Recent Wind Technology Advances
April 16, 2014

Coordinator: Welcome and thank you all for holding. I would like to remind all parties that your lines are on a listen-only mode throughout today's presentation. Also this call is being recorded. If you have any objections please disconnect at this time.

It is now my pleasure to turn the call over to Mr. Ian Baring-Gould. Sir, you may begin.

Ian Baring-Gould: Thank you so much and thank you everybody for joining this month's webinar. And what we're doing is we're focusing primarily on kind of recent technology advances and more importantly the impact of those advances on wind energy deployment.

And so we've got a nice gathering of speakers today that are looking at how the wind turbines have changed over the last number of years and then how they are being deployed in different markets and then what those impacts are in kind of the economic deployment of these technologies.

And kind of the undertext that we'll get into is the expansion or the movement to the Class 3 turbines, which are bigger rotors on taller towers that make wind economic in places with just a few years ago we didn't think as being economically viable, but then how these technologies, the Class 3 turbines, are actually being deployed more widely in areas that are not just Class 3 but are moving the bigger rotors, taller towers into Class 2 areas which give you much better power performance even in areas that were energetic.

And this again lowers the whole cost. So without getting kind of—stealing the thunder of the people who are going to be speaking, we have three great speakers today that are taking this from three different angles.

Simon Mahan is going to speak looking kind of how these different technology changes really start to open up markets in the South, which again is an area we haven't seen development. And we're starting to see that development.

And then Aaron is going to talk more from the technology side and what are happening in the trends.

And then (Owen) is going to wrap things up looking at the potential increases that we could see based on the deployment of these technologies. So we'll get into the presentations.

Just a reminder to everybody that the Q&A is done through text, not live Q&A. So if you go up to the Q&A button on the top of your window, just tap that and you can type in a question. Some of the questions we'll answer kind of on the fly. And then the rest of them we'll wait until the end of the session so everybody will go through. And then we'll address all the questions at the end.

So without further ado, we'll move on to Simon. And so Simon joins us form the Southern Alliance of Clean Energy where he started in September of 2010 and with the SACE really focuses on the promotion of clean energy technologies with a strong focus in the wind area offshore, land based, and then the transmission, which we all know is critical, especially in the South looking at wind deployment.

And Simon specializes in these questions about policy, energy analysis, and then engaging stakeholders to inform them about the different opportunities that we have in regards to wind.

Before joining SACE, he worked in ocean conservation out of Washington, so has Beltway experience again in primarily looking at this offshore wind space and energy efficiency and then also mercury.

Simon has a bachelor's of science and political science from Missouri State University where he minored in biology and communications, so certainly has a good background to talk about this stuff. So Simon, what is happening in the South?

Simon Mahan: Thanks Ian. As Ian mentioned, I'm Simon Mahan. I'm the renewable energy manager for the Southern Alliance for Clean Energy and just want to thank everybody for the opportunity to talk to you today about what's going on down here in the South.

A quick word about the Southern Alliance for Clean Energy. We are a non-profit organization that's based in the South. Our offices are in Knoxville, Tennessee; Asheville, North Carolina; and Atlanta, Georgia. And then we have quite a few staff like myself who are based in their home offices.

And I am based here in Lafayette, Louisiana. And as Ian mentioned, my primary role and responsibility is to look over all things wind energy in the South.

So today I'm kicking off our webinar today to tell you why it's important to update information regarding wind energy technology. The technology has

advanced so much in the past several years that there are new frontiers for the wind market. And the South is definitely one of those frontiers.

So today I'll be discussing some wind power demand here in the South, supply from wind developers that are interested in developing in the region, wind resource mapping and how important the gradual evolution of the maps that have been publicly available for nearly 30 years now has changed, and then how we need to keep an eye on social acceptance and stakeholder engagement regarding some of these maps because they have been misused and they are being misused even here in the South today to try and stop additional wind energy penetration into the region.

So first and foremost we do have a good amount of wind that is being brought into the South already. These are some quotes from utilities that are either currently buying wind or very interested in buying wind energy from other parts of the country, including Illinois and Oklahoma and Kansas, places out in the Midwest that have very high wind speeds.

But generally what this is showing is that companies like TVA—the Tennessee Valley Authority—Georgia Power, Alabama Power, and then SWEPCO down here in Louisiana—these companies are really looking for a bargain. And they have been finding that bargain in wind energy.

Because the wind prices are stable, they do not fluctuate with the price of fuel because the fuel is free. So that's why companies like TVA are buying over 1500 megawatts' worth of wind. Georgia Power is in the process right now of procuring 250 megawatts of wind.

Alabama Power is purchasing right now 404 megawatts of wind. And then SWEPCO in Louisiana is collecting about 460 megawatts of wind. So we do have demand for wind energy so long as it's good quality and low cost.

