WIND POWER ECONOMICS: PAST, PRESENT, AND FUTURE TRENDS WEBINAR

December 14, 2011

Coordinator: Welcome and thank you for standing by. At this time all painrticipants are in a listen-only mode for the duration of today's conference. If you should need assistance throughout your call today please press then 0 to reach an operator.

Today's conference is being recorded. If you have any objections you may disconnect at this time.

I would now like to turn the call over to Mr. Ian Baring-Gould, technology deployment manager for the National Renewable Energy Laboratories. Sir you may begin.

Ian Baring-Gould: Great good afternoon everybody and thank you for attending this kind of special encore performance of the Wind Powering America Webinar series. This one focused primarily on wind power economics.

And we have a great set of speakers today that certainly warrant this kind of special Webinar. It is going to be an hour and a half so we are taking a little bit more time today than we do during the normal WPA Webinars just because the material we are going to cover between Mark, Ryan and Eric is pretty expansive and very important. So thank you all for joining.

We are going to do Q&A at the end of today's session like we do normally. Everybody will notice up on the menu bar in the upper left corner there is a little Q&A.

Just if you have a question, tap that and it allows you to type the question in. If you would like to address it to a specific speaker please don't hesitate to do so but if you wanted a more general discussion we can do that.

At the end I will be moderating the Q&A and we will only be doing it through the type in submission of questions.

So without further ado let's get into the heart of the presentations and we are going to start off with a presentation from Mark.

Mark is a senior researcher at the Lawrence Berkeley National Laboratories where his work focuses primarily on analyzing cost performance and the value of renewable energy (unintelligible) within the utilities markets with very strong focus on finance, renewable energy policies.

Mark has been doing this for many years and it is a definite treat whenever we get a presentation of Mark on the current work that LB&L is undertaking. So Mark, please.

Mark Bolinger: Okay thanks Ian and good afternoon everyone on the line. As Ian mentioned we've got a three part Webinar today and it being mid-December I couldn’t help but notice the thinly veiled but I think unintentional reference in our Webinar title to Charles Dickens’, A Christmas Carol.

So sticking with that analogy for just a minute I guess I'll be serving as both the ghost of Christmas past and Christmas present as I examine trends in wind turbine prices over the past decade and what has been driving them.

Ryan will then reprise the same two roles but he'll be focusing on the levelized cost of wind energy as opposed to just the upfront cost of turbine equipment.

And then Eric will note out, shock us all to the very core as the Christmas of yet to come by revealing potential future developments in the cost of wind generation.

And as we all know, the last ghost in that story is always the most exciting. So I would encourage everyone to stick around for all three presentations if possible.

Okay holiday nonsense aside, my portion of the Webinar today is based on a report that we released in late October of this year. The title page of which, you can see on the right hand slide of the slide.

And the motivation for this report really stem from the significant swings in wind turbine prices that we've seen over the past decade.

The big story today of course is that turbine prices have fallen in the order of 20%-30% in the past few years which is certainly good news at least for turbine buyers.

But of course these prices have fallen from very elevated levels after having previously doubled from 2002-2008. And this price doubling is what really caught our attention a few years ago when we first embarked on this work because it flies in the space of standard learning curve theory.

For those of you not familiar with it, the most basic form of learning curve theory holds that for each doubling in production or installed capacity, technology costs should decline by a certain percentage.

And in the case of wind power that percentage decline has been estimated to be somewhere on the order of 10%-15%.

Now what's interesting here is that over the period from 2002-2008 global installed wind capacity actually doubled not just once but twice which would suggest a 20%-30% decline in wind project costs at least according to learning curve theory.

In reality though, turbine prices which account for roughly 2/3 of total project costs actually doubled over this period at least in the U.S. And we felt that this rather glaring discrepancy between theory and reality warranted a bit of a further investigation into other causal influences.

So I'll begin my talk by documenting empirical turbine price trends over the past decade just to establish what we are trying to measure and replicate.

Then I'll run through seven different drivers that have been implicated in varying degrees in turbine price movements over this period and I will also estimate the contribution of these drivers both individually and in aggregate to the empirically observed price trends through 2010.

And the finally I'll draw a few conclusions that will hopefully segue nicely into Ryan's presentation.

So here is our estimate of wind turbine prices in the U.S. going back to 1997 with individual transactions differentiated by the size of the turbine order.

And starting in 2005, I've also plotted implied average Vestas turbine prices as derived from Vestas data on its global order intake in each year. And I have included these implied Vestas prices which are represented here by the large black circles really just to validate our other empirical data.

It is not very often that a major OEM will come out and report what its prices have been. So it is interesting to see just how closely the Vestas implied prices actually match up with our overall empirical sample.

And once again understanding what drove this doubling in prices from the low point in late 2001 through the height of the market in 2008 is really the motivation for this study. This was a significant price swing of somewhere in the order of $750 per kilowatt.

So here are the seven different drivers that I will be looking at. The first four are somewhat endogenous in nature meaning that they are more or less within the control of the wind industry and can be influenced by technology learning.

The final three on the other hand are largely exogenous, meaning that they mostly fall outside of the direct control of the wind industry.

And before taking a closer look at each of these drivers I just want to take a minute to clarify our general approach in this report because we've had a number of people respond to this report by asking some version of the question at the top of this slide which essentially boils down to aren't turbine prices set by supply and demand rather than or in addition to the seven drivers that you examine?

So I thought I would just respond to this question right off the bat by noting that the supply and demand balance or perhaps imbalance as the case may be is certainly an important factor. But really only within a given range that is bound by a cost base floor price as well as a ceiling price that reflects the limits of what the market will bear.

And I've tried to illustrate that here stylistically. The red cost base floor price is determined by at least six of the seven drivers that we look at in this report, namely labor costs, warranty provisions, turbine scaling, commodities prices and foreign exchange rates.

The green ceiling price meanwhile is based at least in part on the PPA prices that developers are able to obtain in the market which in turn dictates how much those developers are able to spend on turbines while still having their project be profitable.

And in between these floor and ceiling prices is really the range in which turbine supply and demand is able to influence turbine prices.

And to the extent that manufacturers are able to sell turbines above the cost base floor price then that should be reflected in their profitability with higher prices obviously leading to higher profit margins.

So our approach in this report is simply to estimate the cost base floor price by looking at the six drivers that I have listed here and then to try and capture the influence of supply and demand by looking at a seventh driver which is profitability.

Okay just one more caveat before moving on. Our analysis of the first three drivers that I'll run through, namely labor costs, warranty provisions and profit margins relies heavily on financial data reported by Vestas.

So I just want to explain that because it is not our intent to focus specifically on any single turbine manufacturer or to come up with results that are applicable only to Vestas.

The table at the bottom of this slide shows that the Top 6 turbine manufacturers active in the U.S. over the 2002-2010 period supplied 92% of all installed wind capacity.

Among these Top 6 only Vestas files financial reports that contain directly applicable and complete historical data on these three drivers. The other five either don’t report the necessary data at all or else have certain issues that limit the usefulness of their data going back in time.

As a result we are basically forced to rely almost entirely on Vestas data for these three drivers but I do just want to note that there are a number of reasons to believe that Vestas can serve as a useful proxy for the overall U.S. market during this period.

And I have listed some of those reasons here in the third bullet for you to peruse at your leisure.

So with all that said let's get into the drivers themselves. This graph shows generally rising labor costs at Vestas since 2001 expressed here on a dollar per kilowatt delivered or a dollar per delivered kilowatt basis.

Specifically the green line is cumulative in nature and shows that labor costs rose by more than $140 per kilowatt through 2009 before giving back almost $40 per kilowatt in 2010.

And I should just note here that these impact numbers and all others that I will show you today are expressed in real 2010 dollars. So this is real escalation that you are looking at here above and beyond the general rate of inflation.

And here are the cumulative changes in Vestas warranty provisions to the graph shown by the black line. Warranty provisions simply represent the amount that the manufacturer sets aside to cover expected future warranty claims.

And in general the expected cost of a warranty is capitalized into turbine prices so all else equal as warrant provisions increase so too will turbine prices.

And you can see here a rather significant $80 per kilowatt increase in provisions through 2005. This had a lot to do with some reliability issues that Vestas and other manufacturers we are grappling with at the time.

