CLEAN ENERGY SOLUTIONS CENTER

Measuring the "Smartness" of the Electricity Grid

—Transcript of a webinar offered by the Clean Energy Solutions Center in conjunction with the International Smart Grid Acton Network on 26 June 2012—

For more information, see the clean energy policy trainings offered by the Solutions Center.

Mackay Miller: Hello and welcome to a smart grid webinar presented by the International Smart Grid Action Network in conjunction with the Clean Energy Solutions Center. This morning we will share a webinar from Leen Vandezande: on Measuring the "Smartness" of the Electricity Grid. My name is Mackay Miller from the National Renewable Energy Laboratory. I will first hand it over to our webinar staff to talk about some basic housekeeping items and to talk about the Clean Energy Solution Center. Then we will move through the description of the agenda for today's webinar. And then we will hear from our presenter. So Vickie?

Vickie Healey: Yes, thank you Mackay. Good morning everyone. Again, my name is Vickie Healey and I'm with the National Renewable Energy Laboratory. Before we begin today's webinar I just want to go over a few of the housekeeping items regarding audio and such. So I'll quickly go over some of the webinar features for you. For audio, you have two options for listening. First, you may listen through your computer. And secondly, you could take the option to listen over your telephone. If you choose to listen through your computer, please select the Mic and Speakers option in the Audio Pane and this will avoid the feedback and echo we sometimes get on webinars.

This will eliminate that, if you make that selection. If you choose to listen by telephone, select the Telephone Option and a box on the right-hand side will display the telephone number and audio pin you should use when you dial in. We also ask that you please mute your telephone or your computer before the presentation begins. So today, we have a great presentation prepared for you today. It is focused on smart grids and defining what makes an electricity grid smart and proposing a methodology to measure grid smartness. We are fortunate to have Leen Vandezande:, a post-doctoral researcher in the Electric Energy Research Group ELECTA at the K. U. Leuven presenting today. Before Leen begins her presentation, I'm going to provide a short informative overview of the Clean Energy Solution Center, and following that I will turn the mic back over to Mackay to discuss a little bit about the International Smart Grid Action Network.

[Next Slide]

Just to give you an overview of the Clean Energy Solution Center. This slide provides a bit of background in terms of how the Solution Center came to be. The Solution 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 include support of developing countries through enhancement of resources on policies relating to energy access. We also have a feature or service that we provide. Its no-cost expert policy assistance provided to countries, government agencies, and institutions supporting government agencies developing Clean Energy policies. We also offer peer-to-peer learning and training tools including such things as the webinar you are attending today.

[Next Slide]

This is just a little slide about how you can become involved with the Clean Energy Solution Center. We want to encourage you to explore and take advantage of the Solution Center resources and the services that we provide including the no-cost expert assistance that I just described. You could also subscribe to our newsletter for upcoming information and highlights of what the Solution Center has been doing. And you can also participate in the webinars as well as blogs that we have on our policies forum page. And so that is pretty much just a quick overview of the Clean Energy Solution Center. Mackay I'll turn it back over to you to discuss the International Smart Grid Action Network.

Mackay Miller: Thank you Vickie.

Vickie Healey: You're welcome.

Mackay Miller: The International Smart Grid Action Network is an international collaboration that serves as a mechanism for cultivating high-level government attention and action to accelerate the development and deployment of smarter electricity grids around the world. There are a number of activity areas of the International Smart Grid Action Network which I will also refer to as ISGAN on the call today. Primarily we sponsor activities that increase the global understanding of smart grids, address gaps in knowledge and tools, and accelerate deployment.

Broadly speaking we build on the momentum of the knowledge created by the substantial global investments that have been taking place in smart grids over the past decade and attempt to leverage those learnings to again accelerate smart grid deployment. ISGAN

is organized as a task shared International Energy Agency Implementing Agreement. That was established in April 2011. Before that, it was launched as an initiative of the Clean Energy Ministerial in 2010, fulfilling a key recommendation in the Smart Grid's Technology Action Plan released by the Major Economy Forum Global Partnership in 2009.

[Next Slide]

The membership of ISGAN is quite diverse. We are also happy to welcome some new members, specifically China which very recently officially joined ISGAN. There are a number of additional countries who have been invited to join and are working through the process, including Brazil, Denmark, South Africa, and Turkey. But as you can see, the membership of ISGAN spans both hemispheres and countries with various levels of grid modernization.

[Next Slide]

On the other steps, the primary areas of work of ISGAN, there are six annexes of ISGAN. These are the focus areas for work under ISGAN. Annexes one through four have been part of ISGAN since it's initiation in 2011. These are Global Smart Grid Inventory, a focus on Smart Grid Case Studies, Benefit Cost Analyses and Toolkits, and finally, Synthesis of Insights for Decision Makers. There are two new annexes under ISGAN. The first is the Smart Grid International Research Facility Network, which aims to link and coordinate research facilities around the world, and finally an annex focusing on Power Transmission and Distribution Systems, which we began on specifically the challenges and opportunities of modernizing transmission and distribution systems around the world.

