AMBER PASSMORE: Good afternoon, and welcome to the WINDExchange webinar. My name is Amber Passmore, and I'm the Collegiate Wind Competition Manager for the Department of Energy's Wind Energy Technology Office, and I will be your moderator for today's webinar.

For WINDExchange webinars we bring together a set of speakers on topics important to wind energy technology and deployment. Our webinars are recorded and posted to the WINDExchange website one to two weeks following the live broadcast. You can find recordings, transcripts, and presentations from previously-held webinars at wind.energy.gov/windexchange, under Information Resources and then Webinars.

Today's webinar is on the Energy Department's Wind Industry Update, the 2015 Wind Technologies Market Report released by the Energy Department and Lawrence Berkeley National Laboratory. It highlights the exciting growth of U.S. wind power including the continued rapid growth in wind power installations in 2015 demonstrating market resilience and underscoring the vitality of the U.S. energy market on a global scale.

The U.S. wind power market remained strong in 2015 thanks to continued low prices, more efficient wind turbines, and fast-growing demand nationwide. The U.S. ranks second in the world for wind power capacity and remains first in the world for electricity generated from wind power.

And to help us talk about the report in a little more detail, we have Ryan Wiser and Mark Bolinger from Lawrence Berkeley National Laboratory. We will held the Q&A session during the last 15 minutes of the webinar with Mark and Ryan. Please note that you are in listen only mode and unable to speak. So please enter your questions in the Q&A box within your control bar on your screen and click Send. You are welcome to submit questions at any time during the webinar.

And additionally, if you experience technical difficulty, you can use the Q&A box to communicate with our webinar organizers.

With that – excuse me. Let's see here. Sorry about that. All right.

With that I'd like to introduce our speakers. Dr. Ryan Wiser is a Senior Scientist and Deputy Group Leader in the Electricity Markets and Policy Group at Lawrence Berkeley. Ryan leads and conducts research on the planning, design, and evaluation of renewable energy policies, on the cost benefits and market potential of renewable electricity sources, on electric grid operations and infrastructure impact, and on public acceptance and deployment barriers.

Mark Bolinger is a Research Scientist in the Electricity Markets and Policy Group at Lawrence Berkeley National Laboratory. Mark conducts research and analysis on renewable energy with a focus on costs, benefits, and market analysis, as well as renewable energy policy analysis and assistance.

Ryan and Mark together led the effort of the daily 2015 Wind Technologies Market Report, and I want to thank them both for their time and participation on this webinar, and we look forward to hearing their presentations today. So I'll go ahead and hand it over to Ryan and Mark.

RYAN WISER: Great. Thanks so much. This is Ryan Wiser here. Good afternoon all. It is a pleasure to be on the webinar today with my colleague Mark to provide what you will all discover is going to be kind of a whirlwind overview of this year's recently-published Wind Technologies Market Reports, in this case covering, I think, 49 slides over the next hour or so.

Now I imagine that most of those on the call are quite well aware of the goals and scope of the annual Wind Technologies Market Report, but to provide just a brief refresher, really the purpose of this report is to summarize key trends in the U.S. wind power market with a specific focus on the previous year, in this case 2015. Our scope principally includes land-based wind turbines over 100 kilowatts in size. And I would not that there is a separate DOE-funded report on distributed wind, and indeed a separate webinar on that particular report led by PNNL as well for those interested in the distributed wind sector.

This annual Wind Technologies Market Report published by DOE is really a team effort. Mark and I lead the charge, but we've got tons of contributors from Berkeley Lab, from the National Renewable Energy Lab, and from Exeter Associates, so I would like to start off by just thanking all of the contributors to this report as well, of course, the Department of Energy's Wind Energy Technologies Office, which has funded this report now for ten years running.

The scope of the report is pretty broad, as indicated on this next slide. We're going to be covering much of this breadth and content during the course of this presentation, though we have had to strategically cut some elements out in order to fit the presentation in the requisite amount of time. In particular, I'm going to start us off talking about installation, industry, and technology trends. We go through those sections pretty quickly. I'll then turn it over to Mark who will talk about really what is the heart of this report, performance trends, cost trends, and wind tower price trends. We're going to skip over the policy and market drivers components of the report for the interests of this webinar given time constraints. And Mark will then hand it over to me for the last couple of slides in terms of future outlook.

