do your stress calculations and then once you have your stresses and strains you will basically do your limits stay analysis.

And so you'll be looking at your ultimate to strength, you'll be looking at fatigue strength, stability which means bucklings, especially for something like a tower. And then deflections which are mainly applicable to your blade for instance the tower clearance.

So the simple design equations you can only -- these are - these are bunch of fairly simple equations which you could probably easily program in a spreadsheet.

We'll ask you for certain parameters of turbine and then basically we'll calculate loads for a number of load cases which are indicated there on the top right on the table.

Now since those equations are really simple there's only limits to the - the physics that are in those equations. And so we have limited the use of those equations to only horizontal access, wind turbines they have to be two or more bladed per type rotors, cantilever blades, a ridged hub not teetering or hinged. And then in the latest revision we've had to add coordinated pitch.

And the reason for that is that we found that turbines were using these equations where each of the three blades in this case were allowed to - to find their optimal pitch setting independently which basically puts all sorts of asymmetric loads into the rotor which were not covered in these equations.

On the bottom right you'll see in the - in the -- an example of what one of these equations could look like. And so this is a blade bending moment which is basically it's got a thrust force which applies a little bit above the center of rotation.

It's got a yah movement or yah rate basically, a blade inertia and so this is basically if I remember correctly this is lower case b over here which is yawing.

The aerolastic model you have to do a whole bunch of more load cases and so here you have an idea of what these load cases look like. So for instance here you have the Norman's stubble model and so this is the main fatigue, fatigue load case so that's why they're under F indicated here in the last column.

And surely you will be running a model for normal turbulent winds at a range of wind speeds. And so this is where the majority of the work will be that this could be 100s or maybe 1,000 of simulations depending on how much effort you want to put in.

And then there's also some other things indicated load case 1.3, it's an extreme operating gust with a 50-year occurrence and then there is an extreme direction change and then an extreme change with gusts.

Now once, once you have derived your loads from either the simple equations or your aerolastic model basically you're asked to multiply those with the safety factors.

And you'll see that the safety factor for the aerolastic modeling is 1.35 but the safety factor for the simple load's equation is basically 3 and that's because we have less confidence in the ability of these equations to predict the loads accurately.

As far as for control protection or control and shutdown as it's called, and the standard, there's a - there's a slightly new requirement in here. Right now we've asked for a manual shutdown buttons, switch, lever, etc. along with some procedures.

And then this - basically this devise will basically bring this turbine to a parked condition and in parked is stenced or idling and that has to be happening for all normal external conditions and normal external conditions are conditions that have a probability of occurring once a year or more frequent.

So you don't have to do this if the 50-year extreme winds come by but you are expected to be able to do this when you're one year extreme wind comes by. So this - this is something new.

Previously we - we had asked for a procedure which basically could mean leave the thing alone and run away from it. This time around we found that that's really not acceptable for the industry.

Here's a - kind of a busy slide for summary of all the changes that we've to year -2. Currently the second edition is in place and we've been working on the third revision and so here's a couple things that we've changed.

We added material factors for UV degradation of fiber and reinforced plastics and for temperature effects. We added a lot more clarification to the duration testing as we now had the ability to use these procedures for the last five years or so and came out with a lot more experience with them.

And we also had more people use them and anytime more people use the same procedures you really find where the room for interpretation is or where the wording was confusing. And so it's really been helpful to be able to use these for a few years.

Just covered the revision of loading over control and shutdown systems. We now also added the requirement for a resonates analysis for the turbine system. As you know most of small turbines of variable speed and some will say, okay the argument that they are a variable speed is that they will run through the natural frequencies and they will never sit on a natural frequency.

And that's correct if you do it in a smart way but we just wanted to make sure that we could show that you're -- that people are really smart about it then that we were not sitting on a resonance when the RPM was leveling off.

There's always been a concern on how to deal with multiple support structures, if you had to recertify the whole thing, redo all your loads, redo all your testing.

So we - we dealt with that where you have to go through a process at least at once. You don't have to repeat everything but then of course it depends on what you're doing.

