March 4, 2014

A2e Merit Review Panel
Feb 4th & 5th, 2014
Marriott Metro Center, Washington, DC
Meeting Minutes

Attendees:

Merit Review Panel:

Sandy Butterfield - Co-Founder and Chief Technology Officer, Boulder Wind Power

Robert Poore - Senior Advisor, Renewables Advisory, DNV GL – Energy

Bruce Bailey - President/CEO, AWS Truepower

Henrik Stiesdal - Chief Technology Officer, Siemens Wind Power Division

Mark Jonkhof - Wind Technology Platform Leader, GE Global Research

James (Jim) Lyons - Chief Technologist, Capricorn Investment Group and Novus Energy Partners

Charles (Charlie) Smith - Executive Director, Utility Variable-Generation Integration Group

Dan Brake - Renewable Fleet Director, Technical Services Power Generation Division

William (Bill) Mahoney - Deputy Director, Research Applications Laboratory, National Center for Atmospheric Research

Executive Committee:

Jose Zayas - Director, Wind and Water Power Technologies Office

Mike Derby - Program Manager, Research, Development and Testing, Wind and Water Power Technologies Office

Mike Robinson - Senior Science Advisor, DOE/EERE Wind and Water Power Technologies Office

Joel Cline - Physical scientist, DOE/EERE Wind and Water Power Technologies Office

Shreyas Ananthan - Lead Aerodynamicist, DOE Wind & Water Power Technologies Office

Daniel Laird - Program Manager, Water Power Technologies, Sandia National Laboratories

Paul Veers - Chief Engineer, National Renewable Energy Laboratory

Will Shaw - Associate Director, AS&GC Division, Pacific Northwest National Laboratory

Presenters:

Mike Knotek – Deputy Under Secretary for Science and Energy, U.S. Department of Energy

John Meissner - Senior Analyst, DOE Wind and Water Power Technologies Office, DOE Contractor (New West Technologies)

David Womble - Senior Manager, Computational Simulation Group, Sandia National Laboratories

Steve Hammond - Director, Computational Science Center, National Renewable Energy Laboratory

Scott Schreck - Principal Engineer, National Renewable Energy Laboratory

Jonathan White - Wind Plant Optimization Team Lead, Sandia National Laboratories

Chitra Sivaraman - Manager, Data Integration Group, Pacific Northwest National Laboratory

Patrick Moriarty - Manager, Turbine Modeling and Wind Resource, National Renewable Energy Laboratory

Kathryn Johnson - National Renewable Energy Laboratory and Associate Professor, Colorado School of Mines

Carsten Hein Westergaard - Senior Advisor, Sandia National Laboratories, Wind and Water Power Program

David Wilson - Wind and Water Power and Control Technologies Lead, Sandia National Laboratories

Jonathan Keller - Senior Engineer, National Renewable Energy Laboratory

Other Attendees:

Noel Bakhtian – Science and Technology Policy Fellow

Samantha Rooney –Business Support, National Renewable Energy Laboratory

Alana Duerr – Ocean Engineer, DOE Wind and Water Power Program, DOE Contractor (New West Technologies)

Greg Matzat – Senior Advisor, Offshore Wind Technologies, DOE Wind and Water Power Program

Jason Wynne – Senior Energy Analyst, DOE Wind and Water Power Program, DOE Contractor (Energetics)

Not in attendance:

Eric White (invited as MRP member but not yet confirmed)

Peter Hauge Madsen (confirmed MRP member unable to attend)

Agenda:

Tuesday, February 4th

07:30	Merit Review Panel Breakfast (Marriott Metro Center)	Sandy Butterfield

Morning Session:

08:30	Welcome / Introductions / Agenda Review / Comments	Mike Robinson
08:50	DOE Executive Perspective DOE Deputy Under Secretary for Science and Energy	Mike Knotek
09:00	DOE Wind Program Strategy - Vision	Jose Zayas
09:15	DOE Wind R&D Portfolio – How A2e Fits	Mike Derby
09:45	Atmosphere to Electrons (A2e) Initiative Overview	Mike Robinson
10:30	Break	
10:45	Financial Risk, Uncertainty, and Portfolio Analysis	Meissner
11:15	High Fidelity Modeling	Womble/Hammond
12:00	Merit Review Panel Lunch (Marriott Metro Center)	

Afternoon Session:

13:00	Experimental Measurement Campaigns	White/Schreck/Wilczak
13:45	Data Archive and Portal	Sivaraman
14:30	Integrated Wind Plant Control	Johnson/Wilson
15:15	Break	
15:30	Aeroacoustics and Propagation	Moriarty
16:15	Wind Plant Reliability	Westergaard/Keller
16:45	Integrated Wind Plant Design and Analysis	Ananthan
17:00	Adjourn for the day	
18:30	Closed Panel Dinner & Discussions	
	Bistro d'OC (518 10th Street, NW, Washington DC)	Sandy Butterfield

Wednesday, February 5th

07:30	Merit Review Panel Breakfast (Marriott Metro Center)	Sandy Butterfield

Morning Session:

09:30	Panel Discussion with EMC & Chairs	Sandy Butterfield
12:00	Adjourn	

Tuesday, February 4th

Following each of the presentations, on Tuesday February 4th, the Merit Review Panel was invited to ask questions and create a dialogue about the topics. The notes below capture those discussions points.

09:00 DOE Wind Program Strategy - Vision Jose Zayas

Mark Jonkhof – How do you calculate the value of renewables or wind?

Jose Zayas – In the Wind Vision study, we use known references and methods for these calculations. In previous analyses, numbers were tweaked, applied to curves or additional assumptions made. Now we have reference-able data that supports monetary values tied to wind energy benefits.

09:15 DOE Wind R&D Portfolio – How A2e Fits Mike Derby

Sandy Butterfield – The AWEA R&D committee is engaging in a constructive way with industry and other stakeholders. Is there any part of this presentation that we can share with that R&D community?

Mike Derby – Definitely, the DOE Program wants to acquire feedback.

Sandy - I'll take an action to distribute to the AWEA R&D committee for feedback.

Mark – On wind forecasting, what is the time horizon used to determine savings?

Joel Cline – The short-term, meaning 0 to 6 hours ahead, as well as the day-ahead forecasts.

Mark - Do you have a set LCOE (Levelized Cost of Energy) curves as a function of time that you're using?

Jose – For the Wind Vision we are using high, low, and median LCOE scenarios. DOE is conducting sensitivity analysis on the high and low scenarios and have data to support those assumptions.

Charlie Smith –The previous "20% by 2030" study contained a target GW (gigawatt) deployment number, roughly 300 GW, however DOE was cautious not to state this as a Programmatic goal. Will the new analysis (Wind Vision Report) establish a deployment goal?

Jose – DOE is supportive of a deployment goal however, the Program does not control all the variables and therefore cannot own any particular deployment goal. The DOE charter is to reduce LCOE for U.S. wind industry. The deployment goal in the new analysis will be lower than in the "20% by 2030" report due to increases in energy efficiency, which has reduced the projected installed wind capacity needed to reach 20% in 2030. We will hit the 20% penetration number with fewer, more efficient turbines.

09:45 Atmosphere to Electrons (A2e) Initiative Overview Mike Robinson

Bruce Bailey – There is still a limited understanding of how projects are performing due to a lack of data access. There has been progress made over the last decade with plant operators sharing their data, which has led to the discovery of plant performance over-prediction. There is a lot more clarity that can be made, and further access to proprietary data, which could be used to improve performance, without infringing on IP (intellectual property). I see this as a key area where the A2e program can play a role in bringing visibility to what causes certain losses.

