SOCIAL ACCEPTANCE OF WIND ENERGY

October 17, 2012

Coordinator: Welcome and thank you for standing by. For the duration of today's conference all lines will be on a listen-only mode. Today's conference is being recorded, if you have any objections you may disconnect at this time.

And now I would like to introduce your host for today's call, Ms. Suzanne Tegen with Wind Powering America.

Suzanne Tegen: Thank you and good afternoon everybody. Thank you for joining us today for the Wind Powering America monthly webinar. Today's topic as you probably know is one of growing importance and interest in the renewable energy arena.

We're talking about the social acceptance of wind energy, which is also known as public acceptance, public involvement, public perception of wind energy and this is a topic that spans a wide range of fields. From the social sciences to technology and we're lucky today to have three great speakers with very appropriate backgrounds for this topic.

We have Eric Lantz who's with the National Renewable Energy Lab. We have Gundula Hubner from the Institute of Psychology at Martin Luther University in Halle-Wittenberg, Germany and we have Pat Moriarty who is also with NREL.

Just to remind everybody we can type questions to the speakers and to this topic at any time during the Webinar and we'll address the questions after all three presentations are finished, so we'll do kind of a Q&A at the end. And you should see at the top of your screen there's a Q&A bar where you can type the questions and then again we'll do those at the end.

The webinar will be posted online at windpoweringamerica.gov, that usually takes about a week to get them posted but if you missed something or want to send this to somebody else we will have them posted on the website.

So I will introduce our first speaker, Eric Lantz. Eric is an analyst in the markets and policy analysis group at NREL. His primary research includes the study of current and future costs of wind energy and also economic development impacts from wind energy.

In addition Eric represents the U.S. in a collaborative effort of the International Energy Agency, focused on understanding public perception and responses to wind power. He holds a master’s degree in energy policy from the University of Colorado. So Eric thanks for being our first speaker and we can turn it over to you.

Eric Lantz: Great, thank you Suzanne. Good afternoon everyone, I'll be kicking this webinar off with a brief glance at some current NREL work that's actually ongoing that's focused on social acceptance and more generally what we've - at least for the time being labeled as deployment barriers.
We see deployment barriers as encompassing social acceptance, wildlife, radar and transmission obstacles or barriers to wind. I'll be giving sort of a high level general overview of this project and then the following presentations will provide you with a little more detailed insights on some explicit social acceptance topics.

Now before I get to far along I might say that what I'm presenting today here is preliminary, so please take that into consideration when you think about what's put in front of you. We have not fully vetted the material that's in my presentation.

In addition what I'm presenting today is for information and educational purposes only and we can't be responsible for any successful or unsuccessful business ventures that you might pursue as a result of what's contained in the presentation today.

My presentation this afternoon will have four primary components. I'll start with a brief background of this project, talking about some of the developer perspectives and their decision-making processes that we've gleaned from a series of semi-structured interviews with developers.

I will highlight how we are currently working to quantify the impacts from public acceptance and wildlife on the industry and wrap up with a few preliminary conclusions.

So our projects that's I'm going to be covering today really starts with kind of three primary premises. One of these is that regardless of the cost in performance of wind power projects, there are some projects that will not be able to be fully built and become operational because of non-technical deployment barriers.
And similar to this even if wind was unquestionably competitive on purely economic grounds, there would be many places or regions in the U.S. where developers would not be able to build because of non-technical hurdles.

In addition the current methods that are in use for developing research agendas and for understanding these non-technical barriers to wind are inadequate in some respects - in mainly two ways.

One they fail to accurately characterize the cost of the industry and two they fail to really clearly define the extent of the challenges faced by the industry. And so this project was formulated with the idea that these barriers must both be better understood in terms of their impact on costs and on - and the amount of developable land area that wind projects can occupy.

So as we look to kind of use those initial premises and turn that into a concrete project, there was really two primary objects that were developed. One is that we wanted to quantify the potential impact of barriers on the developable capacity for wind in the U.S.

And so we conducted a series of semi-structured interviews with developers, we looked at population density data, we looked at wildlife and what part of the - what wildlife habitats and how they're distributed across the U.S. to examine kind of what would be the impact on the amount of wind capacity that could be placed in the ground.

And then the second objective we kind of arrived at was to quantify the potential impact of barriers for installed costs and total system costs from something like a 20% wind by 20/30 scenario.

So at this point I'll take you through some of the initial findings that we received and insights that we developed from our semi-structured interviews with the development community.

