Hurricanes and Offshore Wind Farms
July 17, 2013

Man: Please continue to stand by. Today's conference will begin momentarily. Thank you.

Coordinator: Welcome, and think you for standing by. At this time, all participants are in a listen only mode for the duration of today's call. Today's conference is being recorded. If you have any objections, you may disconnect at this time.

Now I would like to turn the meeting over to Mr. Jonathan Bartlett. Sir you may begin.

Jonathan Bartlett: Thank you. Good afternoon, this is Jonathan Bartlett. I'm speaking to you from the Department of Energy in Washington, D.C. Welcome everyone to the July Edition of the Wind Power in America webinar. This month we have two speakers, Joel Cline and Mark Powell will discuss the impacts of hurricanes on offshore wind farms and how insurance companies can potentially improve the risk assessments.

Joel Cline is a meteorologist. Here I am, within the Department of Energy's Wind and Water Power Technologies Office in Washington, D.C. He's a technical advisor for meteorological input to planning and program execution for when power, mainly working on with terrestrial-based wind structures in short-term forecasting.

Mark Powell is an atmospheric scientist for the National Oceanic and Atmospheric Administration, NOAA, Hurricane Research Division located in the Atlantic Oceanographic and Meteorological Laboratory in Miami, Florida. He's now stationed at the Florida State University's Center for Ocean

Atmospheric Predictions Studies in Tallahassee, which is a NOAA applied research center.

As the operator indicated, we do questions and answers at the end of both sessions. So we'll do the presentation, and then we'll open it up to Q&A. And we handle the questions and answers over the web. So if you have questions, go to the top of your screen. In the menu bar you'll see a little Q&A option; drop that down. It allows you to type in your questions, and then I'll moderate those questions at the end of the session.

So each of you knows this is recorded. So for the whole presentation and it's the Q&A is also recorded, and it will be put up on the Wind Power in America website in approximately seven days. It takes a little bit of time to go through and upload it. But it will be recorded, and we'll let you know via the WPA newsletter when it's up and available. And that will be found on the WindPoweringAmerica.gov site.

So without further ado, let me introduce Joel as we begin today's presentation. As I indicated, Joel Cline is a meteorologist where I am here within the DOE Wind and Water Power Technologies Office in D.C.

Joel began his career working as an intern and progressed up to become a hurricane specialist at the National Hurricane Center. He also worked as a lead forecaster for the rally office of the National Weather Service before moving to program management of the Meteorological Services and Pacific Region, including the tsunami program after the Indonesian tsunami.

In addition, he has specialized in specific and demanding forecast. As a forecast team member of the 2002 Winter Olympic Games, the winner of Paralympics Games, and lead the team of forecasters for the 1999 World

Games of the Special Olympics. Additionally, he was an incident meteorologist, and made forecasts for wild fire crews onsite and onsite at grounded ships. He moved to Washington D.C. to work direct for NOAA leadership and that has been in program management in D.C. since July 2008.

Let's bring Joel Cline up to our virtual stage. Joel, thank you for joining us today on the WPA Webinar Series.

Joel Cline: Thank you Jonathan, and thank you everybody for being here and hopefully being quite interested in hurricanes as I am, as Mark is. You've got a great speaker in Mark Powell coming next so that's quite a wonderful thing to be able to hear him.

I just wanted to set the stage for what it meant to look at hurricanes, and maybe some aspects of hurricanes that you haven't thought of, especially the way that people will try to statistically look at risk for offshore wind farms today, and show a few examples. And Mark will quite clearly get into more of some pros and cons of today's way of doing things.

But essentially everybody knows about the track forecast. And for wind plants, of course, there's three critical time periods: the time period where you try to make assessments and plans to shut down a wind plant, the 24-hour day ahead where you're really going to move energy sources around and power sources around, and the zero to six hour time frame for wind ramp events and that type of thing.

So, you know, track forecast now go out seven days, and say day ahead really affects the market value in planning any type of evacuations that need to be done for plant operators, and their energy needs that they're going to be having onshore as the hurricane's going to be impacting the cost line near

them as well. Of course, there's all the transportation interests there from helicopter and ships. And eventually utilities will have some shutdowns of power and/or natural gases at that time.

