Eli Levine: Hey, everyone. We'll get started in about 30 seconds.

[No conversation from 0:00:18 to 0:00:34]

Alright. Well, welcome everyone for those of you who are able to attend in real time here with us today on this Thursday afternoon and for those of you who will be watching the recording later because of whatever restraints that we all have in this new environment where we're providing childcare and teaching school and managing all of our responsibilities. My name is Eli Levine. I lead our Better Plants program here at the US Department of Energy. We're thrilled to have you with us for this second installment of our online learning series. This one should be really great.

I'm excited for it and it should be a really informative time. Next slide, please. So just as a reminder for you, this is the second installment. We're going to be going over the basics of energy. The next one will also be a bit of a training and tutorial week focusing on lighting, HVAC and building envelope. After that, we're really excited to bring you some resources that our colleagues in the federal family have as well from the US Department of Commerce. They're manufacturing extension partnership centers.

These are centers located in all 50 states that are really a great resource for the manufacturing community as well as the US Department of Agriculture's Rural Development program where they have tremendous resources to offer, so that should be an exciting webinar as well. So with that, I will turn this – next slide, please. Before we turn this over I'm excited just to remind you all that in addition to these webinars we are hosting our Better Buildings, Better Plants summit for 2020. It's a virtual leadership symposium.

Like everything else these days we'll be gathering virtually through our computers and tablets and it should be a great couple days with a lot of the sessions that make the traditional summit so special, a lot of learning, a lot of sharing with each other and observing what leadership looks like amongst our partners. So the link is there at the bottom. It's free to register. I encourage you to start registering today. Next slide. So with that, I'm really excited to turn this over to my friend and college Tom Wenning from the – look at that fresh face – at Oak Ridge National Lab.

Tom is going to lead us through this week's webinar on the basics of energy. Most of you know Tom. He's a tremendous asset to the

program and I am excited to turn this over to him. So Tom, two and a half weeks after adding a new baby to your family, we're thrilled that you're managing to use some of the time you're awake and not too sleep deprived to join us and share some of your knowledge. So Tom, over to you.

Tom Wenning: *[Laughs]* Thank you, Eli. Wide-eyed and coffee-fueled over here. Actually, this is something I guess timely and it's good that we're all getting together and focusing on energy. And I see a lot of folks are jumping on and there's a lot of friendly faces that I know, and then it looks like there are a couple of new faces in there as well, so hopefully we'll get to know a lot of you over, you know, maybe this virtual and then at the summit and in some of the future events when the world may return to a little bit more to normal. But really today, and maybe just to set the stage, you know, we're going to go over the basics of energy, okay?

And for some of you – you know, I see some veterans here on the attendee list – for some of you this might be just a really basic refresher whereas some others – you know, if you're just getting into energy, energy efficiency, energy management now this might help provide some of the foundational components in terms of your energy learning, in terms of that energy journey where, you know, we can just stack one block on top of another, okay? And so I think one thing I will preface here, to be super safe and precautious I did end up prerecording this, and so when we're jumping into things here we're actually going to be watching something that I recorded a little bit previously, partly – maybe mostly because of what Eli just mentioned, a newborn and the craziness of life right now and just kind of everything going on and everyone also taxing the internet lines. I just wanted to make sure that we're able to provide something really good for you all.

So one of the things I will mention, and I think this might be on the next slide here, if you are on the line, at least what we just found out here recently, you will need to be connected through your computer in order to really hear most of what's going to go on for the rest of the webinar today. So if you're dialed in through your phone there's a good chance it'll cut out, so you might need to turn up your computer speakers. But with that in mind, we still want this to be very much of a dialogue. We want this to be, you know, a virtual dialogue of sorts. If you have questions, if you have comments, GoToMeeting has that chat functionality so please be sending comments and questions in, but we're going to be stepping over or stepping through all the basics.

Kind of the fundamentals, the foundational stuff that many of you probably learned once before and this will be a good refresher today. And if not, if you're just stepping into things, this will be a fun journey that hopefully we can build a lot of things off of, okay? So with that, Marissa, I think we can jump in.

[Prerecorded portion begins]

I'm going to kind of set the funnel here at a really high level and then we'll start getting a little bit more specific. At a really high level, you know, you all are Better Buildings, Better Plants partners. Hopefully most of you know what that means. If you don't, the high-level summary is that it's a voluntary public-private partnership program where we are working with industry – you all, right? – and you set a long-term aggressive energy intensity goal. For a lot of companies that's, you know, something like 25 percent in 10 years or 20 percent energy intensity reduction over 10 years, right?

So ambitious stuff. And then as part of that commitment on your side, you know, DOE comes to the table with a slew of technical assistance. Really it's a giant toolbox full of tools, right? We provide this networking platform as well as opportunities for national recognition, so really being a program of leading companies. And then one that's not even on here but I think it's on the next slide is the connection to the DOE technical resources in terms of research and development, so some really good things on that front. And I'll just jump right into that one.

So kind of going a little bit more in depth here with this technical assistance, you know, you have technical account managers, so I think you all have a true shining star in our program who's really been doing a lot with you and you've been taking advantage of things such as our in-plant trainings and the industrial assessment centers. These are opportunities for you all to get outside experts into your facility for either several days or for a one-day activity if it's through the industrial assessment centers, but these are real true hands-on opportunities to make a difference. But then we have a lot beyond that. You know, we have some diagnostic tools down here at Oak Ridge that we will lend out for free to help you get whatever measurements you need, okay?

And then, you know, there's a lot that we will go in depth on in terms of benchmarking, baselining; you name it we'll likely go there with you. But in terms of some of these other areas outside of technical assistance, the Better Plants program does also have this

national recognition aspect where we really are aiming to be a program of leaders in using that platform to help elevate the success stories of companies that are just doing fantastic things, and so we have awards for obviously achieving this big, audacious goal of sorts, but in addition we have some other awards, or we call them our better project and practice awards. So, you know, as we get towards the end of this Energy Warrior training hopefully you all have either implemented a practice or a project in your facility and it may be worthy enough to put together a short application for one of these better plants, either the project or practice awards.

And heck, I'd say there's a good chance you could get one, and that's pretty powerful stuff. And then the last thing I think I have on this slide is this networking platform, this peer-to-peer based networking opportunities. This is in the form of some of the national conferences that the Better Plants either hosts or is involved with. The big one that we typically run is the Better Buildings, Better Plants summit, which tends to happen in the summer timeframe. Next year it'll be held in June. So a lot of your colleagues show up to that, and it's just a really fantastic opportunity to benchmark and hear from others in terms of the trials and tribulations, the struggles that they face.

And I can cut to the chase and tell you a lot of them face the exact same problems that you all have. Some of them are in the area that they're trying to overcome. Others have, you know, experimented and tried a couple of different approaches, and so that peer-to-peer networking is just wildly important and valuable. So hopefully we'll see all of you at one of those at some point in the future.

Okay. So now we're going to jump a little bit more into the technical depths of today's discussion. So here's the outline of what we're going to be covering today, everything from the high level, you know, what is energy efficiency into maybe the accounting, we'll spend a little bit of time on the utility bills and then kind of wrap things up on the benchmarking and assessment front, okay? So this is setting the stage really for some of the future sessions that we're going to be covering, and to some extent it's this logical progression of, you know, how you might even implement or perform your own energy assessment of sorts, right?

So we start with some of these high-level things and then we're going to get to the more technical stuff later on. So let's jump in. Why energy efficiency? I think most of you know because you're kind of in the space, you're playing and wearing the hats of energy

or doing something that touches energy. You know, even if you're like the production engineer or the maintenance department head, most of the things that you do touches energy or affects energy in some form or fashion, and at the end of the day energy is one of the few levers that you can actually pull on and you can change and for the most part people aren't going to yell at you, right?

If you stop using those kilowatt hours, if they stop showing up to work for you because you don't need them those kilowatt hours aren't going to go on strike, right? Whereas if you do that in labor that causes problems. Kilowatt hours or MMBtu, you know, the energy we buy and purchase, this is one of the true levers that is pretty easy to pull back, and at the end of the day it helps our bottom line, okay? In many cases, you know, that goes literally directly to the bottom line, and if you think about it in a slightly different way you can do this mental math; how many more pieces of product might you have to make and sell to make that same profit margin as though maybe you turn off some lights or turn off equipment?