First, the development timeline is generally five plus years. Increasingly the industry is being pushed from the investor side to be five years or less but from the regulatory side there's pressure to be five years and plus. And as many of you probably know because the regulatory side ultimately determines whether projects can be built or not, there's a lot of pressure to be five - to be, you know, more than five years of development lead time.

And this is a little problematic for the industry because the investor community really five years a long time for them to have their money at risk and there's a lot of pressure and it's very difficult for developers to make a business case for projects that at least coming into the pipeline appear to require more than five years to develop.

That being said we have heard of projects that have taken 10 or even 12 years to complete but those are certainly the exceptions and not the norm. Some of the things that result in extended timelines - they run kind of the five-year typical timeframe would be post construction wildlife work. If you initiate or trigger a NEPA process or a similar state level process for example in California or New York.

If you have to go in and revise the general county level land management plan, that's often times a public process with a series of public meetings and that can add as many as two years onto your development timeline. And then obviously if you have a litigious opponent present in the vicinity of your project there is an additional time requirement to address those types of concerns and engage possible litigation.
From the perspective of the developer, the longer the development time lasts, the more in capital must be invested to develop a project. What we found with our discussions with developers is that you're usually looking about $30 to $50 a kilowatt for a project - to develop a project that has little or no public acceptance hurdles or wildlife issues or for that matter radar transmission issues as well.

In some cases though costs can exceed even $150 a kilowatt and that's in the total installed cost. That's the share of total installed cost constituted by development itself. And from some of those extreme cases you can see that you can easily double or even triple what might be common in terms of expenditures for typical projects.

One example project that's publicly known is a 60-megawatt project in California that's been in development for eight years. The developer has put more than $6 million into the project, so that's roughly about a $100 a kilowatt. And in this particular case there's still no assurance that the project will be built.

Those numbers that I just referred are really pure development costs. We've also determined the mitigation costs so if someone has to come in after the fact and do additional wildlife work or curtail turbines or any number of kind of mitigation strategies. That's obviously an additional cost above and beyond what the 30 to 50 or even $100 to $150 a kilowatt that's noted for just the development itself.

Another key kind of highlight that's come out of our discussions with the developer community is that uncertainty in the development timeline is really probably the most significant hurdle. While it is difficult to justify development timelines of more than five years to the investor community, if you could say, you know, specifically that it will be six years or even seven years that would be palatable to some investors if they knew that that's what exactly it was going to require. But when you say it's well three to five years or five to seven years that becomes much more challenging for them to sell to investors.

In addition it's really important to engage public acceptance and other deployment barriers that we're analyzing as early and as regularly as possible. These are issues that you have to be aware from - aware of from the very first conceptualization of a project and you have to review kind of what the current issues might be as the project advances through the various development stages.

In addition adopting a strictly linear development approach does not allow projects to proceed in a way that allows them to be successful. You can't just take one step at a time if you were able - or if you only took one step at a time you would often be looking at possible over commitment and even a longer development time period than the five years noted on the previous slide.

In addition for these issues policy risk is significant. When you're looking at timelines of five years or more there's at least two political cycles in that timeline and that's a pretty significant risk for projects.

Finally a key finding that we've come across so far is that deploying the barriers alone aren't necessarily going to block project success. If you know that you have an off taker or you have a PPA contract signed, it's very likely that you'll spend more to resolve whatever deployment barrier related issues you might have.

But it does significantly increase the risk associated with projects such that if you have deployment barriers you're likely to avoid certain regions where they persist and pursue only those regions that are - have less concerning deployment issues.

The industry has also become more sophisticated in this space over time. There's been a few different areas or (EPOC's) in the way developers have prospected projects. In the early days people went out and bought simply as much land and as good of wind resource sites as they could find.

Then kind of the mid-term period between 2005 and 2010 you bought as much windy land as you could that was close to transmission and now the market has really shifted to focusing on where are the PPA's and where are the lowest risk projects and certainly the deployment barriers are a part of that risk calculus.

Within kind of the broader scope of the industry there are a number of variables that do shape developer strategies. So it's not just whether you have deployment barriers or not, it's also whether there's a demand for wind power, who your competition is, whether there's available transmission and then how close or approximate are you to specific protected or sensitive areas.

As the industry has matured developers have become much better at picking which projects are going to be successful but this also means that pipelines are smaller and the risks associated with any one project failure is actually greater in today's market environment.

I'm going to touch just briefly here on some insight (unintelligible) with respect to radar and transmission. It's a little bit off topic for the Webinar today but I did want to provide a few insights just to the group on these two issues for the time being.