Mike Robinson – John Meissner will talk more about this but the A2e group agrees. We are making strides to access more of these data and are now attempting to standardize this information so we can evaluate across areas, and determine improvements.

Bill Mahoney – Early on you mentioned a broader view of the grid and how A2e is looking at wind plant-level operations. Will A2e also encompass plant-level design with a focus on increasing geographic diversity to reduce variability?

Mike R – We made a conscious decision to focus on a systems perspective without getting into specific geographic locations or regions. The initial goal is to establish a framework, with the opportunity to expand the scope of A2e later on.

Jose – Keep in mind that there is communication with other aspects, but right now, the scope is intentionally limited.

Robert Poore - You mentioned reducing curtailment, is that incorporated as part of the A2e initiative?

Mike R - Issues of curtailment are on the boundary of the initiative as it stands currently. We know we have to address it, however it is not within the scope of this initial step.

Robert - Is improvement of wind forecasting part of the A2e effort?

Mike R - Yes, Joel Cline is leading that effort.

Jose – The boundary established is DOE's attempt to maximize the probability of success without disturbing all parts of the R&D portfolio. There are communication touch points among the various R&D aspects and the boundaries may expand as the initiative grows but, right now, A2e does not currently look at curtailment.

Dan Brake – Does A2e not encompass grid integration?

Mike R – As Jose mentioned, there are communication channels with this part of the R&D portfolio but it is not part of the embodied initiative as it currently stands.

Bruce – The Program should maintain a macro view of the overall effort, thinking long-term and including all stakeholders.

Jose – A2e is packaged this way since it is a bold new initiative and we needed to set boundaries. Having National Labs and the Wind Program work collaboratively is a new paradigm for us. We would appreciate recommendations from the panel if they feel other parts of the portfolio, such as grid integration, should be part of A2e.

Sandy – In summary, to the extent that this impacts grid integration, the grid is not part of the initial embodied A2e scope.

Jose – There is an important distinction to be made to the panel regarding the A2e team. SNL (Sandia National Laboratory), PNNL (Pacific Northwest National Laboratory), and NREL (National Renewable Energy Laboratory) leads in this group represent the interest of the A2e initiative and not their laboratories' interests.

10:30 Break

10:45 Financial Risk, Uncertainty, and Portfolio Analysis John Meissner

Charlie - Annual resource variability, is that still considered a source of uncertainty? Is climate change with regards to long-term wind patterns also a concern?

Mike R - Climate change issues came up at the very beginning of internal discussions. The Program made an effort to not address climate change impacts at least at the outset of the A2e initiative. In a holistic perspective, it will have to be factored in.

Jim – With regards to resource assessments, how do you take short-term measurements and extrapolate them to predict long-term trends? Is this an area of concern for investors?

Robert – Until there is a major shift, or perceived shift, in wind patterns, I would not expect climate change to be a serious concern for wind energy investors.

Bruce – NOAA's re-analysis data sets help to reduce this uncertainty. In reference to long-term changes in wind speed, such as over the life time of a wind plant, this uncertainty is assumed to be relatively small and is included in a plant's energy production projections. However, this topic does present a validation challenge.

Joel – The Office of Science has conducted research on temperature and precipitation changes on the climate scale. Long-term changes in wind are something for A2e to address down the road.

Bill – Is uncertainty around resource assessment and inter-annual variability going to be addressed with A2e?

Mike R – We will make a note to add this topic for future discussion.

Sandy – Current design standards for extremes conditions in each IEC Design Class need validation. Could A2e focus on this issue to see if current values are representative?

Dan Brake – What do you see as largest uncertainty cost relative to LCOE?

John Meissner – Wake losses and OEM component failures.

Bruce – Focusing on LCOE ignores many other value propositions of wind, such as environmental offsets. It's important to recognize that these other values make wind a choice.

Mike R –These other value propositions will be quantified in the new Wind Vision report.

Sandy – Viewing wind through a pure economics perspective, such as LCOE, is common ground politically.

Jim – The current financing rates related to capital costs overwhelms other cost components for wind. All benefits and costs should be considered. For example, in some parts of the world water consumption is a direct cost. Do not ignore these costs when comparing with other forms of electricity generation. The Program should also maintain the view that wind is part of a balanced portfolio.

Sandy – Are there opportunities for people on the Merit Review Panel to actively engage with the initiative?

John M – Definitely.

Henrik – Some costs are unrecoverable. For example there will always be wake losses and costs associated with wake effects. Rather than focusing on mistakes, detail the real and perceived risk, and look at other ways the industry has addressed these uncertainties. We want to make sure we are focusing on real science issues and not just mistakes. Additionally, DOE should take caution in publishing statistics that can be taken out of context.

Robert – This thrust represents a way to communicate to the financial industry that there have been improvements in energy assessment methods which have led to reduction in uncertainty and as a result, should lower finance charges.

Mike R – Part of this initiative is to get rid of some of these areas.

Dan – From a project-level view, the industry is not good at characterizing the uncertainty. Another challenge the industry faces is that wide uncertainties existing in IEC power curve standards hinder our ability to make incremental changes. Making a one to two percent reduction in uncertainty may not be detectable as an improved performance in the existing IEC power curve.

Charlie –Are O&Ms and plant operators part of your review panel or committee?

Sandy – We will take that as a recommendation. However Dan Brake is serving on the MRP and he is an excellent representative because NextEra is the largest operator in the US. But I agree that adding another would be useful and I will take an action to discuss it will the ExCo and invite at least one more.

11:15 High Fidelity Modeling (HFM) David Womble/Steve Hammond

Charlie – High fidelity modeling is central to this entire effort. How many of these time scales are you looking at and how many of those can we expect to model? Or, are you talking about several different models, each that simulate different time scales?

David Womble – The latter.

Charlie – There are models we can utilize already. However, defining a common framework for plugging in these different models is something this initiative can help with.

Bill – Understanding performance metrics upfront is critical. We should focus on what is the user-centric verification metric, identify it upfront and measure it. We also need to make sure to have a discussion in parallel with the field experiment component of the program so that we can verify model improvements during the field experiments.

Sandy – You can't have one model across all these spatial and temporal scales. Defining where the important interactions are among models, is that something you've done already or is that part of this effort?

Steve Hammond – That is part of this effort.

Sandy – Where does validation happen? End-users may only take away certain elements of the code. What's the strategy for validation of these elements?

Steve – We'll work closely with experimental data campaigns to document data collected and model runs.

Sandy – Will this group write validation reports?

Mike R – Yes, that's part of this effort. We have access to resources to do this but we need to have an informed exchange to discuss how to validate metrics.

David Womble – Validation is cross-disciplinary. The model and use of the code has to be validated as much as the technical aspects of the model. What we've done in HFM is to bring in expertise and representatives from other groups to address quantities. Engaging this effort broadly to gain confidence in the models is a priority.

Sandy – Identifying a lessons-learned through validation process is important.

Henrik – Is modeling group going to focus on maintenance and design modeling? I think that would be wrong. If you are able to supply an open-source package that delivers wind flow, you will have done well. There is enough on your plate by just focusing on high-quality wind data.

Bruce – When you say "insufficient wind energy models", what do you mean? Insufficient for what? Modeling has been evolving over time. I challenge this initiative to be more quantitative in nature. What quantitative targets are you addressing? What gains do you want to achieve? Existing codes have value and are progressing. There are ways to accelerate or add functionality to what already exists.

Jim – The framework with which you can attach other models to is the critical part of this portion of A2e. What you are after is inflow and wake flow modeling.

Bill – You need to define the ultimate goal, which will alter how you go about the finding the solution. There are lots of nuances in this effort that need to be sorted out in order to identify the right goals and solutions.

Robert – Focus on areas where the existing community has identified gaps. Do some benchmarking now to identify those gaps and then build upon them.