Also wanted to speak to you about intensity forecasts. One of the things that people will seem to miss is that the wind industry for some reason seems to take wind measurements at a ten-minute average. And hurricane forecast winds are based on one-minute average winds with a ten-second gust period. And what that means is a hurricane is usually several hundreds of miles across—unless you get something like a Hurricane Gilbert or something which is several thousands of miles across—and the wind that's reported in the forecast and warnings, is the highest wind that you find anywhere in that thousand miles, okay? So it's at that or less most likely, okay?

And you know, you don't just report what you see from the hurricane hunter plane like you see on Mark's first slide here up on the screen now, because they may be in a convective type complex, and that may not be indicative of what we're seeing with other reports, satellite included, or other aircraft in a hurricane. So it's important to note that the highest wind is a one-minute average and it can be anywhere in that wind field that surrounds that.

Of course, you're always getting your observations to leave; that's the point of the warning. You want people on land to shut down and go away anything above 50 miles per hour, the Air Force and Navy are by law have to leave. We're constantly warning ships and aircraft not to go in there. So you're trying to forecast something as your observations are becoming less and less in areas. So satellite and hurricane reconnaissance are quite critical to the forecast aspect of these and the intensity and track forecast.

The big thing is rapid intensifiers, storms that can come up quick. So that even though you may be planning for a tropical storm or one that's a category one, it may hit the coast as a category three if it rapidly intensifies.

Back in 1995, there was a storm that was quite that way. I worked the day shift at the office. It was an October storm—early October 1995, Hurricane Opal. And it was in the middle of the Gulf of Mexico, and I left shift 4 o'clock and we were expecting at cat one or a tropical storm to hit the Florida panhandle area—the Western most part of the panhandle area. We woke up the next morning and there was a cat three that's intensifying gin the middle of the Gulf of Mexico. And it didn't get that strong.

But then we were also competing against trying to get the word out against the verdict from the O. J. Simpson trial and that was taken over all of the networks time, and we weren't able to tell people these rapid changes too. So it's not just noticing and forecasting rapid changes, getting that word out to where people can make decisions based on that.

I wanted to take a moment, not familiar with how many people know too much about hurricanes on here. But you should note that these—and I see a lot of times where people compare these extreme events to Nor'easters. It's important to note that the things, the physics that drive a Nor'easter and the physics that drive a hurricane are entirely different. A hurricane is driven by baroclinicity or the sameness of temperature from the outside of the storm to the inside of the storm, should be warmer if it's really growing and operating that it should be to intensify.

And it needs to be vertically stacked. All those things are different than—excuse me, I said baroclinicity, didn't I? Baratropicness is what drives the hurricanes. Baroclinicity is what—the differences in temperature is what

drives most of the systems that everybody in the United States is quite familiar with, and they are not vertically stacked and they're driven by the differences in temperature, therefore you have cold fronts, warm fronts and everything.

Now what's particularly of interested and why I bring this up is in storms on the East Coast where we're looking at wind farm development, all the systems have to recurve. If they're coming out of the tropics, then they have to recurve.

When they recurving, they're not as healthy. They're not as vertically stacked, if you will, and usually there's a reason that they're recurving and large upper level patterns and so usually they're a high just inland from the mid-Atlantic coast or maybe one even up over the Canadian Maritimes.

What can happen then is this storm is not truly tropical as it starts to move up the coast. And when things become less tropical, the wind field lessons in intensity but expands over a greater area, and so that wind field now, instead of being hundreds of miles when they go out, a thousand miles.

And so the duration that you have maybe category one hurricane force winds is going to be days on a wind farm as opposed to six hours of the category three type storm over a wind farm. So you need to know that in relation to where our wind development areas are most likely to occur on the Atlantic seaboard.

We also look into the Gulf of Mexico. This type of thing happens a lot less in the Gulf of Mexico but can still happen. Certainly, Sandy, as people recall was a tropical transition storm as it moved inland to New Jersey and those winds spread up as well as the waves out in front of it days ahead of time into New York and the New England areas.

So I wanted to bring those types of things up. We've had tropical storms move up the East Coast of the United States and there'd be a high over the Canadian Maritimes and the pressure difference between those two would be so great that it has blown 50 knots or more for three days and more, too.

So the duration of the winds, the duration of the wind are all going to impact those wind farms and I don't think you'll get that from a statistical analysis or something that may pass within a circle around the wind farm or the closest city to the wind farm which is a 65 nautical mile circle.

