[Richard Kidd]

Hello, I'm Richard Kidd, program manager for the Department of Energy's Federal Energy Management Program. Welcome to First Thursday Seminars. If you've participated in previous seminars, welcome back. If you are new to the program, you can access our earlier seminars at any time by visiting the FEMP Web site. Each year, the Federal Government consumes more energy than any other single organization in the nation. That energy provides light and electricity to our buildings, heats and cools our facilities, fuels our fleets, and provides power to Federal projects across the country and around the world.

Because of this, we have a responsibility to use that energy wisely. With Executive Order 13514, the President has challenged each agency to set and meet new targets to reduce energy and water use, and to increase renewable energy production, with greenhouse gas reduction as our common collective metric of performance. FEMP assists Federal customers in meeting these goals by implementing cost-effective energy management practices and smart investment decisions. We work with agencies to identify and leverage financial and technical solutions to meet and exceed our national energy goals. We hope this program, and others in the series, will help you reach your energy, water, and greenhouse gas reduction targets.

While we have selected six of the most important topics, no single one is a stand-alone solution. Only through an integrated, whole-systems approach can we meet our executive order mandates. Visit the FEMP Web site for additional resources, technical assistance, and guidance. Thanks for joining us, and enjoy the seminar.

[Kathy Hyland]

Hello. Welcome to the Department of Energy, Federal Energy Management Program First Thursday Seminars. I'm Kathy Hyland, and I will be your moderator today. Today's seminar is on advanced metering requirements and best practices. If you have not already printed the learner guide, you may do so now by going to: www.femp.energy.gov/training. You may also wait until after the seminar is over. The materials will stay on the Web site.

Let me cover our objectives for today. After completing this seminar, you will be able to define advanced metering and talk about some of the potential benefits. You'll know how to determine projects for advanced metering. You'll be able to discuss advanced metering possibilities in terms of water, air, gas, electricity, and steam. You'll be able to explain the metering approaches: one-time, run-time, short-term, and long-term. You'll be able to explain steps in an overall process for approaching advanced metering. You'll be able to talk about some of the technological considerations when considering advanced metering, including communications, data collection, and storage; hardware, backup systems, and single and multiple vendor options.

You'll be able to give examples of advanced metering technologies and some of the selection criteria to consider. And finally, you'll be able to locate advanced metering resources for further study. Our format today is simple. There will be a presentation, followed by a question-and-answer session, and you will be able to ask your questions in one of three ways. You can speak live with the instructor by calling in. You could also call-in and leave your questions for me, and I will ask them of our instructor. You can also e-mail your questions in, or fax your questions to the information that's on the screen.

I want to introduce our instructor, Greg Palko. Greg is a certified facility and energy manager. He has had 25 years of experience in operations and management in the Department of Energy's East Tennessee Technology Park. Currently, Greg is an energy efficiency manager at Oak Ridge National Laboratory, in the facility management division. He works on process and energy efficiency projects with the goals of saving costs and streamlining operations. Greg has a BS in engineering and mechanics, and an MS in industrial engineering. Also with us today will be Ab Ream, by video tape. And I will introduce Ab further during the presentation. But now, I'd like to turn it over to Greg Palko.

[Greg Palko]

Thank you, Kathy. I appreciate the opportunity to be here today, and I'd also like to thank Ab Ream, as well as Greg Sullivan and Bill Sandusky for their help in preparing for today's presentation. As Richard Kidd pointed out, I think it's going to be very important as you go through the presentation today, and afterwards, to refer back to the earlier presentations, as well as the guidance in the learner guide that Kathy mentioned. There's a lot of information to cover. We only have a few minutes together today, so let's get started.

Let's talk just a second about the difference between advanced metering and traditional metering. Everybody's familiar with residential metering, which is typically a walk-up type of meter, as shown here on the slide. Advanced metering has a couple of things that are going to be important as you go forward. You need to be able to track interval time-stamped data, and you have to have the ability to ship that data to some other system. So, you want to make sure that you've got that ready. Another subject that we're going to talk about today that I want to touch on early in the presentation is that metering, for our purposes, covers a lot of different commodities. The earliest legislation that we'll go over talks specifically about electricity, but there are other items that you'll see, as the new legislation comes out, you're going to need to be concerned about. So, when you hear the term "wages," you're literally talking about water, air, gas, electricity, and steam. And we'll talk a little bit more about that as we go today.

Let's touch on why metering is important. First, let's talk about the legislative drivers for this. The first piece of legislation that impacted metering was the EPAct 2005 requirement for metering of electricity. Since that time, the Energy Independence and Security Act has also asked that we meter steam and natural gas. And the new executive order on greenhouse gases, because of the way some of the goals have been set, also requires that moving forward we're going to need to be able to track water consumption and the savings that we have on that. So, there are a lot of specifics in the legislation about this, and a lot of confusion. So remember, EPAct 2005 only required metering for electricity, but the newer legislation has other requirements that you now need to be considering.

Probably a more fundamental question is: Why would you want to do metering? And for our purposes, it's important to understand that there are differences between the legislative requirement for metering and the reasons that additional metering might be important to your operation. We're going to use some examples today to talk about uses of metering that aren't necessarily legislatively required, but would be a good practice for you. The best-practices guide, as well as our discussion today, will help with that process. It's important that you think of your metering as part of an overall approach to how you're managing your facilities, and we'll talk about that.

There's a simple process that you could go through with your advanced metering and how you're going to implement the metering, and it's important that you take each of these steps in turn and work your way through a process. This is a very simplified version of that process that can be extremely expensive and involve lots and lots of people. But, you need to start out with that process approach to how you're going to deal with that.

The first thing you need to understand is: Why do you want to do your metering? If you don't understand the uses of that metered data, then you've probably shortsightedly approached your problem. If you don't understand where you're going to end up with your metering, then you probably are not going to have the right metering when you get done with your process. Talk to your facilities people. Talk to your business people. Establish early on the different uses that you're going to use for the data that comes out of your metering, because the meter, in and of itself, won't help you save any energy or any water or your natural gas; it's only through the use of that data. You need to make sure that you've done the right level of metering for the appropriate approach.

Thinking about how you would use that metered data, whether it's at the executive level or at the first-line supervisor's level, is going to be important to your process. I'm currently at the Oak Ridge National Laboratory, part of the facilities management division, and the lab has had a wonderful opportunity these last few years to revitalize the campus with a lot of new construction. Metering is seen as one part of a larger approach to providing those world-class facilities. And so, our operations staff is very involved in not just operating those facilities, but making sure that as we make changes in those facilities we're aware of how those changes impact the energy efficiency and any opportunities to conserve. What we're seeing is a movement away from facilities management being one of having the facilities available and reliable, to now we're worried more about the efficiency of those buildings; and certainly, the legislation supports the need to move in that direction.