Steve – Do you have gaps in mind?

Robert – Starting with the core team, I'd add more experts from the modeling community and industry members who work in this space. They can help identify and prioritize gaps.

Steve – We will take the recommendation.

David Womble – A question for the panel. HPC is a tool. In your opinion, how do you prioritize the translation of HPC results through ordered-models? How can you take a few HPC model runs and do something useful that informs a decision-maker?

Henrik – That's a very ambitious exercise. It is difficult to answer until we know what application you are addressing. Then, we (the industry) can help provide input on what to focus on within that application. Look at the overall premise. The extent of the program should be reducing turbine and plant uncertainty rather than developing a new tool.

Bruce – Lack of input data is a huge limitation on current modeling efforts. There is a lack of measurement networks and things we currently don't measure that are important such as boundary layer stability. We can't move inflow modeling forward without observations. Some say more validation, I say more inputs. For example in the WFIP (Wind Forecasting Improvement Project), we added more observations to feed into the initial conditions of models to improve forecasting.

Robert – If the program showed the value of additional inputs then the community would be more willing to pay for these inputs and make that information available. However, the value of additional observations has not been demonstrated.

Henrik – The wind industry has unused data in calibrated anemometer and temperature sensors at hub heights and on the ground. Collaborate with the industry to acquire these data among wind plants and show that there is value in studying this information.

Sandy – I agree, the initiative should make sure you can tap into these data sources. We should test the existing IEC External Condition models and assumptions such as IEC turbulence models in this initiative. IEC design models should be compared with what is really going on in the true environment and to see if there is a spectral gap for example.

Bill – There isn't currently a repository of in-flow test data sets for extreme, but not necessarily rare events to put into codes and test. We should develop a repository of test data sets of true atmospheric conditions.

Sandy - Current models were used in the past because it's what existed at the time. Now these same models still exist, but have not been updated with better information. There needs to be a roadmap for this portion that defines the strategy for HFM.

Carsten – Do you have specific ideas on how to develop that roadmap?

Sandy – Nothing specific just the thought that a road map would help industry collaborate. Industry is likely to pull out pieces of codes and use that in their own processes. Perhaps there is an opportunity for a "Unsteady Aero Experiment" style validation collaboration.

Daniel Laird – The idea here is to get the physics correct so the impacts on other areas of A2e initiative can be identified.

12:00 Merit Review Panel Lunch (Marriott Metro Center)

Afternoon Session:

13:00 Experimental Measurement Campaigns **Jon White/Scott Schreck**

(Following Jon White's portion of the presentation)

Bill – Some of the biggest blown power prediction periods occur when there is ice or snow accretion on blades. In these planned experiments, I think we should add sensors to address some of these issues, and factor in other sensors based on the location of test wind farm.

Sandy – There's a need to have data systems up and running, or a battery to survive if power goes out, during these ice and snow storms to capture the true environmental conditions.

Bill – Also the field experiments should have the ability to capture information that may not be part of the primary data campaign. For example, ice accretion may not be useful for characterizing the wind in-flow, but it has a large impact on turbine blade performance and should be measured during this campaign since it is becoming an important factor in power production.

(Following Scott Schreck's portion of the presentation)

Charlie – The initiative currently does not show areas where power system disturbance conditions are captured. Power disturbances can cause a torque on the rotor and affect reliability. Similarly, balance of plant equipment such as transformers follow a similar path.

Scott – This is something we are looking at capturing. In the near term, we will take measurements on the GE 1.5 MW turbine at NWTC. In the long-term, we plan to use modeling to simulate these conditions.

Jon White – We could also incorporate the A2e reliability thrust area into existing facility testing.

Sandy – The challenge here is to link data across spatial scales such as atmospheric, to wake flows, down to turbine-scale. What are you thoughts about how to collect data across these scales? Is there a physical basis for decomposing the data sets? From the instrumentation side, this is a challenge. Is there a need to connect those across large scales?

Mike D – One of the efforts is to collect a more comprehensive data set at the same time. Right now, we don't have the resources to do those types of tests, so we have to combine the instrumentation data. This is one of the challenges with this initiative.

Scott – We can decouple measurements. The computational-ists can formulate methodologies in order to be consistent across scales and to validate instrument data. Decoupling makes physical sense.

Bill – We want to make sure we use measurements from sensing campaigns with the models in this initiative. We need to know what scales are important and level of accuracy that is required. There should be a feedback loop between the instrumentation campaign and the modeling.

Scott – Atmospheric physicists should work with turbine designers to resolve the scales and measurements we need in the atmosphere.

Mark – What is the top priority for this part of the initiative?

Scott – We're still very early in the process and need to understand the needs from the community in order to prioritize.

Henrik – Wouldn't it make sense to design a test with data that is already available? The gap here is between what you believe is available and what is actually available. You can make a database of this information but several other players can make more data available. Focus on what others have already done as opposed to uncharted waters.

Scott – Ok, so we should see what's available first, then identify where to go from there.

Henrik – Yes, get access to data that already exists.

13:45 Data Archive and Portal **Chitra Sivaraman**

Sandy – The data management structure presented, is this model used currently with the ARM program?

Chitra – Yes.

Sandy – Is the data duplicated anywhere?

Chitra – The data is centrally located but back-ups are created every 5 years.

Bill – The scale issue needs to be addressed when you move to high-resolution modeling. One terabyte of data per day can quickly become multiple terabytes. The questions or focus should be on designing a data management and dissemination system that allows the end users to select only the data they need (data element, time range, and geographic domain, etc.) as opposed to pulling all the files.

Sandy – How much of the resources presented do we need to create this type of data management for A2e? Are we leveraging ARM resources or will this initiative need its own new data archival system?

Chitra – I'm not sure if we can leverage ARM resources.

Mark – How flexible is the process for using VAPs (Value Added Processes) to analyze data. Is there a platform that supports this type of development?

Chitra – We have version control on the data and the code, and can apply VAPs to old data. We can make new VAP data available while still maintaining the older versions of the data.

Mark – How do I create a VAP?

Chitra – It has to be a based on a published algorithm. We can then send it to working group members where they recommend and prioritize the VAPs for distribution.

Charlie – Data visualization is a huge challenge. Is there an opportunity to draw on existing large data analysis and visualization efforts or are you developing new ways to visualize the data?

Chitra – We have our own data quality built-in. We are hoping to tap into the planning group's expertise for data visualization.

Bill – I want to emphasize the importance of metadata and defining the metadata dictionary. I can recommend some names in the community who work in this area.

Sandy – Deciding the standards for data archival should be determined before the development of a new database.

Chitra – We can also store data as its captured and apply the standards to that data afterwards.

Bruce – In reference to measurement campaigns earlier, NWS (National Weather Service) stations establish standards for collecting data, however there is a gap in the existing regional monitoring systems which can improve atmospheric forecasting, boundary layer conditions, initial conditions etc. We need to keep this in the discussion.

Also, models assume certain parameters such as albedo and soil moisture, which aren't measured. These types of parameters need to be measured in order to significantly improve the state-of-the art. In the land cover database, approximately 25% of the information is wrong. The (experimental measurement) initiative should focus on getting things right and establish quality controls, not necessarily only adding a host of new measurements. We should get the easier stuff done first, which are cheap fixes and often overlooked.

Mike R – We are keeping open-access to data as a priority.

14:30 Integrated Wind Plant Control **Kathryn (Katie) Johnson/ David Wilson**

Dan - Is there a need to look at the grid and grid interactions here?

Katie – We cannot optimize without considering the interconnection point. We can avoid talking about the interconnection among multiple wind plants, but the one point where our wind plant touches the grid, we have to have a little bit of interaction there.

