POWER PERFORMANCE

April 3, 2012

Coordinator: Welcome and thank you for standing by. At this time all participants will be placed on a listen-only mode for the duration of today's call.

This call is being recorded. If anyone does have any objections you may disconnect at this time.

And I'd now like to turn the call over to Tony Jimenez. You may begin.

Tony Jiminez: Hello everybody. This is Tony Jimenez at the National Renewable Energy Lab. And this is the fourth of our five preconference webinars for the International Small Wind Association of Testers conference. It's going to be held at in Ithaca, New York April 24 through 26.So we hope you can join us there.

Our speakers today are a tag team of Arlinda Huskey and Paul Molta. Arlinda is been with NREL since 1995. Her activities include field testing of wind turbines both small and large.

She is involved in noise, power performance and load testing of wind turbines as well as duration and safety and function specifically for small wind turbines.

She's a member of the IEC Power Performance Maintenance team and Secretary of the IEC Acoustic Noise Maintenance team. Arlinda is Supervisor of the Test Projects and Partnerships which includes certification field testing.

She holds a Bachelors of Science in Mechanical Engineering from Arizona State University and a Masters of Science in Mechanical Engineering from University of Colorado, Denver.

Paul has been with us since 2011, so just a year. He is an engineer for the testing and operations and test projects in the Partnerships Group and works on certifying turbines according to IEC standards with a focus on power performance and power quality.

He holds a Bachelors of Science in Electrical and Computer Engineering from the University of Rochester and a Masters of Science in Electrical and Computer Engineering from the University of Rochester.

So with that Arlinda and Paul it's all yours.

Arlinda Huskey: Good morning. So if you can see our first slide, it's a picture of our wind site. It's a little gray but you've got several turbines and I think a couple more have been added since this picture.

And today you want a picture where we're at there's snow on the ground. So let's get started.

So what we're covering is the power performance standard. And here it is The IEC61400-12-1, the first edition. It was released in May of - in December of 2005. And this is the first version of this standard that includes an annex for small wind turbines.

So the basic objective of the standard is to provide a consistent, accurate, and reproducible methodology for power performance testing.

And the results of doing a power performance test you should get the output power of the wind turbine versus wind speed which is called the power curve, the overall efficiency of the turbine which we call CP, and an annual energy estimated Annual Energy Production of the turbine for different wind speeds. And that's what we call the AEP.

Basically what this test does is your kind of characterizing how the wind turbine will perform.

If I were to relate it to a car it would kind of be your miles per gallon estimate.

So for small wind turbines the power performance test is important because it's required for certification of small wind turbine. And the three main certification standards that we have out there right now are the IEC, the International Electric technical Commission, there's the American Wind Energy Association, the AWEA standard which follows the IEC with some modifications.

And also coming out of the OES standard is an AWEA rated power which is basically the power output at one point on the power curve at 11 meters per second.

And there's also a definition for the AWEA rated annual energy which is basically that AEP at 5 meters per second average annual wind speed.

And then there's also the British Wind Energy Association Standard. And it has similar numbers, similar definition to the OES standard.

At this point there is a revision of the IEC power performance standard in development. And its goal is to try and harmonize all the different versions of (unintelligible) power performance type methods.

And that should probably be released probably within the next year or so.

But what the AWEA and the BWEA standards are trying to do since small wind turbines are purchased by consumers the AWEA and the BWEA standards are trying to give some numbers that allow consumers to compare one wind turbine to another.

So the contents of the IEC standard, there’s a lot of information in this standard. So what you see here is mostly is the main body where you have references, and terms, and definitions, symbols and units.

And then you start with the main body which you’re talking - when you’re talking about the preparation for the power performance test, where do you locate your met power? How to determine a measurement sector? How terrain can cause some flow distortion?

And then there’s a section on the test equipment, the measurement procedure, the derived results and the reporting.

And after the main body there are several annexes that you will use in the power performance test. And we’ll cover a few of those annexes in this presentation.

But you can see that there’s, like there’s methods in Annex 4 obstacle assessments, terrain assessment, flight calibration, how to do the uncertainty?