Metering is one element of a larger effort. You need to think about your metering approach in that context. For example, the legislation might require a building-level metering approach, but there may be drivers within a facility that, while you're doing other upgrades to the equipment, it might make sense to do some level of sub-metering. You may not be required to do metering of all the commodities, but if you have an operational need that would help with that, then it's certainly an appropriate use of your resources to work through your financial folks and try to make those strategic investments as part of that larger undertaking.

The last thing I'd say, too, is metering should be targeted to where it's going to do the most good. In our case, although we have a campus with hundreds of facilities, only 25 of those buildings consume most of our electricity. So, obviously, we'd want to make sure that we understood, in great detail, what the use of electricity in those facilities is. Your situation may be very similar. The other thing that I would point out, and we'll talk about this a little bit later, is that everyone has a different situation. At the lab, we're fortunate in that we do a lot of our own utilities distribution internally to the organization. I know a lot of sites are provided their electricity and their other utilities from a local utility provider, and so those folks need to be brought into the discussion as well.

One of the things that we try to do, and we'll use examples as we go today, trying to make sense of that data is going to be an important part of that. So, in this example here, we have certain buildings that we've captured the energy consumption over a range of data, to try and show – are we making process at the upper level against the goals? Well, without some level of facilities metering, it's hard to make sure that you're headed in that direction. As we go through this, we'll look at other uses of the metered data as well.

Probably the largest challenge that you're going to face around your metering is the use of the data, and that pertains to how is that information moved from the meter to some sort of data storage? Your IT organization is going to be a critical part of how you make use of this data. We'll talk a little later about different technologies that are available, whether it's power line carrier, wireless, some use of your building automation system. All of these facets of your local site are going to help you understand the best approach for you, but remember, the requirement is that the data be able to be stored and that it be time/interval based. Data storage and then the use of that data is going to be important to that. We're moving past the days where you had the local utility guy walking up and doing a reading off of a mechanical meter. New challenges around metering are going to be a big piece of this. And as we move through the presentation, I want to talk a little bit about the fact that some of these technologies, and some of these issues, are not going to be familiar to your IT organizations. I want to talk about how you best approach them to help you solve your problems.

Another component of this, beyond just taking the data through a communications system into some sort of a server storage, is do you have the right software to support the use of that data? While you can imagine a local meter being able to be not only read locally, but to be able to store the data, when you try to start aggregating this data for an entire campus the process can be fairly daunting, especially when you start talking about multiple commodities. Energy information systems are going to be a vital part of that process. There are a lot of different vendors out there that can do this. There are systems that do it independently. There are systems that do it as a function of your building automation system. Working that part of the process out is another thing that you'll need to worry about. So, again, first understand how you're going to make use of the data, then how are you going to communicate and store that data, and then the last part of that is what kind of system do you need?

As you can imagine, if you're in a facility where most of your space is leased, that brings on one set of circumstances. If you're in another facility where you have a large turnover in research types of equipment with large shifts in load, then you may need a more robust system to help you do some of the simulations for how you would make use of that data. Having lots of conversations up front is going to be important to your success.

Budgeting, as a career facilities engineer and facilities manager, I can tell you that there's never enough money. And the last time I checked, maintenance and ops was still dead last on the pecking order when it came to funds, right? These are common problems that everybody experiences. A lot of uncertainty at the executive levels about: Is this a requirement for me? How does this requirement have to be weighed against other requirements that we've got? What are the options that we have? How long do we have to implement it? All of those things really boil back down to a budgeting process. You really have to be able to have the financial conversation with your executive team, and you have to be able to build that case, not in technical terms, or not in terms of the requirement, but you have to be able to show some benefits to your finance folks of why the metering system is ultimately going to help run the business better.

Going back to our experience at the lab, metering is part of a larger discussion. Whenever I have a conversation around additional metering, I start with the legislative requirements, and then I'll have a little bit of a discussion on the technical part. But, the power is really in being able to have the conversation with your folks that says: If I have this metering, here's the return that you can expect on that investment. The guidance document talks a lot about this. I would ask that you certainly make that reference available to you, so that you can look through some of the different options that you have there. And I have a couple of examples that we'll use today as well.

First example I'd like to show, we had a number of facilities – in this particular case, 1505, 6000, and 4500 N-and-S, are actually building numbers at Oak Ridge National Laboratory. Had some aging infrastructure, and we needed to do breaker replacements anyway, as part of an ongoing revitalization program. What we discovered was that, in some of the vendor's suite of tools now, they provide onboard metering as a function of the breaker itself. We didn't justify the project as a function of – we needed to do metering, but while we were doing breaker replacements in this switch gear in these motor control centers, we had a small adder of cost for the metering trip units that were available. Then it was just a question of providing the communications and the data storage for these devices and how we were going to tie it back into some existing infrastructure. So, again, a good way to think in terms of: How can I get some metering at, more or less, a no-cost option to me?

Strategies around that are going to be important as you continue to try to look into some of the new legislation that's coming out; whether we're talking about the specifics of the greenhouse gas legislation, or some of the earlier requirements that we ultimately start moving closer and closer to net-zero campuses and those kinds of things. The more data that you have that's useful to your staff, the more important it's going to be to you.

As we start to move into project selection, identifying the buildings that are going to require metering and determine that cost effectiveness is going to be critical to that – if you go back to our example, I've seen similar examples at NASA and at some of the Department of Defense installations, where some early, early investigations can help point you very quickly to the buildings that you have the largest consumption problem. If your site is mostly rented office space, that's one set of constraints that you've got. If you've got large process buildings, that's a different problem. A lot of sites have large numbers of buildings that are mostly warehouses. The assumption would be that those are fairly stable kinds of environments that you may not need to do a lot of continuous monitoring in, but some early, one-time metering can give you an opportunity to go in and try to get some early data to help you with that.

The obvious answer is: Select the ones that have the highest payoff and execute those first. The other thing that does for you is, if you have some early successes, that gets you some credibility with your executive team and your finance folks. The more that they can have confidence that you're being good stewards of the resources that you've been given, then the most successful that you're going to be as you continue to work on the more difficult metering problems to solve.