Sandy – I'll leave to program folks to define the boundary but to the degree we are capturing the wind plant dynamics in this thrust, grid interconnection should be considered within the scope.

Mike R – We are taking recommendations and none of these boundaries are set in stone. If the panel feels we are not considering something then they should make that recommendation.

Bruce – The cost of energy reference is a debatable point here. This thrust might have a different frame since cost is not directly tied to wind plant controls.

Katie – We can frame this different, cost of energy is just the initial construct.

Bruce – I think things like O&M costs may not be the area to focus on in relation to controls.

Mark – This is an area where the industry is engaged already, using lidar feed-forward information and turbine controls. You should focus on areas where the industry is not playing.

Mark – Industry is already working on plant controls and wake-level controls. We need to make sure that A2e research and industry roles are separate.

Katie – Are companies and industry using active wind plant power controls?

Henrik – It is well-known in Europe that the industry is doing this.

Mark – GE and others are also using active power controls.

Bill – Are you distinguishing between reactive and proactive controls?

Katie – It doesn't have to be reactive versus proactive controls. It is more of a coordinated strategy among all the turbines to evaluate fault detections and determine controls in a dynamic environment.

Dan – Some of us (industry) are doing some of that. It's a dynamic interaction and this is happening on multiple scales and in multiple locations.

Mark – In my view, this is very much industry space.

Mike R – We will follow-up on these discussions.

Sandy – We should talk among the Merit Review Panel. There could be opportunities to partner and make sure A2e is producing information that helps industry accomplish their goals.

Mike R – A2e does not want to infringe on IP. Advancing the methodology and approach to controls is the initial outset, however we need to discuss more in-depth.

(Following David Wilson's portion of the presentation)

Katie – Are there recommendations on who to invite to the first planning workshop for this thrust?

Mark – Who do you see as leading these efforts from the scientific point of view?

David Wilson – Researchers from Sandia and NREL (identified on slide 18).

Mike R – Resolving the underlying physics issues is the original intent. We are not focused on developing products, only advancing the science and the research.

Sandy – A2e needs to understand what is the state of the art. There needs to be a deeper conversation about where the industry is and where A2e can help in order to establish a supportive collaboration.

Jim – You can't do this initiative without looking at plant-level controls.

Carsten – Can you see a future where you can develop HFM of wind plant performance without controls?

Merit Review Panel (consensus) – No.

If A2e is treading where state-of-the-art is established, then there isn't much value. Wilson – In California, renewable systems require some level of energy storage and we considered incorporating that element into this thrust later.

Jim – The rules, as currently written, do not require all renewable energy systems to have storage.

Henrik – If you add energy storage then you are crossing into the grid integration boundary. I believe you cannot conduct this initiative without crossing the boundary of where industry currently plays.

Jim – There should be an objective to have the research community get closer to understanding these plant level controls. Right now there is a knowledge gap between what the research community is looking into and what the industry is doing. I have some questions or comments. The development of an intelligent learning model, such as those used by forecasting to learn to predict trends, is interesting. This model could be applied to controls to better predict the yield of a wind plant. Are there active control methods for lift or disruptive boundary conditions?

Katie – There are various aerodynamic techniques that can do flow controls and grid integration.

Bill – If you can capture and/or predict flow characteristics, can you develop a control strategy to help a wind plant optimize production? That is to say, if you can anticipate changes in wind flow (e.g., wind speed, direction, turbulence, and wind shear), can you prevent a curtailment or anything (such as wear and tear) that might reduce revenue to a wind farm? This may be something where A2e can play a role.

15:15 Break

15:30 Aeroacoustics and Propagation **Patrick (Pat) Moriarty**

Bruce – Is this thrust area going to address public perception from noise?

Pat Moriarty – Yes, but from a stance of bringing better information to light.

Charlie – Is there any analysis done on frequency and how it influences noise?

Pat – Yes, the focus is on high-band frequency, not low-band.

Mark – There is debate around the environmental impact of low frequency noise. Scientific work through this A2e thrust area could help provide better understanding and objective data.

Charlie – You may be able to resolve this issue by characterizing the frequency ranges from wind turbines and plants, and then compare with the frequencies that actually create noise in the human ear.

Sandy – Some thumping noise is subsonic and difficult to measure. We need to establish techniques to measure the full spectrum and then determine sensitivities, such as varying atmospheric conditions.

Bill – Are humans the only ones impacted by this noise?

Pat – There are claims out there on how noise from turbines can impact milk production from cows.

Bill – How do you measure noise for wind plant siting? Is there a basis for measuring decibels?

Pat – It depends on the area.

Mark – There's nearly always some time-averaging associated with the measurement.

Bruce – How does dealing with public perception issue play into A2e wind plant optimization?

Pat – In order to design or optimize the system for energy production, we have to capture limitations such as noise that can result in slowing down turbines to stay within the noise threshold.

Bill – This may also play into a control strategy, depending on the atmospheric conditions.

Mark – Simplistic noise propagation methods are conservative. Usually safety factors are added on top of expected noise levels to ensure the decibel level is not exceeded. However, in reality you could produce more power and still stay under the decibel level but there isn't enough information to demonstrate this. You could add dynamic controls to the wind farm that measure noise, stay under the defined decibel thresholds and produce higher power. Essentially, you could optimize the wind plant over time considering the noise limit.

Bruce – It's hard to get a data point on what the public perceives to be an issue relative to the noise produced.

Sandy – The role from this thrust should be to try to establish a scientific basis for the public perception, so this issue can been seen as objective rather than a subjective issue. Willet Kempton has done some work on public perception for the wind community and there is also a siting committee at AWEA. There is real value in objective data from these areas.

Mike R – We are already having noise concerns and are envisioning high-penetration wind scenarios. We need to have a better handle on this issue now and if this means we have to cross over into public perception than we that's something we should do. It goes back to avian issues where scientific research is needed to gather data on these issues.

Henrik – In Denmark 33% of electricity generation comes from wind, with 20% of that coming from onshore so these issues of noise are very relevant. We've found that the only way to sensibly deal with the spreading of disinformation is to provide peer-reviewed data. There should be a link between the propagation model and the atmospheric model so we can get to know what conditions create noise impacts. A lot of work on noise was done 10 to 20 years ago in the UK. I support discovering what data is already available, as mentioned earlier.

Sandy – DOE should provide objective data and when it becomes a messaging or political issue, that's the role for industry groups like AWEA.

Charlie – Is there any opportunity to professionalize the noise measurement?

Sandy - IEC 61400-11 is a noise standard. The standard only measures sound pressure level of a single turbine in the audible range and doesn't measure sub-audible range. If a standard is needed for community noise measurement, that could be done. This might be helpful in reducing the variability due to different measurement techniques in the reported community noise level.

Henrik – On amplitude modulation, this is also not well described in any statement. Once you have these data captured in a spectrum you can conduct human response studies across that spectrum to gather information.

Sandy –Also, the IEC standard addresses sound pressure from a single turbine, where A2e is looking across multiple turbines.

Jim - Agree this is important. I don't quite see how it fits into the rest of A2e, but still support it.

16:15 Wind Plant Reliability Carsten Westergaard/Jonathan Keller

Dan - Equipment availability is not the same as equipment reliability.

Mark – The remaining useful life is something that resonates with me. There is a lot of system value there and it should be a key priority. How will you be able to determine remaining useful life from data that's typically aggregated, like in the CREW database?

Carsten – We're considering an auditing process on how the data is taxed. We see the data streaming and can use algorithms and mining to make data replicates. We can take their data, audit their tax, and develop benchmarks from this information.

