CLEAN ENERGY SOLUTIONS CENTER
ASSISTING COUNTRIES WITH CLEAN ENERGY POLICY

The SmartSacramento Smart Grid Project

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Sean

Hello Everyone. I'm Sean Esterly with the National Energy Laboratory and welcome to today's webinar which is being hosted by the Clean Energy Solutions Center in partnership with the International Smart Grid Action Network also known as the ISGAN and today's webinar is focused on the SmartSacramento Smart Grid Project. One important note of mention before we begin our presentations is that the Clean Energy Solutions Center does not endorse or recommend specific products or services. Information provided in this webinar is featured in the Solutions Center's resource library as one of many best practices resources reviewed and selected by technical experts.

And for the webinar features you have two options for audio. You may either listen to your computer or over your telephone. And if you do choose to listen to your computer, please select the mic and speakers option in the audio pane. Doing that will just help eliminate the possibility of any feedback and echo. And if you choose to dial in by phone please select the "telephone" option in a box on the right side will display a telephone number and the audio PIN that you should use to dial it in. If anyone is having any technical difficulties with the webinar, you may contact the GoToWebinar's help desk at the number displayed at the bottom of that slide. That number is 888-259-3826.

And so we encourage anyone from the audience to ask questions at any point during the webinar.

And to do that simply type your question into the question pane and it'll be submitted to me where I can present it to Jim during the question and answer session following the presentations. If anyone is having difficulty

viewing the materials with the webinar forum, you will find pdf copies of the presentation at cleanenrgysolution.org/training and you may follow along as Jim presents. Also an audio recording of the presentation will be posted to the solutions center training page within about a week of today's broadcast and we're also now adding webinars to the solutions center YouTube channel where you'll find other informative webinars as well as video interviews with thought leaders on clean energy policy topics.

Now today's webinar agenda is centered around a presentation from our guest panelist Mr. Jim Parks and Jim has been kind enough to join us to provide an overview of the SmartSacramento project and lessons learned throughout the project as well as interact with audience during a question and answer session. And before our speakers begin their presentation I just want to provide a short informative overview of the clean energy solution center's initiative. Then following the presentations is when we'll have the question/answer session followed by closing remarks and a brief survey.

This slide provides a bit of background in terms of how the solution center came to be formed.

And the solution center is one of thirteen initiatives of the clean energy ministerial that was launched in April of 2011 and is primarily led by Australia, the United States and other CEM partners.

So now comes to this unique initiative include support of developing counties and emerging economies. Through enhancement of resources on policies relating to energy access, no-cost expert policy assistance and peer-to-peer learning and training tools such as the webinar you're attending today.

And there's four goals. Four primary goals for this solution center. The first goal is to serve as a clearinghouse of clean energy policy resource. Second is to share policy best practices data and analysis tools specific to clean energy policies and programs. Third is to deliver dynamic services that enable expert assistance learning computer peer sharing of experiences. And then lastly the center fosters dialogue on emerging policy issues in innovation around the globe. Our primary audience is energy policy makers and analysts from governments and technical organizations in all countries and we also strive to engage with the private sectors, NGO's and also civil society.

And so this slide shows one of the marquee features that solutions center provides which is its no-cost expert policy assistance known as Ask-An-Expert. An Ask-An-Expert program has established a broad team of over 30 experts from around the globe who are each available to provide remote policy advice and analysis advice to all countries at no cost. So for example in the area of demand and policy evaluation were very pleased to have Bruno Lapillonne the vice president and cofounder of Enerdata

serving as one of our experts. So if you have a need for policy assistance in demand and policy evaluation, or any other clean energy sector, we do encourage you to use this valuable service. And, again, it's provided to you free of charge. So you can find out if asking an expert's service can benefit your work, please go ahead and contact me directly at the email displayed on the screen there. That's sean.esterly@nrel.gov or you can give me a call at my office number 303-384-7436 It's also on the site we also invite you to spread the word about this service to those in your networks and organizations.

So now I'd like to provide a brief introduction to today's panelist Mr. Jim Parks. Mr. Parks is a program manager at the energy research and development department at the Sacramento Municipal Utility District also known as SMUD and his current focus is on completing the $308 million SmartSacramento Initiative with over 50 individual projects including distribution automation, smart readers, demand/response, customer initiatives, dynamic pricing, electric vehicle infrastructure, hardware and software upgrades and more.

And, so with that introduction I'd now like to welcome Jim to the webinar.

Jim

Thank you Sean. I am excited to be here today to talk about the SmartSacramento Project and I think we have a very interesting project. Its broad base covers a lot of different smart grid areas. It's more than just one topic. And I think if you are working for utility and you're considering a smart grid initiative, or if you're in the middle of one or if you're just interested in smart grid I think you'll find this presentation to be very informative. So about SMUD. We are a public utility which means we don't make a profit. So any profit that we make comes back to our customers in the form of reduced rates so they would pay lower electricity bills. We have about 600,000 customers. Probably about 60,000of those 60, 70,000 are commercial, about 540,000 residential customers, service territory population of 1.4 billion and about 1.4 billion in revenues. Our service territory covers 2330 square kilometers or 900 square miles. And our board of directors which really governs the utilities are elected by the people, so each board member serves about 200,000 in population. We have a little over 2000 employees, and 3299 is our peak load, we are a summer peaking utility, which in essence means that our load gets highest in the summer when the days are hot. So here in Sacramento we are not that likely to have a blizzard, but we have heat storms, so if we have hot weather where the temperature is 37c or 100f for 4 days in a row, that's a problem for us and we see the load grow so we want to do things to decrease that peak load. And from a size perspective if you compare us to Destrone utilities, they're very big. If you compare us to other municipal utilities, we're the sixth largest in the nation and the second largest in the state of California in terms of customers served.