Something that we're going to be seeing in the near future is additional demand for wind energy in the region. And the reason why—this graph actually comes from the Union of Concerned Scientists from a report that they published this past December called "Ripe for Retirement" where they evaluated the cost of upgrading existing coal fired power plants with new, modern emission control technology that is going to be required due to federal regulation.

And what they did was kind of unique. They looked at the cost of upgrade versus the cost of wind energy that's currently available that you could technically procure either through power purchase agreements in other regions or potentially developing it within the region.

And so what this graphic is showing is that the South has thousands and thousands of megawatts of coal fired capacity that is going to be uneconomically competitive with wind energy in the near term. So it provides a real market opportunity for the wind industry to look at the South as a potential customer for wind development either out of the region or within the region.

But I'd like to focus a bit more on in-region activities going on. This is a smattering of different logos of wind energy companies that historically and traditionally developed wind farms in other parts of the country that are actually looking quite actively here in the South.

We've got wind farm proposals that we know of that have been proposed for just about every single state in the South, which is quite a surprise even from just a couple years ago where it was not very well known that wind developers were poking around in the region.

And part of the reason why they are here is because the turbine technology has gotten significantly better. They put up anemometers to actually measure the winds and the winds are better than what had been predicted before.

And then there is this interest in the market of the region as well. So by having a free fuel integrated into the portfolio, we can help some of our utilities in the region as well. So we have an awful lot of interest from these developers to develop wind farms within the region.

So let me step back and talk about why people don't historically think about the South as a place to develop wind farms. If you look at these maps, I'm sure folks have seen these maps at some point in time in your wind energy career.

And the map in the upper left hand corner is really kind of where it all started in the late 1980s where it came out and it indicated that there was not much of a wind energy resource in the South. That map was a map created from a computer simulation which was on the right hand side. And then that map slowly started to get updated with some state based maps here and there over the years since the 1980s.

But these maps are really too low to gauge proper wind development with current technology. These wind maps are a 50-meter hub height. Today the standard tends to be 100 meters or more. It's going to be taller than that here in the South.

These maps created a system called a class system where if you had a Class 2 wind speed regime it was a marginal to poor resource. We no longer use that system. It's an old system, it's outdated. These maps relied on some very course resolution. It's very difficult to see what's going on, right down to the geographic level that wind farms are actually developed.

And generally what ended up happening was that the South ended up getting ignored. And so while some states as you can see in the lower left hand corner of Illinois, Illinois had a fairly updated map whereas the rest of the South didn't. And so we remained blank while the other states started to advance.

So these maps are bad. Don't use them any more. They're not useful for utility scale wind farms.

What are better are these updated maps which were developed in 2010 and 2013. They developed wind resources looking at 80 to 100 meter hub heights, which is better. They finally got rid of the classification system and moved more towards a meter per second wind speed, which is generally better.

But we still have a problem of course resolution. So these maps, while generally are good for basic research, they're not good for developing actual estimates of what a particular proposed wind farm would end up doing and looking like. There's a lot of different variables involved when developing wind farm and these maps just don't show it.

So what I'd like to do is kind of go through the evolution of an anti-wind farm argument that uses these older maps as justification. One primary argument that we've heard in some of our states and even in Southeastern Oklahoma is that the maps show that there isn't any wind. But the reality is that the

resolution of these maps is not great enough to really discover what's going on.

So you can see for instance in Alabama you have these huge brown blocks whereas with Illinois you have quite a bit better granularity and you can see a little bit better in Illinois. But you can hardly see anything in Alabama. And according to these older maps there's nothing in Tennessee which we know to not be true.

And the image on the right just kind of shows you what resolution means for maps. On the left hand side you have a 15 meter resolution. And on the right hand side you have a 30-meter resolution. So the lower the meter the better the resolution, the more you can see. And so in this case, there's actually a mountain that you can see quite clearly if you have better resolution.

Another variation of this argument is that oh we just need to put all the wind farms in Colorado because nobody lives out in Colorado so put all the wind farms out there. But again the maps don't show transmission capacity. And if you can't transport the electricity from the wind farms in Colorado to the folks living in Georgia, that's a problem. And the maps just don't show that.

Another variation of this argument is that oh, you should put a wind farm over by the airport. Put it away from me and by something else by the airport.

But that sort of argument ignores the fact that there are other regulations and there are other limitations to siting a wind farm. FAA regulations pretty much limit the area that wind farms can be developed. And again the maps don't show that.

And then kind of the final argument here is just that the wind turbines just will not work here. But again the maps aren't showing that the technology has advanced, which (Owen) and Aaron are going to cover here in a little bit. But generally the taller you go you get more wind energy and it's better.

So it's operating at more time and it ends up reducing the cost of the power overall. So the maps aren't showing these different nuances. And there's always a danger with these maps that if they get into the wrong hands and they are used for the wrong purposes that you can advocate against something and end up prohibiting a certain activity.

So in this case we have a sheik from Saudi Arabia who believed that the world was flat and that if you thought otherwise you need to be punished. Whereas here in the South we're starting to hear a slight chorus that the maps show we have no wind in the South but we still need to ban wind farms, which doesn't really make an awful lot of sense, but that's how the argument is going.