So this has to be a discussion with your certifying body in the end. But at least we wanted to make clear that it's not expected you have to redo everything for every tower that you have because sometimes turbines can be sold with 50, 60 different towers.

We -- other than formative annex on high turbines environmental inflow conditions. And this was basically to address a concern that the turbines model that we have are basically nicely developed boundary layers open field conditions.

And we've seen more and more turbines being installed in non-ideal conditions in an urban environment on toppled buildings even. Or even if they are just above the tree line, we are afraid that our turbines models might not be capturing everything.

We added an annex on tropical storms this is based on some of our Japanese co-workers that have basically seen that okay for Japan you have to -- you don't fit in any of the four standard categories for your design. Plus you have to incorporate some of the typhoons in your design over there.

And so they wanted to give some guidance on what the wind speeds actually look in these turbulent storms. Other than further annex on 3 in external conditions so these are high and low temperatures. So I think desert in Australia versus perhaps up high in Canada, solidity and then sand. I mean these could all have severe impact on how your turbine operates.

And so we want to give some guidance on how - how you deal with those and last we - we actually - we also wanted to - toward the end of our revision cycle we edited some caution on the use of simple design equations and I'll deal with those in a couple slides later.

And then last though not in -2 but it kind of came out of the group we basically developed a small wind turbine noise annex which goes into the -11, the noise test standard.

And then we updated the power performance small turbine annex in -12 and -1 to incorporate as many of the OEM Buoy standard language, you know, that - that tend to harmonize - harmonize these things.

So as I said there were some concerns raised late in the revision cycle of the -2 and this was based on several turbine fillers that they had in the U.K. Several of which were certified turbines.

And of course any time a turbine fills this could have many, many different reasons. I mean the turbine could not fit the designs simple design equations. It could have to do with manufacturing quality. It could also have to do with they're not manufacturing what day have to certified basically.

It could also be a problem on the - the certifying side where the certifying body may be wasn't paying attention or lastly of course could also have indicative problem with the design equations.

And we haven't seen the evidence that it is the - the design equations. Hold on. But either way I meant there's - there's always been a concern about our fatigue load case and the fatigue load case is - is always been a weak case but we've never been able to really improve it.

Now the fatigue load case will give you very low stress cycles but very high cycle count. And so it basically not realistic but the high cycle count will make up for the low stress.

We've also seen that for some turbines actually the ultimate loads are uncovering for shortcomings in the fatigue load case. And so one concern that we had is people say they might know their ultimate loads much better and they're trying to shave up some of the safety factors in that area.

Then basically exposing a problem in the fatigue - the fatigue loads. So we added a sort of a caution in there saying okay you have to take all the loads as they are. You cannot say okay I know my direct loads much better so I'm going to reduce them over there. Because if you do so, you might expose the problem on the fatigue side.

We also found that the - there's an equation there for a maximum thrust load and there's two equations in there. One for when the turbine is parked when - basically when everything is - is drag driven. And so you can have a stationary turbine and you'll basically calculate a certain area apply to the wind speed and the conditions.

But also if the turbine is spinning you might - might get different results. It's more of a - a lift driven thing and we found that the equation there which has a - it's got a - the number of blades a protected area of its blades and it basically has a tip speed ratio.

So the ratio of the - the speed of the tip or of the wind speed and we were pointed towards, if the tip speed ratio goes really, really low, thus the closer you get to being completely parked, this load gets ridiculously low and it's no longer realistic.

And so we have to have put the caution there to basically you do your calculations based on drag. You do your calculations based on lift and you'll have to use the higher one of the two.

Some here's a review of where some of the important standards currently are in the revision cycles. So the -2 the comments to the CD basically had been received and they - they are being incorporated. And if the committee deems that the CD is - is ready we'll basically release a CDV and then we should be expecting that in the next month or two.

The -11 is currently also under revision and it's in the CDV stage and it should be - be coming in pretty soon. The -12-1 is currently in a CD stage which basically the committee has just released a committee draft.

The national committees have time to submit their comments and in April they'll be meeting to discuss those comments. And if they think they were major issues, they might decide to release another CD, a CD2.