Henrik – I'm somewhat suspicion of what you are creating here (remaining useful life). The industry experience here is, if the machines are maintained, they tend to run forever unless infant mortality occurs early on. A 20 year old turbine sells for the same price now as it did 20 years ago. I doubt that this leads to something where costs are saved under a high-penetration of wind scenario. The financing body will look at the turbine type and model and know the reliability of the machine. The complexity of finding the root causes for failure will take too long.

Carsten – We are not looking at anecdotal history, we are looking at data we can mine from owners and operators that have an interest in this area. We have a hard time proving that machines will not fail without having the data to prove they can last forever.

Henrik – This is something that is better created by GE, Vestas, or Siemens. They know their products and can have a dialogue with their customers regarding the reliability of their machines.

Carsten – In order to improve the industry's reliability we have to have the data and metrics to establish a baseline.

Henrik – Yes but we are making decisions here on how best to optimize wind plant performance. I fail to see the fundamental value of this thrust area that has not already been addressed by an owner or operator.

Robert – If you broaden the dialogue to include GE, Vestas, Siemens, a consensus would emerge as to what the priorities are, which could shortcut some of this process. You can get a sense of where the industry is, start from there and then focus on the most meaningful solutions.

Sandy – Let me rephrase. A2e should focus on the items that need attention. If there is a sense that power electronics is an issue then address that. The group that's missing in this discussion however is the insurance company.

Dan – I think this is beyond where the OEMs are right now. We should come up with reasonable field responses for blades, gearboxes, power electronics, that drive lower costs and higher reliability.

Carsten – We are looking at it from an owner-operator perspective.

Bill – Does the A2e expect to design data sets that are prone to certain extreme atmospheric conditions in an effort to develop new standards that inform reliability?

Cartsen – Yes. We can use atmospheric data and tie into reliability.

Bill – We should also develop regional design standards for areas that are more prone to certain conditions, which can affect reliability.

Sandy – Let's talk a bit more to the owner and operators first.

Mark – This thrust should address "what process does a NextEra need to follow to extend the lifetime of its machine for a specific site, so that a financing institution will buy into it?"

Robert – New owners of existing assets want to know the value of assets at time of purchase, so there's a need to know how much life is left in that asset.

Mark – Is it worth it to replace a gearbox in year 18? Are other components going to fail soon? Is it worth it based on the remaining useful life of the turbine? Understanding remaining life is key to making informed decisions on these topics.

Robert – Getting in front of that discussion would be an effective thing for DOE to do.

Sandy – We can discuss this topic more when we come back (tomorrow).

16:45 Integrated Wind Plant Design and Analysis Shreyas Ananthan

Jim – I see confusion here between plant design and turbine design. Optimization of turbine siting you could improve with better tools and incorporate that go into a model to balance loading, improving yield and layouts. I don't see how you need to get into turbine design standards.

Mark – The IEC, with addition 3 and 4, is already taking a probabilistic approach to standards development. Is this something IEC should look at or A2e?

Robert – A2e can lead the studies that go into the process of IEC standards development.

Shreyas – We can do a lot of verification and validation with A2e, so we can help provide data for the standards process.

Mark – On the tools for design space exploration, Europe has various programs working in this area.

Henrik – What is the intent here? We have inflow modeling, then a commercial service that takes inflow and determines impacts on turbines and IEC design standards. What do you expect to do here that is not already done somewhere else?

Shreyas - I assumed that we would not always use HFM, and some reduced-order models are needed to get loads right.

Jim – At a plant-level you are not supposed to get the turbine-level models. The reduced order models are valuable when you want the optimum loads and variables on loads. This is where you can have a contribution to the science.

Henrik – Sharpen the scope to be more like reduced order model contributed from another A2e thrust. Otherwise, it seems duplicative in the industry and IEC space.

Sandy – The IEC standards hatched from a process developed 25 years ago. There is significant improvements that can be made based on information we've learned since then. This thrust area could look at how the user takes this information and input into their site-specific or site assessment design.

Dan – This area can answer how we are applying atmospheric loads, are we doing that in the best way, and, once we do that, are we applying the IEC standards correctly?

Jim – Site assessment standards could be improved.

Sandy – We are trying to get the appropriate information into the design process but I am just not sure if we're there yet.

Henrik – If you look at the reality, it is not clear that turbines are failing, beyond cases of extreme events. You should seek permission to access databases and determine what turbines experienced 10 or 20 years ago. GE,

Vestas, and Siemens have recorded data on the issues that this thrust area is attempting to capture. Why not access that information?

Sandy – You should have a conversation with some folks at Denmark before solidifying the roadmap. There is a need here, however sharpening the focus and talking to the industry would help.

Paul Veers – The capabilities over time have improved but the standards have remained the same. The question is "how do you go about changing that"? We need consensus that we can indeed improve the standards. A question for panel: This thrust is the link between the atmospheric science and what we apply to the design. There is going to be a need to create a model to test hypotheses and validate them against other models. How do you structure this type of activity?

Sandy – The question is how do you test the hypotheses and how to make sure these things work for the next 25 years?

Henrik – Standards take a long time to develop. If you want to refocus than you should start with what's available now rather than waiting for the wind modeling to develop. Acquire big data and determine what is actually happening, then you can use today's data rather then waiting on other thrust areas and then begin developing or improving standards.

Sandy – We could call this the "Validating the Design Process" thrust. It is a valuable task but how to approach it needs work.

Mark – We need a definition and measurement standard of wind farm performance. Besides the absolute performance standard we should aim to develop a relative measurement technique that can demonstrate performance changes with less than 0.5% uncertainty. A2e can help create this guideline or standard.

Sandy – This was attempted some time ago but it was deemed too challenging by the IEC group. We need a standard or agreed upon process with or without a high accuracy just so there isn't too much variability in wind plant design.

Bill – Keep in mind that nacelle anemometer data will not give you the flow across the plant.

Henrik – There is more data than just anemometers, you also get load information.

Sandy – Thanks for everyone's attention today! We had some good discussions. The Merit Review Panel will meet tomorrow morning in the same place to have further discussions.

17:50 Adjourn for the day

Wednesday, February 5th

Each Merit Review Panel was given the opportunity to provide feedback to the A2e Executive Management Committee and other group members. The notes below capture each panel member's comments and the discussions that followed. Panelist Bruce Bailey was unable to attend this session.

10:05 MRP Discussion with EMC:

Sandy Butterfield

Sandy – We talked a lot about the presentations. I'll go over some common themes that came out of discussion yesterday and then we'll go through each panel member for comments and further discussion. We hope this is the beginning of a constructive dialogue. The merit review panel appreciates the invitation to be part of the project, especially at the early stages. We also recognize that this is the formative stage. So our comments are not judgments about work done but rather suggestions for fruitful directions as the leaders plan the program. And finally these suggestions come with a commitment to collaborate wherever it makes sense.

With that said one item that came out the discussion was scope. The scope is huge. There should be a strategy that keeps DOE on the right track and allows for course corrections over the long haul. We recognize that we're brought in early on this and so there are some areas that may not have quite gelled yet.

It's the "how to" piece that matters. Where does industry need help and where the industry feels they can do activities better? Because you've invited us to be part of this dialogue, the panel is excited to be part of the A2e initiative moving forward. I have commitments from the members to engage directly with them throughout this process. There is a desire to share certain information, however anecdotal information. I don't think industry members will open up their database with all the details, but I don't think that's what you need. Anecdotal information is sufficient. So DOE has an invitation from the panel to engage with them and come and see what they have to provide for this initiative.

We talked a little about calibration. Knowing where industry is, and then determining where to go. We could really use help in strategizing how to operate a plant to optimize performance. For example, what I'm hearing is that they're working to manipulate the plant to optimize performance, but what they're struggling with is why the strategy works one day and not the next. So, we need a better understanding of overall flow field and an overall understanding of why the strategy works sometimes and not others. Obviously, understanding underlying physical flow processes can help that.

