UNDERSTANDING THE IMPACTS OF WIND TURBINE SOUND
July 13, 2010

Coordinator: Welcome and thank you for standing by. At this time all participants are in a listen-only mode until the - until Mr. Bob Grace begins to speak. He's President of the Sustainable Energy Advantage and Moderator of today's call. You may begin sir.

Bob Grace: Thank you. I'm going to need control put over to me for my - to advance my slides please. Thank you.

Okay. Welcome. This is Bob Grace with Sustainable Energy Advantage. Welcome to the New England Wind Energy Education Projects Webinar Number 2.

We have a lot of folks on the call today, which we're very excited about. I know we have a topic that many are interested in. So we're going to plunge right in here.

I wanted to start by giving a quick overview of the New England Wind New Energy Education Project or NEWEEP, it's objectives, the project description and funding. First of all, the objectives of the project are to provide citing decision makers and other potentially impacted members of the public with objective information on which to make informed decisions about proposed wind energy projects throughout New England.

We do this by collecting and disseminating accurate objective up to date information on critical wind energy issues impacting market acceptance for the hundreds of land based and offshore wind projects being developed in the region. The objective here is to enhance the region's public acceptance of appropriately sited wind energy generation.

Now the NEWEEP project is a three-year project, which will run through December 2011. We are scheduled to deliver at least eight Webinars as well as a full day in person conference next spring; this is the second of our Webinars. And we will also provide additional out reach and awareness. The Web based home for the Webinar related information will live on the New England Wind Forum. We'll tell you how to get there later in the Webinar.

The NEWEEP project is funded by the Department of Energy. In late 2008 DOE sought proposals under a project looking for input on market acceptance. The NEWEEP project was selected in 2009 for grant funding as part of Wind Powering America's Market Acceptance Program. So one important point here is that this effort is not industry funded.

The grant co-applicants were my firm Sustainable Energy Advantage and the National Renewable Energy Lab. Our role is as coordinator of the project. And the project is directed by a steering committee consisting of New England state agencies, regional and national research organizations, New England's regional grid operator, all of whom have committed to participate in the project. Those Webinars are going to be moderated this one by myself or by NREL or by other guests with particular expertise.

Here I'm put up on the screen the slate of our steering committee members again ranging from national labs to state agencies to ISO New England. The - and again you can tell that NEWEEP is neither industry funded nor industry driven. That's been a critical component of our - of our effort here to attempt to bring information that is not seen as tilted one way or the other. And in fact let me talk a little bit more about the philosophy.

The philosophy of the project is to seek out objective information. What do we mean by objectivity? Well the philosophy is that wind energy has benefits but that not every place is going to be the right place for wind energy generation.

And perhaps a framing principle from what we found the consequences of wind power are rarely as dire as made out to be by organized opponents and they're often not as free of consequence as wind proponents would hope and sometimes represent.

Our approach is to seek knowledgeable speakers who can convey with credibility and objectivity and address the research that's been done on various topics and the various points of view. The content we look to present is to provide what is known and what's not known. You'll certainly here today that there is a lot that is not known about impact of wind and sound.

We focus on the speakers who can present their own research or reviews of literature focusing on scientific of peer review of research and studies. In addition, we will create a literature review an annotated bibliography of references on the subject matter, which will include that scientific and peer review of research but also extend beyond that to other writings on the topic.

Those resources will be made available on the project Web site and we hope to end every Webinar with a discussion of mitigation issues and identifying future research needs.

We welcome Webinar participants question and answer. That's a critical part of the platform. So we'll talk a little while later about how we're going to run that. And again the repository for the Webinar materials will live on the New

England Wind Forum Web site, which is maintained by National Renewable Energy Lab.

So today’s Webinar - well actually a moment - a word about objectivity before I introduce our speakers. Objectivity is in the eye of the beholder. Collectively the NEWEEP team, the grantees, the steering committee are aiming to deliver on that goal but ultimately we won't be able to please everybody on that front.

So it’s important that we acknowledge that even though NEWEEP is not industry driven or funded, we the coordinators, many of the Steering Committee members are involved in activities that are aimed to support wind industry growth.

We’re hopeful that we can diffuse those concerns that if we’re moderating this, if we’re coordinating this, we’re not objective and therefore by association this whole Webinar series isn’t objective.

First despite or perhaps because of the roles of the grantees and many of the steering committee members who are looking to increase the role of wind, individually and collectively we all acknowledge that like any electricity source, wind power does have impacts. Our stake is in the NEWEEP process and the outcome.

There are hard decisions to be made. Decision makers in the public need to be armed with good information, and that information solely from parties whose goal is either to build or obstruct specific wind projects. And at the end of the day unless wind can be sighted appropriately, policy goals aren't going to be met.

So we're doing the best job we can at trying to get at the object knowledge. The best way we know how to is to put ourselves in the shoes of those who are being asked to be neighbors of the wind power facility. Some day we may be asked. And if it were me, I'd want to know the research the facts and the data.

We want a good outcome. That's why we want a fair presentation of these issues. We'll never be able to convince everybody that NEWEEP doesn't have a bias but we'll try.

And the way that we gather our speakers and the way we provide annotated bibliographies including gathering data and positions that our counter to the speakers conclusions and posting all of that on the Web site and the way we conduct our Q&A sessions. So we're doing our best job to make sure that this is a search for the answer and not one that starts with the answers.

So on that note, I'd like to introduce our speakers. I'll introduce the whole panel now and then we will turn the floor over to our speakers in sequence. Our first speaker is Mark Bastasch who is a registered professional Acoustical Engineer with CH2M Hill.

He will speak to us about an introduction into sound and wind turbines, some of the scientific underpinnings of our discussion. His experience includes preliminary sighting studies; regulatory development and assessments; ambient noise measurements; industrial measurements for model development and compliance purposes; mitigation analysis; and modeling of power, industrial and transportation projects.

His wind turbine experience includes some of the first major wind developments in the country including the state line project in the Northwest.

That was built in 2001. At the time was the largest in the world. He serves on organizing committees of the Biannual International Wind Turbine Noise Conference first held in Berlin in 2005.

Our second speaker is Jim Cummings. Jim is a writer, editor and father, director - I'm sorry, Executive Director of the Acoustic Ecology Institute. And he will present to us on wind farm noise, public perception and annoyance. His long-time work has been writing for a lay audience about science and the environment, which led to the founding of the Acoustic Ecology Institute in 2004.

Since then AEI has become a leading source of clear unbiased information on a full array of sound related environmental issues. Agency staff scientists are among their most enthusiastic supporters and users of the news and science summaries and special reports produced by the institute.

Jim has twice been a plenary speaker at the Alberta Energy Utilities Board Biannual Noise Control Conference. Has been an invited presenter on ocean and wind farm issues in Canada, the U.S. and Ireland.

He is the author of many freelance magazine articles including Listen Up Opening Our Ears to Acoustic Ecology and several others. And is the Executive Producer of 11 earth year environmental sound art CDs. He received a BA from Wesleyan University and an MA from John F. Kennedy University.

Our third speaker Ken Kaliski will be speaking to us about wind turbine noise regulation. Ken is a Managing Director at Resource Systems Group, a consulting firm located in White River Junction, Vermont. He is a licensed

Professional Engineer, is board certified and serves as Vice President for Board Certification at the Institute of Noise Control Engineering.

Mr. Kaliski has been involved in wind turbine acoustics since 1994 and conducted the nose impact study for the first large wind project in New England at Searsburg, Vermont.

Since then he's worked on many projects involving wind turbines in New England and throughout the U.S. He's written several articles and papers on wind turbine noise and presented in such forums as Wind Power 2008, the National Wind Coordinating Collaborative, the Acoustical Society of America and the Institute of Noise control Engineering.

So at this point, I will turn you over to our first speaker. When we are done with the three, we will return and open up the lines and start a Q&A session. At that point, I will give some instructions to participants for asking questions.

I would suggest however - actually if the controller could give me the ability to flip to one more slide please. Well, I'll return to the Q&A instructions when we're done with our last speaker. Why don't I turn it over at this point to Mark Bastasch. Mark, welcome aboard.

Mark Bastasch: Thank you. Okay. Looks like I've got control now. Thank you. Again thank you for the opportunity to speak this afternoon. My name again is Mark Bastasch. I'm an Acoustical Engineer with CH2M Hill. I'm based out of Portland, Oregon. Oregon is one of the few states that has a PE in acoustics.

The purpose of my presentation here is really to provide a brief introduction to sound and wind turbines and some of the terminology used in acoustics. This can be a very technical subject matter and this is by no means an exhaustive review of the subject. I have tried to keep the equations to a minimum to illustrate a few key concepts.

First I'll start with a discussion of what is sound. Sound is a rapid pressure fluctuation above and below the static atmospheric pressure and the sound level is measured in decibels. Typical sound levels that we are likely familiar with include freeway traffic, which relatively close to the freeway may exceed 70 decibels. Interior levels are typically on the order of 30 to 40 decibels.

The typical audible range of a human ear extends from 20 hertz to 20,000 hertz. Hertz are used to quantify the tonality, the base or treble of a sound. Those with graphic equalizers on their stereo systems may be familiar with the term. Those who are musically inclined middle C on a piano is approximately 260 hertz while lowest C is approximately 33 hertz.

Infrasound is considered to be sound below 20 hertz. And low frequency sound can overlap the infrasound range a bit considered to be between 10 hertz and 2,000 hertz. The threshold of hearing is generally higher for lower frequency but all frequencies are audible if the level is high enough.

When we talk about sound and how we measure it and hear it, how we talk about it in terms of sound pressure levels. This is a logarithmic quantity and as we see here a sound pressure level of 94 DB, a fairly loud sound, is a function of small fluctuations in pressure.

This is a common chart that shows sound pressure levels for various sources, their decibel level and their relative energy. There’s a very large variation in absolute pressure and energy between a very quiet sound and a very loud sound. This spans many orders of magnitude. There’s one reason why we deal with sound levels in terms of decibels.

It is also important to note that charts similar to these are in terms - are generally always in terms of sound pressure levels, not sound power levels, which will be discussed later. These charts are also indicative of relative levels. They do not mean that all sources the same level will sound the same.

Now the math in acoustics is not normal math based on logarithmic quantities. So when you have a source of the same level that is added to another source of the same level, the increase is 3dB. That is a 50-decibel source and another 50-decibel source will equate to 53 dBA.

This is generally considered the threshold of a perceivable difference when comparing similar sounds. When a source is 10 dB louder than another, there is no incremental change. The main point here is that 50 plus 50 does not equal 100 when we are talking about sound levels in acoustics.

When we combine sources of the same level, the increase will depend on the number of sources. If we have two sources, the sound level as we just discussed will be 3dB greater. If there are ten sources combined level, it will be 10dB greater and so on as shown here.

This simplification holds true when we're talking about sources that result in the same level at the point of reception. If you've got various sources that contribute various levels, you have to use the logarithmic sum, which was shown on the previous slide.

The sound power levels are different than sound pressure levels and is a measure of acoustical energy. This is typically what is used to develop a sound model. On an energy basis, one watt of acoustical energy results in a sound power level of approximately 120dB.

(From) a pure energy standpoint again we're not talking about a lot of energy when we're talking about sound levels. This is a distinction between sound power levels and sound pressure levels and I'll touch on a little bit further here as well. But I think it can be a point of confusion when reading technical reports and analysis.

Sound, power and pressure levels are related quantities but it's important to note that a sound power level is independent of the distance of a source. Think of it as the wattage of a light bulb. Sound pressure level, what one hears or measures, does vary with distance. The sound pressure level is used to quantify the sound emissions of a source, specify the distance such as 60 DBA measured at 100 feet.

Again, although sound power and pressure levels are interrelated quantities, they cannot be directly compared. The sound power level takes into account the size of the source and is a calculated quantity. It is not appropriate to say a source of the sound power level of 120 DB and compare that level to a chart of sound pressure levels that we discussed earlier.