You know, what does that look like? That's a really powerful kind of reframing of sorts. But, you know, energy efficiency is beyond just the competitiveness. More and more we're also seeing a lot of impacts in energy security, right? So, you know, keeping your facility operational, whether it's being hacked by other things in this world, whether it's just the power grid going down, you know, there's a number of security-related things, but energy efficiency is really critical in all of that. And then last but maybe not the least is the impacts on environmental regulations and what's going on in that front, right?

We want clean air to breathe, we want clean water to drink; energy certainly has a big role in all of that, and more and more where the world seems to be going we're looking more at the greenhouse gas emissions, and while there may be some activities going on in a few states it's not national yet, but at some point it is conceivable that it could be, you know, regulations on greenhouse gases on a national level. So energy efficiency is really important. It touches everything in our facilities. It's something to spend some time on, okay? Alright.

So there's a number of organizations, there's been a number of people that have been working in kind of the energy realm for many years, and they've been developing codes and standards in areas. Some are specific to energy and energy efficiency, whereas others, because energy touches a little bit of everything, they're in

related areas. So here are some of the more important codes that are out there just to be aware of. You know, whether or not they impact you all directly, maybe, maybe not.

But some of the more important ones or the more valuable ones to be aware of, you know, there's ASHRAE 90.1 and that's on commercial building, energy performance, really kind of some prescriptive stuff as to how our buildings are built and operated. We have ASHRAE 62.1, which really impacts our indoor ventilation requirements, so making sure that employees have fresh air to breath and we don't get dead rooms and things like that with too much carbon dioxide, right? There's ASHRAE 55, which is focused on the thermal environmental conditions. You know, so making sure people aren't too hot, too cold, so there's codes and standards around that.

And then finally, as we start to get more into really the energy efficiency-specific things, we have ASHRAE 211, which is focused on building energy audits, so how to perform a building energy audit based on a code, on a standard, right? And taking that even a step further would be the ASME energy assessment standards that are – they're developed around four specific areas. There's one for process heating, there's one for pumps, for steam and compressed air, and these are really fairly prescriptive standards as to how you should do an energy assessment in each one of these system areas. So these are kind of the relevant codes and standards in the energy space, so something to certainly log in the back of your mind. If any of you – you know, if you maybe go to private consulting at some point in the future and are doing things in energy these are the relevant ones that you'd have to play by.

Within the manufacturing role where you're at, you know, you might have vendors. You know, if you have a vendor coming in and doing work for you, you might want to make sure that they comply to some of these. Okay? So the next item on our list here is energy accounting. So we're going to step through kind of the high level of how to understand energy and what it means on the accounting side, so recognizing the difference between energy and fuel types. Most of us are very familiar with some of the main ones.

You know, electricity *[laughs]* – most of us may have not really thought about it, you flip the switch, lights come on. Boom. The electricity is typically generated far away. Historically, it's been through cold fire power plants. Now that's starting to shift amongst

the nation to more natural gas fired units and we're seeing a lot more renewables, but at your site hopefully you're able to just flip the switch and you get your electricity. But for most companies they are typically buying natural gas as well, and so those are the two main fuel types for most organizations. And then from there it will typically dwindle off a little bit.

Some folks are using propane. Maybe they're using them for fork trucks or something of the sort, diesel fuel maybe running some backup generators or some equipment on site, and then there are many other different types, but we'll step into that and then we'll also step into these energy units. You might be looking at that as a bit of an alphabet soup. And it is, but super important here in the energy world. So we have a couple slides on this stuff and then we'll even talk about conversions, how to be conversant back and forth between these various units. Okay?

So let's step through the most common energy units. The core one, at least as it pertains to electricity, is our kilowatt hour. So that's the first one on our list. And this kilowatt hour, all it is is just one kilowatt of power being sustained for one hour long, right? So it's a power demand essentially multiplied by a timeframe, and this is what we use for our electricity.

The next one on our list is this Btu. This is a British thermal unit, okay? The technical way to think about it is the amount of heat required to raise the temperature of one pound of water by one degree F. Okay. So that's the kind of technical definition. In reality, one Btu is the equivalent of lighting one match. So if you still smoke, right, you get a match out, you light that, that's one Btu right there.

Some other common ones, we have CCF, so this is 100 cubic feet of natural gas. And then MCF is thousand cubic feet, and so these are still – really all these in the middle are all for fuel-fired systems for the most part, so this is typically what we use to describe natural gas or in some cases fuel oil, it could be the diesel or the propane, coal, for the Btu and Therm aspect, but these are all related to our fuel-fired systems. Okay? The next one on the list is this Therm.

A Therm is just a larger version of Btu, 100,000 Btu. Okay? So just being conversant – you know, they're just different levels of energy and how we talk about it. And then the last one, and this is coming back to electricity again, is one watt. Okay? So watt is the power of the current flow of one ampere with voltage of one volt.

So that is our power and there's – you notice it's not watt hour, right? It's just watt.

So that's purely the power, whereas the kilowatt hour is really our energy consumption, so we'll step into that a little bit more in a few slides. Alright. So a few of the unit conversions, and this is just to help us kind of go back and forth, something to really be familiar with. Some of the most important ones to really make note of is this kilowatt hour to Btu conversion, so one kilowatt hour is 3,412 Btu. And so all it's just – it's a conversion, a back and forth. You know, technically we can use Btu to describe electricity. It's just that people typically don't, unless you're using that electricity to, let's say, drive some Therm incremental or electric resistant heaters, things like that.

Then you might be changing those units back and forth. Okay? The megawatt hour, that's the second item on our list. It simply is 1,000 kilowatt hours. So standard stuff, not too difficult here. The third one is, you know, one cubic foot of natural gas, the energy content in there is a little over 1,000 Btu. Okay? And so on that one we just scale it up to those next two, 100 cubic feet and then 1,000 cubic feet of natural gas, okay?

So just keep adding zeros onto these things, alright? Now if we jump down into the middle here we have our MMBtu. So this is some fuel-fired systems. On MMBtu is 1 million Btu. So each one of these M's right here stands for 1,000. That's all. Hence, 1 million Btu. A Therm, from our previous slide, a Therm is just a tenth of that, right? So it's 100,000 Btu.

And now some utilities – the problem is with all utilities they use all these different acronyms, they use all these different values in the utility bills they send you, so unfortunately there's not a pure standard way that people do that, but one of the common ways that you might get billed for your natural gas would be in dekatherms. So a dekatherm, all it is is just 10 deka and Therms, okay, or 1 million Btu. Okay. At a national level, not that you all at a facility will ever look at this, but one Quad is just a lot of extra Btu's there, okay?

And so it's more important maybe at the national level in terms of what we're talking about. Alright. And then the last unit conversions at least on this page here, and these are really important ones as well, is converting our horsepower into kilowatt hours, and so for one horsepower it's either 746 watts, or the more common terminology is kilowatts, and it's 0.746 kilowatts. So one

horsepower is 0.746 kilowatts, and that is really the unit that we look at when we evaluate our motors, you know, the motors that are driving everything in our facility. So that's a really important conversion.

And then for boilers specifically sometimes they talk about boiler horsepower. That's slightly different than kind of the standard horsepower that we use for motors. When they talk about a boiler horsepower it's really a little over 33,000 Btu per hour. So that's kind of a size rating for boilers. Okay? Alright, so a few more unit conversion aspects here, and this is on the fuel side and really this is for the energy contained within different types of fuel. Okay?

So if you buy, you know, one cubic foot of natural gas you get about 1,000 Btus out of that by burning it. Okay? If you bought one gallon of propane, you know, you're looking at 91,000 Btu. One gallon of gasoline, higher still, 125,000 Btu. So you can see the energy content of these things is going up. Diesel is even higher, 139,000. So when you're burning some of these things maybe for heat, these are the conversion units that you would use to maybe calculate the heat that would go into your facility or the heat for a process or the energy that would be required to turn an engine, right?