So starting with installation trends, and really just a quick summary of installation trends, the year 2015 was, as I'm sure most of you are well aware, a very strong year for wind additions, both globally and in the U.S. We saw 8.6 gigawatts of new wind capacity added in the U.S. market. That capacity represents roughly $14.5 billion of investment in new wind project additions. And those additions have led to a cumulative total at the end of 2015 of 74 gigawatts, now 75 gigawatts as of mid-2016, bringing that cumulative capacity up 12% from the previous year.

As a consequence of that growth, wind has represented a significant proportion of total new electric capacity additions in the U.S. market, both last year in 2015 and, historically, at least over the last decade or so. Last year, 41% of all new generating capacity additions in the U.S. did come from wind. And if you look at that longer timeframe, the lower left-hand chart, so the ten-year period of 2006 through 2015, you'll see that 31% of all electric capacity additions over that timeframe in the U.S. came from wind with thereabouts 50% in the interior region and the Great Lakes region. And somewhat lower percentages in the west, the northeast, and especially in the southeast.

As for the location of that deployment, Texas did once again lead the way with 3,615 megawatts of new wind power capacity added in the year 2015. That being said, somewhat impressively we now have 24 states that have more than 500 megawatts of capacity. Again, that's as of the end of the year 2015. And we have 12 states that are at or above ten percent of their in-state electric generation coming from wind, including most prominently Iowa, at 31%, South Dakota, at 25%, and Kansas, at 24%. So wind clearly is a significant contributor to electricity supply in a growing number of states.

In addition to that, as some indication of the development pipeline, there is a large volume of wind projects also in transmission interconnection hue. The transmission interconnection hue is a requisite part of the wind development process. It signals to the local transmission owner or operator that a wind project would like to interconnect with the local transmission system. And we found that there are 110 gigawatts of wind power capacity in these interconnection queues. Now to be clear, not all of that capacity will be built, but that is certainly a significant aggregate total in terms of wind capacity and is the second leading source of capacity in these interconnection queues after natural gas.

The location of those projects and these transmission interconnection queues is pretty diverse, as shown on this slide. But with the most significant new capacity planned for Texas, the Midwest, the southwestern power cool area, the northwest, PJM, and the mountain regions, with somewhat smaller amounts and capacity in New England, New York, California, and the southeast.

Now, as I think probably again all of you are well aware, all of the projects that I've just described in terms of the projects that have come online historical, and most of the projects in transmission interconnection queues are land-based wind projects. We have not yet seen any commercial deployment of off shore turbines in the U.S. That being said, 2016 will be the first year in which a commercial project does come to fruition, the 30 megawatt Block Island project. There’s been a lot of other reasonably good news over the last couple of weeks even in the off shore wind sector as well.

So that does it for industry trends. I guess I would now like to turn to – or installations trends. I now would like to turn to industry trends, and here the trends are just a little bit mixed. It’s first important to observe that since about 2009, the U.S. wind power market, at least in terms of turbine supply, has really consolidated among the big three OEMs, namely, GE Wind, Vestas, and Siemens. You can see that the share of those three OEMs combined has grown since 2009 on this particular slide.

And in part as a consequence of that consolidation, as it were, but also as a consequence of growing competitive pressures, both domestically and internationally, we have seen a bit of a realignment in terms of the domestic supply chain. Some of the smaller manufacturers deciding to leave the wind industry altogether.

That being said and recognizing that there has been some realignment, there are a large number of manufacturers that remain in the domestic market. All three of the big OEMs, which supply the vast majority of the U.S. market, have one or more manufacturing facilities. And we saw some growth in wind-related employment over the last year as well, increasing from 73,000 in the year 2014 to 88,000 in the year 2015.

In addition to that, some of the major components of wind turbines, in particular the towers, the blades, and the Nacelle assembly, are very well served by the domestic manufacturers and the domestic market. This slide, for example, shows the Nacelle assembly capacity over time as well as tower manufacturing capacity and blade manufacturing capacity in the U.S. market, and it compares that capability or capacity with historical wind deployment growth as well as projected growth over the next couple of years. And you can see that domestic capability, it may not all be used in any given year, that that capability to manufacture blades, manufacture towers, and assemble the cells, is pretty well in balance with demand and forecasts.

In addition to that, many of the global turbine supplier, the OEMs, have increased their profitability over the last three years. That is depicted on this particular slide.

