Perspectives for the Deployment of Wind Energy Overview of Global Trends by 2050 and Guidance to National Road-mapping Efforts

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Webinar Panelists

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Simone Landolina	Coordinator, International Low-Carbon Energy Technology Platform, IEA
Cédric Philibert	Senior Expert, IEA
Simon Muller	Renewable Energy Division, IEA

This Transcript

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Sean Esterly

Hello everyone, I'm Sean Esterly with the Natural Renewable Energy Laboratory and welcome to today's webinar which is being hosted by the Clean Energy Solutions Center and The International Energy Agency, and today's webinar is focused on the perspectives for the deployment of wind energy and overview of global trends by 2050 and guidance to national road mapping efforts.

One important note before we begin our presentation is that the Clean Energy Solutions Center has not endorsed or recommended specific products or services. Information provided in this webinar is featured in the Solutions Center's resource library as one of many best practices resource as reviewed and selected by technical experts. And you have two options for audio for this webinar. You may either listen to your computer or over your telephone. If you choose to listen to your computer, please select the mic and speakers option in the audio pane to eliminate echo and feedback, and if you choose to dial in by phone, please select the telephone option and a box on the right side will display the number and audio PIN that you should use to dial in. And panelists, we just ask that you please mute your audio device while you are not presenting, and if anyone's having difficulty with the webinar platform, you can call their help desk number at the bottom of that slide which is 888-259-3826. And this webinar will include a short question and answer session following each speaker's presentation as well as a longer question and answer session at the end of all of the presentations. So we do encourage anyone that has a question to submit those and you may do that by copying—or sorry, typing it into the question pane in the webinar, the GoToWebinar window, and if you're having difficulty viewing the materials through the webinar portal, we'll be posting PDF copies of the presentation to cleanenergysolutions.org/training and you may follow along as the speakers present. Also, we'll be posting an audio recording of today's webinar to that site within about a week of today's broadcast. Now today's webinar agenda is centered around the presentations from today's expert panelists, Ingrid Barnsley, Cedric Philibert, Simone Landolina, and Simon Muller. These panelists have been kind enough to join us to discuss the findings from three different wind publications, IEA Technology Roadmap on Wind Energy, the How2Guide for Wind Energy, and The Power of Transformation Wind, Sun and the Economics of Flexible Power Systems. Now before we begin our—the presentations, I'll provide a short informative overview of the Clean Energy Solutions Center Initiative and then following the presentations we'll have the main question and answer session and then closing remarks and a very brief survey for the audience. This slide provides a bit of background in terms of how the Solutions Center came to be formed. The Solutions Center is an initiative of the Clean Energy Ministerial and is supported through a partnership with UN Energy. It was launched in April of 2011 and is primarily led by Australia, the United States, and other CEM partners. Outcomes of this unique partnership includes support of developing countries through enhancement of resources on policies relating to energy access. No cost expert policy assistance and peer-to-peer learning and training tools such as the webinar you're attending today. And there are four primary goals of the Solutions Center. First of all is to serve as a clearinghouse of clean energy policy resources. Second is to share policy best practices data and analysis tools specific to clean energy policies and programs. A third is to deliver dynamic services that enable expert assistance learning and peer to peer sharing of experiences. And then the last goal is to foster dialogue on emerging policy issues in innovation around the globe. And the primary audience for the Solutions Center is energy policy makers and analysts from governments and technical organizations in all countries. But they also strive to engage with the private sector, NGO's, and civil society. One of the marquee features that the Solutions Center is proud to provide is an Expert Policy Assistance know as Ask an Expert, and Ask an Expert has established a broad team of over thirty experts from around the globe who are available to provide remote policy advice in analysis to all countries at no cost. So for example in the area of renewable energy policy and market design, we're very pleased to have David Jacobs, a research associate at the Institute of Advanced Sustainability Studies serving as their expert, so if you have a need for policy assistance in the renewable energy policy and market design sector, we do encourage you to use this useful service. Again it is provided free of charge to those requesting and to request assistance, you may submit your request by registering through our "Ask an Expert" feature at cleanenergysolutions.org/expert. And we also invite you to spread the word about this service to those in your networks and organizations. So in summary, we encourage you to explore and take advantage of the Solutions Center resources and services including the expert policy assistance, Ask an Expert program, the database of Clean Energy Policy resources, subscribe to the Clean Energy Solutions Center newsletter and participate in more webinars like this one. And now I'd like to provide brief introductions for today's distinguished panelists. Our first speaker today is Ingrid Barnsley, head of International Partnerships and Initiatives at the International Energy Agency. And then our second speaker today will be Cedric Philibert who is a senior expert at IEA, and then following Cedric we will hear from Simone Landolina who is the coordinator of the International Low Carbon Energy Technology Platform at IEA, and then our final speaker for today's webinar is Simon Muller who is with the Renewable Energy Division at IEA, and so with those introductions, please welcome Ingrid to today's webinar.