So we need to make sure that we're providing new updated information to stakeholders and to decision makers to make sure that they are making the best decisions possible for the wind industry and for their region. So thank you very much. If you have any questions, feel free to shoot me an e-mail and I look forward to the questions at the end here.

Ian Baring-Gould: Great thank you so much Simon. Our next speaker, Aaron Barr, is responsible for monitoring global wind turbine technology trends in support of MAKE Global Research and advisory clients. So for those not familiar, MAKE is one of the companies that does a lot of work in regards to market assessment, both here in the United States but internationally as well.

And so Aaron focuses strongly on the technology trends and pushing those trends out into the future as the company does its forward looking projections in regards to wind development. So he provides technology forecasts, economic tradeoff analysis, market assessments and due diligence on projects as part of this.

Before joining MAKE in 2013, he spent quite a few years working in GE's wind energy business in a number of leadership positions doing a number of different jobs—conceptual design, wind turbines, reliability engineering, and such. So certainly a long pedigree of work in the wind energy technology area.

Aaron holds an engineering degree from Virginia Tech and then an MBA from UNC Chapel Hill, where he's joining us from. Aaron.

Aaron Barr: Great, thank you Ian. As Ian mentioned, my name's Aaron Barr. I work with MAKE Consulting. And as a quick introduction to MAKE, we're a renewable energy consulting firm headquartered in Denmark. We have U.S. offices in Chicago, Boston, and South Carolina.

Our clients include all of the major turbine manufacturers, component suppliers, wind farm developers, state and regional governments and as well as non-profit renewable energy advocacy organizations.

So the next slide shows just a contents—I'll flip through that and get into the executive summary. But really just a high level summary of what we're going to talk about today.

The U.S. is really facing a lot of market volatility in the wind energy market. It's largely due to federal policy uncertainty as well as low growth in

electricity demand. However despite these challenges, there's a lot of opportunity in the U.S. market, a lot of the dramatic improvements in turbine technology—that we'll talk more about—and the widespread availability of good wind and good project.

These dynamics dictate that the wind manufacturers must maintain a very long term technology view as far as balancing intense cost pressures with ongoing research and development. And all that must be done in a tremendously competitive environment.

A lot of this—as we'll talk—a lot of this innovation is focused on the blades, the rotor system, and innovative controls. So just to highlight, technology has never been more important to the wind industry as wind is really quickly becoming competitive with conventional power generation without the use of subsidies. And this is even true in regions with lower wind speeds.

So the next slide shows some of the short term demand dynamics happening across the U.S. in wind. So this chart represents a number of the macro economic factors that dictate wind energy installs. So these are things like the reserve margins, some reserve margins, and where those minimum margins are represented by the green numbers on the chart. This would dictate that more power be installed in a particular region

In addition we've highlighted other things such as state renewable energy obligations. The prospect of coal retirements, water shortages, which helps to boost the case for wind energy installs, volatility in the gas pricing market, the general pricing of electricity, as well as transmission buildout and capacity.

So there's a number of converging factors here that help to dictate where wind energy is installed. And based on all this, over the next two to three years we

expect that a lot of wind, most wind will be installed in Texas, the Plains, and the Midwest. And really that's due to low reserve margins, prospects for coal retirements, newly constructed transmission capacity.

If you look to other regions of the U.S. such as the Southeast, you did hear from Simon that there's a lot of coal retirements ongoing in the Southeast. But the conflicting issues of a lower wind resource as well as very healthy reserve margins in the summer time may limit the adoption of wind in the Southeast over the next couple years.

But we think there is a strong potential for wind (third) markets within low wind speeds. That's really drive by the technology advances that we'll talk about. So in general wind has become extremely competitive with conventional power generation on a cost basis.

The chart on the left illustrates levelized costs of electricity. And what this shows is that onshore wind in the U.S. has become extremely competitive with natural gas despite historic lows in natural gas pricing.

And it's well within the range of being—in terms of grid parity in key markets within the U.S.—(unintelligible) that the new health and safety as well as environmental regulations imposed on coal and nuclear have made those technologies a lot more expensive, prohibitively expensive in some markets.

We think that technology is key to this. This is something that will continue to get better for wind whereas the prospects of fuel price escalation, and the risk associated with that will continue to increase the cost of natural gas and coal over the long term.

In terms of the technology trends, one thing is very clear, turbine technology continues to evolve at a very rapid, almost frenetic pace. You can see the number of new product announcements that are made every year for the past four years.

It continues to increase in an intensely competitive environment, and that's good for the industry. It really helps push the technology needle. It helps make turbine manufacturers think differently about the way they do things.

Most of those new products are being introduced into Class 3 environments. So I've labeled on the right hand side of the right chart the wind speeds that correlate to each one of the IEC wind classes. By 2016 we expect that most of the turbines installed globally, the majority of them will be IEC Class 3 turbines.