Now to be sure the U.S. does remain a net importer of wind equipment. Notwithstanding the fact that we have strong domestic manufacturing capability for some of the largest components, we still import a large volume of components, especially the smaller components and more transportable components that are internal to the cell.

This slide provides some information over time on those components that are tracked in U.S. trade code data, and showed some variability from year to year and the import volume among those tracked components, but still significant overall import volume over time, albeit with significant variations from year to year.

Where are those imports coming from? Well, they come from a diversity of locations, but 40% of the imports in the year 2015, at least, again, among the tracked components, are coming from Asia. Thirty-eight percent from Europe, and 22% from the Americas.

Now the trade codes that underlie the data that I just presented are imprecise and not complete. That being said, those same trade codes can be used in concert with some other data sources and assumptions to estimate, at least loosely, the amount of domestic content in the U.S. market for various turbine components. And as shown on this slide, and as I indicated earlier, some of the larger items, the towers, the Nacelle assembly, the blades and hubs, are significantly supplied by domestic U.S. manufacturers. That being said, many of the components internal to the Nacelle, which are not oftentimes tracked by the trade codes, probably have domestic content of under 20% in most instances.

Let's now turn to technology trends, here focused really on turbine size. We'll then transition into Mark's portion of the presentation where he will focus on cost performance and pricing trends.

But focusing for a moment again on technology trends, and especially turbine size, it will come as no surprise to most of you that turbines have gotten larger over time. This slide, for example, shows growth in average nameplate capacity. Those are the kind of blue-shaded bars. Growth in average hub height. That is the red line as it were. And growth in average rotor diameters, which is the blue line with circular markers.

What you can also see on this slide, though, is that especially in the more recent years, over the last five, six, seven years, we've especially seen growth in rotor diameters, and greater growth in rotor diameters than in nameplate capacity or in hub heights.

Now those large rotor machines were really originally designed principally to be deployed in lower wind speed sites. But those large rotor machines are now being deployed really across all wind source classes in the U.S. and have gained significant market share over the last couple of years.

The lower left-hand chart on this slide, for example, shows trends in IEC classifications of installed turbines over time, and demonstrates, in the most recent years of 2014 and 2015, the vast majority of turbines have been Class 3 machines or Class 2/3 machines. These are basically low wind speed turbines with large rotors.

In the upper left-hand corner, on the other hand, we can see trends in specific power. Specific power is simply the ratio of the nameplate capacity of the turbine to the swept area of the rotors. And as rotors have grown at a more rapid pace than nameplate capacity, we see a concomitant drop in the specific power of turbines over time.

So, again, significant deployment in the U.S. market over the last number of years of larger rotor machines, machines originally designed for lower wind speed sites.

Now although those machines were original perhaps designed for lower wind speed sites, we find, in fact, in the U.S. that they are deployed across a wide array of regions and across a wide array of wind resource sites. There are some variations from region to region depending on wind turbulence and other factors. There are also some variations across the quality of the wind resource. But the bottom line here is that these lower specific power turbines, these lower wind speed turbines, are not being deployed in some of the highest wind speed sites in the U.S. market. And as Mark will now describe, those particular trends have had a significant recent impact on the performance of wind projects as proxied by their capacity factor.

So here I'm going to turn it over to Mark, hoping that whoever has control of the slides can transition them to Mark and he will then go through some of the performance, cost and pricing material before turning it back to me to close the webinar.

MARK BOLINGER: Okay, thanks, Ryan. I think I now have control here. So before I get going, actually, just a quick reminder for everyone to type in questions you have into the Chat Bar and send them on in so we have something to talk about after we're done presenting.

So I'm going to, as Ryan mentioned, I'm going to start off my portion talking about performance trends as measured here by capacity factor.

So here we see fleet wide or sample wide capacity factors by calendar year going back to the year 2000. Though it's a little bit hard to see here, average capacity factors have been increasing over time, though that trend is obscured somewhat by really three factors here. First, the cumulative nature of the sample on this graph with sample size increasing pretty substantially as you move to the right makes it difficult for any new trend to really emerge from the data.

Second, the green line shown here shows the inter-year variability and the strength of the wind resource, and, as you can see, as that line moves around, capacity factors seem to follow it somewhat suggesting that it is a pretty strong influence here.