You won't see that from that, so that is a—is something that you need to take into account. And the other part, the last part that I wanted to make is the translational speed or the forward speed of the hurricane. Of course, if something's moving slow, the duration of those winds, those intense winds can be over a wind plant, wind farm, could be quite some time.

We've had several storm stall off the coast of North Carolina and circle for days. And so all those things need to be taken into consideration. We've also had things like a Hurricane Hazel back in '54 and other fast movers, Hugo in '89, et cetera, that can move inland quite rapidly and go far inland to maybe impact more of the inland plants, but they can go over something and be totally gone within a six hour timespan.

So you can have things that last three days. You can have things that last six hours. And then the last thing, of course, is the heavy rains that come that have been shown to impact the blades as well on the hurricanes—on the wind turbines themselves. So that's all I wanted to do, as a lead in, and turn it over to Mark Powell right now.

Mark Powell: All right, thank you, Joel. I'm really happy to be able to be presenting to such a large audience, really excited to turn out for the webinar today. I'd like to start out by just mentioning my laboratory. I'm with—now with Atlantic Oceonographic and Meteorological Laboratory, which is in Miami on Virginia Key.

And we work very closely with the Cooperative Institute for Marine and Atmospheric Studies which involves nine regional universities including Florida State University where I'm currently stationed.

AOML focuses on hurricane research through the Hurricane Research Division as well as oceanographic and physical oceanography and ocean chemistry.

As an outline on this talk, I'm first going to mention some of the impacts on wind farms from both typhoons and hurricanes over the last decade or so. Then we'll get into a discussion of risk modeling. And then finally, we'll get into more detail on design conditions and a field program that we hope to be able to collect the observations to help inform the design conditions.

Now in the earlier—a few years ago, there have been some super typhoons that have had some serious impacts on wind farms onshore, both in China and in Japan. The image on the right shows some damage from some island wind turbines in Japan.

And there've usually been publications in the wind engineering literature that discusses the failures. From what I've been able to tell, most of these seem to be associated with a loss of yaw control or if the yaw control is still operating, it has to be able to respond to the turbulence which can sometimes be enhanced by complex terrain.

For offshore wind turbines provided we're sufficiently offshore, the complex terrain interactions should not be that important. More recently, with Hurricane Sandy, Sandy actually affected some—a wind farm, actually a couple of wind farms in Cuba.

The media reports seemed to indicate that those farms withstood the full impact of the storm when it actually—if you look at the wind analysis below the photo on the left, that's an H wind analysis of Sandy as it was going across Cuba.

The wind maximum was actually on the Eastern side of the storm so it's—it may—that wind farm may not have even reached hurricane force winds. On the right is the Jersey Atlantic wind farm in Atlantic City which was where Hurricane Sandy or subtropical or post-hurricane or I call it a hurricane hit New Jersey and that was a storm that was becoming extra tropical, losing hurricane characteristics, had its wind maximum on the south side of the storm as it was making landfall.

So, again, the wind farm there probably did not get hurricane force wind but most of these wind farms survived just fine. So wind farms should be able to withstand hurricanes provided they have been designed for hurricane conditions and they have active yaw control.

And the next topic is risk. To be able to establish a design, you need to know something about the wind climate or wind risk at a particular location where the wind farm is proposed.

And for onshore wind farms, sometimes this is done through looking at couple years' worth of data, looking at frequency distributions of the wind and trying

to look at the tales of the distribution to see the, you know, based on the wind climate, how often do you get strong winds.

Unfortunately, our wind records are not completed enough. We need to go out way beyond just a year or two. There're very few records that go that far back. You really need to go—you'd want to go at least, you know, 30, 40, 50 years. Very few records go that far back and the ones that do, they often have dropouts because power is lost or various other things happen that keep you from getting a complete record when an episodic event occurs.

So usually you have to make up for that by doing risk modeling. Now back in February of 2012, a study conducted at Carnegie Mellon got quite a bit of attention. It was spread all over the media, various different outlets which seemed to indicate that offshore wind turbines would have a really hard time withstanding hurricanes.

In fact, they had some very compelling—some provocative language in there quotes saying the—nearly half the turbines in a farm are likely to be destroyed in a 20 year period. And that was for the test area off of Galveston.

