ISGAN Smart Grid Webinar – Transactive Control

—Transcript of a webinar offered by the Clean Energy Solutions Center on 6 July 2013—
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Webinar Panelists—AM Session

Eric Lightner	International Smart Grid Action Network
Dr. Ronald Melton	Battelle
Rob Wilhite	Global Director, DNV KEMA

This Transcript

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Vickie Healey

Hello everyone, I'm Vickie Healey with the National Renewable Energy Laboratory and I'd like to welcome you to today's webinar, which is hosted by the Clean Energy Solutions Center and we're presenting today in collaboration with the International Smart Grid Action Network. We're very fortunate today to have some great panelists. We have Eric Lightner; we have Rob Wilhite and Dr. Ronald Melton with us.

They're here to discuss the Pacific Northwest Smart Grid Demonstration Project and also the Transactive Control.

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One quick note before we begin our presentation, we have a little disclaimer that we do need to read which is the Clean Energy Solutions Center does not endorse or recommend specific products or services. Information provided in this webinar today will be featured in the Solutions Center's Resource Library as one of our many best practices resources reviewed and selected by our technical expert.

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Just before we begin I'm going to go over a few housekeeping items. I'll just quickly go over the webinar feature, for example audio. You have two options and you may either listen through your computer or over your telephone. If you choose to listen through your computer, please select the mike and speakers option in the audio pane and by doing so this will eliminate the possibility of any unintended feedback and echo. If you select the telephone option above from the right side we'll display the telephone number and also an audio pin that you should use when you dial in.

Just a very gentle reminder to our panelist, we ask that you please mute your audio device or you're not presenting, and again this eliminates the possibility of background noise. One other quick note, if you're having technical difficulties with webinar you can contact the go-to webinar's help desk and that phone number is 888-259-3826 and they'll be happy to assist you.

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Regarding questions, if you'd like to ask a question we ask that you use the questions pane where you may type in your questions. Also, if you're having difficulty viewing the material through the webinar portal, you will find a PDF copies of the presentation at cleanenergysolutions.org/training and if you pull up those PDFs and follow along as our speakers present. Also, we want to let you know that there will be an audio recording up to date webinar that was because this is a Solutions Center's training stage within a few weeks, so not only can you go back and view the slides or download the PDF copies of the slide, you'll also be able to listen to an audio recording of today's presentation.

Next slide please.

Quickly go over the agenda, if we do have a really exciting agenda prepared for you today, which is supposed to some providing an overview of the Pacific Northwest Mark Grid Demonstration Project with an emphasis on Transactive Control. Eric Lightner will begin with the introductions and he will be followed by Dr. Ronald Melton who will be covering the overall efforts of the project and introducing the basic elements of the transactive control techniques and then presenting preliminary results on that. We'll also have a discussion moderated by Rob Wilhite, which will provide the panelist with an opportunity to address questions from the audience.

Before our speakers begin their presentations I'm going to provide a short informative overview of the Clean Energy Solutions Center Initiative and then following the presentation and discussion. We'll wrap up with a few closing remarks and just a brief survey to get some of your feedback.

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The next slide just basically provides a bit of background in terms of the how the solutions in there actually came to be. So, the Solutions Centers is an initiative of the Clean Energy Ministerial and it is supported through our partnership with human energy. It was launched in April of 2011 and it's primarily with by Australia, the United States and others some partners and country members. The outcomes of this unique partnership includes supportive developing countries through enhancement, resources on policies relating to energy access, we provide no-cost expert policy assistant and peer to peer learning and training tools including the webinar you are attending today.

Next slide please.

The Solutions Center has four primary goals, which I'll go over really quickly. It serves as a clearinghouse of clean energy policy resources. It also serves to share policy best practices, data and analysis tools specific to clean energy policies and program. The Solutions Center delivers dynamic services that enable expert assistance, learning and peer to peer sharing of experiences and lastly the center fosters dialogue on emerging policy issues and innovations that is occurring around the globe.

Our primary audience includes energy policymakers and analyst from government and technical organizations in old countries that exist in clean energy or energy policy but we also strive to engage with the private sector and NGOs and civil society.

Next slide.

Billy want to deliver quickly our mark key feature that the Solutions Center provides which is expert policy assistant and we call this "Ask an Expert" it's a valuable service offered through the Solutions Center and we have established under this umbrella as an expert, a broad team of over 30 experts from around the globe who are available to provide remote policy advise and more importantly this analysis and advise and support is provided to all countries and it's provided at no cost.

The area of Smart Grid policy we're very pleased to have Bruno Lapillonne who is the Vice President and Cofounder of Enerdata and he is our expert again on supporting Smart Grid policy.

So if you have a need for policy assistance on Smart Grids or any other Clean Energy factor we encourage you to use this list of service and again this assistance is provided free of charge. To request assistance you may submit your request by registering on the Clean Energy Solutions Center Ask an expert page and we invite you to spread the word about these services thus in your network and organizations.

In our next slide basically talks just a little bit about how you can become involved with the Solutions Center. We encourage you to explore and take advantage of the Solutions Center resources and services including the expert policy assistance which I just mentioned but you can also subscribe to our newsletter, continue to participate in webinars like you're attending today and we also your recommendations on resources, the report, tools, data that would be valuable to policymakers and that we can include in our resource library.

Next slide please.

On our next slide we're going to just quickly introduce our very distinguished panelist today. First off is Eric Lightner who's the director of the Federal Smart Grid Taskforce at the U.S. Department of Energy. Following Eric, we will hear from Dr. Ronald Melton. Dr. Melton is the director of the Battelle-led Pacific Northwest Smart Grid Demonstration Project. And then we have Rob Wilhite. And after Dr. Melton, we'll hear from Rob who is the global director at DNV KEMA where he provides leadership and direction to a worldwide team serving clients with advisory services for utility operations, automation, business strategy, markets and regulatory analysis. So with that I'm going to turn the webinar over to Eric, and Eric, Welcome.

Eric Lightner: Thank you very much and again my role here is really a welcome and introductory type role. Again, I'm with you as Department of Energy and I'm the director of the Federal Smart Grid Task Force but my main role here is as Annex 1 lead for the International Smart Grid Action Network. So this is our first in a series of webinars, we hope to conduct in partnership with the Global Smart Grid Federation. Today, we'll hear from a U.S project on Transactive Control by Battelle and in subsequent webinars we hope to hear from other Smart Grid projects, demonstration projects around the globe and from other member countries of ISGAN as well.

Basically, I just want to welcome everyone to this initial webinar and hopefully you will find it of interest and of value and we want to listen in and attend the following webinars to come.