This is a chart based on pure tone equal loudness. Anyone who's had a hearing test recently may be familiar with what a pure tone is. The dashed line here represents typical hearing threshold for a normal ear.

We do not hear all sounds equally. Our hearing is much more sensitive to high-pitched sounds. A low frequency sound has to be at a higher sound pressure level to be audible. And as we see here as the frequency lowers, the audible range is compressed leading to a more rapid rise in loudness as the sound pressure level changes to lower frequencies.

There are many metrics used in acoustics. One of the more common metric is the A-weighting. The A-weighting is primarily used in the realm of permeating an environmental noise analysis. The A-weighting reflects the sensitivity of the ear to low or moderate sound levels and that has the inverse shape (of) these lower sound level curves.

The C-weighting was originally intended to measure louder sounds has a flatter response similar to the higher loudness curves; would be these levels. Both weightings are now used independent of level and the C-weighting may be used as an indicator of high levels of low frequency noise, which is important to look beyond the C-weighting at the actual frequency spectra.

I touched briefly on the nose generating mechanisms associated with wind turbines. The primary one aerodynamic noise is the noise of the blade passing through the air. The trailing edge of the blade is noted to be the most important surface.

The noise level is generally proportional to the tip speed raised to the 5th power. There are various complex mechanisms at work and our typical noise control solutions of enclosures or silencers are not applicable. It requires an aero acoustic design of the blades.

There are several mechanical sources of noise associated with wind turbines. These include gearbox - the gearbox, the generators, yaw drives; that is the motors that rotate the turbines into the wind as well as cooling fans. Standard noise control measures are used to mitigate these and aerodynamic noise remains the likely dominate source.

There have been several very detailed evaluations of noise emissions from turbines. This is an acoustic picture showing that the majority of noise such as with this testing is from the trailing edge of the blade, not necessarily the blade tip.

The turbine sound emissions or sound power levels are calculated in accordance with an IEC protocol, IEC 61400-11. The microphone is mounted on a ground board at a specified distance. Measurements are collected with and without the wind turbine operating.

From this the sound power levels are calculated. They are calculated much more detailed than A-weight or C-weight or any weighting. My recent update here is going to require 1/3 octave bands between 20 hertz and 10,000 hertz being incorporated.

They have historically been referenced - they have historically been referenced to a 10-meter height. This is likely to change to hub height to avoid potential confusion. I'm seeing a note here I need to speak up. So hopefully next one here will improve.

Okay. So as this is a measurement technique used to determine the sound power level, leaving the microphones on the ground for long periods of time makes them susceptible to damage and long-term background monitoring or operational measurements are typically collected in a different manner. Again this is - the IEC method is a method used to calculate the acoustic sound power level.

As far as the adverse affects of sound, hearing loss is generally associated with levels above 80 to 85 dBA. Task interference is generally associated with levels above 70 dBA. Beach interference is generally occurs at levels between 50 and 55 dBA when voices begin to raise during normal conversation.

The guidance for sleep disturbance varies and is often based on transportation sources which may be characterized by loud intermittent events such as over flights, train or vehicle pass bys. Then there's always the potential for annoyance.

Characteristics that may inclusive - increase annoyance include tunnel components; that is a discrete whine or hum. There is also the potential for swishing or whishing noises of the blades, which may result in some change in sound level over time.

This is referred to as amplitude modulation. This is typical of most wind turbines and it is not low frequency sound nor infrasound thought it has often been confused as such.

A study conducted by the University of Salford in the U.K. evaluated levels of - at over 130 operating projects included that additional study on excessive amplitude modulation was not warranted. So it is recognized as an audible characteristic but it is typically not problematic.

With regards to infrasound and low frequency sound, infrasound from wind turbines is not perceptible and does not exceed levels produced by natural sources. Low frequency sounds from wind turbines are not distinguishable from background sounds for frequencies less than 40 hertz. At frequencies greater than 40 hertz, that may be perceptible under certain conditions.

The audible swishing sound as we noted is typically in the 500 to 1000 hertz range and it is neither infrasound nor low frequency sound. There is a different in the way sound attenuates in the atmosphere. Low frequency sounds are not attenuated as rapid of a rate as high frequency sounds.

For example here, a 250 hertz at a distance of about 1000 meters or 330 feet, we would see a - we would see a one decibel drop due to atmospheric attenuation or as a 2000 hertz we see an eight decibel drop.

With regards to wind sheer and potential for - with regards to wind sheer and potential for masking, increases in wind speed do typically yield increases is background sound levels. At the same time, sound emissions generally from wind turbines also increase with increasing wind speed.

Wind sheer is a measure of how wind speed increases with height and the ratio between the wind speed at ground level or any - or between two elevations will vary based on the number of factors.

When you - when potential for wind sheer is not evaluated, turbines may reach their maximum sound power level under low ground level wind speeds. This is particularly true when turbines are located along ridgelines. Under this situation, you may not have very high ambient or background levels.

It is therefore helpful to consider evaluating a project at its maximum sound power level irrespective of wind speed. And it’s also important to avoid implying that project will be silent or completely masked by the sound of the wind.

With regards to the federal environmental noise policy, this slide shows ample regulations has as simplified their policy to a couple slides. Generally we see that they are regulated in terms of either Leq, which is the hourly average - generally an hourly average level; or DNL or Ldn, which is the day night average and the 24 hour average that includes a ten decibel penalty for the nighttime hours.

For example, the Federal Energy Regulatory Commission for FERC has established a 55 Ldn threshold. For a continuous source that operates at the same level 24 hours a day. That would equate to a 49 dBA Leq.

Alternatively, it would equate to a source that equated to 55 dBA during the day and 45 dBA at night. The U.S. Department of Transportation Federal Rail and Transit Authorities are really the only federal agency that have established firm incremental guidelines. They are shown on this slide.

Again, it's an Ldn based threshold and they show varying thresholds based on existing noise exposure whereby the existing - the allowed increase decreases with increasing existing exposure.

There are several ways to regulate and Ken will touch on this later. But they basically all deal with the concept of either a relative limit or an absolute criteria or high rate between the two. (When) we're dealing with a relative limit, we need to define increase over what.

There are many metrics that can be used in acoustics. There's the average level. There's the median level. There's the level exceeded 90% of the time. As we see here, below is a - below is a correlation of sound level with wind speed.

And so the questions that regulators and others need to address is how do we address perhaps the scatter that we see in this data. We are dealing with natural systems. Do we draw a line down the center of that data to draw our correlation? Do we look at the lower end or the higher end of the scatter?

How do we deal with increases over existing levels? Do we establish a maximum level beyond which levels should not be exceeded? And how do we want to assess the variability or the scatter in this data? And finally, is wind really to be evaluated differently than other sources?

Lastly, I think it's been noted by many that non-acoustic factors may be important as acoustic factors and the wind - and the planning and execution of a successful wind farm. Visibility, attitude and understanding of the necessity of the source play a key role.

The public relations and outreach is imperative. Field trips to operating facilities are likely more reasonable now given increased development and should be encouraged and, you know, people should be above to visit facilities both during the day and nighttime hours under a variety of operating conditions.

I think it's important to note that silence is not a reasonable goal nor should it be implied. It's helpful to coordinate construction and startup activities to avoid conflicts with the neighbors, ensure that local communities and landowners understand the benefits and to respond to any concerns as they may indicate a potential maintenance issue.

That I conclude and I hand over control.

Bob Grace: Mark, thank you very much. At this point, Mark has given us the - some of the fundamental tools for our discussion of sound. Now we'll turn it over to Jim Cummings who will take over control here. I will remind you again that we will be taking questions for the panel after each of the three panelists are complete.

And I'll turn it over now to Jim Cummings. All yours Jim.

Jim Cummings: All right. Thanks Bob and thanks for allowing me to be part of this session here.

What I'm going to address today is that in addition to the sound models and the other quantitative research taking place, we also have access to a body of information coming from people that live near wind farms. What we might call quality of life issues or qualitative data.

So this presentation's going to look at public perspective and annoyance and we're going to include some experience and reports from wind far neighbors and research into annoyance rates around wind farms and a larger body of work in noise sensitivity.

I'm going to move through quite a lot of themes fairly rapidly. So I'm going to encourage you to come back to these slides online and take a bit more time to ponder all this.

So the heart of the challenge around noise is that while sound models tell us that wind farms ought to be quiet enough to live within them, hundreds of wind farms worldwide are operating without all that many complaints. And they're not as loud as a lot of other industrial and infrastructure noise sources.

We're still finding that especially in farm and commuter country, we're getting far more noise complaints than were expected. So the question is are these rare exceptions, just a few individuals? Or are there more people being affected indicating weak spots in our models or power feeds that could be addressed?

Before I head into the heart of the presentation, I'm going to start off with a couple of kind of key points that I want you to keep in mind as context for everything else I'm going to talk about.

The first is the noise issues are seem to be the exception rather than the rule. The vast majority of noise issues occur within half a mile or so of wind turbines. And even in this area half or more of the residents are not generally that bothered. There’s very few noise issues beyond 3/4 (mile). A lot of wind farms are this remote and are generally free of incident.

The second point is also equally important. And that is that in rural areas annoyance rates in relatively close to the turbines are often over 20%. Especially in especially quiet rural areas the noise issues often become more than rare exceptions within the half mile or 3/4 of a mile. And fairly often can affect 1/3 to 1/2 of this particular nearby population especially when the noise is above 40 decibels.

And here’s the three main questions that I'm going to address here in the next 20 minutes. What are some of these experiential reports that we tend to hear repeatedly from people living near wind farms? How common are these negative experiences? And then at the end of that try to make a little bit of sense of the fact that in a given community you have people responding very differently to similar sound load.

But anyone that’s been following this issue for any period of time, this list of the types of experiences that people living near turbines are having will be familiar. I'm not going to read this slide or the next few slides. I'll let you scan them while I just give some context.

I'm going to focus in a little more detail on two of these that have not gotten quite as much coverage in the press though they're very common to people around wind farms.

The first is that the noise can seem to be very louder intrusive even when it's at a objectively fairly moderate decibel level. This may largely be because of the exceedingly quite background sounds - background sound levels in a lot of rural areas which can be as low as 25 or even 20 decibels especially at night so that a 40 or 45 decibel sound stands out quite.

Another interesting thing is that a lot of wind farm neighbors have noticed that the turbines make very different kinds of sounds in different wind conditions. This is a factor that makes it especially hard to get used to the sound. Definitely not just a gentle whishing that you kind of gradually get used to. When there are changing sounds coming from a given turbine, that's going to make it a little more difficult to just learn (unintelligible).

Now at the same time we do want to note that the qualitative response for a lot of wind farm neighbors is that the sound is really no big deal even when they can clearly here it. This is part of what we're going to try to address here at the very end of this presentation to try to understand how it is that people can have such different reactions (unintelligible).

So how common are these negative reactions? From the industry side you get the impression that it's very few individuals, often people who just don't like the wind farm and from community advocates you can get the implication that almost anyone that hears the wind farm will be driven crazy by it. And of course not surprisingly it seems like the reality is somewhere between these two extremes.

There have been these two recent issues I'm sure you've heard about around New England in Vinalhaven and Falmouth. In both cases we're finding that about 1/3 of the nearby families are struggling with the noise. Vinalhaven, 5 out of 15 year round residents have formally complained about the noise (impact) on their quality of life. Several more have been dealing with their moderate annoyance and trying to get used to it.

In Falmouth, there's been 12 formal complaints which is a relative high number of formal complaints; well know that only a small portion of those who are struggling with an issue with actually file a formal complaint. Seems like more informal reports again look like about 1/3 of the people within a mile or so are having some struggles with it.