The other thing that we've learned early on is, use those reporting requirements as part of your strategy for the metering. Right? Some of this stuff doesn't necessarily make sense the first couple of times people hear it, but some of these requirements have been there long enough now that we've got to establish metering plans. We have revitalization of facilities going on throughout the complexes. Trying to make sure that you continuously update people as to where we are, what's our progress, how are we doing. The other thing that I think is really important is participating in forums like this where you can share successes, talk about the lessons learned. Certainly not everything that we have tried from a metering standpoint at the lab has been successful. And you have to be willing to go back in and tell the boss, "Look, this one didn't work, and here's what we've learned from it, and here's why we're trying not to let that happen again." It's not always the most pleasant conversation, but its part of the process. You just have to be really open about where you are in the process, and what's working, and certainly make sure people know what's not working, too.

There are different ways that you can approach the metering. And as you start to move beyond electricity into some of the other metering, some of these things are going to be very helpful. There's actually one more that I think is important to the process, and that's to understand that some things you don't necessarily have to have metered data to know that it's a problem, if you've got good O&M data that can help support – I know I've got a steam problem in this building. We know we've got industrial water leaks associated with this particular facility. We know that we've got large process equipment that uses a lot of electricity, right? So, the first assessment should be: How do you want to start, based on the knowledge that your staff has of the facilities? Then, you can go in and do some single time metering, some short-term run-time metering that you can start to develop time-of-day information from.

Ultimately, what you're looking for, for the purposes of the legislation, is having building-level long-term metering, so that you can historically track progress against the various mandates. But, you don't have one size that fits all. Some of what we were able to do was to show justification for not doing more extensive metering, by going in and doing one-time metering and confirming our belief that there wasn't a lot of consumption at a particular facility. Sometimes short-term metering can help you make your strategic investments better. You're not wasting money by metering things that don't need to be metered in a permanent way.

The requirements out of EPAct 2005 talk about building-level metering, and there are some requirements that say, if a building is small enough, you don't have to have metering on that. I would ask you to refer to the FEMP guidance document for that. But, in general, if a building is below a certain threshold, and there's a calculation that's done for your site on the energy consumption of a building, in our case – I'm wanting to remember it's about $30,000.00 a year is the bill. We typically look at, for our purposes, trying to meter buildings of a particular size. I think the new legislation talks in terms of nothing smaller than 5,000-feet. Again, don't go by my recollection, but confirm all of that when you look at the guidance documents.

Anyway, there's a certain level threshold that you need to approach for that. When you're selecting your meter, that'll get you at the whole building level. In my case, some of our buildings are hundreds of thousands of square feet. Building-level metering is good, but it doesn't really give me the level of detail that I need to be able to go after energy efficiency projects and conservation. We – because of those desires to ultimately meet the other targets, we choose to do substantial sub-metering at some of our larger buildings. Also, some of our larger processes require sub-metering. For example, if you have an exempt facility, you're required to meter that building for purposes of the exemption. Right? That's against the requirement for the Btu per square foot reduction of three percent per year that we've got.

Understanding which buildings are in and which buildings are out, and which buildings that you need to do sub-metering in, is part of the process of selecting those meters. For example, in the buildings where we added the meter-capable trip units when we did the breaker upgrades, we also had a whole building meter that that those trip units reported up to. We have both sub-metering, but we also do whole building level metering as well in that facility. Working through that process is important to you.

The other thing is that, sometimes, your users have desires for particular meters. For example, the requirement would be that you have a revenue-level metering that's capable of time-of-day reporting on an hourly basis. But, it may be that you have a process that some of these other parameters are important to you, so the accuracy of the metering is going to be a piece of that. If your processes require a meter that's more robust, if you need more aggregation on your time of day, if you need millisecond reporting or some of these other things, there are other things that you'll need to understand. And certainly, the last bullet, I think, is critical, and that's that, certainly, in many cases, because of the way the processes work, the installation costs may exceed the cost of the metering itself. When you start to talk about the communications that are involved and the outages that are often required for some of these larger systems, do not ignore those impacts.

And so, in our case, in some facilities we have a metering plan that says we will meter that building at a particular outage that may be scheduled as much as two years down the road, making sure that everybody understands going in that we're not going to have a separate outage for that, but we're going to coordinate that with another part of our process. It's an important way to help you save some of those costs.

We talked about the fact that these meters need to measure and record interval data. Different agencies are taking different approaches to how they want to be able to use that data. So, we move into the second part of the presentation, I want to give some examples of that. The requirement currently is that you be able to measure and record that interval data, and then communicate that data up to a remote location. By agency, there are certainly very different approaches to how that data is being collected. Some agencies are providing region-wide energy information systems that are common throughout. In other cases, it's a site-by-site. In some cases, we're still relying on the utilities to provide that data. So, the ultimate goal is that you have to be able to do this, and so anything that you're trying to install now, you need to make sure that it at least has the ability to upload that data so that you can meet the full intent of the EPAct requirement. It's not good enough for you to be able to do it locally, but ultimately, you have to be able to shift that data on up to your agency.

The different types of electric meters – it's not sufficient that you have an electromechanical meter that your utility can drive by and gather that data from, because an advanced meter actually has some time-stamping capability on that. An electromechanical meter, basically, is just a way to digitize the data that's recorded on the mechanical meter, but it's only as good as the time interval between the two readings. Don't fall into that trap of thinking that you – because you have electromechanical meters, meters that meet the intent of the act.

Two-way communication is something that is unbelievably complicated and very painful right now, because of the cyber-security issues. Working through how do you manage that part of the process is going to be important to you. Multiple modes of communication are also another challenge. Some sites, I know, have moratoriums on any kind of wireless. Other sites are more open to that. Making sure that you have the ability to both store the data and time-stamp the data would be the

requirement of the legislation. That said, you shouldn't do yourself a disservice by defaulting to the cheapest meter that's available. Make sure that you understand, as we pointed out earlier, what ultimately you could use this data for. In our case, some of our researchers actually have a desire to have the metered data available to them to use. If you have a situation like that, make sure that you've had those conversations early in the process and not after the fact wish that you had asked a few more questions.

The good news is, with electric metering, it's a fairly straight forward commodity and a well understood commodity to measure. When you start to select meters for these other commodities, it gets to be a lot more problematic. Water is fairly straight forward, but depending on where you do your sub-metering, you could have lots of line losses. Some of the older sites have huge amounts of leaks in some of their water systems. In some cases, the utility provides a local meter and there's no sub-metering on your site, and you're responsible for any leaks on your side of the meter. Just like at home. Right? If the water is shooting up in the front yard, it's always on my side of the meter. It's never the utility's problem. Well, it's the same thing when you're talking about a lot of our sites.

