ISGAN Smart Grid Webinar – Transactive Control

—Transcript of a webinar offered by the Clean Energy Solutions Center on 6 July 2013—
For more information, see the clean energy policy trainings offered by the Solutions Center.

Webinar Panelists—PM Session

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

This Transcript

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Sean Esterly

Hello, everyone. I'm Sean Esterly with this National Renewable Energy Laboratory, and welcome to today's webinar hosted by the Clean Energy Solutions Center. We are very fortunate to have Eric Lightner, Dr. Ronald Melton, and Rob Wilhite with us to discuss the Pacific Northwest Smart Grid Demonstration Project and Transactive Control.

One important note of mention before we begin our presentation is that the Clean Energy Solutions Center and ISGAN do not endorse or recommend specific products or services. Information provided in this webinar is featured in the Solution Center's resource library as one of many best practices resources reviewed and selected by technical experts.

Before we begin, I'll quickly go over some of the webinar features. For audio, you have two options. You may either listen through your computer or over your telephone. If you choose "listen to your computer," please select the "mic and speakers" option, and that's in the audio pane. By doing so, we will eliminate the possibility of feedback and echo. Now, if you select the telephone option, a box on the right side will display the telephone number and also the audio PIN that you should use to dial in.

Panelists, we ask that you please mute your audio device while you are not presenting. That will eliminate any echo. And, if you have technical difficulties with the webinar, you may contact the GoToWebinar's Help Desk at 888-259-3826.

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So we have an exciting agenda today that is focused on providing an overview of the Pacific Northwest Smart Grid Demonstration Project with an emphasis on transactive control. Eric Lightner will begin the introduction, followed by Dr. Ronald Melton who will be covering the overall efforts of the project introduced in The Basic Elements of the Transactive Control Technique and presenting preliminary results. We'll then have a discussion moderated by Robert or Rob Wilhite, which will provide the panelists with an opportunity to address questions from the audience.

And before our speakers begin their presentations, I just want to provide a short informative overview of the Clean Energy Solutions Center initiative. And then, following the presentations and discussions, we'll wrap up with closing remarks in a very brief service.

This slide provides a bit of background in terms of how the Solutions Center came to be. The Solutions Center is an initiative of the Clean Energy Ministerial and it's supported through our partnership with UN Energy, was launched in April of 2011 as 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, no-cost expert policy assistance, and peer to peer of learning and training tool such as the webinar you are in today.

Solution Center has four primary goals, serves as a clearinghouse of clean energy policy resources. It also serves the share policy best practices, data and analysis tools specific to clean energy policies and programs. 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 innovation around the globe.

Our primary audience is energy policy makers and analysts from government and technical organizations in all countries, but we also strive to engage with private sector, NGOs, and civil society.

Our key feature that the Solutions Center provides is expert policy assistance or known as Ask an Expert. It's a valuable service offered through the Solutions Center with established broad team of over 30 experts from around the globe who are *able* to provide remote policy advice and analysis to all countries at no cost.

In the area of energy access, we are very pleased to have Bruno Lapillone, Vice-President and Co-founder of Enerdata, serving as our expert on Supported Smart Grid Policy. If you have a need with policy assistance on sustainable buildings or any other clean energy sector, we encourage you to use his useful service. Again, this assistance is provided free of charge.

To request assistance, you may submit your request by registering though our Ask an Expert feature at cleanenergysolutions.org/expert.

We also would like you to spread the word about this service to those in your network and organizations. And we encourage you to explore and take advantage of the Solutions Center resources and services including the expert policy assistance, subscribe to our newsletter, and participate in webinars like this.

Now, I'd like to just provide brief introductions to our distinguished panelists for today's webinar. First off is Eric Lightner, Director of the Federal Smart Grid Task Force at the U.S. Department of Energy. And then, 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 after Dr. Melton, we will hear from Rob Wilhite, Global Director at DNV KEMA, where he provides leadership and direction to a worldwide team serving clients with advisory services through utility operations automations, business strategy and markets, and regulatory analysis. Eric, welcome.

Eric Lightner

Well, thank you very much and again, my name is Eric Lightner. I'm with the U.S. Department of Energy and I'm the Director of the Federal Smart Grid Task Force at the department. I'm also the U.S. lead for Annex One of the International Smart Grid Action Network.

This webinar is first in a series of webinars that we are planning in partnership with the Global Smart Grid Federation and it'll highlight many of the Smart Grid projects that are currently within the Annex One Smart Grid Project database that contains Smart Grid Projects from countries around the world that are members within ISGAN.

Today's webinar by the Battelle-led Pacific Northwest Smart Grid Demonstration Project is why many demonstration projects that were funded under the U.S. stimulus funding and today's presentation is again, by Dr. Ronald Melton who is the director of that project at Battelle Pacific Northwest Natural Labs. And there, he is also the Team Lead for the Distribution Systems and the Demand Response Programs at the laboratory. He also is the administrator of the GridWise Architecture Council and he will be giving the presentation today.

Following that, as has already been mentioned, and partnering on this webinar again, will be Rob Wilhite who is part of the Global Leadership, we must say, from DNV KEMA and also an officer of the Global Smart Grid Federation. He also serves as the Board of Director for the GridWise Alliance, which is a U.S. Smart Grid atrophy group here in Washington, DC.

So, as I mentioned, this is the first in a series of webinars that we are planning through ISGAN. And this being the first one, so we are very excited about having the opportunity to present these projects and really start to connect the communities of interested participants that are doing demonstrations and deployment of Smart Grid technologies throughout *the world*. So with that, I just want to, again, welcome everybody to the webinar, and I will turn you over to Ron.

Ron Melton

Thank you very much, Eric. So, thank you everybody. Good evening, good afternoon, good morning, depending on where you are. I appreciate your taking the time to join the webinar today and hear about our project. We are having a great time working on this project, developing a new technology and understanding how it might be useful in our systems of the future.

Before I get into the details of the project, I'm going to spend a little bit of time on some of the motivations for this work and the research that we do here at Pacific Northwest National Laboratory that leads to projects like this.

So, if I could have the next slide please?

So, we here in the United States and many people throughout the world are recognizing a number of challenges opportunities as we'd look at the power system of the future. We have challenges of increasing our asset utilization, making better use of the resources we have. We have new resources been involved in the systems, of course, under the Clean Energy Ministerial efforts. We're looking at reducing carbon for the prints, which means increased, renewable. We, of course, have the challenge of maintaining or increasing your liability in the system toward keeping the cost low and accommodating new potential loads that could *ups* the overall balance and load profiles, little things like electrification of transportation.

So that's our challenge. And the question is, how do we respond to that? How do we take advantage of Smart Grid Technologies to leverage them and create opportunity to meet these challenges? We want to fully engage all of the different resources at all locations, all elements of the electric power systems, to meet those challenges. And this is the fundamental purpose of this technology area that we work in, that we refer to this transactive control and coordination.

