Eli Levine: All right, great. Well, thanks so much. We're excited to have you all here for Week 3 of the Better Plants Online Learning Series. As the slide indicates, should be a real interesting one covering lighting, HVAC and building envelope. Thank you to all of you have been able to join the ones in the past as well. It's been a really great turn out and something we've really enjoyed. Hopefully, it's bringing us together just a little bit through these crazy times. So next slide.

This is a picture of me, I believe. We can move quickly over that. It's nice to have everyone with us here today. As I mentioned, this is week three. The next week one that I'm pretty excited about as well is called Resources You Should Know. So we are going to bring in some of our cousins in the federal family, the USDA, Department of Agriculture role development program. And then the Department of Commerce and Manufacturing Extension Partners Centers. So these MEP Centers are located in all 50 states and are really just a great resource for manufacturing sites you should be taking advantage of. So please join us. That would be back to our regular time of Thursday at 1:00 PM. And then after that, we will return to our technical trainings on compressed air systems and water efficiency. Next slide.

Also, in case you missed it, if you weren't able to join either of the previous ones, the recordings are online. They've been transcribed for compliance with posting them online. Please go back and watch them. I know I'm guilty of this for those of us juggling all sorts of responsibilities, childcare responsibilities, and everything else. Often times I will sign up for webinars and then go back and watch the recordings later. So our turnout has actually been remarkably high. It's been great to see. But for those of you who might have missed the previous ones or signed up later, please go back and watch or listen to the previous webinars. Next slide.

And then a continued reminder. We're really excited for the virtual 2020 summit. We had a meeting on it today. I think it's going to be a really exciting couple of days with plenary speakers and recognition and identifying the panels that are most easily adaptable and best for the virtual summit. So we will have our Better Practice and Better Project awardees hopefully presenting what made them get there recognition this year and showcasing some of the cool stuff that we've seen from our partners this past year as well as the PechaKucha session which is really challenging our partners to think about how they are talking and presenting about what they've done in an interesting way. So a reminder on that. Thank you. Next slide.

And with that, I'm excited to turn this over to my colleague, Tom Wenning. Before I do, just, we will have our contact information at the end. Please send us feedback, let us know your responses to these. Let us know what we could be doing differently. We are about halfway through the first six weeks that we plan. I'm really enjoying these and the response has been pretty good. So there's interest on our end in continuing this beyond the first six weeks but if there are particular topics you'd like to see covered. If you want us to move back to having Partner Share like we did with Al Hildreth in the first panel. If there's other ways where we could do this, we are very open to your feedback. Please let us know. We want to make this; we want to make this so you get the most out of it. So with that, I will turn this over to Tom. Tom, take it away.

Tom Wenning: Yeah. Thank you, Eli. So I really quickly just want to echo Eli and what he was saying there. We realize all of you are spending your time here today with us and we really do appreciate it. But we want to make sure that your time is well spent. So as Eli mentioned, we have the first six weeks mapped out here but if there are other topics, other items or if you'd want to hear success stories of other partners, right? Let us know. We really do take your feedback pretty seriously here. Okay?

So transitioning into today's topic. We are going to be chatting a little bit about lighting, HVAC and building envelope. Okay? So these systems are ubiquitous. They are everywhere. They are not necessarily the biggest hitters for some of our manufacturing sites. They don't use necessarily the most energy but they are extremely important, nonetheless. Everywhere I go, a lot of people I talked to, they are still talking about low hanging fruit. And when you say low hanging fruit, that term itself makes me cringe. The reality is a lot of times they are referring to lighting and switching out lighting. So we still know these opportunities exist. These things are important. So we are going to be stepping into that today. And I will caveat a lot of the discussion around today's lighting, HVAC and building envelope, they are going to be a little bit more manufacturing industry oriented. So we are not necessarily going to be talking about let's see HVAC strategies for residential and commercial buildings. I'm not touching on that. If you want to hear about that, let us know.