When you start to measure and try to meter steam, it continues to be extremely challenging. And so, data reliability is an important part of that. Strategies around measuring condensate return as opposed to steam directly, having a good understanding of the efficiency of your system so that natural gas metering can be a part of your steam metering, all these things can help you with that process. Working toward some of the things where you have wireless on some of these steam systems, as you can imagine, steam regulation and steam pits out on a large campus like many of us have, is a great place to apply wireless technologies. And you have to have a conversation with your IT folks and your cyber-security folks around what exactly is this system capable of?

You talk about wireless, it's not like the world-wide-web wireless, right? There are limitations to these systems. There can be security issues that can be worked through with discussions between your vendors as well as your IT folks. You're probably going to get "no" for the answer on the first go-around on some of these things. Be willing to have other conversations and say, "Okay, I understand what you're saying as far as the limitations are concerned. Let's see if this particular technology still might be applicable in my case." So, again, it's all about having these larger discussions and then working through those details.

Natural gas meters, fairly stable, well-understood commodity. The volumes that we deal with in some of our systems are fairly high, but natural gas metering is a fairly straight forward thing to meter, and I think we've got a good track record with that. Typically, it's going to be one of these particular types of devices. The best practices guide is an excellent reference for that, as well as the other FEMP references that Richard Kidd referred to at the start of the presentation. I don't want this to be a technical discussion, but working through your suppliers is typically a good way to help manage your natural gas consumption, and those types of meters.

Rotary flow meters, as well as diaphragm meters, and these other kinds of positive displacement are all well-known technologies. You shouldn't have much trouble working with your providers for those kinds of things. At that point, it really becomes a question of: Is your current level of metering sufficient? I think in most cases, a service entrance metering kind of an approach at a site is probably pretty common right now, because you have to pay the natural gas bill. Not a lot being done right now as far as sub-metering at the building level for natural gas. And again, as we move into the greenhouse gas legislation and EISA 2007, trying to understand what those requirements are, as opposed to just electricity metering, is going to be part of our process.

[Kathy Hyland]

We're going to take a brief break and listen to some comments by Ab Ream. Ab is an energy technology program specialist with the Federal Energy Management Program. Ab's areas of expertise include operations and maintenance, energy audits, metering, commissioning, and measurement and verification. Ab is the former chair of the executive committee of GovEnergy, and he currently chairs the Operations and Maintenance Working Group for the Federal Government. Ab has a BS in technology management from the University of Maryland.

[Ab Ream]

Hello, I'm Ab Ream, an energy technology program specialist with the Department of Energy's Federal Energy Management Program. Today's unpredictable energy rates make it difficult to meet Federal energy reduction mandates. To help achieve

their goals, agencies are implementing advanced metering technology systems. These technologies allow us to continuously monitor, measure, and manage utility data accurately and securely. Simply put, metering helps us understand what's going on, because you can't manage what you can't measure. However, just the act of installing a meter will not help you reach your goals, unless you first know what data you need and why that data is important.

With advanced metering, we raise the bar to enable interval data collection and the storage and transmission of information. Advanced meters are used to analyze this information in near real time, to understand what is really happening in our buildings and facilities. Smart meters enable two-way communication, with analysis and control systems, to achieve energy and cost-saving opportunities with greater speed and scale. EPAct and EISA require the installation of advanced electric meters by 2012, and natural gas and steam meters by 2016, in all Federal buildings to the maximum extent practicable. To help agencies meet these fast-approaching deadlines, FEMP provides resources in two broad areas. The first area involves metering system capabilities and functions, and guidelines for implementing provisions of EPAct 2005 and EISA. FEMP's guidance for electric metering in Federal buildings was developed in consultation with utilities, energy service companies, national labs, universities, and many others. It provides excellent clarification to ensure you understand the key terms, definitions, and applications required under various Federal statutes and regulations.

The second area is covered in the metering best practices guide, which explains the primary approaches to metering and provides a detailed outline of the process typically used to evaluate design, finance, install, and implement successful metering programs. The guide also provides case studies that show practical and successful examples. It covers the use of metered data for building system monitoring, revenue billing, benchmarking, and related topics. It's an excellent reference to help you choose the best solution for your specific site.

We hope you will use these resources to help you in your decision making, whether you are just beginning or far along in your metering plans. Visit the FEMP Web site to find the best resources to fit your needs.

[Kathy Hyland]

Thank you, Ab, for those comments. Now, back to Greg Palko.

[Greg Palko]

Thank you, Kathy. We continue to look at the challenges associated with the various meters that we have. Steam metering will continue to be, for quite some time, one of the more difficult commodities to meter. By its very nature, it's a very harsh operating environment. While we do a great job of measuring pressure, and by extension temperature of steam, steam flow continues to be one of the great challenges that we have. Most of the technology that's currently available operates off of a differential pressure. Typically, you have an up-stream and a down-stream pressure tap associated with some kind of an orifice, or an annular opening, that you use in that activity. These can be different types of devices. Other meters that you might see are turbine meters, as well as other devices.

Your steam provider at your steam plant, the challenges of the installation of a steam meter are extreme. There are some external metering technologies that are evolving now, that can give you baseline data temporarily, so that you can do that; also, more permanent installations with that. Obviously, installing an in-line meter in an operating steam system is extremely challenging, and so I don't want to minimize that at all. But, I would ask, again, that you – as Ab pointed out, refer to the best practices guide as well as the metering documents that are available at the FEMP site to help you with that process. Lots of great technical resources are out there. I would also say that we've had a lot of good relationships with vendors of various technologies in the area of steam, so your steam equipment providers can also provide you with some information on the latest technologies that are available.

Another thing that we've tried to do is to visit other sites, try to make sure that we understood what they were doing. This continues to be a challenge, not just for steam, but as well as electricity and the other commodities. Certainly GovEnergy is one of the conferences that can provide you an opportunity to do those kinds of benchmarking visits and talk to a lot of people. As a former member of the planning committee, I should put in a plug for GovEnergy. But, all kidding aside, certainly a great opportunity in one spot to visit with a lot of your peers who are working with these same kinds of challenges.