When we say use this term transactive here, it represents that there is an economic *comfort* to what we're doing, but as you can see from the notion of control, there's also an engineering aspect. So, we have that coming together of this engineering and economic dimensions to create engineering economic solution. Through that solution, we can coordinate distributed assets, engage domain response, take advantage of resources such as these three generations of storage, and hopefully do that in a seamless manner that integrates well with traditional elements of the power system.

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So, where do some of these come from? Well, historically, you know, the power of system could be operated in somewhat of a deterministic way. On the supply-side, we had generation resources that we would dispatch based on our estimate of what the load behavior would be over the next hour, say. I like to think of this as coming up with the load estimate in setting the dial and pushing the big buttons, and the operators of the Grid would do that over and over again throughout the day working to match mass supply with demand.

The load side, of course, their stochastic are random in nature, but could be estimated reasonably well to supply side deterministic. But that's all changing because we have increased penetration of renewables in the system. We now have significant random works [inaudible][00:12:34] compliment on the supply side.

And so, one of the questions is, how can we take advantage of intelligence that's been introduced throughout the system and intelligence that's especially being introduced in the actual demand side assets as we call them, to engage them in behavioral changes that can help balance the random nature that's been introduced on the supply side so that they can work in concert with one another to help reduce the cost of integration, integration of those renewable asset? And that's again what we're trying to do with the transactive control of coordination to meet multiple set of objectives in coordinating generation transmission and distribution, and to mitigate not only the load variability on the demand side, but also mitigate it in a way that complements the variability on the supply side.

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So, let's have a few definitions here so we can start to talk about things in an orderly way.

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So, I mentioned that transactive has to do with using economic and market-like constructs and transactive control and coordination says let's use those to manage the generation consumption of flow of electric power taking into account reliability because we do that looking at the system from end to end, from generation through transmission, distribution, and now, to end use.

And in doing that, this transactive control and coordination make they do account not only sort of slow time activities such as markets, may operate in intervals ranging from five minutes to out to a day or beyond. And it also may take into account much faster time scale activities are pretty in the milliseconds to minutes strange where we're typically applying traditional control techniques to help its engineering economic solution that you might think of as a transactive network.

We want to do this to help us organize management coordinate potentially millions of assets. If we look here in the Pacific Northwest for example, in the Bonneville Power administration's balancing area footprint. One estimate I've heard is that we may have as much as pretty 500 megawatts of response available just from electric water heaters, 3500 megawatts, 3 1/2 gigawatts, that's a significant resource if we can tackle that resource, if we can get access to that resource.

Now, one approach we could take is the traditional centralized control approach with the direct load control, say. Now, I'm trying to do a direct load control of a million or more water heaters. How am I going to do that? How am I going to manage the decision-making process to say in which water heaters to use at any given point in time, how to spread the opportunity, how a am I to sell to different people with water heaters if then some appropriate remuneration for their involvement in the program and so forth.

We think that problem just comes increasing the complex and intractable, especially if you add in "I want to do that with an optimizing solution so I'm having to run some centralized optimization calculation potentially every 5 minutes for millions of responsive assets. It just doesn't seem like we're going to get there.

So we see more of a need to move into a distributed decision-making process that still respects the boundaries that exist organizationally within the system between both power side and the distribution system operation side and between customers and third parties. So, as we go through this, take a closer look at what that all means.

Next slide please.

So, some of the key constricts that we've come up with for this transactive control coordination are beginning to be described in this slide. First is the notion that we're making local decisions at local places in the power system points in the topology of the system where we can affect the flow of power. Then we call those decision-making point nodes. We'll often refer to those as transactive control moments. Those transactive control nodes in our approach are dealing with two fundamental pieces of information that flowed through the system as forward projections, forward forecasts, if you will.

First is something we call feedback signal. That's the forward forecast of the behavior of the responsive assets in particular loads, but even potentially in the distributed energy resource world, things like storage systems [inaudible][00:17:22] generators and so forth, which we may choose to treat as negative loads rather than trying to model them independent of loads. The second signal, which again is a forward forecast, is an incentive signal that represents the value of the electricity at slowing in the system and delivered to any point in the system.

One of the features that we introduced in our work is the notion that these signals follow the path of electricity in the system. With the feedback signals, roughly speaking, in aggregated up from load towards resource and the incentive signals flowing down from resources or generation towards loads.

The node's job is to set a value for that incentive signal with precision. So, we're not trying to just do a rough approximation. We're trying to come up with a meaningful value that can elicit desired response from the behaviors of the assets attached to the nodes that are served power from that node making the decision. Our key point though is the responsiveness of those other nodes at the points where it's possible to have a response used to be set the nature of the responsiveness set by the node owner.

So for example, if I'm engaging an area heating or air conditioning in a residential setting, the homeowner needs to be able to decide how much they want to respond. If they're in a situation where they can save a lot of money, then they can go for more savings. If they're in a situation where they're having a dinner party that night, say , and they need to make sure the environment is ideal for their guest, they may go for more comfort. We're not going to save money that tonight. We want to have the appropriate environmental conditions. And so, we're going to turn off the responsiveness, perhaps, for the night.

Another key point, because we're talking about these sort of things happening continuously so they can help mitigate things like variability when is that they need to be automated. Well, we can get some benefit from manual responses. We'll get the most benefit from responses for the consumer or the owner of the responsive assets doesn't need to worry about it. Very few people want to get up at 2 A.M. to run their clothes dryer or run their dishwasher, or turn off their hot water heater, or turn it on perhaps, just because that's the time when electricity is the cheapest.

So, next slide please.

So, one of the things we're trying to do through this coordination and through these value streams that are represented in the incentive signal, in the behaviors, and the feedback signals achieve a multi-objective control that linked all of these different values and benefits, and tries to produce a global optimum from local optimization of each of the nodes. And during that, we are trying to address many of these different objectives that you see on this slide except just reducing peak loads, minimizing production cost and prices, dealing with transmission congestion, helping stabilize the grid, freeing up capacity in the transmission system wherever possible for lighting the ancillary services to help manage the system better dealing with fluctuations in the systems for things that we've talked to you yet so forth.

So, this is our broad brushstroke of sort of the background of work that we are doing in the motivations were. Let's take a look now, as we go to the next slide, at the specific details of what we're doing in the Northwest demonstration project.

So next slide please.

So, zero client intervention. This project is one of the 16 regional Smart Grid Demonstration Projects funded by the U.S. Department of Energy and with the American Reinvestment and Recovery Act. This project happens to be the largest of the 16 with $178,000,000 total budget, $89,000 million coming from the Federal Government in the United States, and $89,000,000+ coming from the participants of the project in the funds that they are spending in support of the effort. I say 89,000,000+ because many of them are doing more than the 50% cost required which is all that's represented in the spite of number.

This project has a geographic extent covering the broadly defined Pacific Northwest including the state of Washington here in Green, state of Oregon in the light blue color, the state of Idaho in magenta, state of Montana or part of it in orange, and the North East corner of the state of Wyoming. They are in yellow. Eleven different utilities involved. Two universities and five different vendors or technology participants in the project, started February of 2010 and will end in roughly the same time, February of 2015.