Back in October of 2009 which is five years ago we received word from the Department of Energy that we received the smart grid investment of $127.5 million and that was to fund $308 million project.

So we went into this, everyone was required to do at least 50% cost share and we decide to do a little more than that. Maybe a 60 40 split. So were paying 60%, DOE paid 40% of the project. We were utterly thrilled and excited to get this grant and only $203 million went to the state of California for smart grid investment. So SMUD being right there in the very center of California and the fairly small footprint covering about 4% of the state's electricity needs we got 63% of the smart grid investment grant funds the due requires when we talk about the smart grid projects to say when we talk about the smart grid projects no warranty expressed or implied about the content of this presentation.

So what we did, we did seven areas under our smart grid investment grant and then in addition to that we did research and development projects which were not part of the smart grid investment but also had some grant funds associated with it. The largest project was smart meter installation and we did a consumer behavior study which we call smart pricing options which is providing time of use and critical peak pricing rates to our residential customers so there was a dynamic rate pilot. We did quite a bit of work in the demand response area with many projects focusing on demand response but three that I'll highlight in this presentation and lots of distribution automation, that was our second largest project. Several customer projects and technology infrastructure cyber-security, and at the very end today I'll talk a little bit about some of the R & D projects that we did. So here's the pie chart showing how the money has gone out with these projects. Once again you can see that AMI the advanced metering infrastructure is about $145 million, which is a big chunk of the project. Distribution automation was second. About $59 million and then customer applications at about $54 million.

This is just a graphic kind of showing one view of our SmartGrid vision and if you look at it closely you can see portable tanks distributed throughout the system, there is energy storage, there's electric vehicles, we got dairy digesters, I will talk a little bit about that in the R&D section. And then all centrally controlled from SMUD. Here's a micro grid all these projects are centrally controlled through SMUD, all these projects are centrally controlled from SMUD and that's kind of our vision for SmartGrid, that eventually there can be thousands, literally thousands, tens of thousands, of devices out in the field that we could manage to optimize grid such that we can reduce the need for expensive new infrastructure. And in addition to that we can increase the reliability of the system and reduce the number of outages and the length of outages. And furthermore when you happen to build new things in California there's a thing called, called NIMBY. People say, not in my back yard. That's actually very real and active in California. And there's the other one called BANANA build absolutely nothing anywhere near anything. And I sometimes wonder if

that's the attitude when we decide to build say a power plant or new transmission line it literally takes years and years to maybe ten years to get something through. So those are some of the hurdles we have to look at. When I think about it, if the smart grid can reduce the need for some of that infrastructure then that's a positive step forward and that what we should be perusing to optimize the existing infrastructure that's already there.

The smart meter project. We installed 620,000 meters and all of the communication infrastructure that went with that. We installed a remote connect and disconnect switch or, it's in the meters and that has been a big benefit to SMUD. That single disconnect, connect, disconnect switch has saved us about 400,000 truck rolls per year. So anytime someone moves someone new moves in, or any reason we need to shut off power or turn it back on, we can do that automatically. And it used to require someone to go out to the house do that and for people that were say, late on payments we would send someone out, you know, a few days ahead with the door hangar saying you're going to be turned off then this, then send someone out and physically turn off the power. Now we can just do that automatically and then when people come in and pay their bills or when someone moves in say, you're power is on, no problem.

One of the other things that we did was we allowed the customer to opt out of smart meters and this is something that most of the utilities that have smart meters, generally have some mechanism for customers to opt out. But in general there are two reasons the customers opt out- don't want to do smart meters one of those is they felt their health issues associated with radio frequencies and the second one is they don't want big brother to be watching because now with the old meters we used to do a read once a month and you really couldn't tell what was happening to the house other than how much energy they used. Now, you can see that information hourly 24 pieces of data every single day 365 days a year going to the utility, and so the concern of some folks is that we're going to analyze that data and figure out when they're home and when there not. I'm not quite sure what we'd do with that even if we knew if they were home or not, but that's the worry. We have had about 380 customers opt out and we charge $127 upfront fee and $14 a month to opt out. And even though it may sound heavy handed, it's actually a money loser for us because it cost us more than that to manually read the meter every month.

So when we started doing our deployment, we noticed that some of the utilities around were experiencing fairly significant difficulties in the area of public perception, and so we had entire city councils saying, no smart meters in our territory. There were big problems, articles in the papers all the time and so we installed 80,000 meters in kind of the hard to read areas in our service territory, we installed all of the communication infrastructure and the by hard to read, I just want to identify that was basically the dense urban areas and the rural areas so in the dense urban areas, you got buildings that are close together you got meters that are in

rooms that are inside a building or in a basement or something and so it can be difficult to get the reads. In the rural areas you just have such long distances between the meters and it can it can also be difficult to get the read, and so we figured if we did the difficult areas first and the system worked then the rest of the implementation would be a lot easier and we would be sure we were going to get the reads and that is what happened.

But with all the problems going on around this after 80,000 meters were installed we stopped the installation and thoroughly tested the accuracy of the meters. You know, how often they were communicating, how off they were getting the reads or bad reads or things like that and make sure it's working well. And at the same time we trained 40 staff plus our executives and boards and sent them out into the community to make presentation and we talked to really anyone who would listen- Kiwanis Club, Lions Club, Boy Scouts, Girl Scouts, Churches. We made sure to speak to all of our elected officials because SMUDs serve six cities plus the county of Sacramento so we have seven governing boards of the sort city councils and county board of supervisors that are in our territory. So we made sure to talk to all of our elected officials, tell them what we were doing, tell them why we were doing I, tell them what the benefits were to them, what the benefits were to their constituents, what the benefits were to their community, what the benefits were to SMUD and so that way when their constituents come to them and go, "Hey I'm worried about smart meters" Then they can say, "Well here's what smart meters are, here's why SMUD is doing that we think it's a benefit to our community and we should support that."