That doesn't necessarily mean they're all going into low speed sites. Many turbine manufacturers are pushing these lower wind speed turbines into more aggressive wind regimes. That just is kind of a double dip into the project economics to make it more viable, something we're seeing across the globe, particularly in the U.S.

A lot of this migration is due to larger rotors and larger blades being installed on turbines. So the charts on the left show a slightly different view at the rapid rate of technology improvement. So the X-axis here is the year of introduction and the Y-axis is specific rating. That's a measure of the watts per meter squared of the turbine.

A lower specific rating generally has a larger blade and will result in a higher capacity factor of the machine. So this chart just shows that the latest turbines

are performing the best, and that's a trend we expect to continue for the next few years.

The chart on the right illustrates the impact of this technology jump. So if you look at a best in class turbine back in the 2009-2010 time frame, (unintelligible) rating was roughly 275 watts per meter squared.

Fast forward just four years, which is really not that much time, you can see that we're now pushing the envelope of 200 watts per meter squared. And this has a very positive impact on the capacity factor, building roughly a five to six percent (unintelligible) capacity factor.

So this step change over the last few years has really been a game changer for the industry. It's made a lot of low wind speed projects that were previously unviable very aggressive and competitive. And we think this is a positive move across all global regions but could particularly help these ones with low wind such as the Southeast.

So the question is how much longer can this continue? Has to be a point when technology is pushed just too far. Well we did a little sensitivity study to look at this to say if we look at the best in class turbine today, roughly 230 watts per meter squared, that's a 1.8 megawatt, 100-meter rotor.

We kind of look at the baseline capacity factor, cost position, capex—capital expenditure per megawatt. Just think about what would the next gen have to be to see a sustained improvement in levelized cost of electricity.

If we throw out 150 watt per meter squared specific rating, that's a huge blade with a very, very good capacity factor—very, very low wind speed sites. And

so that's very positive. The tradeoff is there's a lot of extra cost in making that move.

The blades are 12 meters longer. That adds a lot of weight. Longer blades increase the loads on the turbine, requires a taller tower, and all the mechanical structure inside the turbine needs to be (unintelligible).

In addition there's effects outside of the turbine, so balance of plant systems have to become more expensive, the loads between turbines need to become longer, electrical collection systems, etcetera. So we think this is achievable to a certain degree, but there will become some kind of (unintelligible) returns where reduced specific ratings just aren't beneficial any more from a cost (unintelligible).

But the trend is clearly there. We think ratings will continue to go down, capacity factors will continue to go up, and that's all great news for low wind speed areas such as the Southeast.

Another key trend that we see happening globally is the turbine megawatt ratings are continuing (unintelligible). (Unintelligible) the (unintelligible) ratings have been largely on average been less than two megawatts where in Europe they use much larger turbines. We see that dynamic starting to change as well.

Globally we expect turbines less than 1.5 megawatts will essentially be extinct. Economies of scale of having a larger turbine really become apparent globally. The 1.5 to 2 megawatt range will really continue to have a strong market in India, China, and the U.S. where there's very few land constraints and very large wind farms can be built.

But the mainstream segment of turbine technology will between 2 and 2.5 megawatt machines. And this will really represent the majority of (unintelligible) except for the ones really operating in China and to a lesser extent, the U.S.

Much larger turbines will also continue to develop, largely for the European and the offshore markets. But this is a dynamic we see shifting very quickly over the next three to four years.

The name plate ratings are increasing but rotor diameters are also increasing at an even more dramatic pace. So similar to the name plate ratings, we expect that blades that are less than 40 meters in diameter will become largely extinct over the next few years whereas the 50-meter segment or 45 to 50 meter blades will become really the global mainstream.

Many of those very long blades are being deployed in the U.S. right now, and that's essentially all of what's being deployed in a larger—often in places like India and China where smaller turbines have largely been (unintelligible).

One dynamic that we see happening because of the intensely competitive environment, huge focus on cost is these larger blades, many turbine manufacturers have found a way to do these larger blades without the use of carbon.

While carbon penetration has increased over the last few years as a number of key manufacturers have adopted the use of carbon for their very long blade platforms or their low wind speed platforms, many of those same OEMs—turbine manufacturers—have moved away from carbon after trying it for a little while.

A number of reasons for that, but cost is the primary reason. Carbon fiber is a very expensive material and there have been a lot of advancements in glass fiber technology and manufacturing processes that make it very cost effective to make a very long blade (unintelligible).

And finally the taller towers really are needed globally for lower wind speed sites, particularly those sites with forested terrain or high shear factors. But this has been a slowly evolving dynamic over the last few years because the taller towers generally come with a price.

In many markets the additional energy captured at a larger hub height isn't paid for by the increase in power cost. However there are a lot of really interesting technology advancements rolling into the market lately that should help solve this problem.