In late 2005 Vestas got a new CEO who very quickly implemented what was known as the "Will to Win" campaign with the purpose of returning Vestas to healthy profitability through a dual strategy of both cost cutting and price increases.

And one of the first changes implemented as part of that campaign was an across the board reduction and the standard warranty term to just two years. And you can see that cut reflected in the data with the significant drop in warranty provisions in 2006.

(Unintelligible) Vestas profitability which as you can see declined rather sharply through 2005. Again one of the first acts of the "Will to Win" campaign launched in late 2005 was to raise turbine prices which in turn boosted profitability starting in 2006.

Given the tight turbine market at that time caused by demand outpacing supply Vestas and other OEMs were able to sustain these price increases and rising profit margins through 2008 before having to give some of it back in the wake of the global financial crisis.

Okay the last endogenous driver that I will look at is turbine scaling. You can see here that the average nameplate capacity of turbines installed in the U.S. over this period essentially doubled while hub height increased more than a third and rotor diameter increased by nearly two thirds.

In order to isolate and measure the cost impact of this rapid scaling we used NREL's turbine cost and scaling model which was first developed back in the mid-2000s based on a 1.5 megawatt turbine platform.

This model is made up of a series of functions that calculate how both mass and costs change in response to certain changes in turbine design parameters including capacity hub height and rotor diameter.

The model also uses general wind shear assumptions and power curve data to estimate how turbine scaling impacts the levelized cost of wind energy.

The model does have at least two limitations that I have listed at the bottom of this slide but in general it is largely suitable to isolate and evaluate scaling impacts among turbines within the general size range that we looked at in this study.

And the results shown here by the dash line suggests that the rapid scaling over this period pushed turbine prices higher by more than $230 per kilowatt through 2010 which is clearly a large impact. It is the largest of the four endogenous drivers shown on this graph.

This significant cost increase though is not without benefit. One of the main reasons for scaling of course is to increase energy capture resulting in higher capacity factors and a lower cost of energy.

And the NREL model confirms that this has indeed occurred over this period of rapid scaling, so unlike most of the other drivers that push turbine prices higher through 2008. Turbine scaling actually resulted in a benefit that justifies or even outweighs its incremental costs. And we'll hear more about this later from both Ryan and Eric.

Okay that does it for the endogenous drivers. Now let's turn to the three exogenous drivers.

We looked at a number of different lifecycle analyses of wind projects in order to gather data on the mass of the various raw materials that go into making up a wind turbine.

And this table shows that across four different types of turbines just five basic materials consistently account for more than 98% of all of the mass in a wind turbine.

You can also see that the distribution of mass across these five materials tends to be relatively uniform among the various turbine types.

For our analysis we chose to use the mass data from the Vestas V82 1.65 megawatt turbine mostly because this particular turbine most closely matches the average turbine size installed in the U.S. over the period of our study.

This graph shows the real cumulative price change in these five materials since late 2001. You can see that there have been some pretty wild swings in metal prices in particular.

And although steel price movements are not among the most volatile shown on this graph, steel does make up the bulk of the mass of a turbine at around 70% and so has the largest impact on turbine prices.

And here the dark blue line with diamond marker shows the cumulative impact of changes in the price of these five raw materials over time. And you can see it is an increase of $71 per kilowatt through 2008 followed by a $31 per kilowatt drop through 2010.

The price of energy inputs to the manufacturing process also increased significantly over this period at least through 2008 before dropping. But their impact on wind turbine prices has been surprisingly modest.

As shown here by the red line, energy inputs added just $12 per kilowatt through 2008 followed by a $7 per kilowatt drop through 2010.

Okay the last driver I'll run through is changes in foreign exchange rates. And the basic premise here is that all else equal and weaker U.S. dollar will likely push up the dollar denominated price of goods imported into this country.

And this one gets a little tricky to quantify because there a number of moving pieces that need to be properly accounted.

First we need to take into account that the imported contents of turbines installed in the U.S. has been declining on average in recent years as the turbine supply chain becomes more localized.

We also need to account for the fact that the mix of countries from which the U.S. imports turbines and components has shifted over time. In the early years of our study the mix was very Eurocentric and it still is to some extent though in recent years there has been a bit of a shift more towards Asian countries.

We also need to account for what's known as exchange rate pass-through which basically just reflects how much of a given change in exchange rates is ultimately passed along by exporters to importers in the form of higher or lower import prices.

There is an existing literature on this topic though it is not specific to wind turbines. And this literature suggests that in general the U.S. has experienced relatively low exchange rate pass-through in its imports perhaps due in part to the dollar status as an international reserve currency.

For a lack of any specific estimates relating to wind turbines though we decided to take a middle of the road approach and simply assume that 50% of all exchange rate movements are ultimately passed through to import prices.

Okay this graph shows the change in the value of the dollar against those eight or nine currencies that represent the countries from which the U.S. imports the majority of wind turbine components.

Since 2001, you can see that the dollar has fallen by roughly 40% against the Euro, the Japanese Yen and the Canadian Dollar. It has fared a little better against some of the other Asian currencies but is still in general lost between 10% and 20% of its value.

And the brown line was circled here shows the resulting impact of this dollar weakness, again assuming 50% exchange rate pass-through.

And you can see that the impact has been fairly large actually, a $136 per kilowatt increase through 2008 followed by a $15 per kilowatt decline through 2010.

So here we finally see the impact of all seven individual drivers on a single graph. With the exception of profitability, all other drivers do exhibit positive re-escalation over the entire period pushing turbine prices higher to varying degrees with scaling having the largest impact.

Now if you add all seven of these drivers or lines together you'll end with the blue line shown on this next graph which is clearly a lot smoother and more stable than any of the individual drivers on their own.

The red line up top meanwhile shows the empirical turbine price trend that we saw on an earlier slide. Comparing these two lines you can see that the seven turbine price drivers in aggregate which again is the blue line on the bottom.

I've done a reasonably good job at replicating empirical turbine price movements over this period.

There is however a notable wedge between the two curves that begins to widen out in 2005. And this wedge or gap could be explained by a number of different factors. Perhaps most importantly, we have not captured the impact of changes in labor costs and profitability among components of pliers.

We did do this for turbine manufacturers but not for their component suppliers mainly because the required data just weren't available. And I suspect that this omission could be the primary cause of the wedge.

But other possibilities include exchange rate pass-through being higher than the 50% that we have assumed or it could be our inability to capture the impact of design innovations that are not size related or scaling related but that nevertheless do likely add some upfront cost.

Well finally it could be our reliance on Vestas data for three of the seven drivers when the U.S. market was clearly more diverse than that and in fact was dominated by a completely different manufacturer, GE Wind over this entire period.

Okay this table aggregates results in a slightly different way. It brings the dollar per kilowatt impacts from all seven drivers together over two major periods of interest, namely the period of turbine price doubling through 2008. That is the first column shown. And then also the period of turbine price softening since 2008.

In total, these seven drivers explain nearly $600 of the $750 per kilowatt empirical turbine price increase during the first period and they also capture some though not as much of the decline in turbine prices in the second period.

And again you can pretty clearly see here that no single driver has been entirely dominant over either of these two periods.

It is interesting at least to me that the endogenous drivers collectively outweigh the exogenous during this first period of price doubling.

I personally would have expected based on part on the apparent breakdown of learning curve theory over this period that most of the price shock would have been exogenous in nature or in other words it would have been driven by factors that fall outside of influence of technology learning. But that doesn't necessarily seem to be the case.

Of course one of these endogenous drivers and the driver with the largest impact overall is turbine scaling and as mentioned earlier and as Ryan will discuss in more detail in just a minute.

Scaling has brought with it benefits in the form of lower cost of energy suggesting that the incremental cost of scaling has thus far been a reasonable and justifiable expense.

And then last thing I want to mention here is that among the three exogenous drivers, dollar weakness appears to have had the largest impact in the price run up though in recent years greater localization of the supply chain has since mitigated some of the risk of further adverse exchange rate movements going forward.

And I think I've actually covered most of these conclusions already. So in the interest of time let me just finish up by thanking you all for your time.

And then I'll go ahead and turn it over to Ryan who will look at these trends from a different perspective focusing on the cost of wind energy rather than just the cost of wind turbines. Thanks.