And then Annex E is actually a really good example of how to go through the uncertainty procedures.

There's annexes for how to mount instruments. There's special annexes for the anemometers, the instruments to measure wind speed because that's a very important parameter in power performance testing. It's also the cause of the largest uncertainties in our - in the power performance test.

And then there's - the last annex is this (unintelligible) comparison of anemometers. I'll cover that when we get into the procedure a little bit more.

So I'm going to walk through how NREL does a power performance test.

The first thing we do is we'll get a request. And what we ask from our client is a little bit of information about the turbine. Sometimes it's at our site, sometimes it's away from our site.

So we want to get an idea of the terrain, what type of turbine, some of its operating characteristics, dimensions and things like that.

And then we take that information and we go to assess the test site whether it's on our site or away from our site.

We have to determine the - this measurement sector which minimizes flow distortion. And if there are flow distortions we will conduct a site calibration.

And then we go on to prepare for our test. We select our instrumentation. We consider the layout of all the instrumentation. We write a test plan. Usually this is just an agreement between us and our client and it's something that we do. It's not a requirement of the standard.

And then we go and we would install the instrument. We have instruments installed on a met tower and on the turbine. And then we have a central place that all those signals go to to our data acquisition.

And to make sure that we are making accurate measurements we will do an end to end check from the instrument point all the way down to where we're reading the values at the data acquisition system.

And then before we start collecting data we do this readiness check. We ask the client is the turbine ready to be tested?

Can we - is it - will you - because the turbine cannot be changed. The performance has to remain the same. You can't make any changes to the controller you can't change a blade in the middle of a test or anything like that.

So our client has to be sure that that turbine is set and its configuration is set and ready for testing.

And then on our side on the test institute side we make sure that our instruments are all installed, they're all checked out, our DAS is, our Data Acquisition System is working and everything is ready to go.

So then once we're assured that the turbine's ready, our data acquisition systems ready we start collecting data. And we keep to our - to the procedure in the standard which is specified in Section 7.

And we also make sure we keep the test log because if there's - if the turbine is not operating for some - for whatever reason we like go back and look in the test log to see if it was faulted. Maybe it was taken down for maintenance or maybe it was shut down for - because there's another test going on nearby. So we like to keep a test log of the events that happen around the turbine.

And then we start - once we start collecting data we like to analyze the data periodically, a weekly - by on a weekly basis, biweekly basis, by month.

And we are looking at - we're trying to find any problems that we see maybe with the turbine if the performance suddenly changes, or maybe one of our instruments has a malfunction, or maybe the anemometers - I- something like that we're looking for incidents like that through our data.

And we're also keeping track of how close we are to finishing the task when we have enough data.

And when it's - when we're when we determine that we do have enough data and we're done with the - with data collection we want to do this post test calibration of the primary anemometer, the main wind speed measurement.

But there's also a procedure in one of the annexes to compare, to look at your anemometer calibration as when you first started the test to the end of the test to see if anything changed in the anemometer.

And then last we write a test report. And we have the client review the test report and in the end we'll sign it.

So we're going to go a little bit more in depth into each of these sections.

So the first part is about that test site assessment. And I'm going to hand it off to Paul here.

Paul Molta: Good morning. So in the site assessment we're trying to determine the best location to place the wind turbine and what obstacles and what disturbances and how that can affect and how it does affect the test.

So the site assessment ultimately determines the valid sector for data collection. And so at our site this comes - this is usually the Western direction because we have dominant winds that come from the West.

And the site assessment is done to determine the best location so that the flow distortion between the met tower and the wind power is minimized.

And the standard has fairly rigorous site assessment procedures and requirements. And this is done in order to avoid a site calibration which can be both costly in terms of money and also in terms of time to complete the site calibration.

So there are three aspects to a site assessment. And they're covered by Annex A, B and C.

Annex A is the assessment of the obstacles at the test site. And this includes buildings, met towers, other turbines whether they be operating or parked, and the test turbine itself.

Annex B covers the terrain. And so this looks at the elevation whether or not there are ridges, or creeks, or what have you in terms of natural objects that will distort the wind flow.