All of the original demonstration projects in the United States have an objective of gathering data in a process defined by the Department of Energy to help quantify the cost and benefits of Smart Grid technology, and we are doing that along with the others. And some objectives specific to our project relating to the development of the transactive control technology in particular are first defined in a set of signals for transactive control and the communications approach to communicating those signals, developing standards, or contributing to the development of the standards to help incorporate the results of the work into the Smart Grid Standards Process and the broader motivation at Pacific Northwest for this is assessing and demonstrating how this technology can help facilitate the integration of wind and other renewables.

Bonneville Power Administration has in its balancing authority the highest percentage of wind penetration against the total generation in the balance of authority anywhere in the United States. So this is an important problem in our region and one of the reasons why Bonneville's a strong participant supporter of this project.

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So, I mentioned Bonneville. They are key part of the project. They provide some of the findings for our work here at Battelle and the Department of Energy supplies the other half. Then, we have the 11 utilities. The utilities range the full set of business miles here in the United States. We have industrial utilities: Avista, Portland General Electric and NorthWestern Energy. We have municipal utilities, in this case, represented by City of Ellensburg, City of Milton-Freewater, Idaho Falls Power, and Seattle City Light. We have rural electric co-ops represented by Flathead Electric, Peninsula Light, and Lower Valley Energy. And we have a construct that's somewhat focused here in the Northwest of a Public Utility District which is also represented in Benton Public Utility District.

We also have technology participants working with us here at Battelle to develop and implement the transactive control technology. That'll include 3TIER, a Seattle-based company that does wind forecast from any of the wind farms in the region; ALSTOM Grid, also a Seattle-based company or element of a larger company that happens to be based in Seattle that does their market management and energy management system models; IBM Research Thomas J. Watson Research Center of New York, IBM Netezza—Netezza, when we started the project was not a part of IBM but was required by them during the project. They supply large-scale data management appliance we're using to manage the data that we're collections.

Last but not least on this list, QualityLogic, which is a company that does interoperability and performance testing that's been completely involved in Smart Grid efforts with its market interoperability panel here in the United States. And I should mention one company that's been a key to the project, but not listed on the list here because they aren't quite at the same level in terms of their relationship to the project, but that's as Sparay (sp?) from Fort Collins, Colorado that is a key participant working with the different utilities and is working with four of the utilities in their *implementation*.

So, next slide please.

So, this slide gives us another way to start talking about transactive control a little bit more detailed. So, if you look at this cartoon representation of the electric power system, we see here different complements, for example, the distribution transformer or the substation, and so forth, that represent places where real opportunities to affect the flow of power where in the cases of those edges of the grids, they were battery storage or the appliances on the far left side of the cartoon, places where it can consume power and can have a particular behavior that we might like to have in that consumption pattern.

So, the two green arrows at the bottom are another representation of the intent in the signals, the incentive signal and the feedback signal. So the operational objective that are flowing from left to right represents the opportunity to [inaudible][00:27:09] incentive signal how a representation of operational objectives in the system. Our approaches to monetize everything that we can and put them into a single signal so that if I'm at any given point in the systems in that distribution transformer, I have incentive signals coming in from all the sources that can feed power to me and that the volume set of incentive signals gives me a representation of the global state of the power system from a supply side point of view.

You might think about what we're trying to do here. Why don't we take the action there at that particular point in the system of applying the old mantra from global climate change of think globally, act locally. That's why I have this representation of the global state in my incentive signal. I will take into account the pattern of predicted behavior representing the status and opportunities that the loads I'm serving, and all, like I said, are local decisions based on that information and take action to adjust the incentive signal to a incentivized behavior for the loads that will be both best for me at this particular location in the system, but also because I am modifying and then retransmitting the signals that have come in to me also representing the ability to respond to the global needs of the system.

Next slide please.

So, this is summed up slightly different way here on this slide. We have this distributed method of transactive control for doing this coordination of these assets wherever they are in the system providing a level playing field for all the different sorts of assets. So if I'm looking, for example, at whether I should try to firm wind with demand response or should I try to firm wind with the gas turbine? Well, both of them have an opportunity to provide an input and respond in this so that might decision making can choose the most appropriate resource at any given point in time.

The incentive and feedback signals summarized here, but the other important thing on this slide is at the bottom with the little box with the arrows pointing each way, the notion that add a transactive control node these signals come together, they flow past each other if you will. They are modified and updated based on the actions that are desired to happen or that will be taken at that particular point in the system. We'll look at that in a little bit more detail as we go through the rest of the slides about transactive control.

So, looking at the next slide, we'll see the notion of the incentive signal a little more detailed. So again, this is a dynamic signal. We update the signal at least every five minutes. It's a price-like signal. It's not literally a price for two reasons: one, because we haven't created a market for this project. We are creating what we might call engineering economic signal. It could be a basis of a market. It could be used for money to change hands, but that's not our purpose here. Here, we're trying to show the ability to use this as an effective way to engage different assets throughout the system. It also is not quite a price-like signal because we're representing unit cost of energy delivered which is not necessarily a complete equivalent to price.

Some of the factors that go into this signal are shown on the slides. We have things like fuel cost, infrastructure cost which it turns out are a little bit harder to represent that might seem at first glance. Constraint cost can be included, factors from existing markets from demand charges from rate tariffs or some things like that can be incorporated. Green power preferences can, in principle, be incorporated. We first have to have some means of incorporating profit for producers and any other factor that we might like to include representing resources in the system that can be included as long as we can come up with a way to monetize it in a reasonable and agreeable way agreeable to the participants in the system.

The resource functions, as we call them, we've actually implemented in the project include consideration of wind, fossil, hydropower, demand charges which are levied by BPA on their customers based on high load hours during the month, transmission constraints, infrastructure cost, transactive energy cost. If there are such things, those would be transactive energy here in the sense of energy exchanges between balancing in authorities and similarly imported energy.

Going to the next slide, we'll get a view of a more detailed here on the transactive feedback signal. So this is a dynamic feedback signal that looks at the prediction of the power that will be consumed by those energy served by a particular node. Exchange between a node and all of its neighbors. There's one important thing that we have to include for any node that has load *served*. And that is an estimate of the inelastic load. Only some loads can respond. There are other loads that are not going to respond, but we need to be able to protect their behavior because we have to look at the total load pattern not just the responsive load pattern.

For the responsive loads and actually even for the inelastic load, this would put it mainly to look at weather, occupancy, and so forth. And for the responsive loads, we have other things like storage strategies or the charging strategies, say for a battery storage system. You may have to take into account practices and policies of the community or regulatory constraints within an investor-owned utility, say. We have to account for demand response action. We have to take into account preferences as I mentioned.