So radar barriers are actually one type of deployment barrier that are less of an issue today. Some of the work done by the Department of Defense and the FAA in compiling information and databases on hazards and where radar towers are located or where sensitive towers are located is available to developers and has greatly facilitated their ability to identify and avoid potential radar hazards.

And generally today in most cases radar issues can be resolved through some sort of mitigation although there are still the exceptional cases where you have to avoid areas all together.

In terms of transmission, many of you know that transmission is a significant barrier to win projects. There's both issues with limited available - limited capacity and then the inability to effectively move power across different control areas.

Also the transmission and interconnection process is one of the more expensive elements. Transmission and interconnection itself, when I talked about that $50 per kilowatt development cost, that works out to be about a $5 million investment on a 100-megawatt project. Transmission and interconnection alone can easily double that cost making it in excess of $10 million and there's a lot of uncertainty in the interconnection process.

So now I just want to touch briefly on the second aspect of this project, which focuses on quantifying the impact of these types of issues on the industry. I'm just going to highlight public acceptance and wildlife here in this specific talk.

So for public acceptance what we've tried to do is look at population density, where turbines are sited today and what kind of set backs are typical for the industry. We initially developed the scenario that said that we wouldn't build turbines any closer than 1500 feet to a residence and that it would be an additional $75 - I'm sorry it would be $75 a kilowatt to build in the area of 1500 to 2000 feet from occupied residence. That's $75 a kilowatt versus $50 a kilowatt for a typical project or if there is no public acceptance hurdle.

We also came up with a more extreme case, which said we wouldn't build turbines any closer than 2500 feet and that it would cost $125 a kilowatt to build in any location between 2500 feet and 3000 feet within proximity to a residence.

We did modify these scenarios as we kind of - as the projects going forward such that we decided that regions with a population density or actually a residence density of less than two homes per square mile, you could put turbines effectively anywhere.

The idea there is that when you have a low population density like that it's highly likely that those residences or the individuals that occupy those residences would probably be leasing land to the projects and therefore be more willing to negotiate on turbine locations and how approximate they are to their homes.

This has been a quite revealing exercise. We've actually used some GIS data to create some maps based on these types of setbacks and we can see relatively significant impacts in terms of areas set aside that are no longer available for development. Particularly in the Midwest and the East. In the West obviously with the lower population densities it's not as significant of a problem but a large swath of land in the East and parts of the Midwest are effectively removed from developable potential when we apply even buffers that are of this magnitude.

In terms of wildlife we're using a similar approach though that's based more on the habitat area for sensitive species. We're looking at species that are at risk for collision, species that have habitat risks and then protected species. And effectively we've again looked at kind of broad based GIS data and identified, you know, what percentage of that land may be unavailable to developers should - based on kind of the current practices or regulations that are in development. And again I think we see a relatively significant removal of developable land area effectively taking projects off the table.

I will say I can only speak generally to the results for these - for this part of the analysis at this point in time due to the preliminary nature of the results but we do hope to publish some of this work at some point in the future and so you'll be able to see a lot more detail at that point.

Just some preliminary conclusions before turning the presentation - or the Webinar over to the next speaker, deployment barriers including public acceptance are very important to the industry but to some extent developers are really more fundamentally concerned about whether they have a buyer for power or not. Whether there's actually a demand for new wind projects or not.

And I think that's a reasonable and not to surprising conclusion. Ultimately there has to be demand for wind power first and then it becomes a question of well, where can we put wind projects and how much do we have to spend to develop them.

In addition, deployment barriers appear to have a larger impact on the developable wind area or the land that might be - have wind projects built on it but impacts the cost of energy are not trivial. We're talking about for development costs somewhere between two and five percent of total installed costs. So that's not necessarily going to make or break most projects but when you're dealing with a technology that's maybe only marginally economic or really needs to shave as much - shave as many costs off as possible even a few percentage points here or there can make a difference.

And just as a side note for this audience - for a public acceptance piece of that two to five percent is for a typical project about 20 to 25 percent but we have seen projects where dealing with public acceptance itself may effectively consume the full development cost budget. So you may have to spend $50 a kilowatt simply to deal with public acceptance issues plus an additional $40 or $50 a kilowatt to resolve whatever deployment barriers might be present.

And then finally analyzing the impact of deployment barriers on the industry is actually pretty challenging. We are making some, you know, gains and some steps forward in terms of quantifying the impact of public acceptance and other non-technical issues on the industry. But it's particularly challenged because many of the issues - these types of issues as you all probably know are very context specific and sometimes - in some cases the regulatory environment or the policy environment is changing and so that adds some complexities to our work.