So that really got my attention along with my colleague, (Steve Cock) at Florida State. We decided to look at that paper in detail. This was the paper that was published in the proceedings of the National Academy of Science.

And we found a lot of problems with their approach, one error in unit conversion and at least three flaws in how they did their work. So we published a comment on the paper which is the bottom half there of this slide. This was published—unfortunately it's only published in the PNAS online site.

And for some reason, they don't send out press releases to USA Today and Popular Mechanics and the New York Times withdrawing a result of the earlier study so the word never really got out but I think there's still this impression that hurricanes will have a tough time withstanding—I mean, wind turbines will have a tough time withstanding hurricanes.

And here's just a quick review of what they did. This dash box here, this is for the Galveston location. They looked at a very long period of record, 1851 to 2008, of historical storms and they assumed that every hurricane in that box, at peak intensity, would be—would contribute to a frequency distribution that they would sample from—they would fit this by an extreme value distribution.

And they would start running storms into Galveston at the historical rate and sample from this distribution. And the problem is that they would assume that every storm that hit Galveston would be at its peak intensity so there'd be no decay on the way to landfall and that the entire county sized area would receive the highest wind anywhere in the storm.

So these are big flaws and anybody whose, you know, done hurricane work understands that the hurricane is a wind field that has a horizontal distribution of wind. The peak winds are usually in a localized area, sometimes a very small area, typically on the right-side of the storm.

I've given an example here of a hypothetical wind farm on the western end of Galveston Island. One storm on the left there, moving towards the Bolivar Peninsula, you know, it's possible that wind farm might only just barely receive hurricane force winds.

The example on the right there where it's moving more parallel to the coast, they could receive the left-side of the (eye wall), so you really—to do a good

job with risk, you really need to know the distri- the horizontal distribution of the wind.

Our study, we replayed the historical track affecting Galveston from 1900 to 2010, used the same loss curves as in the PNAS paper from the Carnegie Mellon researchers. And we found on order of magnitude less risk and again, these are with now yaw control.

So our analysis suggested you would lose on the order of two turbines per 20 years in the Galveston region compared to 24 turbines per 20 years in the original study.

So the types of models that are using extreme value theory, they are still used but for insurance risk applications, they're typically not used. In fact, the—in Florida, the Florida Commission on Hurricane Loss Projection methodology regulates the modeling that's done that's used to establish residential and commercial insurance rates.

And they don't allow using an extreme value based model. What they regulate are stochastic models which have a lot more complexity and physics which allow you to simulate the entire lifecycle of each storm in a historical record and repeat that basically simulating thousands of years of hurricane activity and then coming up with products similar to what you have on the right where the top right is a map of the 100 year reterm period wind speeds for Florida for open terrain and the bottom right is the 250 year reterm period wind speed.

So in summary, to properly establish risk using state of the art methods, stochastic modeling is used which is based on the observed tropical cyclone climate. There's the complexity and physics of storms are included such that you can model the lifecycle of each individual hurricane.

You simulate thousands and thousands of years of activity and then you can use the winds at any location from each event to establish return periods. And once you have that, then you need to downscale to determine—downscale and have the observation to determine the design conditions that might be expected at a wind farm location.

Now the image on the right here, I believe this is after Hurricane Ike and, of course, after Rita and Katrina, the Gulf of Mexico is very susceptible to hurricanes. Tall, offshore structures are susceptible and continue to experience losses when we have major hurricanes.

And so the expectation is that we really need to be careful about how we design offshore wind farms so we don't have this kind of thing happen especially in a nascent industry where we can't really afford to have failures that might keep the whole industry from taking off.

Right now the design conditions are stipulated according to standards. There're a lot of different standards out there. I looked at—I'm showing three of them here—the European standard, the Norwegian standard and the American Petroleum Institute based standard.

These are primarily based on research supported by the oil and gas industry. And what I found fascinating is that a lot of them reference a study that was conducted off the—in the Norwegian Sea, some islands in the Norwegian Sea, a lot closer to the Arctic circle than where you might have any hurricane activity.

And in those days, there were very careful studies that were done. The winds did not go up to the strength we have in hurricanes. So the question is, do

these standards that are based on data collected in regions where you don't have hurricanes or at least where the data didn't go up to hurricane force, are they appropriate to apply in areas that do have hurricanes?