So the chart here shows this kind of losing battle that taller towers face in terms of cost, in terms of dollars per meter. But as you go up in height from 70 to 120 meters in steel, you're facing this uphill battle of each meter costs more and more and more.

That's largely driven by the material cost of the steel. However there's a few new turbines that are being introduced by major turbine manufacturers including GE, Siemens, (unintelligible), that are trying to approach power manufacturer with a lower cost material base.

The early prototypes indicate a much higher field assembly labor. (Unintelligible) time to manufacture these advanced towers. But this is something that can be optimized, can be leaned out over the next few years.

And we expect that to happen rapidly where, you know, 120 to 140 meter towers become very cost effective with these advanced turbines. We think this is one of the most promising areas of the turbine industry in terms of technology, and could really unlock some very big markets, particularly areas with lower wind speeds.

That's all I had. I look forward to hearing your questions at the end of the conversation. And I'll turn it back over to Ian.

Ian Baring-Gould: Great. Thank you so much Aaron.

Our last speaker, Joseph Owen Roberts, is an employee here at NREL. But he graduated with an MSNE from Western Polytech in '07, and then went from there into the wind turbine industry—primarily working for Wind Farm Construction and Deployment Company as an EPC contractor.

So lots of experience or a couple of years' experience working kind of boots on the ground, putting up wind turbines both domestically and internationally before coming here to NREL in '07—sorry, '09 where his work really has focused in three primary areas—the hybrid power system implementation, optimization and modeling, doing a fair amount of work with doing feasibility assistance studies for federal and international clients, and then also spending a fair amount of time working on construction, cost modeling and optimization.

How do we reduce some of the costs out of the construction as Aaron was just talking about looking at foundations and towers? So a lot of his work, just to highlight a little bit—a lot of his work is doing these feasibility studies for the federal clients covers a whole range of kind of alphabet soup that is the federal system Department of Defense, state, EPA, DOI.

And then he's done a lot of work internationally as well in support of project deployment overseas. And Owen is going to talk primarily about the analysis that he's been working on that really looks at what are the implications nationwide and specifically in areas like the southeast for the deployment of class three turbines. So Owen?

Joseph Owen Roberts: Thanks Ian.

Wow, basically Simon and Aaron have answered a lot of these questions already.

As Aaron kind of indicated, you know, five—last five to ten years have changed dramatically in terms of the technology and the performance of these machines. But I wanted to talk specifically about the southeast because there's so little conceived potential for wind down there, whereas we think that there could be a fairly robust market for various reasons.

I'm going to show these two plots. And basically what they're showing on the left is assuming only the capital cost and capacity factor differences between say a 2002 to 2003 wind turbine versus a 2012 to '13 turbine. You can see that the levelized cost of energy for one—let's say it's the upper end of an IEC class three machine at around eight meters a second.

You see basically very little difference in the cost of those machines, or the levelized cost. However if you look at lower wind resource areas, say at six meters per second, there's a very significant cost reduction. So that means that the technology's sensitivity to the wind resource is actually decreased.

If you look at the right hand graph, that's kind of a further illustration. But it just varies operations and maintenance cost, availability and financing, which have also been improvements in the past ten years.

Some of the advantages in the southeast are the electrical and transportation infrastructure. There's a lot more electrical infrastructure due to the demand of energy in the south. But the availability of that transmission may arguably be higher to build wind projects.

And that coupled with potentially available land may be a huge advantage in the sense that some of these areas that may have higher wind resources may have fewer people that are opposed to it as well as constructability advantages.

Obviously electrical demand is supposed to increase fairly dramatically in the southeast by 2040. And again the proximity to the load centers just for these generation—well for wind generation—is a huge advantage.

One of the trends that we're seeing right now is that the transmission availability is really curtailed, simply due to the fact that windy areas in the United States are towards the middle of the country. The issue is that there are two separate grids—well there's technically three separate grids in the United States.

But there's an eastern grid and a western grid, and so they are very weakly intertied in the middle of the United States where the wind is the strongest. So you have very weak pieces of transmission that go out into states like Kansas or Oklahoma or North Dakota or even eastern Colorado. So there's, you know, that impedes the ability for us to utilize those big pieces as well—to use those resources as resource areas in the United States.

But basically my approach for connecting this kind of back of the envelope study was we had a very large data set from AWS Truepower at a 200 meter resolution. This was organized into 20 kilometer cells.

Then we ended up assuming, you know, the kind of the best in class turbines, the GE1.6 100s all the way up to some larger rudder diameter machines like the Nordex 117 which has 117 meter rudder diameter. The rest of the assumptions are there if you're super interested.

But the illustration that's most—the largest takeaway are the next two slides. Basically this slide shows, you know, the wind belt in the US. Here are the windy areas. You know you see the Midwest, you see the central US and Texas, eastern Colorado all the way up into Wyoming, etc.

These are using the past testaments that NREL has used. If you see the capacity curves that Simon was showing earlier, and it's basically a plot that has a red and a black line on it that shows the amount of potential within the states at 80 and 100 meters above ground level.