So with that - that's my last slide and here's my contact information. You can feel free to give me a call or email me and I'll look forward to the Q&A.

Suzanne Tegen: Great thank you Eric for that really informative presentation. And next we will hear from Gundula Hubner who is as I mentioned before an associate professor at the Institute of Psychology at the Martin Luther University in Halle-Wittenberg, Germany. She leads the research group there for health and environmental psychology.

She and her research group have experience with a broad range of topics concerning the social impact and social acceptance of renewable energies. Supporting the German Ministry for the environment, she's a member of the International Energy Agency Task 28 on the social acceptance of wind energy.

She holds a diploma in psychology from the Christian-Albrechts University in Kiel and a PhD in psychology from the Universities of Kiel and Halle-Wittenberg. With her, and with Dr. Hubner today is (Johannes Pol), he is a research assistant in her group at the Institute of Psychology. He holds a diploma in psychology from the Heinrich-Heine-University in Düsseldorf and a PhD in psychology from the Julius-Maximilians-University in Wurzburg.

And his main area of focus - main areas of focus are biology - or biological psychology, specializing in stress psychology and neuro psychology. So we look forward to this next presentation.

So we look forward to this next presentation. Welcome to you Dr. Hubner and (Johannes).

Gundula Hubner: Yes hello this is Gundula and (Johannes) from Germany and thank you very much for the invitation to be with you this evening and we are very happy to join this meeting with you.

So we are going to read parts on some aspects of our work and this evening it's on the impact of wind turbine obstruction markings on residents. And the background of our research is that in Germany we are starting to (unintelligible) and also we have more turbines with an increased height that is above 100 meters and from then it's applicatory to have obstruction markings - aircraft obstruction markings.

Due to this in the last times we had more complaints but it was unknown whether it was really a severe stress that people experience or whether it's a few people who are very sensitive and this was also questioned for the regulations, whether it was necessary to react to this complaint or not. So that was the starting point of our research.

And to find out we were using a crazy experimental design - research design. That is we were trying to compare the different types of day markings. For this we have the (clear) markings, the LED markings and the red, white, red markings.

And another question was whether they have different impacts on residents due to the fact that they live in a simple landscape or in a complex landscape. How we define simple landscape - that's just a flat landscape like you have at the coast for example. A complex landscape is something hilly and other more marks in the landscape.

So our main question here was whether the three different type of day markings do have a different impact on residents. Furthermore we compared day to night markings and the night markings are just constantly red lights. That's the permission law in Germany so they are all the same.

And another question that was very important is whether the single windmills in one park should be synchronized or non-synchronized. We have two - both types of wind parks in Germany, where we do have synchronized windmills and non-synchronized. Non-synchronized is that they blink in different time periods so it looks like the stars in the sky at night.

The next question was whether it does make a difference whether this markings are lights - adjusted to light intensity. I'm not sure whether you know that, so when it's a foggy day the light intensity will be stronger and if it is a sunny day, a clear day you don't need so much light intensity and then it will be reduced.

And furthermore we were checking whether - yet how to describe persons neighbors who are highly annoyed to non-annoyed subjects. So that was the main area of our experimental design.

How did we proceed? Our method we used was, first we lay on stress in environmental psychology methods. I cannot explain this in detail now but we do have lots of message to measure stress for example or social acceptance.

And another point very important to us was to analyze moderators. For example the question whether people do own part of the wind farm, whether how old they are, how long they lived in this area and et cetera.

So we choose then to have 420 neighbors and those neighbors who would participate in our survey, they have to have view on the wind park, that was a precondition to include them in our study.

And we got people from certain different wind parks throughout Germany and we had found out that in the research conditions - in our research plan I just showed to you, they were comparable regarding age and other conditions.

And we made a questionnaire - our students drove up to the different wind parks and they put the questionnaires into the mailboxes of the persons. So to really make sure that they do have view on the wind park.

So the questions in there were 590 different items, I'm not going to tell all of them today but to some - to group them up we did have several stress indicators and it's very important to have several stress indicators to really make a - you have to be sure that you have valid and reliable data.

So we asked a lot about annoyance, somatic and psychological symptoms and also ordinary behaviors such as people are disturbed when taking a sun bath or taking a walk just around the houses. And we also asked them for stress coding activities as such whether they have installed blinds to keep the lights out of their houses, whether they stopped using certain rooms and such things.

Then we also asked on the general level the acceptance to (unintelligible) energy wind energy and also the specific park and we did this to compare whether the people have a different perception of the close by park or wind energy in general.