With that, again, our presenter here today is Dr. Ron Melton. He is with the Battelle, Pacific Northwest National Laboratory. He is the director of the project on Transactive Control, which is one of the ARA or stimulus on these projects here in the U.S. He is also administrator of Gridwise Architecture Council here in the U.S. and serves a leadership role at the Pacific Northwest National Laboratory.

Following the presentation of the project, Rob Wilhite who is part of Global Leadership team for the DNV KEMA and more importantly for today he is an officer of the Global Smart Grid Federation which is it's in partnership with ISGAN on these webinars and he's also the board of directors with Gridwise Alliance which is a U.S.-based Smart Grid advocacy group here in Washington, DC. He will lead the discussion, the Q&A after Rob Melton presents. With that, again, welcome everyone and I'm just going to turn it over to Ron for the presentation.

Dr. Ronald Melton: Thank you very much Eric. Let me get this in the presentation again. Good morning everybody let me first confirm in the afternoon or evening depending on where you are. Let me confirm that you guys can see my slide on the screen there.

Vickie Healey: Yes, we can see it, thanks.

Dr. Ronald Melton Thanks, so today, I'm going to go through this information on the Pacific Northwest Smart Grid Demonstration Project as Eric and others have told you. I'm going to start out through with a little bit of background information about some of the motivations for why we're doing this research and what we hope to contribute to the evolving nature of the electric power system here in the United States and across the world.

So we're facing a number of challenges in the power grid.

Dr. Ronald Melton Okay, go ahead to the next slide please. So, we're facing a number of challenges with the power grid. We want to increase the efficiency of the grid, increase asset utilization. We're of course trying to keep cost down and accommodate new uses of electric power. It seems like electrifying transportations and so forth. So what do we want to know about this? Well, taken advantage of the Smart Grid technology, we really want to be able to fully engaged all of these different resources, all over the different moving parts of the system so that we can meet those challenges and this is the underlying purpose of this technology and this research area that we are engaged in Pacific Northwest National Laboratory that we called Transactive Control and Coordination.

We wanted to be able to coordinate all of the different Smart Grid assets that might be out here in particular engaging the distribution level assets like demand response but also distributive generation and storage and we want to do that in a way that we can integrate in a seamless way and a smooth way with traditional grid assets and also be able to do this incrementally as we go forward. These were the first camp just throughout the existing system.

Next slide please.

One of the key parts of this channel which is the shift in the grid from a very deterministic situation on the supply side where one could dispatch resources according to an estimate of load in the future and basically engage in load following with this deterministic resources with the increased penetration of renewables on the supply side that we've gone from that deterministic situation to stochastic or fluctuating situation on that supply side. We of course always had that on the load side but now it's that when both sides and this is why we want to have this control and coordination functionality so that we can in fact enable the ability to manage the variability on the load side to help us balance the variability to spin and introduce on the supply side.

Let's go to the next slide please. Let's get a few definitions of what we're talking about in general on the table here. Next slide.

What we're trying to do here with what we have called transactive control and coordination is take advantage of market type or economic type functionality to help us manage this situation but blending that with the engineering or the technical side of things. So that we’re doing that in a form of a control system, blending the large time dimension construct such as markets looking out from five minutes to days or weeks or months even with the smaller time scale elements of control into what we might refer to as a transactive network.

One of the reasons we want to do this, if we look at the potential on the demand side looking just here in the Northwest for example at electric bar heaters, we have potentially as much as 4, 500 megawatts, 4.5 gigawatts of potential resource available but it’s in millions of devices. And so we have this problem of how are we going to be able to reach out and coordinate millions of devices which we think requires a very distributed approach and also do that in a way that is respecting boundaries from a business sensor who owns what in the system stance and especially letting consumers be in control of their responsive elements, water heaters, HVAC systems and so forth but letting them participate in helping operate the raw system in a positive way for both the system and the consumer. Next side please.

To do this, we’ve formulated the notion of distributing this control problem throughout the system in what we referred to as nodes. A node is basically any point in the system where we can make decisions about the flow of power in the power system. We communicate between nodes two basic pieces of information and we’re going to go into these in a fair amount of detail as we go through the presentations, so I’m just going to give a general view of them here.

But the first, we refer to as a feedback signal contains information about the projected behavior of the consumption of electricity or in the case of some distributed energy resources like storage systems for example, we may treat them as positive or negative consumers. The other signal is an incentive signal which represents the economics of the situation. In our case this is a unit cost of power delivered to a point in the system or by a point in the system to those loads that it serves. The job of the node then is to set the value of the incentive signal for those nodes it serving and to do that based on the information about their expected consumption pattern going forward in the future.

If I have an asset, I may have a node, for example my water heater may have a node or my electric vehicle charging system. If I own that asset it’s very important that I am in control of the pattern of interaction of that vehicle or that water heater or that air conditioning system or whatever it might be. If I got a dinner party that evening and I want my house to be perfectly temperature controlled, I need to be able to choose to do that for example as opposed to saving money and helping that balance the system that evening.

The other thing that’s important to consider is that this is all typically going to be automated. This is not likely the work that were expecting home owners to be doing this continuously because in our case we work with a five-minute time interval and if people can't respond in a five-minute interval without our mission this is not going to work.

Next slide please.

This approach is intended to really link together a number of different values and benefits and what you might think of as multi-objective control. We have efficiency sort of objectives and system, reliability sort of objectives like producing peak loads so that we can minimize the need for new capacities, so that we can make better use of the existing resources in the system. We want to do this not just on the bulk power side but also down in the distribution system and the distribution system operator is an opportunity to help manage their different operational problems and realize value streams from participating in that broader system, new value streams that they might not have today.

We'd like to be able to help with some of the traditional problems such as reducing congestion in the system and stabilizing prices taking into account in doing all of those things, traditional techniques like ancillary services and dealing with the problem of increasing penetrations of renewables and the distribution system. That's the general background of what or why we're doing what we're doing, what we're hoping to achieve in the broader sense. Let's take a look now at the demonstration project itself. So let's start that on the next slide.

I'm going to give you a pretty good overview of the project with a very strong focus specifically on the transactive control elements.

Next slide please.

As Eric mentioned, this project is one of the 16 regional of Smart Grid Demonstration Projects funded by the American Reinvestment Recovery Act. This project is a five-year project that started in February of 2010. One of the most important things about this project is the geographic extent of the project. We're working with utilities spread across five states. You can see in the green, the state of Washington, and bluish color, the state of Oregon, then the magenta sort of color there, state of Idaho, orange, state of Montana, and yellow, the state of Wyoming. We're working to integrate the ability to respond to regional conditions, regional needs and the Booneville Power Administration System across these 11 utilities a shown on the slide here integrating their ability to respond so that we provide a regional benefit through the actions of the individual utilities. This is one of the unique aspects of this project. It's one of the things that make it exciting.