Finally, before I hand the presenter's microphone to Leen, I will encourage our audience to ask questions. You should see a Questions Panel in your webinar set up. Please type your questions there at any time during the presentation. We will take questions and answers for as long as we can after the presentation. We should have at least 15 to 20 minutes. I see now a question that I should raise my voice. Perfect, thank you. I will try to keep my volume high enough. At the conclusion of Leen's presentation, I will begin to moderate Q and A. If you have any technical issues that you would like to ask the staff about you can open the Chat window. There is a chat pane, and you can direct questions directly to the staff and we can help resolve any technical issues, if there are any, through that pathway.

Well we are very excited to have Leen Vandezande: presenting this morning. The presentation covers methodologies for measuring the "smartness" of the electricity grid. I'm very pleased to introduce Ms. Leen Vandezande:.

Leen Vandezande: Okay, thank you. Hello everybody. In this presentation, I want to introduce you into a methodology developed at the Catholic University of Louvre, which aids our policy makers in measuring the "smartness" of their electricity grid. So today, everybody is talking about smart grids and there exists several definitions. But most of them are often vague. So if policy makers really want to give right incentives towards smart grid development they need to have a clear idea of what smart grids really are and how they can measure how smart their electricity grid is. So the methodology I will propose here aims to contribute to this. The methodology has been developed by the people mentioned on the slides.

[Next Slide]

I will give a short overview of this presentation to start with. I will start with a short introduction with some background on European Energy Policy because the methodology we developed is focusing on European Energy Policy, which can most likely be largely applied to other continents as well. So the methodology is based on key performance indicators. After the introduction, I will very shortly explain what KPIs are and why we are using them. And then we will dive into the methodology itself and finally some conclusions. So first the introduction.

[Next Slide]

The European Commission is setting ambitious targets with respect to a Climate Policy, etc. They want to move toward the low carbon economy. And this respect they put three ambitious targets that have to be met by 2020, which are these targets. First, they want to cut the greenhouse gas emissions by 20 percent compared to 1990 levels, by 2020. Secondly, they want to reduce the energy consumption also by 20 percent. And finally, they want to reach a 20 percent share of energy in their generation mix that has to come from renewable energy resources. This is what they want to achieve by 2020. They also set a target (but this one is not yet binding) to achieve a minimally 80 percent reduction of greenhouse gas emissions by 2050. All the European organizations indicating this respect that a smart electricity grid will be one of the key aspects to reach these climate goals.

[Next Slide]

And in the respect of smart grids, one of the most important policy instruments that was launched so far by the European commission was the Strategic Energy Technology Plan, or what we call the SET Plan. The SET Plan in effect has the objective to accelerate the development of several low carbon technologies and also wants to stimulate these technologies and lead them to market take up. The Technology Plan focuses on six initiatives and they are listed there. One is focusing on wind energy; one on solar, one is focusing on the electricity grid; one on bio energy; one on carbon capture and storage; and a final one on nuclear energy.

The most important for smart grids is, of course, the one concerning electricity grid. This has been sort of developed in cooperation with all the network operators in Europe and resulted in what we call the European Electricity Grid Initiative, the EEGI. The EEGI is in effect a nine year Research, Development and Demonstration Programme with an estimated cost of €2 Billion Euro. So within this program, several demonstration projects will be launched and these projects are organized in ten clusters. Some of them are more focusing on transmission aspects. Some of them are more focusing on the reduction aspects, etc., and are organized according to several functional projects, each focusing on a specific aspect of the smart grid.

Besides this, also the regulators in Europe are looking a little bit at smart grids. And in this respect, they want to formulate an adequate regulatory framework to stimulate the deployment of smart grids and also to ensure that the benefits of the smart grids will be efficiently reaped also by the final end consumers. So in 2010 one of the European regulating bodies issued a position paper on smart grids. And last year another body issued the status review of the regulatory approaches to smart grids. This is a little bit to set the European scene with respect to the energy policy with respect to climate goals and smart grids.

[Next Slide]

Now a short introduction to Key Performance Indicators because the methodology I want to propose today is based on KPIs.

[Next Slide]

What are KPIs? Well I think most of you know them already. They are in general used for performance measurement. So they are typically used to measure how successful a certain business activity is. You can find several applications in the construction industry, health industry. There are also, for instance, useful

quality regulation in electricity distribution systems, etc. Now in the smart grid context we see up to now that there is not yet a clear framework to evaluate what is going on. When we look at the European Energy Policy, we see in fact that there are several things that we have to evaluate. So certain measurements would be interesting.

If you look at the SET Plan it would be interesting to evaluate how much progress we are making with the SET Plan towards the 20 2020 targets. If you look at the European Electricity Grid Initiative, it would be interesting to evaluate how each of the demo projects SET is launched within the EGI is performing. And finally, for the regulators it would be very interesting to evaluate how right the regulatory incentives are and how effective they are.

[Next Slide]

Why will we use KPIs in this methodology for measuring the "smartness" of the grid? Well in fact, we would like to try to answer two questions, first what makes an electricity system smart, and secondly how can this smartness be measured?