A homeowner needs to be able to have some influence over what happens at any given point in time and so forth. The specific load functions that we have worked on for our project include battery storage, our bulk inelastic load with, I said. All of the different nodes need, building thermostats, water heaters, dynamic voltage control with some of the utilities you're applying in a dynamic form of conservation, voltage reduction, portals, and home displays. Where we may have a person there given the opportunity to respond even though that’s not necessarily the most effective technique. There are still some utilities that may like to do that.

So, next slide please.

So this slide just gives us a general black diagram of what the internals of a transactive node look like. So, you’ll see the two boxes with the function and “L,…” there also represent the overall things that we call toolkit functions, that would be a resource function or a load function that represent how we would develop the response of a given asset. And you’ll notice that those may be operating on the incentive signal or the load signal, or both. The load signal here in the equivalent, the transactive feedback signal I mentioned earlier. We also have the functions in the middle of the slide there that have to do with how we combine multiple inputs of load functions or incentive signal functions.

On this slide, you see a single signal going out either direction of the incentive signal and load estimate. It’s a single signal because we only do one calculation. It’s actually sent to all of the neighbors. So there are multiple pads out versus there are multiple pads in, and they will be the ones that *were in correspondence* between those. This is a very well defined set of operations that one of these nodes does. We have an object model, a state model, finite-state machine model of the behavior of one of these nodes. And so because it’s very low represented in that way and because it’s conceptually really quite simple, it’s highly scalable and highly replicable that can be applied at any point in the system that we think in the transmission distribution of generation or loads.

So, next slide.

So now I want to go through a simple example with you to try to sort of crystallize some of the concepts we’ve been talking about, make them hopefully more evident and clear. Let me say this is a hypothetical example. It’s not something that we’ve actually implemented on the project, but it’s a representative of what we are implementing on the project. So in our example, I want you to imagine the following situation.

We have three neighbors. They all own electric vehicles. They all have a different approach to how they want to charge their vehicles. We’ll see more about that in a minute. There, I say, in a cul-de-sac at the end of a street, all three fed by the same distribution transformer. And in our example, there are all three going to be coming home in the evening and they’ve got a plan that they’re going to reveal to us about how they want to charge their car that evening. They’re all going to want to do a fast charge roughly at the same time, not absolutely the same time, but certainly within about the same time window.

Now, the problem of course is that if they all three do a fast charge at the same time, our distribution transformer which wasn’t sized for three electric vehicles in the neighborhood is going to start to have a problem because it's going to be overloaded. And so what are we going to do about that? And you'll see that as we go through the example.

So, the transactive control solution to this has to do with the feedback signal which is the way the cars inform the transformer of what their plan is, and the incentive signal which is how the transformer informs the cars of what the results of implementing their plan would be in the negotiation that takes place, if you will, between that exchange of information in the incentive signal and the feedback signal as they flow back and forth between the transformer and the car chargers.

So let's go to the next slide.

So here, we see the charging strategies. House #1, they are flexible. They're willing to adjust what they're doing. They'll be willing to accommodate a variable charging rate, for example. House #2, not flexible. They are the antithesis of flexible. They want to charge now. They don't care what it costs. When they plug in their car, they expect it to be charged as quickly as possible. Don't trouble them with our problem. They got their own problems. And House #3, as we could say here in the United States, they are the Wal-Mart shopper. They want a bargain. They're going to be willing to modify their plans to find the best bargain available.

So, now let's try to see the situation before we have the cars on the next slide here. So, here we have in the top line, the orange line, that's our transformer limit. So, we got a 40 kilowatt transformer installed and if we go above that 40-kilowatt limit, we're not going to blow the thing up, but we are going to start to have noticeable degradation of its service life. And that's going to be the basis of how we decide the changes that we want to make in the incentive signal to help recover the cost of uploading the transformer should that happen.

You see in the middle there, the signal with the little crosses on it, the value of the transactive incentive signals through this evening period represent just a normal increase in load. These people are running their air conditioners or things like that, that happen in the evening. And then at the very bottom, we see the current total load for the three houses in the absence of charging any cars.

You see on the left scale, the kilowatts is *preceded* with the loads and with the transformer threshold that you see on the right, the price dimension. So we see here the signal range in between four—roughly three-and-a-half to about $0.07 to a kilowatt hour. It should be somewhat typical real time price signals here in the Northwest if we had them.

So, go to the next slide and we'll see the first house reveals its plan. And its plan is to start charging that 4 P.M., 1600H, and charge for two and a half hours. It’s at point kilowatt to charge for a fast charge, and so we see then the bump up in the total load for the three houses results in that. Now, we’re not going to see the changes in the incentive signal until all three houses reveal their plans and then the transformer will respond.

So, next slide.

We see the plan of House 2 build now. So it wants to start charging at 5 P.M., also go for two and a half hours, also adding 20 kilowatts. So now, between those two, we already had some load we had to accommodate. So we had plan 20 hour *up* over 40 just because of the normal load that we had for the three houses, and we’re up over 24 about an hour and a half here if I’m looking at my scales right—maybe it’s just an hour? But anyway, we’re overloaded already and we haven’t even taken into account the third transformer. Let’s see where the third car—let’s see what happens when he comes in.

Now you see we have also a 20-kilowatt charge for two and half hours, starting now at 6 P.M. We’ve got a half hour in the middle there—I think it’s half an hour—where we’re overloaded significantly. We’re overloaded by 20+ kilowatts for that half an hour and the transformer is really going to be unhappy about that. So let’s see how the transformer responds on the next slide.

And there we go. The transformer says “Okay. You know, as you’re starting to overload me, I need to increase my cost signal by just costing money for you to overload me.” And so, we’re going up from, you know, from down in the range of about $0.06 a kilowatt hour up to over $0.18 a kilowatt hour for a while, and relatively speaking, a lot of money involved. And now, it’s the cars turn. The cars get a chance to respond to what the transformer says is going to happen if their plans are executed.

Let’s go to the next slide.

House 1, takes a look at this situation, says “Oh, I don’t like this at all when the price is way high. I mean, I’d just go into a flex-charge mode. I’m going to cut my charger even at half and I’m going to extend it out further in time, and I can live with that. So, that’s my plan now.”

Let’s see the next slide.

House 3 responds, says “Hey, I don’t like any of this, you know, higher cost stuff. I’m going to move out further in the evening when the cost aren’t so high.” Now, you noticed, we skipped here from House 1 to House 3. House 2 didn’t respond. Remember, I said they don’t care. They’re going charge no matter what it cost. So, we now have a revised plan based on House 1 and House 3 responding.

Let’s go to the next slide and see the response of the transformer.

The transformer comes back. Now, the high price of around $0.18 a kilowatt hour, you see, has gone down. It’s down now maximum of around $0.12 a kilowatt hour and it’s only for a short period of time, and then it gets back down into the normal ranges. For purposes of our example, we’re going to say the negotiation has ended here, that the cars see this and they don’t offer a change in their forecast of their behavior, and so the intent of signal has no reason to change. So we basically reached the end of our negotiation.