As a Smart Grid Demonstration Project we're collecting data that will help inform policymakers, decision makers, researchers and the community in general about the cost and benefits of Smart Grid technology and then with the other three bullets here this relates with the Transactive Control technology where we first had to think about how we're going to communicate between the different elements of the system distributed throughout the region. As we've developed the technology what can we do to help contribute to the standards processes for Smart Grid Technology and how can we demonstrate that this technology could be used to facilitate the integration of wind or other renewables. This is especially important for Bonneville Power Administration. They have the highest percentage of wind in their balancing area of any regional operator in the country as a percentage of the total power managed in the system.

Next slide please.

There's a quick view of the different participants in the project. Department of Energy of course providing the federal funding for the project at $89 million, the participant is matching that with a minimum 50% cash requirement making the total budget a $187 million. Bonneville Power Administration, a key participant in the project providing the funding for our research here at Battelle as well as its circle role, a guidance and relationship with the utilities involved. Most of whom are Bonneville customers. Eleven utilities include all the different types of utilities here in the United States, investor-owned utilities, rural electric co-ops, municipal utilities and public utility districts.

We have five technology partners shown on the screen here, a three-tier who does wind forecasting Alstom grid who is helping with some of the regional modeling, IBM research [indiscernible] [00:26:20] towards some research center, a company called Netezza that has a data management appliance that will use to manage the large amount of data we're collecting. They were actually acquired by IBM after the project started so they're now a part of IBM. The last but not the least Quality Logic who does the interruptability and conformance testing on the project as well as some other activities related to standards and data quality assessment.

One company involved in the project that isn't shown in our list is their role sort of emerged later in the project is Aspray out of Fort Collins, Colorado. Aspray is a very important participant helping some of the utilities directly but also helping and it's more broadly with troubleshooting and debugging for the utilities.

Next slide please.

Let's start taking a look at the basic idea here of the transactive control in this project and we'll do that through this cartoon on this slide. Remember what I said earlier about nodes in the placement of nodes at places where we can affect the flow of power, so each of the different icons in the cartoon represents a place where we might have one of those nodes. We'll pick that distribution transformed it right in the middle just to talk about a little bit. So at that transformer we have coming into the transformer from those things supplying power to it, the transactive incentive signal which is shown in the green arrow to the left, on the bottom is that incentive signal basically as our way of representing operational objectives in the system. We do that monetizing everything that we can relative to the cost of production and delivery of power.

Going the other way in the status opportunities line presented by that as I mentioned is what can loads do, what are loads planning to do and so we—and it sense what can they do. And these are all forward forecast in time.

Next slide please.

As we look at those two signals flowing through the system, we have representative in the box in the bottom of the slide here. The fact that they're flowing past each other and as they flow past each other in one of these transactive control nodes that's where the decision making is taking place. If you will it is a form of negotiation between the two signals or between those interviews that create the signals and we'll see an example of this in a few minutes, hopefully we'll drive that notion of negotiation home.

Let's look a little bit more detail at what makes up these signals. Let's start out on the next slide with the incentive signal. As I mentioned, this is a, it's a price-like signal although rather than a price in a market that determines sense here we're focused on unit cost. It is representing the cost to supply the demands served by that node. So in a sense of electrical flow downstream from that node, it includes factors such as the ones listed in the bullets here. Fuel cost is very important. Infrastructure cost it turns out including infrastructure cost is more difficult than it might appear because when you just put infrastructure cost say flat across the calculation when power demand is low you end up with actually higher cost because the relative allocation of infrastructure cost at that point in time is higher than it is when a lot of power has been served and the unit cost of infrastructure is lower.

Some of these things seemed simple in concept that it turns out and actually implementing a solution there, some settled problems that have to be dealt with. A capacity constraints can be taken into account, the existing economics from markets and demands charges and so forth also can be taken into account. If one can choose a way to monetize it that's agreeable to everybody taken into account things like green preferences and of course one has to take into account profit. Anything basically related to the cost of production and delivery of power can be included as long as you can come up with a reasonable and agreeable way to monetize that factor.

In our project, some of the resource functions, and we refer to the elements that have to do with the adjustment of the value of the incentive signal is resource functions, so we've incorporated resource functions that account for wind power, fossil generation, hydropower. One thing that's very important for the distribution system operators in the Northwest is the ability to deal with the demand charges that are levied on them by the Bonneville Power Administration based on their high load hours during the month, transition constraints infrastructure cost and so forth.

Next slide.

Looking at the feedback signal, now again, this is the idea of what is the behavior of load going to be looking into the future? There's two important basic distinctions that have to be made here. First is the distinction between inelastic load that load that cannot be affected by the value changes in the incentive signal and the loads that can be affected, the responsive loads. So we have a bulk inelastic load prediction function that does the statistical process to estimate the bulk inelastic load based on weather factors and things like that. And then we have a variety of different responsive asset load prediction tools for things like battery storage, thermostat control in the buildings, water heaters, dynamic voltage control, in other words doing conservation voltage production dynamically and even attempting to understand behavioral patterns that might occur if responses aren't automated but consumers are presented information in portals or in home displays.

We've implemented these functions, both the feedback signal functions and the resource functions on the other slide in a toolkit that we've make available to the utilities involved in the project to help implement this. Looking at the next slide, we have a simple view here of what is inside a transactive control node. You can see here the notion that there's—I just pick for example here one that's labeled as a supply node, but you see in these examples, some of the features including the functional elements that correspond either these resource functions or load functions that I was mentioning that take into account local situational information such as weather conditions or forecast or weather conditions or the state of a given asset system like the water heater, and issue also what we call asset control signals or advisory control signals to the asset system telling at what behavior is desired from that system at the future point in time.

And the flow of the data in the incentive signals, it shows three incentive signals coming in one side and one going out the other. That's just to try to keep the diagram clean. All the signals are shared with all the neighbors of any given node. And same is true for the load estimate series or the feedback signal shown going the other direction. This is a very simple representation functionally and it's the same functional elements anywhere in the system where you apply one of these nodes and because of that it's—we believe highly scalable.

Next slide please.

Let me take you through now a simple example, this is purely a hypothetical example. It's not something that we've implemented in the project but it helps us explain and illustrate this notion of negotiation between the feedback signal and the incentive signal.

Next slide please.