This plot on this slide actually shows the growth capacity factor of 30% or the assumed turbine—the same turbine that was used to create the plots on the Wind Power in America or now Wind Exchange web site that created those curves. So here's, you know, the windy area.

The next slide—this shows the amount of area that is now developable with the same assumptions—with the only variable being assuming a modern, you know, high specific or low specific rating turbine—so a G1.6 100 at the same hub height as the previous turbine.

So that's about a 50% increase over the previous estimate in terms of gross area that's developable. And this already excludes, you know, bodies of water, like half of forested areas. It also excludes populated areas, you know, extreme—well habitat for wildlife, things like this.

So we can see spots in Louisiana and Arkansas, western Tennessee and chunks around Tennessee, Georgia and Alabama. So this kind of gets back to what Aaron was saying about the resolution of these maps.

If we zoom in on the southeast specifically, this assumes or this is showing a gross capacity factor of 35% for the G1.6 100 at 80 meter hub height. If you look at the scale on—or the legend on the maps on the lower left hand corner, the trick here is that you see these different shadings.

This is developable area at that gross capacity factor number within a 20 by 20 kilometer cell. So anything greater than 300 square kilometers within, you know, a 400 square kilometer cell roughly means that you could put a whole bunch of wind turbines, you know, in a very large area, and you would have, you know, an average capacity factor of greater than 35%.

What it's not showing very well is that these blue areas say in central Tennessee or even western North Carolina, is that you may only have, you know, say one to 50 square kilometers. So that's where we see these ridge line developments—those potentials coming in.

Some of the areas you see 50 to 100, and the same can be said for those is that maybe they're a little bit more complex terrain. But soon we'll see the totals for different states. And that will be a little eye opening.

Now we start to vary, you know, the cutoff for gross capacity factor. But we also start to change the hub height. So things get really interesting now with almost all of Louisiana having a gross capacity factor of 30% or greater. But we are assuming 110 meter hub height.

So there are some costs associated with the installation as well as the towers for turbines such as on this scale. But the takeaway here is that it's very sensitive. If we go back to the last slide, same turbine only on a 30 meter to shorter tower—if we look at the same areas obviously with a 30 meter taller tower, we get some very interesting results.

One caveat there is that the gross capacity factor value was decreased by 5%. So all of the technology is very sensitive to what threshold you draw. And so that is what developers will look at in terms of how tall of a tower they need or what capacity factor that they need to make a project cost competitive in this region.

Here's another way to slice and dice it. There's 35% gross capacity factor at 110 meter hub height. You can see the Mississippi River valley become a very hot area as well as central Tennessee and pockets even in Florida and in South Carolina.

A lot of the developers that we know are in this area are prospecting in some of these very blue—dark blue spots. So we have some confidence in the wind data. But again it's, you know, once you start looking above 80 meters, the uncertainty really grows because the number of measurements at those levels is very few.

You know once we get to 40 meter or 40% gross capacity factor, we end up seeing, you know, the performance tailing off or the amount of developable

area decreasing. But again that's just an illustration of the sensitivity of all this to, you know, turbine pricing or turbine technology development.

This is really the takeaway. Basically we're in—the whole analysis again for the southeast assuming a Nordex 117 meter rudder diameter 2.4 megawatt machine at 140 meter hub height. The reason that we were bumping up the hub height so high is that a lot of the areas in the southeast have very high shear.

And that shear is just how wind speed changes as the height over the ground changes. Essentially if you have very high wind shear, it may not feel very windy at the ground level, but it may be very windy the higher up you go.

So essentially what we end up with is, you know, lots of gigawatts of potential—Louisiana being one of the largest. But some states like Mississippi and Tennessee having, you know, over 20 gigawatts of potential. You know all the rest of the states like Alabama and Georgia actually have projects that are being prospected and being pursued.

But again the fraction of projects that are actually going in in places is always much lower than the overall potential. I mean it's just like you see in Colorado. If you look at the total or any central state—if you look at the total potential for the state, it's a very small fraction that even gets developed even for an example Texas.

So the takeaway there is that the potential is there. We're waiting for the technology in both tower construction as well as turbine pricing and turbine—basically larger rotors to get to the point where things will become economic in the south.

And a couple of notes on barriers—there is an FAA height restriction to—there's the predetermined permitting process for turbines that are less than 500 feet tall or structures that are less than 500 feet tall. The trick is that right now, all the tower—the turbine manufacturers are putting their blade tips at 500 feet and adjusting their tower height to match that.

Basically you can't increase the rudder diameter any more without making the tower shorter at this point until there's a clear path for—with the FAA—to permit towers taller than 500 feet in the United States. And obviously local communities are not accustomed to wind development.

We've already seen projects that have been killed because of local lack of understanding and lack of outreach on our part—on everyone's part. So the next steps—we will be releasing maps similar to what we've presented her today on the NREL web site. And then we all just have to agree upon what technology we're going to assume.