Potable and non-potable water meters are something that we're really just now starting to do. Executive Order 13514 requires that non-potable water also be metered, as well as our potable water. As you can imagine, some of the sites that have large – make up water for steam systems, there are still a lot of sites, such as ORNL that have a large amount of once-through cooling water that we're trying to deal with. In some cases, the outfall is your measuring device. Right? We've seen examples of tens or hundreds of gallons per minute flow rates at some of these discharge points that can provide not just a good location for a water meter, but also can help you determine where's the best place to go after your next water-reduction project as well.

Chilled water is a common utility at most sites. Typically, you see chilled water being metered at the chiller plant itself, but a lot of the newer systems have metering installed in the devices themselves. As you're doing upgrades for your various equipment, just like we talked about earlier with the electricity and having the trip units have metering capability, then the same kinds of things are not becoming more and more common on these various systems. A lot of – once-through cooling is being replaced with facility loops. Different kinds of chiller applications are becoming more and more common. Another one I mentioned earlier, sometimes you can achieve some of your steam metering if you look at going after the metering of the condensate return. It doesn't give you a direct consumption of steam comparison, but it can at least help you understand a little bit more about that commodity and what you're working with.

Let's move now to a little discussion on the communications that are required. Certainly the best advice that I think we can take with this is, what is your local system capable of now, and is there a way to piggy-back your metering information in your existing systems? Now, this is- this brings its own problems. I'll give you an example from my own experience. When we first put meters on our system, some of these things were IP capable. And so, hooking a meter up to the Internet, on our site, looked just like hooking a laptop or a desktop computer up to the Internet. It had an IP address, and so therefore it was subject to the monthly fee for a computer hook-up. Now, as you can imagine, the data transmission coming out of the meter is unbelievably small when compared to what your desktop computer is compared to.

I jokingly told my site manager the good news was that I'd saved him a half a million dollars in utility costs. The bad news was, it had cost him in $750,000.00 in IT support. So, make sure that you're having a good relationship with those folks when you do that. The building automation system also has some great capabilities. We've been able to piggy-back a lot on our existing building automation system. A lot of phone line carrier, power line communications, there's lots and lots of options that are out there. First thing you need to understand is, what do we currently have capability for and is there a way that I can use my metering to do that?

The good news is, most of the vendors are familiar with all of these forms of communication, and so if you work closely with your vendor, it's a fairly straight forward approach. But, the conversation needs to be on the front end as you're selecting the meters, and not after the fact. There could be bad assumptions that you could make about interference in buildings, as you can imagine. Most of these meters live out in a process facility somewhere, and so lots of interference if you install the wrong kind of communication. So, you want to make sure that you understand that going up front. Is a twisted pair going to be sufficient? Do you have Internet available in a particular facility? Or, are you going to have to run a line hundreds of feet, which can be extremely cost prohibitive? You need to work through that as you're dealing with that.

Again, the options are all things that you're currently using, it's just that we now have a new type of a device that we're going to try to tie into our system. The other thing that I'd say is that – and we've talked about this a little bit already – wireless is not an easy problem to solve. It's an easier problem to communicate the data wirelessly, than it is to solve the potential problem with that data becoming corrupted or being used for the wrong purposes by people who have bad intentions. Working through some of the standards that are now available for wireless communication, and some of the emerging discussions, it may be that we're not able to do wireless at a particular site today, but it may be something that you can plan for a year, two years, five years down the road. Trying to look at it sort of from an open-ended standpoint of, is this something that, ultimately, we want to be able to do? Or, is it something that we should leave off the table permanently? And again, those are discussions that you need to have at your local site.

Most of the data storage software is compatible with all of the current standards. Most of it is capable of being time-stamped. Almost everyone has the ability, either directly or through some sort of a patch, to be able to work with different kinds of applications. It's more and more all password protected, and so having that conversation around, you know, is this something that I need a server for my own uses? Can I use somebody else's server? Is that something that you buy through your IT department and they manage for you? Those are all questions that you need to be having as you start to work through that discussion.

The other thing you need to think about is: Who's going to use your data? Is this going to be something that is strictly going to be your utilities and facility folks, and they're going to print-out paper reports for executives? Or, do you have other users who would like to be able to see the data, even if they're not going to be able to manage the devices? And so, trying to think through is there a good reason why I would want these other folks to be involved in that process? In our case, typically, the answer is: Yes. Right? The more information that I can give my financial people, or my executive team, about the progress that we're making, the better off the success of my program is. Certainly, in our case, it's easier to err on the side of giving that information to as many people as possible. Again, the storage of the information is one piece of that. The software to be able to retrieve that data in a useful form at the appropriate level is another piece of that puzzle that you need to work through.

One of the things that continues to happen around these kinds of devices, is that these systems are more and more capable all the time of producing larger and larger amounts of data. What's the right amount of data storage for my site? Do I need millisecond kinds of readings on every single device out there with two year's worth of data storage? Or, is this particular building sufficient that I can get by with one percent accuracy recorded on a 15-minute, or a one hour interval? Right? Trying to understand how you're going to work through that. The bullet talks about considering hosting the data with a third party. That raises huge red-flags at some sites. At other sites, that's a fairly straight-forward non-issue. Thinking about it in terms of: Is this something that I need to own, or is it something that I can lease from somebody else, and let them manage that process for me?

In our particular case, we have a vendor on site with our building automation system that has people on site, and they are an active part of the process that we use for managing a lot of that data. Other times, we've had specific pieces of data that we wanted to host, and we've done some things in a limited way with those devices.

Let's talk a little bit about vendor selection and the advantages of whether you should have multiple vendors or single vendors. In our case, we have quite a few different product types. We have different vendors on site. I've seen other installations where they were able to have a single vendor who was able to keep things updated, manage that process for them. I don't want to give the impression that there's a right way or a wrong way. Price and features are another example of that. The right answer is, while there are advantages to a single vendor, our reality in many cases is that we have a lot of legacy systems that we're going to have to accommodate. The real issue is, are all the various components able to communicate with each other? If you've got a system that's capable of taking the data that you need to gather, put it in a reportable format for you and provide those reports to the appropriate level of management or operations staff, then that's really the right answer.

Again, it's not any different than the issue with the communications. In some buildings where we have IP available, we go that route. In other cases, we use phone line carriers. It's as different as there are sites out there. Thinking through that process is the important thing for you.