If they think they can properly address all the issues when in consensus, then they might go to a CDV. And then the -13 which is the - the loads document -- it's currently actually in a working draft form. The committee's been meeting for about a year and a half and thinks it sh- will need at least until January of the next year to - to be able to wrap up a CD.

Lastly, we are in WEA and basically WEA - the WEA standard grew out of the - the WEA standard use to be a one-on-one copy since then. But WEA standard has undergone a little revision on its own. And so it's separated.

But in general they've taken the power performance test out of the -12. They've taken the acoustic noise test out of the -11, the safety and function and duration test out of the -2 and the design loads plus some design evaluation out of the -2 as well.

And then they've made some modifications to each one of those where - where the IEC standards were not detailed enough or not to their liking. And they basically they added the - the process of turbine rating which is an important thing where it's makes it easy for the consumer to compare turbine to turbine.

Then they basically took the power out in the OE standard and said okay this is not going to be part of the certified system and that's debatable on this if that's a good thing or not.

Most will argue that towers are part of the struc- the building structure and will be part -- subject to the building code anyways. Other's will argue that - that the towers and integral system all of your turbine and so it's kind of silly to certify the turbine without the tower.

And then of course a third of the party will say, "You order the very small turbines you will not know what the tower is because we're not selling the tower, the consumer will find whatever they want to put the turbine on. It's be a tree, it's be a - a piece a pipe that they fine in their hardware store."

And then they also added a couple of indicators of how much you are allowed to change your design to still have your certification basically applied. And WEA, WEA a standard or a least the WEA standard grew out of the - an attempt to lower the cost of wind turbine certification.

I'm not sure how successful they've been but it definitely was the hope the streamline this process. And in then also since there was no for instance no small turbine noise test procedure in the IEC realm that basically filled gaps that were - that were present in the IEC standards.

And so that's my last slide, so Tony I guess I'll turn it back over to you.

Tony Jimenez: All right, thanks Jeroen. Since we don't have -- don't have a big audience here I think the probably the easiest way to do questions is just to let people ask them directly.

We did have -- one person ask- typed in a question and asking about the full names of the acronyms. And maybe we'll go to that person first and for these particular acronyms she wants to know what they mean and Jeroen can - you can spell those out. So at this point I'll open it up for questions.

Woman: Tony, we're not set up for live questions but I'm sure the operator, if the operator is standing by we could - we could do that, I - I believe.

Coordinator: Sure, would you like all lines open or we can do a formal Q&A session? It's up to you.

Tony Jimenez: Let's do a Q&A.

Coordinator: Okay, one moment please. If you would like to ask a question, please press star 1 on your phone. You'll be prompted to record your name. Please make sure your phone is not muted and record your name slowly and clearly when prompted.

To withdraw your request, you may press star 2. Once again, to ask a question please press star 1. One moment please as we wait for questions to queue. Our first question comes from (Lisa), your line is open.

(Lisa): Hi, just a simple question about the use of the acronyms, CDV and CD if you could remind me please?

Jeroen van Dam: Yes, so CD stands for Committee Draft, CDV is then a Committee Draft for Vote. And then after that it would go into the FDIS which would be Final Draft International Standard.

(Lisa): Thank you.

Coordinator: And at this time I show no further questions in queue.

Tony Jimenez: I guess I'll ask one. Jeroen, how much -- do you have any sense for how often or how much the - the standards are used by the manufacturers while they are developing new turbines?

Jeroen van Dam: I think as far as I know most manufacturers will use it even if they don't certify their turbines through these standards. Because I think beyond -- I mean even if you're not planning to - to certify things. I think it's a valuable guideline on - on the kinds of things you have to think about when you're designing a turbine.

It will give you good very good ball park loads if you want to get the simple design equations. So I'd like to believe that - that the majority of manufacturers are indeed using these standards even if they're not certifying their turbine.

Tony Jimenez: Okay, great. Any more questions?

Coordinator: And again to ask a question please press star 1. And at this time we show no questions.

Tony Jimenez: All right, last call.

Coordinator: And I do not show any questions, thank you.