And Annex C is the site calibration procedure if Annex B determines that the terrain influences the flow of wind above an appropriate threshold.

So let's start with Annex A. So the assessment of the obstacles we look at how the met tower, through the placement of the met tower with relation to the test turbine.

And so this distance, the standard requires that this distance be between two and four rotor diameters. And it's recommended to be at 2-1/2 rotor diameters. And this distance is called L.

The other obstacles are neighboring turbines - there can be neighboring turbines. And they can either be as I mentioned parked in which case they are considered regular obstacles or if they're operating then the wake distortion also needs to be taken into consideration.

And if the neighboring turbines are larger than the turbine under test then that rotor diameter becomes the other variable D.

And so we have these three equations that determine the exclusion zones and whether or not these obstacles affect the flow of wind by more than 1% at the hub height. And if they do then we need to calculate the - this disturbance angle.

And this calculation - these calculations need to occur on all obstacles that are within a sector of L over D up to 20.

So when we approach Annex A we have a detailed layout of all the obstacles at the site. And so this includes all met towers, all wind turbines that are up right now in all buildings.

And so we go out with a GPS and we tag the location of everything and place it. And we also need to take into consideration the orientation.

So we have the distance of each object to the wind turbine and to the met tower. We have they're bearing towards these two objects and the width and height of the obstacles.

And so the shed we have shed number two. We see that it's orientation, the access of orientation is important because it helps - it determines the effective width that is seen by the met tower and the wind turbine.

So we populate a table with all these values. And so in this example we're going to be testing the one, the name future small wind turbine, the fourth one down. And then it's met tower.

And so we see - we label everything in terms of turbine, met tower building. And then this helps - this determines basically the porosity of the building whether or not it is a solid object that will influence the flow significantly or if it's a fairly porous object such as a met tower which has very little influence on the flow.

And then we have the hub height or the height of the building or object, the diameter and - or width of the building.

And then the last column is the affective height. And then this value can be influenced. Its most notable for neighboring wind turbines that are operating. And so they have a larger affective height because of the wake effect.

And so here this example that we'll be going through and revisiting is a turbine of 18.3 meters in height with a diameter of 6.7 meters.

So the three values based on the first I guess two equations that we see and annex A that obstacles must pass is first of all the spacing, so all objects must be greater than two rotor diameters away from the wind turbine.

Then we calculate the free stream effect. And so this is whether or not that object based on its porosity affects the flow of wind by greater than 1%.

And if it does disturb the flow by greater than 1% we then have this wake angle. And so this is seen as, I'll just call it Alpha seen A to B.

And this value is then used with respect to the (ESNTH). And you take the (ESNTH) and you split the Alpha degree in half and you apply that on each side of the (ESNTH).

So with a 34 you split that and you apply half of that to 20, so plus minus 20 you have then an excluded angle of 3 degrees to 37 degrees with respect to due North.

This same analysis is then performed with respect to the met tower because it is as important that the met tower have undisturbed wind than it is for the wind turbine to have clean wind because that's how are characterizing.

And so here we see the same thing, A1, A2A and A2B. And we have these alpha degrees. And so we have sets of excluded angles for both the met tower and the wind turbine.

And so we then take these values and they can overlap, and we combine them into a total excluded angle sector.

And so here we see it goes basically from 3 degrees to 84 degrees. And then there's the jump from 84 degrees to 93 degrees. And then again excluded from excluded from 93 degrees to 195 degrees.

And so this small sector in between from 84 degrees to 93 degrees as we'll see later, it is up to the test center to determine whether or not they want to use that in data collection or if they just want to cover it up and then just call the excluded angle from 3 degrees to 195 degrees.

But there is according to the thresholds of the standard that sector is valid.

So from the initial, from Annex A we then get a measurement sector. And so here we see the influence of small wind turbine two and three on the met tower and the turbine under test.

And we see that wind turbine number four it's further away but it also has an important influence perhaps because it has a larger rotor diameter.