Ingrid Barnsley

Thank you very much Sean for that beautiful introduction and hello, good morning, good afternoon, good evening all. I'm delighted to provide some opening remarks today for the first webinar organized jointly by the IEA Energy Technology Platform in collaboration with the Clean Energy Solutions Center, and I would like to start off by giving a sincere thanks to Sean and also to Heather Stafford for their precious help in making this webinar happen. In February of this year, the IEA Technology Platform organized a workshop on strategic opportunities for international collaboration on low carbon energy technologies, and on that occasion from [inaudible] proposed that we organize our webinar in the framework of the CESC. We accepted that invitation with much pleasure and we're grateful for the opportunity to work with the Clean Energy Solutions Center for disseminating IEA analyses on low carbon energy technologies. We are going to present today three recent IEA publications that are relevant for the deployment of wind energy globally, and I have the pleasure to share the stage with three of our senior IEA experts. Firstly, Cedric Philibert who is the senior IEA solar and wind expert will present the recent update of the IEA global technology roadmap on wind energy, which was released in late 2013. The IEA's suite of energy technology roadmaps seek to set out how low carbon energy technologies can help achieve global CO2 reduction targets by 2050 in line with a 2-degree scenario. Wind power has made considerable progress since the IEA produced its first roadmap on this topic in 2009, and wind already provides 15 to 30 percent of annual electricity in several countries. What we see since the 2009 addition of the wind technology roadmap is that costs have been further reduced for land-based turbines and most recent machines are taller, greater and can work in many more places with lower speed winds delivering a more regular output. This has led the IEA to revise upward its long-term targets of wind power now at—from 15 to 18 percent of global electricity by 2050. This is 12 percent in the 2009 roadmap and Cedric will tell you more about that in a moment. Secondly, Simone Landolina, coordinator of the IEA Technology Platform will present the first publication in a new IEA series, The How2Guide series. This publication series aims to build on the IEA's Energy Technology Roadmap, in particular, the How2Guide for Wind Energy builds on the IEA Technology Roadmap for wind as well as on a general IEA policy manual called Energy Technology Roadmaps, A Guide to Development and Implementation. In view of the IEA, national and regional roadmaps can play a key role in supporting the deployment of low carbon technologies including in this case wind. The How2Guide for Wind Energy is a tool that policy makers and industry stakeholders can use as a reference manual when developing their own national strategies for wind energy deployment, and I should say that it has been developed equally as a starting point for relative newcomers to the field as well as a checklist for those with more experience with wind power if you may be wishing to update or improve existing national or regional strategies for this technology. The IEA How2Guide series is coordinated by the International Low Carbon Energy Technology Platform. The platform I will just mention is a chief IEA tool for engagement with countries far beyond the IEA's membership and with international organizations to foster the deployment of low carbon energy technologies. The How2Guide for Wind Energy was published in March of this year and there are two other How2Guides currently underway. One for Smart Grids and one for Bioenergy, the latter being developed in collaboration with the food and agriculture organization. Alongside these activities, the IEA Technology Platform also uses it convening power to organize expert workshops on key topics of relevance for emerging and developing economies in an effort to disseminate and adapt to IEA global and technical analyses to those countries and to share with respect to those lessons learned among international and regional experts. Lastly, the technology platform is currently working on an insight paper that will analyze the existing landscape of international collaboration on low carbon energy technologies and strategic opportunities for the future, and this is a paper that we have discussed already with the Clean Energy Solutions Center and we look forward to an opportunity to share that with you by the Clean Energy Solutions Center in some months' time. Lastly but certainly not least, Simon Muller, Senior IEA Analyst of System Integration of Renewables will present the recent publication, The Power of Transformation. This publication has been developed as part of a very important IEA project, the Grid Integration of Variable Renewables which some of you may know by its acronym GIVAR. Renewable energy, in particular wind and solar, I suspect the audience of this webinar will know that it's playing an increasingly important role in diversifying and decarbonizing our energy supply systems; however, integrating variable renewable energy into the power grid is one of the most pressing energy challenges that policy makers and indeed industries are presently facing.

This recent IEA publication helps to address these challenges and it attempts to do so in a fairly comprehensive manner. It could indeed, the integration of renewables we know is not simply about adding renewables to the grid but also about transforming the electricity system as a whole, and Simon will share more with you on that topic. With that said, it is my great pleasure to pass this along to Cedric. Thank you.

Cedric Philibert Hello everybody. Thank you Ingrid. I think you've made a very good summary of what I'm going to say. I'll try to do my best to add a little information to that. There's probably an easier way to get to the slides I want to show you. Yes, here we are. Basically—oops, this way okay—as you said, we publish this wind technology roadmap. It was one of the first technology roadmap published by the IEA into the line. It was at the request of the G8 that we tried to illustrate the key technologies that are needed to achieve the global aim of keeping global warming below 2 Celsius degrees and respect to the power sector to basically how global energy relates to CO2 emissions by 2050 from 2009 levels, and this is what we did at this first roadmap. But even after 4 years we felt the need to reconsider and think more closely and to take stock of the progress that has been made in both deployment but also development of the technology but also all the elements of the changing context, energy context, and in particular the Fukushima disaster or the slow development of carbon storage—capture and storage technology and all this has led to reallocate the efforts in the successive energy technology perspectives publication which have regularly published denials for how to achieve the 2 Celsius degree target, and this mix of solution has—it's slowly evolving year after year because the energy context is changing. So in this roadmap we look at the technology and cost evolution for wind power. We reconsider all recent trends and we revise the long-term targets. This is what we call the vision. It's based on this global energy context and system optimization, and we as in all roadmaps, we look at a list of barriers that can prevent the smooth deployment of wind power to take place and propose a number of policy recommendations for overcoming these barriers. So looking just at the recent past, we've seen a big global committed growth of wind power with now 300 gigawatts installed plus and this came basically out of the blue if you can see that on the slide. It's well spread around the planet. It's not only a handful of countries but it's the U.S. It's Europe. It's China. It's India. It's other countries so it's a bit everywhere. We have a short-term or medium-term outlook where we see that we'll have a stable deployment in Europe with about 6 to 7 gigawatts added every year. We still have China and [inaudible] the onshore wind market. We see that America is growing fast but also a bit more erratic because you have this kind of annual [inaudible] of tax incentives, which make some years very good and some years very bad. 2013 was not a good year, but we expect the wind power industry in the U.S. to recover in 2014 and beyond. In the meantime, we've seen offshore deployment facing more challenges than expected, and in fact, the outlook for offshore wind has been revised down, and we tend to revise it almost every year down because we have policy uncertainties and we have connection delays. We have [inaudible] and supply chain bottleneck, so it appears not as easy as we have thought and we of course take stock of these deficiencies. In the future, Europe will be a quarter of offshore wind and China will come second. Now in technology evolution, this has been dramatic of course of a long period. It’s incredible because we moved from turbines of 100 kilowatts to multi-megawatts turbines, but even in the last few years we’re still seeing the growth in size, height, and capacity of wind turbines, but also we are seeing in the last 2 years or 3 years I would say, we have seen the emergence of a new class of turbines which are adapted to lower speed winds. They are very tall, very big but they don’t have a very big turbine inside and don’t have a very big electrical capacity compared to their swept area, and because of that, they have higher capacity factors for whichever wind speed they work in, and this allows to work with a number of sites with lower speed winds. At the beginning of the industry, you had to go on the top of mountains or on the shores, [inaudible] onshore wind came from because you had to be exposed to the strong winds coming from the sea to be cost effective. This is not the case anymore. We can go into—much more into the land. Well, that’s not entirely new. You already have Texas and Midwest but more and more you can go to a wider number of places to have wind turbines that will be cost effective, and they also are more power system friendly because they have a more regular output and as Simon will show in some minutes of this and how it integrates the variable power from wind turbines into the electric systems. Now of course we’ve seen a decrease of cost on land, which has been quite significant with the reduction of the investment cost and, therefore, the levelized cost of electricity ranging from 25 percent to 45 percent in some cases for different wind speeds. In the meantime, we haven’t seen cost reduction of offshore wind partly because as we made improvements in the technology we also had to go farther from the shore for a variety of reasons and this is a cost increasing factor which has overcomplicated the cost reduction due to learning, so we believe that we have not yet really entered into the era where learning effects will multiply and allow for real cost reduction, at least we haven’t seen it before so far. This slide is interesting. It shows also how great operations have learned to work with and of course wind plant owners have learned to work with variable wind resource and have reduced their forecasting errors by [inaudible]. That’s very important of course to be able to manage when you get to a large share of wind [inaudible] energy when you are at 20 percent or over 20 percent like last year in Portugal or Spain. Of course, you have to manage it because on some days it’s 70 percent or 80 percent or more. Now this is the vision, the way we see the deployment of wind power in this roadmap. The target if I may say so in 2009 was for wind power to take 12 percent of the global electricity generation by 2015 and now we have pushed it to 15 to 18 percent; 15 corresponds to what is called the 2DS, the 2 degree scenario, and 18 percent responds to a variant of the 2DS which is the 2DS with more renewable, the high renewable, variants which also accounts for less or slower deployment of nuclear capacity and carbon capture and storage. So this range of 15 to 18 is of course significantly more important than the 12 percent we had in mind just 4 years ago, and you see from the colors starting from below China and we see the Europe and then the United States in green how you see that these 3 areas of the world accounts together for two-thirds of the global capacity in the future. And here you will see the share of electricity wind power on the right hand side [inaudible] you will see the [inaudible] is the global [inaudible]. And what you see at the bottom line and what you see now in the red is the 18 percent share which is not broken down by countries but you can imagine it's [inaudible] at the 15 percent it reached so they are both [inaudible]. Here look at the share of land based and offshore winds in the deployment. Of course, we account for some deployment of offshore really having peaked after 2020 and growing but now it's clear that land based will remain the backbone of this wind power generation over the decades to come. By 2050, about 20 percent of the wind capacity will be located at sea up from 6 percent in 2020. We expect investment costs to further decrease by about 20 percent to 25 percent on land but [inaudible] 45 percent offshore at the end of this period. Now the contribution to CO_2 reductions are also an interesting aspect. In 2050 if we were to do nothing, we would have a power sector CO_2 emissions growing to 25 gigatons CO_2 per year, but if we act as we ought to do, it should be down to a tenth of that to 2.4 gigatons CO_2 per year so it's a big, big difference of course, and wind power is to provide 3 gigatons of 13 percent of this difference and offshore being more than a third of that. Now of course when you have large shares of renewable, you will need more flexibility in the systems. The flexibility is not only storage, as most people believe. It's grid infrastructure interconnection. It's dispatchable generation whether hydropower or thermal power. It's storage of course illustrated here with pumped hydro storage which currently represents 99 percent of storage on grid and of course it's [inaudible] integration and load management all the way to shift a load in time and all these means together are very important to accommodate larger share of variable renewable in the grids and one of course necessary condition that the value of flexibility needs to be reflected in the market. It's not really the case today. Of course, you need a suite of all the different flexibility options but again Simon will further elaborate on this hopefully. Transmission and integration of course remain key for long-term continued growth because in many places, you have very good winds in some places and the load center may be relatively far from that. Of course, this is turning a bit with the new class of turbines, which I explained earlier but still there will be a need for more interconnection and you see here how we further interconnection around [inaudible] to integrate more wind power in Europe. Wind power will be the real backbone of the electricity system in Europe even more than in solar, so it's very important to be able to realize this [inaudible]. It's not always easy but the technology of high voltage direct current is significantly easier and significantly lower and [inaudible] footprint than the well-known AC overhead technology. I keep going the wrong way. This slide is just to illustrate what we have in the roadmap actions and timeframe. We look in different areas and I describe a number of topics for which we accommodate recommendations or not so it goes from technology with system design, [inaudible] resource assessment, manufacturing to system integration of course which will become more and more important [inaudible] market, completion, development, power and flexibility, and of course policy and finance. Renewables are highly capital intensive so that's a key issue of financing and finding a business model that will refund the investment over the next 20 years is more important than ever, so it's—even when you get more competitive you still need to find solutions to this which ought to be tailored to the great characteristic of renewables that have very low [inaudible] cost but very high investment cost. So we look at that and on the funding of [inaudible] collaboration of course are a part of the routine work at IEA. With this, I think I'm done and I would like to turn the floor to Simone unless there are questions for me. Maybe Sean I give you the floor back and thank you very much for your attention.