Ian Baring-Gould: Great thank you Mark. Fabulous presentation and I certainly like the analogy to the holiday season.

Next up we have Ryan Wiser who really needs no introduction. Ryan is another staff scientist at LB&L, has worked very extensively in the area of renewable energy, planning design evaluation of policies, cost benefit market analysis.

Just recently was a key lead author on a very good document from the Intergovernmental Panel on Climate Change looking at the renewable energy sources for climate change mitigation that captures a lot of great information about wind technology.

So without further ado, hearing from one of the masters is always fabulous. Ryan.

Ryan Wiser: Thanks Ian.

Well good afternoon all. It is also a pleasure for me to be here. In my talk I'm going to some extent at least be picking up where Mark Bolinger left off to discuss trends and the levelized cost of energy or LCE from U.S. wind projects over roughly the same historical period as covered in Mark's presentation and up to the present.

And we'll as you see be documenting the rather substantial improvements in LCOE that we are currently witnessing.

I would like to thank my colleagues and collaborators on this work especially Eric Lantz who you will be hearing from next. He was a key participant in this activity and of course also the Department of Energy for funding this effort. As well as I suppose the other presentations being offered in today's Webinar.

So as background and motivation from the analysis that I will be presenting notwithstanding the recent decline in wind turbine prices that Mark described, there has been some recent focus in the wind factor.

On the rising capital cost of wind projects that was observed from the early 2000 through at least 2010 as well as an apparent flattening and fleet-wide average wind project capacity factors.

As a result there is perhaps some concern among the wind sector or the broader energy sector that perhaps the technology had matured to the point where significant technological innovation learning in meaningful continued cost reductions were unlikely.

But those trends and concerns ignore some other important developments. Continued improvements in capacity factors within an individual and resource classes, significant recent improvements in low wind speed technology, pretty significant reductions in turbine prices negotiated over the last couple of years as mentioned by Mark and some possible longer term reductions in the cost of O&M, financing as well as improved turbine and project availability.

Now I'll be highlighting all of those trends with actual data a little bit later in this presentation but for the purpose of this introduction, one of the implications of those developments is that an exclusive focus on historical capital costs and/or fleet-wide capacity factors individually really fair to convey what have in fact been rather significant recent innovations that have impacted the levelized cost of energy from wind projects that have opened up new lower wind speed areas for development that previously were really not possible for economic development.

And in addition, focusing on each of those individual factors alone fails to really understand the fundamental interdependency between capital costs and capacity factors.

Certainly one would be willing to accept a higher capital cost if the improved performance that resulted from that higher capital cost resulted in a lower LCOE.

And indeed wind turbine manufacturers, wind project developers, wind power purchasers are not so focused on minimizing capital cost or maximizing capacity factors individually but are instead much more interested in minimizing the levelized cost of wind energy or alternatively increasing the amount of land area that might be reasonably open for future development.

So given that context, the purpose of the work that I'll be describing today is to develop a consistent LCOE level as cost of energy estimates for wind in the U.S. to do so over various wind resource regimes and to do so for three time periods.

Projects installed in 2002, 2003 basically the low point of wind capital costs. Projects installed in 2009 and '10 what is likely to be the peak of wind project capital costs.

And finally projects to be installed in 2012 and 2013 when current wind turbine pricing is likely to more fully make its way into observed capital cost figures.

The emphasis will be on direct costs. I am excluding transmission and integration. Not because they are not important but because they are outside the scope of this presentation.

And in the core analysis I will be focusing really on the impacts of capital cost capacity factors on LCOE. However I will also be presenting a side case analysis where I demonstrate the potentially significant additional impact of improvements in O&M, financing and availability and their impact on LCOE trends over this decade.

And finally in addition to presenting LCOE results I will also be presenting some findings related to the impact of wind energy advancements on the amount of land area plausibly open for future development.

Now there are as always a whole raft of caveats that apply to this analysis. I'm not going to go through all of these on the phone.

One of them that I would like to emphasize is that this work is still a draft assessment. It has not yet been published and part of as a result of that I certainly welcome any feedback from folks on the line here via email or otherwise on the assumptions and results that you are about to see.

I should also note that though a lot of this analysis is backwards looking we are estimating LCOEs for projects to be installed in 2012 and 2013. And so those results are at least a little bit speculative and that should be acknowledged.

And finally I should warn you before I really launch in that I have, you know, a large number of rather dense slides to go over in the 30 minutes that I have for my presentation.

That will not allow me to really walk through the slides in any detail but the presentation as well as the other presentations I understand will be made available after the Webinar for folks to pour over in more detail as all of you wish.

So before I discuss the assumptions and results of our LCOE analysis in particular, I'd like to first document some of those recent trends in wind energy cost and performance that I mentioned just a couple of moments ago.

As those trends both helped motivate the analysis that you are about to see as well as help develop the assumptions for the analysis that I will also be quickly summarizing a little later in the presentation.

To look at historical trends I will be relying in large measure on good solid data sets that we've developed for the purpose of the U.S. Department of Energy's wind technology's market report.

And starting with project level capital costs it is apparent in this graphic which I imagine that many of you on the line has seen many times before that wind project capital costs didn't experience a sizeable increase from the early 2000s through 2010.

There are some preliminary data for 2011 suggests that that curve may now be bending downwards.

In addition, the documented by the figures on this slide which many of you perhaps also seen. Fleet-wide, wind project capacity factors have generally increased over time but you can also see here that over the last six years or so those capacity factors have largely stabilized.

We haven't seen considerable increases in project level capacity factors on average over the last number of years. And as I mentioned earlier it precisely those two trends that might lead one to think that perhaps onshore wind technology has matured to the point that learning related cost reductions are really no longer the rule.

At the same time though as I mentioned earlier that those trends individually fail to tell the whole story about the technology's recent evolution.

First with respect to the capacity factors, the moderation of capacity factor increases that we have seen over the last couple of years is in part a reflection of the fact that wind projects have increasingly been cited in lower wind resource regimes.

We are not running out of high wind speed project locations or possible project locations but we may be running out of those high wind speed possible project locations that have ready access to existing transmission and that lack substantial and permeating barriers.

And as a result, projects installed in the U.S. from 1998-2001 were mostly commonly cited in Class 4 or Class 5 wind resource regimes while those projects installed from 2006-2009 were more commonly cited in Class 3 or Class 4 wind resource regimes.

In addition there has also been a growing amount of curtailment of wind generation. In this case primarily due to transmission limitations in West Texas for example as well as in other locations.

And the result of those two trends at least to a degree is that they mask the rather substantial increase in project level capacity factors that have occurred within individual wind resource classes as a result of upscaling in hub heights and rotor diameters.

At the figure on the lower bottom right of this slide for example, clearly shows that within individual wind resource classes those projects installed most recently or more recently have substantially higher capacity factors than those projects installed in the more distant past.

So clearly sizeable improvement and capacity factors over time within individual wind resource classes.

Moving from capacity factors to capital costs, you all have seen this particular chart before. While it is certainly true that project level capital costs did in fact increase through 2010 as Mark described and again as reiterated here.

Turbine prices have declined rather substantially since 2008. And given the lag that we often see between turbine orders and project installations those turbine price declines are anticipated to lead to pretty substantial near term reductions in the capital cost of wind projects as well even if we have not yet seen those reductions fully quite yet.

And finally there is also somewhat weaker admittedly evidence of a longer term improvement and other factors that might also impact the levelized cost of wind including apparent reductions of cost of wind project O&M, the upper figure here.

Improved wind turbine availability shown for GE in the figure on the bottom of this slide. And since the early 2000s at least also some improvement in the cost of financing wind power projects.

And as a result of really all of those trends, recent chatter or news stories from the wind sector suggest that delivered or the levelized cost of wind energy has declined rather substantially in recent years as suggested by some of the quotes on this slide. Again none of which I will bore you with lest I run out of time.

So, with that run up as background information then using a consistent method our analysis really sought to estimate trends in the typical wind energy capacity factors, levelized cost of energy of LCOE and developable land area.

And to do that over three timeframes as I mentioned earlier, 2002 and 2003 the low point of project level capital costs, '09 and '10 the likely peak. And again projects to be installed around 2012 and 2013 when current turbine pricing is likely to more fully make its way into observed capital costs.