One of the tricks, of course, is in the algorithms to have the algorithms have damping factors, if you will, that caused the negotiation to converge and also that represent that we’ve reached the stable point in the system now. We basically come to the equivalent and it is where a double auction market system of a market closing we’ve agreed on our price over time and we have no reason to perturb that unless new information is introduced that will change either the constraints on the transformer or change the significant pattern of load behavior. In which case, we would have to go through another negotiation cycle.

So, this was a hypothetical situation. Now, let’s take a look at how we’re applying this in the Northwest Smart Grid Demonstration Project.

So one of our challenges in the Northwest Demonstration Project is that this being new technology in the research project, Bonneville Power Administration wasn’t ready for us to try to apply this directly in the current transmission system and both power system in that region. And still, we’re modeling that part of the system. That’s where ALSTOM Grid comes in with their market manager and energy management system models. And we chose to develop those models so that we could create a transactive incentive signal to feed the utility participating in the project that would be an approximation to the signal they might see from a transmission substation feeding their utility or a particular set of sites at their utility.

So, we broke down the region into what we call transmission zones based on cut planes that define sort of electric regions in the system according to the way Bonneville manages it. Cut plane is represented by the red lines on the diagram and the flowgates represented by the double-arrowed blue lines representing the major *lumped* power flows between those regions. So the crossed regions represent large copper plain electrically connected logically here in the model.

Going to the next slide.

We see this translated now into a set of transactive control nodes. So each of the gray nodes that has a title, for example, in the upper left there of Northwest Washington or just below that, Western Washington, the West Washington, represent the different transmission zones and the balancing authorities to some extent that are within those transmission zones.

Inside of the bluish boxes in white are the representation of the transactive control nodes of the utilities involved in the project. So you see two of those, for example, in the West Washington zone you see one, down in the Western Oregon zone in Salem. Over in south Idaho, you see two: one at Lower Valley Energy and Northwestern Wyoming, and one at Idaho Falls Power there in the middle part of eastern Idaho.

So, going on to the next slide.

You'll see the way we do this regional modeling. We have a variety data that is fed continuously from Bonneville Power Administration including load forecast in recent schedule, outages or outage forecast and so forth, into the ALSTOM model. In parallel with that, from 3TIER, our variety of renewable generation forecast for the different wind farms on the region. So this gives us an influence of wind variability into our signals. ALSTOM takes that into their market management system and energy management system models and works on the overall power flow in the region.

To create for us, as much as possible, a set of signals similar to what we would get from the actual transmission system where we are able to tap into it. This runs in parallel with the real system and is trying to approximate that state of the real system as closest as possible with the information we have.

Going to the next slide.

We see then the ALSTOM Grid models and with these outputs that would represent the local conditions, if you will, within the transmission zone of feed to each of the individual transmission zone transactive control nodes. So, you see those. Here, we have, for example, Zone 5 and Zone 14 represented. Those nodes are operated here in our facilities at Battelle, and they create the transactive incentive signals that are then sent by us to the individual utility nodes that are operating within the facilities of the utilities themselves.

And so, we have three of those nodes represented here on the slide, Portland General Electric, Lower Valley, and Idaho Falls. Those nodes then are connected to the specific responsive asset systems that the utilities have brought for the project. To participate in this project, we ask each of the utility to identify a specific set of responsive assets that they would be willing to engage with the transactive control system. And that varies from utility to utility. Quite common in the project are utilities using existing demand response technologies such as direct load control rather than operating that system with a manual dispatch, say, we've done in the past, they then would operate that system based on a control signal coming from the transactive control node.

Going to the next slide.

I mentioned this already, but I want to mention it one more time. We formalize the transactive control with a formal model. It's a state machine model and it's been documented and defined in a way that it's highly scalable, it's based on specific algorithms, and it got specific support for interoperability both at the syntactic and semantic levels through their definition of the transactive control signals such as transactive feedback and transactive incentive signals, and also interoperability through much of the implementation being based on ISO/IEC 18012, which is an interoperability standard that comes out of the home energy management system world, but is broadly applicable to other energy management systems.

Through that use of that standard and the other techniques that we've used in the XML schema definitions for the signals, for example. The standardized approach provides a toolkit and the reference implementation of that toolkit with well-defined interfaces that the utilities can use the interface to whatever type of assets systems they may want to bring to the table and a common set of algorithms approaches for determining this control signals.

So, let's go on to the next slide now and start to take a look at what some of this looks like.

So, what I got here on the left is a major load signal from Lower Valley Energy. This is the inelastic load estimate or the overall load estimate for their utility, the transactive feedback signal if you will. And on the right is the prediction of that load from the toolkit algorithms that we implemented with them. And so you can see there's a reasonably good comparison both in scale and in structure, temporal shape of this. The other thing you see here plotted on the screen with the different colors representing different points in time for that load estimate and you can see the further out in time we get the cruder [inaudible][00:51:10] we get, but we still get a good overlay of the predictions as time is moving on and we're creating a new prediction every five minutes.

Now, going on to the next slide.

I want to show you an example of a combination of functions in the system when a resource function at the utility level—and this is the resource function that provides an ability to respond to Bonneville Power Administration demand charges that the utility faces. So, demand charge in this case, is levied on the utility retrospectively looking at the months after the months ended and setting a threshold based on average load, and determining a load charge based on the highest load hour of the high load day during the month.

So the utility, if they can avoid this charge depending on the size of utility and their contact with Bonneville, maybe able to save significant amounts of money. We are talking about, potentially, several hundred thousand dollars over the course of the year for utility. It's the large utility potentially even more. So the challenge here is, since we're doing this prospectively not retrospectively, to be able to have an algorithm that can look at the predicted load pattern, detect through the activity in that data load pattern that once approaching a high load hour and then take action through changes in the incentive signal, to incentivize the response of the assets to respond to that situation to reduce load and avoid that high load hour.

So we see here the view of the load estimate side in the transactive feedback signal, and you see the orange arrows point where we've identified a high load hour potential as we see an increase of the load when above a threshold. And there, we indicate down below, where you see the second set of orange arrows, that we've identified an event where we wanted to avoid demand charges.

Now, let's look at the other side on the next slide, which is the view of it from the transactive incentive signal.

So the transactive incentive signal is the blue signal that's on the first plot there at the top half of the screen, and that incentive signal is gradually growing up as we see the transactive feedback signal climbing. And we have a threshold that we are relaxing slowly, slowly, slowly through time. And you see here we started at the beginning of December and we're going through the whole month. So that is slowly coming down to making it easier for us to find a peak, and it's found one finally as the incentive signal has climbed as we saw a high load hour developing. It hits that first intersection of red with blue and like below that, you can see some events. It's a binary event. It's basically is at zero or one because we're in looking the demand response system here of water heaters. And so we see which of that event being the amount of time that the water heaters are engaged.

And then you see the threshold climbs up. So we send the threshold up a little bit, we let it drift down until we hit another event. Now, after our second event—our third event actually—we increment even more and we gradually increment even more because we have a total here of five events that were allowed in this particular program. And so, we're making it harder and harder as we go through the months to hit an event we had another one so that we end up not missing an event, but also not having more than five events in the total month. You see here, on this slide, the parameters of the events at this utility that control the amount of the settings for this algorithm at its specific utility.