Okay? And I guess on that front, the letting us know part, for most of you, there should be a chat box or something similar as part of that Go to Webinar software. Use that please. So as I'm going through the presentation today, as we are stepping through the different things, submit your questions. At the end, we will wrap up with some Q&A and go from there.

Class outline today. So lighting, HVAC. We will talk about the different types of equipment in each one of these and then we will get to the building envelope stuff. So we will jump into lighting first.

So lighting, pretty simple but there's a couple high level terms that we just need to be converse in it. So similar to last week where we were talking BTUs and watts and things like that, there's some similar lingo in the lighting world that we just need to be aware of. So the first and kinda foremost when we go and buy lights, most of the time they are rated in wattage. And the watts is really what's being drawn in by the lamp or the fixture. So that's our power input. So watts, power input. And then as that electricity is going through, the electricity is converted into light and that light leaves the lamp and then we start talking about it in terms of lumens. And so the lumens are really what's leaving the lamp and heading off to brighten our day of sorts. And so that's another one of these components that lights will typically be sold by. It's the wattage which is the energy consumed and then there's the lumens.

And from there, it goes in a number of different directions. But sticking to kind of the power, the efficiency aspect of things, if we combine those two, the output over the input, then we are starting to get into this lighting levels the two most common ones that we talk about our footcandles and/or locks. Essentially, it's the same terminology, it's just there are different units. So lumens per square foot, so that's a fairly common thing here in the US. We talk footcandles. If you are maybe across the pond, it's lumens per square meter. There's obviously conversions since it's a matter of area and if you are super interested, you can see the conversion factor, the one footcandles to .8 lux. Now you should be conversant on that front.

From there is where we get into efficacy. Efficacy is just think of it kind of like efficiency is what it boils down to. It's the light output vs. the power input. So that's the efficacy of our lights. And we are going to step into a couple different types of lights and you'll see that this efficacy or in a different way of thinking about it, it's kind of an efficiency rating of it changes from lamp to lamp. And so if we use the words that we were just talking about, that lighting output per power input is simply the lumens per watt. So that's this LPW. So we are going to use that acronym a couple times later on.

Now with that said, those are the big-ticket items that we typically look at when we're purchasing and then looking for installing lights in our facility. But there's a number of other criteria that are also associated with lights. Probably the biggest one or the next most important one is the CRI, color rendering index. And essentially what that is, it's the ability for us to be able to tell different types of colors based on the light. And I think we will step into this here in a couple slides that CRI and how that's important.

So from a lighting standpoint, a lot of these are fairly simple to understand and, in some cases, you've already seen it all around you throughout life. The basic one that goes back all the way to the Thomas Edison days is our basic incandescent. Then we have the compact fluorescent switch, in our homes, that's a little swirly twirly light bulbs, right? In industrial settings or maybe in your garage at home, you might have the linear fluorescents and that's these big tubes. Typically they are 4 feet long. Older times, they used to have 8 feet long ones. And then it gets a little bit more exotic where we are typically only seeing some of these next ones in either industrial settings or outside. And this is our high intensity discharge light lamps. So mercury vapor, there's metal halide and then the high-pressure sodium. And then last but not least, and these are ubiquitous is LED light bulbs.

Okay. Let's step into some of the characteristics of a lot of these here. So incandescent, this is the standard light bulb that we have at home or used to have at home, I should say, because these, for the most part, have been legislated out. The rules are changing all over the globe. And some countries they are much further ahead than others but this is the old Thomas Edison lightbulb, right question mark there's a little filament in there. It gets really hot. It glows. The efficacy is not great but these things are super cheap. And that's why they really stuck around for so long. But you'll notice out of all the lighting examples, the efficacy or the efficiency of the light is on the poorer side, okay? And the life is on the lower side. But it's always been kind of the lowest-cost item so that's why most of us have went with them. That's not the efficient way to go. So that's incandescent. I think we can all wrap our heads around that.