Sean Esterly Great. Thank you Cedric and good for the presentations and do have a couple of questions for you Cedric regarding your presentation, and the first question I have for you is what is the most relevant innovation you see coming to further reduce the costs?

Cedric Philibert That's an interesting one. In fact, I would hesitate between two or three areas. One is new materials. Lighter materials are more robust but lighter with reduced cost and reduced strain on the material though it's important. Another one is further improvement in the power electronics that allow again to reduce the load and the fatigue of the structure and also respond to new needs from a system point of view, and finally, but this is a little more optimistic, it may happen or may not happen, but the tech drive superconducting generations of course would be very interesting in reducing the mass on top of the mass and that would provide a huge number of benefits but again this may take place or not. I'm not sure yet.

Sean Esterly All right, thank you Cedric. The next question I have for you is do you ever see offshore wind becoming as cheap as onshore?

Cedric Philibert No, as cheap as onshore I don't believe that will happen. Of course, you have more regular winds offshore and if the investment costs reduce in greater proportion for offshore wind then the cost of both—actually both will turn to—the gap will tend to narrow but cheaper than the land-based wind, it's not in our modeling. It's not what we see, but we see that at some point we'll need to go offshore anyhow because some countries that are near the shore won't have enough room inside to accommodate that many wind turbines and they will—and people will have a preference to pay a little more and to have the offshore winds offshore and not on land. So it's unlikely unless we find—unless we have big improvements in the marine energy that allows for synergies like you know creating bigger [inaudible] that are pumped hydro—marine pumped hydro storage and tie all the machines and supports for all wind power at the same time but this again is a bit speculative.

Sean Esterly Thank you Cedric. And before we move onto the next presenter, I do just want to give a quick reminder to the audience if you have any questions, please feel free to submit those to the question page in the GoToWebinar window. And with that, let’s turn it over to Simone for his presentation.

