The Wind Vision
July 15, 2015

Coordinator: Welcome and thank you for standing by. At this time all participants are in a listen-only mode for today's conference. Today's conference is being recorded. If you have any objections, you may disconnect at this time. I'd now like to turn today's meeting over to Suzanne Tegen. Thank you. You may begin.

Suzanne Tegen: Thank you and good afternoon. Welcome to the webinar everybody. Today we'll be talking about the Department of Energy's Wind Division Report. The report was released in March, and can be found very easily by typing in D-O-E wind vision into your search engine of choice.

Today we're going to kickoff a series of webinars that will focus on this very important report. Because the report has so much information, we're going to provide additional webinars on specific parts of the wind vision in the coming months. So, we'll have one for example that focuses on transmission; one that focuses on citing and permitting kind of to break it up to make it easier to digest and also so we can have a little bit more Q&A about each of those topics.

And I'm pleased to tell you that today we have four distinguished speakers all of whom led parts of the wind vision research analysis and report writing. And as the agenda shows here, we're going to start off with Rich Tusing. He will be talking about the wind vision the impacts, followed by Eric Lantz and Ryan Wiser who together will present the analysis highlights and key results.

And then we'll conclude with (Unintelligible), a little bit of an overview and then that kind of wind vision roadmap sort of looking ahead into the future. If you have questions during any of this webinar, please click the Q&A little

button at the top of your live meeting window. And then type your question in that box and click ask to send the question. And we'll do questions at the end. So when all of the speakers are finished we will have our questions.

So, let's go ahead and start, our first speaker is Richard Tusing. He is a senior analyst under contract with New West Technologies to the department of energy's wind and waterpower technologies office. Rich conducts policy and market analysis, and was one of the leads for the wind vision project, coordinating four national laboratories, 11 task forces, and over 250 contributors from industry, environmental stewardship, academia, transmission operators, and science-based research organizations to produce the wind vision report.

Rich has a diverse background as a CEO and COO for multiple early-stage product development companies with over 35 years of managerial experience, additionally he's held positions as CFO, Chief Technology Officer, Senior VP of merges and acquisitions, director of information systems across a broad range of telecommunications, consumer products, energy and consulting service companies. So, to sum it up Rich has a wealth of experience across the energy world and managerial arena, and we're lucky to have him as part of our wind power team. So, Rich if you'll take it away.

Rich Tusing: Great. Thank you Suzanne, very nice. Hi everybody. Thank you very much for the opportunity to talk to you about the wind vision project. I think you'll hear today from all of the speakers the amount of passion and the amount of commitment and effort that the overall team had for this over a two-year effort for the report to be issued in March.

At the heart here on as we stay on Page 1, at the heat of the objective for the wind vision project was really to provide the best information, the best

analysis, the best insight that we could offer as the government having a role to help facilitate this best information to enable energy stakeholders at a federal, at a state, at a regional, and at an individual voting public level access to information about wind that was the most up-to-date, and hopefully the most informative to really help people engage and to understand how to make smart decisions related to wind power and wind power related policies.

Moving to Page 2, wind vision has a history, interestingly, back in 2008 the department of energy issued a report called 20 Percent Wind by 2030. And that original report was a really important seminal report from DOEs perspective because it was, wind was its initial cusp related to having an impact in the industry. And it was very small at that time when the report was drafted it was back in 2006.

And there was really fundamental questions that the report was trying to address. So the 20 percent by 2030 report really asked questions, can wind play an important role in the overall energy/electricity portfolio? How much wind resources are available? It is possible that you could actually scale this wind technology and have substantially U.S. manufacturing? And could it be cost competitive? And boy can you actually even deploy large amounts of wind?

All of those questions really were unknown when the 20 percent by 2030 report was originally issued by the department. Today, we know the answers to all of those questions really well. There's a lot of data to support the answers to those kinds of questions of can wind make a material impact and can it make a substantial contribution in everything from the amount of energy it could generate the amount of jobs in local domestic manufacturing?

So when we revisited that question here in the wind vision 2015, we knew that we both had to first document the answers to those questions. But, we really had a next generation of questions that we were really trying to address. Things like if we look at both the short, the medium, and the long term, which we defined as 2020, 2030, and 2050, can we really answer the question of what's a reasonable scenario?

How much wind can be supported? What kinds of steps and roadmap steps do we need to do? What kind of values and impacts? And so the wind vision was originally germinated from this idea of trying to say can we really understand the value of wind, and can we understand the quantitative value of wind, and can we understand the necessary steps that are going to be needed to achieve substantially more levels than the levels of historical?

So on Page 3 there are a couple of very specific objectives; one was in the original 20 Percent by 2030 report it was really focused on the 2030 timeframe. And wind vision said there's more information that we need to help inform stakeholders and individuals. And so, we really decided to look at all three set time segments. That is the 2020, which we call the near term, 2030, and even a longer-term vision out to 2050.

And hopefully by trying to understand the trends to see if in fact things look different in different time periods. And we have a lot of data and Eric or Ryan will give you an opportunity to see some of those conclusions that we reached in our analytical and modeling works.