And then finally the third thing is curtailment. The orange portion of each column here shows how much higher capacity factors would have been absent curtailment. So you can see that curtailment was a pretty significant problem from 2008 through 2011 or so. Since then it has moderates somewhat, which is confirmed by this next slide which shows the percentage of potential wind power that's been curtailed in the seven ISO or RTO regions where we track it.

As you can see here, curtailment was a particularly significant problem within ERCOT back in 2009 when it reached 17% of potential wind generation. But since then a massive transmission build out as part of the Competitive Rural Energy Zone process, has largely alleviated that problem.

In the other six regions, curtailment is fairly moderate on average with the possible exception of MISO where it has trended up in recent years to the five percent range.

So here's a different way of looking at capacity factors. In this case we are looking at capacity factors in a single year, 2015. And we are breaking them out along the X axis by project windage. And when you view them this way, it's much easier to see the recent trend of higher capacity factors on average as shown by the blue columns here. And that recent increase has been driven by a lot of the technological trends that Ryan described previously.

In fact, if you go to the next slide here, the blue columns shown in this graph are identical to those that you just saw in the previous graph. And here they are plotted against three drivers of the trend that are shown here, namely hub height, specific power, and also average site quality in terms of the strength of the wind resource at sites that are being built each year.

Focusing just on the most recent period from 2012 to 2014, you can see that the strong upward move in capacity factor over that period has been driven primarily by lower specific power turbines. That red line actually shows the inverse specific power, so as it increases, specific power is actually declining, and all else equal, a lower specific power will generate a higher capacity factor. So that's a primary driver.

But you can also see from the green line that after having declined for a number of years through 2011 or 2012, average site quality that's being built has picked up considerably over the past few years, and that's reflective of this very intense focus that we've seen on developing and constructing projects, primarily within the interior region of the U.S.

So this combination of building turbines with larger rotors and lower specific powers, insights that are progressively more energetic over the past few years has really combined to drive average capacity factor significantly higher by project vintage.

Okay, on the previous graph I mentioned both specific power and average site quality. And if you control for both of those drivers, as this graph does, then you get a really nice picture of how each can influence capacity factor. So regardless of which of the four wind resource bins you look at along the X axis here, you can very clearly see that as you move from projects that use turbines with high specific power to those that use turbines that have a lower specific power rating, there is a very clear upward move in capacity factor.

The same is true as you move across wind resource bins, so within any specific power bin, say, for example, the red columns here, as you move from left to right, from lower to higher wind resource bins, you can also see the capacity factor moves higher, which is probably a more obvious thing.

What's interesting here is that the impact from specific power seems to be significantly larger than the impact of moving from a lower to higher resource bin, and that's good news for those parts of the country that historically haven't been quite windy enough to support wind power to the degree that we've seen it in other regions.

Okay, for those of you who would prefer to think in geographic terms rather than in terms of the strength of the wind resource, here we show 2015 capacity factors among a sample of projects that were built in 2014 broken out by region. Not surprisingly, the interior region has the highest capacity factors on average, while the southeast and the west tend to have the lowest capacity factors. To some degree this ranking here reflects the relative uptake or adoption of some of the technology trends that we've talked about. In fact, Ryan showed a graph earlier that suggests that the west, in particular, has been a bit of a laggard in terms of adopting taller towers and larger rotors, and perhaps as a result its capacity factors here are lower than some of the other regions, like the Great Lakes, which has really been sort of at the forefront of adopting both of those – both of those technological advances.

Of course, sample size here is quite small for the five regions shown, which makes it a little bit difficult to read too much into this graph.

Okay, one new thing that we've added to the report this year is an attempt to see whether the U.S. fleet is suffering from long-term performance degradation. And this graph attempts to get at that by indexing capacity factors across the fleet based on the number of years each project has been operating, or the number of years since commercial operation. And the graph suggests that indeed performance degradation does appear to be occurring, perhaps starting somewhere in the eight-to-ten-year range, so right at the end of that ten-year PPC window, and then continuing on a little bit thereafter through year 16, which is as long as this graph runs.

All that said, I think it's really important to note here that so far we've made no attempt to weather-correct any of this data. That is, we've not made any adjustments for inter-year variability in the strength of the wind resource, which could have an impact here. At the same time, it's important to note that as you move along the X axis, we're not looking at a consistent sample of projects in each time period. So as you move to the right, more and more projects drop out because they haven't been around all that long, which means that as you get to the out years, we're really focusing here on a sample of older projects that are using first or second-generation wind turbine technology that may not be all that reflective of what's being installed today.