But the best and clearest overall picture of the prevalence of noise problems around wind farms comes from a series of large surveys in Scandinavia that happened over the last decade. Here in green you see the three main studies. The next few slides will include several charts that look at this data.

There's been an ongoing series of papers from this research team looking at the data from different perspectives. And tracking these researchers is a good way to stay current on what's being found from this. So far only ongoing research project looking at annoyance.

This chart gives the best overall view. It shows all three studies and the blue or purple bars, the tallest ones, are a study that took place in a rural area. The red or maroon bars, the lowest ones, the study that took place in an area that was 75% suburban. In the yellow or in between bars took place in an area that was about 70% rural.

So we see this clear pattern. The annoyance is quite a bit higher in rural settings than more built up areas, about 40 decibels. The people who said they were very or rather annoyed topped 1/4 of the rural population. In the totally rural areas you can see topped 40%.

And even at 35 or 40 decibels, a level that a lot more people here because it includes an area much larger around the turbine, the annoyance was 15 to 20% in the rural area.

Now this chart takes another - or a different angle at looking at the data. We're seeing all five of the one to five ratings that people gave to their annoyance. The bottom dark purple is people that were very annoyed and the light blue or light purple at the top is people who didn't even hear the turbine.

What we find here is that the very annoyed proportion likes to over 25% - I should also mention this was two of the studies combined and just about 50-50 suburban residents. So the - we're seeing three things that caught my eye on this chart.

The very annoyed spiking as the sound passes 40 decibels up to over 25%. The slightly annoyed is the yellow. And this isn't - this is not tracked as annoyance by the researchers. They focus in on just the four and the five on the five-point scale, the dark purple and the light blue.

But it's interesting to see that people who were slightly annoyed just about doubles the numbers of those that are marked as more annoyed. But equally interesting is that red or maroon section, the big chunk. These are people who hear the turbines and aren't bothered at all.

So overall what they found is in moderate wind farm noise seems to trigger about twice or little more annoyance than is caused by other typical noise sources at the same level. But here at 45 decibels, roads and airplanes cause 5 to 10% of the people hearing that to be annoyed whereas wind farms a little over 20%.

So as we consider these annoyance rates, both the fact that large numbers are not bothered and also that the minority who is can be quite large, just a few factors we should keep in mind.

First of all, annoyance doesn't necessarily imply a constant plague. For many of the people who reported annoyance, it’s occasional and temporary. Of the people in the Scandinavian studies who reported any degree of the two higher levels of annoyance, about half were disturbed just once or twice a week; about 1/4 daily or nearly daily; and the other quarter less than once a week.

About half were bothered only outside and the other half were also bothered inside their home. And a third or less of those who are annoyed reported any kind of physical or health affects including sleep dysfunction.

Now there’s a couple of correlations that are often noted. There’s a tendency to be even more annoyed when you can see the turbines and this is sometimes presented as evidence that people just don't like seeing them and also report being bother by the noise.

However, there are a couple of perceptual reasons that there’s - there are concrete reasons that seeing the turbine will tend to make you notice it more. The strongest is that when turbines in the line of site, there’s going to be more sound transmission and more variety of sound getting to you. And also there’s this perceptual affect where when you see the turbine, it’s going to draw your attention to it.

Annoyance is also strongly associated with a negative attitude toward turbines. However, in the Scandinavian surveys, those attitudes were measured concurrently with already being annoyed or not. So the causality isn't crystal clear.

Three are other studies that did do some research before the farms were build and there is a partial correlation between the negative attitude toward wind farm and later being annoyed by the noise. But it does not explain away most noise issues.

You have to remember that the high proportion of annoyance is mainly when it’s over 40 decibels of sound. In the Scandinavian studies the vast majority of residents did not experience 40 decibels. Though when farms are built in and amongst existing homes and many of them are within a half a mile of homes, there’s a good chance that a higher proportion of that population might regularly hear the sound load.

When we look at the overall annoyance figures in those Scandinavian studies, they can look kind of - pretty reassuring. Among all the people studied in these studies, which studied to go out to a mile or a mile and a half from turbines, 9% expressed the high degrees of noise. In the rural areas it was 13%.

But over 1/3 of these people didn't ever hear the turbines. So if we just look at the ones who are close enough to actually hear turbines, then what we’re seeing is 15% annoyance over the whole overall three studies and a little over 20% in rural dominated.

So how do we make sense of the fact that some people are so annoyed while many others are - hearing that same sound aren't particularly bothered at all? Well the Scandinavian researchers did a very interesting interview study where they did in depth conversations with people on the two ends of the spectrum; who are hearing a similar sound level and they talked to people who weren't annoyed at all and the ones who were very annoyed.

And what they found is actually very fascinating. We saw that annoyance tracked really closely with these two ways of viewing the rural lifestyle. For some people the countryside is a place for economic activity and technological developments and experimentation.

These people like new machines and technologies. They tend to be indifferent to sound exposures. When there is turbine sound, they experience it as something outside their territory.

Countryside is a place for peace and restoration is a different attitude that a lot of rural people have. And for these people looking for peace and quiet, sound and flicker become disruptive. And when there is turbine noise, they experience it as intruding into their space and privacy.

Now I'd say this way of viewing living in the country makes a lot of sense to me. I've lived in rural areas most of my life and I know a lot of people of both of these types very well. So it’s a very kind of interesting overview that these folks came up with.

Now parallel to this there’s a 40-year body of research of noise sensitivity. This is psychology research and noise sensitivity is an innate personality characteristic. It’s not something that we control or change. And from all the different directions the people have looked at noise sensitivity, there's a fairly consistent breakdown in population they found, where about 20% of people are noise sensitive. And for these folks there's a good chance that any audible sound will catch their attention and potentially be bothersome.

Conversely, half the population is noise tolerant. These people don't really pay attention to sounds. Even moderate noise levels they won't even notice it a lot of times. And even loud noises only bother them once in a while. In between, 30% of the population are what they call moderately noise sensitive. People notice sounds but the reactions depend on the sound itself and the situation.

In terms of looking a wind farm annoyance, the things coming out of this research is the most interesting or that the differences between how a noise sensitive a noise tolerant person responds to sound are most striking with soft and moderate noise levels which is exactly what we have around wind farm.

In particular noise sensitive people experience more arousals during sleep. Sleep will be more disrupted again, especially at a low sound (unintelligible). But perhaps most interesting in terms of working with communities is that researchers in both of these lines of study have found that there's a strong tendency for people on the opposite ends of the spectrums to have a hard time understanding the other type.

The noise sensitive people find it hard to imagine that anyone could tolerate the noise that's bothering them and vice versa. And the work land type people understand the extreme reaction to their neighbors who are looking for peace and quiet or those restorative type identity people have a hard time imagining how anyone could not be bothered by the noise that's driving them crazy.

What I found from looking at both place identity and noise sensitivity research was that they're surprisingly well aligned with what we find for annoyance rate. The wind farm noise is below 45 decibels, we're finding half or more aren't noticing it or aren't bothered by it. Well, this is the noise tolerant half of the population and also likely to be a similarly large proportion of farmland population sharing that rural identity of technologic innovation.

On the other end of the spectrum, as soon as the wind sound becomes - wind turbines become audible and so those 25 to 35 decibels, you start to see the annoyance rates creeping up toward 20%. Well, this is that noise sensitive chunk of the population and the restorative place identity folks who are going to be annoyed by any audible sound coming from technology around their home.

So most interesting is the moderate noise levels, 35 to 45 decibels because that's when the annoyance really begins to rise, the 20 to 45% in rural areas. But what we're seeing here looks like those moderately noise sensitive people beginning to be bothered as the noise becomes more notably audible and intrudes in some of the core activities or more of those in that restorative peace and quite rural identity camp finding their quality of life being impacted as the noise levels increase that much more above the background.

So what can we do with this information about the rates the qualities of annoyance that seems to be happening around wind farms? I'm going to close with just a few suggestions.

First, assessing place identity patterns in a community could help customize noise standards for that location. Definitely more negative reaction in areas that have a substantial population looking for peace and quiet.

We also have a pressing need for better analysis like the Scandinavian studies with annoyance around existing wind farms in a variety of settings. Are there common qualities to wind farms that have lower than average noise complaints or higher than average complaints? We should be replicating our successes and avoiding the areas that are likely to spur a problem.

Expectations are definitely key as Mark mentioned especially acknowledging that wind farms will be audible sometimes as far as a mile in some conditions and that would be fairly faint but will still be audible at times. When people are surprised at hearing them, that becomes a trigger for a lot of upset.

Also putting noise concerns in perspective. Acknowledging some annoyances and stress may well result of audibility but that it will be moderate and manageable for most people.

Most important is local engagement and respect. Some communities may well want lower noise exposure levels than others. Listening to and more importantly responding to these qualitative reports and experiences coming from people in your community when you're operating wind farm is really central to keeping the industry moving forward in a productive way.

Having proactive mitigation plans in place to address possible and foreseeable issues could reassure communities to know that there'll be a willingness to reduce noise if their area becomes one of these problem (pieces).

It really all comes down to this fundamental social question that we're going to have to answer. And that's what proportion of those close to wind farms do we feel it's okay to bother and how often? And bad nights of sleep a year, something that, you know, people may just have to put up with in order to move forward into a renewable energy future.

How about 10% of nights. That may not seem like much and it may not be but it does mean 35 nights a year of disturbed sleep. These questions are difficult to assess and are going to be challenging in answer but they are something that we just can't ignore.

That's what I have for you today. You can check out a few supplemental slides when this is online as well offering a bit more detail and a few additional topics we didn't have time for.

But now back to Bob and I guess Ken will be up next.

Bob Grace: Great. Thank you Jim. I'll point out that at the end of Jim's slides, there are a number of Jim's references listed and we will put an annotated bibliography up on our site. Jim, you've given us a lot to think about.

I think now Ken will take us from that range of experience to how wind turbine noise is currently regulated today. Maybe we can talk about how adequate that regulation is and what we can learn from all this good information. Ken, over to you.

Ken Kaliski: Thanks a lot. So I'll start my talk today by talking about wind turbine noise regulation. And in particular we'll talk about noise impact studies and then what components of noise regulation are good, what components are not so good and then do a review of noise regulations in New England as they apply to wind turbines.

In the first set of slides, I'll talk about the noise impact study process for a wind farm. And it's basically seven parts that we go through. And I'll talk bout each of these a little bit more after this slide. But the first part is to identify the preliminary turbine locations for wind farm and the sound power, sound emissions of the turbine that Mark had talked about.

And then depending on the protocol or the standards that involve, we may monitor background sound levels in representative areas of the project. And then conduct sound propagation modeling to determine what the sound levels are at the various residences and what we call sensitive receivers around the property.

We then compare the results to standards or guidelines. And if those standards or guidelines are not met, then we find the turbine locations then remodel it. If all the standards and guidelines are met, a report is prepared and testimony is given as far as the project.

So in the first part, we look at the sound power levels of the turbines and in this first chart we have a individual turbine brands or turbine models and the sound output here on the X-axis or the horizontal axis ranging from about 500kW to a little over three megawatts.

And as you can see over the years as the size of the turbines have increased, the sound power has increased to some extent although within each group say for the 500kW turbines there's quite a range of sound powers. The same thing in the range of two megawatt turbines as well.

Sound power varies turbine to turbine by frequency as well. And the un-weighted sound power, this is for a certain turbine, ranges fairly flat response here from 20 hertz up to about 315 hertz and then the sound power or the sound emissions by frequency drops.

And then in terms of the A-weighted sound power, which is essentially the weighted to the even perception of the sound, most of the sound we perceive as Mark had mentioned is roughly between 200 hertz and 800 hertz.

If background sound monitoring is required, the first step is to identify sensitive receivers. This can include homes, places of worships, schools, wilderness areas, campgrounds, et cetera.

And we'll identify representative areas. We’re not going to monitor every one of those. But representatives areas represented by how close they are to different roads, which are the primary source of background noise in the area or to streams, rivers and more remote areas.