Simone Landolina Thank you very much. So I will briefly introduce—I will not introduce again actually the International Low-Carbon Energy Technology Platform because my colleague, Ingrid, already provided a good overview of what we do. I will just say in a few words here that the technology platform is the IEA vehicle for engaging with partner countries on and support of low carbon energy technologies. It was created in 2010 [inaudible] IEA [inaudible] and basically, we have key main types of activities. One being the How2Guide, which helps [inaudible]. Another tool being [inaudible] workshops to engage with the IEA partner countries, member countries, private sector as well as policy makers on low-carbon energy technologies and selected [inaudible] analysis. So with regards to the How2Guide, this is a new series. Our first publication was just launched a couple of months ago but it is on our successful [inaudible] IEA which is the global technology roadmaps over 20 publications made in recent years as well as the IEA established roadmap methodology. And it’s also our response to growing the quest for a system from partner countries for support on developing technology specific strategies of policies [inaudible] and we send this through the IEA China wind roadmap [inaudible] 2012 and more recently with the [inaudible] roadmap and working now on [inaudible] with solar roadmap, but because the IEA cannot produce bilateral roadmaps for each energy technology with each of our partner countries, so the How2Guide is a response to this request so this need indeed, and it is consists of series of manuals for policy and decision makers to develop technology roadmaps which have tailored to national and regional frameworks. We do this primarily as I said to scale up our capabilities to provide support to our partner countries in this exercise, but it’s not only for partner countries. Indeed developing economies and emerging economies are [inaudible] this initiative. Those countries which are not in the process of developing—develop [inaudible] energy strategies and now are in the process of developing energy technology strategies and our member countries is—you know develop [inaudible] countries which already have technology roadmaps in place can use this as a provision tool. For instance, aiming at a higher share of wind in this case in their energy mix. So far [inaudible] publish it in the [inaudible] launched by our executive director at the conference in Spain of the European wind energy session is the How2Guide to Wind Energy. We’re working on two additional titles; How2Guide for Bioenergy and How2Guide for Small Grids are expected at the beginning of next year. For the How2Guide for Wind Energy defines the process of developing and implementing a wind energy roadmap. This is what the document is about and from this perspective from my guidance to decision makers to four steps which are illustrated the [inaudible] taking both from IEA member countries and partner countries namely in this publication China, United States, Brazil, and South Africa. I should say it focuses on large-scale selections. It’s not just—it’s [inaudible] wind power plans. The How2Guide series [inaudible] lessons, which are learned across regions. Lessons for the successful stories and experiences which turned out to be less successful than the policy makers told it would be and they’re upset. So we collected data and key information through a series of regional workshops for wind energy. We [inaudible] had two workshops, one in the Philippines supported by the Asian development [inaudible] 2012 and one in South Africa in February of 2013 in close collaboration with the South African National Energy Development Institute. My [inaudible] presented the technology roadmap for wind and also because they covered pages of this publication, so I figure I would spend a minute here and present you with the difference and the complement side is indeed [inaudible] technology roadmap and How2Guide. So what technology roadmaps look at the market there and technology outlook over the short, medium, and long term indeed including a vision of the technology evolution with—that was just presented for wind and presenting a series of actions and timeframes. The How2Guide is a manual, so it only includes the short introduction technology market. A lot of references. Also, the experience of what’s being developed at by for instance other international [inaudible] which are working on the same managed technology [inaudible] in connection with [inaudible] agency. And what it really focuses on is the process for developing a roadmap. So, it’s a step-by-step decision-making guide answer, which guides the reader through the analysis of drivers, barriers and action options to work on the barriers. And here is the next struggle some [inaudible] that you will find in two publications you know just to give an example of what—how they are different and complementary [inaudible]. So we’ve seen with the technology for [inaudible] wind energy that the focus is on projections of growth for wind energy. By 2050, how much wind power can be deployed and work? What the How2Guide will address after [inaudible] like which type of questions need to be asked in terms of [inaudible] research for wind energy growth and development. Which type of stakeholders and how they’re categorized which are the barriers they encountered indeed in development say for instance a wind power plant and now the barriers can be [inaudible] options as well as indicators is an important dimension of the—how we monitor progress and how we can track our developments. So I say that the How2Guide for Wind adopts the methodology which was developed by the IEA for roadmap, technology roadmaps, and this methodology is composed of four key phases. Phase 1, which is the first one, it’s about planning and preparation of the technology roadmap. Phase 2 is about vision so it is [inaudible] drivers which would define a vision which consists of the desired level of deployment in this case wind energy. Phase 3, which is about developing, is the drafting part of the technology roadmap production, and phase 4, which is about implementing the roadmap and monitoring evolution. So here you can see also how we distinguish between activities that in the orange corner which are related to research and analysis, and I feel this is more related to consensus building and [inaudible] take other step. Both important. They take us through different approaches and I should also add that here we indicate timeframes also which is expected time required for the implementation of each of these phases, but [inaudible] are indicative because it needs to be adapted to the specific barrier so the specific situation so it should [inaudible] in which the roadmap is implemented. Phase 1, Planning and Preparation. So the very first perspective identified which are the wind energy stakeholders and the IEA approaches to classify the stakeholders in four main categories. Those were responsible for driving the production of the roadmap process and polices. [Inaudible] responsible for drafting the roadmap. Those were [inaudible] so [inaudible] workshop and this where I inform them that they're not expected to provide inputs and definitely not decision makers in the process. We also identify in the How2Guide for Wind about a dozen of the categories of the stakeholders which are involved in different roles in the development of wind energy technology policies and strategies. I clearly gave a specific role which is taken by each of the stakeholders depends for instance on whether the technology roadmap is driven by policy makers or whether it's driven by industry which is the role of existing market [inaudible] and so there are number of factors which are valuable. Also in the planning and preparation phase, an important aspect is [inaudible] research of wind energy, so there are a number of aspects which need to get drafted at this stage starting with analysis which is the wind energy potential within the designated geographic area and this is [inaudible] based on the resource assessment both of onshore and offshore wind and following with the extent to which the energy system market can manage without [inaudible] would come back at this point and [inaudible] presentation. Another important dimension is the extent to which the supply chain, so the workforce, the wind energy industry market can match level of [inaudible] of policy makers. This is a very important dimension of the preliminary analysis which needs to be undertaken in the [inaudible] phase. The 2 important aspects are the role of wind power in the water energy [inaudible] so looking at how wind power relates to the water energy makes and in fact people are with competing energy technologies not just renewables but also fossil fuels. Phase 2 is about visioning. So one strong statement that we use to repeat [inaudible] each roadmap contains a vision, so a specific pathway for achieving the desired outcome, and in order to define a vision it's very important to identify which are the drivers. Why are drivers important? And [inaudible] first of all because it is important that all stakeholders share a common understanding of why we're pushing a higher share wind in the energy mix, and based on why whether this is because we want to create more jobs, whether we want to [inaudible] be diverse how the energy mix, whether we want to reduce CO_2 emissions, or whether we want to—higher uptake of renewable energy effect competing practice of fossil fuels for instance and [inaudible] side. All this consideration needs to be discussed at this stage and will have an impact on the vision of wind energy. Phase 3 is about drafting the roadmap and see how the guide provides a number of tools of tables which are all support the policy makers in identifying barriers and action option to overcome the barrier [inaudible] identify [inaudible] five different categories of possible barriers. The first one we're at the planning phase developing new power [inaudible] including going off the track which are related to [inaudible] environment analysis [inaudible]. A second dimension is related to development aspect again including social acceptance factors. A third [inaudible] is related to the [inaudible] market and system aspects and finance and economic aspects needs also to be taken into account as they can definitely represent [inaudible] all indeed conversely effect the [inaudible] if the [inaudible] wind energy development, and finally infrastructure aspect and [inaudible] who also emphasize and stress the importance of looking at the world supply chain including the workforce aspect. And finally phase four, this is the final phase in which a roadmap has been developed. It's been discussed [inaudible] stakeholders and how it's implemented. So implementing a roadmap is a process which is undertaken over a period of time and, therefore, clearly one of the main or primary direction is to [inaudible] itself would need to be adjusted in light of experiences which are gained through the implementation whether we need to make changes because you know if things are not on track, and to measure whether we are on track or not, we need a set of indicators what's [inaudible] specific indicators are very important to document the progress and implementation of wind energy development. The How2Guide for Wind Energy identifies 35 such indicators. We definitely do not recommend to use all 35 indicators at the same time but the choice of which ones to use is [inaudible] which is specific and [inaudible] also dependent on the drivers for the adoption of higher shares of wind energy and the energy mix. One important consideration is that for each indicator should also [inaudible] already from the early stage, which are the stakeholders responsible for monitoring progress against this indicator report and [inaudible]. So conclusions as you've seen in the previous presentation wind power can really provide a major contribution toward the [inaudible] supply up to 18 percent by 2050, great savings of CO_2 emissions. For all this to happen we need national and regional roadmaps and we need really countries to identify priorities and pathways which are tailored to these local resources, market and drivers. One of the main messages again in the conclusion, which is just you, know a short slide here but other indications are provided in the publication data. Cost is not [inaudible] and cost effective [inaudible] wind energy. That's why it's the engagement of a very wide range of stakeholders with different roles. And with this, I conclude. Thank you very much for your attention.