[Next Slide]

Let's now dive into the methodology itself. On the next slide, you can see how the methodology has been built up. We started from six characteristics. So six characteristics of what a real smart grid typically looks like. These characteristics were formulated by the Department of Energy in the United States in their Smart Grid System Report. And these characteristics have from years ago already been adopted by the European Technology Platform on smart grids as well. We use the characteristics. There are some overlaps between these characteristics but we thing together that they describe very well all the aspects important in a smart grid.

For each of these characteristics we defined several categories. Within these categories, we derived then KPIs. In deriving KPIs, it was very important that they were bound to the smart criteria. What are the smart criteria? It means that the KPIs have to be specific, measurable, attainable, relevant, and time bound. The six characteristics—you can see them on the next slide.

[Next Slide]

They are simply taken from the United State Department of Energy. The six characteristics are first, enable the informed participation by customers; second, accommodate all generation and storage options; then more than kilowatt-hours alone; then

provide power quality for the 21st Century and optimize assets and operate efficiently; and finally operate also resiliently to disturbances, attacks, and natural disasters. But we will now look into more detail into each of these six characteristics.

[Next Slide]

The first characteristic: consistent enable informed participation of customers. As you all know, in a passive grid the customer is not actively participating. But in an active grid, the customer will get technology in house which will enable him to actively contribute to the grid. So we defined five degrees of importance with respect to this. The first one is advanced meters. Smart meters are a key technology to enable the participation of customers. Then a second one is focusing on dynamic pricing signals. Dynamic pricing signals will be sent to customers and customers will be enabled to react on these prices. Then a third one is smart appliances.

So in a smart grid people will get in their house smart appliances, like for instance a smart heat pump or a smart dishwasher. And these machines will be remotely controlled and can, for instance, also react on dynamic price signals. Then there is demand side management. Demand side management is a good tool to get an idea of the level of informed participation of the customers as it influences the final consumption of the consumer. Several demand side management programs exist. And finally, there are the producers. In a smart grid, we see that more and more consumers are also producing. They have they own distributive generation at house level.

Because of this, they are not only taking electricity from the grid but they are also injecting and this will pose some new challenges. These are the five important categories in this characteristic, with respect to this characteristic.

[Next Slide]

On the next slide, you can see the KPIs that we derived for each of these categories. With respect to the advanced meters, we identified two KPIs which threat the current implementation and evolution of the meters. So simply the number of the meters, but also the percentage of the total demand that is served by the meters, because you can see in some countries that focus in the roll out on specific customers, for instance industrial customers that are consuming much more than the residential customer. They will, for instance, have a small score on the first KPI but a larger score on the second KPI.

Then with respect to the category of the dynamic pricing signals, we also identified two KPIs and they give an idea of the fraction of customers served by the tariffs but also the fraction of load. Then with respect to smart appliances, we also identified two KPIs. One is focusing on the sales volume of the smart appliances, expressed in Euros. The other one is focusing on the load capacity that is actually or can potentially be modified because of this smart infrastructure in the appliances. Then with respect to demand side management, we identified three KPIs.

The first one is a fraction of consumer's contributing in the onsite management programs. The second one is the percentage of consumer load capacity participating in the programs. The last one is the potential for time shift. So if you are contributing to demand side management you will be able to shift your load for only typically, for instance, a few hours. And this last KPI will focus on this time range. Then finally the category of the prosumer we identified three KPIs in this category as well.

The first one is looking at the total electrical energy locally produced versus the total electric energy consumed. The second one is looking more at capacity. It's comparing the minimal demands from the grid. So when you have maximal own production versus the maximal demand, so when you are not producing. And then there is the last KPI which is the fraction of time prosumers are net producers and are net consumers.

[Next Slide]

The next slide is focusing on the second characteristic which consists in accommodating all generation and storage options. In the smart grid, we will typically see more and more renewables going in more and more distributive generation facilities. But we also see is more and more storage facilities which offer flexibility and which can, for instance, be used to balance these reliable, renewable energy resources. So we identify three categories with respect to this characteristic. The first one is distributive generation and storage. It's focusing on how the grid can host both this reductive generation and storage facilities and how the grid operator was able to balance reliable renewable energy resources.

Then a second one is focusing on plug in hybrid electric vehicles. Plug in hybrid electric vehicles have a battery, a battery that can be recharged, for instance, at moments that the electricity prices are rather low and which can offer flexibility to, for instance, a transmission operator at times the electricity price is high or at times that the transmission system operator really needs them.

Then there is a final category focusing on data interconnection. So with data or distributed energy resources we refer to all kinds of components that can be connected at the distribution level, distributive generation active loads, and storage facilities. Because more and more of these kinds of data do have to be connected to the distribution grid, it is important that there is a kind of standard distributed research interconnection policy. The last category focuses on that one.

[Next Slide]

In the next slide you can see that the KPIs that we derived for each of these categories. With respect to distributed generation and storage, you can see a first KPI focusing on the generation, the amount of generation. The second and the third one are more focusing on storage facilities. The first one is focusing on direct electrical energy storage. The second one is focusing on indirect electrical energy storage by using heat pumps because heat pumps allow for shifting the electricity consumption because the flexibility in one head pump will work so the house will be warmed up.