So the bottom line here, there are a ton of caveats with this graph, but this is something that's of interest to us, and something that we hope to look into more closely over the next year or two.

So let's move on now to talk about cost trends. Here we see wind turbine price trends in the U.S. over time. From three different sources, really. First from any individual transactions where we're able to glean relevant details. Second we've been able to kind of derive or back into global average turbine pricing for Vestas based on some of its financial reporting. And then finally we show Bloomberg New Energy Finances Global Wind Turbine Price Index as well. Fortunately all three of these sources show more or less the same pattern where wind turbine prices have largely peaked out in 2008 and since then have fallen considerably to where they stood in 2015 at a range of around $850.00 to $1,250.00 per kilowatt depending on the type of turbine in question. And typically the Class 3 turbines with the larger rotors tend to be at the upper end of that range, while the Class 1 turbines and Class 2 turbines are towards the lower end of that range.

Okay, not surprisingly we see the same pattern in installed project costs that we saw for turbine prices, though in this case with a big of a lag. So whereas turbine prices peaked in 2008, here we see installed project costs peaking a year or two later, in 2009 or 2010. And that simply reflects the normal development and construction cycle.

Since then installed project costs have fallen by more than $600.00 per kilowatt on average to roughly $1,700.00 per kilowatt or just below that in 2015.

Now these are average prices for average costs that I've been mentioning here, but you can see from the individual circle markers here that there is quite a bit of project-level variation around those averages.

And one potential driver of that variation is project size. That is, we do see economies of scale in installed project costs, particularly at the low end of the range. And that's true whether you're looking for economies of scale by project size or project capacity, which is shown in the top graph, or instead by the size of turbines that are used in projects, which is what the bottom graph shows.

It also depends on where you build your project. This graph focuses on a sample of 2015 projects. Break them out by region here. And you can see that the interior region, not surprisingly, has the lowest average installed cost, whereas the northeast region tend to be a bit higher, though, again, sample size is a pretty serious problem in three of the four regions shown here.

This is just another way to look at installed costs. These are histograms which show the distribution of costs, either by the number of megawatts, which is the graph on the left, or by number of projects, which is further to the right. Either way, most projects that were built in 2015, and really all of the low-cost projects, are located in the interior region, while the other three regions represented here, namely the northeast, Great Lakes, and the west, each had really just a few projects built in 2015, and all of those tended to be higher cost projects.

Okay, so the capacity factor trends and installed project cost trends that I just ran through really come together to influence the price at which wind developers or wind project owners are able to instill their power.

So what I want to do now is move on to wind power price trends.

As you can see here by the orange area, merchant or quasi-merchant projects have made considerable inroads over the past ten years or so and accounted for nearly 30% of all new capacity installed in 2015. But that said, long-term power purchase agreements with utilities, or increasingly with corporate offtakers, or commercial off takers, are still really the most common form of offtake arrangement. Which is good news for us because it gives us a way to track the price of wind through PPAs.

And to that end we've amassed a sample of 387 power purchase agreements totaling more than 34.5 gigawatts of wind capacity that was built from 1998 through 2015, or in some cases is planned to be built this year or next.

All of these PPAs are fully bundled in the sense that they convey all energy, capacity, and rec value to the buyer, which means that we exclude merchant plants as well as other projects that strip off the renewable energy credits or recs and sell them separately.

In all cases you should think of these prices that I'm about to show you as post-incentive pricing, given that we do assume that developers and project owners will take into account any and all state and federal incentives that are available to them when they are negotiating these PPA prices.

So with that intro, here we see levelized PPA prices across the full sample and also broken out by region. Not surprisingly, you see PPA prices following the same trend that we saw earlier for both turbine prices and installed project costs. In this case PPA prices appear to have peaked out in 2009 and since then have fallen quite a bit to the point where it's now fairly common to see a PPA sign in the interior region at a levelized price of around $20.00 per megawatt hour. And that is expressed in real 2015 dollars.

Now I want to call your attention to this 200 megawatt project in the interior region that is labeled there in the graph. It was signed in 2015. It's got the arrow pointing to it. This is a project that is located in the interior region but is selling its power into California, which tends to be a higher-priced state. And so this contract does appear to be above market, and it is for the interior region, though for California it's probably actually a pretty good price.