Sean Esterly Thank you Simone. And we do have a couple of questions for you that we've received before we move onto the next presentation, and the first question is can you please make an example of some of the barriers related to finance and some approaches suggested by the How2Guide to overcome those barriers?

Simone Landolina Yeah, well thanks for this question. These are explored in the [inaudible] publication. I can make you some examples here. For instance, one of the barriers to wind energy we have [inaudible] is the high upfront cost of wind energy selection which might prevent for the you know deployment of wind energy and a number of options here including starting with removing substances for fossil fuel but also including you know establishing stable government support making [inaudible] you know in support of wind power plant developments and this also takes an additional barrier which is [inaudible] investor uncertainty which is what really effects a number of markets worldwide, so long term stable supporting policies whether they are composed of a range of support [inaudible] which can be used in different markets whether this is [inaudible] or auctioning [inaudible] or tax based incentives, probably a mix of these is the best solution but it's not one size fits all, so the How2Guide provides an overview on a number of these barriers which effects development. A final thing on barriers which I think development of wind power plants as well as a number of options which one to adopt is really [inaudible] region standard specific.

Sean Esterly Thank you Simone. And then a content question on the How2Guide. Does the guide take into account the specific barriers and also the regulatory measures that exist in countries across the world that have different levels of deployment of wind energy?

Simone Landolina Yes and indeed in one single publication we could not address you know all countries across the world but what we have done we have integrated a number of case studies. This case study is referable to you know more advanced countries in terms of deployment of wind energy like you know China and countries which only recently have started developing wind energy technology strategies and lessons learned as I say which are not necessarily not best practices. Also, lessons learned from things which didn't go well or processes which took longer than originally envisioned just like in the South African example in the How2Guide.

Sean Esterly Great. Thanks again Simone. And that's the last question I received at this point. Before we move onto the next presentation, I just want to let the audience know that if you would like to download either the Technology Roadmap for Wind or the How2Guide for Wind, they can be downloaded for free from the IEA website and then we have also linked to them on the Clean Energy Solutions Center website as well. And so now we'll move onto the final presentation for today's webinar and that is from Simon Muller. Simon?

Simon Muller Yes, hello ladies and gentlemen also from my side. In the next 10 minutes or so, I'll be presenting to you some of the results and conclusions of a study that the IEA has recently launched called the Power of