With respect to the electric vehicles, we identified four KPIs. The first one is simply focusing on the number of electric vehicles. The second and the third one are more focusing on whether these electric vehicles can be controlled or not, so whether their charging capacity can be controlled and whether their storage facility, whether the battery can be controlled. And then the last KPI is focusing on the number of charging points that are provided to charge the vehicles. Then finally with respect to the data interconnection, only one simple KPI, it is the percentage of grid operators which this standard distributed resource interconnection policies.

[Next Slide]

Let's go to the third characteristics which consist in selling more than kilowatt-hours. In a smart grid, we will typically see that new services will arise. New market parties will arise, etc. This characteristic is focusing on these aspects. We identified five categories as relevant. The first one is new energy services. In a smart grid we see typically arise what they call ESCOs or Energy Service Companies are, for instance, offering on the house level energy efficiency assessments. They offer an optimization of your energy bill, etc.

That's where the new energy services category is focusing on, and flexibility. In an intelligent grid we see also typically markets arise on which flexibility is traded and also new market parties arise, often called aggregators that act as a kind of intermediate party that collect the flexibility in several components, like in a storage facility, like in active demand, so like in households with a smart meter. They collect this flexibility and they offer this flexibility into the flexibility market and try to make money out of it. Then a third category is customer choice. In a smart grid, we want to offer customers a large choice in the supply they want so they can, for instance, choose for a total green supply. They want a supply at lowest cost, they want a really reliable supply, or they don't care that they are often interrupted, etc.

There will be a lot of different tariff schemes—then the fourth one, support mechanisms: a lot of services, market players, markets, etc. will arise but with the launch of these new services, etc. there are some risks because several investments have to be made. So if we want these services to be launched we will need to get some public support for them. We need some public funding or some private funding, etc. Support mechanisms are focusing on that aspect. Then the final category is interoperability maturity level. Open architectures and standards will be needed if you want a successful creation of new markets because we need the recent kind of interoperability between all the stakeholders in this market instance: new products and services, new technologies, etc. They will have to be aligned in one or another way.

[Next Slide]

On this slide, you can see the KPIs that we derived for this third characteristic. With respect to the new energy services, we derived three KPIs, one focusing on the number of customers served by these Energy Service Companies, one focusing on simply counting the additional energy services that are offered to the consumers, and then the last one is looking at the effectiveness of the services offered. So how many kilowatt-hours the consumers saved. Then with respect to the category of flexibility, we identified five KPIs. The first one is simply counting the number of customers that are offering flexibility. Then there is a KPI that is counting the makeup of power. So looking at the flexibility that the aggregators can offer to other market players, and also the time range in which they can offer the flexibility. Then the last ones are more focusing on storage and distributive generation, whether they are able to provide ancillary services to the system operator and how much capacity they can offer in this respect.

Then with respect to customer choice, we only identified one KPI, simply the number of tariff plans that are available to the end consumers. With respect to support mechanisms, we identified two KPIs. The first, the average percentage of investments that can be recovered through rates or subsidies, and secondly the percentage of the smart grid investments that are covered by external financing. Now with respect to the last category, the interoperability maturity level, we formulated one KPI, more specifically the weighted average maturity level of interoperability realized among the system stakeholders.

This KPI will have to be identified using a certain kind of interoperability. This has not yet been developed but if you look for instance at software aspects, we see on the picture that you have, for instance, software capability maturity models and we could derive a model similar to that. That is the third characteristic.

[Next Slide]

On the next slide, you can see the fourth characteristic: providing power quality for the 21st Century. So in the smart grid, we see a lot of distributive renewable energy resources and they will have a certain impact on the voltage and frequency level in the grid, and also on the power quality. It is important that we keep this power quality at a good level. In this respect, we identified three categories. The first one, simply power quality: also in a smart grid it is important that we will keep the power quality just like today at an acceptable good level.

A second one is required power quality. What will be new in the smart grid is that people will be able to choose which kind of how much power quality they want because an industrial company, for instance, might be interested to get another level of power quality than a simple household. In this respect, you will get different tariff plans and associated with this you will get a different level of power quality. The last one is the category of microgrids. A microgrid is a grid that is in a normal status connected to the distribution grid. And on this grid, you have several components like distributive generation like a storage facility or like some active demand household.

But the microgrid has the ability to be islanded from the grid and it can operate reliably in an islanded mode. So in case the network operator is facing problems he can disconnect this microgrid from its distribution grid. These are the categories.

[Next Slide]

On the next slide, you can see the KPIs that we derived for each of these categories. With respect to power quality we identified three KPIs, the first one focusing on voltage variations, the next one as well, but more focusing on the timing of the variations. The last one is simply the percentage of customer complaints related to power quality problems. With respect to required power quality we identified one KPI, more specifically the range of frequencies that customers can contract and also the range of the voltages they can contract. With respect to microgrids, we identified three KPIs, so simply the number of microgrids, the capacity of these microgrids, and their capacity relative to the capacity of the entire grid.