I want you to imagine the following situation. We have a neighborhood with three houses, each of those houses, the house owner house and electric vehicle, three different charging strategies with three different electric vehicles we're going to look at. The three electric vehicle charging stations are all fed by the same distribution transformer and that distribution transformer of course has a limit, how much load it can serve at any given point in time without beginning to degrade the server's life of the transformer. And all three of these customers are going to want to come home and do a fast charge in the same timeframe. So we're going to see what happens with the transaction control process in place as they try to do that. There'll be a give and take that you'll see between the transformer and the charging sessions.

Let's go to the next slide, please.

In our example, the three houses' charging strategies are summarized in this slide. House number 1, the charging strategy is I'm flexible, I can vary my charging rate, I can vary my charging duration, I can help out in a variety of ways. House number 2, the exact opposite, not flexible at all. I want to charge, I want to charge right now, don't bother me or trying to get me a change what I want to do. House number 3 is the bargain hunter; I guess we might say in the United States it's the Wal-Mart shopper. They are looking to minimize the class and they're willing perhaps to delay charging for example until the best time rather than insisting on charging right now. Let's start our story here with the next slide.

On this slide you see the situation before we're trying to charge any cars at all, so we just have a transactive incentive signal represented right in the middle of the screen with darker bluish line with the crosshatches on it. We have the transformer limit with the orange line at 40 kilowatts and then we have the typical load pattern in kilowatts across the gray bottom just changing slowly through the afternoon here going up with a little bit in the evening. On the right hand scale we have the economics and on the left hand scale we have the power.

Next slide.

House number 1 gives us their plan for charging. House number 1 is a flexible person. So they want to start charging, at 4:00 PM they planned to charge for 2.5 hours and finished charging at 6:30 PM. So you can see that the total load curve for the three houses goes up to match their desire.

Let’s go to the next slide.

Now, we see house number 2’s plan revealed. Remember this is the inflexible person. Now, we’re not seeing a change yet in the transactive incentive signal that’s the one with the crosses on it going through the middle because we’re right now just looking at the aggregation of the plan from the three different houses. House number 2 reveals it’s plan, it wants to start charging at 5:00 PM, it wants to finish about 7:30 PM and we add the two plans together and you see now just with the two vehicles such charging plans were already exceeding for a period of time of about an hour and a half. The operating limited the transformer so the transformer is going to be feeling some pain. House number 3 in the next slide, shows the seats plan, it wants to start charging at 6:00 PM and go to 8:30 PM and now you see we have a half an hour or so there in the middle where all three vehicles are doing a fast charge at the same time. We’ve significantly exceeded normal operating limits of the transformers so that transformer service life is going to be degraded by that and so now it’s the transformer’s turn.

Let’s go to the next slide

We see the transformer comes up which is a transactive control node. It comes up with its revise transactive incentive signal based on the specs for cost. It’s going to be incurred by damaging the transformer or reducing its service life by the overcharging. So you see it says okay, you can do this if you want to do this, your three houses. I can certainly serve that much power but it’s going to cost you because you’re reducing my service life and I have to be able to pay for any transformer sooner than we have expected. This is the transformer’s response, now the house has charging stations get a change to respond as well.

Go to the next slide.

The first house, let’s take a look at that. Remember this is the flexible charger and that the charging station says, “Okay, well I don’t like that higher cost so I’m going to reduce my charging rate. I’m going to cut it in half and I’ll extend out further in time and that will be better for me than paying that high price when the price really jumps up a lot. Now, house number 2 doesn’t respond because they don’t care, they’re going to pay anything. But house number 3 takes a look at the situation, says well I don’t like this at all. I’m just going to reassess my entire plan and I’m going to move out later in the evening because I see that prices are going to be lower out there anyway. Now, we have heard from the houses and so now it’s the transformers turn again.

Next slide.

Now, the transformer puts out a new TIS that corresponds to the action under the new plan and the cost of power goes up a bit, it doesn’t go up nearly as high as it did before. For purposes of our example, this is where we're going to stop, everybody decides they can live with this price over this time in the future, the transformer can live with the charging pattern of the cars now and so we've reached the form of agreement in our negotiation and so barring any perturbations, the change in plans by one of the houses on what they're going to do or some change in the transactive incentive signal do the factors upstream, congestion, a wind ramp, up or down or something like that, this is the plan now going forward, so we close our negotiation.

We haven't formally closed a market in the sense of a bit of an offer process but for our technique this is the equivalence sort of action. The trick is in the algorithms to have the algorithms constructs it so that they drive to convergence of this negotiation and the algorithm is also have to recognize when you've reached a stable point in the negotiation so that they don't start to process over again without other stimulus coming in or changes in the signals coming in to cause it.

Now, let's move on, next slide please, and take a look at how we're actually applying this technology in the Northwest Demonstration Project.

This slide represents the Bonneville Power Administration system, the balancing of area of Bonneville and we've broken it into a set of transmission zones as we call them represented by the crosshatches areas on the slide. They're divided by the red arks or lines which are presented by the cut planes as Bonneville calls them that separate the areas as they do the balancing of the system and they're connected by flow gates which are the blue arrows, double arrows that represents a constrained transmission pass between the transmission zones.

We broke the region down into these elements so that we would have a way to provide a geographically differentiated incentive signal to the different participating utilities into the utilities represented or each of the sides of the utilities represented by the stars in the transmission zones there has a transactive control node that needs to receive a transactive incentive signal from the bulk power system.

Next slide.

If we look at that in terms of a block diagram we see here the grey areas representing the transmission zones, the different geographic areas. For example over on the left hand side you see Western Washington, where Seattle City Light is located down in the lower left of western Oregon which is the area where Port Internal Electric Salem site is located for example. And then you see the different connections between the different transmission zones. So we take this representation.

Next slide.

We model the bulk power side. We were not able to identify way at the beginning of the project that we could directly connect to the Bonneville system and so we chose in formulating the research to use Alstom's market management system and energy management system models to model the bulk power side driven by data from Bonneville that includes load forecast generation schedules out and schedules and things like that from the independent power users and some from Bonneville zone operations and also when data coming in from three-tier that does a number of the renewable forecast for different wind farms here in the Northwest.

The Alstom model then calculates the power flows and the results for the different transmission zones that can then be used as inputs in the transactive control nodes for each of those transmission zones. Let's go on to the next slide.

We see that on this slide where the Alstom grid models are providing those inputs in the different transmission zones here by number because that's really the only way we have to refer those which then provide the transactive incentive signal represented by the down arrow going into the different nodes, for example Portland General Electric, Lower Valley, Idaho Falls here and coming out of there transactive control node then the asset control signals to the assets that they're engaging this responsive assets.