And I mention this simply because on the next slide which attempts to kind of smooth out the bubble graph and focus on longer-term trends. This single contract really has a pretty significant impact on our average pricing in 2015. So you can see that our 2015 sample is quite small with just six projects totaling 401 megawatts, which means that that single 200 megawatt contract makes up half of our sample and capacity terms, and therefore has really an undue influence on average pricing that year.

You can also see here by the increasingly close agreement between the nationwide average shown by the blue columns and also the interior average shown by the purple line here that our PPA price sample is increasingly dominated by projects in the U.S. interior. Now that doesn't necessarily mean that this sample is unrepresentative. As we mentioned earlier, really the vast majority of development and construction over the past few years has been focused on the interior region. So to that extent, this PPA price sample, which is also focused in that region, is largely representative of what's going on in the U.S.

That said, for those of you who live outside of the interior region, so along either of the coasts, you're probably unlikely to find wind PPA prices down around $20.00 per megawatt hour.

So this graph attempts to get at the value that wind provides by comparing the average levelized wind PPA price, shown by the blue diamonds here, to the range of wholesale power prices, both across the U.S., as shown by the blue-shaded area, and also solely within the interior region, as shown by the tan area here. And we added the interior price range this year for the first time, again an acknowledgment of the fact that our sample is increasingly dominated or located in that region so we might as well compare it to wholesale prices in that same region.

Notwithstanding the artificially-inflated PPA price in 2015 that I just described, you can see here that wind is fairly competitive against wholesale power prices despite the fact that wholesale prices are currently so low.

That said, this is a far-from-perfect comparison here, and there are quite a few caveats that we've laid out in the full report that should be taken into consideration when viewing this graph. So I would encourage you to take a look at those.

And then finally, I think this is the final graph for me, this is another one that attempts to get at wind's value, in this case by comparing PPA prices from recent PPAs and looking at how they play out over time, and comparing that to the range of fuel cost projections for burning gas in a combined single unit.

So the two red lines here show the average and median PPA price among 24 contracts that have been executed since 2014. And those are compared to this blue-shaded area here which represents the range of fuel cost projections from the latest annual energy outlook publication from the EIA.

And what you see here is that even though at present or in 2017, these wind PPAs are priced very close to what it would cost you to burn gas in an existing combined cycle unit. Over time, as you look out further in time, natural gas prices are expected to increase somewhat, and the uncertainty around those gas prices also grows quite a bit.

In contrast, the wind PPA prices, which have already been locked in, more or less just kind of drift lower in real dollar terms over time, and as they do so, they get more and more in the money, and look more and more attractive relative to where natural gas prices could potentially be.

So in this sense, wind can provide a bit of a hedge or long-term insurance against the prospect of possibly rising natural gas prices down the road.

So with that I'm going to hand it back to Ryan. I'll maintain control here, but Ryan will take us through the future outlook session.

RYAN WISER: Great. Thanks, Mark, for taking us through the – really what I think we consider to be the heart or the core elements of the wind technologies market report.

So to conclude the presentation, partly as a result of the wind economic information that Mark just described, the positive economic positioning again, but also partly as a result of the longer-term extension and phase down of the production tax credit and a variety of other demand drivers for wind, you can see on the slide the forecasts for wind deployment over the next five years are strong. Across a wide range of analyst projections from EIA to Navigant to BNEF to MAKE to others, these analysts are projecting roughly eight gigawatts per year of new wind capacity build from 2006 through the year 2020. And that would put us solidly on the path laid out in the Department of Energy's Wind Vision report that sought to analyze a scenario in which wind achieves 20% electricity production in the year 2030 and then progressively higher, up to 35%, by the year 2050.

That being said, these forecasts, as you can also see on this slide, begin to drop off after the year 2020, and show a certain amount of uncertainty in wind deployment after 2020 as well.

Next slide, Mark.

And that uncertainty and that drop off as well is, to some degree, a direct reflection of this somewhat uncertain balance between divergent trends and the wind factor. On the one hand, as Mark just identified, we are seeing very low prices for wind energy in the U.S., around two cents per kilowatt hour. Prices that are somewhat hard to beat if you can get them. There's the prospect of technology advancement that will further reduce costs potentially. There's, of course, the prospect of new EPA regulations including clean power plants. And we see a growing share of the market going towards direct retail sales of wind to corporate, business, governmental, and other purchasers.