So those are on the top. If we keep going there's a couple other fuel oil types with each one of the associated Btus represented, and then at the very bottom we have our solid fuels. So there's a ton of coal. Coal is typically bought in tonnage there, with the average of 125,000 Btu, which is very dependent on the type of coal that you buy. There are different grades that you can purchase and they all have inherently different Btu value. And then the last one is wood, a cord of wood.

You might be buying a cord of wood to burn in your home's fireplace. In an industrial setting you might be purchasing biomass to, you know, run in a biofuel boiler. Okay? And so that one will range and vary significantly based on the water content of that material. Okay. So now that we know a little bit about the units that our utilities are billing us in, let's take a look at the general rate structures offered by utilities, and we're going to spend some time looking at our electricity rate structure as well as our fuel-fired natural gas rate structures.

Those are the two most common and there are some nuances in here. Okay? So for our electricity rate there are really four components that you will see on every utility bill if you are a

commercial or industrial end user. As a homeowner you don't see all of these things. They just roll it into one number for you. You know, if you're at home and you get that utility bill it's just one number.

For industry though, for large commercial, there are four main components. The first one is our connection fee, and really it's per meter. You pay for each meter. Okay? The second one is our demand charge. Okay? And for a lot of organizations that's, you know, maybe 50 percent – 40 to 50 percent of your bill, and this is billed in this kilowatt or kilovolt amp type of a rating.

The third one is our consumption. Okay? And this is the standard one that most of us probably recognize because that's how we're billed at home in terms of kilowatt hours. How many kilowatt hours did you use over the month? And then the last one that is really sneaky sometimes is this power factor. Okay? So some utilities will ding us if we have too low of a power factor.

And then – so these are the four main ones that are spelled out on your utility bills, but in addition to that obviously, you know, everyone wants some of your money so there's lots of taxes, there's lots of fees and riders that are tacked onto that, but in some cases those things vary over time. It's a little bit of a moving target. But these are all the main components. This last item that we have listed on here, this owning your transformer, really I would say this is a proxy for the rate structure and the rate structure that you are on. So depending on typically the size of a facility and where you're located utilities offer different rate structures.

Some are really simple and they're standard, you know, there's just one fee for each one of these four items. In other utilities, for maybe a really large customer, there might be slightly more complicated rate structures set up where you get – it might be tiered, where you pay less for that last kilowatt hour that you buy than the first one, right? This is a rate structure thing. And the one item that does sometimes impact in a really big way is whether or not you're on a primary versus secondary rate structure, aka, if you are owning your own transformer or if the utility owns it. Okay?

So we'll step into that just a bit more. So just to be really clear on a couple of those things, I think for those four main charges that we get, the meter one, I think that's really – everyone understands that. If you have a meter *[laughs]* you go out, you see it spin, you're paying for that meter. Okay? But the other ones, once we get into demand and consumption, sometimes people get a little bit tripped

up on this, and so hopefully break it down and make it a little more simplistic.

You know, demand is simply how much you need at any given moment, whereas consumption is how much you use over time. We have a little graphic here that kind of illustrates this in terms of like a water system. Okay? So if you want to fill up a five-gallon bucket you can either do it really slow or you can do it really fast. Okay? And that rate at which it's coming out, that the water's coming out, that's your demand. So essentially it dictates how big of pipes you need, right?

And so on the left-hand side, one gallon per minute is pretty low, so you have a low demand, whereas on the right-hand side you have five gallons per minute in this illustration, and so you have a might higher demand. Okay? At the end of the day your consumption is only that five gallons. Right? In the energy world it's the same theory, it's the same concept here; you get billed for how much you might use at any given moment but you're also getting billed for the amount that you use over time.

And essentially the way it breaks down or the way you can think about it, you know, that demand charge, you're paying for the line capacity, you're paying for the transformer capacity, and everything in the line for the utility to get you electricity on the highest point of use that you might see, but overall you're paying for the amount of, say, coal or natural gas that they had to burn back at their power plant to then deliver electricity through the line to you. Okay? So hopefully that makes sense for you. And the one thing I will say, in terms of utility bills this breakdown between the two depends really on the number of shifts that you're running as well as maybe the rate structure that you have, but a lot of times it's a 50/50 breakdown in terms of your bill; 50 percent might be associated with demand, 50 percent is with consumption.

If you're running more shifts it'll lean more towards consumption. If you're running less maybe it's in the other direction, okay? So that's the breakdown between demand and consumption and a good way to think about it. Again, demand is just in kilowatts typically, consumption, with it being over time, kilowatt hours. Okay. The other – this is the tricky factor that's typically on our utility bills. Again, there was that meter, there's demand, consumption and power factor.

Power factor is definitely a tougher thing for most people to consider. Power factor is essentially power that you can't use in the

line, and it gets a lot more complicated and detailed in terms of the voltage wave and the current wave coming in and not being harmonious. You know, they're a little bit out of sync, so there's opportunity for unusable power. For most people that's really tough to grasp. The easy way to think about this with power factor in one of the more common analogies is our beer.

I work a long day at work, I want a beer, right? So you go and when they pour the beer for you at the tap, you know, part of it is the actual beer that we drink and that's what goes into us, whereas that reactive power is really the foam. You know, we need the foam, we need that carbonation in the beer, that needs to be in that tap to get us a nice, fresh beer, right? But at the end of the day we're not necessarily drinking the foam. We're just drinking the liquid.

In the utility world it's essentially the same concept. There's this kilowatts that is the actual power that we use, but then there's this other stuff that they call reactive power and that's in this term of kVAR, and that's stuff that we can't use. It's not really used by our motors, it's not what we're typically built on, but they need it in the powerlines, they need it in the system to keep everything operational. Okay? The problem is with the power factor, based on how you run some of your equipment and what's going on in your facility, you can get more foam. Right?

You can get a lot more foam and the utility doesn't want that. You know, the utility wants you to have the good liquid, you know, that you can be drinking, and so there's some things that we can do to adjust and correct for that. So the utility incentivizes us by billing us if our power factor's really poor. Okay? Alright, and then the last thing was the item on the – really the service that we're billed on, and I said the big one is primary versus secondary service, which is essentially just who owns the transformer and where they're metered.

So primary is on the front side of the transformer. Secondary is on the backside. Okay? Typically, if you own your own transformer your utility rates are slightly lower because you're on the hook for, you know, upkeeping the transformer and making sure that it continues to work, whereas if not, if it's the utility's asset, you know, they need to cover that cost. Something to consider for most people, the general rule of thumb is about 1,000 kilovolt amps for your demand. If you're above that you should think about or at least investigate owning it.

If you're lower than that, typically it's much more beneficial to have the utility own it. Okay? Alright. So here is an example. We've been talking at a high level about what's that rate structure; what does one actually look like? So here's an example of an electric rate structure, and this is a simplified version. But for this, this connection fee, this is our meter fee, we're paying $50.00 per month, and really that's going to be per meter that we have in there. The energy charge – okay, this is our consumption.

They're billing us on this kilowatt hours. In this case it's 5 cents per kilowatt hour. Our demand charge in this case is $6.5 per kilowatt per month. Okay? So that changes and can change and typically will change every month. So you can set a new demand charge on there. And then in this case they also have a low power factor penalty, a $0.3 dollars per kVAR per month.

That may seem really low, but I think we'll step into an example where we show it's real money sometimes that you have to pay for that. And then obviously there's kind of the standard stuff in terms of the fuel adjustments, other charges, riders, taxes. I think we have an actual example right here. So here's an actual utility bill for a facility, and so let's break this down here. We want to look for essentially those four items on there, and in this case we can look for a couple things.

We're looking for some of these units that we had talked about earlier, okay? So in here you're going to have one meter. So this is electric, our count number probably, there's our days of operation. You can see that, oh, they didn't do a full, true month, right? It was 29 days. And then here's our usage, aka, consumption, and then there's this actual kilowatt. You know, so already they're not using the exact same terminology, right?