[Next Slide]

On the next slide, you can see the fifth characteristic which focuses on optimizing assets and operating them efficiently. If we look at the European grid, we see that most investments in the grid were made in the previous century, in the 60's and the 70's so the equipment is now about 40 years old. Huge investments and reinforcements will have to be made soon. This is an opportunity to do this in a smart way, using smart technologies. With respect to this characteristic, we identified four categories. The first one is transmission and distribution automation. Automation will occur in the smart grid in all aspects of the transmission and distribution grid.

You will get more monitoring. You will get more controlling. You will get more automation, so a remote control of several parts of the electricity grid. So for instance, data systems will use remote sensors, smart switches, digital relays, etc. The second category is focusing on dynamic line ratings. Dynamic line ratings are a tool for enhancing the capacity of the electrical grid. They are based on specific real time measurements of, for instance, the weather conditions of the surface temperature, of the tension in the line, of the loading conditions, etc.

And based on this it will be possible to get a kind of optimal utilization of the line at every moment. So the capacity will be used closer to its limit. Then the third category is capacity factors. Capacity factors are also a means to measure how smart the grid is, how smart the electrical infrastructure is, and how optimally it's used. Capacity factors are a kind of ratio that compare the amount of energy that was generated and actually delivered to the final consumer, compared to the total energy that could have been produced or could have been delivered. In a good grid, all the energy can be delivered to the final consumer.

Then there is the last category: efficiencies. This category is focusing on an efficient operation of the grid and an efficient utilization of the assets. So for instance, it is looking at how large the energy losses still are in the transmission and distribution infrastructure.

[Next Slide]

On the next slide, you can see the KPIs we derived for this fifth characteristic. With respect to transmission and distribution automation only one KPI was defined, which is the percentage of substations that are applying certain automation technologies, acting as what we call an active substation. With respect to dynamic line rating, we derive the three KPIs. The first one is simply the number of lines that are operated under these dynamic line ratings. The second one is the percentage of kilometers that are operating under these dynamic line ratings. And the last one is the yearly average transfer capacity expansion that you gain due to using these ratings. The last one is more focusing on the effectiveness of the ratings.

Then concerning capacity factors, we identified three KPIs. The first one is the yearly average and peak generation capacity factor. The second one is looking at the transmission lines. And the third one is looking at a capacity factor for the distribution lines for the distribution width. Then with respect to the category of efficiencies we identified two KPIs, the first one focusing on the efficiency of generation facilities, the second one focusing on energy loses in both the transmission and distribution grid.

[Next Slide]

On the next slide we get the last characteristic that was identified, which focuses on operating resiliently to disturbances, attacks, and natural disasters. So the smart grid should be able to react automatically and correctly to certain disturbances that go on, certain frequency or voltage dips for instance, and should also be able to react immediately to affect natural disasters. In this aspect, we identified four categories. The first one is advanced sensors. So if you want to react optimally to disturbances, etc. the first thing you have to do is do some good measurements. And for this you have to put a lot of advanced sensors into your electricity grid, like for instance, Wide Area Measurement Systems or what is called WAMS.

Then secondly, information exchange—if you are measuring things you also want to collect the data and bring the data to the

stakeholders that need these data for managing the grid. You need an efficient information exchange of the data to the transmission system operator, to the distribution system operator, between both, and also the distribution of some data to the final consumer. The third category is transmission and distribution reliability. So this is also important in the grid as we know it today. We want good reliability. This is something we can measure with initiatives that exist already today.

And then finally standards in telecommunications infrastructure: telecommunication infrastructure communication is very important in smart grid. But in this respect, it is very important that there are standards for this communication infrastructure. This is something that has to be defined on the European basis and then has to be applied by the telecom operators.

[Next Slide]

If you go to the next slide, you can see the according KPIs. With respect to the first category, the advanced sensors, we identified three KPIs. The first one is simply counting the grid elements that can be remotely monitored and controlled, so where advanced sensors are installed. The second one is looking at substations that also have this advanced measurement technology. And the last one is simply looking at all kinds of applications that are supported by these measurement technologies. Then the second category of information exchange we identified also three KPIs. The first one focuses on the total scatter points shared per substation. The second one, the fraction of measurements points shared multi-laterally, and there is the last one that is again more focusing on the effectiveness, so the performance of the communication channels.

Then there is the category of transmission and distribution reliability. So the initiatives that you see there are initiatives that are also used already today. You have SAIFI which focuses on the average number of minutes that customers are interrupted on a yearly basis. SAIFI is focusing on the total number of customer interruptions. Then there is CAIDI representing the average outage duration that a customer experiences, and finally MAIFI, which is the total number of customer interruptions per customer that is lasting less than five minutes. Then finally, with respect to the last category, standard in telecommunication infrastructure we identified one KPI. That is the extent to which electric power industries are compliant with European and international telecommunication standards and protocols.

[Next Slide]

These were the six characteristics, and for each characteristic some categories and some KPIs which should enable you to measure the "smartness" of the electricity grid. If you have the results of such an analysis, how can we use these results for policymaking? First, they can be used to assess the progress towards the smart grid on the national or on the European level for instance and you could benchmark between several countries or you could compare the situation on a European level with some other continents for instance.