And the preliminary answer is that these standards are out of date with the latest research. Not just the latest research but the research published within the last ten years.

The European standard suggests that roughness should increase with wind speed. Roughness helps determine the shape of the wind profile so you need to know the wind profile to know the loading at the—within the rotor zone of the wind turbine.

The American Bureau of Shipping Standard, which is based on the American Petroleum Institute publication, has a power law that has no roughness dependent and the sheer coefficient that's in that power law is equivalent to an open terrain roughness over land.

So it's actually a lot more sheer than you would get over the ocean. And they make suggestions that these more laws should apply in strong wind conditions such as a hurricane. However, there is no roughness dependence in this profile law which is an alternative to the profile power law.

Another out of date stipulation is that the turbulence intensity should increase with wind speed when it's been found that it really depends on the roughness. So if we want to establish design conditions, we really need to go out in a hurricane and collect the data.

And so I just wanted to share with you a few slides that will give you an indication of what a hurricane is really like. This first image was a photograph

taken by (Michael Black) from the NOAA research aircraft from a very scary altitude of 65 meters.

Here the winds are actually below hurricane force. This is on the right side of the storm where the swells and the wind are tending to go in the same direction. And some of the features that you see in the image, you can see these curves, wave faces that are breaking.

You can see patches of foam. You can see streaks of bubbles in the water columns that are left behind after a wave breaks. When a wave breaks, it's—a lot of air is injected into the water column which can go down, the bubbles from the wave breaking can go down as far as 10 meters or so into the water column and these bubbles have relatively long lifecycles.

So they stay in the water column for, you know, a relatively long time in the meantime before they come to the surface and break. When they break, they add spray to the air. Another wave is broken and another and another. So we have a very rapid increase in the amount of air injected into the water column which results in a very rapid increase in the whiteness or white—or streakiness of the sea surface, which I'll show you in the next couple of images.

I also wanted to comment on the way waves propagate. From (unintelligible), our altimeter data collected from the NOAA aircraft, this is an image from Hurricane Bonnie. The light dashes you see in the background are actually wind unit sectors.

The heavy dark marks are representing the wave propagation. So on the top side of this figure, you'll see that the dark heavy lines are going across the

wind so the waves are actually propagating away from the hurricane but across the wind.

And—see if I can get my—so over here on the right side of the storm, you've got winds and waves in about the same direction. Over here, you've got them going across the wave. And I also wanted to mention, in this location here, where you tend to have the strongest winds, you also have the highest wave height.

Actually, the highest wave heights are over here a little further out in the storm. Those are the largest significant wave heights. This is the direction the waves are moving and even at some places where the waves are moving against the wind.

So you have along the wind, against the wind and across the wind. And these all have an impact on the friction of the sea surface. Now the second image here, this is taken again, in Isabelle. This is on the left side of the storm, this is where the swells propagating outward across the wind.

This is in stronger wind. It's from a little bit higher altitude. There's less whiteness in the water. The cross swell tends to reduce the amount of wave breaking. So these are important considerations for—that actually affect the wind profile.

And this image here, the top part of the image—I'll have to use the pointer again here, over in this area, hopefully you can see it. There's a little more haziness. That haziness there is caused by sea spray. Over in this area, it's a little crisper, a little clearer, not as much sea spray there, so there was probably a large wave breaking event that injected a lot of water particles into the air.

And these kind of stream along just above the water surface. It's amazing to see this from when you're flying in the aircraft. It's really a beautiful image of how nature works, but I can—it's analogous to the flow of snow, blowing snow over hard packed snow, or sand on a windy day at the beach when sand gets picked up and it is, you know, through saltation is moving just above the surface. That's the same thing you have in spray.

It does this along theses linear lines. And then you also have these lines of water bubbles in the water column, these streaks. As we go on to much higher wind speeds, the surface of the ocean changes really into an emulsion so you have both the sea spray or water that's in the air, and then you have the air, the bubbles that are in the water and it forms an emulsion.

So instead of the stress on the ocean surface being picked up by the relatively hard water surface, now it's being picked up by, you know, billions of bubble particles that are on the surface. The physics of the surface change completely and the properties—the fictional properties of the surface also change.

So you actually have where you get to these really extreme winds, like on the right, where the surface is completely covered by this foam. You—the surface actually becomes more of a lubricated surface. The friction actually goes down.