Transformation. I'll try to make this time as worthwhile and interesting as possible as I can for you despite the fact that I can only speak to you from the invisible depth of the internet. So I'll start with a brief project overview of their grid integration of variable renewables project. In fact, this publication we have done in the framework of the third project phase. The first phase started in 2005. Now in this phase, we have a team of about a handful of analysts working from the IEA secretariat complemented by some external consultants and we covered the following aspects. First of all, we did a set of seven case studies which cover a total of 15 countries and in these case studies, we did over 50 in-depth interviews with market operators, system operators, regulators, and policy makers to really understand how are they dealing with grid integration challenges on the ground. In addition, we used 3 different modeling tools to on the one hand asses the technical challenges as you integrate higher shares of wind and solar generation and how that is possible in the different case study regions but also to look into the economics of the different flexibility options that my colleague Cedric has already mentioned in his presentation. Now before I present these results, I want to make the first important point which is grid integration is actually an interaction effect. This means whenever someone tells you well grid integration is actually like this because I observe it in my country, chances are that's not the full story because actually it depends on the way that variable renewables on the one side and the power system, the remaining power system on the other side interact with each other. This interaction is different from system to system and, therefore, the integration challenges as well. At the same time, it's only a limited number of factors on either side that are really relevant and this allows to learn from each other. What you see on the left side here are the factors that count for variable renewables themselves. There are six in total. I can't go into the detail of every single one of them but what I'd like to underline is the stretch in time from years to seconds and in terms of geographic extent, it could be that you have a variable renewable power plant on your roof very close by to the load or far away in a distant offshore wind power plant. In essence, what the challenge of these properties constitutes is the following. They mainly circle around the variability and uncertainty of these generation technologies. On the one hand, the variability and uncertainty sends the residual power system so the flexibility option you see here on the right side on a roller coaster ride. So for example when there is a loss of variable renewable generation, other generators need to be able to back down quickly and come back up in the moment that the variable renewable generation is no longer available. So going along with this roller coaster being able to ramp down output quickly at short notice and to a large extent is a key attribute of flexibility. At the same time, there's a different effect, which is the following. The residual part of the power system become part-time workers. That means they're only needed in some cases when variable renewables are either not available for example flexible generation or when they're very abundant such as certain storage options. So what this system needs is not only assets that can follow this roller coaster but also assets that are cost effective part-time workers, and I'll speak about that a little bit later. When we look at the challenges that this interaction effect actually poses and practice, the interesting observation is that it's not a big deal at low shares depending on the actual system circumstances let's from 5 to 10 percent in annual generation. Now why is that? The principle reason for this is that power systems already deal with vast amounts of variability today coming from the demand side. The picture you see here illustrates this. We have an exceptionally high variability of power demand on this day in Brazil as you see at the difference between the red line with the variability and the blue line representing an average day. Now the reason for this is not a contingency or an exceptional failure or exceptional variability of power generation. No, in fact it is a soccer game. What you see here is the match between the day of the match between Brazil and Chile and the curve closely follows the development of the football game including the half-time break. Now what is important in this picture is if you look at the up ramp at the end of the game, this ramp that has passed in a little bit less than half an hour roughly corresponds to 3 times the installed wind capacity in Brazil today. This clearly illustrates that the variability coming from variable renewables is initially dwarfed by that from the demand side; however, countries did get into trouble at initial low levels of deployment. Now why was that? You need to stick to a set of basic rules in order to avoid problems at low shares. This is to avoid uncontrolled local hot spots of deployment which have formed in a number of countries. It is critical to adapt the way the power system is operated on the day ahead schedule and in particular, it is very important to make effective use of variable renewable generation forecasts, and finally, it is important that standards requests stay to the art technology that can actually help to support the grid when it is needed. Now as we consider going to higher shares of variable generation, it's important to see the problem in the right framework. It is only then you actually see how to reach high shares cost effectively. The classical view these variable renewables themselves at something that is foreign to the overall power system that has to be integrated so then, therefore, causes integration costs. Now I can't go into the details of the problems with this methodology; however, I'd like to stress the following. Power systems are highly complex integrated and interacting machines, so it is very difficult to separate out one individual subpart of this system. What we need is a system that works together in an overall sense that is sufficiently flexible and where generation grid storage and the demand side are harmonized in a comprehensive way. To underline this, we've actually titled this publication The Power of Transformation because we say integration is actually about transformation. Now what does this transformation look like? It has three pillars. Firstly, it's important to realize that variable renewables can contribute to their own system integration if they're asked and allowed to do so. I'll show you one example of this in a minute. Second, it's critical to make better use of what you have already to extract flexibility from existing assets, and third, it's important to make a strategic system wide approach to investing in additional system flexibility. Now this slide shows one example of what we mean by system friendly variable renewable deployment. On the right side, you see a graph with two different types of wind turbines installed at the same site. A conventional turbine will exhibit high peaks or pikes of generation during times of high wind speeds. Now such spikes and the corresponding high variability can be avoided by designing a turbine that has a higher rotor to the same installed generator. While this might increase the levelized cost of electricity for the individual turbine, it might contribute to minimize total system [inaudible]. I'll show you one additional example of the second pillar, which is better operations. As part of the project, we have done a systematic review of the market design of a total of 10 different markets. We have scored them according to a framework that you see in the spider diagram on the right. The example coming from the market in Texas. For the sake of time, I will not go through each of these. The critical point here is the way electricity is traded on markets have to be sufficiently fast to mobilize all available resources to deal with the variability and uncertainty of variable renewable generators. At the same time, the structure of the power grid needs to be represented in market prices and also variable renewable generators themselves have to participate on the market. Now the third pillar consists of the investments in the different flexibility options, flexible generation, interconnection, storage, and demand side response. As I mentioned initially what is needed are assets that are cost effective part-time workers. For a power plant, this means power plants with lower investment costs that are the most cost effective solution running as mid-merit and peaking power plants. If we turn to the demand side, we realize that there already are certain assets that only operate as part-time workers. For example, electric boilers or water heaters are only used or only charged during 4 hours of the day and there is flexibility when they can be charged. In a cost benefits analysis that we've done as parts of this project, we found that precisely this type of demand side integration is actually among those options available with the most favorable cost benefit profile. The perspective of cost effective part-time workers also helps to understand why it is often difficult for electricity storage to reach cost competitiveness. Storage can be quite expensive initially and if it is only used seldomly, it is actually not a cost effective part-time worker. Now this is not to say that storage should be dismissed all together. In fact, at higher utilization rates, pumped hydro storage can be cost effective already today and distributed options might be cost effective also already today where different revenue streams align. There's one final point that I would like to make regarding investments. The first two pillars that I presented to you are applicable across the board in all countries wherever and whenever wind and solar are deployed. The approach to going about additional investments actually depends on the system context. We separate the context into two different types of power systems, stable systems and dynamic power systems. Now in a stable power system, electricity demand is not growing or only growing slowly and as a result, it may be the case that there is little need for investments in the system short term. These systems will tend to be capacity adequate even in the absence of additional wind and solar generation. So the existing—the preexisting system assets can be used to extract flexibility. While this puts countries in a favorable situation and in fact, the pioneers of wind and solar integration are precisely among the stable power systems. It can also put the system as a whole under economic stress. One way of dealing with such stress can be the decommissioning or mothballing of inflexible capacities in order to foster the overall system transformation. The situation is fundamentally different in dynamic power systems where growing power demand or the decommissioning of a large amount of existing capacity call for new investments in the power system. This opens a window of opportunity to implement holistic long-term transformation from the onset; however, precisely here it is critical to take a system perspective and for example, deploy variable renewables together with other flexibility options in a concerted fashion. Now it's precisely in dynamic power systems where we see the highest deployment rates of wind and solar are going forward and these countries which are often emerging economies really should use the opportunity to leapfrog to 21st century flexible power systems. Finally, on the last slide, what does this mean in terms of cost? What we've compared here are results of a test system. It is about the size of Germany but modeled as an island and we've done a first simulation that optimizes the overall system in the absence of any variable renewables. Now in a first case we imagine or pretend that we add 45 percent of variable renewable generation practically overnight. Now this is a rather extreme scenario and what we see is that the overall system cost decreased by 40 percent; however, this neglects a number of important flexibility options that can be deployed in the long-term. This is illustrated in the next picture you see here. The system on the right side is very different from the system that you see on the left side titled Legacy System. A transformed system has a higher share of flexible gas generation and in this case, also 8 percent of the power demand is made flexible by via thermal energy storage, and what you see is that this system only experiences a cost increase of 10 to 15 percent above its system with no variable renewable generation at all. So to sum it up, if you transform the system in a coherent and comprehensive way, the variability penalty is actually not that expensive. Now I could only present a selection of the most relevant results to you today. If you're interested to see more, this publication is for sale at our bookshop and you're most welcome to visit it via IEA website. Thank you very much.

Sean Esterly Thank you Simon for your presentation, and we did receive a few questions from the audience so we'll move onto those and then I'll offer closing remarks by all the panelists before we move onto the brief survey for the attendees. And so Simon, the first question that I received is asking in system-oriented turbines, can they be more effectively deployed if there are more uniformed grid codes on variable energy integration?