And we also see that there is an area Southeast that is excluded. And that is because the wind turbine under test influences the readings of they met tower. And so that area is excluded even though the wind turbine itself will get undisturbed wind flow.

And so we see this small sliver from 84 degrees to 93 degrees which is fairly perpendicular to both of those, the met tower and the turbine. So that can be used but it could - it's also up to the discretion of the testing.

So Annex B is an assessment of the terrain. And the - there are a couple different sectors under that one considers. And this is based on the distance L which is the distance from the met tower to the turbine.

And so we have from the turbine location to 2L, from 2L to 4L and from 4L to 8L.

And we look at the terrain both within this, within the valid sector and outside the measurement sector.

So each sector has different requirements and thresholds for the variation of the terrain. And the variation of the terrain increases as the distance from the wind turbine increases.

So within the immediate surroundings of the turbine, within 2L and even within two to 4L you have a maximum slope variation of 3% and 5% respectively.

And as we increase in distance that threshold goes up to 10% both from outside and inside the measurement sector.

So then to perform this we gather - we use elevation data. We pull our information from USGS on their Web site or if you have local records of the elevation data then you overlay that and you use that to fit the best plane to determine the maximum variation and compare those values in maximum variation to each of those points to the values in this table.

And you see does it - does the slope fall within 3%? And if so then this - then the 2L sector is okay and so forth.

And what is important and actually quite critical is that the granularity of the elevation data must scale with the rotor diameter dimensions.

So you cannot use elevation data with a granularity of 30 meters when testing a wind turbine with a rotor diameter of 3 meters.

You may when you run the analysis you may get - you may see that it passes and that everything looks good but you're actually getting inaccurate results and you could actually be failing.

So when dealing with small wind turbines it's critical that you have elevation data of the same order of magnitude.

So as the result of the analysis in Annex B we get a comprehensive analysis of the terrain. And we see this is both for the wind turbine and for the met tower.

And we see that there are variations in the terrain for example the max variation is .6 meters. So that indicates that the wind test site is - our facility is a fairly flat area. And so that everything falls within the allowed variation.

And so by doing this fairly rigorous process it helps to eliminate the need for a site calibration because we have with high confidence we know that the site, the location is subject to undisturbed wind flow.

Then we get this final valid sector and so we have a realistic understanding of both the site, the obstacles, and the wind conditions as they change with the terrain.

However this only characterizes the site in one static timeframe. But it provides a baseline for changes.

For example if a neighboring wind turbine starts to operate we can then change the analysis or revisit the analysis to then treat that turbine as a weight disturbing object instead of a single object. So that would change its effective height.

Additionally if a building is put up or if a new one is removed we can then revisit this measurement sector and alter it, you know, make it larger or smaller -- what have you.

So if the Annex B if anything fails in Annex B then a site calibration needs to be done. And then this is detailed in Annex C.

There are two methods to approach the site calibration. The first one is a physical site calibration. And as mentioned it is both costly in terms of time and in resources.

A second - or a new met tower needs to be put up at the location of the test turbine of appropriate height so that the instrumentation is at hub height.

Using this met tower we then gathered 10 minute data of wind speed, mean, standard deviation, max and min. And this data is organized in- in bins of 10 degrees.

However if the flow distortion in those bins is greater than 2% then we need to make it even smaller and have 5 degree sectors.

The site calibration then needs to be completed 24 hours of data per bin of degree, needs to be collected with six hours of that above 8 meters per second and six hours below 8 meters per second.

On that data we then perform an uncertainty analysis. And this falls under two categories. A is determined from the standard deviation of the ratio of wind speeds. And B is due to the operational characteristics of the anemometers.

However category B is often neglected because the standard also requires that the anemometer used in the site calibration procedure be the same make and model as the anemometer that is on the permanent met tower.

So we have a correlation between these two kinds - between the two anemometers used.

And lastly a flow model can be used if the values in Annex B are within 50% of the limits.

And so what the site calibration does is it's required because there is not enough confidence in the wind speed at the turbine hub height.

So we need to do a site calibration to come up with this flow correction factor so that there is a high level of confidence that the wind that we are seeing at the turbine location is or can be correlated to the wind that is measured at the met tower.