These are really important. These are all based on open ocean conditions. Of course, on the coast, they may be a little bit different. So how do we sample these—how do we know about what's happening in these conditions?

The GPS drops are what allowed us to really investigate how the friction changes under these conditions where we've been able to drop these little

cylinders. They go about 10 meters per second. They sample the wind speed every half second, temperature, humidity and pressure as they fall.

And here's a look at their—when you drop one, the radar image, they tend to go cyclonically and as they fall down closer to the surface, the inflow or surface friction causes them to bend in more towards the surface.

We have thousands of these wind profiles that have allowed us to construct mean wind profiles. And here're some examples of mean wind profiles that were published in a paper that some colleagues and I published in Nature back in 2003 where we were able to use the profile method to diagnose the roughness and stress of the ocean surface based on the shape of the wind profile and the lowest 150 meters.

What we found is that the sheer in the profile is quite a bit less than what you might expect if you use the kinds of assumptions that are in some of the standard and, in fact, the roughness has actually leveled off as you got to about hurricane force winds and then started to decrease as you got to more extreme winds.

And so I have an example here. This is a mean wind profile. If you have a surface wind on the order of about 51, 52 meters per second here, and use the observed wind profile, by the time you get up to hub height at 100 meters, you've got a wind speed of about 60 meters per second if you use a mean wind profile based on actual hurricane wind conditions.

If you use what's in the standard, there's a lot more sheer in the profile and you're up to a category five conditions by the time you're up to that height. So depending on how you're going about engineering these things, you could be

way—if you're starting at the 10 meters and going up, you could be way over engineering in how you design the turbine.

If you're starting with your design work at turbine height and then going down, you may be referencing it to the wrong surface wind speed. So, for example, if we start up here with 100—a turbine hub height wind of about 60 meters per second, if we go down using the observe profile, you know, we're about 50, 51 by the time you get to 10 meters.

If you use the power law profile, you're down to category two conditions, about 45 meters per second at 10 meters. And if you use the Norwegian Sea type profile, by the time you get down to 10 meters, you're at category one conditions just a little bit over hurricane force.

So this is a big deal if you're trying to design wind farm to withstand a hurricane. So the big question, still, is most of the wind farms that are being planned as a demonstration site or already established wind energy areas or areas where lease activity is ongoing, these are sites much closer to the coast.

So the big question is, okay, we've collected most of our data further offshore. Closer to the cost you're going to have shallower water, showing waves. We need to see if these same conditions apply closer to the coast.

And so this is some of the energy areas. What we are proposing is some work with DOE to partner on collecting data on hurricane coastal design conditions whereby if a storm is in the vicinity of any of these pre-identified locations, and the hurricane hunter aircraft are already flying, we will go a little bit out of our way and drop some additional fronts to collect profile information.

We also would like to collect additional information using our wide swap scanning radar altimeter to collect a two-dimensional wave spectrum data, actually issue individual waves, collect some information on the oceanographic current profile and the two-dimension wind distribution.

So we have a field program experiment that we're hoping to execute this summer and start collecting some of this data from the NOAA research aircraft.

So we think a comprehensive observational framework will really help to inform and design conditions to make sure that as we get into offshore wind farms, they're able to withstand hurricanes.

Man: Thank you.

Jonathan Bartlett: Thank you very much Mark. This is Jonathan Bartlett again. And we'd like to open up the floor to the attendees who have been listening to the presentation to ask questions. So at this time, if any of you have questions, feel free to ask them. Otherwise we can let Mark continue on. He's got a few additional points he'd like to make but we want to make sure we had that opportunity for people in the audience.

Well, I can answer one question that has come in. The slides will be available approxi- the—we won't upload the slides, per se, but the entire presentation is being recorded and will be available online on the Windpoweringamerica.gov site approximately seven days from now.

We have an additional question coming in regarding do any of the (unintelligible) team get funding from the fossil fuel industry? I don't know if you can address that, Mark.

Mark Powell: I think if you look at their paper, it discusses where their funding comes from and then you can look into their—you can go online and look at their center and get a little bit more information. I prefer to leave it there.

Jonathan Bartlett: Thank you. And next we have a question from (Brian O'Hara) who wants to know where—what are turbine manufacturers and insurance providers telling you about their response to hurricane risk in the U.S?