This next category is really our fluorescents, okay? So at home, there's little spiral guys and that's what we have to the right here. These are pretty – they were pretty common for a number of years when people were originally moving from incandescent over to fluorescents. The one that has been around in the manufacturing world for quite some time and the commercial sector for really long time are our linear fluorescents. And so for the most part, these are 4 feet long. They are these long tube lamps that typically as you are walking around, you might have them again in hallways, you might have them out in the manufacturing space. But there will typically be a fixture with two, four, maybe six depending on the arrangement. And if you ever look really closely at them, there's a couple different sizes of these guys. Typically they are sold in either like a T5, a T8 or if you have a really old facility, you might have T12's. And what those numbers mean, those numbers are just a proxy for the diameter of that __ *[audio garbled]*. If you are looking at these things, T5's are the thinnest. There are actually rated in kind of one-eighth increments so T5 is 5/8 of an inch wide in diameter; a T8 8 over 8 and that's one inch. And then T12 is going to be larger than that. T12's are for the most part, you don't see those too often anymore. They are being phased out for people are replacing and upgrading or have upgraded already to the T8's long ago. T5 and T8, there are some differences in between the two and the situations where you might want to use one vs. the other but these are super common. They have been for a pretty long time. The efficacy is a lot better. So that lumen per watt is much better than our incandescents and the life can be quite a bit better.

So the next level here is stuff that we typically only see in industrial settings or let's say outside, a lot of outdoor lighting has historically been one of these three. Or maybe in our schools in our gymnasium, these things have been popular for a long time. So there's three main types on this front. There's mercury vapor, there's metal halide and then high-pressure sodium. The difference here with all of these is well, there's a lot of differences I should say. The ones that are most common are probably the metal halide's as well as the high-pressure sodium. And these are really easy to spot for the most point. The metal halide's, if you ever remember growing up and playing maybe basketball in a gym or maybe riding your bike outside at night and a light goes off, you can't flip these lights back on, these metal halide's. All of a sudden, it's this warmup period, this restart period where it takes sometimes 15, sometimes even longer than that 20 minutes to fully come back on. So I remember growing up and playing basketball and the lights go out because there's a little blip in the power and then you're there 20 minutes later waiting for the game to restart, right? So these are still common in industry. They are just not very efficient.

And then the high-pressure sodium, these are typically still found outdoors. These are the ones that throws off a really yellow, yellow light. Kind of an orangey yellow type of a – it's kind of a Freddy Krueger dingy type of light. High-pressure sodium's put out a ton of light, it's just not a really good quality of light. So if you stand under one of those and you're trying to look at a nice red apple, that apple is not going to look very red whereas if you might be under a metal halide, it will be popping some colors there.

The problem with all of these, though, are still there just not that efficient. You still see these things but there is a major trend and there has been for a really long time now to upgrade all of these. And that brings us to the current LED, this Light Emitting Diode. By and way it has kind of all of the characteristics we want out of ___ lights. It has a pretty good efficacy so again, that's our efficiency. It has a really long life in comparison to all of the other types of lights that are out there. They can have a great CRI, this color rendering index. It's a fairly mature technology now. These things have been on the market for quite some time. There's a whole number of different form factors, whether it's bulbs, it's tubes, it's the HID replacements; there's a whole slew of different form factors. For the most part, they are fairly plug and play and some systems you can actually just pull out the old tube or the old light and put in the new one. But you some caution there to make sure that there's compatibility. But in some cases, there are.

More and more, these things have a great return on investment. So really the way to go if you are looking at your lights not only in your facility, at your home, everywhere you are at. Chances are that there are LEDs. They are a slightly larger upfront cost but in the long run, they will pay back in about every form and fashion.

So here's just a really high-level overview of all the lighting comparison points. So you can have access to this later and you can kind of scan through things. But the LEDs which are highlighted in that green column there, you can see that they are essentially the most efficient. So this efficacy in the fifth row down, for the most part put out the most light or can put out the most light for the least amount of electrical input. They have great CRI's for the most part across the board. They have low-maintenance lives. They have really long lives which is important. The longer it is, the longer it lasts in the fixture, the fewer times we need to call the maintenance guy to come out, get a lift, get a ladder to get up there and replace it. So that's a major selling point as well. And then there are some other aspects of having contamination. So some of these old ones have mercury in them so you have to be really careful when you dispose of those things. I'm not trying to sell LEDs but that's where you want to be thinking.