And of course to us it's also important to know whether the experience strain or stress of the structure markings, whether it's stronger or less strong compared to other turbine emissions. So we also asked for other turbine emissions such as noise and also landscape and of course source of demographic sectors.

So I'd like to show you some results - just selected results. We have more results, which you will find on the energy policy of course if you're interested. So what did we find out? One first result is the comparison between the three day marking types, (Xenon) LED and red, white, red.
And what you see if you look on this slide, you see that from the - I myself feel annoyed by the day marking zero is I do not feel annoyed at all and four is I feel strongly annoyed.

And what you see here are the means and - of the answers and what you see is that (Xenon) overall seems to be more stressful, more and more in compared to the other day markings. And the lesser annoying seems to be the LED marking but note that in general the annoyance wasn't very strong so the mean was just in the middle of the scale.

Then we have a look at the results concerning the synchronized to the non-synchronized wind parks and what we can see here again is that you see here a significant difference between non-synchronized and synchronized wind parks. The non-synchronized wind parks are overall more annoying compared to the synchronized ones.

And again in most conditions - cloudy day, rainy day or rainy night the people are not strongly annoyed but what you see is the cloudless night and here you can see that in this case the non-synchronized wind parks really reached the level of strong annoyance. So there seems to be a problem at the nights - of the cloudless nights if you have non-synchronized parks.

Though we have more of these results we just want to give you slight insight into our results and what I just told you about the (Xenon) lights. It was throughout several results we found this problem that (Xenon) lights are more annoying and also the synchronized ones - the non-synchronized ones, sorry.

So what we then asked the people also that - about how they experienced the light intensity adjustment and what you can see here is from this light that the people who did not have light intensity adjustment in the wind park close to them, they were more frequently and this is a significant results - more frequently applying blinds. And they also state less time in the bedroom and they were also taking more sleeping pills.

So and now we also come to the very brief comparison between strongly annoyed and non-annoyed residents. And first of all we have to say that we have only a small number of residents who were strongly annoyed that were 16% and these people were staying more at home, they were home workers.

And so what was important to us was to see that they have more health problems compared to the other ones and the wind farms were larger compared to the people who were less annoyed.

What does this tell us to us, it says that people who are sensitive, that if they do have more health problems might suffer more from the - from the wind farm compared to people who don't have these problems, just very briefly.

So then I come to the summary and the recommendations out of the many results we do have. First of all and that's a good message, overall we didn't find substantial annoyance. In just the single cases I just pointed to you just in the last slide, we see that we do have some strong annoyance for some people who are very sensitive for different reasons.

And it appears that they cloudless nights are the problem with (Xenon) and it's also a problem in the case you do not have light intensity adjustment we found out as well. And what we also found was that if people are annoyed by the obstruction marking, the stuff not only influence the general acceptance of the local wind farm or wind park but it does also influence their general acceptance towards wind energy.

And what we are - found out or doing are moderate analyst - analysis. I couldn't present them today because it's too much work for this evening - I mean too much time for the presentation but what we found by the analysis was that we did sort of find only one significant impact that is the strain during planning and construction phase.

People who experience the stronger strain during the planning and construction phase had a more negative attitudes towards wind - this wind park in general. So it seems to be very important sector.

So our recommendations is to use LED or red, white, red and don't use (Xenon) lights and to synchronize the wind parks, use the light intensity adjustment and what we haven't talked about yet is the demand orientated navigation lights. So that is the navigation lights just turn on when there's an aircraft coming close to it by a transponder or radar solutions.

That is what the people would prefer and would appreciate then. At the moment - sorry - at the moment we do have one project, one pilot project going on in the North of Germany close to the Danish border where we try to find out whether it's really working to convince the government to allow for this demand orientated navigation lights. It's not permitted at the moment but it would be a good solution to create more acceptance.

Yes and the last point that seems to be very important is the positive transparent planning and building profile. So I'm through with my presentation but I'd like to show you a small slide of the West Coast of Germany, it looks different to California.

And thank you very much for your attendance and we're welcome to answer your questions.

Suzanne Tegen: Well thank you so much from calling in all the way from Germany, we really appreciate it and that was a great presentation. I'm sure we'll have questions about it.

The next speaker that we have is Pat Moriarty, also with NREL. He is the lead of the aero and system dynamics group and has been here at NREL since 2001.

His research focuses are wind turbine design and systems engineering, statistic loads extrapolation, aerodynamics and aero acoustics of wind turbines.