To be clear the industry wants you to know exactly where they are. Make that your starting point and craft a strategy for taking the next steps. In terms of scope, keep the big picture vision but craft a strategy that will yield results along the road. To that end, there was discussion about having a number of workshops.

Have periodic downloads, to make course corrections and keep industry engaged throughout the process. You can possibly do this at the AWEA WindPOWER conference or separate workshops. Have discussions and presentations similar to yesterday but in more depth during these meetings.

There is a recommendation to have at least two more industry members in each one of the planning groups. The Merit Review Panel reps can give the committee names and commitments to truly engage.

There is a need to create metrics; a way of establishing a baseline to define where industry is today. If you do not have a better definition of where we are today, you cannot justify the value of these improvements.

We understand you are in the early planning stages, but it would be good to have a more crisp definition of A2e. This recalibration process should start sooner rather than later, within the next 3 months. We would like something that is maybe rougher than the planned effort for October but sooner. If you look at effort versus value, shoot for the 80% mark over the next 3 months. That's what I got from the discussion. Get the general direction more crisp in the next few months.

Mark Jonkhof – That specifically applies to the plan for the first year.

Sandy – We discussed grid Integration and, from a technical standpoint, we don't think there should be any boundaries. Areas that affect the grid should be modeling the grid. The grid dictates a lot of design requirements. The grid is an important factor to consider for wind plant performance.

Charlie – A feedback loop between wind plant performance and grid integration is critical. We would like to see it more explicitly recognized and addressed in this effort.

Sandy – There are opportunities here for collaborations here (grid integration). There are IEC modeling standards that are being developed for grid models. The group at UVIG is doing a lot of this work and attending some UVIG meetings is worthwhile. Again, we're willing to introduce the Executive Committee to folks that work in these areas. Come to us (the merit review panel) if you need help in identifying people to contact and we'll help open the doors and start the dialogue.

There are some early focuses. When we're modeling the broad fluid dynamic process scale, there's a sense it's a great thing to do to focus on the flow physics but do we need to go all the way out to the atmosphere? I'm not sure. Perhaps think about re-scoping that so you have a manageable modeling task. There are some early benefits. We talked about inter-annual variability being a problem for the industry. We don't know how the understanding of the flow physics will help that problem but it is an area where the industry would like some engagement.

Back to the big modeling effort: narrow the scope to understand flow through wind farm and provides a basis to understand wake interactions. Once you have that tool, we think you can better strategize how to operate a wind plant. Develop a roadmap that, based on atmospheric conditions, can help better strategize how we create efficiencies.

On the noise question, we think it should include atmospheric stability as part of the scope. We study turbine noise but we don't get down to the level of defining how noise transports through wakes and how long it persists.

Bill Mahoney – One of the things we talked about yesterday was modeling across scales, from global to CFD-scales. One of the things we're trying to articulate is focus on Meso-scale to turbine scale rather than measuring across a total range of possible scales.

Sandy – We talked a bit about extreme events and how can we do a better job characterizing extreme events that can improve standards. There's an agreement that standards are currently working, turbines aren't falling over, but there's a lot of data that exists. Can we access this data to better define extreme conditions? Pay attention to the extremes and standards to see if there's a match or how they can be improved.

I think the industry agrees that our wake models are underperforming. They don't currently capture the right physics and there's a desire to improve that. A strategy on how to develop better wake models would be very, very helpful. We felt this could be one of the early goals of the initiative.

You need a target. We talked about high performance computing and the ability to handle large data sets. Come up with some problems with which that database can be helpful in solving. Make that the goal, not scientific computing. Pick one of those realistic problems that are going to be difficult to solve. We feel wakes is one of those problems. Come back with design models. We understand that design models cannot use high performance computing. What industry would like to see emerge from this is a better understanding of the physics in order to develop design tools. You're going to have to collaborate with industry to come up with what those design tools look like and what will work within their design environment.

End of life monitoring. This is a little controversial. Industry knows what's failing and what it's costing. What they don't like is how much it is costing. We talked about the value of a new database when there's a lot of data already out there and NERC might require that data be provided soon. However, that database is not going to tell you why the failures are occurring. A higher fidelity database might be able to tell you what the failure modes are. Focus on the generic issues that concern the industry, such as gearboxes. Collaborate with industry to find commonalities. Sit down with folks like Dan and Mark that have access to these big databases. There were some good ideas on how to develop a standard database. End of life monitoring and extension is something the industry is interested in and strategizing around on how to attack that problem is welcome.

There was some discussion on how to reduce operation costs. I'm going to let Dan speak to that.

Dan Brake – We were wondering if there can be more focus on reducing operating costs. Focusing more on what can be done up tower or at the turbine rather than bringing it in for servicing which can cost twice as much. Maybe through forecasting and other atmospheric information, being able to better predict weather windows. Commonly, crews go out and cannot conduct maintenance until weather window changes.

Sandy – Part of that which may not work well with this program is hatching a different way to design a turbine. There are ways in which you can operate that help minimize costs as long it does not infringe on design choices that a company may make.

Robert Poore - We also talked about field inspection techniques that can be improved and save money for industry.

Dan – We also heard the idea for sensing blade defects and using micro sensors embedded in components that can provide information on the when there's going to be a problem rather than reacting after the fact.

Sandy – Going back to wind plant performance and flow modeling, there needs to be a way to measure wind plant performance in a consistent way. There is a standard power curve that measures turbine performance in relatively flat terrain but it's difficult to come up with metrics that measure wind plant performance in a consistent way to know that a strategy for operating a plant has improved beyond the standard. Use flow modeling to develop a technique to measure plant performance in a consistent way and use that to help inform standards development. We can introduce you to the IEC standards folks, IEC working group 12, that worked on this before but gave up. The Program can start there and see what the challenges were and why it didn't work.

Bill – When you are trying to estimate the power output, it's best to create empirical power curves as they incorporate the actual weather conditions and, by design, are less likely to be overly optimistic. If, before a plant is built, you could come up with better techniques to do that or optimize the performance of a wind farm and control mechanisms, then you may reduce the risk of financing upfront because you know what the real power output will likely be rather than be disappointed after the plant is built because you never factored in real world (in-flow) conditions.

Sandy – DOE should look at the initiative from the perspective of the end-users and, to the industry, the end-users are the financial community. Engaging financial community to understand what drives them and what they would like to see with respect to risk assessment, end of life monitoring, and other things that affect performance.

I would like to go around the room and have the panel members make comments and I invite you all to have a dialogue.

Bill Mahoney

Bill – On the field campaign and experimental design process, I would emphasize that knowing exactly what you want to get out of it, short-term, mid-term, and long-term is critical. Identifying the appropriate instrumentation, the sampling rates, and have the right people around the table to develop the appropriate experimental design and game plan.

We also talked about the importance to develop a test-bed site in flat terrain so you can exert control over the conditions which are more representative of where wind plants are located. But also look at areas of complex terrain which provides an opportunity for us to capture some conditions we weren't able to capture before. The campaigns should be long enough to capture four seasons or more and have some flexibility in the instrumentation that's used, some items may want to be fixed while others may want to be moved around or supplemented.

Ice, frost accretion and snow deposition tend to be overlooked but it certainly changes aerodynamics, wakes, and performance. There may be an optimum strategy on how to monitor a plant under these deteriorating conditions. It can be looked at as predicting the problem, predicting the degradation of service and impacts of performance and return to service.

We didn't talk that much about uncertainty and probabilistic information. This is one area where the atmospheric science community is trying to get a handle on; what are the issues of importance? There is still uncertainty in what uncertainty information should be provided to the industry to allow it to grow. This is an area where A2e could play a role.