So a couple other items as far as lights. So one that most people don't really know about or is not super obvious, is that all of these lights degrade over time. And here's the common types of lights that we look at. So there's LED, there's florescent in the yellow and then we have the high-pressure sodium, the metal halide's. And what you can see, when you buy it, when you buy these light bulbs, they start off at essentially the rated amount. What's the lumen outputs that it was sold at. The problem is, fairly quickly within the first year, some of these lights dramatically start tailing off in terms of what it can put out, okay? So even if you were to – even if you had to say, this metal halide which the lowest rated life here. Even if you just replace some of those lights from time to time with newer lights, all of a sudden it's like wow, I can see a whole lot better because you might be jumping from let's say a 50% lighting output and you go back to a 100% output. So this is something to just keep in mind. You might re-lamp a whole facility, right? But over time, the lighting quality is going to degrade for your whole facility. And so that plays into how many lights you put on, install at first or how often you might need to replace lights, things like that.

But I think one of the real clear takeaways with this is that LEDs are by far kind of the best option. Not only are we looking at 50,000+ hours, that's more than five years of continuous 24/7, 365 type of operation. And it maintains its lighting level much better than most of the others. And so this is really important. That's a really critical factor to consider here.

All right. So another item that we had talked about earlier is this color rendering index. And this is important, especially if you are doing detailed task work or let's say you're trying to match colors. That color rendering is what allows us to see essentially the true color, okay? So if you're outside, outside, daylight is the best light by and away. So it would have a CRI of 100, right? And any time we try to mimic the sun, the sunlight, right, to be able to see what our strawberries might really look like. Our baseline is going outside in the natural lighting. And from there, it just kind of tails off. So we have incandescent and halogen's really at the top end which is one of the beauties of those older technologies. But from there, we have our fluorescents or metal halides. And you can see things just seem to tail off. The high-pressure sodium, these are those yellow lights. Imagine standing under the yellow security light may be outside of your building or outside of the parking lot and trying to tell the color difference between an apple and an orange. It's really tough. LEDs aren't on here but LEDs are, for the most part, appear on the top end at typically 100, somewhere 90-100 in terms of CRI.

All right. So now that we've talked about a couple of the basics, a couple things to consider in terms of lighting and really how we best light our facilities, so the first step really in terms of looking at our light is that we don't want to under light or over light the area. Not enough light that we are straining our eyes and we are making people fairly uncomfortable. And it kind of wears us down, it drags us down. But on the other side, if we have too much light, then that also really kind of affects us. And both of these items, not only is it a comfort level but it's on a productivity level. And there are some studies out there that have some pretty remarkable effects or outcomes from having the right levels of lighting and the right type of lighting. So it's a really important aspect to pay attention to. Obviously, on over lighting, we're wasting energy so even more so, we are paying extra dollars out of our pocket to someone else and we ought not to be doing that.

So with all of these, you're like okay. So I don't under light and I don't over light. How do I know if I'm doing either one of those? Well, there's a number of resources that are available over here on the right-hand side of the screen. These are just an example of recommended lighting levels for different spaces, for different applications. So here towards the bottom we have our industrial interiors. And there's a couple recommendations in terms of what we should be doing. And this is all based on footcandles, so that term we had talked about earlier, this is how we measure our lighting. We measure the footcandles in an area and then we just want to make sure that we're providing enough lumens per square feet essentially to meet these different types of lighting levels. And I think we go into a little bit more detail here on this page in the next one.

So by and large, a lot of people in them lighting world, they all point back to this IES organization, the Illuminating Engineering Society of North America. These are really the standards, folks. Not necessarily standards but they have the best information. They spent a lot of time doing the studies and setting some of the criteria and guidelines for happy, productive employees and persons.