We'll monitor for a shorter time if the background levels are not critical to the standard and a longer time for relative standards where background levels are critical. And if seasonality is important, if we do background monitoring for example in the summer where there are a lot of crickets, we may redo that monitoring in the winter time when there are leaves off and there are no insects.

And the next step is doing propagation modeling. And that’s to predict the sound levels from the wind farm at these various locations. But the most important thing is the standard we’re using and for the most part in the U.S. we’re using the ISO 9613 standards, the International Standards Organization standard for outdoor sound propagation.

And in that we look at sound power, which is the sound emissions from the wind turbines. We look at spreading loss and that’s just the loss of energy as the acoustic wave spreads out from the source. And typically that’s around six decibels for doubling of distance for a point source.

We look at atmospheric attenuation and as Mark mentioned, that mostly affects the sound - the higher frequency sound barriers which for winter means mostly - especially in New England are mostly terrain barriers that is the affect of terrains and hills blocking the line of site between the source of the turbines and the receivers.

And then a big factor is ground attenuation and that's the affect that the ground has on the sound. The ground can reflect sound, the ground can absorb sound and has a significant affect on modeling results.

And then finally meteorology. Meteorology we typically use what's more or less a worst-case meteorology in nighttime inversion condition or winds blowing from the source of the receiver. But other meteorological conditions can cause sound to propagate essentially worse or that is have lower levels as the downwind receivers.

So in such cases it is with you're upwind from a wind turbine, the sound levels will be less. Under what we call unstable atmospheres like sunny days where the ground heats up and creates a lot of turbulence and sound tends to bend upward in those conditions or get scattered and the sound levels tend to be lower. And then finally with lower wind speeds or flat or vertical wind speed gradients, the sound tends to be lower downwind.

So when we do the modeling, we typically model a maximum sound level from the wind turbines. We look at the maximum sound power from machine. We look at the nighttime condition where the sound tends to propagate better.

But there are other conditions as I mentioned that cause lower sound levels. And if you look at sound levels over a time, this is a model where we have a model conditions of a year's worth of meteorological data and we have the sound level down here on the horizontal axis and the hours per year experienced as a specified level here in the - on the vertical axis.

And we see that the maximum here is almost 40 decibels. But most of the time you're spending - most of the time this receiver is spending is not at 40 decibels, the maximum level but it's on lower level in this case around 34 decibels.

And in fact you're only within about five decibels of the maximum about 12% of the year in this case. So it's important to recognize the model results are not necessarily the results that people will be experiencing all of the time.

So now I'll get into regulation. And in particular I'll talk about standards; standards that have been used locally by countries, by municipalities. And the things that are generally regulated in terms of wind turbine noise are the total level and it's usually expressed in units of A-weighted decibels; levels by frequency.

These are fullest or octave bands. These are spectral standards, tonality which regulate the appearance of pure tones and through either penalties or limitations on generating pure tones and impulsiveness.

So I think I consider good regulations as having several factors. Number 1, that they detail the noise limits and the parameters around those limits. And we're going to get into that in a minute. They include the requirements of what needs to be put in an application.

They include detailed components of pre-construction noise studies including details on what needs to be done for background sound monitoring, acceptable models and parameters, spatial limits of monitoring and modeling, details of receivers. And then finally they address post-construction issues as well.

And good standards are fair to both the people that are impacted by the noise and to the developers as they provide essentially a level playing field for everybody.

So the sound level limits as mentioned earlier can be absolute, that is a level that can't be exceeded. They can be relative to the background sound level. So they can't exceed X decibels above background or they could be a hybrid. They can't exceed the greater of X decibels above background or Y decibels.

The relative standards are very difficult to enforce if they’re not written well because sound levels in the background change with wind speeds and so do sound levels generated from the wind farm. And so it’s very difficult to determine exactly what is the background sound level at any point or any place or any time.

Nevertheless they’re in common use and I could talk about a few standards that are essentially well written that have relative standards that define all of these parameters.

Low frequency noise standards are primarily intended to limit noise induced vibration and I mentioned an ANSI standard here, American National Standards Institute S12.2 which is a room criteria standard but it includes low frequency sound levels in the lower octave bands that will create noise induced vibration.

So that is - if you have very low frequency sound so you may have experienced this. If a plane goes overhead or a low flying plane, you might get rattles in the windows or in furniture or in the partitions. And these standards are intended to protect against those types of vibrations.

And in some instances I've heard people complaining about noise induced vibrations from wind farms. And these types of standards would protect against that. Tonality standards - most or many standards use ANSI S12.9.4 appendix to apply for tonality. And it’s basically a definition of what a pure tone is.

And then it’s important to identify what the averaging time is for your standard. You can have a - say a 45-decibel standard but you need to know whether that’s a one second average, a ten-minute average, a one-hour. Does it apply to the daytime or the nighttime?

And then finally there’s the time above. Many standards recognize that there is a certain probability that a standard will be exceeded for a very short period of time and generally that’s okay. I've got a train that goes by my office every now and then and, you know, so long as it’s not constant, it’s probably fine.

So there are standards that present time above but you can't exceed say 45 decibels more than ten minutes in any hour or one day in any month for example.

The positional components of regulations include exemptions and exceptions. Construction noise is probably the major one. There are many exemptions for construction noise or standards that are specific to construction noise that are different from the main standard.

There are exceptions for routine maintenance, emergencies such as emergency sirens and the opportunity for waivers. Good regulations also can include complaint response procedures (with) construction monitoring requirements and guidelines on who is required to be offered to participate in the project.

When I talk about participation, there are landowners that participate. They receive a fee from the wind developer yearly in order to be a project participant.

They'll give you some examples of regulatory approaches. New Zealand is a - actually that has a standard that is specific to wind turbine sound. There are detailed modeling and monitoring protocols, what standards need to be used when you're doing monitoring and modeling.

It's a hybrid standard that is it's the greater of 40 decibels or five decibels above the 90th percentile limit with no maximum sound level. And there are special standards for more sensitive areas.

Now I had mentioned that relative standards have problems because it's very difficult determining exactly what is a background level when you have varying wind speeds and output from the turbine.

And in that standard they define essentially a regression analysis to determine what this wind speed sound pressure level correlation is. There are penalties in the standard for tonality and impulsiveness and the detail compliance protocols for post construction.

Oregon is a state that has a standard that is also general but has a component that is specific to wind turbines. The existing regulation was modified to address wind turbines and the existing regulations consisted of essentially a hybrid standard; was a greater of 36 decibels or 10 decibels above the L50 or L10 which is the 10th percentile over the median sound level.

And it included a maximum sound level so that even a project participants a certain maximum couldn't be exceeded. And the existing regulations included tonal penalties and optional standards for octave bands especially low frequencies, which is a concern with wind turbines.

And the wind turbine portion of the standard established rules on participation identified options for evaluating existing sound levels. And if you have questions on the Oregon standard, I believe Mark Bastasch had written parts of it or had a contribution in that so you can ask him in the question and answer period.

Now I'll go through the New England state regulations on noise and these may not be specific to wind turbines. They may be general laws and regulations but it's important to note what they are and how they may apply to wind turbines.

Maine site law is a regional planning law. It's not specific to wind turbines but the laws are applied to wind turbines. It is an absolute limit with a lower quiet area limit of 45 decibels. The measurement procedures are specified.

There are penalties for tonality and what's called short duration repetitive sound, which has been interpreted in the case of wind turbines to apply to amplitude modulation or the swishing sound. It includes submission requirements for the applications and includes exemptions, variances and in some cases you can get waivers of the standard.

Connecticut also has statewide noise regulations but it's not specific to wind turbines as well. This is an absolute standard and the standard - the nighttime standard is 51 decibels for noise generated from an industrial use to a residential use at night.

And it includes penalties for impulsive noise, tonal noise and it also disallows excessive infrasound and ultrasound, which is defined above 100 decibels. That's 100 decibels of infrasound or ultrasound. It details measurement procedures. It has exclusions and exemptions, variances and violations and enforcement provisions.

Massachusetts has no regulation that specifically applies to wind turbines. The precedence set for wind farms are varied. The Massachusetts Department of Air Quality Control has a policy. It's a very brief policy and it essentially limits sound to no more than ten decibels above ambient which is essentially the background sound level, the L90, the 90th percent level and it's applied to both the property line and the home.

There are no pure tones allowed and there's a different definition of what pure tones are compared to the ANSI standard. But there's really no consistent approach at this point on whether and how it's applied to wind turbines.

And then we have New Hampshire and Vermont. In New Hampshire there are no statewide noise regulations. The Site Evaluation Committee at the state level has a precedent. For example, for (Lemster) an absolute limit of 45 decibels with post construction monitoring required to confirm that the standard is met.

In Vermont again there are no statewide noise regulations. The Public Service Board issues certificates of public goods through the Section 248 law. And the precedents there have been wind farms that have been granted permits with this precedent, an absolute limit of 45 decibels measured outside the home and 30 decibels measured inside the home. No pure tones allowed and post construction monitoring is required.

The next slide is - I'll just talk about mitigation either before or after the wind farm is up and running and invite Mark to chime in as well. In - especially before a project it's important if you're looking at (re-siting) project turbines if noise standards aren't met.

You can increase setbacks, reduce turbulence by increasing the distance between wind farm - sorry, wind turbines or identify quieter turbines or components. They said there's a range of turbines that operate with different sound power output.

After the wind far is up there's several things you can do as well. There are automatic controls to slow tip speeds, produce noise under specific conditions. As mentioned under Vinalhaven there is a proposal to lower tip speeds or shut down turbines with winds over I think it was 22 miles an hour or 22 meters per second.

You can improve noise insulation on target homes. Provide them with air conditioning so that they can keep their windows closed or increase the number of project participants.

Anything more you want to add there Mark?

Mark Bastasch: No. I think that - I think that's great. I think if you don't touch on it, we just might want to just introduce the concept of, you know, there have been some stall regulated machines versus pitch regulated machines but I don't recall if you get to that later.

Ken Kaliski: Oh no. This is it.

Mark Bastasch: Okay. So with a stall regulated machine, the wind - as wind speed continues to increase, the sound level may jump up and that's when limiting the turbine operations under high wind speeds can be of great benefit with regards to reduced noise emissions.

With regards to other machines, it does come down to controlling the rotational speed and there are some significant energy penalties associated with that.

Ken Kaliski: That concludes my presentation. Thank you.

Bob Grace: Great. Thank you Ken very much. So at this point we're going to switch over to our Q&A session. Ken if you could look (unintelligible) for a moment and respond there. And (Sue) if you could put up Slide Number 15 please.

What we're going to do here actually while we're putting this up. I just wanted to make note of one thing. This presentation today provided a brief overview of the topic of sound and wind turbines. There's a lot here as you can tell. So more time would need to be allowed for a very in depth review.

A couple of points. One, today's focus is not on health impacts. While this is an important and potential issue of concern to many of our listeners, addressing health impacts would have made the session too long and unmanageable in this format.

Instead we're pleased to announce that we will be having a follow up session two evenings from now, a third Webinar in the evening on Thursday will be simulcast. It'll be a live briefing co-sponsored by the Cape Islands Renewable Energy Collaborative.

We will have a medical perspective, Dr. Robert McCunney, MD of National Hospital at MIT who will address his perspective on the connection between sound and health impacts based on a panel review of peer review data. Please think of that session as an extension of this one and the right venue to really get into questions pertaining to health impacts.

Both Webinars will be available online if you can't make both or if you want to look back. It'll take us a little while to get the information up there. But within two weeks everything will be up there.

And on the final slide at the end of the session, I will put up further information. You will need to register to participate in that Webinar. And again, will be a simulcast of a live Webinar and a platform like the one we have now.