So, consumption, kilowatt hours, and then actual – this would be the demand, kilowatts, but that's what it is. They have it down here listed again consolidated, so we have our usage in terms of kilowatt hours, we have our demand, this kilowatts, and then, oh, here's that kVAR. That's kind of sneaky, right? That's our power factor. Okay? And then I've also highlighted – this is for a rate schedule from Duke Energy and they specify.

A lot of times if you're going to do a utility billing analysis or you want to go a little bit deeper, that's what you need to be looking at. A lot of times you can just go to the utility website, you can Google it in some cases or you can call your rep and they can give you the rate structure and breakdown of how you're getting billed

on all these things. So this is typically what we pay for and this is what we get in the mail. I have another tab here that's showing, you know, that second page with more of the details and all of a sudden it gets quite a bit uglier, but now if you get the second page you start to see the actual details. Okay? So here's our rate structure again at the top.

It's for a low load factor primary service. Our connection fee, so this is our meter fee, $75.00. Oh, look. We're actually looking at the demand charge, so they're using the same terminology now that we are. And in this case it's $4.11 per kilowatt, okay? Then there's the energy charge. This is how much we've used over time, and this is a simple one. It's only at a little over 3.5 cents per kilowatt hour.

And then there's that kVAR factor. This is that power factor. Okay? That's what this means, the power factor. In this case this plant is paying $1,000 a month essentially for a low power factor, which if you look over here on the left-hand side, it's all repeated once again. And over here they actually tell us what that power factor is, okay? 78 percent. For most utilities they set some threshold. A lot of times it's either 80 percent or 85 percent as the threshold, that minimum threshold.

If you're below that you're paying them. If it's above that it doesn't matter how far above you are or not; as long as you're above it you're not getting billed. So in this case it's an opportunity for doing something to save really money. You're not saving energy but you're saving some money here, and that power factor is something that can be changed and modified upward by simply installing some capacitors for the most part. Okay? The rest of this bill though, as you can see, there's a whole lot of other things on here.

These are all riders, they're credits, they're adjustments. You name it, they put it in there. Okay? Everyone's trying to get their hand in the cookie jar to do something. And so here's a specific one that they give us. This is for an energy program. They're charging us $10.00 per month for the energy program. When you see something like this you ought to be thinking in your head, how do I get that money back?

A lot of times when they're taking money out of your pocket there's an opportunity to reach back and take advantage of their programs, so make sure that you're looking to see if you are putting in projects maybe for their – for an incentive program. Okay? So

you can get some of that money back. If not, you're kind of just wasting your – you're losing some money there, okay? But here are just other standard, typical things. We have our monthly graph as well as the numbers charted out.

Ideally, for most of you, there's someone in your organization that takes all this information and is maybe porting it over to Excel or some other program where you can actually start doing some real-time tracking in the long run. Okay. So that was on the electricity side. The other major fuel stream for most of us is natural gas, okay? So natural gas luckily is much more simplistic. There's only two parts to it.

Electricity's confusing and it can get a lot more confusing than what I've even shown you. Natural gas, for the most part, is broken down in two areas, so it's already a little bit simpler. There's the wholesale commodity fee of natural gas and then there's a transportation and distribution fee, okay? So the best way to think about it, you know, you're paying for that cubic foot of natural gas in the pipe but then you're paying someone else to take that natural gas maybe from the gulf area, pipe it all the way up to you. Okay? So there's just two different fees here.

I got a couple of examples on here. Similar kind of approach. In this case, this procurement, commodity cost is $0.3 per Therm, okay? So we've got to know how to change Therm to dekatherm to all these other things, right? And then for our distribution – so this is on the wholesale. The second one, this is the distribution transportation. There's a customer charge and in this case they have this distribution charge that is tiered, so you actually pay less for that last Therm than you do, say, for the first block of Therm.

This is actually pretty common both in electricity and fuels. Then similar to the electricity side there's lots of other charges that they put in there and other tax items that get thrown on. Okay? So we have an actual example here of a plant. *[Laughs]* Okay? And you can see it's for one month. It's not even necessarily a full month. This is pretty close, 31 days. Oh, it's a full month.

We can see the 100 cubic foot used. Okay? So that's kind of our consumption. That's essentially our wholesale. But then you can see in the areas that I've highlighted things you can see a little bit more detail on all of that here. So there's the throughput charges, the customer facility charge. That throughput, this is really our – that's that distribution charge. You know, what did it cost you to move it to your facility?

And then on the right-hand side, this distribution detail, this is really our wholesale charge. So right now they're talking all of a sudden dekatherms, okay? So up here they used CCF and all of a sudden they're billing us in dekatherms, though. Just knowing and being conversant to go back and forth there is important. Okay? Alright. So now with that said we hopefully understand the basics of looking at a utility bill, and you're like, "Okay, great. Now I know how to look at my utility bill, but what does that do for me?"

You know, we just pay the bill, right? Yeah, you should pay the bill. That doesn't always happen in a timely manner, so make sure that your folks are paying utility bills. I've seen it way too many times where you're a little bit late and in some cases all of a sudden it gets really late every month and you pay a lot of extra money just because, you know, Bonnie down in accounting or procurements just took a couple extra days for the review and didn't get paid on time, and so every month you're stacking up a couple thousand dollars in late fees. So it's really important to take a look at this stuff, and I would say do a utility billing analysis, and there's a couple major things to really look for.

It's not overwhelming. There are a couple big things to look for for sure and then I'll step into some other things. The biggest one is just making sure you're on the correct rate structure. This seems really simple, but there's a handful of times where there are sites or plants that are not on the right rate structure. You're getting overbilled for your situation and in some cases it's as simple as, you know, just asking the question to your utility, hey, you know, are we still on the right one?

Our business has grown maybe or changed in some form or capacity; are we still on the right rate structure, okay? Another one is looking for billing errors. I hate to say this, but billing errors happen a lot. The utility, as great as utilities are, they don't always get it right. They are still human and we do get utility billing errors, and unless you do a billing analysis where you kind of recreate your own bill or pay someone to do that for you there are times where the utility just bills you incorrectly for sometimes it might be a month and in other cases it might be a really long time, but it's important to just look at those a couple times throughout the year to see if you're getting billed correctly.

And you're not going to know unless you do that, you know, the actual multiplication of sorts; kilowatt hours times kilowatts times the rate, that type of thing. And then the last really big thing

obviously to look for is this power factor correction. If you have a really low power factor the utility is going to ding you. I don't think I've seen a utility yet that will let you slide on that. So if you have a power factor under 0.85 or 85 percent or certainly under 80 percent, it's a good chance you're getting nailed with a power factor correction.

Here's some much more specific opportunities in this area. So under that rate structure at the very top, you know, switching to or negotiating electric rate structure that's lower, or another somewhat genius program to enroll in if you have it available in your territory is enrolling in demand response programs. These are opportunities where you designate maybe a couple pieces of equipment, a power size of a certain quantity that you could shut off if the utility company gives you a call and asks you to shut it off. In some cases some companies can do this immediately. You know, think during the middle of a summer; everyone has their electricity humming along to run their AC units and the utility might be maxed out.

The utility has an overloading problem in their system and they're looking for companies, they're looking for really industrials to have an option to turn off some pieces of equipment, and that's these demand response programs. I have found that it's a really good opportunity for a lot of facilities. You get a monthly check from the utility and they rarely, if ever, call you. The only thing is you do have to be prepared if that one day during the summer, you know, July 5th hits and the hottest day of the summer and everyone's worried about brownouts or blackouts, you have to be able to show or prove that you can shut off some piece of equipment and it's something you can define.

You can work with the utility. So certainly something to look at on that rate structure front. I already mentioned this, but this billing error, it happens unfortunately much too often, so it really is important to recreate your own utility bills just to double check, just to make sure. What's the saying? Trust but verify. *[Laughs]* An opportunity in the meter consolidation. This is a really small change, but there sometimes is opportunities to consolidate electric meters. If you have, you know, multiple meters that you're getting billed on, you might be talking about $100.00 that you can save per month.