Tony Jimenez: All right, well thank you Jeroen. And our next speaker is Ismael Mendoza. And he's going to -- we're going to start diving into one of the forecast that are commonly done for small wind turbines, the safety and function testing.

Now Ismael Mendoza is a Test Engineer at NREL. He's been here since 2010 and he is involved in the IEC Accredited Testing for wind turbines in the areas of power performance, power quality, duration and safety and function.

And he has a background in electrical engineering from the Colorado School of Mines. So with that, you're on Ismael.

Ismael Mendoza: Thank you Tony. We're talking about the subset from the -2 IEC standard regarding the safety and function testing? (Unintelligible), of the turbine behavior of the is what to find determine that has personal safety and procedures and well documented information in track how a turbine behaves at a natural site.

But for the most part this test doesn't verify that the turbine is overall safe. And so pretty much binary type of an execution of a pass or fail but that's up to the certifying body to determine that.

And than we which is characterized to see, you know, seemingly, you know, get our data information to see how the turbine actually controls it's power and it's spin speeds, it's rotor speeds.

And verify on the manual that everything is well documented. The center that covers the safety and function is the IEC 61400-2 section 9.6 that describes verification of power and speed control, wind alignment what determinates it do regarding the loss of loads forcing prediction as well as if it has a cut how it's supposed to protect itself.

We also have guidance regarding Section 8 the petition in chapter system, Section 10 electrical system and Section 12 1.46 which talks about personal safety.

As we heard on the previous presentation you know, small standard refers to follow the guidance from the IEC standards. This test pretty much depends on the turbine by turbine and the first thing we do here is verify and sit down with the manufacturer to help us understand how the turbine behaves and they can undress any particular situation that we need to look for.

The wind turbine for power wind speed, rotor speed to determine fetters as well as wind duration, yah angle and wind voltage will usually collect all the data and one minute intervals and we try to block all the give us information to try to turbine regarding situation IEC testing that would get you inside.

(Unintelligible). We verify with the manufacturer to in the manual and the schedule inspections, the manual that the turbines require, verify behaviors the control machine a pitch break or if it has to - it doesn't have any cut out wind speeds or there's any particular be sure you have to take into consideration so that determining can not be turned off.

And then we do a data analysis to try to present all of the (unintelligible) of how the wind turbine has been performing at different scenarios that we have done and that from that results to IEC standards.

And then finally have a review with the client and send the other results and the test results. So one of the first integrations that IEC cost power control is things that we want to verify that the turbine itself has part limitations every instrumentation has its own limitations or ratings.

They don't want to produce current but it's greater than what the all on turbine that could cost to fall or even to an extreme of a injury of a fire. Rotor speed is that the rotor doesn't all the speed that generator and maybe create a fault or miss one of the line verify that the actually controls the rotor speed of the yah system or the breaks and things like that. So it's like I mentioned before its very turbine dependent.

And then the - the ability of turbine to - to try the wind and the all control consideration and prevent that over treating of the drip cable from the turbine to try to avoid putting the effect on their control system.

And it says if every turbine has their own now unique control capabilities so that's why it's - it's not as defined but it's very turbine dependent and then again it's controlled to control at certain speeds or power level to get by the signed documentation and of the manufacturer.

Here I'm going to show you an example of a power implementation, this is why the over wind turbines that we have here that we just a machine, it's a 10-1 machine, the red data points are one minute or the whole data points are one minute averages and the red data point in this illustrates how the itself limits part production to total watts.

Trade any in fact it's internal and burn wiring for some is long-term limitations. As you can see here, it flat lines at 12, - 12 kilowatts. This next example is of another turbine that has full control but doesn't have any kind of wind speeds.

This illustrates how the rotor governs itself at higher wind speeds. The turbine is said to govern itself or it's four inch deep at about 14 years per second.

As you can see the way that the curb just drops in here this which will capture wind speeds up to about 30 meters per second and we can see the (furly) itself, controls and keeps rotor speeds at in a controllable level.

This particular turbine has a rating between zero to 115, RPM as normal operations. As you can see in the average you never store passes that even in the expected that you're pouring was an instantaneous high speed of almost 500 RPM and being able to control itself maybe furlough.