So at this point we have a number of questions. I want to bring you attention to the Slide 15 here now. We have 521 registrants here. We understand that many of you are passionate about the subject matter, have important questions you want to ask and we want to encourage respectful dialog and not allow individual to monopolize our scarce time.

So what we’re doing - your Webinar window has a Q&A chat box. We encourage you to enter your questions there. Please identify yourself at the beginning of your question. Your name, your organization or if you’re a member of the public, just put public; what state your in. That’s of some help here. And if your question is directed to on specific panelist, please say so. Otherwise we'll assume it’s to all.

Please one question each. We have a lot of folks here. We want to be able to get in a variety. I will read the questions posed in the order that they’re asked until we run out of questions or time, whichever comes first. Some of our panelists are going to be able to stay on longer than others. I think we lose Mark first and then Ken and then Jim. But we do have some time here.

I won't screen or prioritize the questions but I might skip questions that we feel have already been addressed. So I'm going to go quickly to a couple of questions that the panelists had posed for each other and then to some of the questions posed by our audience.

The first question is how is wind turbine sound similar to or different than other sound sources? What might explain the higher annoyance levels? And maybe a different way of laying that out responding to one of Jim's points is if decibel for decibel people appear to be more annoyed by wind other than sources of - other source's sound, why is that? Is there something special about wind sound or is it a function of some of the other perception issue. I guess I'll ask Jim to start with that and then anybody else who wants to chime in.

Jim Cummings: Well, probably the most striking difference in at least some of the types of noises that people are reporting on wind turbines including the amplitude modulation is that the wind turbine noise is what they call impulsive sound. So the change in the total decibels shifts over the course of a half a second or less and with amplitude modulation often in the five to ten decibel range, very often around five.

So, you know, the other roads and, you know, especially more distant airport noise is more steady state sound on that second to second basis as wind turbines tend to vary a lot over short timeframes. That's one big difference.

Bob Grace: Great. Ken or Mark, anything to add to that?

Mark Bastasch: Well I also think that as kind of all touched on, there's the level of expectations and I think it's helpful for folks to have realistic expectations and to understand that these are not silent nor do - nor is silence really required of many sources or in many areas.

So, you know, taking the opportunities to go visit and hear something for themselves I think is quite helpful and will help people understand what we're talking about when we're talking about numbers and levels and charts and graphs.

Ken Kaliski: Just following up on that, two items. One is that wind turbines are fairly new to the U.S. Most people don't have experience with them. And as you compare road and traffic impacts, you know, people have lived around roads and airports for a long time and for the most part people who move into places with airports or near roads aren't by definition really sensitive to that type of noise.

But wind turbines are new so a wind farm might go in in an area where people aren't familiar with that type of noise and have no expectation that that would be there. So maybe higher - may have a higher annoyance level. Over time that annoyance level may shift as the demographics around the wind farms shift.

And the other thing is that, you know, wind farms are on at night and as compared to, you know, traffic noise which tends to lower at night and at nighttime, you know, the background sound level is lower. And so, you know, wind farms might be more noticeable than other sources at nighttime.

Bob Grace: Great. The next question was are there notable differences in sound characteristics between the largest say 2.5-megawatt turbines and smaller turbines say in the 100 to 500kW range? If anybody would like to chime in on that.

Mark Bastasch: I don't have a direct experience with more of the smaller individual type turbines there but they generally rotate at a higher RPM. So their noise level can be as high as some of the larger utility scale turbines as well.

I do know that NREL is involved in establishing standards for smaller wind turbines and they have developed a classification and ranking testing procedure similar to the IEC standard.

Jim Cummings: Another thing that might be worth considering when we're looking at wind turbines growing, there's a lot of people studying the sources of amplitude modulation and there's still a lot of different ideas about where that pulsating (nature set) is coming from.

One of the possibilities is that it has to do with the wind sheer over the diameter of the blade swept area. So having a lower wind speed at the bottom of the blades than at the top; higher wind speed at the top.

And so in that sense as wind turbines get bigger, they'll have more amplitude modulation I suspect most of the smaller, you know, kind of back yard turbines aren't really dealing with amplitude modulation issue. But as we go forward with larger turbines, it may become something that is more predominant if this line of research, you know, pans out.

Bob Grace: Great. So the next question was posed by (David), didn't indicate where he was from. And this is a question for Mark. Why is snoring more annoying than wind blowing outside or a conversation in a nearby room? I think that was reacting to one of your earlier slides.

Mark Bastasch: I'm not quite sure how to answer that. It probably has to do with context and expectations. And then again I think we do see that some people probably habituate to their partner’s snoring as well.

Bob Grace: Okay. Thank you. The next was posed by (Glen) who is a wind developer based in Massachusetts. He asked regarding people who get annoyed or otherwise disturbed from wind turbines, have there been any studies about whether or under what conditions such annoyances may get lessened as time marches on post construction?

Maybe to put it another way, do people adapt to noise over time and maybe is there research on that topic?

Ken Kaliski: I'll just point out one theory that in the European studies the earlier study was done - the earlier study which showed higher annoyance levels than the later two was done at areas where the wind turbines were relatively new.

And one of the reasons why the later studies showed lower annoyance, it was postulated by the author, was that either there was some habituation or some demographic shift where, you know, people who don't mind the noise move in and people who do mind the noise move out.

So that is - that’s one. It’s a postulation but I don't think it has been proved at this point.

Bob Grace: So that might be an interesting area for future research?

Ken Kaliski: It would, yes.

Bob Grace: Any of the - any of the other panelists have thoughts on that one?

Jim Cummings: I have seen conflicting, you know, research results on how much people habituate over time to a new noise source. I've seen some studies that suggest they do and others that suggest that they don't. So it doesn't seem like it's a question that has a clear-cut answer yet.

Bob Grace: All right. The next question is posed by (Jesse Moreo). Are the slides available for download and study at a later time? Yes, they will be. Up on the screen now we have a couple of wrap up notes here, information for registering for the follow on wind turbine noise and health Webinar.

But also listed lower down there is the URL, the location on the Web, for the materials, which should be posted by approximately July 27. And those materials will include the Webinar and a transcript as well as an annotated bibliography and references.

We will also pose all questions asked by the participants and any other related resources and studies as are identified over time. So think of that as a living site.

The next question is from (Dorothy Allen). The following is from Massachusetts regulators. "A source of sound will be considered to be a violating the department's noise regulation, (310CMAR7.10) if the source increases the broadband sound level by more than 10 dBA above ambient or produces a pure tone condition when any octave band center frequency sound pressure level exceeds the two adjacent center frequency sound pressure levels by three decibels or more. Please correct or comment."

I assume that's either for Ken or Mark.

Ken Kaliski: That is the noise policy that she's mentioned, of the Department of Air Quality Control. And how it is applied to wind farms is it's not quite - we're not quite sure how to apply it to wind farms and what circumstances it applies. It's not as far as I know a rule or regulation, but it's - and it is applied right now to sources that are required to obtain an air quality permit, which wind farms do not have to have.

So how it's enforced - I'm not a lawyer, and I don't want to speak to how laws might be enforced and how they may be enforced, but I can tell you -- in working in Massachusetts -- that it's difficult to understand how the rule is applied and interpreted.

Jim Cummings: I might add in terms of a comment that these relative standards, such as this one that addresses sound when it's 10 decibels above the background ambient, it's generally - like it was mentioned I think in Mark's presentation, somewhere around 3 decibels to 5 decibels increases where you being to actually perceive that it's louder. And around 10 decibels is when it's loud enough above the background to begin to be bothersome. So that between 5 decibels and 10, it shifts from being just noticeable to beginning to be bothersome.

So, how much of a relative standard the community wants to bring in if they're going the relative direction would depend on if they want to avoid getting into that bothersome threshold or make the threshold at the point like this one where people will begin to get bothered at the threshold.

Mark Bastasch: Well then, I think you also have to look at increase over what there.

Jim Cummings: Exactly. And (unintelligible)...

((Crosstalk))

Mark Bastasch: And, it depends on the metric that you're choosing. I don't think that they're - - you know number there can be looked in in absence. And, you also probably have to look at the resulting level, and again at the -- as Ken kind of indicated -- the - perhaps the frequency of time that that may occur.

Jim Cummings: Yes.

Mark Bastasch: So, that's - we know with natural systems, when you've got significant scatter in the data as we typically see, as I think Ken and I both eluded to, you know that can leave some ambiguity, which is difficult to handle in a regulatory environment.

Bob Grace: All right. So, we have a backlog of about 25 questions here. Let's see what we can get through.

The next question is from (Peter McVeigh) of the Massachusetts Clean Energy Center, and he asks this of Ken and Mark. "Could you clarify what causes the swishing sound? Is this a result of the acoustic interaction with the tower, and can this be mitigated?"

Ken Kaliski: I think there's been several hypotheses that have been discussed here, but I don't know that that has been completely put to rest as to the exact cause. And, I think it's also probably helpful to put some of that into context, in that while there is swishing sound, it's - at least based on the studies that were done in the UK, they didn't find that there was significant evidence to continue investigating additional instances of that. That is that it was found in a few locations, but those locations the level was not overly significant that they thought that there was a significant issue there.

Mark Bastasch: Those - it's - you know - so, there's a difference between amplitude modulation and excessive amplitude modulation. You know, the swishing is sort of a normal part of the wind turbine sound. But when it gets excessive, you know then we're looking at what's causing that. But you know in general, I think that just the normal swishing is - again, it's not definitively determined, but there are factors that contribute to it, such as the difference in the wind speeds from the top and the bottom of the rotor, and also the directionality of sound as it comes off the blades.

Bob Grace: Great. All right, next question takes us in a different direction. This is from (Jennifer Fuser) - I hope I pronounced that correctly. Did not give a location, but she asks, "Are there any studies providing models of financial compensation for people whose homes/farms are near wind farms?" I guess that's for anybody who's familiar with that topic.

Ken Kaliski: I'm not familiar with that.

Jim Cummings: Yes. I'm not quite sure what she means by models of compensation, but...

Mark Bastasch: Maybe Mark, it could be worthwhile talking about the Oregon Standard and the participation guidelines?

Mark Bastasch: Well, I think any standard that has participation guidelines, there is some sort of agreement for people who participate into a project, and then maybe you know, waivers or others that are obtained that has some financial aspects to it.

But again, I'm not aware of any real model or compensation models that maybe they're looking for. I mean, it'd seem more of a business transaction.

Jim Cummings: Right. And in that context, they've been - you know, it's varied from project to project. There have been projects that gave some financial compensation to landowners that didn't have a turbine to compensate for various types of intrusions, but those are rare.

Ken Kaliski: I've seen standards that require you to offer participation to anybody within a certain setback.

Jim Cummings: And, it does seem fairly clear that people who do have some kind of financial compensation are less apt to feel put out and really disrupted by the presence of the turbine.

Bob Grace: Well, maybe what we can do here since there are number of ad hoc experiences, if any of the Panelists or anybody else listening for that matter has information on experience with financial compensation for wind turbine neighbors, if you send them along we'll build a resource page so people can take a look and learn from those.

The next question is from Christy Johnson-Hughes at the US Fish and Wildlife Service Headquarters. She asks, "The human perspective is very important, but has there been any discussion or consideration of sound impacts on wildlife?" Good question.

Jim Cummings: There's definitely been a continuing body of research on general sound impacts on wildlife. Not a lot of studies specifically on the effective wind turbine sound on wildlife. The studies that do look at the effects of wildlife around wind farms is extremely hard to separate out the visual impact or the disruption and even presence of road impact from the sound part.

But, there is defiantly an ongoing body of research and an annual or biannual conference that takes place in Denver this October, specifically on wind farms and wildlife.

In general, it seems like some species tolerate the wind turbines, either noise or presence very well. And, others seem to try to stay at least several hundred yards away. So, the range of impact is probably somewhere in that several hundred yards range when it does exist for a particular species or individual.