So there's a number of different criteria that they base their lighting requirements off of. There's technically 13, I guess, which ranges based on the type of tasks that are being performed, maybe the size of objects that you are trying to handle as well as I think the level of detail worth and even the age of workers that are in that space. So a couple obvious points, if you are working with really small items, right, maybe you have small screws, they need a little bit more light to see what you are doing there vs. we are working with say a giant part, a big chunk of metal. And similarly, in areas where you need more contrast, you need more light. So if you are doing parts, let's say they are both the same exact color or silver and you are trying to I don't know, align some things there, obviously you need some more light. And then the last things on here, this adjusting for the age of the worker, this is to me, kind of funny because I was looking at one of the studies yesterday in that as you all know, we all age, we all start to break down a little bit. And while our eyes have one of these issues where we start to lose some of our vision of sorts and over time, our eyes are not able to pick up the brightness of things. And so there are, I'm trying to remember the exact numbers here but it was if you are 20 years old, you can be doing a task at say 30 footcandles. That's our standard lighting that we have in our office. If you age 30 years, if you turn 50, you need over double the amount of footcandles so that you essentially have the same level of light and the same vision acuity, that you have when you were 20. So there is an adjustment factor for when you are older. Okay. And I thought it was interesting.

So going a little bit deeper into these lighting level recommendations, we pulled out just a couple examples here. So these are high-level examples on this front but ordinary tasks say, in your office or manufacturing world, you might be somewhere on the 50 footcandle level. That might be pretty standard. If you are let's say and a storage room picking parts and let's say they are just normal size parts, maybe the size of a baseball. You can get by with 30 footcandles. If you are picking large boxes, you might need a lot less than that. It could be 10 to 20 footcandles whereas if you are picking really precise parts, maybe it's much more than that. Loading and unloading, so maybe on our docs, were looking at maybe 20 footcandles. And then there's this really, what I would consider a judgment call in terms of the difficulty ___ but it starts at 100 footcandles and goes all the way up until 1000 footcandles. So that's really depending on specific tasks that you are working on manufacturing wise. If you are maybe soldering really tiny wires, right? You need a lot more light for that. But these are some of the standard criteria that you would find out there. Okay?

So with that said, there's still quite a few lighting opportunities. There are savings opportunities for helping us to save money or really to save energy and that saves us money at the end of the day. So the big one that most of us are typically most attuned to our well, let's just change the lights. Yeah, that would work for the most part. And that is a big one. So switching to LEDs. I wasn't trying to sell them earlier but based on some of the information I was showing you there, LEDs are just really kind of a clear front winner at this point in time with some pretty massive savings over some of the previous technologies.

So once you or if you do that, there are still a number of other approaches that maybe are not too capital-intensive but very much on the behavior side that can save us a lot of energy. And that gets into this occupancy sensors, the avoiding over lighting and then using task lighting so using spotlighting.

So the occupancy sensors, if you have really well-trained individuals in your workplace, you might be able to get away with switches and the last person who leaves, turns them off. If it's anything like my children in my house, for some reason, those things are – it's like they are haunted by the bogeyman. No one touches them. So that's where you might look at timers as a simple alternative to making sure our lights are on schedule going on and off. But more advanced approaches really are photocells, that's for helping to account for natural lighting that might be having in a space or occupancy sensors. And there are a number of different types of occupancy sensors that can turn lights on and off for us. And this really just helps us to be able to provide just the right level of lighting when you need that lighting. Because let's face it, if you're in a stock room and Jim the stock man goes in there once a day, you don't need that whole stock room lit 24/7. You just need it when he's in there. So to be able to effectively control the technology that probably in a lot of cases even has a bigger impact than just changing out the type of technology in the type of lighting that we are doing. There's also opportunities with the occupancy sensors to dim areas. This area with less traffic, we definitely have seen in a storage facility, you might have an occupancy sensor on each row. So as you go to that row, the whole row kicks on. And then as you leave, it all kicks off. You actually might see this if you go to your local grocery store because more and more that are doing that within their refrigerator sections. So the freezers, the upright freezers. As you get close to the aisle way, the lights kick on and then as there's no one in there, they turn off. Same concept in theory there.