And but the average back down to where it had normal operating behavior. Again, we don't want to forget the observation of actually behave at normal operating conditions so that determines to fall up when the winds come in at about cutting and that turbine actually turns back on if it has a cut out wind speed that all turbines have a cut out wind speeds or some of them are instrumented differently.

Some of them have a mounted moment event when they detect a high wind of they shut down for about five minutes, 10 minutes or some of them continually monitoring the - the wind speeds.

And once they detect an average of normal operating conditions then the be easy to break on the motor and the turbine starts back up. And also I'll serve that Romanians are full, they're clear breeze is big and start spinning predict power.

Another observation is that Rome was shut down under when winds fall below cut in or about cut out conditions and the once you put the there you open the breaker where it defaults in the system that the turbine actually goes, you know, to an out peddling mode.

Or rotor or in a fake state. We verified that although safety precautions are ones that on the manual in talking to the manufacturer, are well described such that when you push the ESOPs that torrent and actually either stops or sit down to a state of operating conditions.

As wind turbines might have on restrictions that you have stop it at certain like high wind speeds you have to wait on actual below a certain level or that be if you remove the - the grid that they could still load unloaded.

You know, to verify that, the turbine has a phone protection system for the generator or rotor or speed or if there is a shutdown or a fault the turbine doesn't just go painfully, covenant will eventually hurt itself or destroy itself.

And here you can see a graph of one of our high wind's shutdown for one of our programs. They predict that their turbine behavior was that some of us had detected high wind event and would immediately unwind itself from the grid.

And here it's a high wind event, we saw that the wind spiked about 35 meters per second and the deadline you see, the rotor speed was going about 60 RPM. Once it detected that it immediately probably in the one or RPM's completely stop its rotor and its power production that after either a five minute waiting period from the turbine, it went out and monitored the one speed and it noted that it was above or below its cut out wind speeds.

So it gives the okay for the system to start ramping up on the - on the RPM and immediately couple that grid and start producing power. But again sometimes if you think about these things we don't have control over one - this one speed segment come so we sometimes work with the manufacturers to allow us to make change, change some primers in their controllers so that we were able - we can able to capture this wait for the right conditions to happen.

It's really paramount to have a - a clear relationship and understanding with the manufacture of when you're taking the steps of turbines. Then on the next slide there are the control systems and so we want to know that - what the behavior of the turbine wind there's grid outage where there's voltage where there's current space in balance, where there's really noisy frequency, there are fluctuations.

The other thing is a lot of these small turbines are used for battery charging their control system has to be monitoring in the voltage if the battery is below 15% but they need to do more over voltage or if they finally lost power or get disconnected from the battery.

Again, they don't want to be running on unloaded or without a - a way to relieve all their energy into a - a system, either the grid or a battery here is all of those values are just for a particular turbine limits can vary depending on the manufacturer.

Some of the have - have greater tolerance depending on what type of instrumentation wires and systems and control systems that they have. Again, I can not stress enough of how dependent it is from the turbine that this primary are - are not set in stone and they're not defined as a standard.

So they're defined by the manufacturers of how they finally created this turbine. Here's is the Malian temple of a great outage as you can see here the red line is the rotor speed; the green line displays the grid voltage.

As you can see that the turbine looked at the default and immediately disconnected from the grid. The rotor speed went down. Unfortunately for this turbine it's not an automatic reset once this was created. In fact, the grid came back on line.

But somebody had to go in and manually clear that fault. Some of the turbines depending on the manufacturer, they continually monitor once the grid comes back on line the - that's an internal check.

And then the turbine can return to normal operations. And I have understood that the standard is a sense of vibration some wind turbines need to be instrumented wind direction sensors, sensors that there's turbine inside or that the wind direction is changing from - changing direction so drastically that the turbine doesn't try to keep up with it and end up hurting itself instead of continue some producing power.

So the overall system has to be smart enough to - to protect itself over temperature sensors. Loss of controller, rotor speed as well as anemometer vaults when capsulate and verify that is it turbine is it with all of this type of safety measures that they're working as they're supposed to.