Simon Muller Well, that's an interesting question. First of all, of course it's important to have grid codes that are sufficiently demanding so that you have turbines that show performance that is good when you get to high shares. Now this has led some system operators to ask for capabilities which are actually so demanding that one can wonder whether that is the most cost effective solution to get these capabilities. Now I think the approach that is currently taking in Europe to define an overall performance envelope that is agreed upon and where we say okay, this is a minimum set of capabilities that we want across the board. I'm sure that this of course helps to streamline these capabilities into the industry as a whole and, therefore, drive down costs as a whole. I hope that this answers the question. Or maybe one additional remark. This is work that we'll be looking into in the future. The question is how do you design renewable support policies in a way that actually incentivizes the system friendly deployment. Now turbines with higher rotor surfaces installed capacity have already been deployed simply because they sometimes help to minimize generation costs where wind resources are not that favorable, but for example by exposing wind generators to a certain amount of market prices can also help to incentivize to actually get generation at the moment in time when it is most valuable and not when the wind is blowing the strongest.

Sean Esterly Great. Thank you Simon. And the next question that I received for you asks, in your cost benefit analysis, do you know if the cost of wind curtailment were considered?

Simon Muller Yes, so in fact wind does not enjoy priority dispatch in the modeling results that I've shown to you, and in a flexible system—in the transformed system we see curtailment at about 2 to 3 percent of the overall wind generation, and I would say that these amounts of curtailments are actually a quite healthy sign of a successful tradeoff between the desire to get the most low carbon energy from a wind turbine as possible but also to save some of the investment cost that you might need for infrastructure. So just an example, to evacuate the last kilowatt-hour from a distant wind park might actually not make sense because it could be that this wind park is only at full capacity during a few hours of the year, so it's just not worthwhile to build a transmission line up to that full capacity.

Sean Esterly Great. Thank you again, Simon. And the next question is what do you do with the need to backup intermittent wind turbines?

Simon Muller Well, this is a quite broad topic. I think the first observation is it's not so much that we need to backup variable renewable generation. What a power system needs is resources that are adequate to reliably meet load during all credible operating conditions and that can come from a various number or services. So for example, if I can actually have a responsive demand side that to a certain extent follows the variability patterns of wind and solar it's much easier to integrate them. Now it is true that even when you interconnect wind and solar on large geographic scales you will have sometimes where you can a persistent shortage of both wind and solar generation and you need to find alternative options to deal with that. Now there are some options that are in a particularly favorable place to do that. For example, [inaudible] hydro—many [inaudible] hydro power plants can only reach let's say utilization factors or capacity factors in the order of 50 percent because of water availability. It can often be a very cost effective option to then fill these gaps where wind and solar generation is not available. Maybe one additional remark on the question of you know how much capacity do you need per installed megawatts of wind and solar power. Now firstly, in a stable power system, you have enough capacity anyway so you can go ahead and install wind and PV generation and you won't run into any adequate [inaudible] because the preexisting capacity will be sufficient and in fact wind and solar generation do have a capacity credit of their own. This capacity credit, however, does become smaller at higher penetration rates, but just one calculation example, if you want to have a contribution from a PV power plant that is the same as from a base load power plant and a load factor of let's say about 10 percent or 15 percent, 1 megawatt of PV generation even if its capacity credit were zero which is a very extreme assumption would only need about 0.1 megawatts of [inaudible] capacity to actually balance the contribution in terms of energy and capacity. I know this is a somewhat complicated subject. There's a box in the publication that explains this much better than I was able to do so in this short time.

Sean Esterly Great. Thank you, Simon. I think that was good for a very broad question, and this talks a little bit on—the next question follows up a little bit on some of the points you were just making. So do you believe that further breakthrough on energy storage at the utility scale will help further development of wind and avoid the investment in transmission, and maybe to get into more detail on that question, are there any specific breakthroughs in energy storage that you can point to?

Simon Muller Well, first of all, if we speak about centralized large-scale energy storage, I think if you only consider that you still need a grid to connect that large-scale storage to other consumers on the system. Definitely if we had cost very inexpensive energy storage tomorrow, that would change the integration question quite a bit. Even more so, if we had very cost effective electricity storage in a distributed way. At the same time, we already do have cost effective energy storage in the form of thermal energy storage, and in fact, our modeling showed that demand side response enabled by thermal energy storage is one of the most cost effective solutions we have today. Now looking further into the future, it's extremely hard to anticipate the possible technological revolutions that might come. I mean this is just extremely challenging. Cost reductions of battery technologies in past years have been impressive and I'm very curious to see how they will develop further, and also I think it's important to know that the up scaling of energy or electricity storage we've seen in the past in the form of tontiter storage complements the deployment of nuclear energy and some of the storage technologies that we have today were actually not available at that point yet, and I think they might be particularly interesting options. So for example, [inaudible] flow batteries to name just one.

Sean Esterly Great. Thanks again, Simon. And one more question that I have regarding your presentation is it's been noted that the country that—often times the country that has the highest share of wind power also has a lot of CO2 emissions, so in Germany coal use is growing along with wind power and so are CO2 emissions. How do you explain this trend?

Simon Muller I'll be very happy to answer that question, but before I do so, I'd like to give the floor to my colleague, Cedric Philibert, to just make some additional remarks on the storage question.

Cedric Philibert Yeah, thank you. I wanted to say a little more about [inaudible]. It's a common mistake to believe that all options have been tapped already because that's what most people believe about hydropower by and large although even for hydropower it's only true in mature economies. It's true in the U.S. or in Europe, but it's not true in the [inaudible] world and the emerging economies. When it comes to pumped hydro, it's even less true because pumped hydro for mitigating viability of wind and solar requires hours of storage while hydropower is way too accumulate [inaudible] weeks and months of rain into behind dams. When you do a pumped hydro station, what you do is to start from an existing dam and you add a little additional dam on top of the [inaudible] surrounding them and in fact the options for doing so are very many. A recent report by the joint research center of the [inaudible] commission has suggested that in Europe we could multiply by 10 the amount of storage in gigawatt hour terms in Europe with a simplest design and of course the electrical capacity could even be multiplied by a higher number because when we have a reservoir then we can just decide to have a [inaudible] depending on what we want to do and if we want to just to shoulder the extra system for a few peak hours, we can go for higher capacities [inaudible]. What's missing for now is nothing from a technological standpoint. What's missing is the business model for this deployment to accelerate because it's taking place in Switzerland. It's taking place in Portugal. It's taking place in Spain. It's taking place in Morocco and other places, but for deployment of pumped hydro storage to accelerate what's needed is a better business model where flexibility would be rewarded and you know the first effect of deployment of renewables is to reduce the gap between peak hour prices and base load prices of it. In the future of course is the price gap will get bigger and then this will recreate a business model for storage. If we don't see a lot of storage deployment taking place, it's just because we don't need it for now.