Secondly, the results could be used for regulation. You have different kinds of regulation, for instance, a regulator could go for Sunshine Regulation which means that he would determine a set of performance indicators for each network operator, that he would display the results of it publicly, and then compare the results among operators. That's Sunshine Regulation. Another possibility is Incentive regulation, which means that the network operators will get a penalty or a reward for the achievement or non-achievement of a certain target. And finally, you have direct regulation which simply means that you impose a strict target which has to be met by the network operator.

Finally, the methodology also allows us to evaluate project results on smart grids. So for instance if you remember, I talked about the European Electricity Grid Initiative in which several demonstration projects are launched. Those KPIs can help to evaluate the results achieved in these projects. It is important in all these things that you use all kinds of aspects you use for policy making, that you encourage progress in each of the six characteristics.

[Next Slide]

Now we come to the conclusion. On the next slide is my conclusion. First I want to say that we have different initiatives going on the European level and that evaluation of these different initiatives have to be done in a different way as well. So far, there is no common understanding of an evaluation methodology. There is no common understanding of KPIs. And if you look at discussions on KPIs you see sometimes that measurability is neglected, which is very *[inaudible]* for KPI. Then we translate to the list of KPIs the formulated *[inaudible]* we defined them around six characteristics, characteristics formulated already some time ago by the U.S. Department of Energy. And then we clustered them into several categories which we attributed to one of the six characteristics.

This methodology is only the first step towards the measurability of the smart grid. Depending on local conditions, depending on the specific purpose for which you want to use KPIs, you will have to further refine them or you will have to select some of them because it is important to get all the relevant stakeholders around the table to do some studies, survey, etc.

[Next Slide]

On the next slide, you can see an example of this. Here I focus again on that European Electricity Grid Initiative. What is going on at the moment in Europe is that the JRC, the Joint Research Center, which is a certain part of the European Commission, is now trying to formulate specific KPIs to measure how efficient the EEGI program is. These are very high level KPIs which have to be easy to understand for everybody. Then another project, the Grid Plus Project is going on and they try at the moment to formulate more specific KPIs. They made several clusters of projects, clusters as they are also identified within the EEGI program itself, and they try to formulate KPIs to measure some technical aspects of these KPIs to get an indication of how smart each of the project are and also to assess the implementation effectiveness of each of the demo projects with respect to the total EEGI program.

[Next Slide]

If you want more information on the methodology as I proposed it today, I want to refer to the full paper and you can find it at the link that is provided in this slide. Okay, this was my presentation for today. Thank you already for listening. Thank you.

Mackay Miller: Thank you Leen for that very informative presentation. We have a number of questions. I will begin to ask those on behalf of the audience and if there are additional questions please feel free to ask those in the Question Pane of your webinar. The first question—I'm going to combine a couple of questions from the audience because they were asking a similar question. I will try to take these questions more or less in the order of the very specific, and then we have some questions up at a broader level of your work.

But this first question is, in the measurement of demand response performance could you speak a little bit more about how you measure demand response, both in terms of quantity and responsiveness? For example, are there time bounds that are important thresholds for measuring the performance of demand

response? Perhaps you could comment a bit on the specific measurement of demand response performance.

Leen Vandezande: Yes, so we identified several KPIs that address the demand response. Some of them are simply focusing on counting the amount of consumers that are contributing to demand side management for instance. But as I said before we are also focusing on the potential for time shift in this KPI. So we will look on average how many hours, for instance, that consumers are able to move their consumption. There are no real thresholds for it so the fact is also if this methodology is applied in more cases we will be able to compare results and you will get a better idea of what is really smart, what is not yet so smart, etc.

Mackay Miller: Thank you. And on a related question an audience member asks what are the—The audience member comments that in some configurations of demand response markets there is some level of automation that takes place at the customer device. In other configurations there is less automation but much more market driven responsiveness. The commenter makes a point that in advance we may not know which of these configurations is optimal from a performance point of view. Perhaps you could comment about how to measure—What are your thoughts on measuring the overall performance of the demand response resources in a way that may cross several of these KPIs, but looks at the system performance at the aggregate?

Leen Vandezande: Yeah it might be interesting to have, for instance, separate KPIs. One, for instance, to measure a demand response in reaction to electricity prices and on the other hand you have a KPI to measure how much people are going into a contract with their system operator for instance and are automatically controlled by the system operator in terms of spacing, certain disturbances in the system. So it might be interesting to look at both of these aspects with a separate KPI maybe. But yeah, both are –

Mackay Miller: Almost –

Leen Vandezande: Excuse me?

Mackay Miller: Yes, almost a sort of an aggregated KPI that looks at system performance.

Leen Vandezande: Yeah, now there is not a real separation made in the KPIs but it could be interesting to look at them separately as well I think. But they are both contributing to the "smartness" of the grid, of course.

Mackay Miller: Leen, we have a question: can you comment on the status of these KPIs out in the real world? Are there specific projects that you can talk about that are piloting the use of these KPIs to measure their work?