So what you want to avoid seeing is this kind of a thing if you go to nosmartmeters.com or something like that they have all kinds of information and you can look at this listing of things that can theoretically happen to you if you have smart meters near you. The one that I really like the most is down there third one, talks about smart reader radiation associated with memory loss and here I always thought that was a function of my getting older and hadn't realized that that was a smart meter side effect. But a lot of things here, there's nonscientific evidence that the smart meters cause these problems but people definitely believe that. The other thing we would see on occasion you get a few people who hang these on their meter and, one of them we found on a smart meter we thought was a little funny. Got their little smart meter didn't even know they had one.

Some of the benefits we get from it we get a lot more data which is good and bad because you have to figure out how to store that data. Talking to our IT people they told me that our data storage needs are growing, they're doubling every 18 months, and throughout this project, you think about it we were getting one meters read per month now, we are getting 24 meter reads per day so it's just grown exponentially the amount of data that were collecting. But there are a lot big effort now on data analytics, how do we take that data how can we use it to improve our system so what we

are doing now is providing our customers what we call 'yesterday's data today' so I could actually log onto the SMUD website today and put in my password and I could see 24 bars showing the energy I used each hour yesterday. I can look at a week I can look at a month, I can even see last year and see that data. And what this does for me is if I'm really active about monitoring my energy or if I want to really control my energy use, I can see where I am in the middle of the month as opposed to waiting till I get my bill and then it's too late there's nothing I can do about it. If you get a $500 bill well, what are you going to do you just have to pay it, and so now I see "oh I'm exceeding my budget so I better do something to scale back" so you have a lot more control.

The other thing it provides is, a time of use critical peak pricing enablement so before in the mechanical electro-mechanical meters we could not provide time of use rates. Now we can and this is kind of a big deal for us that were going be moving in that direction, it allows communication in the home area networks in home displays so people can see their energy use real time. We can start an in-home display checkout program where we gave, I don't remember how many dozens of in-home displays to the library here in Sacramento where people can check them out for two months and monitor their energy use and we get the last gas notification, if someone's tampering with the meter, automatic connect/disconnect I talked about earlier. We're also able to ping the meters after an outage and I will show you a slide on that so, lots of functionalities, it's a big, big benefit for us.

If you look at this picture you'll see all these green dots and they basically represent meters out in our service territory. Sometimes you know, big storm comes through we get an outage this would be a fairly significant outage here so we sent the crews out to repair that outage. When they're done repairing the outage, typically they would come back to SMUD or somewhere else, whatever their duties require, and they would be done, but some of them find especially in a really bad storms you'll have nested outages, so you might have one or more outages inside the big outage and here the crew comes out, fixes the outage, moves on, they're done. Well now we can send out a ping and we can verify that each of those meters is communicating with SMUD. If a certain subset of meters is not communicating with SMUD, we keep the workers in the field and they're able to go out there and fix that nested outage so it reduces the duration of the outages and improves customer services.

I remember a couple of years ago we had a big outage before we had the smart meters in and had this functionality and a large grocery store knew that we were on it and that we were fixing the power. They knew it was severe and it might be out for a little while. A crew went out to fix it, went on about fixing other outages and then the customer sat there thinking, "Well, it's going to come on any time." Well finally, after a day they called us, "Hey, can we have the power back." Oops! And there was this

massive outage inside that outage we hadn't known about it but now, we would know about that we could fix it while we were out there.

We did a pilot. This is what the DOE calls consumer behavior study, but we called our project smart pricing options and this was really a premier study in the United States. If you go to the smartgrid.gov website you can find lots of final reports on smart grid projects and if in fact you are considering a smart grid project utility, I would highly encourage you to go to that website and look up some of the reports that can help you avoid mistakes and can help improve the chances of a successful project.

Our project included both time of use and critical peak pricing and in some cases both, in one or the other, both. We have two categories. You can look here on the left. You see we had a default group of customers and on the right, kind of the orange block we had an opt-in group of customers. So what we did on the opt in customers, we sent them a mailer that basically said would you like to go on this rate and customers look up the rate and thought they could benefit from it and they would sign up. The thing is with opt in customers since they self-select the only ones that will select that rate those that think they can benefit so it doesn't really represent your customer base. You might learn some really interesting things from it, but it's not really representative of what if we would full scale time of use what would happen because the numbers will be skewed one direction because they self-selected.

So we also provided a default rate where we basically or I'd call it opt out we sent a bunch of customers information that said, you are on this rate if you want to get off this rate you have to call us and we expected a 50% drop off from that and when all was said and done it was a 90% drop off so most of the people stayed on that rate. And if you look in the in the individual boxes you can see the number of customers that were on the different rates. And then in the greenish boxes on the bottom you can see they talked about in-home display options so some customers were offered in-home displays some were not.

Now on this chart what I want to highlight really is the red numbers in the middle there, those are the critical peak price rate. So we called up 12 events per summer season they were called a day ahead. They were called between the hours of 4pm and 7pm. So we called them a day ahead your on this rate, critical peak rate tomorrow were calling in event, so any energy you use during that time is going to cost you 75 cents. So this was a significant rate if you look across the second row you'll see the off-peak rate was 7 cents 7.2 cents and so there was an over 10 to 1 differential between the off peak rate and the peak rate. Then we also the time of use rates and just some of the different rates we had on the this task and we found if you look impact just on the time of use does not include critical peak pricing customers, you can see the base-load in the yellow line in and then the participant load in the orange-ish line and you'll see the

customers in the peak periods did reduce their usage so they were actually shaving the peak for us.