Simon Muller So I'll pick up the question on variable renewables and coal generation. Now of course one prominent example here is Germany where despite a quite dynamic growth in wind and solar generation, the power sector CO2 emissions have actually gone up. Now the question is why has that happened, and the reason for this is two-fold. Firstly, with the halting of 7 plus 1 nuclear reactors in March of 2011 or in spring of 2011, Germany has lost a large amount of low carbon generation which was replace by the available capacity that could run with cheap fuel which in this case has been fossil generation, so this is the primary reason for driving up CO2 emissions. Now secondly on the short term, wind and solar will displace at least in countries where power plant dispatches is based on marginal costs, wind and solar generation of the short term will displace generation with the highest fuel cost. Now this in Europe at current gas and coal prices is gas generation and, therefore, a lot of the displacement effect that is taking place in Europe is actually displacing gas. Now why is this gas displacement happening? Firstly, the CO2 prices that we see in Europe are quite low and lower than a number of stakeholders including the IEA believe than they should be to provide a firm signal to decarbonize the system. Secondly, gas prices in Europe have increased significantly over the past years. Thirdly, with quite high coal prices in 2008 and 2011, there's been a lot of investments in coal infrastructure, which is now leading to very low international prices on global markets. So in summary, this leads to the CO2 effects that we see in some systems; however, there's also a competitive message embedded in this. If you look at the daily operations of the German power system and partially of the Danish power system, you can see that coal units are actually kicking up the bulk of the ramping burden to exactly go on this roller coaster ride that they need to do in order to follow the combined variability and uncertainty of load and variable renewable generation, and actually they can do that quite well. The national renewable energy lab of the U.S. has recently also released a study that investigated a case study in North America where coal power plants were converted from base load units to peaking plants that actually went into double shift operation, so this illustrates that whenever you ask for flexibility you will tend to get it even from those technologies where normally you wouldn't expect it.

Sean Esterly Great. Thank you everyone and that is the last question that I've received from the audience, so at this point, I'd just like to give everyone a chance to make some brief closing remarks and we can go ahead in the order of the presentations if you'd like starting with Cedric.

Cedric Philibert Thank you, Sean, and I won't be long. Wind is going ahead and I think it's reputably smooth story so far. We are turning our attention to other technologies in the coming months with the IEA has just published the Energy Technology Perspective 2014 publication with a number of interesting chapters. One is related to solar, both solar [inaudible] and solar thermal electricity. By the end of August, the IEA will publish a new edition of the Medium Term Renewable Energy Market Report which will illustrate the recent development and short term forecasts for renewable energy deployments [inaudible] 2019 or maybe 2020, and by mid-

September we are going to publish 2 roadmaps which are to update of existing roadmaps on solar PV and solar thermal electricity also known as [inaudible] power, and I think your audience might be interested to know this and possibly we'll have the opportunity to discuss the results of these exercises with you in the future. Simone?

Simone Landolina Thanks Cedric. Well, I will just build on what you say [inaudible] how wind has really developed into a mainstream competitive technology but there are still a number of barriers which could delay progress [inaudible] which was [inaudible] written by Michael Leeks and this includes financing aspects [inaudible] issues indeed, social acceptance and [inaudible] plan in process as well. In the end, what we see is that increasing the cost effective transaction of wind energy requires a number of actions to be taken and regardless of the mix in the energy supply, efficient and competitive markets are our key to reducing the cost of [inaudible] and the cost of energy departments [inaudible]. And from this point of view, we can provide proper guidance to roadmaps that if national and regional policy makers that have a key role to play here in designing strategies and implementing actions which would enable a higher share of wind energy at the peak [inaudible]. This is the [inaudible] also [inaudible] we are working now after publishing the How2Guide for Wind, we are working on other 2 technologies, one being small grids and the other one being bioenergy and we have a workshop coming up in just a couple of weeks in [inaudible] bioenergy and if anyone is interested in this technology, we'll be happy to extend the invitation to the workshop [inaudible].

Simon Muller Yeah hello, this is Simon Muller again. I would say a couple observations from the work that I just presented. I think when governments go about designing let's say a governance framework for the energy sector, it's very important to have let's say a sober look at the cost and benefits that variable renewables actually bring to the system. You could also say what really the value of these resources is on a power system, and what we see is that even in context where there is no price for some of the important [inaudible] such as environmental, pollution or CO2 emissions, variable renewables are now an attractive option to just meet power demands at least cost and also diversify the mix and make it more resilient and less dependent on fossil fuel imports. Now I think in the long term it's clear that to maintain progress, a strong price for carbon is necessary although not sufficient so we will need a continued conducive framework as to deploy these technologies in particular around finding [inaudible] financing solutions because they're capital intensive technologies, and adding to the question of what value these resources bring, I think it's also important to see the contribution that variable renewables make in terms of diversifying the energy mix and thereby increasing the security of supply. When it comes to the variability issue that wind and solar do bring, it's important to realize that it can be somewhat of a challenge but that's on an operational scale we know today how to deal with it. In countries that are just starting deployments, it's very clear variability is a nonissue as long as you stick to a number of rules, and as we go to higher shares, we're also getting growing experience here. I think it's very important to then look at the energy sector in a more comprehensive way to link to the heat and transport sector and really going and pushing—let's say pushing this integration frontier further will be an area where not only emerging economies can learn from the former or the historically pioneered the variable renewable deployment but also vice versa where industrialized countries can learn from emerging economies.

Sean Esterly

Great. Thank you everyone and now I'd like to quickly move onto the audience survey, so heather if you could display that first question for the audience, and attendees you can respond to this survey which will help us improve future webinars directly in the GoToWebinar window. Great. Thank you and the next question. The webinar's presenters were effective? Great and the final question is overall the webinar met my expectations. Great. Thank you everyone for answering our survey and on behalf of the Clean Energy Solutions Center, I'd like to thank our expert panelists and our attendees for participating in today's webinar. I very much appreciate your time and I do invite you to check the Solutions Center website over or about the next week, if you'd like to view the slides and listen to a recording of today's presentation as well as any previously held webinars. Additionally, you'll find information on upcoming webinars and other training events, and we also invite you to inform your colleagues and those in your networks and organizations about the Solutions Center resources and services including the no-cost Ask An Expert policy support. Hope everyone has a great rest of your day and we hope to see you again at future Clean Energy Solutions Center events, and this concludes our webinar.