For purposes of the research project we're working right at the interface between the transmission system and the distribution system which is a good place to be working because that's fundamentally what we're trained to understand is how we can provide a point of integration between those two systems to have a regional effect from the multiple distribution system operators for distribution utilities.

Next slide please.

As I mentioned earlier we've done a quite a bit of effort in the project as we've take in the research and design the specific implementation for the project to create a toolkit that enables us to have if you will a platform that takes advantage of the two-way communications offered by Smartgrid technology takes advantage of all the different information available for our problem of transactive control. It does it in a very standardized way with the state model of a transactive control node and a specific ability to define individual toolkit functions that can plug in a uniform way into that underlying state model to provide the functionality of the system.

So this has been implemented in a reference implementation by IBM that is made available to the different participants or the design is also available to them if they choose to implement their own transactive control node functionality independent of a reference implementation. But some of the characteristics of this include the well-defined interfaces or asset systems and the simple signals in the transactive incentive signal and the transactive feedback signal that are used as the control signals in the system.

I mentioned these ones before but just to reiterate those signals are updated a minimum of every five minutes. There can actually be a faster update cycle if you'll have one of these negotiations taking place such as we saw on the example. The signals are projected forward into the future for 72 hours in its varying granularity of time going out in the future, they project every five minutes for the first hour and then they go to a 15-minute interval out to an hour interval and then out to a day interval for the last day.

So as you have less and less certainty in your ability to predict you of course don't have any reason to be trying to predict to find time granularity and so we recognize that in this varying level of granularity out in time.

What I want to do now is how you a couple of the results from some of these algorithms. So if we go to the next slide, this is an example coming from a flathead electrics node in Libby, Montana. What we've got here is the load prediction function. On the left hand side is the actual measured load. On the right hand side is the output of the load prediction function that was predicting this load. A nice match between those, this is one of the ways where validating the technology is by doing this kind of comparisons, the other thing you see here is different colored lines representing the different time—CEPs into the future as we're marching through time getting new predictions as we go through time and you're seeing the overlay of those predictions so we can see how much variability there's been in that as time rolls on for predictions.

In the next slide, we have the first half of sort of the two-part story. As I mentioned one of the things that's a key potential value of the distributions of some operators in the Northwest, the public power providers who are customers of Bonneville is the ability to predict and then manage their loads to avoid demand charges. There's this example is dated from the City of Milton-Freewater which is a small utility in northeastern Oregon about 4,500 customers. They've been doing this manually for almost 30 years using water heater direct load control and air conditioning direct load controls. So one of the challenges for us was to take advantage of their experience in doing that to help us formulate automated approaches to managing loads to avoid this demand charges. So what you see on this slide is the transactive feedback signal for Milton-Freewater and you see in the first red arrow there a detection of their first high load hour and you see on the corresponding line on the bottom running across from the zero on the megawatts field there, you see an asset control signal output or an event being declared based on having detected that peak as a high load hour and you see then a second high load hour, a third high load hour, and a fourth high load hour as we go across.

So this is the detection, that part of the algorithm looking at coming up with high load hours and if we go to the next slide we see the other half of the story which is the transactive incentive signal being varied in response to detecting those high load hours. And we have a threshold for the transactive incentive signal that is being relaxed overtime is part of that detection process so that we make it harder and harder to achieve a high load hour at any given point in time because they only have as you'll see here a maximum of five events a month and so as we find an event and then issue the asset control signal which you see in the middle of the screen here. If you stop one of those negotiator with their customers events for the month and we want to save opportunity just in case the highest high load hour comes later in the month.

And so you can see every time we relax down and then finally declare a high load hour event and send out the asset control signal, we'll make it a little bit harder each time when we've used up our five, we of course don't have any more so we start a threshold high enough that we won't detect anymore. So this is an example of the type of data and the functionality that we get with the tools that we're implementing with the utilities.

Next slide.

Let's take a quick look here at what some of the utilities are doing in sort of the progress that we're making.

Next slide please.

The different utilities have implemented a variety of Smartgrid technology in there systems. This shows the list of the utilities. Again, University of Washington at the bottom is of course not a utility exactly but they are one of the participants working with their buildings across their campus and they are an interesting one in particular because they have put in over 200 meters to meter all the buildings on their campus prior to this project they had no meters on campus except the 7 meters for their seven different feed points from Seattle City Light. They spend a million dollars more a month on electricity and they didn't have any particular data to show them how that electricity was being used in their facilities until they installed that infrastructure.

Now, with that infrastructure installed not only do they have a much better handle on how electricity is being used but they're also working with several, they're more advanced, buildings that have advanced building controls to be able to respond to the incentive signal and that help with the overall management of the power system and also have opportunities to look at flying this answer to techniques within the buildings themselves to help manage the energy footprint of the buildings.

This at the top is an investor-owned utility and the Spokane, Washington area you see they're doing a variety of things including the conversation voltage detection, the CVR, there are some demand response in home displays. Working at Washington State University in Pullman, Washington, they have a thermostatic control options industry generation options as well. They also invested in a number of smart transformers which are helping them implement a very sophisticated distribution automation system, which is not going to be really a part of the transactive control but it's been an extremely valuable system for them.

Benton PUD in the middle, that's the public utility district involved. They are using a technology for a demand shifting with a small into a lot level storage system. The City of Ellensburg are doing renewable energy at a community level flat head electric, a real electric co-op doing the combination of residential demand response and home displays using smart appliances. The City of Idaho Falls municipal, they have the broadest cross-section of activity going on here, you can see. Lower Valley Rural Electric Co-op also an interesting cross-section. They also have some flow battery storage technology that they're working with which is going to be interesting to us.

The City of Milton-Freewater I mentioned earlier, northwestern, another investor on utility with a little bit of conservation [indiscernible] [00:56:25] introduction and some demand response. Peninsula Light another rural electric co-op primarily doing demand response. Portland General Electric investor on utility serving Portland and Salem and they have a 5-megawatt battery storage system that's quite interesting to the project coupled with distribution generation and rooftop solar to form a microgrid area that they refer to as high reliability.

The project will have about $77 million in investment in these assets systems when we're done with the project, really have invested about $11 million in the computing infrastructure to support the experiment and we have a total sort of response range of 56 megawatts of load reduction and 7 megawatts of load increase. For the nonresponsive assets just addressing efficiency for example this conservation voltage reduction about a 10-megawatt impact we expect.

Going to the next slide you can see some of the views of some of these things, so here's Northwestern energy on the left with some of the gear. They're installing for the conservation voltage reduction, the City of Milton-Freewater who did their advance meter infrastructure and automation of their demand response with your customers. The University of Washington is doing some interesting experiments in the dorms with the engineering students doing floor-to-floor competitions to conserve energy and see which floor can do better.