At the same time there are a variety of head winds. Probably the most relevant one and the most significant one is the phase down of the federal production tax credit. But continued expectations of low natural gas prices, rather meek electricity demand growth expectations, in some regions state RPS policies that are largely achieved, inadequate transmission infrastructure, at least in some parts of the country, and finally growing competition from solar, all place some pressures on the wind factor as well. And it's the combination of all of these uncertain factors which makes growth outside of the next five years still quite uncertain.

So with that, the presentation is basically done. I would like to leave the audience here with two final notes, the first of which is for those of you who are masochists and would like even more information on the wind market over the last year, you could, of course, read the full report, Wind Technology Market Report, at the link identified here. That report also has not only the kind of PDF version of the whole document, it also, briefing-style slide decks that look at little bit similar to what you've just seen, as well as an underlying data file in Excel form for those of you who would like to see the data in those form as well.

Next slide.

And then, finally, I would make note of another webinar that we're going to be having next week. This webinar, of course, focused on the past, focused on the Annual Wind Technologies Market Report, the primary purpose of which is to track historical cost, performance and pricing trends, as well as industry and installation trends. But over the last week, the Lawrence Berkeley National Lab, in concert with a whole slew of other folks, has released a major new report that consists of an expert survey of 163 of the world's foremost wind experts. That work is now available, and we will be having a webinar on that work next week, September 27th, 11:00 to 12:00 Eastern time, and those of you who are interested in hearing about what the experts believe the future might look like as it relates to wind cost and performance, feel free to join us then.

And with that I will turn it back to Amber who will lead us to the Q&A I believe.

AMBER PASSMORE: Great. Thanks, Mark and Ryan. Appreciate the great insight.

We will actually go ahead and start our question and answer session, so let me go ahead and pull some questions here.

Let's see. On the slide comparing to natural gas, are these just the fuel costs or is it fuel costs plus (inaudible)?

MARK BOLINGER: Yeah, so those were just the fuel costs, so it was a natural gas price converted at a heat rate of 7,000 BTUs per kilowatt hour into a power price. So it does not include Capex. If you were to include Capex, it would increase the gas price range, it would shift it upward on the graph by, I don't know, maybe $20.00 or $30.00 per megawatt hour. And the reason that we're comparing wind to just the fuel costs of gas-fired generation is, well first of all it's the most conservative comparison you can make, and, you know, we tend to like to be conservative when we're comparing these two resources. And I guess the second reason is that in markets where new capacity is not necessarily needed, new wind generation is often competing against existing gas-fired generation, and so if you've got an existing gas-fired generator where you've already paid off your Capex expense – or, I'm sorry – already recouped your Capex expense – then really it's just the operating costs that matter. So we've proxied those operating costs by looking only at fuel costs.

AMBER PASSMORE: Great. Next question. Why has there been such a drop off in wind projects in the western region?

RYAN WISER: I guess I can take that one, Mark, and maybe you can supplement it as you wish.

I think a big feature in the western market is that the primary demand, at least on the Pacific seaboard, has come from California. California's aggressive renewable energy policies was prominently the renewable portfolio standard in the state. And over the last five years, solar PB in particular has declined in cost by dramatic amounts. And so certainly within California, and certainly within the desert southwest we've seen head-to-head competition between solar and wind, and wind does not always end up being the victor in that particular competition.

So at least as it related to the western U.S., as for California and the desert southwest, I would point to competition with solar being a primary factor.

AMBER PASSMORE: Great. And referring to the degradation graph, what is the likelihood that your eighth step is directly related to mean gearbox life? Any other possible drivers of that notable drop?

MARK BOLINGER: Yeah, that's certainly a possibility. I mean I guess I would say that we've not dealt deep enough into this issue to say one way or another what's driving it. I mean, we're simply looking at project-level capacity factors and not the underlying causes of any changes in those necessarily. So while gearbox failure is a possibility there, we are not able to definitively say one way or the other at this point.

AMBER PASSMORE: All right. Next question. As costs continue to decline and capacity factors continue to improve, what are the prospects of wind additions expanding beyond the interior region, especially with respect to the southeast?

RYAN WISER: Yeah, I guess I'll take that one.

So, you know, I think that the prospects are decent, and we are seeing some projects, in fact, get developed in the southeast where there previously had been none or few. So there definitely is some interest in the southeast region. I guess I would, again, point to solar as being a challenging aspect in the southeast, as much as it is, maybe, in California and the desert southwest, and we are getting some pretty attractive solar pricing in that region as well. And so for a utility that is trying to achieve certain environmental objectives or even cost-related objectives, solar might be a tough competitor.