Joel Cline - How big of an issue are other forms of precipitation such as rain and dust storms?

Dan – Ice is a big issue which can degrade performance. We really don't see appreciable problems related to precipitation or dust storms in the U.S. I think some work needs to be done on the economic solutions involving ice, such as de-icing solutions, heating internal temperature of the blades, and different coating.

Henrik Stiesdal

Henrik – It would make sense for all of you to re-read page 7 (of the A2e Overview) presentation. I, as an industry player, missed a clear indication that DOE is completely up to speed as to what industry highlights, and what turbine manufacturers and operators do. We discussed a simpler approach of saying "what is today's standard? Where would we like to be when we have successfully completed this effort? What are the gaps? How is it best to approach the gaps?"

With regards to high-performance computing, I still think it makes sense to go from larger scales down to finer scales, however you should prioritize where to best start modeling scales is and think about how to sequence those events to determine downstream benefits. We support anyone who comes to us to discuss where industry is and

where best to deliver. For high performance computing we want to ensure DOE is doing something that has benefits for industry design tools.

Look at existing studies already and make some aggregation of that information for noise, field testing, standardization etc, and then make a summary of that information. Applying data and data visualizations to existing databases and make this information available to industry is relatively low-hanging fruit.

Reliability and overall controls parts of the program need the biggest refocusing. Have a discussion with broader industry not just OEMs and owners/operators, to discuss what the needs are. They don't need a database of information, they need support for things that are out of reach of industry at the moment.

Thanks for the opportunity to provide feedback and I look forward to having another discussion about the plan at the conference in May.

Robert Poore

Robert – I appreciate being involved in the early stages. We need to think about focusing this program in bite-sized pieces that are most important to the industry today and that each of your teams have appropriate industry members who are actively engaged in these areas. Have at least two industry people who are actively engaged on the advisory panel.

In my mind, the focus areas are understanding the atmospheric conditions, particularly atmospheric stability which affects wake models, turbine performance and flow modeling. The wake models work fairly well in some conditions but we don't completely understand the fundamental physics. If we understand the fundamental physics then we can improve our wake models. We currently see a 1% to 5% power performance difference in some sites due to differing atmospheric conditions and season. Understanding what's going on there to prevent that loss from happening, or at least anticipating these problems, would be valuable. Complex terrain and flow modeling has the same challenge, in some atmospheric conditions the models work well, in others they don't work well at all. Also with loading and reliability, we're getting a better handle on the design conditions but still there are some areas of improvement there.

Map out a roadmap that focuses on small, important pieces and then gets broader and broader over time.

Be careful not to underestimate the importance of validation. We're going to need multiple test-sites. Pick them carefully to find conditions of interest to the problems that we see.

There is potential in data mining industry data bases for understanding what is going on in industry. Looking at operating data and deriving it in a way to find improvements is challenging. If we had more dedicated resources and bigger data sets we could probably make more progress. The challenge there is that some might say, "we can't get that data", which may be partly a credibility question. Some people are more open to give access to data depending on the receiving organization. If we can start to build some engagement from the industry on these panels, we will start to get more buy-in from the community.

Carsten Westergaard - We've talked to owner/operators about this and the question becomes how efficient you can become in sharing this data. Data sets are commonly not aligned and when data is aggregated, it is difficult to identify what you are actually getting.

Robert – I'm using data mining in a broad context. There is reliability data, which we aren't convinced there's value in creating another database from. I'm thinking more in terms of turbine performance data with information from met masts.

Carsten – This is something we're actually looking at; adding two levels of fidelity to those data sets to determine which gaps need to be closed.

Jon White – We interviewed ten major owner/operator and they all agreed they wanted a benchmark. There seems to be a disconnect between this group and the owner/operators we've interviewed. Are we missing terminology or is this just a difference in opinion?

Robert – I think the answer is that owner and operators are looking for in the way of a benchmark because their management wants them to have an independent benchmark to justify what they're doing. What we're talking about here is research and development data that will actually improve the reliability of the projects.

Dan - I believe that's correct. At the same time, its management that wants to know this benchmark but yet doesn't want to provide it themselves. When NREC requires us to provide all the data at the same time, that's when we'll be able to provide these types of benchmarks

Henrik - I do not think DOE should play in the space of developing these types of benchmarks. I believe they should focus on providing data on a research basis that can help move the industry forward.

Robert – My last point is to emphasize the speed for the initiative. We need to operate at a different pace, have annual meetings with transparent dialogues about progress, transparent dialogue about what isn't working.

Steve Hammond – When you talked about atmospheric modeling, do you need to have better certainty about when you can use them and when you can't? Would you like better uncertainty quantification of when to use wake models and associated error bars?

Robert - We are not happy with what we have; the uncertainty band is too big. If we had a better understanding of the fundamental physics then we can develop better models.

Will Shaw - How does industry measure when an atmospheric model is working and when it's not working?

Robert - When we model wake loss and compare with measurements, we aren't coming up with similar numbers in the aggregate for the project. The better resolution we have in terms of time, the better the industry will be. At a minimum, we should be able to get it right on an annual basis.

Will - Ultimately what matters is to define the wake losses in a variety of meteorological conditions in aggregate for a plant.

Dan – If we can determine the right parameters to measure to be able to describe what's going on with the wake, then we can get it correlated to performance testing so we can characterize the differences in order to understand what our performance expectations will be.

Robert - The same thing goes for complex flow.

Mike Robinson - Are we capturing the issues right in terms on wakes and their influence on O&M costs?

Dan - My sense is that there are some problems but not on the major components. We cannot describe complex flow well enough to determine these impacts.

Joel - Is it an appropriate time to get meteorological information from operating wind plants for the purpose of improving foundational models and then provide these models to the community?

Sandy – My sense is that the industry would be interested in sharing this information if you showed them the plan and came up with a benefit to them.

Robert – I think a key piece of that is having these people involved in the planning group, which will help illustrate the need for the data, rather than starting with data request.

Dan - If you have a plan on what you want to model and what data you need, you can request just that data.

Will – It sounds like we need to know what we want to get out of it before we make the request.

David Wilson – On atmospheric conditions and wake modeling, is it important to understand the fundamental physics behind the phenomena or is it just modeling and the data that's of interest?

Robert - Think we need to understand fundamentally what's happening in the atmosphere in order to model it.

Sandy: Wake models are almost entirely empirically developed and physical representations within models are minor. There needs to be much broader representation in those models if they're going to have an impact on engineer.

Mark Jonkhof

Mark- I'll build on a couple things. If we want to make a transition to farms, we need to get a farm performance measurement standard out there. The IEC has tried it and failed. If DOE can take on this challenge and delivery, it could change the way the industry designs turbines.

Understanding flow field and wakes and then getting the aggregate right is important for financing. From a turbine controls perspective, I want to know what the wake propagation is right now based on atmospheric conditions, inflow conditions, shear etc. I want to know if the wake is decaying so that I can operate my turbines differently. So,

besides getting the aggregate right, I want to know real-time and semi real-time what the wake is doing. Focusing on the scales from meso-scale to farm is going to be key.

Jon W - Do you know a way to scan production machines so we can get enough information out of them without infringing on intellectual property rights.

Mark - This is solvable if you work with industry.

Dan – I don't think it's a problem to see how a turbine performs or to measure the wakes for sold machines.

Carsten – With the SWIFT facility in mind, do you have anything in mind on how to connect the dots between full-scale down to the controller scale?

Mark - We need the bigger farms and we also need different sites with different atmospheric conditions. We can use SWIFT but no one site is going to give us all the answers.

Henrik - We should prove that we can model the flow in a real-life environment.