Here's an example of an - an actual over temperature vault that we were to capture here on our sites from one of our turbines. The turbine was rented with a - a variation load, controller voltage plan that we have here with was instrumented with a sensor that monitor the temperature on both of then it allows the turbine to have a primary cold down.

So it was continually monitoring the - the temperature because the temperature is still continuing to be above a certain threshold and smart to allow the turbine to operate until it was normal operating conditions.

And on the December 5, 2008, during the high wind event we went out there to the site and we'll make sure that the direction load temperature was -- has reached 33.27 degrees Celsius.

The had 41.2 degrees Celsius and then the temperature in the air that particular room reached 34.4 degrees c and confirming the temperature that was detected after a certain amount of time and admit it made some errors.

Air ventilation and speed of cooling system, cooling of the room when the system was able to go back on line and the turbine was able to return and operate in a normal behavior along with the center so that given that the manufacturer or that the turbine itself has to be able to inform and provide indication of hazards as well as instructions of one client over appointed time for, what to do and how to perform inspections and that they complied with electrical codes here in the United States or in the world where around the world has to be compliance with the leader electrical codes.

That the turbine has an emergency just in the case maybe they're determine when free being a resource being between one of you can have the capabilities to engage the turbine to make it stop have the lock out tag out refrigeration such that and somebody been meaning of the turbine nobody can walk in to them to the data center or the turbine and just turn it on having some harm to somebody that's out there.

Up in the air the safety signs indicating that there's some potential hazards for either electrical shock, fire or load experience or locating parts. Interlock holds electrical cabinets that when you open a particular turbine it automatically engages the making the - the system is to prevent people from harming themselves.

And then you don't want to - you want to prevent the unauthorized change in control settings again to try to limit the capability of somebody going in and changing the parameters and destroying the turbine or maybe over producing power and bringing some of the cables to the system itself.

Then the present function of the rotor log or log you want to - you know, you want to do some type of maintenance because you want to be able to approach the turbine and from the turbine in to same operating conditions either idly or completely stopped or it could be instructions of how to approach a turbine when you want to do some - some work on it.

Continuing on the same theme instruction from a better description of the - of what we look for and with that menu has well instructions of the cover that removal or reign solution of the cover operation maintenance activities indication of the turbine menu schedule.

And that if there's maintenance that has to be performed by either the owner or somebody that's trained personnel to have an understanding of how disengage the turbine from the grid if there's an emergency and stopping, how to stop a secure rotor, stop and secure the yah system.

If it's a free flowing machine how to approach the turbine or how to maybe have a lock in pin for that really locks the - the yah for the mechanism of the turbine and also indicates the climbing or the ordering of the color.

Well mark climbing points that you can or that the turbine has been certified for to human climbing. There's a couple of examples of how to information. We had a turbine had a controller had instructions indicating that it should be operated at the voltage time it only be opened after you push the stop button.

This allows to completely disconnect from the grid and driven any future hazards when people actually open the cover and actually troubleshoot the part of the turbines.

They're turbine was instrumented with a wind converters came with their manual describing how to disconnect the inverters on the both the DC and the AC connections and making them accessible for maintenance without any harm.

And we found information on how to slow down the rotor and when we - when you put the turbine on pause or was a grid load, grid lost then the turbine was put into an alloying and an idling mode or allow somebody to actually approach it and do maintenance on it.

On this particular turbine there was no provision of securing the yah mechanism to say that tons of them it all depends on the manufacturers and what they say and what the detriment regarding situation that you need to do some work and some retailer doesn't have any - any yah referring logs there should be a wind spin limit such that it would allow you to approach the turbine without getting harmed or maybe getting hurt because the turbine just yah because of a gust of wind causing some - some injury to the - to the personnel.

Again, this particular turbine was equipped with a climbing mechanism that included the safety instructions of how to use it and how to maintain it. Accept again power climbing cables have to be well able and rated for what - what are their capabilities.

They if you're presenting climb with the tower by themselves or they could go in and carrying their tools and path point has to be well labeled and accessible when you're climbing the tower your on the tower or actually yourself depending on what type of that particular turbine is going to be required.