To get down into a little bit more detail, for the customers who were on the time of use rate, you can see that the opt-in customers were say between 10% -13%% and the opt out customers were say between 6% and 8%. So the default customers you'd kind of figure this out you know on your own.

The default customers were not saving as much because some were paying close attention. Some were not paying attention at all. On the opt in rate, they're kind of all paying attention. They selected that rate they knew they could shift load during you know during peak periods. When you take it over to the CPP rate you can see that the opt-in customers saved almost 1/4 reduced their peak load during those peak periods and this would indicate to me that 75 cents kilowatt-hour is, is a driver. Even the default saved between 12 and 13% which I think is just amazing.

So the question that we have to answer now is if we go full-scale deployment of time of use rates, are these numbers indicative of what would happen across our entire system? And, we will find out because were planning time of use rate for all of our customers in 2018.

On the demand response side the first thing we did was to procure a software platform the demand response management system or DRMS. We bought it from Lockheed Martin. Lockheed Martin has several products in the utility space but this one for DRMS is called SEELOAD and we did a couple of pilots of the residential side in 2012. We did power-sat and we did a precooling strategy so, in other words as we were coming up to that peak window that 4 to 7 window, we would precool for either 2 hour or 6 hours and then see if we could get bigger load reductions during the peak period in 2013, we just offered an incentive in a rate but didn't ask them to precool they could if they wanted to and the we also developed for commercial customers and auto DR or automatic demand response then we signed a 3 1/2 megawatt for that I will say that all, well not all 3, but the 2013 powerstat and the auto DR have moved into full scale customer programs and we will be adding new customers to that programs over time so I see growing those over the coming years to be a significant programs.

If you look here at the precooling pilot that we did you can see the blue line showing the 6 hour precool. What we did what we basically we sub cooled the home by 2 degrees and it was done automatically with a signal from SMUD on the day of the peak event and then there was also a precool 2 hours which was 4 degrees cooling so, people could theoretically wind up a little bit cool in their homes depending on what their thermostat was set at. And then during the peak event you can see that everybody reduced energy. Even the base load customers which were the green, they were not precooling. What you notice on the back end of

critical peak event is a rebound where all of the customers use more energy on the rebound side so basically you have the two sets of customers. the precool customers using more energy before then using less during the peak period then using more on the rebound after the peak period.

If you look at a levelized based on temperature you can see that the higher the temperature the greater energy use before, the greater energy use after, due to rebound but the greater the savings during the peak period. So you can see on a 110-degree day that the peak load reduction is you know, more than 105-degree day a 99-degree day. This is pretty intuitive but we were just verifying that is in fact what happened.

With respect with how much energy they used and the impact on their bill, the people that did not precool, actually they saved just a little bit. Those that pre-cooled for 2 hours spent little bit more on their bill and those who had 6 hours pre-cool saved a little bit. It's only fair that in2012 we did not have the rate in place so they were just on a standard tier rate so, in essence there was no significant benefit during the peak period of reducing load, it was just normal rate some of them still saved money on that. And if you look at the range of impact it was between people saving $10 and people spending $10 extra with savings representing 3, saving 3% to plus 5% of their bills. Kind of interesting.

If you look at auto DR performance, what we found was that it matched very closely with what we projected so we can pretty closely understand which equipment was being put on the program and what the KW load reduction would be when we tested it, it really tested out very closely to what we had projected.

Now in the distribution automation area we did quite a bit of work. We automated 118 distribution feeders. Now if you are thinking about a feeder, go outside look at your distribution line. Usually it's the one higher up the pole and the lower is one maybe, you know, it's usually communication of some sort. Think about 1000 to1200 customers that would be a feeder. Feeders go into substation and substation have you know, 3-5 feeders typically they can have more. They can have less. And so we automated 118 feeders. We had not automated any feeders prior to this so we could not see what was going on, on our feeders. We have lots of automated substations so we can tell what was happening at the substation level but we can't usually tell what's happening at feeder level. So if a car runs into a pole we typically would find that out from customers calling us.

The automation of the feeder included several devices your online capacitors, there were re-closers and something called motor operators that helped automate and communication infrastructure so that you can actually communicate with, you know, get signals from the feeders to get you know to understand what was happening on that feeder. We put

controls on 40 substations that allowed us to understand what happening- 2 way communications is. They call that a SCADA, supervisory control and data acquisition. We operated conservation voltage reduction on 2 substations initially in 2011 and are currently wrapping up a project on 14 substation and I'll talk about some of these other ones in a little bit more detail but they both (0:34:36 inaudible) about optimization and conservation voltage reduction. If you look at this chart you will see a substation and then distribution lines coming out from, that substation. Typically what happens to the voltage, the closer you are to the substation the higher the voltage is and as you get farther form the substation, the voltage drops and so what they do is they do, do what's called voltar optimization. You put equipment out there on the lines like line capacitors in this example and that boosts the rampage up. You figure out where to put them based on the voltage profile. Which places it will benefit more or less and so you amp that voltage up. You need to know that we as a utility need to provide a voltage within a bandwidth is usually plus or minus 5% of nominal voltage which in a home is 120 volts. So we need to provide voltage to your home between 126 and 114 volts so you've got this and you boost this voltage up you kind of levelize that line. What that allows you to do then next is to reduce the voltage at the substation across that entire feeder. So you see the red line there that goes out is dropped off but were still providing voltage within the bandwidth that we need to.