Leen Vandezande: Yes, I know mainly the situation in Europe so at the end of the presentation I talked about the Grid Plus Project. This is a European project that was launched a year ago and that has the aim to create a kind of overview of all the demonstration projects that are currently going on within the Electricity Energy Initiative. The fact is in Europe you now see several hundreds of demo projects going on. But the results are not yet shared and it is difficult to get an idea of how effective all these projects are. So the Grid Plus Project is now trying to formulate kind of common KPIs that can be used. But this European Commission should get an idea of how effective each of these projects is.

Another goal of this project is to scale up the results of each of these projects because you will get—In each small project you will get some indication of the benefits of, for instance, if you install a kind of automation technology in a substation it will create some benefits but you will get only the benefits for your small demo. So in the Grid Plus Project they will develop methodologies to scale these benefits up to a national level for instance. And then there are several demonstration projects that also are formulating KPIs to measure the performance of their project only.

I know for instance a huge European project grid for those who are trying to do this. There was also the EcoGrid project—So several projects are working with it. But it's kind of a new thing so everybody is struggling with this a little bit as well, because it's not so easy to define easy, understandable, and measurable KPIs.

Mackay Miller: Agreed, and I suspect that the collection and the rigorous documentation of KPIs also requires some training. Has there been any comment on that from the pilot project?

Leen Vandezande: Yes. I think indeed it will require some training. So first everybody should understand the meaning of the KPI. And then if you also entail a lot of data collection because it depends on what KPI you want to calculate, but yeah, it will be a huge effort.

Mackay Miller: We have another question a bit about market design. The commenter discusses briefly the way that the United States values demand response. Essentially to some extent there is an equivalence between a megawatt of electricity and then a megawatt of command response. Can you comment on how

Europe values the *[inaudible]*, their consensus on this? Is Europe headed in a particular direction?

Leen Vandezande: Yeah I think the United States are already far more advanced with respect to demand response. In Europe we do not yet have that much demand response. Not that many countries started already with the roll out of smart meters for instance. What I know for instance is that now some demo projects are going on, which are looking at the demand response but that are only demo projects. So there is, for instance, a project that is testing a real time market that is sending every five minutes pricing up to the consumers. These consumers are then enabled to offer balancing services to the network operator. We have other demo projects as well but I think there is not yet a common approach to our demand response and how it will be valued on the market.

But I think we have the vision that in the end, through the use of aggregators and other intermediate parties, consumers will be enabled to participate in the markets. They will participate in the normal markets as we know them today so a megawatt of electricity will, also for us, be equal to a megawatt of demand response in that respect.

Mackay Miller: Perhaps this is a related topic but one of the participants asks whether ENSO-E's demand connection code will inhibit the performance of the smart grid. I wonder if you have any thoughts on that point.

Leen Vandezande: Will inhibit the *[inaudible]*?

Mackay Miller: Will inhibit the achievement of some of these KPI's. I think the question is will this demand connection code make it more difficult or throw up barriers to participation in these markets.

Leen Vandezande: I have to admit, I'm not fully aware of the demand connection code or what is exactly included in this, so it's difficult for me to answer on this question.

Mackay Miller: This is perhaps something that is tied up with the question of how to value demand response so I would encourage the commenter to follow up with Leen individually afterwards. We have another question asking if there is a–Do you have any thoughts about how to measure the type of engagement—customer engagement—that led to, or that leads to participation in demand response? The questioner is from Canada. I know that both in Canada and the United States there has been some resistance to participation in smart metering and demand response programs. Do you have any

thoughts about whether this is an important metric to measure or does this relate to any of your existing KPIs?

Leen Vandezande: I think you can derive the resistance of people also from—if you look at KPIs, like the amount. I know it will be difficult maybe. I would think that the amount of smart meters installed would—Yeah it can give an indication of resistance as well for people who did not accept the smart meter. Yeah I think it's something difficult to measure. You can only measure this by doing surveys I think. It's more focusing on the physical—on the psychological aspects. I think it's—Yes you could do a survey but I think it's rather difficult to get an idea of it, unless you have a forced rollout of smart meters for instance in your country. Then the number of advanced meters installed can in the end give an indication of the amount of people that really didn't want a smart meter.

Mackay Miller: Yes I would almost constitute a test case to look at the different rollouts. We have a question about—I'm going to generalize this question a bit, but is there a plan for expanding or allowing these KPIs to involve—The question specifically asked about the power quality section, which is a fast moving domain in the standards world. IEC and IEEE and others are constantly working on new standards for power quality. Are there plans to expand or allow this KPI framework to evolve to keep up with these standards bodies?

Leen Vandezande: Yes, the methodology we derived is only a general methodology and the idea is that is can be a basis but depending on what exactly that you want to evaluate, whether you want to evaluate demo projects or the smartness of your national network, etc. You will always be faced with some specific conditions so the methodology should be adapted to these specific conditions. And the same—So there will be certain evolutions going on, for instance, with respect to this power quality, so then changes to the methodology can and should be made yes.