Bob Grace: Great. Any other comments on that, or should we go on to the next?

Ken Kaliski: I would have to concur. It's probably species-dependant, and in general I tend to refer those types of questions to some of the biologists who are more familiar with that literature. The number I have seen discussed with regards to wildlife has generally been in the 65 dBA range, but again that's not my area of expertise. And, that level would be achieved relatively close to the turbines, and we do see big game at least and other animals still grazing in and among the areas.

But again, probably a better question for someone else.

Jim Cummings: I would just also add that the Parks Service has done some research just in the last couple of years, it just came out this year, that's looking at the effect on communication ranges for animals of relatively moderate background noise, and they're mostly looking at road noise at some distance from roads. And, looking at even just the 5 decibels to 10 decibel increase in ambient and how much that decreases the animal's communication range - listening area (unintelligible).

Thinking that animals really need to be able to hear the faintest possible sounds, whether you're a predator or a prey. And so, this is a brand new line of research coming out of the Parks Service that probably will become a significant new you know, consideration in terms of the effects of moderate increases of background.

Bob Grace: Thank you. The next question is from (Dillan Bordes) at the Natural Resources Council of Maine. And he asks, "Can you comment on results from attempts to verify sound model propagation conclusions post-construction?" Anyone want to take first stab at that?

Mark Bastasch: Ken, you did some good work on that. You want to touch on that?

Ken Kaliski: Yes. This is an ongoing field, and we did some work down in Kansas on this topic looking at comparing model results and actual monitored results. We even have a slide here I think we could show, but we'll skip that. And, I think there's - a take home on that is that there are parameters that you can use that will underestimate sound levels, and there are parameters you can use that will overestimate actual sound levels, depending on the condition.

There have been a couple of post-construction studies in Maine particularly that were done by RSE -- Resource Systems Engineering -- on in Stetson and one at Mars Hill that I believe are at least partially publicly available through the state. And, I think that confirms essentially - and in most cases, they confirmed pre-construction modeling estimates with the post-construction actual sound levels.

Jim Cummings: (Matt), I would encourage anyone especially interested in this to seek out the Wind Turbine Noise Conference that I think Mark mentioned happens every two years, and there's always a you know wealth of new papers on all topics, including ever refining sound modeling (techniques).

Mark Bastasch: Yes. Thanks for that Jim, and I didn't include that information in my slides, but that'd be windturbinenoise2011.org. It's going to be held in Rome and in mid-April, if I've got the dates right.

Bob Grace: All right. At this point, I see that Mark needs to drop off. I think we have Ken for a little while longer, and Jim for a little longer than that. We still have a backlog of questions, so I will thank Mark for his time and contribution today. And again, his PowerPoint will be available on the site. Thank you, Mark.

Mark Bastasch: Thank you.

Bob Grace: Next, we will go to (Jim Younger) of the Trustees of Reservations. "Are there good examples, case studies of sites where acoustic factors were considered from the beginning and no acoustic issues were uncovered after permitting?" Ken?

Ken Kaliski: You know, I believe that the majority of sites are like that, and maybe when we have the opportunity, I could talk about or try to list some of those sites. But I think you'll find that most sites are (constribed) too much of a problem.

Jim Cummings: And all sites are acoustic and acoustics are considered as they're developed.

Ken Kaliski: Well, they're - yes. I don't know if that's the case. I think that in early on, there are some sites that didn't consider acoustics and some of those had problems. But generally when you consider acoustics and you do a good job at it, usually you don't have considerable problems. And again, it depends on the standard of course, and the parameters you use when you're doing your modeling estimates.

Bob Grace: All right. The next question is from (David Hyman), who I believe is with the Sierra Club, who asks, "What's wrong with tonal sounds, infrasound, and ultrasound?"

Ken Kaliski: Tonal sound is more annoying. For whatever reason, you know when somebody scratches their fingers on a chalkboard, that's more annoying than the same level of sound you know, that a fan makes - broadband sound we call that. So, the tonal sounds like backup alarms - you know, the backup alarms are tonal. They're you know, a single roughly 1500 hertz tone in order to be alarming, in order to stand out. And so, some municipalities - some states essentially (kenalize) pure tones say by adding 5 decibels to your measured sound when you have a pure tone in order to account for that increased annoyance or increased susceptibility or noticeabity.

Then infrasound is not necessarily bad. A lot of infrasound can be bad because it you know rattles windows or shakes things on your night stand because it has the capability to create noise induced vibration. A lot of infrasound you know at very, very high levels can create you know effects like nausea and other types of ill feelings, but those are at very, very high levels. I think that answered that question.

Bob Grace: Okay. The next question is posed by (Dan) in Massachusetts, and he asks, "Are any of the presenters aware of any research that has been done or is currently taking place that attempts to measure impacts on fish or sea life populations by the low frequency sounds generated by offshore turbines?"

Jim Cummings: Yes. There's a fair amount of research going on, again mostly in Europe where the offshore side of things is more developed. And, there seems to be very little sound transmission problems in the water. The towers are not generating significant low frequency or other noises enough to bother marine life. However during construction, there is a lot of noise in pile driving as they you know, create the foundation, and that can cause - especially harbor porpoises who are one of the most sensitive species who avoid the construction area by 20 kilometers or more.

So at this point, that's a relatively moderate issue, but there's a concern that as offshore construction become more widespread, there may be regional scale impacts where that pile driving noise during the you know, kind of temperate part of the year where most of the construction is taking place could actually be insonifying fairly large regional coastal areas with enough noise to be a bother for the animals.

The turbine blade noise that we're worried about on land that's happening in the air, that noise does not pass the air/water boundary with a very high degree of success at all. So, the high levels of noise that we hear from the blades just don't go under water.

Ken Kaliski: There is a study that the Mineral Management Service of the Department of Interior is conducting currently related to wind turbine related noise, including construction impacts on the underwater environment. I don't - I imagine that's not going to be completed for some time now though.

Bob Grace: Great. Thank you for - that was an informative answer. Let's see. We'll next go to (Judith) in New York who asks, "Has there been any study of annoyance with wind turbine generators in rural areas with existing industrial facilities? For example, quarries or slaughterhouses."

Jim Cummings: Not that I'm aware of.

Ken Kaliski: I'm not aware of any. I just know of one particular project that was near a pig farm, and - that's currently being proposed. And, I guess part of the benefit of that is no one wants to live near a pig farm. So, there aren't very many people who live near this facility.

Mark Bastasch: All right. The next question is from (Carlo DiNapoli) in Finland. We have a lot - a broader reach than I thought. "I have a question related to the background sound measurements. What are the current processes in US about the measurement procedures? Is anaphoric stability or day/night changes taken into account in results? We currently do not have any wind turbine noise rules so far, and I'm interested in the particular subject."

Ken Kaliski: That's a big topic. There are two - the ISO standard that I was talking about just considers downwind propagation under a certain meteorological condition. And, if you want to estimate the sound levels during other meteorological conditions, you can estimate that using - it's called (Contowy) adjustments, which were established almost 30 years ago for different atmospheric stability conditions.

And more recently, worked on in Europe on a European model -- it's in development called Harmonoise -- has looked at different types of stability environments, not necessarily the stability classes that were evaluated in the (Contowy) Standards that effected noise propagation.

So, I guess the short answer is yes it can be done, and it's one of the things that are being incorporated into the European models.

Jim Cummings: And, I think the questioner may have also been wondering about assessing current background ambient. I'm not sure. But if so, then you know, one of the things as you know Mark mentioned a couple of times is if you're comparing to the background, then comparing to what? And so, the measure - you know, there is measurement protocols for when you're actually doing the recording.

But then equally important is the averaging time over which you're establishing your baseline. So, if the background ambient is in a 24 hour average, you know, that will be a higher level than what's really happening at the quietest time of the night.

Alternatively, sometimes you sometimes use called - like he said, called day/night level. Other times, people use averaging over you know, very short periods of time as short as ten minutes through the whole day. And you know, you can track more clearly where the quietest parts of the time are.

So bottom line, when you're assessing your background ambient, how you decide to average those results in terms of setting your - you know, you're kind of target that you're going to compare to is crucial.

Bob Grace: All right. Thank you. The next question is posed by (Gordon Durphy) who is a member of the general public, and he asks, "Do you have any recordings of wind turbine noise that we can listen to now? Graphs and formulas don't help in reality shows like this." And actually, I think Ken, hadn't you tried to give us a more dynamic file that we had trouble uploading?

Ken Kaliski: And, that was an animation. And the problem with recordings is that you have no way to calibrate them. You...

Jim Cummings: You have no idea how far away you are, or - and...

Ken Kaliski: You know, to hear...

Jim Cummings: You know, and turn up the volume.

Ken Kaliski: ...a good recording, you might have to jack up your volume to 45, 55 decibels, and is that really realistic? And so yes, you could probably post recordings of sound, but I just don't know what the takeaway would be of that. Whether - like what - it may be relevant to look at the characteristic, but not am I annoyed by this or am I not annoyed? It's really best to actually to a wind farm and listen to it and see what you think of that noise that's actually there.

Bob Grace: All right. The next questions is from (Bridgette) in Massachusetts, who asked, "I thought noise levels are usually higher downwind from a turbine. Why was this not mentioned?"

Ken Kaliski: I mentioned it.

Bob Grace: Okay. Yes.

Ken Kaliski: Yes. They are measured. They are higher downwind.

Jim Cummings: And interestingly, a couple of different researchers have found that they think that the amplitude modulation -- the amount of the sound actually goes up and down a bit -- is strongest off to the sides where the - otherwise, the sound is kind of the least noticeable. So, that's kind of an interesting twist. It may be that areas that are especially impacted by amplitude modulation are bothered, because otherwise they're barely hearing it.

Bob Grace: Okay. The next question comes from a (Mike Aterien), who asks, "Are there any different effect from one wind turbine to multiple wind turbines, other than the classical multiple source 10x log and relationship?"

Ken Kaliski: I guess the question is whether you can adequately model - well, I'm not quite sure what the question is, but there are some theories out there that there's some coherence between individual turbines. And, that is that when they're in synch and they're in phase that they could create a louder noise than if they weren't in synch. And, I just haven't seen anything that's really conclusive on that issue.

From my observations for most variable speed turbines and wind farms, you don't get that type of coherence.

Bob Grace: Okay. The next question is for Ken, posed by (Sally) who lives near the turbines on Vinalhaven. "We were specifically told that we would hear no noise from the turbines, but the noise is for us unbearable. The 45/55 db night time/day time regulations are totally inadequate. What would you suggest? We're trying to get developers to implement some real mitigation. What do you recommend that developers do to mitigate the situation?"

Ken Kaliski: You know, I'm not really familiar with the exact specifics of that, and I know there have been some studies that have been done looking at mitigation. So, I don't want to comment on a specific project without knowing a little bit more about what the studies found and why there are these impacts and what's already been proposed.

Bob Grace: Jim, anything further on that one? I know you've been paying some attention to the Vinalhaven.

Jim Cummings: Well, I mean I guess. And, Ken especially stressed this in his presentation, the fact that they were you know, led to believe I think primarily by the manufacturers that they wouldn't hear them, you know is one of the things that we're gradually getting beyond. And, it's important to make sure that as we go forward that people aren't getting that message ahead of time.

And in terms of fixes, you know the things that were mentioned. Various types of changing the speed or shutting them down at the worst times, which I know is happening in Falmouth now. And potentially, increasing the cutting speed, so it turns on at a slightly higher speed. Those low wind speeds is not making that much electricity, but it can be a higher proportion of the time that they're on. So, there's different things to try depending on which situations are you know, causing the problematic noise.

Bob Grace: All right. We actually have a really good follow-up here from another resident of Vinalhaven. (Adam) who says, "I am a resident of Vinalhaven, Maine, and a rate payer of the Fox Islands Electric Co-Op which helped pioneer the Fox Islands Community Wind Project. My question for the panel has to do with mitigation. The project on Fox Islands has significant community support, including many of the neighbors who are closes to the project, within .5 miles."