The space between the blue line and the red line represents energy efficiency, in essence. So this is energy savings basically based on ohm's law where power equals current times voltage. If you reduce the voltage you reduce the power, and so this is one of the things that's invisible to the customers in that they do not see the energy efficiency themselves but they do experience it so they would see a slight reduction on their bill because of conservation voltage reduction.

Conservation voltage reduction is specific to technologies so, some technologies provide greater savings than others. If you look here, incandescent lights for a 3% voltage reduction provide about a 5% reduction in energy use, fluorescent lighting some were between 2% and 8%. If you look at like the LCD TV's and the plasma TV's, zero these have voltage compensation built in so if you reduce or increase the voltage it is going to keep that voltage level to save the components inside the TV.

So it just varies, depends what you have on the system and our studies have kind of borne that out.

On the study that we are doing, 14 feeders or 14 substations, we found that it ranges from very close to zero to, you know, upwards of 2%, 3 % for 2% voltage reduction, and so I wanted to do a sensitivity analysis on the circuits to figure out what part of the elements that make us save more on one circuit than on another then that way since we've only automated 18% of our circuits, there's still 82% out there that we could kind of do and 80-

20 rule and see is there some way to optimize our conservation voltage reduction just automate those lines makes the most sense to us.

So these are the result from one of the substations we did in 2011. You can see the top one shows the pre-voltage and the line beneath it shows the voltage with the 2% voltage reduction and then beneath that you can see the load curve shows the base case load curve and then the load curve with the voltage reduction. And once again the space between the blue line and the red line, represents energy savings.

Looking at the two substations for 2011, you can see that Madison, Kenneth saved about 150 kW which is about 1% of the load on that substation. That's really within the band with the error and so we can't tell you positively that we saved by doing conservation voltage reduction on that substation; however we believe that we did and we believe that the savings were in the neighborhood of 1%. Mertyl, Dave here showed about a 2 1/2% that is statistically significant. We definitively saved on that substation and were seeing similar results with the 14. There are some big winners and some not so much.

One of the other projects we did is called situational awareness and visual intelligence. This is a geo-spatial tool that our operators use and I'll just give you I think it's easier to show this one pictorially and just talk about it with words. It's on a base of google earth. It's so here you can see the orange line which shows our service territory and you can see our bulk substations represented by the green dots.

You can zero in and you can pick a particular substation and zero in even further to see the substation and see some of the equipment that is on that substation. You can go down even further now and you can select the given circuit and you can see up here on the right hand side, you know, you can see the amps per phase you can see the loading on the circuits here, here this fdr2 has 13.8 megawatts on it, fdr3 has 24 1/2 megawatts on it and you can see the respective amps on there. If you go below that little chart you see the camera image at that substation and then you can push the little buttons here in the circle there to the left of that picture and you can move the camera around to see what's going on real time at that substation and then below that, you can see the chart that shows loading on that substation over the course of a week. So much more functionality and I can't cover all of it but just you can really get into the details that are programmed like this.

Here's an example of a 15 megawatt photovoltaic plant that we have in the south part of our county and you can see the view on this and you can see down below the chart that shows the loading on that over the last week. You can tell by the profile that there were some clouds or something going on here that didn't cause it to be more of a bell shaped curve. In the picture, that shows how much loading—how loaded it is now you can see that it's at 7.2 megawatts but it's got a 15-megawatt capacity. So you know

it's not noon on a clear summer day this is something probably in the afternoon the thing is starting to wind down. But you can see that stuff basically real time through that tool.

We did a variety of customer programs residential programs small commercial, just different things and I you know I could list all those but, we were talking about the other day there were at least 20 projects in this area and if you're not already asleep you'd definitely be asleep by the time I got through all those projects.

I talked about the in home display checkout pilot, we had tools we were providing for residential and commercial customers they could go online and see and manage their energy use. We offered some rebates for advanced lighting and energy management systems. We actually cancelled some programs because of timing in like a lot of manufacturers were coming out with controllable appliances they just pulled them from the market and in the middle of our project we were getting ready to do some pile up projects with those and so they were no longer available. We will talk a little bit about our advanced lighting program because that one yielded some significant benefits. I remember my days in energy efficiency where I'd go out, work with customers and if I could get 10%-15% reduction in lighting and energy use, that was big, I thought that was the greatest thing. Now these new technologies were seeing 50%-90% reduction in energy use and so it's pretty amazing.

What we found through the controllable, the advanced and controllable lighting program is that about 40% of the savings that we achieved were from controls and about 60% were just form the retrofitted cells of going from a basically any efficient technology to a more efficient technology. Here's an example that came from Blue Diamond Almond Growers you can see the red line on the top represent their base case lighting system. And this was an interesting one because it was in a warehouse and there was no switch to turn off the lights. If you wanted to turn off the lights you had to go to the panel and flip the circuit breaker so these light were basically on 24 hours a day 7 days a week and you can see the thing ran, there must have been a switch on a small portion of lights cause the light otherwise the curve would be, you know, completely flat it wouldn't be a curve it would be a line. You can see they're typically in the 31, 33, 34 kW worth of lighting in that warehouse. When they did the retrofit, they brought it down to the blue line which is running under 15kw so you can see they saved well over 50% with that change and then when they added the controls, they saved even more so now they're running typically between 5 and 10 kW. And so you start how you can get that 50% to 90% savings these are huge savings they got in just right in what we said in the previous slide about 60% in the just from the retrofit itself. One of the things they did also in this project, they moved the light fixtures such that they were in the areas that they were going to do the most good. The lights had been there's so long things had kind of moved around, some of the lights were just lighting the tops of you know boxes and things and so

wasn't really providing any useful work. And so the lighting fixtures were repositioned and now when they go through with the forklift, the lights will turn on and then after they're gone for a little while the lights will turn off, so you get the savings form the controls.