Access ways or passageways have to be accessible to ensure the evacuation of at any time. I mean there's lighting storm or anything hazardous that the person can evacuate immediately. There's an access way or there's has to be defined to allow workers to necessary some in-person that's on one of their other systems.

Stand in places kind of form some doors had to be well labeled and marked for the trip hazards. Floors and walkways have to be slippery resistant to be equipped where handrails are that's what they're intended for. And platforms have to be able to lock such to prevent people from accessing the turbine when they're not required to either.

And the personal safety that we look for is that has turbine that's well equipped and lighting protection, electrical and system, fire resistance, turbine that people are going to be exiting in either the tower when it fell, blackout kind of provisions for the converter, the rotor and other things like that has the potential of - of causing harm when a person or doing maintenance on the equipment.

Again, interlock on electrical cabinets making sure that you're going to open the main converter if you remove that cover and automatically has this first safety switch that disconnects it from the grid and prevents any type of hazards.

Continuing on emergency safety, some of the turbines are required to have a either an emergency suite, stop or roll accessible red disconnect or breaker system that could easily be the access to remove the turbine from the grid and prevent any further or hard to anybody.

And then it had to be available for major working places including tar-based control and building sometimes on the small wind turbines the only locations are at the base of the tower and the inside right next to the inverter or just the grid disconnect.

It all depends on the turbine manufacturer how they - they get their time. Again, there about personal safety there's somebody that can -- they need to evacuate or escape. There's a clear pathway that allows them to -- for them to - to leave the - the turbine safety or get to a safe spot while away of harm.

The turbine has to be all the systems turbine has to be well equipped with safety signs, stickers or any type of information that is required and after exchanging of control settings lighting and protection and prevention for emergency communications maybe you're inside of a tower and you're trapped should be some way of communicating there by there some phones or a cell phones and particular line that you need to call.

Here's another example of one of contracts of changing a control settings the turbine was equipped with the inverter but there was only one on the outside and this button only purpose was to reset the vault.

So there was no - no way or easy way to change the parameters or inverter comply with the defenders allowing a printed restrictions that nobody only outright or trained personnel can actually change the inverters that are used.

So again, here's an example that zero voltage inverter as you can see here in the yellow circle that's an emergency stop button or the full reset button. It will label has the danger label high voltage and then here's the close up of the - of indications sticker that still get high voltage and direction of how to open the enclosure that you need to disconnect the AC from AC sources from - from the system. Disconnect the turbine and the wait five minutes for the power electronics to - to have some competitors or similar electronics to be laid out to prevent any - any shocks then gives you the okay or open end closure. And then verify that there's no - no voltage present once you open the enclosure.

Again, a picture is worth a thousand words, observations. Anything that you can think or that explains that these all happen be sure to report it, that's our -- the main purpose is to just to observe and report what you see and if you think that there's any type of - of danger, then you need to express it and talk to your manufacturer. Again this has our set during, you know, that the configuration has to be frozen in the manufacturer finds that it's an omission critical to do any type of changes then it's involves all of our data and turbine doesn't have to be restarted, try to if you allow that type of modifications so it's up to you and the manufacturer to decide if it's a major modifications had it's required for the whole operation of the system.

But it's pretty much up in your hands and see what they want to do and what they want to do to move forward. But if you see something just report it and let them know that's pretty much, that wraps up my presentation. Tony?

Tony Jimenez: All right, thank you Ismael and we'll do the questions the same way we did after Jeroen's presentation. So we'll - we'll open it up at this time.

Coordinator: If you like to ask a question, please dial star 1 at this time and record your name clearly when prompted. We have no questions on the phone.

Tony Jimenez: All right, last call.

Coordinator: There are no questions.

Tony Jimenez: All right. Well, thank you everybody for attending and we have three more webinars we're going to schedule over the next six weeks or so. We'll cover the power performance, the duration and the acoustic noisy missions and so look out for -- watch out for those. And we're done.

Coordinator: Thank you for joining today's call, you may disconnect at this time.

END