And so this shows a brief I guess diagram of what goes into the calibration and how it then affects the power curves.

Arlinda Huskey: So once you've assessed the site and you've gotten your measurement sector and you've made sure that your terrain meets or, meets the requirement - the criteria for terrain or after you've done a site calibration, then you're ready to go on to do data collection for the power performance test.

And for the power performance test, the instruments that you've got for the test include met power instruments including a primary anemometer. And there are strict requirements for what type of anemometer you can use.

It should be a Class I. And that is described in Annex I.

You also have a reference anemometer. The reference anemometer is kind of a watchdog of the primary.

So you're looking - it'll help you identify icing events or make sure that the primary anemometer is working.

It is also used when you do your institute comparison of anemometers at the end of your test to see if your primary anemometer maintained its calibration.

You also have a wind vane to determine the wind direction. So you know that when your winds were in your measurement sector or out of your measurement sector.

You have - you're measuring air pressure and temperature because you need to get the density during your test. And then you have a data acquisition system to collect all that data.

And you also have instruments at the turbine. You have a power transducer to get turbine output power.

You've got - if you have a signal for turbine status whether it's operating, or faulted, or high wind, shutdown -- things like that. If you have that sort of signal you would also take those measurements. But if not for small turbines sometimes you don't have that signal. You only record it if it's available.

Also you have a turbine online signal whether it's putting power into the grid or into the batteries because you're also - you can also characterize a power curve when you're looking at cut out (unintelligible) and things like that.

And for small turbines you also want to get a measurement of the voltage at the connection to the load because there are requirements for staying within certain limits.

And especially for battery charging turbines you've got to adhere to some limits that are stated in Annex H of the - in the small wind turbine annex.

So here are some pictures of some instrumentation. Over on the left you've got a met tower. And you can see the primary anemometer up at the top where you're trying to minimize any flow distortion from the met tower or any other instrument.

And then you've all - on the lower level you see a wind vane on the left. And then on the right you see the reference anemometer that's kind of the watchdog of the primary anemometer.

And down at the bottom of that picture there's a junction box. And there's a pressure sensor off to one side.

And there should be a temperature sensor with a radiation shield that's just to the right on the upper part of the junction box.

The middle picture is a picture of the power transducer. And then - in its own box. And then over on the right you see a picture of CTs that will - and I don't know - I don’t see a power transducer. It’s probably connected to the power transducer in the middle picture.

So here’s a diagram taken from Annex G. Annex G has some guidance on how to mount your met instrument.

So the most important instrument in this picture is the primary anemometer which is at the top. And it’s at hub height of the wind turbine or at rotor center.

So what they’re trying to emphasize in this annex is that you are trying to minimize the flow distortion on this anemometer.

So the preferred method is to top mount this anemometer like you see in this picture.

So if sometimes there are turbines that have a taller met tower and your sometimes you want to mount your anemometer off to the side on a boom well your met tower can cause some flow distortion, some flowing or speeding up of the wind before it even reaches your anemometer.

So that’s why it’s recommended that you mount your primary anemometer by itself on top of the met tower.

And then there’s guidance between the distances, the vertical distances between the primary anemometer, and your wind vane, or any other instrumentation below that primary anemometer.

And here you can see some of the guidelines that are shown for those vertical distances.

And then there’s also guidance about when you do have instruments mounted on a horizontal boom how the vertical distance from the boom to your instrument like your reference anemometer you also don’t want to your booms to cause any distortion on to your measurement.

So Annex G this is just one recommended - this is probably the preferred method of mounting met instruments. But there are also - there’s another configuration in that annex that talks about this goalpost mounting. And then there’s other guidelines that if you do have a side mounted they’re some equations that you can estimate the type of flow distortions.

So Annex G has a lot of information about mounting of these met instruments.

So the measurements themselves what you’ve got, you’ve got a couple of criteria again. So as a minimum you’d like one hertz sampling of their data.