On the technology infrastructure space we installed an enterprise service bus which allows our different computer software programs to speak to each other, they communicate with each other. I was talking to one of our IT folks the other day and they said you know were already in need of a second enterprise service so I don't know that'll probably be another project coming down the pike at some point. We also upgrade our customer relationship management software through this project. We also did a lot of work on cyber-security. This has been a big issue for utilities. How do we protect that data? How do we protect our sensitive customer information? How do we protect our equipment form cyber-attack? The cyber security guys don't give us a whole lot of detail about what they're doing other than saying that its state of the art and they're doing everything they can.

So some of the lessons learned from this project—we found from the beginning that executive support is essential for a large-scale project like this. When we started this project, we knew that we were going to need resources from a variety of departments across SMUD and in fact, now that this project is winding up, over half of all SMUD employees charged times projects. We had over 11 hundred employees that charged time on this project. It was huge, and we were just kind of cherry-picking people from the different departments. It would have never happened without the executives saying you know, you will do everything you can in your power to make this project happen. So if you're starting a project make sure you have that executive support up front.

We found that customer communication was also essential especially if you're doing things like advanced meter-reading infrastructure. Things like distribution upgrades, they're invisible to the customer. I don't think you need as much of the communication plan there, but those things where you're actually going impact the customer, you need to make sure you figure out what to do with that and that's something that we did also communicated with our customers and it made our project go much more smoothly. We didn't get any negative press, we had very customers who were opposed to the meters, and so it went you know quite smoothly because of the communication we did. If in fact you can get somewhat of a flexible scope and schedule if you work for someone like the Department of Energy, that is helpful because it seems like the more you lock yourself into a box, the harder it is to change. If you get in the middle of a project and determine that you need to have some flexibility. And in our project I would say that we had some of both we had some areas where it was pretty inflexible we just needed to do it the way we said we'd do it. Other areas there was a little bit more flexibility in it and that worked well for us we were able to, you know, maybe change the

schedule a little bit or just, you know, move money around from one project to another in order to get the outcomes that we needed.

Data accuracy and timeliness is important, a lot of these project that we're doing now rely on accurate data. The savvy project were talking about just now, if we have bad data going into that our operators are going look at that and they won't get the information that they need. See, we need to make sure your data is accurate. I don't think when you get into these large scale utility projects everything will always be 100% accurate, but you can also have plans in place to correct and fix the data over time so that when you find problems you don't let it sit there, you fix it.

We found that some of the products we thought was ready to go and ready to be installed on a broad base were not quite ready, so some of the technologies, were actually a little immature, weren't quite ready for the market. And so you know things like, these smart appliances, that was a good example where we were starting to get excited about doing it and then they were just pulled from the market. There wasn't enough activity in the market. People weren't buying them. Certain software products, you know, vendors who would come out, so this is ready to go and can do all these things. Dive in a little deeper, it's not quite there, you know, what they sometimes won't tell you is that it's on their timeline. Next year were going to install that functionality. And so you need to make sure that you're getting the truth when you talk to different vendors. Early version product tend to be expensive and so I you know sometimes if you just wait the prices will come down, there may be a compelling need that you need this or you may want to do a pilot test on some more expensive products projects. And then just see what happens over time but these are just some of the things we've found on our projects and we also found that over that 5 year implementation period of our project a lot of these products did improve and a lot of them did come down in price.

Heavily technology dependent assets should be procured as close to implementation as possible, but while still leaving enough time for you to test those devices because the product functionalities and capabilities are improving so rapidly and because prices are tending to come down over time, if you order too early you may be obsolete before you're even ready to implement. And so you want be sure that you've got the latest version as possible and you might be able for a lower price. Also we also found that some vendors tended to overpromise, under deliver and so we just need to make sure that when you work with vendors you work with them to make sure that what they say is true.

So the next steps for steps for us are still a lot of work to do on our projects, some things have been implemented at 100% like advance meters. We're not going to do a new advanced meter project. We'll install the ones we have. We'll install for new customers. We don't need to do a whole full-scale reimplementation because it's done. But things like the automated feeders se did 18% of the feeders. There's still room for 82%

more, theoretically. Some of the customer pilots we did there's room to expand those to include other customers and they have new products and services.

Our project with doe wraps up December 23rd. So we do get to celebrate Christmas here at SMUD and they do get to celebrate Christmas at DOE. So the next thing we plan to do as a result of this project is to develop a smart grid roadmap that will basically guide our future deployments. We issued an RFP just yesterday to help hire consultant to help us with that roadmap and there's basically two major elements to each roadmap. We want them to evaluate SmartSacramento and then we want them to develop a roadmap to direction to where we should go from this point. From the evaluation perspective, we have at least 12 evaluations that have been done on some of our projects. We have 11 additional projects that need to be evaluated. And then we want them to summarize those evaluations and also give kind of a high-level evaluation of the overall SmartSacramento project.

Here's a listing of the projects that were evaluated and those that we need to evaluate and those that we don't plan to evaluate. So you see the yellow areas show these projects we need to evaluate. Look at them. Seems like most of them are kind of in the distribution space. The white lines are the projects that were evaluated and if you look at those it was mostly the customer projects that were evaluated. And then if you look at the green sections you see are the projects we don't think need evaluation so if you look at the first one on that list, mobile data terminal replacement. Those are hardened computers are put in trucks people that are going out in the field and doing service. There's no need to really evaluate that program because we're always going to have those devices on the truck. It's just something that's used until they're worn out or something better comes out and then you replace them. Things like cyber-security. I wouldn't do an evaluation of our cyber-security efforts under a smart grid roadmap is an example.