The second key analysis objective was really to take a look at can we quantify from a department of energy, from a government official, shielded report, an analysis that looks what the costs and the benefits and the impacts. What are the impacts for CO2? How much of a level of CO2 impacts could that have on

our energy portfolio? What kinds of water savings, and how much land wildlife impacts? How much transmission would be needed? So the quantification of that was really a primary objective of the wind vision report.

And a third layer of original objectives was the DOEs wind and waterpower technologies office, which operates underneath of energy efficiency and renewable energy office here in DOE, really wanted to make sure that we were aligned with the right kinds of priorities that would have the optimum kinds of impacts in terms of research and development, wildlife analysis, and other kinds of investigations?

And by having the wind vision, it really gave us an opportunity to work with, as Suzanne mentioned, a really broad range of stakeholders, developers, and OEMs, environmental organizations, transmission and distribution operators, academia, to try to understand how do we prioritize and have a consolidated view that we can all look to in terms of what are the key actions, and how we prioritize the things that are most important?

Moving onto Page 4, one of the things we did take a look at was how the original 2008 report made some projections for how we be doing in 2013 and in 2014, and beyond. And were we ahead of those projections, or were we in line with those projections? And interestingly when the 2008 report came out, I think the general reaction to the report was that it was very aggressive, that it was probably very optimistic that we would be able to deploy the levels that the 2008 report originally designated.

But in fact, as we have on this chart here, we've really had an opportunity to even exceed some of those original targets. In the 2008 report we anticipated 48 giga watts would be deployed. By 2013 we'd actually already installed 61.

The number of states that were looking for utility deployment exceeded our expected values and moved to 39.

And probably most impressively the cost reductions that we were anticipating originally in 2008 that would be around 6.6 cents were already down to 4.5. One the next page, so the wind vision report is organized in three basic sections. It has a section that talks about the current state of the industry, what we've actually accomplished.

Then it has a section that talks about what the analysis and the quantification, and then a section that talks about the roadmap. And so we really wanted to make sure that in the first section where we talked about what we've accomplished to date. And we really made it clear how wind is already a very important part in American clean energy mix, how it's already installed in 39 states.

And as we look to the future we actually believe that wind can have a meaningful value in every state. Some of the analysis and modeling results that Eric and Ryan will go over will talk more in detail about how we look at the economics and look at what impacts it would take in the energy portfolio to achieve the scenario of ten percent of the nation's electricity in 2020, 20 percent by 2030, and 35 percent in 2050.

And the department of energy isn't making a projection. The department of energy is saying in this particular scenario here's what the implications would be if in fact we deploy that much wind. And so our intention here was to help inform policy-makers at a local, regional, and state, and federal level to be able to make regional decisions that made sense to them given this kind of information.

Also, in the report itself we did not actually model policies that have not yet been enacted. If in fact they were in effect, the state's RPS was in effect on January 1, 2014, we included it in our analysis. But we didn't actually publish in the report analysis of the various different kinds of policies that could be occur. But we did look at one specific scenario related to, one specific study scenario related to the EPAs 11D clean power plan.

And wind can make a substantial contribution towards in the 10, 20, and 35 percent study scenario that we looked at under wind vision can have a substantial contribution to achieving the EPAs 11D. Next page. You know, in drawing to some of the conclusions even before you, if you have not yet had a chance to review any of the highlights of the executive summaries to the report, there are a couple of key takeaways.

The first would be that continued wind research and innovation. The combination of government working with private industry beyond what we have as our central industry expectations really is critical to understanding the viability of wind in the next few decades.

If in fact you make investments in wind technology you reduce the long-term need for policy as you enable wind to be more cost competitive regardless of how you think about the policy scenarios, whether you think about new policies, or whether you think about the existing policies that wind competes against in long-term tax code implications.

A second major kind of key takeaway really has to do with when you get a chance to hear about all of the quantified benefits, the value of CO2, the value to the job market place, when you get a chance to hear about all of those, and you put all of those, and you think about them and a cohesive way, the value of wind substantially exceeds the values of the cost necessary to deploy it.

And I'll let Ryan and Eric walk you through those kinds of analytics, but they really are impressive in terms of how much wind can make substantial contributions. The third key takeaway is that high-wind penetration and reliable electric grid management are achievable. We have multiple states today that are in excess of 25 percent, and a number of states that are above ten percent.

And so we have actual deployment experience that tells us that high-wind penetration is viable and reasonable to achieve. And then the roadmap that Ed DeMeo will have an opportunity to talk about will talk to you about the kinds of program activities that have the highest impacts, and where our work with both industry and academia, and across a broad section of NGOs really has highlighted what are the key values that we can focus on to be able to have the biggest amount of impact?

And my final slide, slide seven, we don't think of wind vision as being a static report that when the report's done, the project's done, already after wind vision was produced in March, we've already produced our first follow-up analysis, which is called enabling wind power nationwide. And it builds upon the wind vision modeling and really analyzed from a geographic and regional point of view as technologies continue to evolve to higher hub heights and accessing higher wind speeds, what does that mean for where wind can be deployed throughout the nation?