And, of course, transmission is a big, open question. Some of the southeast markets can be served by wind projects that exist in higher wind resource areas, whether it's Kansas, Oklahoma, or elsewhere. And so to the extent that new transmission is built to the southeast region, some of the utilities in that region might end up preferring long-distance wind, as it were, relative to in-region wind.

So I think we are definitely seeing some trends that are moving us in the direction of some development activity in the southeast. There certainly are some heavy winds there as well.

AMBER PASSMORE: All right. What accounts for the relatively high curtailment percentage at MISO?

MARK BOLINGER: I'll comment on that one, and then maybe Ryan will have a better answer.

But, I mean clearly, one thing I think we mentioned on several occasions is the bulk of wind development and construction over the past few years has been in the interior region where MISO is located. So there's just been a ton of development, possibly more than folks expected. And it's very hard to build transmission. And I know that they've got a lot of stakeholders working on that, in that area, trying to open up some new lines that will hopefully alleviate the problem somewhat. But I think it's just a combination of heavy development and transmission not keeping pace.

AMBER PASSMORE: Okay, great. Could you comment on sensitivity to cost of capital, referring to slide 33, I believe.

MARK BOLINGER: Yeah, so I'm not sure I understand that question in relation to that particular slide. But cost of capital will definitely affect PPA prices, which, I guess, would be maybe slide 40. Or 41. And so clearly we are in a time of historically low interest rates, and at some point that period will end and interest rates will rise once again. And that could have a negative impact on PPA prices. One potentially mitigating factor is the fact that a large portion of the capital stack of most wind projects is made up of tax equity investors, or made up of tax equity. And although tax equity tends to be an expensive source of capital, it's not directly tied to interest rate movements, and so even if we do see short-term interest rates increase, that doesn't necessarily mean that we'll see the cost of capital via tax equity increasing in a proportional manner. So, you know, cost of capital is definitely important when you're talking about winds (inaudible) cost of energy or PPA prices. But it remains to be seen how things will play out as we come out of this historically low interest rate cycle.

AMBER PASSMORE: Okay, great. I have a question here I think referring to some work force questions. Not sure who might be able to answer this, but is there any – are there any online education and training recommendations from (inaudible) career professionals to transition to the wind industry or any online training leading to sought-after certifications for the industry?

RYAN WISER: Yeah, I think we probably are singularly two of the worst people to actually try to answer that question. That might be an overstatement. I don't think we have, at least within the context of our work at LBL, a very good answer to that particular question. Perhaps (inaudible) on the line do.

SUZANNE TEGEN: This is Suzanne. Do you want me to try to answer it really briefly?

AMBER PASSMORE: That would be great, Suzanne. Thanks.

SUZANNE TEGEN: So without going into a lot of detail, you can 'Google Wind Career Map', and there's a Department of Energy website for wind career map looking at different careers in wind energy. And then we also have on the WINDExchange, if you Google WINDExchange, and look at the resources there, the educational resources, we have a map of the United States with different education and training programs for all sorts of – so ranging from technicians to research to everything you can imagine in wind. So I guess I would recommend those. People can also get a hold of me. My email is up there, Suzanne Tegen, and I'm happy to help with this as well.

AMBER PASSMORE: Great. I'm not seeing any more questions in the pop up box, so I think we'll go ahead and bring our webinar to a close if no one else has any questions. And if you do have some follow-up questions, you can, of course, contact any of the contacts up on the screen.

We'd like to thank our presenters for the great information that they've been able to provide. And to thank the audience for their attention and participation today. And we looking forward to seeing your next WINDExchange webinar. We will be having a distributed wind webinar next week, next Thursday. Bethany, I'm sorry. Do you – I don't have the exact time and date up in front of me.

BETHANY STRAW: Sorry. It's next Wednesday. Ryan referenced it earlier in the presentation that there is a distributed wind industry webinar next Wednesday, the 28^{th}, at the same time as this one, 3:00 p.m. Eastern. If you have any questions regarding that or any other future webinars, feel free to email me at Bethany.Straw@nrel.gov.

AMBER PASSMORE: Great. Thank you, Bethany.

We look forward to talking to you all again soon. Have a great day.