And you’re getting one minute from those - from the one hertz sampling you’re getting one minute data sets with statistics -- average, minimum, maximum and standard deviation of all your channels. So that would be wind speed, wind direction, power -- everything that we had listed earlier.

And you’re creating a database of all this data. And what you - what you’re trying to get to is ten minutes per half meter per second wind speed bins.

And those wind speed bins should extend from one meter per second below cut in to 14 meters per second and that’s specifically for small wind turbines.

And in total with the - with all the bins full and in total you should have at least 60 hours of data. And they think that's enough data to characterize your power curve.

And you can also collect other data. I had mentioned that you could also collect the online signal to get this database for cut out histories just so you can characterize the upper part of your power curve when it's cutting out due to high winds or such.

And for furling turbines the database should characterize the performance of the wind turbine when the turbine is furled. And that could be on the upper ends of that power curve again. It might extend your power curve beyond 14 if it's furling beyond 14 meters per second.

So you'll also have to look at the data to see if there are events where you have to reject the data. And those events can include external conditions that exceed the operating range.

For instance you could be taking measurements in winter and it gets - and you have a really cold week or a really cold day and you're below the operating range of maybe some of your instruments. And you might have to exclude that data because you're operating outside the limit of your instrumentation or the turbine. Like in high winds, if it cuts out in high winds you might exclude that data.

If the turbine is in a fault state, if there's a problem with the turbine and it shuts down for whatever reason you would also want to exclude that data. You want to make sure that your collecting data when the turbine is running in its normal operating mode.

If the turbine is manually shut down for maintenance, or maybe there's a test going on nearby, or whatever reason, you would manually shut down the turbine you would want to exclude that data.

If there's test equipment failure or degradation if you're wind vane, if the vane falls off or something like that you want to exclude that data, or if you have icing on your anemometer's, or you want to exclude data that's outside of your measurement sector, or if you had done a site calibration you want to exclude data that's outside of your calibrated sectors.

And if there are any other reasons why you would exclude data you want to clearly report why you excluded any data during the test period.

So here are - now we're going to get into how to calculate the power curve and such. Here you're calculating the density using the measured pressure and the measured temperature. And using that density you are going to normalize the data that you have collected. You will normalize your power curve.

The first normalization will be done to average site density. So over the duration of your test you'll get an average density for that test period and you will normalize your power curve to this density.

The other density that you will be normalizing your data to, your results to, is at sea level conditions.

So depending on the type of turbine you have whether it's a stall-regulated or active power, if it actively controls power you will be normalizing either the power if it's a stall-regulated turbine, if it's actively controlling power wind turbine then you will be normalizing the wind speed.

And I show you - shown on the screen is the normalization for stall-regulated turbines and how you would use the density to normalize that, the power.

So earlier we had talked about bins, half meter per second bins. So you're binning your data in these wind speed bins. And they're half meter per second bins. And they, for example if you see the one meter per second bin that will include any data where the primary wind speed is going from .75 meter per seconds to 1.25.

So the integer, the one is centered in that bin and you're - so you're averaging and collecting that data for the bin for any wind speeds that are going from .75 to 1.25.

And then you can go all the way up - and here there's an example showing up to 18 meters per second.

So within these bins you're calculating the mean for wind speed, for power, for power coefficient. And you're also counting the number of data sets that you have in your bin. And over on the right there's also some numbers for uncertainty.

So here is the equation for power coefficients. And you can see that on top of this the equation is the measure tower. And below is the theoretical power based on the wind speed, the swept area of the rotor and density.

So basically the power coefficient is the ratio of the measured power to the theoretical power. And for a wind turbine this is typically below .6.

And for the results that you're reporting you're reporting the power curve which is the power versus wind speed. And you like - you're normalizing it to sea level density and you're normalizing it to site average density.

You're going to show a power coefficient curve, the CP curve. And you're also showing wind turbulence, intensity, scatter plots, tables of - you're also going to show - you're going to show the data graphically and in tables.

So you also have tables as your power curve with uncertainty and tables of the annual energy production, the AEP.

And here's an example of a power curve. You can see there's also error bars on this data. So we're - in this case we're going from probably about .5 meters per second up to 16. So this is just your power versus wind speed. And in this case this is normalized to sea level, air density.