So on this other one though, this avoiding lighting, a lot of opportunities here. And really there's kind of ongoing opportunities in some cases to make sure that you are providing the right level. I would say these last two, this avoiding over lighting and using spotlighting are somewhat intertwined in that you want to provide a base level of lighting everywhere from kind of a safety perspective but more so, can you just put the lighting right where you need it? Okay. So this is task lighting, the spotlighting. If you only need it, if you only need a highlight on your workbench, then just provide the workbench with a lot of light, not the entire space. And so avoiding over lighting everything. And I think this is actually one of the unique areas of this LED retrofits, if you all have ever seen this is that initially, a lot of LEDs you can tune them or you can dim them to some level. So manufacturers may initially request a space to be over lit in terms of the design. But then as the bulb or bulbs start to degrade over time, you just ramp that power for them back up so that way, you can have a consistent light over a really long period of time so you never have that true degradation which is a really unique functionality of LEDs that some of the others don't necessarily have. But it's all about providing the right level of light to yourself, to your employees and to the others in your space.

So that's all the traditional lighting approach. One of the outside the box approaches that used to be extremely common very early on in civilization and really all the way into the 20s, 30s and 40s is this idea of utilizing daylight. And so there is a little bit of a push where the stuff is coming back to an extent because of all the studies, because of the health benefits of being exposed to natural light, you do start to see more daylighting options being put in. And really, there are three main ones that you'll see. There's this advanced poly carbonate wall. So this is like really a corrugated paneling that you'll typically see maybe on the side of the building. A lot of times they will put it up near the ceiling so you lead and a little bit of light and it's pretty diffuse so it's not super bright like a window might let through. But it provides a general lighting in a lot of cases kind of for safety aspects which is really popular and is really making a big comeback.

There's the obvious skylights which are just kind of the big square holes in the ceiling that you have a covering on. These are really common if you go to some really big box stores. And then the last one is this daylighting tube which is a little bit more unique for say office settings. But it's all about trying to bring in some of the natural light one, to save energy but two, there are some really major productivity benefits, there are health benefits, a lot of other aspects that should be considered. But daylight is definitely a big opportunity to the point where this picture here on the right, this is a manufacturing line where they are making tractors which obviously there's no tractors on the line right now. But there's not a single light on in this facility right now. They have a full wall of lights as well as some of the lights up at the very top that's just bringing in nothing but natural light. So really, there are big potentials in going back to those approaches.

All right. So that's lighting. We're going to move on to our HVAC systems here. Okay? So HVAC is just our heating, ventilation and air conditioning which at the end of the day, we're just trying to provide the right environment for our people and equipment and that takes the form of a number of different things to control temperature, control humidity, move air around and control that indoor air quality.

So a couple things at a really high level, most of us like to work in a pretty narrow range. And some of these are specified by a couple organizations that are out there but the standard range that most of us are comfortable in is that 68° to 76° range with the humidity of 40% to roughly 70%. There are some expansions on either end but that's kind of a rough, comfortable range for most of us. And then as far as the indoor air quality, this is a pretty big factor in ASHRAE 62.1 actually provides some standards for some standards for indoor air quality as well as ventilation for really healthy people. I was going to say healthy and productive but I think health is the first and foremost of that one.

So here's an example. If you get a little bit deeper of what we're looking at right now, it's super busy. This is called a psychometric chart which tells us a lot of things about air. I'm not going to spend a whole lot of time but what I really want to point out here is that there's this comfort zone right in the middle. And this is key because as long as our conditions are anywhere in there, for the most part, we feel pretty comfortable. There are strategies to move outside of it and let me, I guess, point out a couple things with this psychrometric chart if this is the first time you've seen one. On the bottom axis is just our temperature. This is the temperature that we might have from our thermometer. So having the right temperature range in there that we can be comfortable with. And the second piece, and that's where the sweeping lines come in at over here. This is a relative humidity line. So the bottom end, they are actually showing 20% relative humidity whereas on the top End, in this case they are showing 80%. For the most part, if you can provide most people with this level, they are going to be pretty comfortable. You can go outside of that based on different strategy we choose with plastered all over this psychrometric chart. But there's a lot of wiggle room in here that we can provide comfort to our employees.