"Given that sound issues related to wind turbines is highly subjective, and given the extent of misinformation in the anti-wind world, how do we distinguish between genuine sound annoyance versus complaints that are seeking to capitalize on the tide of discontent? How do we ensure mitigation achieves objectivity and balances the benefits to those who are supportive of wind power, and/or are not bothered by wind turbine noise?"

Ken Kaliski: Well, these are exactly those difficult questions that I referred to at the end of my presentation. And, I don't think we really have any answers to these questions. But really, find objectivity in the midst of - it's not just as he mentions - you know, he seems to feel that some people that complain about noise are really just complaining about the wind farm, and there is perhaps some of that, but it's not just that.

And, you know kind of more to the point is the fact that different people are really going to experience it differently, just based on their own way of perceiving the world just perceptually, not attitudinally.

You know, that's why we are in this situation of trying to see how close or what sound levels are really acceptable in rural areas. And like the questioner before mentioned, at least in her mind you know, 45 decibels seems a lot louder than what they're used to there. It's a social question and it's you know, always a difficult thing when we're trying to live together when we have different views in the world.

Bob Grace: All right. At this point - thank you Jim. Ken Kaliski has to sign off, so I just want Ken, to thank you again for your participation and contribution. We've had a lot of compliments on the Q&A chat board here. Certainly, helped build the base of information, and we thank you.

Ken Kaliski: Well, thank you. It was a pleasure, and thank you everybody for joining in.

Bob Grace: So, I guess we're down to Jim. Jim, we seem to have a 125 attendees still listening in, and about 8 questions left. Do you have a little more stamina or do you have to run off?

Jim Cummings: Yes. Well, let's see. I mean, if they're highly technical, then I might not be the one, but you know I've read a lot of the research, so I might be able to help.

Bob Grace: Let's see what we can do here, then. The next one is from (Christopher) in Westborough, Mass., who's an attorney for some of the neighbors to Wind 1 in Falmouth. "With an already built turbine, would it be practical to install permanent monitoring equipment within adjacent residential areas to monitor amplitude modulations applying to the turbine operation to accomplish reductions when certain levels are exceeded?"

Jim Cummings: Well, it certainly - you know, there are recording systems that are made for long-term deployment in the field, so yes you can create permanent or semi-permanent you know recording spots. As to whether you can in real time then adjust the operations of the turbine based on what's coming in through these recorders, you know that would involve a couple of extra layers I'm sure of you know, command and control.

And my impression is such things are possible, but I do not believe anything like that's been implemented, and I have no idea what kind of costs would be involved in that.

Bob Grace: All right. Let's see. I'm going to select the ones that are probably better suited from the remainder here for you Jim. Let's see. That one is probably for me. Yes. Okay, here's one from (Andy Novie) who works for a wind developer based in Massachusetts who's developing projects in Northern New England. (Andy) asks, "Could you give examples of species affected by wind turbine noise?"

Jim Cummings: Yes. Well again, there's a lot of research on animals being effected by noise. Very little on wind turbine noise in particular. And, the research that has taken place around wind farms doesn't really separate out the noise. So, not a lot to go on.

One of the best studies came out of England, and they looked at birds around a wind turbine, and I'm afraid that off the top of my head, I can't remember which species. But, I remember that it was 5 out of 12 species were more effected than the others, though again it was indicating that it was vary species-specific.

There have been kind of casual reports from people in some of the wind farms in Wisconsin that are in farm land where there's kind of small woods in amongst the farm land who have talked about deer that used to be in those small woods that aren't now. Again, I don't think there's been any you know kind of broad based research with controls or before and after you know species counts or individual counts to really answer that question in a definitive way yet.

But it does again, seem like when avoidance has been seen, it has been on the scale of a few hundred yards is about the place that the effect seems to fade out. And, it's defiantly a place where we need more field research though. Any biologist would tell you that the field research of population studies is needed and hard to find in the best of circumstances.

Bob Grace: All right. While we're on that topic, this is another question on a similar note from (Peter) from Marlboro, Massachusetts who happens to be an old fraternity brother of mine. "Is there any known interaction between sound pressure waives propagated by wind farms and native plant and insect populations; e.g. pollination, dislocation of pollinators, overall insect populations, et cetera?" Anything worthy of note, or is this one for the biologists?

Jim Cummings: Yes. Well, that's one for the biologists, and it's nothing I've seen anything on. One thing I just would throw out. People have mentioned feeling what they call pressure waves in the vicinity of turbines. Somebody in Vermont reported it up to even two miles away. And, it's very - this is something that again needs more research, but it's very likely this is not necessarily an acoustic phenomena.

We may not be talking about feeling low frequency sound waves, but rather that those giant rotors are actually you know, changing the air pressure rather than the sound pressure. And so, there may be air pressure differentials that you know are propagating out from wind farms.

It's not something that's been studied in detail at all yet. But defiantly you know, another thing for study, and seems plausible that insects would feel and respond to that. But again, at what range and whether that's going to be problematic on a biological kind of regional or local level, unknown and probably a relatively low level problem.

Bob Grace: All right. The next question Jim is from (Peter) in Rhode Island, who asks, "Is there a noticeable increase in the total of noise as the number of turbines and wind farms increase, assuming that the separation is constant between the turbines."

Jim Cummings: Well I guess you know, the sound models do take that into account, much as Mark outlined. So, that what they do is model across the landscape and at any particular point they're adding up the sound from the wind turbines at various distances to that point and they end up with a map - I think Ken showed a nice map that had a you know, range of colors, each showing a 5 decibel decrease of the sound as you get further away.

Well that's what they end up with, and that is taking into account all the turbines in their specific locations in their specific typography. So, that is what takes place in this sound modeling.

Bob Grace: All right. We're getting down to the last couple here. There are a few here Jim, I don't know whether you feel like their fodder for you or not, but I'll give them a try. (Scott) asked, "What makes for a good acoustical wind setting?" And, (Jessie) from Alberta, Canada asked something related, "Could any of the presenters please provide an example of a noise standard for wind turbines that they feel works well, and why?"

Jim Cummings: Yes. For sure, what makes a good wind study is something that - you know, those other guys would've been you know, better to answer. I certainly have never worked on designing or even critiquing the design of studies. So, I can't say that.

And in terms of what makes a good wind standard, well there's really no simple answer to that either. I think the big question of course is you know, what degree of protection from sound or what degree of increase in sound does that particular community want to accept? And so, it's designing a standard that meets the community's kind of desire for living with wind.

But each community may be different, and as you said - as Ken outlined, there's you know many different approaches to that, and any of them can be done well. The main thing is that it's done in a way that the community understands and that it does meet what the community is trying to achieve.

Bob Grace: Thank you. Okay, I think we have two left that are very appropriately good wrap up ones. (Moe) from Massachusetts asks - this is really for me, I guess, “Can the wrap up page be sent to participants so we have the upcoming Webinar access and data presentations from this Webinar access?” And, that’s the slide that you’re all looking at right now, and I’m sure we can arrange to do that, to email that out to the participants.

And, I guess the final one, (Doyle Fontaine) hopefully speaks for many of us in saying, “This was an extremely good presentation, all of them.” I guess we’ll thank Jim since he’s left here, and Mark and Ken in absentia. Thank you all for your participation and contribution, and Jim especially for hanging on to get through all the questions.

And a thank you to all of our participants. Hopefully, this session has added to the understanding of what we know and what we don’t about wind turbine and sound. Perhaps raised as many questions as it answered.

I will remind all that we have more to go on this Webinar series, and I expect that we will revisit the issue of sound during our planned conference in the spring. Time and location to be determined.

And again, I will remind everybody, the 100 folks who are still online that two days from now, Thursday in the evening, 6:30 pm Eastern Time, we will have a follow-on presentation by Dr. Robert McCunney presenting on wind turbine noise and health, presenting his perspective on fact versus fiction based on a research review of peer reviewed research. This will be held live in person at the Upper Cape COD Technical High School in Borne, Massachusetts, and simultaneously broadcast on a Webinar exactly like the one you’ve just participated in.

To join the Webinar, you must register. The registration email is listed on the screen. And to join the distribution list for being informed of future (New

Leaf) Webinar announcements, please visit the New England Wind Forum Web site sign up page. The URL is also shown there on the wrapped up page, and you can sign up to be informed of subsequent presentations.

Again, the presentation materials - the Webinar, the transcript, the bibliography, and references, questions asked by the participants, and other related resources that will be added over time will be posted on the Web site shown approximately July 27.

If any of you have studies that haven't been referred to supporting or contrasting conclusions, fill in any of the questions that couldn't be answered today, we welcome you to forward them. We'll do our best to put them all up there and in some way that's easily discernable and findable.

And again, we thank you all. At this point, we'll sign out and look forward to talking at some of you again on Thursday night. Thank you.

END

Participant Questions and Supplemental Answers

During the Webinar's question and answer session, participants entered their questions into a "chat box." The questions below were copied as they were submitted. The answers to these questions can be found above in the transcript's question and answer session. In addition, speaker, Jim Cummings, Executive Director, Acoustic Ecology Institute, provided supplementary answers to some of the questions below.

Adam Lachman Asked: I am a resident of Vinalhaven, Maine and a ratepayer of the Fox Island Electric Coop which helped pioneer the Fox Islands Community Wind Project. My question for the panel has to do with mitigation. The project on the Fox Islands has significant community support including many of the neighbors who are closest to the project site (within .5 miles). Given that sound issues related to wind turbines is highly subjective and given the extent of misinformation in the anti-wind world, how do we distinguish between genuine sound annoyance versus complaints that are seeking to capitalize on the tide of discontent? How do we ensure mitigation achieves objectivity and balances the benefits to those who are supportive of wind power and/or are not bothered by wind turbine noise?

Alain Ouellette Changes Question To: Would love more dba with speakers...

Allan St.Peter Asked: Has there been any study that addresses the issue of a steady noise in the background tends to "penetrate" similar to a power transformer sound.

andy novey Asked: Could they give an example of species affected by wind turbine noise?

Barbara Crabill Asked: "Point Source" vs. "Line Source" acoustic modeling. Which is more applicable in modeling possible effects of a wind farm's output?

Barbara Crabill Changes Question To: "Point Source" vs. "Line Source" acoustic modeling. Which is more applicable in modeling possible effects of a wind farm's output?

Barbara Crabill Changes Question To: Ohio Power Siting Board Staff: "Point Source" vs. "Line Source" acoustic modeling. Which is more applicable in modeling possible effects of a wind farm's output?

Bridget Earle Asked: B of Massachusetts....I thought noise levels are usually higher down wind from a turbine. Why was this not mentioned? Member of Public

Carlo Di Napoli Asked: Carlo Di Napoli, Poyry Finland: I have a question related to the background sound measurements: what are the current practices in US about the measurement procedures, is atm stability or day/night changes taken into account in the results? We currently do not have any WTN rules so far and I'm interested in this particular subject. Thank you.

Chris Fried Asked: Comment: Level of annoyance seems to be largely dependent upon neighbors' understanding of purpose and need. They don't understand the impact of rejecting the turbine proposal. Many opponents seem to think that turbines are

Chris Fried Changes Question To: Comment: Level of annoyance seems to be largely dependent upon neighbors' understanding of purpose and need. When they don't understand the impact of rejecting the turbine proposal, they tend to be unwilling to accept any disturbances..