And this particular incremental report enabling wind nationwide really identifies how the Southeast, which has not been particularly noteworthy for installations does actually have the viability at these next generation technologies at higher hub heights and longer rotors that can be economically cost competitive. And if you haven't heard, there was an announcement this

week for the first installation in a southern state in North Carolina that reaffirms that region of the country is beginning to see that there is viability for economic wind deployment.

And then the wind program here in DOE continues to make investments in technologies, taller towers, funding opportunities, (unintelligible) larger played funding opportunities are currently enacted. So, there's a broad range of momentum related to the ability to help wind take its place in the overall portfolio. And DOEs role is really to help inform people and to let wind vision provide the toolkits, some of the toolkits for thinking about what are the costs? What are the benefits? And how can we make intelligent decisions?

So, just wanted to provide that overview. Thank you Suzanne for the opportunity to provide a summary.

Suzanne Tegen: That's great. Thank you so much Rich. And again if you have questions, you can type them in up at the Q&A bar there at the top. And our next speaker, we've got actually a tag team speakers here Eric Lantz and Ryan Wiser. So, I'm going to introduce them both to you, read to you a little bit about them, and then we can start the presentations.

So Eric is a senior energy analyst here at NREL. He specializes in renewable power policy, power markets, and technology. And most recently he was the lead analyst and senior advisor for the DOE wind vision. Previously, he led other high-profile policy analysis work including an examination of tax credit extensions scenarios for wind power conducted at the request of the U.S. Senate committee on energy and natural resources, and also analysis of economic development and jobs impact resulting from new renewable capacity and transmission investments in Wyoming and Colorado.

Eric is active in two working groups of the international energy agency focused on social acceptance of wind and international trends in wind power technology and economics. He holds an MS in energy policy from the University of Colorado, and in his free time enjoys exploring Colorado's mountains and of course playing with his two young kiddos.

Ryan Wiser is a senior scientist and deputy group leader in the electricity markets and policy group at Lawrence Berkeley National Lab. He leads and conducts research and analysis on renewable energy including on the planning design evaluation of renewable energy policies on the cost benefits and market potential of renewable electricity sources on electric grid operations, and on public acceptance and deployment issues.

His recent analytic work has included studies on the economics of wind and solar power, the impacts of higher penetrations of renewable energy, the design of renewable energy promotion policies, the risk mitigation value of renewable electricity, and the treatment of low carbon supply options and utility resource planning, as well as community acceptance of wind and solar power.

He's published over 350 journal articles and conference papers, research reports, book chapters; his work has been quoted in many places. And I think I will skip reading all of them to you, but he has a very impressive bio. He regularly advises state and federal agencies on issues related to renewable energy and works on renewable energy in China as well.

Ryan's been a lead author for the inner governmental panel on climate change, and also has been a consultant to the California Energy Commission, New York State Energy Research and Development Authority, the International

Energy Agency, the World Bank, the Energy Foundation, the Center for Resource Solutions, and private companies.

He holds a BS in civil engineering from Stanford, and a MS and PhD in energy and resources from the University of California Berkeley; so both of these speakers are very well qualified as you can hear, and Eric if you could start us off here?

Eric Lantz: Great. Thanks Suzanne. And thanks for taking the time to share these findings with your network. So, this particular slide deck has five different elements to it, each of these to some degree expanding on some of the highlights that Rich has already provided for you earlier in the webinar. I will start off by talking a little bit more about what the analysis-specific objectives were, and then how we tried to deliver on those objectives through what we consider to be a scenario analysis for the most part.

I'll talk a little bit about the wind specific, the wind industry impacts of deployment and generation, and then how that plays in with the rest of the electric sector. And then the final portion of my talk will cover some transmission and integration related metrics. I'll pass the baton then to Ryan who will talk about some of the costs and retail rate implications of this particular scenario, and then the benefits that Rich also mentioned a little bit earlier in the quantitative form, although in his particular coverage.

So, on the analysis side there were really two objectives, and Rich has already highlighted these to some degree, so I will only spend a little bit of time on here. But, really what we are trying to do is understand where wind sort of sits from an economic perspective in the electric sector today and then into the future, both in sort of the mid-term 2030 and the long-term of 2050.

Then, once we had that understanding, we wanted to pick a scenario from within the milliard of possibilities, and then analyze the impacts of taking the measures to realize that scenario. So those measures could be anything from investing in new policy mechanisms, advanced R&D, or other actions that could be taken in order to help us realize that particular scenario.

Of course, a big portion of the analysis work also went into informing priorities for the DOE wind program, as well as private sector stakeholders. We won't be talking about those in the talk today. So the first slide here details what we call descriptive analysis of sort of the electric sector and wind's role in it over time.

This is essentially, you know, you put in your assumptions for wind technology costs, for fossil fuel prices, for an array of electric sector variables, and you push go on the model and you see what happens. And when we looked at wind at the beginning of the wind vision study, what we saw is that, you know, you could be a future depending on how optimistic or pessimistic you are where wind is pretty flat relative to today, essentially no or little wind capacity additions come online.

If you have high wind costs and you continue to have very low natural gas prices, as an example, or alternatively if we're aggressive about wind R&D, fossil fuel prices are perhaps higher than expected, you might be in a situation where you could see wind penetrations on the order of 40 percent by the 2050 timeframe, so that most optimistic scenario is represented by the top line on this particular plot.