Simple stuff for the most part. Obviously, we mentioned earlier this purchasing your own transformer, so this is switching your rate structures. The power factor correction, this really is a big opportunity kind of on the billing side. Nothing to do with energy

efficiency really but it has all to do with dollars, and so if you have a low power factor chances are your power factor's being draw down significantly by too many large motors that are running very much underloaded. Okay? So, oversized motors that are operating, and honestly it's a really simple fix for the most part by just adding some capacitors into the system.

You just add just enough to the point where you're not getting billed. Just enough but no more. Okay? And then the last thing, and this is starting to get a little bit more operational of sorts, is this demand savings potential where if you don't have to have everything running at once, if you can operationally shift things around, so that way the utility sees a nice flat, steady load, that's what they want to see and it'll show up in your bills. So if you can go from, you know, some demand schedule like that, maybe this is your startup, right? Maybe that's 8:00 in the morning.

If you can stagger things on and change it, that way you only get a little bit – and you could even use that energy throughout the rest of the day. If you can just take that peak and move it somehow in either direction, typically that'll save you some real dollars and cents at a facility. Okay? Any questions or comments so far on the utility billing structures, the rate schedules, things like that?

Male: I don't think so.

Eli Levine: We're doing pretty good. Yeah, doing fine, Tom.

Tom Wenning: Okay. Excellent. So let's keep trucking along then, Warriors. We are talking energy benchmarking now. So benchmarking – most of you know this – it's just a practice of comparing yourself to others or in a facility you might be comparing line A to line B, right? It might be process A to process B, equipment A to equipment B, right? This benchmarking, this activity of just going through and systematically looking. That way ideally we're motivated, we're getting information to make improvements in our facility.

And this is certainly something that you can be doing in the weeds at a really high level. You know, even in the Better Plants program we benchmark different companies. Companies like to benchmark, right? You know, programs, right? We're all just looking for that edge in life, and certainly in a manufacturing world, you know, when it comes to making a profit you want to be doing it as efficient as possible. One of the easiest ways is really quickly looking; what are we doing at a different facility, what are our competition?

You know, what are they doing? So, benchmarking is really important. There's a lot of tools on that front that can help you. So at a really high level, when we're talking benchmarking, for the most part when we're in commercial and residential buildings where, you know, it's more just about people in space. The energy intensity metric is typically in our consumption per square foot, okay? Industry is different, right, because we're consuming products – or sorry, we're not consuming products – we are making products, and so as part of that there's more variation, there's more moving parts to benchmark against.

A really simple one that we see a lot through the Better Plants program is at this basic level of just, you know, number of widgets out the door per the energy that was needed. There are more sophisticated methods for looking at some of that stuff. You know, really looking at some regression-based stuff to account for the weather as well as the production rates. You know, if any of you ever sit down and just kind of do a scatter plot, you know, what's our energy consumption versus our production rate, for nearly most facilities, almost every one I've ever seen, if you don't change anything in the facility other than just the production rate that you're pushing out the back door, your facility is more efficient running at a fully loaded operation than a part loaded operation. Right?

Like it's just kind of the nature of the beast. But when we're doing energy efficiency and we're trying to make improvements that we can be very comfortable with, the problem is we're not always running at the same production rates. It goes up and down and it goes kind of all over the place based on the market, and so that's where some of this more advanced regression stuff comes into play, but it's all in the vein of benchmarking. A resource that I do want to point out are our colleagues over at Energy Star within the EPA have some fantastic tools, software tools available for organizations. If you have maybe corporate headquarters, if you have more of the commercial space, they have an energy – what is it, their portfolio manager, which is a fantastic resource.

But on the industrial side they have something slightly different. They call them their energy performance indicators for plants and these are KPIs, key performance indicators, that are developed by industry and there are 18 specific industries that they've developed them for. And it just gives you that rough benchmark of where you're at in the whole class of companies that are operating, so it gives you something – it gives you information that you might not

have otherwise, so this is important stuff. Okay? Once we get through the benchmarking, you know, maybe we realize, oh shoot, we're not at the top of the world in terms of our energy, right? What are we gonna do?

Well, one of the more common things that companies turn to is energy assessments. This is really the bread and butter for a lot of our energy programs, right? If we can do energy assessments and implement projects, that pays our bills, that pays our salaries, that pays our lunch. And then if we keep that up, you know, typically that develops into a program, right? We need to develop energy programs at a higher level to make sure that we're always feeding that funnel of projects, and so there's a definite link here.

Within the energy assessment though we're going to talk about how to do an energy assessment, because that might be new to some of you out there. So at a high level, an energy assessment consists of a number of different things but there's these major buckets, and it doesn't matter if you're looking at an industry, a whole facility, a process, a building; you know, it's all typically the same approach and that's at the highest level we try to do kind of the footprint of sorts of drawing our boundary, you know, what's coming across our boundary in terms of energy types, what are the costs that are being impacted, and then understanding how energy is being used within that box.

And then once we start, you know, doing those first couple steps then we start going a little bit deeper, looking at our energy saving opportunities, everything from operations, which might be low cost, no cost type things, all the way over to new technology and new processes and that's where you can get into capital projects and in some cases that's where you get into like the step change in terms of intensity improvements. And then, of course, you know, if we're ever going to sell anything to management we need to do the economic analysis to be able to speak in terms of dollars and cents, because the people that write our checks they don't – at the end of the day they don't care about kilowatt hours or MMBtu for the most part; they care about the dollars and cents that they had to pay to get that stuff. Okay?

So being able to translate into that language is important. As far as assessments, there are really quite a few different types of assessments, and so I've listed out a number of them here that you should at least be familiar with. You know, whether you do them yourself or whether you have a vendor come in and do them for you, you ought to know what you're doing or getting. So the most

common levels that are referred to are probably the ASHRAE levels of assessments and they have three defined levels. There's a level one, two, and three.

So each one of them is just essentially more rigor and more details. One ASHRAE assessment might be a half day walkthrough. You know, somebody literally shows up with a clipboard in hand and he's gonna just essentially do a tour of your facility with you, and then on his clipboard he's going to make a couple notes and by the end of the day he'll give you some really high level things; oh, you ought to maybe replace your lights, oh, you might need to change your motors out, oh, you might need to do something else. Right? Half day effort typically. There's not much to it other than just a walkthrough.

That level two is when you extend it out. It might be a full day or a couple days, and that level two is when you actually start taking some measurements, which for a lot of people this is kind of that sweet spot where it's enough details, enough information that you can do some good engineering but it's not so much that it's going to take you away from your day job forever. Okay? So level two really consists of a couple days. It's having some handheld monitoring devices where you take some spot measurement and then you use those spot measurements to then do your energy calculations.

Level three, this is the full shebang, okay? This is where you bring in logging data and monitoring data and you get a week, several weeks – you might get months' worth of energy data, and that way you get a full picture of what an energy saving opportunity might affect your utility bills. Okay. So those are the three different types; level one, two, and three, and those are the most common throughout industry. Some other types of assessments though, we do have the ASME, this is the American Society of Mechanical Engineers. They have system standards for these various system assessments.

So there's one specifically for process heating, they have one for pumps, for steam and compressed air. I believe lately they're even ported over to ASME, ISO recognized standards. So they're very formal and they're very descriptive and detailed as to how you may go about doing a full-blown energy assessment on, say, process heating, so a furnace, right, if you have a heat treat furnace. You know, if you have a vendor come in that does an energy assessment for you, you might want to say, "Hey, I want you to follow this ASME system standard because it will detail, you

know, everything in that system that you want to take a look at, that you want to measure, you want to monitor, the calculations that you might need to do," and then it's pretty prescriptive. Okay?

But it's robust because it's a standard and you want to make sure that you're, you know, counting all the chickens, gathering all the eggs. You don't want to leave things off the farm there. So these are really important, but they're really deep and in depth. For many of us in industry, in the Better Plants program, a newer version or slightly newer approach, something that's called Treasure Hunts. Some people or some companies refer to them as Kaizens. Okay? In the energy world they're used interchangeably and the mindset around both of those, the Treasure Hunts and/or Kaizens, whatever you want to call them, it's an opportunity for engagement in a facility where you father people from a diverse set of backgrounds.