So Ian, back to you.

Ian Baring-Gould: Great. Thank you so much Owen for that presentation.

So we have a number of minutes here to jump back into questions. So again if you have a question go up to the top of your screen, hit the Q&A and type in your questions.

We've got a number of them here. The first one primarily towards Simon, but feel—anybody else, feel free. And this is from (Ella Hammer). RE maps—now we know which maps not to use. Thank you Simon.

What are the best maps to use and where would one go to get those maps? And that includes wind resource, but also trying to get at expansion, transmission and regulation and things of that nature.

Simon Mahan: Sure. Great question. There's a lot of different variables that go into how you define what a best map is. The maps available through DOE and NREL right now are useful for figuring out what the wind speeds are. But if you'd like kind of a more comprehensive map, I'd recommend going to the Eastern Interconnection State's Planning Council.

They have a map called the Easy Mapping Tool that's hosted by Argon National Lab. And they try to integrate a bunch of these issues together. The problem is with each different layer that you add into these mapping techniques adds a layer of uncertainty and complexity that may or may not reflect reality.

So one of the things that is frequently done is a certain amount of land is removed from calculations based on say forested land. But in the south where an awful lot of forested land is actually commercial forest where you're farming for forests, those lands could actually be used.

You could instead of planting trees for pulp and paper purposes, you could plant wind farms. So there are some limitations to it. There are some dangers to it. But that's probably a better mapping resource than have some of these other considerations.

Ian Baring-Gould: Great. Anybody else want to chime in?

Okay. A question potentially—probably for Aaron here—from S. McCloud. Some research shows greater impacts occur with lower cut in wind speeds as

in greater energy capture. Do the latest class three turbines incorporate any features to help reduce bird mortality at lower cut in speeds?

And it's probably bat mortality because that's where we see—at least the research is starting show that we get more bat fatalities at low cut in wind speeds, not bird mortality.

Aaron Barr: Yes, that's a great question and I'm happy to field that. There has been a lot of research ongoing at the low cut in—the cut in wind speed behavior and the entitlement in terms of energy available at lower wind speeds.

But of course lower wind speeds have lower energy contained within them. However they do happen a much larger percentage of the time than high wind speeds. So there is a lot of ability that turbine manufacturers are looking at on how their cut in behavior works.

This is a very detailed controlled question. But it's safe to say there is a lot of work going on into the orientation of the blades around cut in so that the turbine can come online and start making power as soon as possible (unintelligible).

A great follow on question about bird and bat mortality—and it's also something that made me (unintelligible). There has been a lot of research, particularly in ridge line sites such as West Virginia where bat mortality has become a big issue.

And the turbines deployed at those sites have been retrofitted with an upgrade that monitors bat activity, time of day, and actually shuts the turbine down or increases the cut in wind speed during the right time of day. And that's been shown to dramatically reduce the number of bats that have been killed.

I think it's safe to say that this type of research is very, very hot. It's ongoing and it will continue to get better over time, to both increase energy capture at low wind speeds and reduce the environmental impacts to birds and bats.

Ian Baring-Gould: Great. Thank you Aaron.

Another question, probably for you—how are larger turbine generator capacities as well as turbine blades expected to impact O&M costs?

Aaron Barr: That's a great question also. Going to larger megawatt ratings on a turbine level has a lot of positive impacts, many of those being—sorry about the phone ring there. Going to larger megawatt ratings has a lot of economy's scale impacts.

Some of those happen in terms of capital costs, so having lower total costs of foundations, lower total costs of roads and electrical collection systems. But there's also economies that scale on the O&M costs, so the operating costs.

Basically you have less turbines to climb on a periodic basis. These turbines generally need routine maintenance every six to twelve months or so. If you've got less turbines to climb, you need less technicians. And then for unplanned maintenance—sorry about that, my phone is really blowing up here.

For unplanned maintenance—so this is major capital repairs and replacements—you have less turbines that are probable to fail. So that in general will reduce your overall costs even though the cost of a replacement could be significantly higher for a larger turbine—say a larger gear box or a taller tower.

But it's safe to say there are certainly economies that scale on O&M.

Ian Baring-Gould: Right. Thank you.

A question for Simon—what about electricity prices in the southeast? Can a developer secure a higher priced PPA than in other areas?

Simon Mahan: Well it depends—that gets down to a level that is—that has to be figured out between the wind farm developer and then the specific utility that they're talking to. We do have some utilities that have higher rates than others.

In Alabama for instance electric rates tend to be a bit higher than in some of the surrounding states in the south. And that's why a bunch of developers are particularly interested in Alabama because the rates are higher.

One other thing though to mention is that not all wind farms produce wind power at the same time of day. So a wind farm that might be developed on a ridge top might produce wind energy at a different time than one say in a coastal zone.

So a coastal zone one would more likely generate wind on a peak generation capacity which is very valuable to a utility. So in that case the utility would expect to pay a higher price because they're getting a better energy resource.