He has developed design techniques to enable industry to more reliably predict loads and to produce less expensive designs. He's involved in the development of advanced turbine noise measurement instrumentation and has developed aerodynamic and noise prediction models used in wind turbine simulation tools.

Currently he's working on models for wind turbine wakes and ray affects using computational fluid dynamics. He leads an international energy agency task on wind turbine wake model validation and has published over 30 papers related to wind energy.

He also serves as associate editor for the journal Wind Energy, so you can see that is very well (unintelligible) to speak to us on wind turbine noise. And I will hand it over to you Pat.

Pat Moriarty: Thanks Suzanne, that was a - that was definitely a long introduction there. Okay so I'll just give kind a brief overview of wind turbine noise and some of the research that we're - that the community - the wind energy community is trying to address it.

So why is noise an issue? Obviously noise as we saw from the last presentation is another form of stressor for people. So communities typically have noise ordinances that must be abided by and of course wind projects must also abide by those noise ordinances.

So typically a community will have a noise ordinance based on something called sound pressure level that limits any insulation of wind turbines to about 40 or 45 decibels and I'll talk a little bit more about that as we go.

And so our projects are often limited by where they can put turbines based on those standards and then any complaints either before or after building the project from residents can either stop a project from being built or significantly curtail the operation making them less profitable.

And one way that the industry typically gets around or reduces the amount of noise from wind turbines is running in what's called noise-reduced operation. Basically slowing the turbine down but by doing so they actually also lose energy and lose money by doing that.

So before we jump in I just wanted to - I don't want to scare anybody with equations but just give a - some terminology here. The sound pressure level is kind of the most common noise measurement. It's a measurement that's measured in decibels so it's something that you'd see - noise restrictions, community noise levels. Those are often sound pressure levels.

And it's really dependent on the distance that you are from the objects because the farther away you get the lower the sound pressure level will also be. So just to give you an idea of changes in sound pressure level, the human ear itself can detect about a three decibel change.

The only less than about three decibels the human ear is not going to be able to detect and that three decibel level is also about the same level as if you were to double your distance from a noise source. So if you were 100 feet from a wind turbine and then you moved to 200 feet away from a wind turbine that would just be - the noise level that you would perceive would be just detectable by your ear.

If you were to increase or decrease noise level by about 10 decibels you would probably say to yourself that's about twice as loud as the level before. So those - all those numbers are just to give you an idea of kind of differences or changes in sound as we as engineers measure them.

There's also something called sound power level and this is actually a metric that's published wind turbine manufacturers. So if you go onto Web sites of manufacturers this value is often published of 105 decibels sound power level is a typical value for a wind turbine.

And you can actually convert one - a sound power level to sound pressure level. Sound pressure level changes with distance but sound power level stays the same. Another terminology is something called A-weighted. So you'll see decibels and you'll also see A-weighted decibels or dBA and really this is kind of a way that scientists try to mimic the behavior of the human ear.

So people are actually more sensitive to certain frequencies. Between about one and four kilohertz the human ear is most sensitive but then when you get to low frequencies or higher frequencies then people aren't insensitive and therefore probably not as annoyed.
So then going to using these metrics how loud exactly is a wind turbine and this is a pretty good chart from General Electric wind turbine manufacturer. If you're actually riding on the blades themselves it would be pretty loud. So 105 dBA and that's actually about the same as the sound power level, is about the equivalent of a lawnmower.

But then because the noise drops off so quickly, the noise will decrease as you get farther and farther away such that as you get out to maybe 300 meters or close to 900 feet the sound pressure levels are around 45 dBA, which is a typically kind of community noise standard level.

And then further decreasing the farther you get out. And so even on the slide it says but how does or wind turbines are not closed place or placed closer to wind turbines than about 300 meters.

So that's kind of how wind turbines sound depending on how close you are to the turbines but in some ways that not a complete picture of wind turbine noise. A big issue these days with wind turbine noise is something called amplitude modulation.

And so the values that we showed in the previous slide, those are just average over time but with wind turbine where the blades are rotating in time and the noise actually changes in time, the noise is definitely not constant in fact it's periodic and because of this - and that creates this amplitude modulation and that's what most people think these days is what makes wind turbine noise more annoying than other common noise sources like traffic or things like that. Things that are more steady in nature.

So I kind of call this problem the dripping water problem where if you're trying to sleep at night and you turn on your faucet all the way, it's a nice, you know, soothing white background. But if you just have it dripping ever so slightly you get that constant, you know, drip, drip or with a wind turbine it's actually swish, swish, swish. And that's really what's keeping people awake at night and causing a lot of annoyance.