I've got an example here of some of the data that we've gathered. If you look at the left-hand column, these are just facilities that we have on site. One of the things that we're required to report is building savings as a function of BTU's per square foot. This particular report, we've combined both electricity information, represented here in megawatt hours, with the size of the building. It's a way that you can slice and dice the power of this. Another graphical representation of the same kind of data. In this particular case, the point would be that, at the immediate right side of the graph we brought another building online. When people want to be able to say, "Well, gosh, how come the consumption jumped so much in September of '08," we can go back and say, "Oh, that's when building so-and-so was added to the campus."

Steam, again, is a little bit tougher to meter. What we currently do is allocate steam. We have an understanding of the size of a particular building, and we understand our distribution, so some of our steam costs are metered, and some of our steam costs are actually sort of an algorithm that we've developed internally to help us manage that. Electrical demand is another way that you can do this. This is measured at our site level, so we shadow meter the Tennessee Valley Authority, which is our utility provider, so that we can keep track, in an ongoing way, of what our electrical peak has been.

I mentioned that we use our building automation system. In this particular case, you can see the vendor that we use. There are as many providers out there as there are sites. Certainly, I don't want to come across as favoring one versus another. This is just a screenshot from our particular case. But, it gives you some indication that, for this particular building, at this particular level, we're able, online, to give current meter data. The other thing that we're able to do is to talk about that in terms of: Is

this real power, versus imaginary power? Not really, but as the electrical engineers – by the way, did I point out that I'm not an electrical engineer? I'm a mechanical engineer. Real power as a function of power factor is a problem for some people. Cases where you have large turning loads, you can have all kinds of intermittent problems inside of a particular building.

In our case, because we're our own utility provider, we power factor correct at the utility level and then look for opportunities to manage that differently inside of a particular building. Real power is one of the things that we can evaluate. And again, not as a function of reporting for purposes of the requirements, but for our own utilities folks and for the folks in this building who have need for that data.

Another thing that you can do in this particular case, we're comparing the consumption across a series of buildings. This is just four identical buildings that I'll talk about as we move into a couple of the other slides. Another way that you can make use of the data is just a daily demand kW profile. The trick would be understanding what the expected rates are for that, and then you start to measure the anomalies. What's changed? What's different in this particular building? Having alarms set-up on the meters is another way that you can make use of this kind of data.

The other thing in this case is where you're talking about benchmarking and comparing buildings, and we have a number of buildings on campus that, on the surface, would appear to be identical. It's only when you get into the building and you realize that there are sub-systems in those buildings that can provide opportunities that you can look for energy efficient projects.

Water use profiles are another way that you could look for opportunities. In this particular case, you can make inferences about what might be going on in a particular building. As you can imagine, you look for ways to say, "Is there a way to reduce the peak? Is there a way to broaden the valleys?" In the one case, we have water use that never goes to zero, so what's going on with that, versus the other, where you're able to take it down to zero in a recurring pattern; looking for ways that you can identify projects that you can work through that.

Another example of load duration, trying to figure out as much information as you can out of the metering that's available to you, is what we're trying to convey with this series of slides. There are more capabilities in these meters than the typical user makes use of. Primarily, your utilities staff and your facilities staff are your front-line in trying to help you reduce the energy consumption in these facilities. Are you providing them with the level of detail that they need to be successful in the job that you've given them? Are there additional things that, through slight increases in the cost of your metering are going to provide you with greater payback as you move forward?

Remember, we started the conversation about beginning with the end in mind, so do you have a process that says: This is how I'm going to use this data, and this is how, ultimately, I'm going to be able to achieve the goals that have been established for us? Whether we're talking about electricity, steam, gas, or ultimately, water? Metering is the way that you're able to measure the progress that you've got and identify problems that are going to inevitably come up that might impact that.

Let's talk a little bit about lessons learned. In this particular case, we've seen some sites that have done wonderfully well with their metering practices. In our case, it continues to be a mixed bag at the lab. We've had tremendous success in our new campus. But, as you can imagine, in some of our World War II vintage facilities, getting outages and trying to work on these old systems continues to be a challenge for us. You try to work around those kinds of issues as projects are developed. Try to get involved early with your design folks as well. A couple of things I want to point out on the communications system. We had some challenges in that, because of some legacy wiring in the building, we had electrical anomalies that are not common in a new building. Some of these older, vintage, electrical distribution systems can provide opportunities for noise on some of these signals. We did what the vendor asked of us to do, installed it the way that it was asked to be installed, and yet our meters were dropping offline because of this noise problem.

We ended up spending twice as much money, because we had to end-up going back and rewiring with new wiring that was capable of handling this particular noise situation. Make sure that you understand those kinds of issues as an important part of that. The other challenge for us, that I'd point out, is revenue meters versus power quality metering. We've got a number of sites, or a number of buildings on our site that we would like to have additional metered data out of, but because of an earlier decision on a particular project, we piggy-backed our metering on another project and only installed revenue meters there. Their ability to capture the level of detail that we wanted for some operational problems was not sufficient. Now we're going

to have to go back in a small number of buildings and consider whether or not we're going to re-meter with a better quality meter in those particular facilities.

In our own case, not understanding the potential for future uses of a building ended up causing us problems. Ironically, these are not decades old problems. These are things that are evolving in months to small numbers of years. Being able to get the right people in the room early on that understand the future uses of the building, and therefore the future desires for metering, is an important part of that process.

I'll give you a good positive lesson that we had. We had a dozen identical office buildings that were built back in the mid-'90s. And individually, they're not very big buildings, but taken collectively, they represent about 70,000 square feet. One of these particular buildings had achieved an ENERGY STAR rating, and ironically, these very similar office buildings, in some cases, were using three to 10 times as much power as the one that was rated as an ENERGY STAR. We went in and tried to understand what was going on with that ENERGY STAR building, did an electrical upgrade in the equipment to enable us to install switch-rated motor-controlled breakers in those buildings, that enabled us to model the behavior that had been achieved with the ENERGY STAR building. We worked directly with the clients, made sure that they understood what their energy consumption was, and the last time I checked, we had moved, I think, half of the remaining buildings in line so that they're now using less than the ENERGY STAR rated building. So, again, just good behavior enabled us to model for the occupants of those buildings so that they were able, through some small investments, to pursue the kinds of energy consumption that would be attractive.

It wasn't a large footprint for any one individual building, but when we did a project in aggregate, it made sense for us to do building-level metering and try to provide some competition between those folks. I know many of the other national labs have done similar things with their buildings, with getting people involved in: What is my consumption, and how can I conserve it? Base is another opportunity for that, when you're talking about housing and those kinds of things, as well as some of the university campuses. I know here at the University of Tennessee they have those kinds of activities as well, where they have one dorm compete against another dorm. Pizza and beer is probably what they do at the university. I'm not sure we can do that at the lab, but something to offer people an incentive.