Our basic approach for each of those three timeframes was to develop representative assumptions for installed project costs and then to calculate project level capacity factors for different wind resource classes based on available turbine power curves.

Now for the purpose of the core analysis we focused really on only those two trends we held constant, O&M, financing, turbine availability losses and other factors.

However we did do as I mentioned earlier, a side analysis in which we explore the possible impacts of improvements in O&M financing and availability from the '02, '03 timeframe to the 2012 and '13 timeframe.

I should also note that all of the results of this presentation include both the PTC and accelerated depreciation. We've done the analysis without those two incentives as well but in the interest of time for the purpose of this presentation all of the results include those two federal incentives.

For analytics simplicity we have to a degree focused on the evolution of GE turbine technology. You can see on this slide we've really focused our analysis on five different turbines.

For the 2002 and 2003 timeframe we consider GE's standard offering at that time a 1.5 megawatt machine, 65 meter hub height, 70.5 meter rotor.

For the 2009, '10 timeframe we consider sort of a scaled version of that same 1.5 megawatt machine, now with an 80 meter hub height and a 77 meter rotor.

And finally for the 2012 and '13 timeframe we consider three different GE machines. Their standard 1.62 megawatt machine now available, 80 meter hub height, 82.5 meter rotor and then two low wind speed designs that both feature 100 meter rotors but that vary in hub height. An 80 meter option and a 100 meter option.

So those are the five turbines that we are considering in our analysis arrayed over the three timeframes.

Some of the core analysis assumptions are presented here. I don't want to focus too much on how these were generated and exactly what they are.

Focusing though on capital costs. You can see that we assumed $1300 per kilowatt for projects or the turbines to be installed in 2002 and 2003. That matches actual historical costs reasonably well.

Similarly for 2009 and '10 we use a figure of $2150 per kilowatt also matching historical costs.

We then declined those costs somewhat for the 2012-'13 projects or timeframes based on current turbine pricing environment. We also have some cost variations among the three turbines that we consider to be installed in 2012 and 2013.

The low wind speed turbines with larger rotors and in one case a higher hub height obviously have higher capital costs because of those additional design features that we'll show later the improved performance associated with those turbines more than offsets those capital cost increases at least in the kinds of wind resource sites that we've considered in our analysis.

I mentioned earlier we do a side analysis where we vary O&M financing and availability. Those assumptions are listed here. Suffice it to say that our assumptions are benchmarked on our read of the available literature as well as informal discussions with wind project developers and turbine manufacturers.

But again this remains a draft assessment not fully vetted if folks have alternative assumptions that they think might make more sense and have some justification for said assumptions we would certainly be happy to see them.

Okay so with that lengthy run up, what the heck did we find with our analysis? Well, let me start by talking about estimated capacity factors, then turn to levelized cost of energy estimates looking at that from a variety of different perspectives and then finally turn to our land area calculations.

Starting with wind project capacity factors, estimated capacity factors we find that turbine design advancement systems, especially the higher hub heights and larger rotor swept areas have led really to just an enormous expected increase in the expected project level capacity factors within individual wind resource areas.

You can see here for example that that's true when moving from the standard technology available in the 2002-2003 timeframe. For the standard technology available in 2009-2010 and then to the standard technology available for purchase now and in this case to be installed in 2012 and 2013.

But you can also see an additional large bump up in expected capacity factors when you move from today's standard technology to the two low wind GE turbine designs that we have included in our analysis.

More importantly though is that while those higher capacity factors have been accompanied also by higher capital costs, nonetheless we estimate that the levelized cost of energy for projects to be installed in 2012-2013 is now at an all-time low across all of the wind resource classes that we looked at.

More specifically here accounting only for capacity factor and capital cost trends we find that the levelized cost of energy increased substantially from the 2002-2003 timeframe for Class 5 and Class 3 wind resource areas through 2009-2010.

Capital costs increased over this timeframe and the performance improvements were not great enough to offset the capital cost increase and as a result the LCOE of wind increased.

For turbines purchased today and installed in 2012 and 2013 however, those turbines also feature a higher capital cost and in the 2002-2003 time frame. But those higher capital costs are matched with an absolutely enormous increase in expected performance within Class 3 and Class 5 wind resources sites.

And you can see not only a reduction in LCOE from 2009 and '10 to '12 and '13 but also a decline in the LCOE from 2002 and 2003.

Now this next figure presents the same basic data but now across a more complete range of wind speed on the X axis and also based on each of the five turbines that we considered.

And again you can see following the arrow 1 that there was an increase in LCOE from '02, '03 from '09, '10 and then a subsequent decrease in the LCOE following arrow 2 from '09, '10 to the present, the 2012, the 2013 technology.

What's also apparent on this slide though is the economic attractiveness of the low wind speed designs that are currently or that are being considered in our analysis. As we find that those designs are likely to be economically attractive relative to the standard design at least in those wind resource regimes in which the low wind speed technologies can be deployed.

You can also see it in the sign here that we are estimating wind energy LCOEs again for projects to be installed in 2012, 2013 that range from as low as $33 per megawatt hour in the better wind resource regimes considered to as high as about $65 per megawatt in the lower wind resource regimes.

Now what's apparent from even rather simple analysis is that a myopic focus on historical capital costs really fails to fully convey the very substantial and real technological improvements that have occurred over time and have also boosted project performance.

And therefore the trends in the levelized cost of energy for wind look quite a bit different than trends in capital cost alone.

In this slide just as an example to calculate what the levelized cost of wind might have been in Class 3 wind resource sites if one were only to consider trends in capital costs but not concomitant trends and capacity factors.

And we can see here if you only consider the capital cost trends and the LCOE of wind would have increased certainly from 2002 and 2003 to 2009, 2010.

But also that significant increases would have also been witnessed from 2002 and 2003 to those turbines to be deployed in the near future. The three turbines slated for 2012 and 2013 installations.

At the same time though if one were instead to hold capital costs constant and only vary the capacity factor assumptions or parameters. Then the LCOE for wind would have dropped over all of the timeframes and dropped rather substantially.

And what that analysis really demonstrates is the simple probably kind of intuitive but often ignored point that capital cost and performance are in fact related.

And that LCOE trends and learning estimates for wind must therefore consider how both of those factors interact with one another in determining the more important metric of the levelized cost of wind energy.

Now to this point this analysis results I presented have only varied capital cost and capacity factor assumptions. And the results for the 2002-2003 and 2012-2013 are again resummarized on the graphic on the left hand side of this particular slide.

And so again the graphic on the left hand of the slide presents basically the same results that I have already presented though in a slightly different form a and demonstrates that depending on the wind resource site, 6 meter per second site or an 8 meter per second site the reduction in LCOE estimated from '02-'03 to 2012-2013 ranges from 5% for the highest wind speed sites to 26% for the lower wind speed sites.

In the graphic on the right on the other hand we've considered possible improvements in addition in O&M availability and financing, the so called side case that I mentioned earlier.

And when considering those factors as well as the capital cost and capacity factor trends that have already described, here we estimate even greater LCOE improvements ranging from anywhere from 24%-39% depending on the wind resource again from 2002 to basically the present time.

Another finding that is apparent in both of the graphics on this slide is the narrowing in the levelized cost of energy between the low and high wind speed sites.

And that narrowing is further demonstrated and illustrated on this next slide. So here in this slide we are only considering the three turbines that we analyzed for projects to be installed in 2012 and 2013.

And the floating bar on the left provides a sense for the levelized cost of energy range between 6 meter per second sites and 8 meter per second sites if a wind project developer only has GE's standard technology at offers. That's the only technology that they can deploy.

On the other hand, the floating bar on the right hand side says well the developer doesn't just have that technology to choose from. They can also choose from the other two GE turbine designs that we have analyzed.

And in fact the low wind speed sites especially, that developer would choose the lower cost, low wind speed technology design. And you can see as a result a narrowing in the range of LCOEs between low and high wind speed sites.

And so clearly here the proliferation in recent times of turbines that are specifically designed for lower wind speeds have again narrowed the gap of LCOE between the low and high wind speed sites.

Now one important implication of those technology advancements is the amount of land area exceeding specific capacity factor thresholds has increased rather dramatically over time and with the lower wind speed designs.

In this slide for example we're showing the amount of land area that could support certain capacity factors or above. And as one example, if a developer said, you know, I'm only interested in developing projects in wind resource areas that can handle or that can obtain 35% capacity factors or above.