So this is the direction were heading then on the roadmap itself we expect the contractor to basically take all of the information from our projects, plus information they know from other utility projects, plus information that comes from universities and research organizations like EPRI and public organizations like California Energy Commission and then take all that data and figure out what the next steps should be for SMUD. And kind of in a, you know most cost effective order. So I expect them to see to include the evaluation results proposed new projects with descriptions, risks, budgets, staffing impacts, relative project priority, and then, you know, gap analysis too. We've done quite a few projects but are there holes in what we did? Are there things that we've missed or are there some new things that have come up since we started the project and that we should now consider? I expect to have a consultant in place by the end of the year and then our roadmap completed in June. So it's actually a pretty aggressive timeline. A lot of work in a short amount of time. After

the roadmap is finished, we'll have project recommendations well be able to look at those and they'll be business cases for those that make sense and then we will go to our executives and ask for additional money to fund those projects. But once again only where there's a business case and a reason for doing that.

Let me give you just a few slides on R &D and then well be able to take some questions here.

This slide shows our budgets. The green section shows what we did in the smart grid investment grant and kind of the grants that we got and the overall budget. And then if you look down below that you'll see the R & D projects. The whole listing of them and it totaled another $43 million so we have over $350 million worth of projects to implement. One of them we did was an energy storage project that a solar community called Anatolia, which is about 280 homes. They all have between 2 and 4 kw of PV on the roof. And in some cases in the fall and winter when it's sunny, if they're not using air conditioners well get two-way power flow. So we're power flowing the wrong direction that was intended, and it hasn't been a problem before, but I know some systems it could be a problem. Utilities systems typically designed to go from bulk generation through the transmission system then down through the distribution system and to the customer power always flows in one direction. From the plant to the customer. So now with all this distributed energy resources in the field there's area where you get power flow going two ways and a lot of utilities are concerned about that. We installed 15 residential energy storage units that were 10kw 8.8kwh and we installed three commercial energy storage units that were 30kw 30kwh and these were used to help firm up the solar and the possibly use for during, you know, critical peak periods and so forth, to inject energy back into the system during times when it was needed.

We also installed right here on our SMUD campus, a micro grid project which is 3 100kw natural gas engines and 10kw floatable tank. There's also an absorption chiller and you know various things here and the main that we were testing here was a switch that would allow the system to separate from the grid and continue to provide reliable power to the, our central plant and an office building and that then when power was restored on the grid to build the reconnect and be synchronized without any troubles. There have been multiple tests, multiple tests on that and it has worked well.

We had several dairy digesters in our service territory. We always call these 'poop to power' so in essence, we take the cattle waste and it goes into some sort of a lagoon. Either a covered lagoon with a membrane on it, or a tank and then it digests into methane gas and is run through an electricity generator so it generates electricity. This is one way to get rid of some of the you know noxious things we have out on the farm and there's still what's left over's still there's you know, fertilizer that we can use that

comes out of that. We've got I think there's I forgot how many nine in the state and I think five of them are in our service territory. That's pretty amazing. These were the two dairies that participated this year. And then we were doing a lot of work looking at electric vehicles and if you look at this chart, you can see that by 2030 we expect to have almost 11 hundred megawatts of battery load on our system. Now we had a nuclear power plant and it wasn't that big. And so this is a significant load and so we need to figure out how to manage those loads such that our system is not negatively impacted and what we found is that if you get someone who buys a couple of electric vehicles that are on the same transformer- that could be a problem because that's like one car can be over a house worth of electricity in essence, during a peak period. The tesla vehicles actually have the capacity to go to 19kw which is really like 4 homes, and so if your transformer is the right size and if the right number of homes connect to the transformer suddenly you throw a Tesla or two Teslas, suddenly you've got an overloaded transformer. So these things we need to look at and monitor. The other thing that comes into play is when the electric vehicles charge and so, is there a way to charge them during certain times of the day or night that would optimize our system and provide benefits to the utilities? So we developed some rates around electric vehicle charging that promote lower priced electricity during off peak period and higher produced electricity during peak periods.

So a lot of work still to be done. We're seeing the trajectory increase pretty dramatically in electric vehicles it was kind of a slow start but they've really taken off.

So once again, here's a smart grid vision. A little different view from the one I started with and this'll kind of shows it represents distributed energy resources on the grid. All those things we talked about-floatable tanks, wind, energy storage, programmable appliances, electric vehicles. All these different resources out there, that if we can control them through central location, we can definitely improve the reliability and efficiency in the grid, we can definitely reduce the need for expense of additional infrastructure, and with that, I'll turn over back to Sean for any questions.

Sean Great. Thank you very much Jim for that excellent presentation and just a reminder out to the audience that if you do have any questions for Jim, you can go ahead and type those into the question pane and with that I'll get started. We did receive a couple. So Jim, first question I received asks, what changes you saw in load shifting for those TOU and CPP customers with in-home displays and could the cost of in-home displays potentially offset the savings for load shifting?

Jim Typically we saw savings in about 8% range on average 8%-10% which is actually pretty good. I don't think the in-home displays are all that expensive I think they're in the $100, $120 range.

And for our customers being able to check them out at the library was actually a pretty good deal because they could check them out and take them home and use them for a couple months.

What we found was that customers typically would use them, get them and they would be very interested in them for a while. They turn on the lights and they turn on and off different things in-home display, go up and down and, and they could kind of see what impacts on the bill the different pieces of equipment by just turning it off and on. But over time, it loses its luster, and so after a month or two it just becomes another thing sitting on the kitchen counter as an example. However having said that, you can change your behavior in that timeline where you don't really need to look at your in-home display anymore to know how to manage your home load. So we saw typically 8%-10%. Pretty good number on in-home displays.