What we actually found under sort of business-as-usual conditions, so this is more middle of the road wind technology costs projections, and sort of middle of the road fossil fuel prices, particularly for natural gas is that black line

where essentially what you have is some new activity over the next couple of years as the under construction projects are commissioned.

But, then you have sort of a flat period, a period of stagnation in the 2020 to 2030 timeframe, and then over the long term though, as sort of the global industry continues to innovate and some of our fossil and nuclear fleet ages and hits retirement time after 2030, even on an economic basis under business-as-usual conditions you do see an uptick in wind deployment in that future 2030 to 2050 timeframe.

So, when we looked at all of these scenarios, we said well what's an ambitious scenario that allows us to keep the current industry intact and allows us to achieve something that is maybe not going to happen under business-as-usual conditions? We also, as Rich mentioned, sort of looked backwards to the 20 percent by 2030 report and said what would be a good complimentary scenario to consider? And so, that's what's laid out here, and what Rich has articulated previously, ten percent wind by 2020, 20 percent by 2030, and 35 percent by 2050.

So that's the scenario that we thought to examine impacts from. Within that scenario we did take a few measures that didn't necessarily come directly out of our economic modeling results, but because of the nature of the industry and particularly on the offshore side that relatively (unintelligible) state of offshore, but yet the large sort of resource potential for offshore, we tweaked our scenario given those 10, 20, 35 percent levels to include a portion for offshore wind.

We also kept in mind the role of distributed wind, although truly for the residential scale equipment or behind the meter installations generally we're not modeling those kinds of technologies. Nonetheless, they are covered in

other portions of the wind vision report to some degree. For this specific scenario because we were really focused on what the value or what the benefits and costs of the scenario are because we assume policy as written today.

So if you have an RPS in place that stays intact and is ultimately satisfied in the modeling, but we assume also that the PTC is expired and is not renewed. We're not looking at the clean power plant explicitly or even things like (mats or Casper) explicitly by and large in the modeling work that was done. We also don't look at any specific policy scenarios, so we were not trying to understand what policy conditions you might realize, but rather what's the benefit and the cost of doing this particular scenario?

All of the costs and benefits are assessed for this particular scenario relative to a no new wind baseline scenario. So, essentially what we did is we held wind capacity fixed at 2013 levels, and then compared what happened in the electric sector on emissions, on capacity expansion, on generation for that scenario relative to the 10, 20, and 35 percent scenario. What that allowed us to do is understand essentially the cost and benefits of all future wind additions, not just the change from business-as-usual.

So, getting into some of the report results, what's shown here is the wind capacity, cumulative capacity over time out to 2050, actually sorry, this is not cumulative, this is the annual installation, apologies there. What you can see is that in our 10, 20, and 35 percent scenario we essentially sort of stabilized wind installations at recent sort of historical average levels in the near term. And then those grow in the 2020 and 2030, although in the 2020s you're looking at both the expansion of new land based wind capacity, as well as new offshore capacity.

And then in the 2030 timeframe you're actually looking at slightly lower levels of new land based capacity, still growing levels of offshore, and you're looking at a much larger volume of repowering. So, over the long term repowering comes to be a primary source of industry growth rather than a new land based or offshore capacity additions.

In total though, we're looking at, when you sum up all of these annual installations, you're looking at about 400 gigawatts of operating wind capacity in the 2050 timeframe. That varies a little bit depending on what you assume for future performance and how far you think the industry can go with respect to Class E factor improvements. But, overall we're looking at about sort of a mid-point of our scenarios of around 400 gigawatts of wind capacity by the 2050 timeframe.

In terms of where the wind is installed, the mass, the relative size of the pie here, and the map shows you the relative amount of wind in each particular state. Notably, that does not reflect the land area that's required in each particular state. It's just a representative illustration of the amount of wind in each state. So you can see there are three big contributions from some of the states that have a lot of wind today, for example, Texas as well as states like Iowa and Illinois and Indiana.

You also see, to one of Rich's prior observations with the enabling wind nationwide report, new installations in the Southeast portions of the country, as well as essentially throughout all 48 states of the continental U.S. By 2050 there is wind in all 48 states. And actually by 2030 even there's wind in all states of the continental U.S. except for Florida, which comes on shortly after the 2030 time period.

In the 2030 time period, there are 37 states that have over a gigawatt of wind, and by 2050 that number reaches 40. That compares with 16 states today that have a gigawatt of wind installed. In terms of what's happening in the electricity sector to both the generation and capacity mix, wind moves from being about the fifth largest contributor to the electricity generation mix in 2013, to the second largest in 2030, and the single largest in 2050.

Both in 2030 and 2050 wind and gas are kind of neck-and-neck, but in this particular scenario wind happens to edge gas out by a couple of percentage points in both of those cases. What you see on the generation side, which is on the left hand side, is that the nuclear generation is pretty flat out to 2030. And then those facilities start to hit a 60-year lifetime, and they start to hit retirement age.