And the amount of land area in the U.S. that could meet that threshold has increased anywhere from 130%-270% since 2002 and 2003 with that range, 130%-270% reflecting standard technology on the low end and the 100 meter tower, 100 meter rotor low wind speed technology on the high end.

So clearly the low wind speed technologies have opened up a considerable amount of additional land area for potential development when considering certain capacity factor thresholds.

Related and perhaps more importantly though we also find that there has been an increase in the amount of land area that meets certain levelized cost of energy thresholds.

And specifically considering or including both the production tax credit and accelerated depreciation we find that the amount of land area in the U.S. that can support the levelized cost of energy of under $55 per megawatt hour has perhaps increased by almost 50% between 2002 and 2012 and 2013 as a result of the trends that I just described.

Okay so to conclude this multiple many slide presentation, I think it's pretty clear that examining historical trends in capital cost and capacity factors individually or alone gives a rather incomplete picture of recent technological advancement in cost trends.

In fact, the most recent declines in wind turbine prices as well as improved technology has pretty substantially reduced the levelized cost of wind energy and considering plausible assumptions not only for capital costs and capacity factor trends but also O&M financing and availability.

One can estimate that the LCOE for 2012-2013 projects could be as much as 24%-39% lower than the previous low point of levelized cost of energy experienced in 2002 and 2003.

Now those figures again are a little bit speculative. They are based on an assumption that turbine price reductions flow through to fall project level cost reductions but nonetheless those assumptions are at least reasonably plausible it seems to be.

In addition a key trend in finding is that technology advancement for lower wind speeds has certainly narrowed the gap in LCOE between those two wind resource regimes. And in part as a result, the amount of land area are meeting or exceeding certain capacity factor or LCOE thresholds has substantially increased.

And that may help alleviate at least to some extent some of the trends mission and citing barriers that might exist for high wind speed sites.

And what should be clear I think from all of those findings is that technology advancement and learning still very much applies to onshore wind despite its relative maturity.

But when considering technology advancement and learning one needs to really consider all modes of technology and advancement not just capital costs, not just performance but how all of these things interrelate.

And finally I should just note that despite those recent and perhaps somewhat in process technological advancements there are of course always countervailing factors that might also be considered and two of note here.

Obviously if we continue to move towards lower wind speed sites as a result of more severe transmission or siting limitations that could certainly boost LCOEs beyond what I've shown in this presentation.

And of course the potential near term loss of federal incentives whether the PTC, ITC or Treasury grant could also put some of these cost reductions over time at least for the purchaser at some risk.

And with that let me turn it back to Ian who will then turn it over to Eric who will be talking about the future. Thanks.

Ian Baring-Gould: Thank you Ryan. Again wonderful presentation with lots of great information for all of us.

Just as a reminder as Ryan mentioned all of the presentations are going to be made available on the Wind Powering America Web site. It takes about a week to get the audio and visual up there so people can take the time to pour through the slides more exactly.

And then just to point out that we have about 260 people online but I'm sure there are other people that are out there that couldn’t attend. So if you know a friend who would like to see these presentations but couldn't make this presentation, certainly direct them to the Web site in about a week and they can go through it at their leisure.

So thirdly or third of the trio is Eric Lantz and he is going to be talking about projections going into the future.

Eric works at the National Renewable Energy laboratory in the market policy analysis group here and has done a great deal of work looking at the future cost of wind energy as well as assessing the economic impacts of wind energy, working through the (unintelligible) model.

And actually a very interesting, relatively recent piece he did was looking at the economic benefits of expanded transmission and how that allows different areas to develop more energy potential, not only wind but other technologies and how much economic development you can actually get through transmission which is something as Ryan pointed out is critically important.

So Eric is going to talk about future overview of projections and that will finish off the trio.

And if you have questions please hit the Q&A at the top of the screen and type in your questions and we'll get to those at the end of Eric's presentation. Go ahead Eric.

Eric Lantz: Great thanks Ian. Thanks everyone for holding out here until the final presentation.

As Ian mentioned this presentation looks at the future cost of wind energy and primarily over the long term up through 2030.

The presentation today actually is really going to consist of two components. One is to give you an overview of those projections that have been performed by a variety of organizations and institutions. And then talk a little bit about the method they used to make those projections.

The projections will focus on the cost of energy which we have learned from the previous two presentations is really what we want to focus on rather than the installed cost or the capacity factor alone.

The second part of the presentation will focus on some analysis that is ongoing here at NREL. It is also in draft form and so we welcome feedback and questions and comments on it as well, you know, during the Q&A time or via email at some later point.

The second part is really going to focus on looking at one of the specific projections, actually the one that was employed in the 20% wind by 2030 study that was published by the DOE in 2008.

We want to look at whether that cost projection is both feasible and reasonable and what types of technology and innovation will allow us to achieve that or what might be part in addition if we do want to achieve the cost and performance target for wind technology that were used in that particular report.

So moving to the initial part here, when I think about the future cost of wind energy we obviously have to start by taking a look back into the past.

And rather than focusing just on the era of 2000 to the present day we wanted to look back all the way to the beginnings of what we might consider the modern wind industry in the early 1980s.

And then you can see there are actually a relatively substantial decline in the cost of wind energy on a dollars per megawatt basis in most of the North American markets as well as in Europe.

There are three different independent analyses employed here. One specific to the U.S. market and then two on the European side but both with basically similar trends over the long period of time.

Obviously there is the uptick here in the out years in the latter part of this decade but then we have to think about how the broader trend really is going to inform of what we consider going forward.

So as Mark mentioned early on in the presentation, the learning curve has been applied to wind technology to really understand the future cost of wind. And it has really been the most widely used method to assess those future costs.

But obviously as Mark pointed out the learning curve theory breaks down at some time. And there are a variety of reasons for that and I'll get into it on the next slide.

But just as an example you can kind of see there is quite a wide range of what we call learning rates. And the learning rate is essentially the percentage reduction that is anticipated with every cumulative doubling of capacity in terms of number of wind turbines or actually installed capacity in terms of megawatts.

There are some cases where individual studies have focused on electricity production but by and large both the emphasis of learning rate studies has been on installed capacity in megawatts.

Now there are a variety of limitations with these studies of not only the fact that they sometimes break with reality but there are a lot of technological considerations and boundaries that have to be drawn around the fact that analyses sometimes present them from swearing very well with what we actually see out there in the market.

One of these is the fact that the results are specific to a given time period. If one for example were to do a learning curve assessment from the 1980s to 2000 not including the runner up in capital costs that we would have seen in the last decade. Then they would end up with a very different rate than if one were to read the whole analysis from 1980 through 2010.

In addition I've been mentioning various points earlier in the Webinar a focus on fall cost is going to leave us lacking in terms of actually predicting what's going to happen to the cost of energies.

And many of the learning curve analyses have actually focused on installed costs simply due to limited data availability on the other parameters necessary to calculate the cost of energy.

In addition, a learning curve analyses particularly in the early years or in the initial studies that were completed were often focused on national markets.

But the wind industry today is really global in scope and nature and so it is important to associate global cost reductions with global capacity installations.

To the extent that we focus on national markets today that will result in relatively misleading learning curves.

Finally one of the other limitations with the learning curve is that it doesn't explain anything about how we might actually achieve cost and what types of technology are going to be necessary to achieve the reductions that are anticipated.

So to supplement our understanding of future cost of wind energy, along with learning curve most analysts and researchers like to employ some additional methods.

The first of these is expert elicitation. This really is fairly basic. It involves going out and interviewing engineers, researchers, industry stakeholders trying to understand what is going to be the impact of specific tangible technological advancements.

Often these questions are actually quite narrow in focus. They target individual turbine systems or components and you try and get a broad spectrum of insights, develop some probability distributions associated with the responses that you get and the sum up all of the expectations for individual systems or components.

And this has actually been a method that has been employed by NREL and the U.S. Department of Energy at various points in the past. The image that you see on the right hand side of your screen here actually includes some results from one of the more recent really in-depth expert illustrations that were completed and this work was published in 2008.

However along with expert elicitation which as you might assume can be somewhat subjective. Another bottom up approach is the engineering model approach.