ACTUALLY, IT IS QUITE COMMON TO FIND THAT PEOPLE STRUGGLING WITH NOISE ISSUES SUPPORTED THE WIND FARM PROPOSAL, FULLY UNDERSTANDING THE PURPOSE AND NEED, BUT NOT HAVING CLEAR INFORMATION ABOUT THE LOCALIZED IMPACTS OF SOUND. FOR SOME, THE NOISE DISRUPTIONS ARE COMMON ENOUGH TO CREATE SUBSTANTIAL QUALITY OF LIFE IMPACTS. FOR OTHERS, MORE TEMPORARY OR OCCASIONAL DISRUPTIONS ARE WORTH IT, GIVEN THE PERCEIVED SOCIETAL NEED, AND THEY SIMPLY LIVE WITH THE NOISE WHEN IT OCCURS. THE ISSUES OFTEN COME DOWN TO WHETHER IT IS WORTH DISRUPTING THE LIVES OF A FEW TO SERVE THE ENERGY NEEDS OF THE MANY; AND THIS QUESTION IS MOST DIFFICULT WHEN WE ARE SEEKING TO SITE TURBINES RELATIVELY CLOSE TO RESIDENCES (WHERE SOUND LEVELS MAY TOP 35-40dB WITH SOME REGULARITY). MANY WIND FARMS HAVE FEW IF ANY NOISE ISSUES; THESE TEND TO BE MORE DISTANT FROM HOMES, BUT STILL (OBVIOUSLY, SINCE THEY WERE BUILT) CLOSE ENOUGH TO THE GRID TO MAKE TYING THEM INTO EXISTING LINES ECONOMICAL.

Christopher Senie Asked: Christopher Senie, Westborough, MA, Attorney for some of the neighbors to Wind 1 in Falmouth. Question to any of the panelists: With an already built turbine, would it be practical to install permanent monitoring equipment within adjacent residential areas to monitor amplitude modulations linked to the operation to accomplish reductions when certain levels are exceeded? adjustments to keep Are there ways to install post construction permanent monitor stations linked to the wind turbine to regulate

Christopher Senie Changes Question To: Christopher Senie, Westborough, MA, Attorney for some of the neighbors to Wind 1 in Falmouth. Question to any of the panelists: With an already built turbine, would it be practical to install permanent monitoring equipment within adjacent residential areas to monitor amplitude modulations linked to the turbine operation to accomplish reductions when certain levels are exceeded? Thank you.

Christy Johnson-Hughes Changes Question To: Christy Johnson-Hughes, USFWS, HQ - the human perspective is very important, but has there been any discussion or consideration of sound impacts on wildlife?

Dan Marrier Asked: Dan - Massachusetts. Are any of the presenters aware of any research that has been done or is currently taking place that attempts to measure impacts on fish or sealife populations by the low frequency sounds generated by offshore turbines?

David Heimann Asked: David Heimann/Sierra Club: Why is snoring more aggravating to sleep than other noises, and how does this relate to wind-turbine noise?

David Heimann Changes Question To: David Heimann/Sierra Club: Why is snoring more aggravating to sleep than other noises, and how does this relate to wind-turbine noise?

Dorothy Allen Asked: A source of sound will be considered to be violating the Department's noise regulation (310 CMR 7.10) if the source: Increases the broadband sound level by more than 10 dB(A) above ambient, or Produces a "pure tone" condition - when any octave band center frequency sound pressure level exceeds the two adjacent center frequency sound pressure levels by 3 decibels or more.

Dorothy Allen Asked: Apart from construction activities, what other industry or manufacturing, requires the modeling and compliance with sound/noise regulations?

Dorothy Allen Asked: The following is from Massachusetts regulations:

Dorothy Allen Changes Question To: A source of sound will be considered to be violating the Department's noise regulation (310 CMR 7.10) if the source: Increases the broadband sound level by more than 10 dB(A) above ambient, or Produces a "pure tone" condition - when any octave band center frequency sound pressure level exceeds the two adjacent center frequency sound pressure levels by 3 decibels or more. This is from the Massachusetts register.

Dorothy Allen Changes Question To: Apart from construction activities, what other industry or manufacturing, requires the modeling and compliance with sound/noise regulations?

Dorothy Allen Changes Question To: The following is from Massachusetts regulations: A source of sound will be considered to be violating the Department's noise regulation (310 CMR 7.10) if the source: Increases the broadband sound level by more than 10 dB(A) above ambient, or Produces a "pure tone" condition - when any octave band center frequency sound pressure level exceeds the two adjacent center frequency sound pressure levels by 3 decibels or more. Please correct or comment.

Dylan Voorhees Asked: Dylan, NRCM, Maine Maybe I missed it, but can you comment on results from attempts to verify sound modeling/propogation conclusions post-construction.

Ed Marion Asked: Edward Marion - Attorney-Wisconsin Is there an industry standard wind

Eduardo Suarez Asked: Do you that Green Bershires' director beliefs that Nuclear power will meet our 2050 obligations instead of wind energy? Eduardo Suarez, ECHO for Sustainable Development

Eduardo Suarez Changes Question To: Do you know that Green Bershires' director beliefs that Nuclear power will meet our 2050 obligations instead of wind energy? Eduardo Suarez, ECHO for Sustainable Development

WHILE THIS QUESTION DOESN'T REALLY INVOLVE SOUND-RELATED ISSUES, IT IS WORTH NOTING THAT THIS IDEA IS BECOMING MORE WIDESPREAD AMONG MANY LONG-TERM ENVIRONMENTAL ADVOCATES, AND I FOR ONE AM BEGINNING TO QUESTION OUR (THE ENVIRONMENTAL COMMUNITY'S) DOGMA ABOUT NUCLEAR. JAMES HANSEN, STEWART BRAND, AND JAMES LOVELOCK ARE AMONG THOSE WHO SEE NUCLEAR AS OUR BEST SHORT-TERM HOPE FOR DRAMATIC DECREASES IN FOSSIL FUEL USE IN ELECTRICAL GENERATION.

frank oteri Asked: frank nrel Has any research been conducted into land lease payments and level of annoynace/perception?

IN ONE OF THE SCANDINAVIAN STUDIES (NETHERLANDS 2007), THERE WERE A SUBSTANTIAL NUMBER OF RESPONDEES WHO RECEIVED FINANCIAL BENEFIT FROM THE TURBINES (ROUGHLY 100 OUT OF 725), AND THE RESEARCHERS FOUND THAT THEY NEARLY ALWAYS REPORTED NO ANNOYANCE, EVEN AT HIGH RECEIVED SOUND LEVELS (I BELIEVE THAT JUST A HANDFUL, 5 OR LESS, REPORTED ANNOYANCE). LESS DRAMATIC, BUT SOMEWHAT SIMILAR RESULTS WERE SEEN IN A MORE INFORMAL SURVEY (I.E., DONE BY A LOCAL GROUP, NOT OUTSIDE SCIENTISTS) AT A WISCONSIN WIND FARM: HALF OF THOSE LIVING WITHIN ABOUT 3000 FEET RESPONDED, AND A LOWER PROPORTION OF THOSE RECEIVING FINANCIAL BENEFIT REPORTED ANNOYANCE (40%, RATHER THAN 56% AMONG ALL RESPONDENTS); TWO-THIRDS OF LESEES SAID THEY WOULDN'T DO IT AGAIN IF THEY KNEW WHAT THEY NOW KNOW.

Gordon Durphey Asked: Do you have some recordings of wind turbine noise that we can listen to now. Graphs and formuslas don't help in reality showes like this.

Gordon Durphey Changes Question To: Do you have some recordings of wind turbine noise that we can listen to now. Graphs and formuslas don't help in reality showes like this. Gordon durphey- general public

James Younger Asked: Jim Younger, The Trustees of Reservations Are there good examples, case studies, of sites where acoustic factors were considered from the beginning and no acoustic issues were uncovered after permitting??

Jennifer Puser Asked: Are there any studies providing models of financial compensation for people whose homes/farms are near wind farms?

Jesse Moreno Asked: Are the slides available for download and study at a later time?

Jessie Roy Asked: Jessie Roy, Alberta Canada: Could any of the presenters please provide an example of a noise standard for wind turbines that they feel works well? And why?

Joel Fontane Asked: May we have a copy of these presentations?

Joel Fontane Changes Question To: May we have a copy of these presentations?

Joel Fontane Changes Question To: This was an extremely good presentation. All of them. Thank you!

Judith A Henningson Asked: Has there been any study of annoyance with WTGs in rural areas with existing industrial facilities... e.g. quarries or slaughter houses

Judith A Henningson Changes Question To: Judith in NY - Has there been any study of annoyance with WTGs in rural areas with existing industrial facilities... e.g. quarries or slaughter houses

Mark Bolduc Asked: What is the best way to monitor background

Mark Bolduc Changes Question To: Mark Bolduc, GZA GeoEnvironmental, Connecticut What is the best way to monitor ambient background to ensure that sound of the wind itself is property taken into account?

Mike Bahtiarian Asked: Are there any different affects from one wind turbine to multiple wind turbines other than classical multiple source, 10 x Log (N).

Milton Fistel Asked: I would like to get a copy of the slides that each presentor gave or were I can get the information?My name is Milton Fistel, P.E.

Milton Fistel Changes Question To: I would like to get a copy of the slides that each presentor gave or were I can get the information? My name is Milton Fistel, P.E.

Milton Fistel Changes Question To: I would like to get a copy of the slides that each presentor gave or were I can get the information? My name is Milton Fistel, P.E. I have have a Consulting Engineering Firm in Massachusetts for the past 35 years. You can e-mail the info at mfistel@aol.com Thank you

Moe Olmsted Asked: Moe Olmsted, MACan the wrap-up page be snt to participants so we have the up-coming webners access and data access.

Moe Olmsted Changes Question To: Moe Olmsted, MA Can the wrap-up page be sent to participants so we have the up-coming webners access and data presentations from this webnier access.?

Peter McPhee Asked: Could you clarify what causes the swishing sound? Is this a result of the acoustic interaction with the tower? Can this be mitigated?

Peter McPhee Changes Question To: Peter McPhee, Massachusetts Clean Energy Center, Could you clarify what causes the swishing sound? Is this a result of the acoustic interaction with the tower? Can this be mitigated?

THIS IS A CONTINUING LINE OF RESEACH, AND NO ONE EXPLANATION IS FULLY ACCEPTED QUITE YET. IT APPEARS TO NOT BE RELATED TO INTERACTIONS WITH THE TOWER; MORE LIKELY IT HAS TO DO WITH THE DIRECTION OF THE SOUND COMES OFF THE TRAILING EDGE OF THE BLADES. INTERESTINGLY, IT'S OFTEN MORE PRONOUNCED TO THE SIDES OF THE TURBINES, IN EXACTLY THE DIRECTION THAT THE OVERALL SOUND OF THE TURBINES IS THE LEAST.

peter moniz Asked: Is there a noticeable increase in total of noise as the number of turbines in a wind farm? (assuming that the separation is constant between turbines) peter, RI

peter moniz Changes Question To: Is there a noticeable increase in total of noise as the number of turbines in a wind farm? (assuming that the separation is constant between turbines) peter, RI

Peter Skrzypczak Asked: Have the effects of wind farm sounds been studied on species other than Homo sapiens sapiens, i.e., "humans"? Anything worthy of note?

Peter Skrzypczak Asked: Is there any known interaction between sound pressure waves propagated by wind farms and native plant populations? Anything worthy of note? [Peter from Massachusetts]

Peter Skrzypczak Changes Question To: Have the effects of wind farm sounds been studied on species other than Homo sapiens sapiens, i.e., "humans"? Anything worthy of note? [question posed by Peter, Massachusetts]

sally wylie Asked: Ken, we live near the turbines on Vinalhaven. We were specifically told that we would hear no noise from the turbines but the noise is, for us, unbearable. The 45/55 Db nighttime/daytime regualtions are totally inadequate. What would you suggest? We are trying to get the developers to implement some real mitigation, but they won't even talk to us. What do you recommend that the developers do to mitigate the situation?

scott kaplan Asked: What makes for a good acoustical wind study?

scott kaplan Changes Question To: What makes for a good acoustical wind study?