So how do we provide that comfort for folks? There's a number of major HVAC equipment that we'll run into. The biggest are one of the most common are chillers. And were going to talk a little bit more about that here in a couple of weeks. Chillers are essentially creating chilled water. They are cooling water for us and then we are using that cooled water to then cool the space, cool people, cool products perhaps. Another technology that's really common are our air handling units. And these might be on a roof. A rooftop unit. And that's typically these guys over here on the right and we will step into that on another slide here in a second. Another one is our makeup air units. So if you are exhausting a lot of air, say you maybe have a heat treat process in your facility where you are burning and exhausting a lot of air, you need to make that air up in one way or another and temperate before you shove it into the space. And so that's our makeup air units, they are just trying to replace some of the exhausted air. Beyond that, then we get into our circulation fans which take many different forms. We have exhaust fans, unit heaters and then boilers which are either creating our steam or hot water to heat our facility. So we're going to step into each one of these just a little bit here in a bit.

So one of the, I think, most common because it pulls everything together are these air handling units. So here's a diagram of a really basic air handling unit. You probably have several over your head right now up on the roof working. And really what it's doing is it's taking both return air as well as outdoor air and brings it in, it's going to filter it first or reheat it and then I should say it's going to filter and then is going to reheat it and then is going to bring it through and standard in most pieces of equipment, there's a cooling coil and a reheat coil before it gets pushed out into our space. There's different variations of this, say, for a commercial building, but this is the general concept that you'll likely see.

And so our cooling coil, this is where we are maybe taking our chilled water and dumping it in whereas that reheat coil, that could be our steam, that could be a hot water heater that's dumping water in there for us. So that's the standard approach.

Okay. So similar to lighting and similar to what we were talking about last week, there are some basic terms in this area as well. The most common when it comes to most of this comfort, creature comfort equipment, the most common lingo is this ton of cooling which really, it's pretty straightforward in that it's the rate of energy that results from freezing a ton of ice. Okay? And so it could be freezing or melting. It's the same amount of energy, it's just whether it's going into or coming out of that water/ice. So that is 1 ton of cooling. If we look at it from a slightly different lens, 1 ton of cooling equals 12,000 BTU per hour. So that's one of these conversion factors that we might want to use. Another way that you might converted is over to kilowatts. That is not quite as common I can tell you. But you might want to know that. But this tonnage is really the way that you buy most of your equipment. So you would determine the amount of cooling you might need in a space, the amount of heat you might need to remove from the area and then you work backwards to figure out that cooling load. So for a house, it might be, for a lot of houses that are built, you might be in the 3-ton range to just kind of give you the order of magnitude there. Whereas, for a facility, for an industrial facility, you can be talking orders of magnitude more than that; 300 tons, 500 tons, 1000 tons, 3000 tons depending on what you are doing and what's going on at the facility.

This is all based on - the chiller systems really are all based on the basic paper compression cycle. And so here's a diagram of the most simple version where on one side, we have what we call our evaporator which if you're going to think about this, it's evaporating this liquid, this blue liquid that's traveling through that line. That liquid is refrigerant. So this is taking heat, putting it into that liquid where it then boils and turns into a gas. And then from there, we use a compressor and a lot of times this is really the chiller. This is what's making all that noise for the most part. And it converts it from a low pressure, low temperature vapor into a high pressure, high temperature vapor that will typically get sent outside. Sometimes it gets sent to let's say a cooling tower or sometimes it's sent to just a heat exchanger; if it's an air-cooled heat exchanger. And it dumps the heat outside. And that's our condenser. So it's condensing that vapor back down into a liquid. And then there's this last component here, this expansion valve where we take that and convert it into a low-pressure liquid and we just repeat the cycle. So this is the basics of how we cool our facility.

The beauty of this, though, is that it just depends on whether you want cool or heat. It's the same theory is used for heat pumps. You just reviews where we are putting the heat and where we are taking the heat from. So for a heat pump, you're just taking, this might be outside and this would be pumped inside your facility. Same basic theory with all of it.