And this is particularly important because it provides us some sort of a means of perhaps substantiating the findings that we get from the top down learning curve projections.

Again it focuses really on tangible technological advancements those that are in the very near term pipeline because it requires actual engineering design and modeling to understand what the impacts on cost and performance of a wind turbine will be.

In some respects this might be thought of essentially the most useful because it really employs kind of the best analytical tools we have from a bottom up perspective.

Unfortunately however it really can only focus on those endogenous drivers that Mark reference earlier in the Webinar. And it really has only a focus on the various kinds of incremental technological advances.

Because it does require sophisticated design modeling than you really have to focus on concepts or technology improvement opportunities for which you have data or a relatively solid grasp of how it will affect performance and cost.

In addition the engineering modeling methods that are in use today rely on cost models that cannot always capture some of the system level interactions.

For those of you that familiar with wind turbines as a machine you understand quite well that they are a sophisticated optimization and that one little change on the rotor can have impacts all the way down into the foundation.

Often the cost models that are used with engineering modeling today only quantify the cost impacts for example from a change in the rotor or on the rotor itself.

They might also analyze some of the impacts to the tower but probably are not capturing all of the system level's engineering impacts associated with given technological advancements.

In addition the engineering model cannot - it doesn't really capture the economy of scale or volume based improvements that you expect to see as the industry grows and matures.

So with that discussion of the methods we now turn to some of the results for people are projecting in terms of the future cost of wind energy.

This plot here is based on an obviously a percentage reduction scale. The 100% at the top is where we are today and in general when you put everything - a number of studies in this case 13 studies and 18 different scenarios.

When you put them all in a standard and a normalized calculation we can see that we anticipate cost reductions on the order to 0-40% over the next two decades.

That range shown by the shaded area here actually is reflective of some outliers. To some extent however the bulk of the scenarios that are considered in this particular view suggest cost reductions on the order of 20%-30% in terms of the levelized cost of energy.

Obviously as I mentioned the shaded area cover the full range. Each of the individual lines here represents a specific study or scenario produced by an organization or institutions.

However I highlight here the 20% wind energy by 2030 cost trajectory because that becomes the focus of the second part of this presentation which we'll move into subsequently right now.

So in this presentation you really want to take a closer look at that projection in the 20% wind study. And we also wanted to see, you know, what would it take technology-wise to get us to those performance targets and cost targets while also scaling - continuing the scaling of wind turbine (unintelligible) to about 5 megawatts.

And we did this by reviewing a number of proposed technological advancement or innovation opportunities. We did some modeling with these particularly on the systems around the rotor or blades kind of in the cell in the tower.

And then we used some expert elicitation data to try and form the cost reductions that would be anticipated for example with manufacturing improvements.

We combined both the modeled impacts from near term tangible reduction opportunities with the expert elicitation inputs and some of those (unintelligible) to get at the final cost of energy.

As I mentioned before in discussion of the methods, the engineering model here relies very much on an incremental technology improvements or really on incremental changes.

It assumes that innovations are widely adopted to get us to the cost targets. Essentially the technology here must make its way into the "average wind's turbine".

And the other caveat here is that we're really only focusing on cost of the wind turbines themselves not the balance of plant costs presumably we may also see reductions in balance of plant costs over time so they are not reflected in this analysis.

So as we are reviewing and doing our modeling we came up with - well actually prior to modeling efforts we identified a number of technological innovation opportunities that are likely over the near term.

You can see them summarized here. So to save us time I won't go through them individually but you can see that they cover all of the major turbine components and systems as well as other elements of manufacturing and siting and array losses.

As I mentioned before these were derived both through modeling efforts and the scaling relationships that are based on actual design studies and expert elicitations as well as some industry (unintelligible) the newer elements like siting and array losses.

Then we punch the numbers and added in our expert elicitation data. These are the percentages of reduction in costs or in increased energy production associated with the different technology improvements.

We actually considered different levels of technology improvement as summarized in this table. Obviously we had our first case we wanted to measure the difference from where we are today. So we assume no R&D improvements and then we have a second case with expected technological improvements.

And then a third where we have some incremental improvements over expected technology and really what's kind of a best case scenario based on what is in the pipeline for innovation today.

In addition just to see kind of what might happen in the future, we ran one extra scenario where we analyzed what would be the cost impact of producing turbines with much larger and have much higher capacity factors but are still able to have the same normalized mass in terms of for example, kilograms per meters squared of the rotor or kilograms per kilowatt as a machine rating and we ran that additional scenario.

Just another way of looking at the table that I showed you previously, we probably won't spend a great deal of time here. But this compares is our modeled results to the expert elicitation data.

Now the four columns here on the - the four sets of bars here on the right hand side, those relied on expert elicitation inputs to begin with though we would expect relatively good correlation between the modeled impacts that we show and the expert elicitation impacts.

On the engineering modeling side of things on the left hand side here you see actually some differences between what we modeled based on the explicit design improvements and what the experts suggest that might be reasonable.

And there are a variety of explanations for this. Just for example on the tower side the experts were simply asked what would be the impact to cost of simply moving to higher towers in order to capture more wind resources.

Whereas the engineer on the engineering side of things the data we use to assume actual improvements and changes in the power design architectures as well as reduced loads to the towers resulting in improvements in the rotor essentially allowing us to build wider towers up the same height.

So we would continue gain performance increases of higher hub heights but have a much less material intensive tower.

But what did we find? Effectively we found - obviously if we scaled to 5 megawatts and try to increase our capacity factors by about 20% that turbines will get much more expensive unless we apply advanced technologies, relatively intuitive conclusion there.

When we apply our advanced technologies however we find that in order to hit our 20% wind study range of turbine costs we really have to apply all of the kind of - all of the technology that is in the pipeline and really the best version of it up to 3 1/2 megawatts to get the cost reductions that we were hoping to see in the 20% wind study.

What we also found is that at the 5 megawatt level we really need additional innovation opportunities if we want to achieve 5 megawatts and 43% capacity factor.

The very bottom line there you can actually see that was our kind of extraneous scenario based on essentially building blades and the cells that are equivalent in kilograms per meter squared or kilograms per kilowatts to what we see in machines today.

And that is actually quite a challenge to do by the traditional scaling models would actually put us on this curve, our no R&D scenario. Essentially as you move to larger machines the conventional or classical scaling logs tell you is that your equipment will become much heavier on a normalized basis.

However if we were able to include innovations that we don't know of yet that would allow us to achieve the same normalized masses the rotors and the cells that we have today then we could actually be below or at the very bottom of the 20% wind study cost range or turbine even up to 5 megawatts.

Basically the same results are included here for the 5 megawatt turbine. Obviously though with a little more granularity to allow you to see where the individual technology innovations are - what systems are affected and which ones can contribute in the most significant way to cost reductions.

From here we can see actually that even for the 3 1/2 megawatt turbines to hit our 20% study targets per cost and performance we really do need the best technology that is in the pipeline today. We cannot achieve that lowest end of the cost with only the expected technologies today.

We don’t however need to include any technological advances that are not captured in this particular site.

Large contributors to the cost reductions are actually on the efficiency side. That's both in the turbine and in terms of reducing losses from siting or array losses and improvements. In this specific case actually improvements in power electronics sufficiency so that we can actually build slightly smaller turbines and still get the same performance in terms of capacity factor.

The other big piece here is the towers. And you can probably debate whether this is really actually the result of innovation in power or innovation in the rotor itself.

Much of the cost reduction from towers as I mentioned previously is really about rotor innovations that reduce the lows on the towers and allow you to design a tower that is less material intensive.

Similar data for the 5 megawatt machine though. Although you can see out here on the far right hand side that we really need a substantial contribution from new technology innovations not captured in this study that would allow us to achieve our current normalized mass ratios in order to have a 5 megawatt machine with a 43% capacity factor that could be sold for the cost anticipated in the 20% wind by 2030 study.

So that's essentially the results of our work, a few things to consider when we think about what these results mean.

One of these - a lot of the innovation opportunities that are captured in this particular analysis they are not especially new. They have not yet made their way into the kind of mainstream average wind turbine in the fleet today.

However they are certainly starting to have a presence in the low wind speed technology that Ryan discussed previously. And assuming that they continue to make their way more into the mainstream or that those low wind speed turbines move into the dominant or average wind turbine in the fleet then they are starting to be captured. It will be effectively represented in the industry.