So that might be an engineer, it might be a maintenance guy, it might be an operator, it could be the accountant. And you gather them onto a team and you go in to a facility during an off day and you look for low cost, no cost opportunities. So you're really looking for opportunities to turn things off for the most part, but this approach it really drives towards that culture change, the ability for anyone and everyone to affect energy, to ask questions, to make an impact on energy consumption. They're really powerful and potent approaches to finding low cost, no cost opportunities, and they're a lot of fun, to be quite honest. Something that – we do have a Treasure Hunt toolkit through the Better Plants program.

Hopefully you all have stolen it and replicated it and made it yours, right? Make it fun, because it is a pretty powerful way. It's a service level thing, whereas the previous assessments that I mentioned, those are really deep dives. That's where you might need an energy expert. The Treasure Hunts, anyone can do it. Any one of you listening could go out and literally facilitate one of these things tomorrow as long as you knew kind of the general process, so it's not tough.

And then the last thing, while this is not an assessment type it is a fantastic resource, and that's our industrial assessment center energy assessment database, so AIC, industrial assessment center. This is a DOE program run through universities around the country and they've performed thousands and thousands of assessments. I think they're getting close to maybe 18,000 assessments. They have all of the recommendations that they've ever given to industry in a public database. So you can go in and search for your specific operation and dial in, you know, what's the top five, what's the top

ten commonly identified recommendations for my type of facility, and not only will it give you kind of a basic description but it will say, well, the common, I don't know, lighting retrofit or motor retrofit or operation change, you know, here's the dollars in terms of savings, here are the costs associated with that and then here's a simple payback.

So it's a really fantastic resource that feeds into any of these assessments that I mentioned above. Okay? Alright. Stepping into even more detail for these energy assessments, and these are eight common steps that are more or less touched on regardless of the type of approach. It's the level of detail depending on which one of those assessments I previously mentioned that you want to do, but there are eight basic steps. So at a really high level you're understanding the facility, the layout from maps to operating schedule, the hours of operation to the material flow.

Again, this might be – when I've done this you get a simple map and you draw a line; how does that material flow through the facility from when it comes in maybe from raw material all the way to finished product going forward. And then along that path, as that material, as that product is moving, identifying all those energy users. These are simple things that you all are probably doing in your mind right now if you think about your facility. Like you've got that mental map, so you've already accomplished half of this almost. The next step, if you're doing an energy assessment, is then, you know, diving in a little bit deeper and trying to collect some of the operational data.

These next couple steps is what really differentiates those different types of energy assessments in the different levels, so collecting operational data for those large energy users as well as reviewing and discussing operations with some of the operators, the end users there, and then, you know, once you've done that formulating a couple energy saving opportunities and really doing the analysis. Okay? And then last but not least is certainly a report, that way we can tell management, we can tell the facility guys at the site, you know, hey, here's what we found, here's what we recommend. Okay? So these are the common eight steps regardless of the level or the type of assessment that you do. Okay?

In most cases you already have those first several done. They're in your head. You just need to get them out on a piece of paper. And then those next couple, it just depends on, you know, where you're at. Hopefully at the end of this Energy Warrior training you can go through all eight steps on your own. Okay? I think that's our hope

and goal here. So a couple things to mention on that energy assessment.

Obviously, equipment is a big aspect of doing an energy assessment. The Treasure Hunt is something where you don't really need a lot of equipment because you're looking again for these low cost, no cost opportunities that are a lot of times associated with just turning off pieces of equipment and maybe doing some simple changeouts, but when you start doing more of a deep dive energy assessment that's when you're looking at more of this spot measurement equipment as well as maybe the long-term data logging type of equipment, and we have several slides here where we're going to just talk about each one of these. You know, some of the important pieces of equipment for the different systems.

I will preface all this and say, you know, through the Better Plants program we have an entire closet full of almost all these tools I'm going to be discussing and they're free. I'll lend them out to you, I'll send them to you, I'll set you up to get whatever measurement you might need. Just don't break my piece of equipment and send it back to me and life is good. Right? So it's a win-win here. Take advantage of that. So as you're thinking about looking for opportunities or doing any type of MMV yourself or just trying to plan for projects, it's a really good opportunity to get some pieces of equipment.

What are some of the general energy assessment diagnostic pieces of equipment that we use? So on the electrical system, first and foremost really on the safety, please be super safe with everything you do on electricity and electrical-using systems. Ideally, hopefully you have an electrician that's instrumenting or putting this equipment on first and foremost, but as part of that, you know, that's kind of the insulated glove comment there. You know, it's insulated gloves but really there's a lot more to it than that, so really be safe.

As far as some of the specific equipment that you might use, let's say a standard level one, level two ASHRAE assessment, you're looking at multimeters, which is over there to the right. Power meters is a next level where you strap up all the lines. So if you have three lines coming into your motor you strap up all three and you're measuring the power draw in terms of the current, the amperage coming in as well as the voltage, and so you can not only get – just directly measure the power but you can measure the volt

amps, the reactive power, the power factor. You know, these are other important aspects for our calculations. Okay?

So those are power meters. Then for more of the kind of lighting system, since lighting still is very much an opportunity, people are changing these out, a simple light meter, and that's this item here on the bottom left-hand side. So just being able to figure out whether or not you're providing enough light to your workers. You know, poorly-lit areas saves energy, but if you're trying to do high-quality inspection of parts you want to make sure you have the right level of light dialed in, so that stuff is really important here. But that's everything really on the electrical side.

On the thermal side there's a number of different common tools that we use. So a thermometer obviously is really key. There's a couple approaches for thermometers. There's obviously our insertion probes or thermal couples, so for really measuring fluid systems, whether that's fluid as in water or fluid as in air or vapor, using thermometers to measure that stuff. There are electronic thermometers, things like that. For more of surface temperature-type readings, that's where we start getting into the infrared cameras or the infrared guns.

So this one on the left here, this is an infrared gun. It essentially just shoots out a little laser and there's a little beam area that it's reading and that is telling us what the temperature of that surface is. If you get really advanced and you have a little bit more money to spend, or if you want to borrow some of my stuff that's cool too, you have these infrared cameras, and these things are super select because you can start seeing an actual picture out in front and you can see the thermal gradients within that picture. So these are super powerful in terms of being able to identify hotspots.

You can use these things on electrical systems, even for like identifying bad connections, you know, breaker boxes, things like that. Certainly for our thermal systems, identifying insulation loss or degradation or issues like that. The really fancy ones, you can take pictures. You can take a thermal picture as well as a real, you know, live picture. That way you can get kind of the side-by-side comparison. You can even take videos. There's really advanced stuff on that front, but these are super powerful on the thermal side.

Alright. So stepping a little bit further, this is more into our fluid movement systems, so our pressure measurements. This would be for fan or pumping systems. The main ones that we typically look at using are our manometers. We have this Bourdon gauge, which

is essentially the mechanical gauges that so many of us have in our systems, and then the pressure transducers, which hopefully you've seen a lot of these. It's something that you just need a tap somewhere on the line typically and these things are really powerful for certainly identifying and evaluating pumping systems, so having something before and after a pump, but they're important in compressed air systems. Fan systems we're typically using manometers and Pitot tubes, so a couple of the pressure measurement options.

And then on combustion, combustion is so vitally important to dial in correctly the big one is our combustion analyzer. So here on the right-hand side is a picture of a common combustion analyzer, and these things are super slick in that anymore they'll tell you just about everything you may want to know. You can dial in your fuel type, so you can put in natural gas, you can put in whether you're burning propane or other things, and as you start taking the temperature measurement and the combustion measurement, it'll automatically do all the algorithms, the calculations for us to tell us the combustion efficiency as well as the breakdown of the flue gases leaving, so it can give us an O2 level, it can give us a carbon monoxide, even carbon dioxide levels.