This is the example of those generic buildings. The building that you see in the lowest portion of the graph was the ENERGY STAR building across a particular weekend. As you can see, many of the buildings were using quite a bit more electricity. Again, it wasn't that any one individual was using a lot, but it was in comparison, when you took the whole; and so, being able to move half of these other buildings down below the ENERGY STAR building. The other benefit that that gave us was the opportunity to prove to the finance folks that we could take a small project, model the behavior, and there was a lot of the information that we learned from this project that was directly translatable to our larger facilities.

The other thing that I would say is – and this goes back to what we started the discussion with – is how are you going to use the information? If you can begin with what, ultimately, you would like your metered data to be used for, and if you can convince people of how this data can be used to help them not only save energy, but to help them operate their facilities better, if you can take that information and communicate that in a real sense to buy additional metering, I can promise you a return in lower utility bills to your finance folks. Those are all really important pieces of that. Being able to take the results from these metered investments and be able to put those in the hands of your executives and your facility managers is, ultimately, the best use of your meter. It's not just about installing meters, but it's about operating your facilities in a way that makes them more valuable to the complex.

We talked at the onset a little bit about the new executive order. I would ask you to be sure and refer to the First Thursday Seminar on the greenhouse gases. I believe it was last month. The other seminars are also great resources, but in particular, I think what you're going to see as we move forward with this is, as Richard Kidd pointed out at the onset, the use of greenhouse gases as sort of the coin of the realm for comparison of how we're doing against these various goals, is a piece of where we're heading. Being able to take the current legislative requirements for electricity, and now gas – excuse me, natural gas and steam, but be able to see where we think we're headed with water and some of these other metering requirements is going to be important to us as we move forward over these next few months and years.

Starting out with the right plan that has the ability to, in an open-ended way, give you the opportunity to add additional metering as you move forward is going to be a piece of that. Make sure that you don't limit yourself up front. Build a system that helps your campus provide the opportunity that you need to try to make sure that we're ready for not just Executive Order 13514, but any other legislation that's coming down the path is going to be an important piece of this.

Again, I would refer you back to our key resources, the FEMP Web site has a tremendous amount of information, not just about metering but other energy-related activities. And the learner guide that Kathy referred to is going to be an important part of your ongoing approach to this. I would also offer myself and the other national labs. We've got a lot of folks that are doing a lot of work with metering. If I'm not the right person to answer your questions, then I certainly can point you in the right direction to some of these other folks.

[Kathy Hyland]

Thank you, Greg. We have questions. Let me start with my first question. Greg, how do we, as Federal agencies, determine what the optimal level of metering? Do we need to pay for a multitude of capabilities that some of our vendors are offering?

[Greg Palko]

That's a good question, Kathy. What I would say is that all the vendors are capable of the full range of metering capabilities. It's important that you understand that the requirement is for building-level metering that can provide stored data that can be time interval recorded, so that it can be reported up the line. Beyond that, what you need to do is compare the price differences between the various levels of metering, and determine if your local use for that additional data warrants the additional metering. I'll give you a good example from our case. In our small office buildings with fairly limited opportunities for energy savings, we go with, typically, a revenue-level metering. In our process buildings, where we believe we have the need for those other components in the metering, there is a series of steps that you can take toward the various power quality wave-form capture and all those kinds of things that are available in the meters.

I think the right answer is, make sure that, first, you're compliant with the requirements, and then there's a cost/benefit that can come from the various things that the vendors offer. My experience with the vendors is they want to sell you what you need. They'll discuss all of the various features that their products have, and they can provide you some guidance on that. But, again, I don't think you – it's not one solution fits everybody. And even on a given site, we use a variety of meters from the same vendor. In some cases, it's quite okay to say, "I need to low-end meter for these applications, and I want to use the high-end meter for these other parts of the facility."

[Kathy Hyland]

Okay. Another question, kind of related to what we were just talking about. Can you expound more on the value of using one meter manufacturer versus multiple vendors, and how you look at that?

[Greg Palko]

Even when you go to a single vendor, that can have long-term issues that you have to deal with. Right? Today's best-in-class won't necessarily be there five years from now. While on the surface it seems that a single vendor would always be the right answer, it's not necessarily the right answer. In our particular case, it's sort of a two-pronged approach. We're fortunate to have a building automation system that's fairly widespread on our campus, and so for purposes of the data collection in that system, we were able to make the metering through that part of the process a single vendor, if you will. They have their own infrastructure. It has its own support network with it. We get great support. Having said that, there are other places where we use a different vendor, because we have a different metering capability that we're looking for. As you can imagine, someone can be really good at building automation systems, but not necessarily what you're looking for in all cases for your metering.

Being able to think that through is important. As I said earlier, I think the important part for our reporting purposes is that all of the data that you get has to be able to be put into a single system so that you can report it away from your site. Most of the vendors have some ties to some of the open protocols, or they have local patches. Most of them have reporting systems, whether it's Crystal Reports or Excel, that allows them to export the data. We've had good use of that part of the conversation, making sure that whatever you buy, you're capable of gathering the information that you need.

[Kathy Hyland]

Okay. Next question. Data communications is an issue on our site. How do we educate our IT staff on metering, and how do we navigate the IT gauntlet of network communications?

[Greg Palko]

The first thing I would say is that my experience with it is painful. We've got a great IT staff, they have a different set of measurements that they're responsible for. Right? They have to deliver a robust product that's available at all times to the whole site. The second thing I'd say is that cyber-security, in some cases, is actually managed separately from the technology part of hooking things up. You've got a different level of folks that have to be in the room. In our particular case, what we've tried to do is bring those people in early and bring them in often. It's not uncommon for a site to have a chief information officer who has oversight for all of that stuff.

Historically, the problem was that IT applied to everything except those maintenance systems. Right? It's only lately that IT has come to understand that the connectivity issues for devices that live in the operations world and the maintenance world are things that they need to worry about. It's not necessarily anybody's fault, but that's just sort of where we are in that process. I've got people that I've worked with for a long, long time in IT that still get surprised when I start talking about the number of devices, whether it's meters or some control point that we've got in a building automation system, or some piece of a SCATA system that we're using to manage a particular process. The lines are becoming blurred in this area, and it's really important to bring those IT folks in, even if you're going to have to play catch-up.