In addition the scaling that we do as I mentioned previously does not capture all the system level interactions. And the system level interactions can actually affect things in both directions.

So there is a little bit of uncertainty both in the plus or minus side around the cost estimates resulting in specific technological innovations captured here.

In addition if there are social or ecological or potentially even logistics constraints associated with a given turbine design that requires kind of redesign away from what's been considered here. Then there are likely to be cost impacts probably on the increased cost side.

Finally as I mentioned, we do not consider balance of plant cost here. We really focus just on the turbines and their share of the total installed cost in the 20% cost estimates.

And so if we were able to get proportionately greater reductions on the balance of plant side we may not need as dramatic of turbine cost reductions.

Finally we are really not capturing any potentially disruptive technologies or high level kind of market game changers. For example low cost Asian technology or labor.

In conclusion however we really found though that the existing technology in the pipeline today at least for turbines up to 3 1/2 megawatts is likely to result in the 20%-30% cost of energy reductions reflected by both the 20% wind scenario trajectory as well as many of the other studies on a project cost of wind up to 2030.

I think we've been over the 5 megawatt piece but just to reiterate we really need all of our best technology and then some new innovations in order to achieve a 5 megawatt machine as the cost and performance expectation in the 20% wind study.

Another I think key finding from this work is that although there are a few innovation areas and parts of the turbine where cost reduction are particularly valuable we really need cost reductions across the whole turbine itself in order to achieve these cost targets.

And as I eluded to before if the existing kind of prototypes or the cutting edge technology that is hitting the market today becomes more moved into the mainstream and becomes represented average turbine in the near future as it potentially could. Some of these cost reductions are likely to be sooner than we think.

With that I'll turn it back to Ian and I think we can move into the Q&A and thanks for your time.

Ian Baring-Gould: Great thank you Eric and thanks again all three of you for taking the time to make these presentations.

Very quickly dive into the end of this we have the first one is basically to all of you from (Lea Coobe). What would be the turbine price difference between large orders and single orders? What's the rough estimate increase in percentage of prices looking at project size?

Mark Bolinger: This is Mark I'll take a stab at that one. I would actually be kind of hesitant to try and place a specific percentage on the difference in price that you might pay for a smaller turbine order because I think it's going to vary somewhat depending on the market environment out there as well as which turbine manufacturer you are looking at.

If you are in a pretty slack period of turbine supply as we have been in over the past few years you may actually get a decent price on a single turbine order.

Whereas, you know, in the period from 2005-2008 if you tried order a single turbine you basically, you know, you probably wouldn't have your calls returned.

It also depends on which manufacturer you are looking at. Some of these OEMs are more inclined to work with smaller developers and smaller turbine orders. So let's leave it at that.

Ian Baring-Gould: Has part of the technology report looked at project side? I kind of remember that someplace?

Mark Bolinger: Well yes we did look at - we did break out installed cost by project size but we haven't really looked at individual turbine prices per se in any systematic way by project size other than the fact that in the graph I showed of turbine price trends we did try to differentiate the prices by the size of the order.

And, you know, based on the empirical data is has been hard to tease anything out of the empirical data given the other confounding factors that are involved.

Ian Baring-Gould: Thank you. A couple of questions from (Tom Statton). The first one to you Ryan on Slide 31 of your presentation you talk about the Treasury grant and

ITC favoring low wind speed sites. Is that accurate or can you comment on that?

Ryan Wiser: Yes so the investment tax credit because it is delivered as a percentage of installed cost and the production tax credit because it is instead delivered based on performance will be attractive relatively less or more attractive depending on the project's capacity factor and capital cost.

With some increased value from the investment tax credit when you have lower capacity factors and high capital costs. Those are the kinds of projects that will tend to favor the ITC or the Treasury grant as opposed to the production tax credit.

And we actually did do some analysis that is not presented today that suggests that for those projects installed in 2009 and 2010 rather with the relatively high capital cost at the time and with standard wind technology that allowed the projects in the low wind speed sites would prefer economically the ITC. They would get lower LCOEs taking the ITC or Treasury cash grant as opposed to the PTC.

More recently though for those projects to be installed in 2012, 2013 because we assume that turbine prices will flow through to capital cost reductions and because of the increased capacity factors of the latest batch of turbines we find that those projects would almost universally favor the production tax credit over the cash grant or ITC if one is only considering the face value of those incentives alone and not considering other ancillary benefits of getting an upfront cash grant rather than a performance based award.

Ian Baring-Gould: Great thank you, continue with (Tom's) question. The second one is and this is one I'll probably take. Do we know anything yet about the noise characteristics of the new low wind speed technology?

It's not really the focus of this discussion. All of the even the newer low speed technologies still at the same international noise thresholds but I think as (Tom) points out in his question.

The key is if they are operating in lower wind speed environments which have lower background ambient noise than the same turbine noise level could have different impacts on local communities. And I don't think there is any research that has been done on that.

Just last week we did have a presentation from Charles Newcomb as part of the New England wind education project that addressed noise and that presentation will be available on the WPA Web site in less than a week. I just looked and it's not up there now but I would encourage people to look at that if you are interested in the noise issue.

And then to Eric's presentation, does the work Eric has presented suggest that there may be any significant amounts of repowering previous existing wind farms replacing the cells, turbines, blades without replacing the towers? And will developers switch up the older less efficient machines for newer more efficient ones? Eric, do you want to take a stab at that?

Eric Lantz: Sure I'll take a stab at that. That's actually something that we are going to look at a little more closely in the next year I believe. We haven't looked at that up to this point.

My own kind of assessment just based on the advancements in technology that we are seeing is that you are most likely to see complete turbine replacements.

The time in which that happens though will be obviously an economic calculation if it becomes economically viable to replace turbines in year '12 or '15 as opposed to in year '20 or '25. Then certainly I think developers will go ahead and do that.

At this point I do find that it is somewhat difficult to see a large kind of repowering market that focuses on just replacing blades. However that is yet to be determined I think and hopefully we can find more insight into that maybe about this time next year.

Ian Baring-Gould: Yes just to follow up, the Department of Energy is funding several studies to look at this exact issue of repowering not only of components but of whole turbines and what the benefits and impacts of that could be.

So as Eric says we'll know a whole lot more next year thanks to this work that the DOE is funding.

A similar question from (Brian Sordo) along the same lines is thoughts on the manufactured wind turbine market once the installed turbine reaches their end of life? Does anybody want to talk about that or could talk about that?

Man: You are talking about the remanufactured turbines?

Ian Baring-Gould: Yes exactly.

Man: I think that is basically kind of a question of both economics and reliability. In the past I think remanufactured turbines have had to have something like 80%

of their value sort of containing new equipment in order to qualify for the PTC. That is an IRS regulation.

So that has sort of hampered that market to some extent. But I think that at the end of the day the question really is if you do go out and search for remanufactured turbines are you going to pay - how much less are you going to pay and in the end is that really worth it?

And obviously the answer to that question is going to depend on part on once again whether we are in a period of slack turbine supply or tight turbine supply.

You know in a period of tight turbine supply it might make sense to go out and look for remanufactured turbines. There are a number of projects being installed this year or at least one or two that I am aware of using utility scale remanufactured turbines.

And it will be interesting to see going forward what the reliability of those projects is and how well they perform.

Ian Baring-Gould: Great thank you and if I can indulge our three speakers (unintelligible) questions and we fit our hour and a half which I know for all of us is a lot of time to be focused on one specific area.

But a question from (Roger Taylor). Looking at the energy (unintelligible) more specifically to Ryan or Mark. Has anybody looked at the energy intensity of the different (unintelligible) and how that changes with oil price?

So what will the cost of the turbine look like from an energy intensity perspective but $200 per barrel of oil?

Man: We didn't look specifically at that but there have been quite a few life cycle analyses of wind projects out there and they almost universally show an energy payback period of somewhere in the order of eight to nine months which is quite short.

We did - I did present a slide earlier looking at the impact of changes in the energy prices on wind turbine prices over time.

And as you might recall even though, you know, the price of natural gas and diesel fuel essentially doubled between 2002 and 2008, the overall impact on wind turbine prices was actually quite modest. I think it was something like $12 per kilowatt.