And here's a look at what that looks like as far as dBA, this chart here you can see at its worst there's actually a fluctuation in decibels, between about 45 decibels and 38 decibels over a second. So that's every time the blade passes you get that swish, swish and it's a difference of about seven dBA swishes, which is pretty noticeable.

Alright, so what causes wind turbine noise? There's kind of two major categories. Mechanical noise, these are things caused by just machinery that are rotating inside the wind turbine. So gear boxes, generators and fans even the tower and the blades will move.

And then there's also aerodynamic noise and this is - usually the problem noise sources are from the blades themselves. So just the active of wind turbine blades rotating through the air, interacting with the air creates a lot of annoyance from the wind turbine.

And it's also proportional to the speed of the rotation. So the faster a wind turbine spins the more noisier it is, which is why is you look carefully the larger the wind turbine is the slower it actually rotates to keep those noise levels down.

And then this is just a chart of kind of relative contributions of noise from a wind turbine. As you can see here these are all sound power levels but basically as I just said in the last slide, aerodynamic noise is the dominant noise source coming in about 99 decibels.
Another big source are kind of the gearbox, kind of grinding noise that you might get from the cells and every wind turbine is really different. But really most people think the dominant noise source is from the blades.

But you have the production of the noise of the wind turbine but you can really break noise into three separate regimes. So there's the generation of the noise and there's the aerodynamic and mechanical noise sources and then you have the problem with how does the noise propagate as it goes towards someone's house or someone walking close to a wind farm.

And the atmosphere itself will actually greatly influence the noise as it's going towards an observer. So obviously how far away you are depends - or will affect the noise, the wind gradient. So how does the wind change with heights or distance? The absorption, if there's higher humidity noise gets absorbed and terrain, so terrain can be just kind of like a speaker - the terrain can act to either mitigate or amplify noise at different locations.

And then once your - and then kind of the third regime is the receiver or where you are. And so there - the receiver the noise can change depending on the ambient noise, if you're kind of in an urban area or someplace with a lot of machinery around. Obviously the noise from the wind turbine is not going to be as loud as your surroundings but if you're out in the country and you haven't had any noise sources there before then the wind turbines are going to be much more annoying.

The amount of time you spend indoors or outdoors has a big effect, even building vibrations. So sometimes wind turbines, especially in the old days they could interact with turbines - or sorry, they could interact with kind of houses. And people - and they could even vibrate people's houses a little bit, so - to the point where they were getting seasick. You don't see that so much anymore but that was common in the old days.

And then kind of the last bullet there is human perception. So this is kind of a big unknown, different people hearing the same exact noise at the same exact location can have wildly different interpretations of that noise. And I think Gundula - it seems like it's the same with the lights annoyance as well.

All right, so what are people trying to do about noise? Well the easiest thing to reduce noise is to move the turbines farther away from where people live, especially - or sleeping. And this is why one of the reasons why offshore windy energy is so attractive.

Unfortunately it might not be a pure path in that low frequencies tend to travel farther, especially over water. So there are instances in Europe where offshore wind farms have still led to noise complaints onshore.

Mechanically, all the mechanical components reducing the noise, that's actually fairly easy to do. There's a lot of technology out there, isolation mounts, just adding more insulation in the cells will also reduce the amount of noise.

Aerodynamically it's a little bit harder but the easier thing to do is enter this NRO or Noise Reduce Operation and that's basically just lowering the rotational speed of the turbine. But there is a price to be paid as far as energy that's produced, so there's a cost there.

Turbine manufacturers now are actually modifying blade shapes and the picture there on the right are - is a picture of a wind turbine blade with trailing edge serrations. And actually this is an easy add on thing that reduces the noise of the wind turbine blade by about three decibels. So a lot of manufacturers have this as an option on their wind turbine fleet.

And then the last thing is wind farm operation, similar to the light problem we saw in the last presentation. When wind turbines - the blade rotation actually gets synched up - synchronized, wind turbines within a wind farm. That may create a louder noise at certain locations.

So the opposite of the light problem what manufacturers are doing is desynchronizing the rotation of the wind turbine blades and that's lowering - hopefully lowering the noise for local residents.

And then this is just my last slide about who's doing what as far as there's a wide range of activities going on between industry and more fundamental research institutes. But everyone's interested in lowering the noise without sacrificing energy or power.

So at Universities and places like NREL, we're looking into more precise measurement techniques, so better understanding of the physics behind noise production. Coming up with better computer models of noise so we can better design wind turbines.