Sean Great. Thank you Jim and the next question just asked if you could repeat the percentages of customers who opted out of CCP and TOU when they were assigned that as default and then as a follow up, do you have any idea why they were opting out and is there an estimate? I think you said this in your presentations as well, is there an estimate of the savings that customers experience as a result of changing to CCP or TOU?

Jim Let's see do I still have control I do still have control it's a wonderful thing to be control. Yeah here we are. On the TOU rates, you can see here that they did. They saved between 10% and 13% for those that opted in and between 6% and 8%. I won't say this is what they saved on their bill this is what they reduced during the peak periods and then on the critical peak pricing rate, you can see that they reduced their peak period between 22% and 26% for the opt ins and 12% and 13% for the defaults.

There is a report on this on a smartgrid.gov if you look up the Sacramento smart pricing options final report and the interim report. Lots of information. The interim report is about 380 pages, the final report is not as big, but you know it kind of updates the numbers that were in the interim report, we had when we gave customers the default and said you are on this rate, about 90% of them stayed on the rate now. Over the course of time, a few dropped out but it was a fairly small number. And then we also had dropouts from, from people moving. So in essence, if they moved, they were no longer on the rate. We didn't count that as someone really dropping out, per se. They just they left the rate because they were moving and so the dropout rate was pretty low. I think we were still at something like 85% or something. I would imagine the report probably contained reasons that people dropped out they may have got bored of tracking their electricity or didn't want to bother with it I don't know but you could go to the report and find out that information.

Sean Great and I just sent out that URL smartgrid.gov to the audience, if you want to check your chat box, it should be in there. Again its smartgrid.gov a lot of additional smart grid information on other smart grid projects as well as the SmartSacramento project. In the next question Jim, we also received this this morning actually, did you calculate an overall return on investment and given that there was a lot of learning that others can benefit from. Would you say that others that follow the lessons learned and implement similar projects do you think that in most scenarios they would have a positive return on investment?

Jim We have not calculated total turn on investment for this project but it is part of our RFP that we just issued yesterday, so I expect by June of next year have a better understanding of that having said that, we have done at least a dozen evaluation reports on many of the customer programs and you'll find those at smartgrid.gov on the DOE our website. What was the other part of the question Sean?

Sean You don't have the information because the reports aren't out yet but do you, in your opinion, do you think that other projects implementing the same lessons learned would have a positive return on investment?

Jim Yeah you know I think if you looked at our full portfolio of smart grid projects, you'll find some that were just wonderfully cost-effective and you'll find some that were moderately cost-effective and you'll find some that were not cost-effective. And so I think when we get to the end of our roadmap we will probably have that information. I would definitely if I were going to implement a smart grid project today, and let's just say SMUD had done nothing, I would go to the smartgrid.gov website. I would pull down those reports. I would investigate lessons learned of the different utilities and figure out what made the most sense for my utility. Every utility is different just because it worked with SMUD doesn't mean it'll necessarily work with your utility. So I think everyone should evaluate their own needs, their own customer base, and do some investigation as to what's been done in the field and then I think you'd have a really good idea of what you should do with your own utility and you can avoid some of the pitfalls that others have stepped into through their projects. So I think it's a really good time for people to get into the smart grid area because there's so much information out there that can smooth your project implementation.

Sean Thanks Jim and we have another question come in. They do note that this reminds them of the work going on in Juju Island in South Korea which is also a very interesting smart grid project. But their question for you is "Are you developing new technologies for your smart grid?"

Jim That will come from the roadmap. But having said that also, we have an R &D department where we are looking at and testing new technologies. We don't develop them ourselves but we'll do some pilot projects on early stage technologies just to see if they work or not. So we're doing some work in that area and then the roadmap will give us further guidance as to which projects to implement.

Sean Great. Thanks Jim. And that was the last question I had from the audience so unless you have anything else to add Jim or we can go ahead and wrap up the webinar.

Jim Thanks everybody for joining I think it's a great time to be in the utility space. I'm glad to be here working on interesting projects and I think SmartGrid is the wave of the future and I think we're all going further and further down this path in the years ahead whether we keep calling it smart grid or call it something else, I don't know because all of our projects are now parceled out to the different departments that operate them and is it SmartGrid or is it standard operating procedure now. I don't know. But anyway, I want to thank you all for listening in.

Sean Thanks again Jim for the presentation and for addressing those questions from the audience.

And so now I'd just like to ask our attendees if they'd participate in a very broad survey that we have. It's just three questions to help us determine how the webinar was and how to improve the future.

The first question we have for you is "The webinar content provided me with useful information and insight?" And you can respond right in the window there. And the next question states, "The webinar presenters were effective?" And then the final statement "overall the webinar met my expectations."

Thank you for answering our survey and on behalf of Clean Energy Solutions and I would just like to once again thank Jim for joining us today for our webinar and to our attendees for participating in today's webinar. I would very much appreciate everyone's time and I do invite the attendees to check the solutions center website. If you'd like to view or download pdf versions of today's slides as well as a recording of today's presentations.

Please allow about a week for the recording to be posted to that web page. Additionally you can find other previously held webinars on the clean energy solutions site and information on upcoming webinars and other training events. also we'd just like to remind you we are now posting webinar recordings and energy solutions YouTube channel so you can go up there to view those and listen to some other clean energy policy videos and we also invite you to inform your colleagues and those in your network about clean solutions center resources and services including the

no-cost policies support known as Ask-An-Expert. With that, I hope everyone has a great rest of your day. I hope to see you again at future clean energy solutions center events. And this concludes our webinar.