So, going on to the next slide, what I want to do now is just quickly go through some of the things that are actually happening at the different utilizes and how they relate to our overall progress.

So, next slide.

This slide gives you a feel both for the different categories of assets the different utilities have in the table, and also on the right hand side, sort of the range of investment and responses that we have available to us in the project. So you see, for example, here with Avista, they have a range of things including conservation voltage reduction or CVR, some building commercial demand response, in-home displays, programmable thermostats and distributed generation. Those are transactive control-enabled assets. They also have some general purpose Smart Grid assets in the form of our transformers that they are installing which they are, by the way, finding some significant benefits from in terms of their ability now to have a distribution, automation system and a distribution management system that has capabilities they didn't have before they help manage operational cost.

One of the other notable utilities here is Idaho Falls. As you can see, they have quite a breath of activity going on. And I'd like to point out we have several utilities with storage here ranging from some kilowatt little storage at Benton PUD, Idaho Falls, and Lower Valley, up to a five-megawatt battery storage system at Portland General Electric, which is stocked with distributed generation and Rooftop photovoltaics to create a micro grid that they can automatically island and provide a higher liability zone, but also, they can use that storage system to respond to wind signals to a charge and discharge the loss at wind variability.

Going to the next slide, we've got a few pictures for some of these. So you see some of the line monitoring equipment for NorthWestern Energy here. This can help them with the conservation voltage reduction and reliability. You can see the City of Milton-Freewater here, which updated a demand response system they've been using for almost 28 years to avoid BPA demand charges. They also installed automated metering infrastructure, advance metering infrastructure, University of Washington who is working with students in the dorms to do some floor-to-floor competitions with engineering students using energy management devices such as portals and displays listed here to help manage energy in the dorms.

Next slide.

We see Lower Valley Energy here with some small scale local renewables and battery storage system controller shown in the rack. Flathead Electric working with General Electric with some Smart Appliances. Idaho Falls, the only ones what have the electric vehicles in the project you can see a Chevy Volt there in the picture.

Next slide.

Peninsula Light which has water heated demand response units. This actually came in very handy early in the project for Pen Light. They were doing their experiment on an area known as Fox Island, which is an island that's served by them by a submarine cable with a small cable. It goes across a bridge leading the island. Their original submarine cable filed early in our project. They were able to use the water heater demand response units to help manage the load on the islands to get by with a jury-rigged temporary cable and the existing small cable on the bridge while they put on a new submarine cable.

Shown under the Benton PUD picture here on the right is a Manchester, which is a battery storage system about a 20-kilowatt size. And then Avista with part of their concentrating communication system that, I believe, is part of their master network that [inaudible][00:59:27].

Going to the next slide.

Just a sort of recap, the objectives and where we are. We got a significant amount, you know, $77,000,000 of Smart Grid equipment that's been installed by the utilities that does provide a foundation for regional Smart Grid. We've got two main communications and signals developed to support transactive control. We're using public internet for the transmission of the signals between Battelle and the utilities. Once they get to the utility, the utilities themselves use a variety of techniques to communicate within the utility to their asset systems.

We've got the experiment taking place on—illustrate how we can help support integration of wind and the results of the implementation efforts are being put into forms that are suitable for taking in the standards development organization then, helping facilitate our future development our latest market standards. And finally, we've collected over 120,000,000 data records now that worked the data that will help provide cost-benefit information.

Going to the next slide.

That data comes from the different test cases or experiments that went on in the project that are summarized on this slide. We have three main categories, transactive control test cases, reliability test cases, and conservation and efficiency test cases. The latter two categories not being responsive to transactive control signals, but just being allocations of Smart Grid Technology. Several of the utilities were also doing some social experiments looking at customer response to different programs, or use of social media, things like that.

Next slide.

This picture summarizes looking at the different objectives where we are in the overall lifecycle project. You see our "now" bar. We're almost halfway to your data collection analysis period. We've spent a considerable amount of time in this period validating and testing the transactive control technology that turned out to be extremely challenging to model the regional system with the ALSTOM efforts.

So, we spent a lot of time getting good data flowing in that system that will drive the transactive control experiments. We've been collecting data on the non-transactive aspects, the different major Smart Grid equipment benefits since October last year. We've been engaged in the different standards processes and we'll continue to be, and looking at, of course, as we look at the results and analyze the results, how we could support integration renewable resources.

Next slide.

Looking beyond the project. When we get to 2015, we'll have just under 100 megawatts of distributed responsive assets engaged and responding. We'll have validated transactive control technology. We'll understand the benefits and possibilities for using that as a means of balancing intermittent renewable resources. We'll have a good base of smart grid equipment installed at 11 utilities.

And beyond the project, we're also looking at how do we scale it up to more assets in the region. How do we get other energy service providers? Distribution organizations involved were already actually doing that. How to transition it from a research develop project to an operational project, you know, who would operate it? What would that mean? What does that look like? How does that relate to Bonneville Power Administration and their operations, for example? How do we operationalize this technique for balancing authorities, Bonneville, or others? What's the regional value and what is the value stream that has or exists for the distribution utilities?

One of the aspects of this project that I didn't mention yet is this regional nature. This is one of the only project if not the only project that is looking at how do we integrate the ability of multiple utilities to provide a response that can be used regionally provide a regional benefit whether it's wind integration or other regional benefits. And it's the coordination of that response across the regional utilities that is at the heart and soul of this project.

So, with that, on the next slide I have the acknowledgement, of course, of the funding that's supplied by the department of energy for this work and the disclaimer, of course, that says that this work is based on that Department of Energy's support, but it's our results, not the Department of Energy's results that are being presented, and our opinions are not solely of the United States Government or the Department of Energy.

Finally, on our last slide here, I have my contact information. I'm more than happy to answer questions or our project team, which is a great team and I'm privileged to work with all of them, they will help answer those questions. Also, we have our project website, www.pnwsmartgrid.org, where we regularly put those information. It's got a background information on the technology, of annual report, quarterly newsletters, and different summaries of the activities of the different participating utilities and technology companies.

So with that, thank you for your attention. I am going to turn it over to Rob who will now moderate the Question and Answer session.

Rob Wilhite

Ron, thank you very much. This is Rob Wilhite. I'm with DNV KEMA, but as Eric Lightner indicated at the beginning of this webinar, we are doing this as a collaboration between the International Smart Grid Action Network and Global Smart Grid Federation, which I am here representing today. And it's truly—as I look at the attendees—a truly international presentation as it was in this morning. In fact, we have representatives from both sides of the international datelines who I think were struggling both Wednesday and Thursday here in this webinars. We're accomplishing several important milestones.

Ron, I have a nice cue of questions that has developed during the presentation and I'm really interested in hearing your response to some of this very powerful questions. So, let's step right into it. The first question comes from Tom Bialek from Sempra Utilities in San Diego. And Tom, I'm going to combine a couple of these questions. He actually had four questions. I'm going to combine a couple.