Mackay Miller: And is there a schedule proposed? Do you anticipate annual or semi-annual updates?

Leen Vandezande: The methodology that I proposed was made at the university so it was just a voluntary exercise. Now the methodology is, for instance, used in the context of the Grid Plus Project that I talked to you about. We are looking—We take this paper as one of the bases but there are also other efforts normally with respect to KPIs. We tried to combine this and looking at what we want to evaluate we tried to make the best of it. I think—So this exercise will have to be done very case specific.

And then I think in this—in the Grid Plus Project we will finally define these KPIs. Then we will start collecting data with respect to the KPIs. We will calculate them and I think after one year we will learn and we will see that, yes, some KPIs are really difficult to measure, that others do not give us a good indication of what we want to measure. So we can slightly adapt the KPIs. So we will have to test them.

Mackay Miller: Good. On a related question do you think that there is a reference value for each of these KPIs or some sort of desired level of achievement? Would this be a general principal or perhaps something that is best set at the local level?

Leen Vandezande: I think for some of the KPIs we will learn a lot from demo projects, for instance with respect of reacting demand response programs—so for instance the amount of energy that they are able to shift in time. I think demo project will show us how a typical consumer is reacting. I think these kinds of projects can give an indication for certain KPIs. For other KPIs I think policy makers will set targets, so for instance with respect to the number of meters they want to install, also with respect to the amount of voltage variations, etc. they want to accept in the grid. So it depends a little bit on the KPI.

Mackay Miller: Right and this seems if I may say, like an area that will require a lot of collaboration both nationally and internationally over the next several years, to begin the test and compare results from different demo projects, ideally using the same language and the same metrics.

Mackay Miller: We have a questioner who asks that in some regions of German load shifting potential by household has appeared to be a bit lower than expected. Are you aware of these findings and does it resonate with what you've seen in other demo projects? And if so what does this mean for demand response as a resource?

Leen Vandezande: I know for instance of a demo project which is going on in Flanders, one of the main regions in Belgium. And there they are also focusing on activity amount and they installed some smart appliances at peoples' houses. There they see on the yearly basis that there would be savings in energy consumption so expressing Euros savings because people are shifting their loading time. In Euros it would be only about €30 euros so this is also not that much. This is a project I know about. I don't know about results in other projects.

I also know that for instance at the Flemish level they are now doing a cost benefit analysis on the introduction of smart meters in Flanders. The cost benefit analysis also show that the costs are rather high compared to the benefits but it depends on the consumer, because for instance if you look at the consumers who are prosumers who have solar panels and there are a lot of people like that in Belgium. For them it might be more interesting to install a smart meter than for others. And also for people—for companies or industrial companies, a smart meter is definitely interesting.

Mackay Miller: Allow me to ask a follow up question there. Are you aware of demo projects that perhaps examine or work less with residential consumers and more with industrial and commercial consumers? Are there demo projects of this sort and do you know of any results from them?

Leen Vandezande: I'm thinking. I know there is but I don't remember the name so I can't mention it now. But I know there is. I thought it was in the Czech Republic that there was this kind of virtual power plant demo. And their industrial consumers were involved. I'm thinking of a project that –

Mackay Miller: If I could comment, this is another area where ISGAN, the International Smart Grid Action Network aims to compile demo project information around the world and make it much more accessible and searchable. So for example someone who is interested could search demo projects by the type of customers and devices and system characteristics.

Leen Vandezande: Yeah and in this aspect I think it's also interesting to refer to the web site of the Joint Research Center of the European Commission because they did a kind of analysis. I think they did it last year or two years ago of all the demo projects going on. So if you go to their web site you can see a map of the different European countries. You can click on a country and then you will see the several demo projects, main demo projects, in that country listed. And you'll get also some basic information on what they are doing in the project.

Mackay Miller: Great. Yes that JRC resource is perhaps one of the best interfaces of demo projects to date.

Leen Vandezande: Yeah there is also an analysis which has been done by the Austrian Institute of Technology. It was also trying to organize all the projects currently going on within the European Electricity Grid Initiative and to identify gaps and to look in which areas of the

EGI a lot of projects are going on and in which areas further research is needed. I think that document is also publically available. That's also an interesting one.

Mackay Miller: Very good. Do you have time for one more question Leen?

Leen Vandezande: Yes.

Mackay Miller: A questioner asks if you might comment on whether there are standards or particular arrangements for how distribution network operators can or might ask to work with aggregators at the distribution levels. Are there ways of thinking about desirable arrangements between distribution system operators and aggregators?

Leen Vandezande: I think there are no standards defined so far. There are also demonstration projects looking more into this, like for instance the European Address Project. I think, for instance, if I look in Belgium there is still a discussion going on of who will take up the aggregator role because distribution system operators are in fact also interested to take up this role. Suppliers are interested to take up this role. But there could also be a neutral independent new party that wants to take up this role. So there is still a discussion on how we're going to execute the role and I think, no, standards are not yet defined.

Mackay Miller: Well very good. I see that there are no more questions from the audience but that was a very good list of questions. We really appreciate the participation from the audience and certainly appreciate the—

[End of Audio]