Mark Powell: Well, I must admit, I really don't know what the individual turbine manufacturers are doing yet. I think they're, you know, kind of in the preliminary stages because the timeline for getting an offshore wind farm is on the order of several years.

So they're probably undergoing their due diligence to look into some of these issues. But a lot of this is new, I think, even for the offshore oil and gas. They're just starting to be aware of some of this latest research on how the wind profiles are different from what they may have been thinking.

Jonathan Bartlett: There's also a question regarding what can be done to determine design conditions before we have any additional data on hurricanes? Thank you (Simon Henrickson).

Mark Powell: Well, I think you could start with some of the data that's already been published and incorporate that in your modeling. The big question would be whether that is still applicable close to the coast where you can have these (showing) conditions that, you know, may make things a little bit different than what is going on in the open ocean.

Jonathan Bartlett: (Dan), there was a request for your email for correspondence.

Man: (Unintelligible). I'll be gone next week.

Jonathan Bartlett: Okay.

Man: And next week (unintelligible). I won't be until (unintelligible).

Jonathan Bartlett: If there are specific questions, you can also filter them through the WAPA site. Our contact information is one there. We can provide Joel Cline's and Mark, that's at your discretion as well.

Mark Powell: Can I give that now?

Jonathan Bartlett: Sure.

Mark Powell: Yes, my email is mark.powell, P, as in Peter, O-W-E-L-L at NOAA.gov.

Jonathan Bartlett: Next question is from (James Manwell). Do you find a significant veer over the height of the large rotors, e.g., 130 meters, during hurricanes?

Mark Powell: No, based on the data, there's very little wind direction change over lowest couple hundred meters. It's on the order of—maybe on the order of 5 degrees, 5 to 10 degrees at most. This is, of course, a mean. On the mean, you may find that there are cases, individual cases, where it could be higher especially if you're right on the edge of the eye wall.

Jonathan Bartlett: And (Eve Promwell) has asked how many hurricanes were surveyed to generate the wind sheer profile that was shown in your presentation?

Mark Powell: The profile I showed was based on, I think, 33 hurricanes between 1998 and the—2002.

Jonathan Bartlett: (Steven Rose) has a question regarding the Carnegie Mellon electricity industry center, wrote where does that receive some funding from—I guess an earlier response to the funding question—some funding from the electric power industry including fossil fuel, heavy utilities. A large portion of the research was funded by a graduate fellowship from the EPA. Thank you.

Next question is from (Rebecca Meadows). How many miles from the coast is considered open ocean?

Mark Powell: Well, it's kind of hard to say in terms of miles from the coast but it would be water depth greater than 50 meters.

Jonathan Bartlett: All right, thank you very much. And I believe, unless we had a last second entry question, this will be the conclusion of today's presentation. I would like to thank you Mark. Thank you Joel and to the over 100 people who have stayed on for today's webinar.

To finish things up, the Wind Powering America series of webinars occurs every third Wednesday at 3:00 Eastern. Our upcoming webinars include August 21st, the Distributed Wind Market Update, September 18th, the Small Wind Policy Tool, and we don't have it listed on this slide, but next Thursday we're having a special Webinar at 3:00 pm on July 25th for the upcoming request for proposals for regional resource centers.

I will be joining Ian Baring-Gould to provide an update on the RRCRP development. Please join us next week. Again, that's Thursday, July 25th for

this special Webinar. After that, we'll be back to the regular schedule of WPA webinars on the third Wednesday of every month at 3:00 pm Eastern Time.

Each of these webinars will be posted on the website about seven days after the live presentation. We encourage you to forward links to the upcoming webinar or archived webinars if you enjoy them and feel that you have colleagues and friends that would benefit from them. Do not hesitate to pass them along to your friends and colleagues.

Lastly, a special thanks to the National Renewable Energy Laboratory for hosting this webinar series via the Department of Energy funds to the Wind Powering America Initiative.

The contacts for all of us are on the WPA site. That includes myself, Jonathan Bartlett, Ian Baring-Gould, and the rest of the WPA team. So if you have any questions or comments, feel free to contact us about upcoming webinars or thoughts.

Again, a final thanks to Joel and Mark for their time. Thank you all for joining us. We hope to see you again virtually for our next webinar. Have a great day.

Man: Thank you.