For the fancier ones, if you want to do more of the emissions testing they have NOx readings and things like that as well. At the heart and core of these combustion analyzers you're really just measuring a couple things. Your temperatures. Really there's an inlet temperature typically that is being drawn in at the local level. We get the flue temperature. So this probe here is something we would stick directly into our exhaust stack, say of a boiler or a furnace, and so we get that exhaust temperature as well as excess air.

So excess air is either a measurement of our CO2, our O2, but what happens is this is a hollow tube that gets shoved in and it just sucks in some of that combustion air through all that tubing and then it does the analysis inside of that little unit there. These things are super slick, really powerful for tuning our combustion devices, and I'm pretty sure we're going to talk a lot more about that here in a couple more sessions. Alright. So moving along here, for a few more analysis tools. So this is for measuring our velocity, our flow rate measurements.

Again, this is going back to let's say our pumping systems or our fan systems or even HVAC. So for HVAC as well as our fan systems, the most common one is our Pitot tube, and that's this guy

here on the bottom left-hand side, right? So these can be super powerful. Ultimately we're measuring pressure and then we're converting that into a velocity. Analogously, there's these rotating Vane anemometers. You may have seen some of these.

These are pretty common in kind of HVAC applications. As the air is moving by that little fan in there is spinning, and it just picks that up and converts that into speed. A similar but slightly different approach is a hotwire anemometer. It's literally just a little probe here with a thermocouple on it that is measuring kind of the loss of – the heat change really, and that converts that into an air flow measurement for us. And then for our piping systems, really for fluid for sure, so like water and different things, we have ultrasonic flow rates.

You can use these things for gas systems. They're just a lot more touchy. Not quite as reliable. Okay? And then a couple final things, and some of these are really specific for energy assessments. Leak detection, which is so vitally important in facilities. There's a couple different types of leak detection depending on whether you're looking at compressed air system, maybe compressed nitrogen system, some type of compressed gas and/or on like a steam system, right?

So on the bottom left here is our ultrasonic – this is an ultrasonic leak detector where you just point this little guy at a leak – you might not even know where the leak is at in a pipe, right? – and you can be pretty far away wearing this little headphones and a little pinhole leak can be picked up from feet if not many, many feet away, okay? So these are really powerful to just help identify. You can use the old fashioned approach of spraying every connection and junction now with some soap water and seeing where it bubbles, but man, this thing is a lot quicker, okay?

A newer version is this sonic imager, which is up here on the right-hand corner. This is I think really new to market and super expensive, but you can visually see some of these things. And then a steam trap detector is what we're looking at in the bottom right-hand side. It uses the same theory and principle, sometimes the same pieces of ultrasonic equipment to just pick up the sound of steam passing through traps. Okay, so this helps us to determine whether or not steam traps are operational.

Almost everything we've talked about so far in terms of equipment is for the most part spot measurements. If you want long-term measurements then we're talking data loggers, so this would be the

level three ASHRAE stuff where we're doing some really investment-grade type of measurement and we want to really capture what's the operational characteristics of our equipment, and that's where these data loggers, there's a whole slew of different types, everything from really simple ones such as lights being turned on and off. You know, you can have a really simple data logger that will track that. Similarly they have one for motors.

So if you just want to know how long a motor, how often a motor is turning on and off, there's some that you just strap and sit right on the motor and it will detect the vibration. More and more you can get a lot of them for temperature relative humidity, and a lot of them now have general channels where you can plug different types. So you can be plugging in a pressure transducer or a current transducer for monitoring your motor and you can program these things to capture really tight, short time intervals. You know, you could have a couple seconds apart or a second apart, less than that.

You know, you could just take one snapshot per minute or per several minutes and that all just effects the amount of space that's used in there and how much data you can pull in all depending on your application. Okay. And then kind of I think rounding things out here, safety, safety, safety. Please, if you're doing anything in a facility, you know, safety is number one. If you don't go home at the end of the day it's all really for naught. So everything from safety glasses to safety shoes, hardhats, and hearing protection.

First and foremost, be safe as you're taking some of those measurements. Get electricians if you're going to be doing anything in electrical boxes. Really important. Okay. So we've gone through the process of doing an assessment. Okay. We've talked about some of the equipment for doing some of our site measurement. Many of you might be thinking or scratching your head; okay, this is great.

I don't have a clue how to quantify some of the savings. You know, if I want to change the lights out I don't know the first thing about what calculation I need to do in changing light or turning off a motor or maybe shutting a valve and what that might do to my system, right, or what happens when I change the combustion characteristics in my furnace for boiler, right? So we through the DOE have a really nice software program called Measure that's available. It's free to anyone and everyone. It's extremely versatile.

Right now it has modules in there to evaluate a number of different systems. Right now they currently have pumps, fans, process

heating and steam built in. They even have a Treasure Hunt module. So again, you don't necessarily need to be an energy expert to do that Treasure Hunt. It's all the tools and resources in there now, that way you just have to be able to download the tool and turn it on and you can gather some of the basic information to do some of the basic analysis.

So there are these systems modules in there, but in addition there's just a lot of really simple, basic calculators, anything from changing a drive type, you know, switching from let's say a smooth V-belt on our motor drives to a notched V-belt. What's the energy savings there and how do I calculate that? And so there's just a lot of those types of things in there for all different types of systems. There are unit converters, you name it. Maybe we'll step into it during one of these future sessions.

So after we do that assessment and then we use Measure to calculate our energy savings, we need to translate this into the language that our management understands and that's dollars and cents. Okay? And depending on your organization, that can take a number of different forms, everything from a simple payback, which is the most standard but most simplistic, maybe overly simplistic approach, to more of a return on investment. Maybe you have a hurdle rate. And if you're really advanced and doing some pretty slick things, you might be even doing a lifecycle assessment or net present value of equipment where you're looking at the long-term impact, and the most advanced organizations and companies out there are looking at that lifecycle assessment.

They've moved past simple payback and are really looking at some of the long-term aspects because for, let's say a motor – I'll use a really specific example here – a motor, you might buy a motor, but if you have that motor running for the next 20 and 30 years, which many organizations do, operational energy and the amount of energy that you had to pay for that whole timeframe might be 80 percent of the overall cost, and so it really is important to maybe buy the right motor upfront. Okay? So looking at life cycle assessment stuff. Alright.

So we're getting close to the end here. Here are the seven major systems that you typically find in any and all types of organizations, everything from lighting, HVAC, the building envelope, pumps and fans, compressed air, processor. Right? You have some homework. *[Laughs]* You all thought you were done with school of sorts. We have some basic takeaway homework that I want you to – we want you to work on between now and next

week. Unlike the homework and the tests and quizzes that are given to us in grade school, I'm not trying to freak anyone out here.

I'm not trying to really tax you too much. These are simple things, okay? So there are three homework questions for this first lesson, okay? The first one is what were the 2018 annual energy consumption numbers for electricity and natural gas for your facility? So get that together. The annual energy consumption numbers for electricity and natural gas, so that's probably going to be, you know, kilowatt hours, the annual kilowatt hours for electricity consumed, and maybe on the natural gas annual MMBtu or maybe it's annual dekatherms, right?

So get that number together essentially for last year. The second question, and it's very much related here, so what were the annual energy costs for electricity and natural gas? So really basic hopefully for some of you to gather and maybe paying Bettie down in accounting for that number, right? And then the third one, what is the average rate for each of these energy sources? This is a very simplistic number. This is – we're just looking for that blended cost here, so what's that annual cost divided by the consumption that you find.

So that's your homework for week one. It's not too taxing hopefully. You're not going to spend tonight completely sleepless. With that, are there any questions?

[End of prerecorded section]

Tom Wenning: I think that's the thing I was planning to end with there. Are there any questions from folks out there? Really there are a couple ways that this can be done. So for many of you I think that are familiar with GoToWebinar, you know, you have two options here. One, you can virtually raise your hand. You can physically raise your hand but you'll just look like maybe the weirdo in your house at this point, or for those of you in the office, right?