First of all, since this is a voluntary process, transactive control is handling or has to handle stochastic responses from consumers in this regard. So, how is that being handled and how do you handle the potential for insufficient load reduction?

Ron Melton

Well, let me tackle that Tom. Those are great questions. So first of all, because we're not doing the load prediction from a traditional sort of loaf forecast model approach, we actually, to the greatest extent possible, would be doing load prediction based in empirical data being fed from the loads themselves. This is my plan of what I intend to do over the next 12 hours or 24 hours. So, we would see some hopefully mitigation of the variance, if you will, on that load estimate being reduced by having it driven by data coming from the loads themselves.

Now, in our project, we're working just to that interface. So we do actually have to do a calculation based on the sort of gross behavior of that utility, but driven down into a utility down at distribution feed or *wherever* we have e have responsive assets at the individual premises along with feeder feeding in to that estimate, that estimate being aggregated up and up the feeder and up, up, you know, for multiple feeders at the substation to the utility. We should see a reduced sort of variance and variability be associated with the estimate.

Let's see. Rob, remind me of what the second half of the questions was because I've forgotten it.

Rob Wilhite

And let me combine it a little bit with a question from Mark Patterson in Australia on the other side of the dateline, which is in the—let's go to the example where you have three electric vehicle charging at occasions with different responses.

Ron Melton

Oh, what if you ran out of response, I recall.

Rob Wilhite

And is there a penalty associated that consumers going ahead and charging immediately will may say they're to be charged for instance?

Ron Melton

Well, that's a great question. So at this point in the development of the technology, we haven't chosen to apply a formal market structure mechanism. And so, we don't currently have a penalty defined in the system. Should there be a penalty defined? Probably. Would it benefit from a formal market closing where you now have a contractual sort of relationship between the consumer and the supplier? Possibly. That's one way of invoking that sort of a process.

Well, what we expect at this point and it's largely, I think, one of the reasons why you really want this to be all automated, is that if you have automation with vetted algorithms in the automation, you should be able to reduce the opportunity for people *that gain* the system while it's not perfect it would within the next five minutes personally pick up the change in plans and within the next coming five-minute intervals see a renegotiation of the process so you would, in principle, you're only at risk for unplanned behavior for a five-minute window.

Now, what you do—what if you don't get enough load reduction? Well, in our transformer example, you saw that the transformer was willing to serve power up to the point where it was recovering the cluster replacing the transformer early. What if the transformer been even further overloaded or would have failed in that situation? Well, the price would have gotten really high at some point. One then has no argue whether you go ahead and let the transformer fail or whether you implement a reliability control there that kicks in and comes to the systems transactive control *approaching* sort of overrides the fact that you weren't able to come to a negotiated agreement. And that's certainly something that is still in the research part of the technology.

Rob Wilhite

Ron, let me come back to the second question form Tom Bialek. We will show this around. How do you get the incentive signal transmitted down to a single transformer and what additional granularity can the system be applied to beyond that?

Ron Melton

Well, the simple answer which I hope isn't oversimplifying Tom is as you send it, the signal from the point that serves it, where you can affect the flow of power which would presumably be either a transformer upstream in the feeder or the substation depending on your configuration, of course.

The granularity, in principle, this could go down to the individual appliances in your house that could each be a transactive control node.

Practically speaking, I don’t think that’s necessarily the most effective way to influence the technology. So, I would, from a practical point of view see this as having edge nodes that would be energy management systems in residential settings, in commercial buildings, especially large commercial buildings, were actually already working, exploring, how one applies this technology inside the building itself so that you’re not only having the building able to respond as a transactive participant in its relationship to the grid, but within the building using similar techniques to balance the use of energy resources in the building to achieve the building’s energy management objectives.

Rob Wilhite

Great. Ron, Thank you. Another question comes from Yochi Glick at Ericson, and Yochi is asking, what about consumers rooftop PV systems? It seems like the architecture of this system might be inconsistent with feedback incentives and customer source directional flows that you have presented. Can you address that?

Ron Melton

It doesn’t have to be incompatible. If you consider the rooftop PV system and the consumer making the decision whether at this point in time it’s more economic for me to feed into the larger system or to just use the power myself, then that’s the whole idea. We’re trying to optimize the selection of resources so you selected the best resource to provide power to meet the needs of the consumers of power and the system at any given point in the system. So you know, any decision that you can think of that the consumer might be trying to make about the behavior of their rooftop system at any given point in time, as long as you can put it in economic terms, then a transactive control node could be contributing that rooftop PV system as a supply point. It just happens to be on the normally a consumption side of the system rather than on the normally supply side of the system. So, not inconsistent at all. If you were to think of it in terms of a battery storage system in the house, especially if it was *a couple* of rooftop PV system. You know, you’ll be making system decisions for the battery storage system. What’s the time to charge, discharge, or .do nothing?. What’s most economically advantageous for me in my participation in the system?

Rob Wilhite

Great. Another question has just appeared from Anna Gonzales. And Anna is asking, will customers be able to know the source of energy they are consuming from, whether it’s wind energy, high drill, etc.?

Ron Melton

In our formulation of things, no. We’re really not trying to do some sort of green labeling or something like that, but through the constructs of the way one treats the impact on the incentive signal of different resources, one can affect the blend of resources and that has to do with the economics and the economic strategy associated with a different resource.

So, for example, if you’re trying to incentivize the consumption of wind, and one example here would be I could have a general operating principle that I want to consume wind to those locations in the topology of systems that are closest to the wind generator then, I can do that through the way I treated the price of wind coming into the system. I need to construct my economic so at the end of the day my wind resource owner is able to recover their cost and make the profit, but I can do that through a nonlinear curve that’s related to the amount of wind that’s available right now that when wind is abundant, it has a relatively lower cost of wind compared to other resources and lets them integrate over time and recover their costs effectively still. So I can’t—back on a labeled the electrons, but I can’t certainly affect the—sorry about that—I can certainly affect the behavior of the systems so that I incentivize the consumption of those green electrons.

Rob Wilhite Hey, Ron. Let’s talk for a minute about some of the barriers we’ve seen through group modernization in the U.S. and parts of Europe, and elsewhere. One of which is the protection of privacy and data security. And mentioned you’ve got something like 120,000,000 data records already collected through this demonstration project. Can you speak to leading practices that are being applied by the by the 11 utilities in this demonstration project relative to this topic?

Ron Melton Yeah. There are a couple of different answered to that. First is just the basic cyber security dimension where we use industry best practices to control the integrity and the security of the data communications pathway between us and the utilities. That’s pretty straightforward really. There’s a good existing technology for that.

On the privacy side, the question is—oh, the response to the question is, this is one of the reasons why we believe in keeping the simple signals very simple. Reducing the amount of information that needs to be supplied to that information is needed to affect behaviors in the system.