Now, that's a little bit of an uncertain assumption, it could be possible that nuclear plants will extend their permitted life to 80 years, in which case you probably see that flat line continue out for a number of additional years. But, if we only see 60-year lifetimes for our nuclear facilities, they'll essentially go away almost by the 2050 timeframe.

You also see coal generation being relatively flat out to 2030 and then tailing off after the 2030 time period. Again, that's also a function of the age of the existing coal fleet, and the relative economics of building new facilities. That actually applies to both nuclear and coal plants. When we look at it on an economic basis, there's no new nuclear or coal capacity added because the renewables, both wind and PV, as well as natural gas come in underneath those costs in the 2030 to 2050 timeframe.

Wind is growing under this scenario at a rate that exceeds the low-growth rate, and so that means by definition essentially that it's going to take market share

from some of the other players. And in this case that happens to be primarily coal and nuclear. Although, even without wind in the system you see some of these same trends for the coal and nuclear fleet.

On the capacity side a pretty similar story, a couple of exceptions, you see PV play a bigger role in terms of new installed capacity, obviously the generation is hid a little bit for PV based on the lower capacity factors there. You also see a lot of new combustion turbine additions, which don't show up in the generation stack because they're operating a smaller portion of the time period.

Obviously, there's some uncertainty in these results, particularly in the 2030 to 2050 timeframe, and there are a lot of variables that could change over the next decade that'll impact how that time period actually plays out. In terms of the comparison between our study scenario and the baseline no new wind capacity scenario you can see what's actually displaced by forcing wind into the system.

And when I mentioned the nuclear and coal impact, those really do apply across a range of scenarios. So, forcing wind into the system specifically doesn't affect those technologies as much as just the age related dynamics of the existing facilities and the retirement that happens. What really loses market share when you put large amounts of wind in the system in the near term is natural gas generation.

And then over the long term actually other renewable generation is displaced when it's compared to a scenario that holds wind capacity at current levels over the time period of the analysis. With respect to transmission, the expansion of transmission based on this scenario, actually two scenarios are baseline and study scenario 10, 20, and 35 percent levels that's shown on this

slide, you can see that even if we don't add new wind to this system, you need some new transmission capacity.

It's not a large amount, but you do need sort of an incremental amount, about 10 million what we call megawatt miles of new transmission capacity by the 2050 timeframe. With more wind in the system if the 35 percent by 2050 level, you're looking at close to 40 million megawatt miles out there in the 2050 timeframe, so about 25 million megawatt miles of additional transmission capacity is needed to support this particular wind scenario.

That might seem like a lot. But, both on an investment basis and on a general basis it's a relatively incremental addition to the existing grid network, and it's about a 60 billion dollar, half a cent per kilowatt-hour of wind cost. For the integration impact, what's shown on this particular slide are the penetration levels in 2030 and 2050 for wind at this particular regional level.

You can see in the 2030 timeframe some of the wind resource rich states on regions are looking at wind penetrations on the order of 30 percent or 30 percent plus for a few regions, and then out in the 2050 timeframe you're looking at penetrations for wind rich regions on the order of 40 to 50 percent plus, particularly for the SVP and Rocky Mountain power regions.

Obviously, there's new wind penetration that comes online in the Southeast, and in some of the other regions of the country also see relatively significant, but what are generally believed to be manageable levels of wind penetration. So with that, I will conclude my remarks and turn it over to Ryan who will run you through the costs and benefits.

Ryan Wiser: Great. Good afternoon all. It's a pleasure to be here. I'll run through these benefits and impacts, and costs relatively quickly. And really the goal of this

portion of the wind vision analysis was in fact to rather comprehensively evaluate, and where possible quantify in physical and in monetary terms an important sub-set of the various cost benefits and impacts of achieving the wind vision.

You can see the various cost benefits and impacts listed here that we evaluated, and we will click through I believe a singular slide on each of these individual items. So, starting with costs, obviously an important topic. Our scenario analysis shows that our wind vision study scenario may well impose some incremental costs in the near and median term that is 2020 and 2030.

But, in the longer term that central study scenario is found to result in consumer cost savings in fact. That can be seen in the first row of the table on this chart, which shows retail electricity price increases of 0.6 percent in the 2020 timeframe, 0.3 percent in the 2030 timeframe, but then resulting in net savings by the 2050 timeframe of minus 2.2 percent.

These are all relatively modest numbers. You can also see the aggregate consumer costs on an annual basis in the 2020 and 2030 timeframe there, 2.3 billion in cost in 2020, 1.5 billion in 2030, and then significant longer-term savings as the cost of wind is presumed to decrease, and the cost of natural gas and other conventional fuel is presumed to increase over that timeframe.

The study also explored in some level of depth both quantitatively, but also qualitatively surveying the literature. The myriad of other non-monetary cost implications, especially those implications for local communities and eco systems. Those potential impacts can be proxied at least to some degree by land use. This particular graphic shows the aggregate land use from the wind projects deployed in the wind vision study scenario, as well as the much smaller sub-set of that land use that is actually physically impacted.

So, this graphic is showing both the aggregate land that is in effect covered by wind projects, and then the much smaller portion of that land that is transformed. In aggregate the land use equates in the 2030 timeframe to a land amount that is consistent with West Virginia, and in 2050 a land amount that is consistent with Kentucky.