Just recently, we had a situation where we thought we had a particular device that was ready to roll out, and really got some push-back. We've had to step back and gather some additional data so that we're meeting the requirements that those folks have. Just like your financial people need to understand, at least in their terms, the IT folks have an equally valid concern that we have to help them manage through that. Having that conversation is an important part of that. I wish I had a silver bullet to offer people on the IT side. It is the big challenge. Cyber-security is the latest emerging issue with that, but it's just the latest in a long string. Wireless, we talked about earlier, will continue to be a challenge for a lot of sites.

[Kathy Hyland]

We have a question live from Shenandoah National Park. "I was looking for some of the manufacturers of these advanced metering devices that serve the Virginia area?"

[Greg Palko]

Typically, the vendors are national and international in scope. The Virginia area would not be unlike east Tennessee. The distance between the Great Smokies and Shenandoah isn't that far, so we've got a lot of common ground that we cover. A lot of the vendors that we use – I would tell you that the major electrical manufacturing firms and the major building automation firms all have metering that is capable of achieving these goals. If you have a GE rep, a Siemens rep, a Square-D rep, Johnson Controls, those are the – sort of the biggest players in the electrical world. By extension, they tend to be the most capable as far as some of the electrical metering is concerned. I believe some of the FEMP guidance also provides some of that on the Web site as well.

[Kathy Hyland]

Okay. We have another question live from Ellicott City, Maryland. "Would you recommend an energy management and information system that measures and verifies and that is separate from control? So, it's separate from, like, JCI, Siemens, and that group?"

[Greg Palko]

It depends on the complexity of your site. In our particular case, we can get some of the information that we need through our building automation system, but when it comes to trying to do simulations, some of the forecasting around some of the new legislation, for example the greenhouse gases, some of those are capable of doing within your building automation system, and some of them aren't. So, in our particular case, we are currently investigating that very issue.

[Question]

Would you recommend putting an energy management team together, internally, with various stakeholders with different goals and objectives?

[Greg Palko]

Yes, and that's exactly the way that we have done that at the lab. We have an energy – a sustainability group that not only looks at energy, but some of the other issues, and it's comprised of not just facilities managers but also utilities managers, as well as people on our finance team, our procurement team is represented on that, as well as, in our particular case, some of the users.

In our case, it happens to be the researchers. But, certainly, what I always look for as the facilities energy manager is, who's my local person in that facility that's the most passionate about this? So, if you've got somebody in that building who's interested in solving this problem, they can break down the barriers and open more doors than you're ever going to be able to going through the org-chart to try to get that kind of access.

[Question]

Was an IT person a part of that team? And if not, should they have been?

[Greg Palko]

Yes, an IT person was – again, I think I mentioned earlier, I have a counterpart that I've worked with for 20 years, who – we have a lively conversation about, I never tell him soon enough and he's, you know, got lots of issues that he's trying to deal with. And again, it's a very frank discussion, because the answers are not very straight forward on this. So, certainly having those people involved in that, things that I would like to do that vendors say that they're perfectly capable of, we have IT rules around being able to implement. So, you need to have those folks. That's a good catch. I'm sorry I didn't mention that.

[Kathy Hyland]

Okay, I have questions. The first one is: Do you recommend doing metering pilots on a small scale before full metering of an installation?

[Greg Palko]

Absolutely. We've had good success. The power of that is two-fold. One is I was able to make my mistakes and impact a smaller number of people. Right? Because there will be mistakes made. And so, it's easier to get buy-in from a small group of stakeholders than it is for an entire installation. The second thing is that it gives your finance folks the confidence that you've learned lessons from that, you understand the scalable issues with that, and then you can take that to a larger group. Now, having said that, if your site is able to have a campus-wide solution implemented, I still think it's important that you do that in stages, that you need to take a definable sub-set of your campus, work that through, make sure that that's fairly communicated to the whole campus. Because, some people want theirs done sooner, some people will want to have it deferred to the very last. And so, working through that is an important part of that.

But, especially on some of our larger installations, this can be a multi-year kind of a roll-out for some of these systems.

[Kathy Hyland]

Okay. The next one is: Do you recommend sub-metering based on the organization of the building by area, or based on specific energy-using systems within the building, like lighting systems?

[Greg Palko]

We've tried that a couple of different ways. A lot of times, our systems, like lighting for example, aren't fed from the electrical system in a way that would allow us to separate them out. What we'll do is sub-metering in a portion of the facility, and we'll try to use good engineering assessments to determine how much is lighting, versus plug loads, versus HVAC. The other thing that we always try to do, though, is whenever we do any kind of a retro-fit in a facility, we try to include at least

some base-level of sub-metering as a part of the cost of that project. Over time, what you get is a better understanding of what the loads are in a particular facility.

Certainly, the vendors are capable of sub-metering down to a 20-amp breaker, if that's the level of metering that you're interested in for your own purposes. That's probably a little more extensive than what we've had a need for. If I was going to do it by system, I'd start with chiller loads. Then I'd work on the major distribution points. So, if you've got bus work in your distribution system, it's easy to put a meter on a particular breaker as it's distributed out. Power breaker distribution points, transformer replacements is another good location to do that sub-metering. Trying to make sure that you've done that in a way that gets you the most value.

Let's go back to your example with the lighting systems. In that case, my question would be: If I sub-meter lights, is that something that's actionable to anybody on my staff? Right? Okay, now I've got meters on my lights. Can I do anything about the energy consumption on my lights? Right? The point would be, in that case, meter those things that you think you can have the greatest impact on.

[Kathy Hyland]

That's all we have time for today. I want to quickly, before we conclude, show you the next seminar that's being offered.

Your feedback is important to us. We hope you will take the time to complete the quiz and the evaluation. By doing so, you'll be able to print a course-completion certificate for your records, and it also gives FEMP a record of your participation in this training. And we will also use the information that you provide us to develop future seminars that we hope will also be very relevant to what you're doing. There are three ways that you can complete the quiz. If you're watching us by live streaming, there's a paperclip icon on your screen. If you'll click on that, it'll take you to the link. If you registered for this course, you will also get an e-mail with the link. And finally, you can go to the FEMP Web site, the training portion, and access the link.

Please take the time to give us your feedback so that we can continue to offer you quality seminars. I want to thank Greg Palko for his time and preparing and delivering this training, and the team that supported him, Ab Ream, Greg Sullivan, and Bill Sandusky. We'd also like to thank the Federal Energy Management Program for sponsoring these seminars. We will see you on July the first for the operations and maintenance seminar.

[End of Audio]