So, as you saw even in just the simple example with the cars, the only point that somewhere that anybody would see the individual load behaviors of those three car charging activities is at the distribution transformer. Yet, at the levels above that at the substation or at the utility itself, other than their billing records which of course they’re going to have anyway, they wouldn’t necessarily have seen the individual behaviors of the charging stations and certainly in the transactive feedback signals that flows out because that’s all aggregated individual behavior sort of obfuscated. In our 120,000,000 data records I’ve mentioned, for example, we’ve worked carefully with the utilities to make sure that we have no personally identifiable information. So we do not know where the individual date points came from.

Now, in a research project like that, that can sometimes mean having to remove data about meter locations and things like that. In the application of this technique more broadly in a production system rather than a research project, that type of information wouldn't even necessarily be needed. One of the points that is worth mentioning though is our cyber security and other implications because when you take a technology like this, and if we put and actual market in *play* with this economic engineering signals that the money was changing hands, there would be a need to have activities that would be policing the system to make sure that nobody was gaming it to make sure that proper accounting was being done so that the settlements can happen and in that case, to the extent that there was any private information there, it would have to be properly protected.

Rob Wilhite

Ron, one of the upper key enablers to grid modernization is certainly with the regulators themselves. And so, the question that comes in from Mark Patterson in Australia is, what level of engagement and feedback is the project team receiving from regulators at this point?

Ron Melton

So, we have got mostly interaction with regulators in the state of Washington. The three investor on utilities have their own particular reactions with the regulators that they deal with one of those, Avista is a Washington State utility so they interact with the same regulatory body that we've primarily interacted with as a project, a level team. The regulators at this point are very interested in the technology. They're watching it closely. They need to see and understand the value propositions associated with the technology especially from the point of view of the distribution system operator in the potential impact on customers.

One of our key interests and I guess I'd say philosophies around this is that those value streams have to be able to be very well identified. We believe this particular type of approach because it can achieve multiple objectives through the integrated signal and the incentive signal, and the feedback signals, the value streams need to be aligned so that whatever value the distribution utility is realizing, can be shared with their customers and likewise, whatever value the transmission system operator maybe realizing through the actions of the distribution utility can be shared with the distribution utilities so that there's a clear and transparent identification of those value streams. So the things like the regulatory questions can be answered directly and I have to be all in for it or just hypothesize.

Rob Wilhite

Ron, we've successfully exhausted the cue of questions to this point. Let me perhaps just ask you one last one which we discussed earlier this morning which is, can you speak to commercial viability of the hardware and software elements and the architecture being used for this demonstration project?

Ron Melton

So, the commercial liability, there's a couple of different dimensions to that. One is the responsive asset sort of technology at the utilities. That's all existing technology of today. Now one of the problems we have with ideas that most of the demand response technology the data were entered towards load *charting* and the intensity event driven. And to really fully support the integration of renewable, one needs to be able to have a more continuous response rather than a vent driven response and one needs to be able to both add and *shred* load depending on the nature of the renewal variability at that point in time. So there's a potential opportunity and challenge there I terms of more sophisticated load response technologies.

Now, one of the other challenges is that we have in implementation of the technology, we've created a reference implementation and tool kit as a part of the research project. That certainly provides a starting point for a commercial office availability of the transactive control technology, but it's certainly not the endpoint for that.

So there is a technology transfer of path that has to be defined. My personal preference in that would be to have a core platform defined into which one can plug the functional elements such as the demand charge of avoidance function that I showed you an example of. You could see those decision-making algorithms in the system, I'll pick on the question we had about the rooftop PV for example.

So if I'm a homeowner I'm working or I'm served by utilities that's got transactive control implemented, I have a transactive control node helping me manage my rooftop PV system, but I want to optimize my personal return as the homeowner who's invested in that. Well, if I have the platform that gives me the transactive control possibility, I want to be able to go out just like you can go to the Apple app store and pick the best app I want for doing what I want to do with my iPhone. I want to be able to go to the transactive control app store and pick the best app I can find for my PV system to optimize my return on investment for my PV system.

So that's where I think the real commercial opportunity is going to be in the sort of entrepreneurial opportunity this getting the platform out there that enable what I like to think of as smart grid applications and then letting the entrepreneurs go out at developing the best demand charge avoidance function or the best PV integration function, or the best smart car merging function or whatever it might be.

Rob Wilhite

Ron, there's a lot of possibilities here both in terms of the commercial, hardware, software, and even new business models so, very exciting. We are running up against the last few minutes of this webinar and as your moderator, this is Rob Wilhite, you've been listening to Dr. Ron Melton. And I'm going to now turn it over to Sean Esterly who is going to take care of the rest of the details of this webinar. Thank you.

Sean Esterly

Thank you, Rob and thank you, Ron, for the great presentation. Any relevant questions that we're asked and we didn't get a chance to answer will definitely be emailed to the panelists so that they can provide their written response. And now, before we take our quick survey, I just want to provide the panelists, Eric, Ron, and Rob, with opportunity for any closing remarks or any additional statements? [overlapping conversation]

Eric Lightner I would just like to thank everybody for tuning in to the first webinar in a series of webinars here with partnership between ISGAN and the Global Smart Grid Federation. I hope you found this presentation interesting and I hope you will want to tune in to the future ones in the near future. So again, thank you and again, thanks to Ron and Rob as well.

Ron Melton This is Ron. I want to thank Rob for moderating and Eric for the opportunity to do this presentation, *to give way* for their support and I thank all of you for taking the time to join us today and did hear about our project. We’re very excited about it. I’m looking forward to the future seminars and hearing about some of your projects.

Rob Wilhite Yeah, Rob Wilhite. I want to state my thanks as well to my fellow panelists and to all of you, and some great questions that came up in the cue. So, glad to be able to present those to Ron and put him on the spot. So, on behalf of the Global Smart Grid Federation, thank you very much.

Sean Esterly Great. Thank you again, Eric, Ron, and Rob. Now, we’d like to ask our audience to just take a quick minute to answer a survey on the webinar that you viewed today. We have three short questions for you to answer and your feedback is very important. It just allows us to know what we’re doing well and where we can improve. Heather if you could go ahead and display the first question.

The first question is, the webinar content provide me with useful information and insight. And next question, the webinar’s presenters were effective. And the last question is, overall the webinar met my expectations.

All right, thank you everyone for answering our survey. And on behalf of the Clean Energy Solutions Center, I’d like to extend thank you to all of our panelists, Eric, Ron, and Robert, and to our attendees who participated in today’s webinar. Great audience today and we are very much appreciating your time.

I invite our attendees to check Solutions Center Website over the next few weeks that you’d like to view the slides and look into our recording of today’s presentation. And we also have previously held webinars available on there. Additionally, you will find the information on any upcoming webinars and other training events. And we also invite you to inform you colleagues and those in your networks about Solutions Center Resources and Services including the no-cost Ask An Expert policy support.

Have a great rest of your day. We hope to see you again in future Clean Energy Solutions Center events. This concludes the webinar.