Next slide please.

Lower Valley Energy, you see here has a combination of some local small scale renewables including both small scale wind and solar and the rack in the middle there are the controllers for their, I believe it's vanadium oxide battery, flow battery system. Flathead Electric working with GE on their smart appliances as a part of their project. Idaho Falls Power the only part of our project that has some electric vehicle charging included [indiscernible] [00:58:28].

Next slide please.

Peninsula Light working with water heater demand response units, they got some early benefit from this technology. Their experimental area is on an island that they serve with an underwater cable to the island and then a very much smaller cable going on the bridge to the island. Early on in the project their underwater cables failed and they had to serve load with a temporary cable as they ran and also the small cable on the bridge. They use the demand response in this to help manage load so that they could keep things lighted while they were replacing the underwater cable, which took a while.

And then Benton PUD here on the right, this is one of the demand shifter units that is a combination of a battery storage system and the ability to shift load through that battery storage system. Avista with some of their iTron data concentrators there and I think that's it for our pictures. Let's go to the next slide.

Just a recap, the project objectives were laying the foundation for the regional Smart Grid here in the Pacific Northwest through the different equipment that the utilities are installing those asset systems are about 95% installed now. There's a couple that have taken longer than we expected so they're not quite done but most of them are in place. We had to consider the problem of the two-way communications and the signals that we would use to do transactive control that's all developed and in place. We ended up using the public internet with appropriate security technology to protect the signals that are flowing. Each of the individual utilities has selected their own particular technologies for communications at the utility level and there's a variety of those choices.

As we go through this project working with the Department of Energy team defined a metrics and benefits measurement plan and the work with each of the utilities to define specifically what would be measured from them and we collect that data regularly and reported up early to the Department of Energy. We've been working both observing what's going on in Smart Grid standards activities and now we're working on how do we put our project documentation into the forms that can be used to take forward in the standards activities. Finally, one of the key reasons we're doing this all is integrating renewable energy and we have the representation of wind energy in our signals today and we continue to discuss with Bonneville Power Administration how to even more carefully represent wind to be able to help facilitate the tool that could be used operationally by them.

Next slide please.

This gives you just a summary of the experiment landscape. We have three primary areas of experiment first in transactive control with around 40 different test cases there. Test case is the combination of an individual asset systems of the utility with a specific way in which that system will be utilized. For liability we have a much smaller number of test cases but we do have several—these are going to be a little bit more challenging because what we want to see are different events and see the effective technology in helping with reliability during an event but of course in any given trade of time even the roughly two years that will have with these assets installed we may or may not see a reliability event, so that one is a little bit challenging.

Conservation and efficiency you see a number of test cases there roughly a third of the. So these are test cases where the Smart Grid technology is being used for a conservation efficiency purposes by the utility nontransactively so it's not responding to the transactive control so we have a lot of interesting data we help to come up with there. Several of the utilities also had what we described here as social test cases looking at customer acceptance rates, in some cases use of social media and things like that to help engage their customers.

Next slide.

I mentioned at the beginning, this is a five-year project began in February 2010, it ends in February 2015. We're chosen out with the now line. We got third phase of the project, which is data collection and analysis basically and validation of the Smart Grid technology and just a sort of a summary of where we are within each of the threads of the project through the objectives.

The first objective was largely accomplished through the detailed design implementation phase, the transactive control technology represented by an interoperable communication control infrastructure is being validated in the current phase as this contribution of the standard activities and assessing how this technology can help support wind integration.

Next slide please.

At the end of the project in 2015 we're going to have just under a 100 megawatts of distributed response of assets engaged by the technology. We'll have validated the technology shown to the extent that we're able and how it can be a tool in balancing; helping balance renewable resources will have the Smart Grid equipment installed at the different utilities. There's still of course a lot of scale needed, we've engaged at most 60,000 customers across the region out of several million customers, and so there are a number of additional responsive assets that could be brought to the table. This is an RND project. One of the things that we want to really understand and facilitate is how do we transition this from RND to being an operational tool in the region. How do we operationalize it for balancing authorities, Bonneville our administration and potentially other balancing authorities and we look forward to engaging additional energy service providers in the region to help it grow it's footprint if you will.

With that, next slide please

The Department of Energy of course ask us to both acknowledge the funding that they provide to the project but also make sure everybody understands that this is a work they've sponsored but not in any way specifically endorsed by them or warranted by them. This is their standard disclaimer of course. And lastly, I'd certainly be more than happy to answer any questions after the webinar if anybody has them so there's my contact information. We do have a project website shown on the slide here, www.pnwsmartgrid.org where we have a variety of a different information resources explanations of the technology, explanations of what the individual utilities are doing and we have a quarterly newsletter and annual report we post there as well that gives you a view of what we are and what's been accomplished..

With that let me turn it over to Rob Wilhite to fill the questions.

Rob Wilhite | Ron, thank you very much, a very interesting and quite informative presentation. I know that there are some questions posted online already. Just as a reminder to all the participants, please use the online tools to be able to send us questions and I'll start going through those in just a moment.

Again, Ron thank you. I'm very pleased to be representing the global smart grid federation and working in a global capacity. Also in collaboration with international Smart Grid Action Network and even though this project takes place in the Pacific Northwest and is funded partly through U.S. dollars through the ARRA program as Eric pointed out. This certainly is of interest around the world about the results and the outcomes that you're achieving here and just by looking at the 100 or so attendees who are on the call right now. I see a number of international participants so this is certainly a pretty exciting from a global perspective.

With that let me immediately jump to the first question Ron and let me throw it out to you from Steve Hauser. It seems like that there's a bundles cost or bundled price that is being sent for behavior in the system here, have you look at the advantages and disadvantages of having more than one cost signal being sent?

Dr. Ron Melton | I guess I'd say Steve conceptually we have—I guess we're concerned that if you're sending multiple cost signals and how does a responsive device know what to respond to. We think it's much simpler to have a bundle of signal or you represent all of the different dimensions that you'd like somebody to respond to and for example I guess one thing I didn’t mention explicitly but hopefully came through to people is the price signal and the evolution of the price signal or cost signal is following the flow of electricity in the system.

So at any given point in the hierarchical structure of the system the entity responsible for that point either the business entity or the control function at that point has an opportunity to inject their particular operational objectives or needs through the variation of that signal. So it provides in a sense a level of playing field of opportunity. This is really important I think looking at the progression of the signal from the bulk power side into the distribution side. The distribution system operator may have operational objectives they need to achieve their own form of local constraints or local conditions they need to be able to be injected in the signal and maybe more important at any given point in time then those being represented by something you’re higher up in the system if you will. And so if you have multiple signals how do you achieve that ability to have the end device you’ll know what to pay attention to at any time. That’s I think the best that I’ve come up with today but the kind of thinking that women do what we’re doing.