But, if you look at the actual transformed land area, we're talking about land area that is equivalent to about one-third of that currently occupied by the nation's golf courses, so obviously a much smaller portion of actually transformed land. The study also contains a good lit review on the other implications of wind projects on local communities and wildlife, and of course support when considering those impacts that contracts those impacts associated with wind with what would otherwise be meeting our electricity needs in the U.S. whether natural gas, coal, or otherwise.

Offsetting those potential costs, whether monetary or non-monetary, are a variety of public benefits. And we looked at greenhouse gas emissions, other forms of air pollution, and water as three key environmental indicators and benefits of achieving a high wind energy future for the U.S. Starting with greenhouse gases, we find that the wind vision study scenario does substantially reduce damages from global climate change.

In particular, that scenario relative to the no-new-wind scenario is found to reduce lifecycle greenhouse gas emissions by six percent in 2020, increasing to 23 percent by 2050. If we monetize those benefits in terms of reduced damages using the social cost of carbon estimates used by the U.S. government, we find in a central study scenario about 400 billion dollars of present value benefits. That is equivalent to a benefit of wind in cent per

kilowatt hour terms of over three cents per kilowatt-hours, so a very sizeable global benefit in the form of reduced global climate change damages.

We then also looked at a variety of other types of air pollution, sulfur dioxide, nitric oxides, and particulate matter in particular. You can see the reductions in each of those emissions in the upper racks here. And we also monetized the health and environmental benefits associated with those emissions reductions using a variety of different tools.

Using those different tools we find these benefits to equate to somewhat lower or lower numbers than the greenhouse gas emissions benefits that I just reported, but still very significant in absolute magnitude, 52 billion to 272 billion dollars in aggregate present value terms. And again an equivalent cent per kilowatt-hour benefit from wind of .4 to 2.2 cents per kilowatt-hour.

We also looked at water. Now, there weren't any standardized, agreed upon methods to quantify in monetary terms the water savings from the wind vision scenario, but we were at least able to quantify in physical terms gallons in particular, but with the savings in water withdrawal, as well as the savings in water consumption, as you can see both national and regional benefits in the form of reduced water withdrawals and reduced water consumption in the power sector in the wind vision study scenario.

In addition to those core benefits, we also looked at two specific supplemental, secondary benefits, impacts of the wind vision study scenario. One of those relates to electric sector fuel price risks and natural gas prices. And here we have two important findings; the first is that we find that the wind vision scenario is 20 percent less sensitive to long-term fluctuations in fossil fuel prices than is the no-new-wind scenario.

And this makes a lot of sense, obviously that wind vision study scenario has less natural gas and less coal required in our electric power sector, and so changes in the price of those underlying fuels have a smaller impact on the aggregate consumer cost of electricity supplied in that wind vision scenario relative to no new wind.

In addition to that impact, we find that that wind vision scenario reduces natural gas demand naturally. That reduced natural gas demand then also reduces natural gas prices providing consumer benefits outside of the electric sector that we estimate at a present value of 280 billion dollars. And then of course we also look at the wind related jobs that might be associated with this high penetration wind energy scenario.

No surprise here. We find a significant increase in wind related jobs. There is a range from a little over 500,000 total jobs to just under 700,000 total jobs in the 2050 timeframe, and that range is associated with a variety of different assumptions about the domestic content of wind equipment that is used in U.S. wind project development.

We also estimate significant increases in local land lease payments, offshore lease payments, and local property tax payments as well. So in summary, summarizing both Eric's description of the study scenario and our analysis findings, as well as mine, we do, in fact, find that the future of more than one-third of the U.S. electricity demand met by wind is plausible and would certainly support kind of historical capacity additions that we've seen, as well as longer-term growth given the expected repowering of the existing wind assets over time.

We do find significant electric system impacts including grid integration and transmission challenges, but we also find that those impacts and challenges,

though sizeable, are also manageable. We do find some increased electric per system cost in the 2020 to 2030 timeframe, but we find that those costs are more than offset by the greenhouse gas and air pollution emissions benefits of the wind scenario.

And in fact, after 2050 we find that high-wind penetrations may well be economic even without considering those public benefits. Notwithstanding that though, we do have some incremental costs in the 2020 to 2030 timeframe in our core scenario. And as a result to achieve that scenario we would either need to achieve more aggressive wind cost reductions than might otherwise be expected.

We would need to hope for higher fossil fuel prices that might otherwise be expected, or alternatively some form of policy intervention may be necessary. And with that, I will turn it over to Suzanne and then DeMeo.

Suzanne Tegen: Great. Thank you Ryan, and thank you Eric. We're going to hear from Ed. He'll give a little bit kind of a summary, and then talk about the roadmap a bit. And Ed has pursued renewable energy development for the past 40 years. From the mid-70s to the late 90s he managed programs in wind and solar energy advancement at the electric power research institute or UPRI in Palo Alto, California.

And for the past 16 years he's been an independent consultant in renewable energy specializing as an advisor to the federal and state wind power development programs, primarily the DOE and NREL wind programs. And for the past two years he served on the management team for this wind vision report. This brief bio does not suffice as a proper introduction for Ed, but our time also doesn't suffice to list his multiple accomplishments.