Here we've got the CP curve at sea level air density again. The CP is being the ratio of your measured power to your theoretical power.

And for this turbine we're looking at max just - well above 25%.

And here's your data in a table. So this is again, this is data that's normalized to sea level. And you've got your power curve data in here, your hub height versus - your power versus wind speed. You've got your CP curve data and here, CP versus wind speed, the number of data sets and your uncertainty.

And here's an example of an annual energy production table. So here you've got - you're assuming a wind speed distribution and you're applying your power curve to it.

So basically this - for this - this is a AEP curve table for a particular wind turbine. And suppose as a consumer you're looking at this table and you'll say oh at my house I get an average of 5 meters per second wind for the year. And you can estimate how much power you would expect to get from this turbine for the year.

And there's also uncertainty on estimated for these numbers. And then there's this AEP extrapolated which is there's a - using your measure data and as much data as you've got. And then AEP you're extrapolating that you've got data up to 25 meters per second. And there's - it's just a way to look at the estimation of AEP with a more complete data set.

And then the last column you're looking if there's this complete, incomplete criteria. If you're an EPA measures which is in the second column is at least 95% of that AEP extrapolated in the second to last column.

So what we've been covering is just basically the IEC standards, the procedures from the IEC standard.

There is also the AWEA standard which covers - which follows the IEC. But there are some modifications. And these are a few of the modifications.

For - and there are modifications to the small wind turbine annex and the IEC standard.

So it talks about in the IEC standard the - you're not considering the battery bank as part of the system.

For the AWEA standard the battery bank is included as part of the system. There are differences in the requirements for wire run lengths and how that - and the wire run lengths can change your results a little bit.

And then there's also this last requirement about the database shall include ten minutes of data for wind speed, 5 meters per second beyond the lowest wind speed at which power is within 95% of maximum power.

And maximum power is defined in the OES standards or in this case it says when sustained output is obtained.

So NREL does a few things to make sure that we're making quality good measurements.

First we follow the standard and we're using quality instrumentation. So there are requirements for instrumentation in the IEC standard for example, using a Class I anemometer.

There are accuracy requirements for power transducers, current transformers, pressure sensors, temperature sensors.

Where used - and for those instruments we're getting traceable calibrations by accredited laboratories.

We do very careful instrument installation making sure Annex G is met and that we're considering and thoughtful about the flow distortions on our wind speeds and such.

We do end to end checks to make sure that the values we're reading at the instrument gets all the way to the data acquisition system and that there are minimal losses or negligible losses.

We do data validity checks. As our data comes in we look at it and make sure it makes sense, that our instruments are working, the turbines performing, and that nothing - there are no - any - there are no changes in the data.

And we also do proficiency testing. So we compare with other testing organizations. We compare our analysis methods. If we have some macros some automated analysis methods that we have.

And so we try and compare our methods to other organizations out there. And I think that's it. That is the last slide. So Tony?

Tony Jiminez: Okay I guess the - do we have any - we'll open it up for questions. We don't have a very big audience so I think the easiest way would be if - I'm not sure, is there a button or somebody that somebody pushes to say they want to ask a question and then the operator can open their line?

Coordinator: I'll take care of that for you. If you would...

Tony Jiminez: Yes.

Coordinator: ...like to ask a question please press star 1. Please make sure your phone is un-muted and record your name when prompted. Again, that is star 1. And one moment please while we wait for any questions.

And once again if you'd like to ask a question please press star 1 and record your name. And one moment please. We do have a question.

(Matt Perry), your line is open. You may ask your question.

(Matt Perry): Yes what is the certificate look like that you get after you pass these tests?

Arlinda Huskey: You mean the certification?

(Matt Perry): Yes.

Arlinda Huskey: Well the certification is not just the power performance test. It's - it depends on like the IEC is a little bit more involved. But like the AWEA, the AWEA standard has requirements for power performance and other tests like duration, safety and function, noise.

And I am not familiar with the type of certificate that you get. But I also know that you get this label that kind of is like a consumer label...