Rob Wilhite — Ron thanks and is it corollary to that question in your response, one of the things you said was that the price is following the flow of electricity so given that does the price or would you allow the price to actually go negative at some point.

Dr. Ron Melton — Potentially, yes. I guess if in the both the control formulation and the economics of the problem, it was sensible for the price to be able to go negative then yes, that’s not outright prohibited.

Rob Wilhite — Okay, another question has come in regarding the connection between the participating loads in the pricing signals and is it feedback to one operator only or is there a consideration for our client’s server mode of operation here possibly even introducing a third party into the architecture here to operate these signals and the communications?

Dr. Ron Melton — It certainly conceptually possible that you could have a third party. The problem gets back to my answer to Steve’s questions about multiple signals. You need to have a unique paths to a given asset of the signal so that you don’t have competing interest. For example a classic third party could be a demand response aggregator, you don’t want the aggregation process to be orthogonal to the overall control processes and play here. You need the control objectives to be aligned and represented in a single way. So I think the third party within that becoming an operator on behalf of say the distribution system or some other entity in the system as oppose to an independent point of connection.

Let’s perhaps hard to articulate here without a white board in front of us drawing some pictures but I hope the point comes across.

Rob Wilhite — Great. Ron, we have another question from Michelle Denegri from ISGAN and the question is around you know we've optimized these responses based on like of equipment and avoided overloads particularly on distribution transformers but what's the effect on network losses? Have you mentioned network losses or seen any impact as a result of these designs?

Dr. Ron Melton — No, that's a dimension we weren't able to explore with the scope of the current project. So as you hopefully noticed you know we're modeling the bulk power side and we're limited to the first sort of level of interface from the bulk power side to the distribution system in the work that we're doing right now. So one of the things that we really want to find an opportunity to do going forward is to expand the application, the technology and both the power side or transmission side and pushing it down all the way down at the distribution feed or in a distribution utility. Currently, the distribution utilities are using conventional demand response technologies that are just driving the activity of those conventional demand response technologies based on the transactive, the control signals.

Rob Wilhite — Great. Ron, there's a statement that Larisa Dobriansky has submitted that would like to get your response to and essentially it's states that the demonstration project is indicating that there is an ability to manage energy attributes instead of owning hardware of customers which could be sufficient to manage and optimize this, the distributive resources and power system. So what's your reaction to the aim for utility to own hardware in order to manage electric resources versus to just allowing back to the previous question of third parties perhaps to intervene in that process.

Dr. Ron Melton — I'm going to start by saying I'm not completely sure I understand the question. What I think I understand is a reference if you will to differentiating between a direct load control type approaches for the utility is got hardware connections potentially across the meter into the customer premises and is exercising sort of direct control versus indirect control through the changes in the values of the signal with customer-owner equipment and responding to those. So if I've got that understanding correctly that that is the whole idea. We want customers, first of all customers need to have some sort of a value proposition and the value proposition to them here is that they can managed their energy cost by knowing what energy cost and being able to share the savings of using energy when it's less expensive for example in providing the service to the system, they'll manage the system better when energy is constrained.

The distribution utility has the same opportunity to it looking at its relationship to the transmission provider to the extent that distribution utility through their engagement with their customers is able to help manage the system better. They should have a value stream from the transmission side that they can then share with their customers.

There's no intent here to suggest that we need to move away from the hardware of the system but what one could think of here is that we've created if you will a Smart Grid application layer taking advantage of the information flows and information available in a well implemented set of Smart Grid technology to provide a functional application layer. So if the question is who should own and operate that application layer? Does it have to be the utility? It doesn't necessarily have to be the utility but as an operating entity it would need to be somebody doing that on behalf of the utility I would say.

Rob Wilhite: Ron, thank you for that response, although I may not have articulated the exact questions very well your response was very clear as confirmed by Larisa. So thank you for that.

We have the next question, as I mentioned we are certainly live on a global basis and the next question comes from Humad in India. The question is around distributed nature of the system that you have described here. The question is does that mean that each node has intelligence not only to determine the incentive signal but also to trigger control actions.

Dr. Ron Melton: The basic answer is yes. Of course, it depends on the nature of the node. The example I gave with a smart transformer, the transformer itself may not have any particular control action available to it but it is a point of power flow control potentially through the manipulation of the incentive signals to affect the behavior of those loads that it's serving. The transformer even though it may not have a specific control function that it can execute is a point of data in the system both your environmental conditions of the transformer, the transformer conditions themselves, you know oil temperature, other factors that may be measure about the transformer and so forth.

If you think of a substation level battery storage system there you would have an example of a point where you would have a control node for that battery storage system and it would both be able to change incentive signals and feedback signals associated with the charge and discharge plans of that battery system.

Rob Wilhite: Ron, we now have a question from Canada I believe, from Alexandra. How many nodes are planned by the end of the project and how many of them are going to be servers negotiating the TIS with the end nodes.

Dr. Ron Melton: We have I believe 14 utility level nodes. Those are all implemented up and running. We have also 14 transmission zone nodes that that's there's not a one-to-one mapping there. There are a couple of utilities that have two nodes. We're also have implemented a couple of experimental nodes in addition to those operational nodes at the utilities here at the laboratory and we're in fact beginning the process of talking to additional distribution system operators about implementing transactive control nodes and parallel with the project so that they can take advantage of the technology as well. But that's the current footprint of the project and we'll be further remainder of the project.

Rob Wilhite: Great, Ron thank you for that. We have exhausted the submitted questions but that you have one or two more. I'd like to post to you Ron before we turn it over to our webinar organizers. One of which is something the topic that you have already addressed initially in some of your initial slides but I wanted to go into it a little bit more and that's around the concern of the security of data and security of the system in a distributed network architecture as we're seeing with great modernization. And so I wanted to better explore what are you addressing in terms of this particular administration project relative to the concerns that consumers might express relative to the protection of their information, protection of their choices when it comes to responsiveness to the price signals.