Many of you are lucky enough to already know him, and he is a mentor for our other speakers on this webinar, and a longtime leader in the wind power community. So, Ed if you would take us through the final portion of this webinar?

Ed DeMeo: Well thank you Suzanne. Thank you for those kind words. Anyway as Suzanne has indicated, I'm going to give you a very brief overview of the roadmap portion of the DOE wind vision. It's Chapter 4 in the document, and there's an appendix as well, so if you could go to the second slide, the first question is why did we do a roadmap?

You know, well really the main reason it that, you know, this wind expansion that you heard about isn't going to happen by itself. There are some specific actions that are going to be required by a lot of people. It's going to require focused attention. But, you know, the wind community in general and the related stakeholders really have a pretty good idea of what needs to be done. A lot of the work is already underway.

So, we thought well hey let's take pen to paper and write that down. Let's articulate what that roadmap really is, and once we have that description of broad needs what that does is provide a framework that individual stakeholders around the country, around the community can take a look at and see well this is where I might fit in. This is where I have specific expertise that could help in bringing about the substantial expansion of wind.

In addition, that framework also provides a basis for periodically assessing where we are relative to what we would need to do to get higher penetrations of wind, and to revise the roadmap from time to time as the situation changes. And then, the other thing is, you know, there are always the nay-sayers, the

folks particularly those with vested interests who will look at our scenario and say, you know, these guys are crazy. This is pie in the sky.

They have no idea how to make this happen. But, the answer is we do. The roadmap with all of these actions that are defined and that other people will refine even more really indicates that we do know how to make this happen, and that's the answer to the folks who say it can't be done. So going to the next slide, what's in the roadmap?

Well there are nine specific action areas and I'll touch upon all of them in the next slide. And there are 33 top-level actions and we encourage you to look at the document and carefully look at those actions and again see where you might fit in. All of these actions support one or more of three key themes in the roadmap.

The first is to reduce the cost of energy from wind power. The second is to expand geographically the areas in which wind can be economically developed. And the third is to increase economic value for the nation. I mean for example through domestic employment, manufacturing here in this country. And then as I mentioned there is a more detailed second level set of actions, which is in the appendix for the roadmap.

So going to the next slide, here you see the nine action areas. And I will just take a moment here to indicate each one. There's the wind plant technology advancement; there's supply chain manufacturing and logistics; there's wind power performance reliability and safety; then wind power resources and site characteristics; wind electricity delivery and integration; citing and permitting; collaboration, education, and outreach; workforce development; and then analysis of policies.

And again there's a set of activities in each of these, and we encourage you to look carefully through them. In a general sense, what's needed is, you know, government and industry R&D, particularly in the technology advancement, but really across the board in all of those nine categories there's a need for transmission expansion, you know, minimization of wildlife impacts, more efficient citing and permitting, and education and outreach.

And then, you know, as a community we need to insure that there is consistent policy on the national, regional, and state levels, so again a series of activities in each of those areas. So, go to the next slide, I just wanted to touch on two specific examples where activity is needed, where work is needed. One is in technology advancement, and you got a preview of this from Rich a little while ago.

And the other is in transmission expansion to bring the wind energy from where it is to where people actually need it in the demand centers. So on the next slide, this is dealing with the increase over time with the size of wind turbines, both in the height of the hub and in the diameter of the rotor, and the trend has been bigger and bigger because there are economies of scale, and because as you go higher you get to better and better winds.

The next three slides, there are three maps giving indication as to why this is a good trend here. If you go to that first map slide showing the situation with an 80-meter hub height you find that, this is according to an NREL analysis, there's something on the order of 600,000 square miles of developable wind land according to that analysis.

You go up to 110 meters on the next slide, that amount of developable land, using the criteria that they mentioned here, it about doubles. And then if you were to go even higher, and this is the map you saw on the next slide from

Rich a little while ago, you go up to 140 meters you get almost another doubling of the availability of developable wind land.

And what's really significant about this map with the orange area is that it lights up the Southeast. And this is an area that hasn't had much wind development so far, so with the advanced technology the Southeast could very well open up to wind development, a very significant advancement. Now, that doesn't come without cost. If you go to the next slide here showing tower transport limitations, today's towers can make it under highway underpasses for example, and they're designed to do that.

But, these very tall towers want to be a lot larger, so there are logistic challenges in getting those to the installation locations, so something's going to have to change. Either the tower would need to be segmented, or a lot of it built on site, or maybe part of its concrete or who knows? Nobody knows the answer, but this is a really ripe area for technology advancement, and there will be substantial benefits in the event of success.

Going to the next slide, this deals with transmission, and Eric and Ryan have talked to you a little bit about the transmission requirements for the study scenario, and what we know is that scenario requires more transmission than the baseline. But, the good news is that the annual additions in the study scenario picture are pretty much comparable to what the electric industry has been putting in per year over the last few years, so this is not an outlandish requirement.

But, the challenge is that these additions need to go in what we would call the right places, places that would support the transport of wind energy from where it is to where the electricity is needed, and also to increase the general flexibility of the power system.