The affects of the atmosphere and terrain because they're largely unknown so a lot of work needs to be done there. Even perception, there's been a lot of work through the years on human perception of noise but wind turbine noise is a little bit different especially because of that amplitude modulation, more work is being done there.

Active noise cancellation, if anyone's familiar with kind of the Bose headphones, this is a similar concept that's a pretty high risk technology but may have some benefits. Amplitude modulation, that's kind of the big research focus these days. What can we do to mitigate that problem for people living around wind farms?

And then more on the technology side, already manufacturers are designing their blades to be quieter, the airfoil, there's just the shapes of the blades, also adding those trailing edge serrations. Most manufactures will do that gladly and then just operational strategies, so the noise reduce operation and also the wind farm operation. How do you optimize that for low noise?

So that's it as far as my presentation.

Suzanne Tegen: Great, thank you very much Pat and thanks to all of our speakers. We can now address questions and I think again you can go up to the Q&A box and type your questions in the Q&A box if you have questions.

And let's see, we have - I'll just start off, we have one question, which was just a clarifying question I think about Eric's presentation. So was - what was the scale of the scenario studied for NREL public acceptance evaluation and did you consider sub-megawatt or distributed or community scale wind projects at all?

Eric Lantz: Yes, so we can - I can clarify that pretty briefly here. We really did focus on utility scale multi-megawatt to a plus - megawatt plus turbine sizes. And in terms of the distinction between community or absentee owned projects, we didn't draw a specific line there.

The bulk of our information did come from developers who did not work in the community wind space, so I'd say our representation there is pretty minimal. I think that answered the question, really it is a focus on megawatt plus technology and kind of representative industry projects, which only includes community wind to a very limited scale.

Suzanne Tegen: Okay great and kind of a similar one for you Pat about how noise compares from distributed and sub-megawatt turbines to the utility scale in the megawatt and above wind farm.

Pat Moriarty: Sure, those small - smaller distributed winds - the wind turbines when they're operating normally can actually - are about the same noise level as a utility scale turbine. Some machines can even get louder than utility scale turbines because they often turn quite a bit faster.

But probably the biggest difference is the height of the wind turbine and so distributed wind turbines are much lower to the ground and there noise does not propagate as far whereas utility scale turbines can propagate farther just because they're higher up in the air and more people can see them.

Suzanne Tegen: Great, thank you. And we also have a question about the funding and where the funding is coming from for the noise research that NREL's conducting.

Pat Moriarty: Sure, so the funding that - for research that NREL is conducting comes from the Department of Energy and elsewhere there's industry funded projects looking at better blade shapes and a lot of governments, Australia has a big noise project going on right now.

So often it's governments and manufacturers are looking - are most interested in the noise funding.

Suzanne Tegen: And that is a good segue into one thing I just wanted to be sure and say is thank you to the Department of Energy for funding these webinar's as well. And again I wanted to make sure people know that these presentations that you've heard today are going to be available on this website in about a week or so.

They will have audio as well as the presentation that you can download there but you'll be able to get those on the windpoweringamerica.gov website. We do have one last question for Gundula.

Can the (unintelligible) be developed to study stress from lighting be applied to other social acceptance issues such as noise? And are you pursuing similar work on issues like noise?

Gundula Hubner: We are trying to also - we do research - no not we're trying but we're doing actual research on the noise problems where we also use an experimental - crazy experimental research design. And the most important part was to have the comparison between different conditions so that you can make sure which of the - which impacts are really measured.

And we also this part on the noise problem, we work together with physics who really do object to this noise measurement and we asked on the subjective level we asked the neighbors what they do experience and what time. So we try to bring together the objective emissions and the experience problems by the problem.

Yes we shall be happy to present the results maybe at another time, it would be great to exchange with Pat.

Suzanne Tegen: Yes great, and there's one question about your research here also that asks how many surveys out of the 400 distributed about the night time lighting study were returned and fully completed?

Gundula Hubner: I have to ask (Johannes). It was a difference between the different 13 wind parks but on average it was about 26%.

Suzanne Tegen: Twenty-six percent, great thank you. Okay, that rounds up our questions and we're running just a tad bit over to the hour I should say. But remember to - about the third Wednesday of each month we have these Webinar's at 3:00 pm Eastern Time.

And in November we'll be hearing about offshore wind and then, you know, each month we'll be sending out announcements for these webinars. So I want to again thank each of our speakers. Thank you so much, especially Gundula and (Johannes) for joining - taking time out of your evening all the way from Germany.

And to the Department of Energy's Wind Program for funding these informative webinars. And of course to all of you for listening, so we will talk to you again next month. Bye-bye.

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