Dr. Ron Melton: So in this project here in the data that we get, that we'll be analyzing we don't actually get any data that gives us any information about any individual consumer. All of the data that we get is aggregated by the participating utilities in any opportunity to identify individual consumers is obfuscated by the aggregation process. One of the reasons that we think that it's important to have a simple sort of a signal like the transactive incentive signal or the transactive feedback signal is that because it's simple and it's driven by either load or cost information you tend to not have any privacy related information associated with it. Now, you still potentially do have load patterns of individual consumers although if the data was pushed down or the technique was pushed down, a distribution fear to the full extent with the example I provided being a real life example not just hypothetical example, you can see that even at the distribution transformer then we've aggregated the data from the houses served by that distribution transform and the feedback signal it provides to those elements upstream from it in the hierarchy of the system is now aggregated data. So the behavior of the individual consumers is only discernible at the transformer itself and other than any sort of market policing type activity that one we'd need to be doing to ensure the integrity of the any economic processes. That shouldn't really be discernible to anybody.

So I think that one can make a pretty good case that privacy concerns are well dealt with in the overall technique. Security is certainly going to be concerned—it's a concerned now, we deal with it with best practices in a standard network communications technology but any further development implementation of the technology will have to continue to take advantage of and apply security best practices to ensure the integrity of the signals, ensure the integrity of any economic processes that are implemented. In our case we don't actually have a market in play so this is strictly used as an engineering economic control signal which should a market introduce to what actually used out as a real price signal then appropriate security technologies would be applied to ensure the integrity and operation of that.

Rob Wilhite — Ron thank you for addressing that point. Could you also comment briefly about the commercial viability of the various hardware and software elements that go into this architecture and identify you know where are the gaps that you see that harder demonstration projects and we have to prove out further in terms of taking this to commercial scale.

Dr. Ron Melton — So I'm going to be a little liberal in the way I answered your question because there's a lot of different dimensions to that. The transaction control technology itself is relatively simple and straightforward so there it's a matter of potentially having you're multiple suppliers of the basic capabilities. What we think make sense is that there be a common platform into which one can put the different toolkit functions I mentioned resource functions or load functions is there where the real opportunity for an electrical property is. Going back to my Bonneville Power Administration demand charge for example toolkit functions for example, the company that has the best algorithm for avoiding demand charges have more opportunity to sell those and the company that doesn't have a good demand charge functions, so we think that's where commercial opportunity is and of course right now what we've got are implementations for the demonstration project in the platform that could be used as the open platform going forward or perhaps an evolved different platform may emerged.

The responsive asset side though is the other part of the equation, so right now utilities traditionally do a demand response on an event driven bases and they typically do demand response to shed load not to get load. And if we're trying to apply technologies like this to help integrate wind we really need to be able to do up or down regulation depending on what's going on with the wind situation. And so there is a potential gap in the demand response technology even if you still take an aggregator approach to demand responsive energy and at the utility level you still would like to be able to do it continuously so that you can respond at any point in time where you need to respond and you would like to be able to do it most directions with loads being shed or added depending on what's going on. That then also brings up potential implications relative to both utility business models and regulatory processes and so forth. So that there's plenty of work to be done, I'll speak forward on this.

Rob Wilhite — Ron, thank you very much. I know there are a couple of more questions coming in but we are running into the final couple of minutes. Maybe I could throw a one quick question for you Rom, from Roger, and that's around the potential volatility of the system to actually increase as a result of these demand signals becoming more unpredictable. I guess as you even get into a dynamic demand response and fast response of loads to pricing signals could we actually go into a higher volatility situation on the grid.

Dr. Ron Melton — That's certainly something we all have to be concerned about. We think that that is managed through introduction of the equivalent of damping factors in the algorithms that are making the decisions to avoid either oscillations or sort of chaotic behavior. It's certainly something that's given the distributed nature of the system and underlying mathematics certainly something that is a possible to happen but we think it can be managed through both analysis of the technologies and proper algorithm designs.

Rob Wilhite — Folks you've been listening to Dr. Ron Melton. I'm Rob Wilhite and I'm going to turn it over back to our moderator I believe that's to you Vickie, correct?

Vickie Healey — Yes, that is correct, can you hear me okay? I just want to make sure that I took my mute off.

Rob Wilhite — Perfect.

Vickie Healey — Great, so with that I mean excellent presentations gentlemen thank you so much. We had some great questions from the audience. I believe there maybe one or two remaining that we didn't get to because of our time constraints but I will send those questions off to you and perhaps you could respond directly to the requester, if that's all right with you.

Dr. Ron Melton — Absolutely.

Vickie Healey — Okay, thank you. And so now we're going to take a quick survey to just get a little bit if feedback from our audience to see how well we did and it helps us to gauge what we're doing right, what we can do better, so with that Heather could you see basically the first question, survey question, which I'll read real quickly and we'll give you a few seconds to answer this. Our first question is the webinar content provided me with useful information and insight.

Go ahead and click your radio button so next we answer that as most correct or how you feel about that? Great, thank you.

For our second question, the webinars presenters were effective. Okay, thank you.

Now for our third and final survey question, I believe that's our final. Overall, the webinar

met my expectations. Great, thank you. Thanks everyone who participated in that survey. We take our feedback very seriously and appreciate you answering these quick short few questions.

So with that you know again thank you Eric, Ron and Rob. It just provided just altering information and material through your presentations and I just want to in case you have any last minute thought there, comment you'd like to make, I'd like to give you that opportunity now to offer any closing remarks that you have.

Dr. Ron Melton

This is Ron, I want to thank everybody for their attention and enjoyed sharing our project with you today, and as we've said if you have any further questions feel free to contact me.

Eric Lightner

Yes, and this Eric Lightner on behalf of ISGAN. I want to thank everybody for listening in and hopefully tune in to the next webinar in the series, thank you.

Rob Wilhite

And likewise this is Rob Wilhite representing the Global Smart Grid Federation in collaboration with ISGAN and again, thank you to all the participants and I know Vickie we're going to indicate that we're going to do this again and—for the next nine hours.

Vickie Healey

Yes, an excellent performance. So if any of you would like to see your repeat performance, you're welcome to join us and register for this evening presentation. With that again, thank you to all for answering our questions and on behalf of the Clean Energy Solutions Center I really like to send, a very hearty thank you to all of our expert panelist, Eric, Ron and Robert and also to our attendees for participating in today's webinar. It's been a great audience and we really appreciate your time.

I invite our attendees to check the Solutions Center website over the next few weeks. If you'd like to get advice and listen to a recording of today's presentation as well as we do have several webinars in our archive feature welcome to the [indiscernible] [01:32:30] and dealing with them too. Additionally, you'll find information on upcoming webinars and our other training events and we also invite you to inform your colleagues and those in your network it's about the solutions venture resources and services including that no-cost policy support that I mentioned earlier in my discussion.

With that I just wish everyone a great rest of the day and we know we'll see you again each year, Clam Energy Solutions Center Events. This concludes our webinar.