Ian Baring-Gould: Great. Thank you.

A question from (Dwight)—hi (Dwight), good to see you here. And this might be most applicable to Owen. What tools are prospectors using to assess wind potential that are feasible for presentations to investors?

Simon Mahan: Yes. This is a really good question. The trick is that nobody is putting up 100 and, you know, 40 meter met towers quite yet. I mean even at the 80 meter level the cost of the met towers is very expensive.

So when you go to an investor, they need to understand the uncertainty associated with your measurements. There's a lot of remote sensing devices now. So basically some fancy boxes that you sit on the ground which emit sound and light, and they bounce off particles in the atmosphere.

And they can measure the back scatter radiation pretty accurately to determine the wind speeds at much greater heights. So the industry has become much more—well the industry and its investors have become much more comfortable with these sorts of measurements over the past—the very recent two or three years.

And that has allowed much more certainty in terms of financing a larger wind project at taller hub heights. In terms of earlier prospecting, really we're all working off the same wind data sets at this point, either from AWS or Three Tier or others for initial prospecting.

So the maps that you saw are really just created from those data sets. And from that point it's, you know, kind of a, you know, choose your poison as to where you think transmission availability and, you know, where your PPA prices can be cost, you know, competitive.

Ian Baring-Gould: Great. Thank you.

A question for well anybody I guess. For local onsite applications, is there any feasibility for vertical wind turbine technologies in the southeast?

Simon Mahan: I think that's a different technology that we're not really talking about today. The vertical wind technologies tend to be much better for home or business application whereas the turbines that Aaron and Owen and I have been talking more about are utility scale on the order of several megawatts whereas the vertical axis turbines tend to be just a few to maybe ten or so kilowatts in size.

So two different technologies—there certainly can be a role for it. But I don't think I have more of a clear answer than that.

Ian Baring-Gould: This is Ian. I would chime in a little bit that because of the high shear as Owen mentioned in the southeast as well as the relatively low wind speeds close to the ground, it's still going to be difficult for small wind turbine technology to compete in the southeast area.

And so there are certainly vertical axis wind turbines that might be applicable. But it's going to be hard based on the low wind speed in that part of the country.

A question probably for Aaron, but maybe for Owen as well—for a larger rotor on taller towers, don't we expect or have concerns of larger sound emissions because of the increased tip speed of those blades?

Simon Mahan: Yes. I think that's a great question—something that we're monitoring very, very closely. Basically there are a lot of noise restrictions being imposed in a lot of different key markets. And that is requiring that turbine manufacturers pay close attention to the sound emissions that are coming out.

Generally tip speeds themselves are increasing due to some of the performance (unintelligible). That does generally involve a higher noise.

However there's a lot of very clever tip designs that are coming into the market now as well as other noise mitigating features that allow these higher tip speeds without putting out a lot of emissions.

So I think it's, you know, very safe to say this is something the market is watching very, very closely and responding to with a lot of research and development.

Ian Baring-Gould: Great. Thank you. While there was one other question that just disappeared and so I didn't get a chance to read it.

But that's all the questions we have. And we're about ten minutes over. So I want to quickly say thank you to all three of our speakers for great presentations. And I'm sure all of them are more than happy to discuss with you any of their findings.

The webinar will be made available electronically on our web site. It takes about a week for it to get up there. But please if you thought this was interesting, feel free to forward on the link to other colleagues who might also find it interesting.

Upcoming webinars—the one in May is focused on the Farm Bill. So that was just recently pass and so we're going to get a program to talk a little bit about changes in regard to the Farm Bill and how people can implement it.

One thing that's not on the list here but we'll be sending out information shortly is the Wind Exchange Summit simulcast that we do every year. And that will be happening on the 5th of May so look for more information about that as well as the agenda on a number of speakers that we will have there.

And then finally in At Wind Power there is going to be the first kind of formal launch of the Wind Division. And that's going to be done by (Jose Zias), the Director of the Wind Program for the Department of Energy.

And so please come to Wind Power if you can. It should be a very good event—and interesting time. And you'll get to see firsthand information about the wind vision.

But for all of those people who can't make it to Wind Power, we're planning at this point to have the webinar in June focused on the output or the kind of initial results of the wind vision to get that information to people who won't be able to attend Wind Power. But that's tentative at this point. We need to finalize that.

So finally a special thanks to the Department of Energy who funds the webinar series, and then to all of you for joining us for this last hour and a wee tad, and then finally to our three speakers again for their time and energy to this field, but also to join us today for these presentations.

If you have any questions, thoughts or ideas for future webinars that you would like to see, please don't hesitate to contact either (Brie), myself or (Suzanne) with any thoughts that you might have.

So again thank you and until next month, enjoy the spring everybody. Hopefully it will come—I'm sure it will. And we look forward to talking to you either next month or at some point in between.

Take care and have a fabulous day.

Coordinator: That does conclude today's presentation. Thank you all for joining. You may now disconnect.

END