And what that's going to require is cooperation on a regional basis, statewide basis and in some cases national for the approval process, in getting the permits, and citing these transmission lines, and deciding how to equitably allocate the cost for the people that are affected. So, again within the roadmap there's a series of actions that are aimed at those needs.

So, going to the next slide, to pursue this roadmap the key thing here is this is not just the government program here, all sectors need to get involved, need to get engaged because there are things for everybody to do, and that need to be done. The wind industry, the manufacturing supply folks, the electric power regulatory, the environmental organizations, and of course governments, both state and federal. But, again it's not just a federal program.

So, we encourage all of you here to review the contents of the roadmap and ask some questions. First of all did we miss something, you know? Are there major omissions? And the other question is okay where can you fit in? How could you contribute to making all of this happen that we've been talking about? And then what we're going to have to do on a periodic basis is convene, as stakeholder groups and then larger groups as well to see how are we doing?

You know, are we going down this path correctly here? Have things changed? Are there additional needs? What's new? So, and that's a process that's not defined at this point. It will evolve. And we would encourage your input on that as well. So, finally to wrap up on the roadmap, first of all it expands on the activities that are already wet, underway in the nation, you know, as they say people have a pretty good idea of what needs to be done here.

It defines a broad, top-level set of activities for all of the major stakeholder sectors, and we have a second level in the roadmap appendix. As I indicated this provides a framework from which all of the folks out in the community can take a look and decide where they would fit in, and defines specific activities at greater levels of detail that builds on their expertise and their knowledge.

Again, we're going to have to review this from time to time to see how we're doing, and then finally again this does provide a defensible, rationale against those folks that are going to stand up and say we're crazy this really can't be done. So with that Suzanne, I will turn it back to you.

Suzanne Tegen: Great. Thank you Ed. And thanks to everybody for the informative presentations and for listening. I do want to remind our listening audience, if I can here, about our upcoming webinars. The third Wednesday of every month is when we have our regular wind exchange webinars. And we're running short on time here, so we do actually have one question that I'll get to in just a second.

In September we will talk about the distributed wind market report. And we'll also talk about distributed wind and how that's mentioned in the wind vision. Similarly, in October we'll talk about offshore wind. We'll do the market update, and then we'll also talk about offshore wind and the wind vision. And this webinar series that I talked about in the beginning about wind vision, you can kind of see there are more topics there that we do want to talk about for the wind vision.

And we'll sort of breakdown the wind vision report into more bite-sized pieces so we can have this kind of more informative webinar about that. I'm going to

answer the, or let's see, let you all answer some of the questions. One question is actually could somebody get a copy of these presentations?

And as always with the wind exchange webinars, these presentations will be uploaded to the wind exchange Web site in about one week from now. And then one question that was asked, this is probably for Ryan and Eric, can you speak to the wind's technical potential data that's used in this report?

Eric Lantz: Yeah. I can speak to that. So, it's actually not as large of a technical potential as what was shown in, for example Ed's slides or in the map that both Rich and Ed showed. It's something between that and sort of the 80-meter map that also shows up in their materials. What we did is essentially included wind resource potential based on the current sort of commercially available technologies.

So this is a specific power ranging from 200 watts per meter squared to about 320 watts per meter squared. We included sites that are above about a 23 percent net capacity factor today. So some of those maps that Rich and Ed have shown actually go beyond that and those are not included in the modeling work that was done for the wind vision analysis

We do have though in the works future work that's looking at expanded supply curves with a larger technical potential footprint. But that's some point out in the future that that work will become available.

Suzanne Tegen: Okay. Great. Thank you. Thanks Eric. And there was a question about future work, so I'm glad you talked about that. I think there are a couple of analyses that we'll follow up to this one. And maybe do you want to talk about those Eric? Or should we just leave that for the next webinar?

Eric Lantz: Just generally, I mean I can say that as an analyst we have an interest in doing a number of additional follow-on studies. Obviously, that's all contingent on actually convincing our sponsors, namely the DOE that these are also worthwhile studies. A few of the examples that we're trying to understand, you know, how wind affects some of the regional systems at the sort of 50 percent plus penetration levels at a higher level of detail than what we get from our (read) model.

Obviously, the technology piece is a big one to really trying to delve in and say well, you know, we had technology assumptions in the wind vision, but what if we're more aggressive, or what if we focus more on low wind speed technology of the future, how does that change the results? Ryan probably has the short list of other things that he thinks would be interesting coming out of the work.

But, very little of that is actually funded at this point, so we don't know what will ultimately materialize in concrete form.

Suzanne Tegen: Okay. And I think we can ask that question probably on future wind vision webinars that we hope to have the first one in maybe August, and maybe definitely we have that one in September. So, I want to thank everybody for joining us today, and again thanks to our speakers. There are some contacts listed here for Patrick Gilman, for Amber Passmore, for Ian Baring-Gould, and for myself Suzanne Tegen.

We appreciate everybody's attention, and thank you very much, and we'll talk to you again in September. Have a great day. Bye-bye.

Coordinator: Thank you for your participation. That does conclude today's conference. You may disconnect at this time.