Virtually you can just click the button to raise your hand and we can figure out how to unmute you. But alternatively, and maybe this is a little bit easier, there is the chat functionality. For most of you that's on the right-hand side and you can type in a question and we'll try to get to some of these things. And we did see a couple folks send some questions in during the webinar, so I think we will spend at least a couple minutes here trying to answer some of those, but I realize this is a little bit longer of a webinar than most

of us are typically accustomed to, so we do appreciate you hanging out with us here.

But I guess I'll tackle just a few that I've seen and then Marissa or others, if you see some of these questions that you think are appropriate, feel free to bring them up. But one of the standard ones that we have seen, are the slides available and is this being recorded? This answer is yes and yes. I think the team will figure out how to get all of this stuff out to you folks. As with everything that I ever present, everything is free to be stolen, used and abused however you see fit.

So if you saw something today that you think you could use for your own purposes, by all means please take it, use it. An old mentor that granted me some great advice of plagiarism saves time, and that's very much true here. So any of this information we put together feel free to use this in your own energy programs as you see fit. Okay? Okay. Some other questions that are rolling in here. Let me see here.

Okay, so one question – and I'm sorry, folks, I'm trying to multitask and read these things as they're coming in – so one of them is a question about using VFDs to reduce the power factor. Similar to downsizing oversized motors. So holistically – and I'll do a little bit of a swag answer – holistically, the general consensus is, yes, VFDs can be used to help mitigate the effects of power factor and help bring it more into unity to help your facility. The caveat with that is that when you install some of these VFDs some VFDs, depending on the type of technology, can induce a lot of harmonics into the system, so a lot of additional wave forms which can be detrimental and not really help us in the long run.

So generally, the answer is yes VFDs can help you in that the efforts to adjust your power factor, burning it up, but at the same time you do need to be careful. You may need to use some line filters before and after to make sure you're not introducing too many harmonics into the system as that in some cases could actually damage other pieces of equipment. Okay? Let's see here. Another one. Can we use air leak detectors to find steam leaks?

Hopefully I understand this question correctly. So those little ultrasonic leak detectors, I had a picture in there that I showed and it looks like there's a little funnel that you just point around at different places within your facility where you try to pinpoint some of these air leaks, and it could be a compressed air leak, it could again be one of these nitrogen leaks, things like that, where you

can just hear it. Some of those pieces of equipment have an attachment where – there's another picture right next to it – there's an attachment for some of those ultrasonic detectors where you essentially plug in a cord and the cord has a metal tip on it that you would place on a steam leak. Right?

And so you can hear a steam leak, and this is primarily for checking steam traps. If there's a steam leak in the piping you'll almost always be able to see the steam leak hissing out, right? But a lot of times you can get pieces of equipment that will do both of those for you if that makes sense, and hopefully that answers that question. Let's see another one that came in here. Let me see if I can read this.

What about ISO 50001 as a standard for industrial energy end users? So, absolutely. One of the standards that I did not mention in this webinar series is ISO – this is the International Standards Organization – they have standards in many system areas. I'm assuming most of you are probably familiar with popular ones of 9000 or 14000. There is one that has come out a number of years ago – it's to some extent still the new kid on the block – but 50001and it's around energy management; so how do you systematically stand up an energy management program?

So when I talked about some of the codes or regulations and standards, a lot of those were in reference to how to do an energy assessment, so more the grassroots level of doing the projects. But, you know, above that, if we want to be able to fill the hopper-up projects we need a good energy management program, and so that's where this ISO 50001 standard can be really a good resource for you. It is certainly a resource or a program that is getting momentum. The DOE has a sister program through Better Plants program called our 50001 Ready program that is a great opportunity or many of you to get some recognition as well as some help on implementing those standards, and really it's something that is a wave that is coming.

European facilities have been holistically adopting 50001 for the last couple years now. There's a lot of incentives, tax incentives, financial incentives and otherwise over there. In the US, it's not quite the case yet, but there's this wave that is coming in. Let me see if there's any other questions that have come in. Certainly, if you do have any questions please feel free to type them in and then we'll cover them. I think one more question that did come in a little bit earlier when we were going through the utility rate structures

and our utility bills, someone asked how do we know if we own our own transformer?

Okay, so this is that primary versus secondary rate structure. And again, there's – you know, the difference between the two is on who owns that transformer depends on what it's rated. In most cases, the easiest way, if you're not part of the maintenance group and in the know about that stuff, is to just look at the rate structure that you are on. So just looking right at the utility bill, the rate structure should be listed directly on the utility bill. You might Google it and pull it up really quickly to see which of those you are on, okay?

Typically that's the easiest way. If you go a little bit deeper then you might want to go check with some of the folks that do control and know the maintenance, some of the assets in your facility. Okay. We did get another one here. Which energy assessment approach or process do you think is the best for a wastewater treatment facility? Alright, so this is good, and unfortunately I have a bad answer because it depends.

[Laughs] It depends. Okay. Ultimately it depends on what your goals are for your energy program, what you're trying to get out of the program or the effort, I should say. So really I would categorically say there are two levels or two things that not only wastewater facilities but all manufacturing facilities should likely think about. One is the standard deep dive assessment, so that's really that ASHRAE level two or three where you're doing a deep dive and you have an expert likely come in.

You're going to spend several days to a week looking at some really specific opportunities in a deep-dive fashion. Okay? And if you're interested in that, you know, since you're a Better Plants partner, I would highly, highly recommend you look at applying for one of our DOE in-plant trainings where a lot of our in-plant trainings are structured around doing this deep dives in system areas, so doing a deep dive into pumps or fans or compressed air, things like that. In addition, we even have one that's tailored specifically for optimizing wastewater infrastructure facilities, so ones specifically for optimizing your wastewater facility.

So that's that deep dive. But the second level that we had discussed was that Treasure Hunt approach, and a Treasure Hunt approach is something that I think everyone should really look at doing at least once. It's again not very deep but it is very broad and it is a great way to engage all walks of life within your facility. You don't need

to know a ton about energy and energy efficiency to do a Treasure Hunt. Okay? You go in typically on an off day or when things are slow and you can just ask the basic question of, you know, why is that running, why is this on, what's going on over there? Okay?

Those have a really good track record of finding some impressive results from really low cost and no cost opportunities. A lot of Treasure Hunts are able to find somewhere around the order of about 5 to 10 percent sitewide savings, which is pretty impressive, and the kind of typical implementation rate we even see on those is about 50 percent. So 50 percent of the opportunities that are identified as low cost, no cost are implemented immediately. Okay? So a really good option.

Circling back, and I know this is a long answer, but it being a wastewater facility I would really recommend you to look at our Better Plants water and wastewater in-plant training. I think that would be just a great starting point where we would come in and spend a couple days at your facility and help you to do that deep dive, helping you to look for opportunities as well as train a lot of your folks onsite. So, with that, if anyone else has any questions feel free to send them in, but I don't seem to see any others. Eli and Marissa and others, I don't know if I'm missing any other questions, but I really do – I guess I want to say I really appreciate everyone joining us today. I hope you all are being safe and well.

Do remember – and I don't know if we have another slide here, but do remember that have a couple more weeks of webinars coming up. We have some really good stuff coming up soon. Next week I think we have one where we're going to be hearing from our friends over the at the USDA as well as the Department of Commerce on some of the programs that they offer for you all. Actually, never mind. I think I am up again next week. *[Laughs]* So great, you get to hear from me twice.

Next week, when we talk about lighting, HVAC, building envelope opportunities, so building upon these basics to do something a little bit more in those system areas that we all have in the facilities around us. And then the week thereafter then we're going to be talking and hearing from our friends over at the USDA and Department of Commerce. We have some really good things coming up soon, so hopefully you all will be joining us. Eli, I don't know if you're still there and unmuted. I don't know if you want to say any closing remarks here.

Eli Levine: No. Thank you, Tom. That was really excellent. You packed a lot of information. I think everyone got a lot out of it. So, thank you very much. For all of you, we look forward to seeing you again next week, and by all means, you have Tom and my emails there so drop us a note if there's anything we can do better or if there's anything you'd like to see us add in future weeks for additional topics. So, thank you all and please stay safe out there. Take all the precautions and listen to the scientists. So, thank you very much.

Tom Wenning: Thanks again, folks. Take care.