Carsten – At the SWIFT site we have the ability to control and measure details in the wake that provides a step-stone to tune the models.

Henrik – That's fine. It's nice to have in that it would create valuable information but it's not sufficient.

Carsten – But you need that information in the model to validate that the model is performing and you can't get that at the full-scale because you can't measure that extra level of detail and accuracy.

Henrik – I think the effort would be best spent on adding instruments to a couple of real, available machines out there.

Charlie Smith

Charlie – We already talked about the critical feedback loop between grid integration and wind plant performance, this needs to be recognized and incorporated.

On the modeling activities, I think it's possible to build a model structure where you are able to plug in wind plant performance model and have the interactions with the external grid. There are dynamic models that are being developed and used in WECC (Western Electricity Coordinating Council) and IEC. This way you can use these grid models and plug them into a wind plant performance model without duplicating the grid model efforts.

The O&M User Group representing 50 GW of the 60 GW installed capacity has routinely asked the question, based on management requests looking for justification of O&M expenditures, "how are you doing against your peers for operations and maintenances?" So there's a discussion going on among members about how to set benchmarks.

We haven't talked about cybersecurity. I'm not sure if there's a role for cybersecurity but it's a big problem.

Carsten – It's something that I had on the list but didn't have a chance to discuss it.

Dan Brake

Dan –On the reliability side, one area we didn't touch on too much was what I'll call condition-based maintenance. Wind turbine maintenance is based on time and typically serviced once a year but this could be optimized. In the CT (combustion turbine) world we know exactly when to do maintenance, based on number of starts, firing temperatures etc. But for wind we treat every turbine regardless of the conditions it experiences. There may be some work to be done that could benefit the industry and save costs.

On wind plant controls, I re-emphasize what everyone else is saying about finding out what the industry is doing. I don't know if there's something thing out there about setting standards or protocols for turbine-to-turbine communication but that could be an area of research.

On integrated wind plant design and analysis I wanted to re-echo what others were saying yesterday that this might be a good opportunity to look at design standards and review of them. Are we doing the right things there? Are we missing whole areas?

Jim Lyons

Jim - Industry engagement is very important. The Solid State Light program at DOE does a great job at this. They have three annual meetings and they develop roadmaps for the industry and everybody participates. In your planning, plan on engaging the industry as well as academic community on an annual basis.

Another thing we discussed was bound the scale of modeling. We like the idea of developing a software suite that's a framework for plugging in things that academic and researchers can use. Focus the eleven orders of magnitude down to something's that's needed to get results.

We talked about metrics that you can validate with the measurement programs. We talked about coming back in three or four month cycle after A2e group has had more discussions with industry and comes back with game plan, and we'll help you refining everything to come up with a real plan with real deliverables on a yearly basis.

Wind industry is an investment-run business so the investors have so much sway and the cost of money can swamp out all the technical improvements. Understanding how financial guys think about the world is very important.

We talked a little bit about end of life assessments. Once we get to 2 MW we'll want to keep those machines running for 30, 40 , 50 years. We have a 20 year life now, so how do we model all that and what are the real impacts on turbines from wakes? I don't think the industry has dealt with this at all.

One of the other things that was not really brought up was forecasting. It's a large-scale problem that's outside the boundaries of wind plants. One of the things we looked at at GE was, given the forecast; can you predict how your wind plant will operate? There may be a way to develop a learning tool that sees anomalies in performance early that can then be coupled with ISO-run modeling tools so for a given rolling forecast you can provide how your plant will perform.

Charlie – Joel I want to respond to comment asking for data. We do have two O&M Working Group meetings a year and I'd be happy to introduce to that group to describe the ask and get feedback.

Bruce Bailey (represented by Sandy)

Sandy – Bruce Bailey could not attend today but he had some comments which I'll summarize. In his opinion, forecasting is a commonly used tool. In Germany they are working with 5% 24 hours ahead. The question for this team is the potential improvement only 5%. Recognize industry already uses these tools rather successfully and base your judgment on where can we approve things from there.

Katie – When you say 5% do you mean power or speed?

Sandy – Power. 24 hours ahead, wind plant performance power. We invite you to dig into that comment more with Bruce.

Bill – [mentioned during the discussion.] The 5% wind energy prediction skill for the next-day forecast is the aggregate skill across Germany. The low value is due partly to error cancellation across the large geographic area.

Sandy Butterfield, in closing

That's it, we've gone around the room. I'll mention in closing that we appreciate being involved and would like to continue being engaged. You heard commitments from the panel to work together to either gather data that's needed or talk to industry about the issues. I know AWEA R&D Committee could be a useful portal to continue engagement with industry and I can talk to Mike (Derby) about that.

We'd like to see something sooner rather than later. If these presentations are updated pass them along to us for feedback.

Carsten - Do you have a recommendation on how to interact among this group?

Sandy - I'll discuss with Mike (Robinson) and Mike (Derby) to find the best way to do that. My initial thought is to line-up people with their expertise and approach panel members directly.

Daniel Laird – It seems like the general message here is more incremental than what some of us had as an A2e goal. Instead of looking a goal for 2020, the message is focus on a goal for 2015. This is the first time, in my experience with wind to look further down field. If the benefit is to optimize the industry in 2020 how does that differ from a shorter-term perspective? I've been trying to process all the comments as, if we said our goal was to be done in the year 2015, which one of your comments would have been different?

Sandy: I think we sent the wrong message. We like the big plan, but we're saying draft a roadmap that will have incremental goals.

Daniel – And I agree, I just don't want the incremental goals to prevent us from making a fundamental leap. Maybe we need to tackle wake modeling in a very different way than we have up to this point so we're not just making incremental improvements but we actual get to something.

Robert: My point was you want to understand what's going and then people can develop models based on that understanding. You need to develop that core understanding first.

Dan: In some areas it seemed DOE felt they were dreaming big but we felt you weren't doing it. We are already developing controls, we think you should be thinking bigger.

Sandy - Any feedback for us? How would you like us to interact with you better? We invite you to come back to us.

Mike R – First I want to thank the panel. We really want to take you up on your thought to further engage. If I had to summarize I felt the consensus was we are moving in the right direction and changing the focus of the program is the right thing to do. We have to re-draw the box and factor in grid concerns that drive performance issues.

I also felt like the areas that we picked are probably the right areas to focus on, however, we need to ensure we are calibrated. But within that context there needs to be some tuning. We talked about as we make these groups more formalized, to have a path. Do some historical review to define what's been done so far, then talk to industry about advancements and building longer-term plan.

On high fidelity modeling, I heard it's swell but don't make it a hammer looking or a nail. The most appropriate use for that tool is to fully address the fundamental underlying physics that we need to assess and then utilize that to help us advance the technology. Focus this effort down to modular things that are helpful for industry right now.

Sandy – I wanted to mention one more thing that I think is a challenge. I want to recognize that having all the labs work together is a new thing. We're interested in working with all of you. We recognize this is a paradigm change and we applaud you.

Mike R – It makes it easier when we have buy-in on this way of working with the labs from DOE management. Again, thank very much for your time. We will commit to coming up with some schedules, certainly working with you and other members of the team (panel) to come up with better logistics going forward. Gives us a few days to us to sort this out.

Sandy – Just so the group knows, Jason has been taking minutes. We'll go back and forth on those until we get those more readable. Then we'll pass them out for everyone to review.

Mike R – You have to be comfortable with them because they'll have to go on the website. And we don't want to say anything or imply anything that you are not comfortable with. Any other last comments?

Mike Derby – I just wanted to say thank you committee for their commitment here and going forward. We really want to be relevant to your needs and really appreciate the feedback you've given us.

Mike R – Thank you one and all.

Meeting adjourned at 12:08