(Matt Perry): Oh...

Arlinda Huskey: ...which again...

(Matt Perry): ...so this is just one aspect of all the other tests that need to be performed...

Arlinda Huskey: Correct.

(Matt Perry): ...for these turbine manufacturers.

Arlinda Huskey: It's one component for certification, yes.

(Matt Perry): So did - so I know you're NREL and everything but did you have to - I mean what kind of accreditation do you get to be able to do these tests, to perform these analyses?

Arlinda Huskey: There's a standard and it's kind of like a quality assurance standards similar to like ISO 9001. But in this case it's called 17025.

And so the - that's standard has requirements for making sure you have qualified personnel, that you have - that you're using calibrated instruments.

And they have requirements on who you calibrate with, how you report your data, how you report uncertainty, how you ensure that you're getting quality measurements. So they make - and they make sure that we do proficiency testing.

So they're trying to make sure that we are getting good data, that we're analyzing it correctly, and that we do check with other organizations that we compare well.

So it's more about quality assurance more than anything.

(Matt Perry): Now and I know you guys work with regional test labs like down in Bushland. What other labs do this besides the one in Golden?

Arlinda Huskey: Well we do have four regional test centers. There's Intertech in New York. There's Windward Engineering in Utah. There's Kansas...

Paul Molta: Colby, Kansas.

Arlinda Huskey: Can you give the other two? You're the RTC monitor so...

Paul Molta: Okay the other one is and Colby, Kansas managed by the Kansas State University. And then the Texas A&M, the one in Amarillo, Texas.

Arlinda Huskey: Did you get that?

(Matt Perry): Yes the one in Amarillo - you don't know the names of those centers do you?

Arlinda Huskey: It's Texas A&M and it's not Amarillo. It's - they used to be called AEI, the Alternative Energy Institute. Tony, do you know where they're located exactly?

Tony Jiminez: Yes, there and Canyon, Texas which is...

Arlinda Huskey: Canyon, Texas.

Tony Jiminez: ...outside of Amarillo. And it's the Alternative Energy Institute within West Texas A&M.

Arlinda Huskey: There you go.

(Matt Perry): Okay, thank you. Thank you.

Coordinator: Thank you. And at this - I'm showing no further questions.

(Matt Perry): Last question.

Coordinator: Oh sir, go ahead.

(Matt Perry): I know I'm hogging the bandwidth here but how much does it cost to run the whole series of tests?

Arlinda Huskey: For small wind turbine certification?

(Matt Perry): Yes?

Arlinda Huskey: So for small wind turbine, the testing portion for small wind turbine certification includes power performance, duration, (unintelligible) noise and safety and function.

And for our site which is definitely not cheap and we're not set up necessarily set up for commercial testing we typically estimate $180,000.

And I know there are some other testing organizations out there that provide this testing for less.

(Matt Perry): Okay.

Paul Molta: I can speak to that a little bit more. National Lab, we're a bit pricey. The so like the RTC's and some of the - and most of them are not accredited. But the AWEA standard doesn't require accredited test site.

Between the - between the testing, fees, and the certification fees it's on the order of $100,000 combined.

(Matt Perry): Now are you guys seeing that having this certification carries weight in the small wind industry?

Arlinda Huskey: You mean to be accredited? It - I think it carries more weight in the large turbine arena than it does in the small wind.

(Matt Perry): Yes, okay. I think those are my questions. Thank you very much.

Arlinda Huskey: Oh no problem. Thanks for asking.

Paul Molta: Yes.

Coordinator: Thank you. And at this time I'm showing no further questions over the phone lines.

Tony Jiminez: And let's give like last call.

Coordinator: And just a reminder, please press star 1 and record your name.

And at this time I'm showing no further questions.

Tony Jiminez: All right but that concludes our webinar. Thank you Arlinda, thank you Paul. And just a reminder that our last webinar will be at - on April 12 where Arlinda will be talking about acoustic noise testing. Hope to see you there. Thanks.

Coordinator: And this concludes today's conference. Thank you for your participation. You may now disconnect.

END