So turbines are, you know, even they are I would agree with the questioner that they are energy intensive. When you look at the full life of the turbine over the 20 or 30 year period, the payback period is actually quite short.

So I would say, you know, even if energy prices continue to increase it will certainly have some impact but it is not going to be any sort of deal killer.

Ian Baring-Gould: Great thank you.

Another question from (Steve Foreign). The presentations were focused on cost of turbines. Has anyone done any research on how much revenues could be provided by a turbine once built? Obviously different locations would have different numbers. I am looking at onshore turbines in the Eastern Coast.

Anyone want to talk about that?

Ryan Wiser: Sure I mean - this is Ryan here. You know obviously what revenue one can receive depends critically on the market in question, the timeframe in question and eventually what one can negotiate with local purchasers.

In the Department of Energy's wind technologies market report that Mark and I are heavily involved with as well we do include wind PPA prices, historical PPA prices by regions.

And that might provide at least some guidance on what folks have received in the past in terms of revenue for their projects. Though obviously with the declining turbine prices that we have seen, the improved technology. PPAs that are being negotiated today may be substantially below that which were negotiated a couple of years ago.

And so I think we might have to be a little careful with those historical data.

Ian Baring-Gould: Great thank you. Another question for you Ryan from (Steve).

I believe one of Ryan's slides suggested LCOEs for new low wind speed technologies, about $60 per megawatt hour.

Even in Class 2 wind regimes in the 2012, 2013 timeframe he hasn't heard anyone talk about developing projects in Class 2. Do you see this as real potential in the near future? And then what parts of the country do you think this would happen in?

Ryan Wiser: I think that there has been some development in some Class 2 resource areas already. If you look at one of my earlier slides that shows sort of the distribution of where projects are located with respect to mapped wind classes.

You'll certainly see some projects that are in the Class 2 wind resource regime. So it's not a completely new deal.

Yes I think that one could expect to see a little bit more development in those areas but obviously no developer will want to move to Class 2 if there is an available Class 3 site, just as no one would want to go to Class 3 if there was an available Class 4 site.

So, you know, whether projects really have to move to Class 2 is in the end is going to be a matter of whether there is transmission and siting ability in Class 7, 6, 5, 4 and 3.

And since there is so much Class 3 wind resource out there I'm not sure one would necessarily expect to see a dramatic turn towards Class 2 sites.

Until we or unless we have really exhausted available transmission in Class 3 sites which it seems to me we are not likely to be close to be getting to.

Ian Baring-Gould: Great thanks. Just to follow on a little bit. We are certainly seeing a lot of interest in regions of the country where we haven't seen interest before and are we as decision to hold wind power in the Southeast as an example of that. The Southeast is (unintelligible) that historically people have felt there is not strong of winds to handle wind projects.

But given the turbines (unintelligible) that are coming out that are actually in Class 2 sites. Now the whole Southeast or not the whole Southeast but lot of portions of the Southeast that (unintelligible) think not viable and becoming viable. So I think that is an area the market will see this happening.

Ryan Wiser: Yes and I think that is an excellent point and that’s, you know, I think exactly a reflection of the fact that, you know, that you don't have Class 7, 6, 5, 4 maybe even 3 wind resource sites in that region.

And so the fact that Class 2 is now open for development is very impactful whereas in, you know, North Dakota there is really no reason to move to Class 2 when you have got a lot of stuff above Class 2 to be had before you get there.

Ian Baring-Gould: Exactly. The question for (Maureen Reno). First when will paper summarized in the presentation be made available? And if each one of you could talk about, you know, in a lot of cases the papers are either done or will be done shortly.

And as a second follow on, has anybody looked at the impact of increased domestic production on LCOE by holding exchange rates level?

Ryan, do you want to start that?

Ryan Wiser: Sure. Well in terms of reports availability I can answer for Mark. Mark's report is already done. It is available on the LBL Web site at a minimum and so that report is completed.

In terms of the analysis that I described on historical LCOE trends we haven't begun writing anything on that yet. That project has been sort of a slow burn where we have been focusing more on the analysis and less on the report writing.

However we are hoping to make available obviously the presentation that I gave today.

And we might also before the first of the year or shortly thereafter also send our via email list sort of a longer presentation which provides slightly more thorough review of where our assumptions came from as well as some additional results that the actual writing of any report will have to wait until next year at some point.

Ian Baring-Gould: Okay. Eric what about your research?

Eric Lantz: Yes so that work is in a similar position to Ryan's. We focused largely on the analysis at this point and we are kind of working to wrap up the analysis piece and begin writing in the new calendar year.

So there won't be a report available for some time but, you know, the presentation obviously will be available here on the Web site with this Webinar. And feel free to correspond with me if you have any specific questions that I might be able to help answer.

Ian Baring-Gould: Great and then the follow on question about the in fact of domestic manufacturing on LCOE?

Ryan Wiser: Hi this is Ryan. I haven't seen anything specifically on that topic frankly. Obviously there has been an increase in domestic manufacturing over the last couple of years presumably that is because manufacturers have found it economically attractive to manufacturer domestically.

And so presumably there has also been some reduction in LCOE as a result of that domestic manufacturing but I don't have a particularly easy way of hazarding a guess of what that impact might be.

Mark Bolinger: This is Mark I would just add to that that it seems to me probably one fairly large benefit of domestic manufacturing is reduced transportation costs. You know you no longer have to ship this equipment from, you know, Europe or Asia.

So, you know, I've various estimates of what the cost of transportation adds to a wind turbine and, you know, it's somewhere in the range of maybe 10%-20%. So it is a fairly sizeable impact.

Ian Baring-Gould: Great. Just to follow up with each of (unintelligible) I also want to point back out to or do a shout out to the DOE sponsored 2010 Wind Technologies Market Report which all three of these speakers have helped author that provides a great overview of the market

And some of the references in regards to PPAs by region and stuff like that are available in that report. And that is easily accessible on DOE's Web site as on LBLs and I think on WPA site as well.

Question from (Ed Duel). What is the approximate percent in change of LCOEs for offshore versus onshore wind power? I'm not sure if you guys can comment on that but what do you think the kind of changes that we've seen in prices for onshore will impact potential offshore prices?

Eric Lantz: This is Eric I guess I can take a stab at that one. There's not really a great deal of data on offshore wind turbine prices that we are aware of at this point. But an ongoing effort to try and secure more offshore wind turbine price data.

Kind of taking a step back at the really high levels, cost reductions are anticipated to be - they will ultimately be greater in the offshore industry relative to the land based technology.

Land based technology is obviously more mature and it is focused more on optimization whereas the offshore markets they are really looking at - they are at a very different point on the R&D side of development in the fusion curve.

So in general cost reductions are expected to be much greater for offshore. Feel free to send me an email and I can send you some literature on what others have anticipated for cost for offshore. But I can't really speak to that just at this moment.

Ian Baring-Gould: Okay I think we have one last question and then sum it up. And this question a little off topic though. Have any installed - let's see - have you installed or had any intergovernmental installations of wind turbines in Indian countries?

And I'm not sure if the market report specifically pulls out Indian countries from the regional analysis. Ryan, can you comment on that?

Ryan Wiser: No we don't.

Ian Baring-Gould: Do you have data?

Ryan Wiser: Yes we don't have it I'm afraid

Ian Baring-Gould: I do know from other areas that very little wind has been installed on any Indian country although lots of efforts to do so. And if the (unintelligible) asked that question wants to contact me directly and you will see my email address on the next slide that will come up in a second. Please do so and we can follow up the conversation.

So thanks all. In closing just want to point out that we have a couple of more Webinars coming up. One next week on wind and wildlife interaction and then the regular series in January and February looking at market acceptance and workforce development activities that are going on.

There is also a Webinar tomorrow that is focused on a report out of the small community wind market report that was just released AWEA. That Webinar is tomorrow morning and you can go to the WPA Web site under the Webinar section to find links to that Webinar and further details to that.

In final closing, again thanks to the speakers. Also thank you to the Department of Energy who sponsors the Wind Powering America activity and therefore this Webinar series.

So, none of this would be happening without the support of the wind and water power program at the Department of Energy.

So in closing thanks all for taking the time to be with us today and a special thanks out to our three speakers Mark, Ryan and Eric for sharing their vast experience with us.

Everybody have a wonderful day.

END