So when we're looking at chillers, when we are looking at pieces of equipment, some of you can do the calculations and understand that full cycle I just showed but most of us need something really simple. They need this pedometer to tell them how fast they are going. And so in the world of air conditioning, this has been done. This metric, this speedometer has been developed for us. It's this EER and SEER. So energy efficiency rating whereas the S is just a seasonal energy efficiency rating. And they use these numbers to compare different pieces of equipment. So that way you can understand whether or not you have a fairly efficient unit or not so efficient unit. The most standard way for kind of the smaller pieces of equipment are really based on this Energy Star guide. And most of you have likely seen this in one form or fashion. These energy guides will be posted on a piece of equipment. They will typically have a range as to what's typically on the market at that point and what that specific piece is rated at. For most, I would say for the EER, this energy efficiency rating, the most efficient or the most average of those in the top rung of efficiency is right below 14. So if you have a piece of equipment with 14 EER, that's pretty good. Whereas this SEER, the seasonal energy efficiency rating, it's a touch over 19. So we can see down here, the two that I pulled here, there's a 17 and that's okay. Could be a little bit better. Whereas on the left-hand side, it's only 10. So this is much worse. So these are a little bit of that speedometer to help us understand things.

But if you want to go a little bit deeper and start to understand what's going on, I have thrown a couple of equations out here for you. So the EER is fairly simplistic. It's just that BTU of cooling vs. the electrical input in terms of watts. So that's the EER. It's not a unitless number. It's BTU per watt hour. But that's the basis of this. If we make a unitless number, then we get to the COP. The COP is coefficient or performance and that's another really common metric for us to use. And that's really simply the useful output so the useful cooling output vs. the required electrical input. These are just terms to help us be conversant in that space. You can see if we go one step further, all of a sudden oh, that COP is directly related to the EER. This is the equation that essentially turns the EER into a unitless number, that 3.412. And so if we take this another step further, one of the common things that we will see, really chillers being rated at kilowatt per tonnage. So it's just a kilowatt of electrical input over that ton of cooling output. So it's just another variation. It's not super complex but this is how you can take maybe a cut sheet or tech sheet from a manufacturer and then just converted around so you can compare it to other pieces of equipment.

And then the last one is this SEER which is, it's a seasonal average. It's a little bit more complicated so I'm not going to go into that now but just know that it's more of an average of the energy efficiency rating for the season. Okay?

All right. That was on the air conditioning side, the chiller side. On the heat pump side, it's more or less the same concept. Things are just flipped a little bit. So instead of the SEER there's this SPFF. HSPF, there we go. One of these days I'll get it out. It's a metric for evaluating heat pumps. The heating seasonal performance factor. There we go. And that's in terms of this BTU again per watt hour. So that looks pretty familiar, right, to that EER rating. It's a unit number, BTU per watt hour whereas we can take that a step further and now were back into COP, coefficient or performance again with a nice little conversion factor of the two. So these are the approaches that help us to speak the right language and understand that speedometer of how fast or slow we are going here.

On the heat pump side, I showed you some of the EER and SEER, some of Energy Star's better piece of equipment there. For heat pumps, it's right around 11 is what we are looking at here. So if we are looking at this piece of equipment, he's not looking so good. So we can do a lot better there.

Okay. So those are the basics on our equipment. So now let's step into the opportunities. One of the big ones is the set point reset for our facility. So essentially what this means is when the space is unoccupied, we don't want to cool or heat it to the level that we would when people are there. So saying during the summertime, if you are cooling your space down to let's say 70° when everyone's working and doing their stuff, at nighttime when everyone leaves, this is no good to continue to chill that space down. So we can reset it temporarily to go back up to, let it float up to 80° and then maybe cool it down or pretty cool it a little bit before everybody gets back into work in the morning. Do the same thing during the winter timeframe where we just let it drift down and then we reheat it before people come back in. So that's a really basic one. In our home environment, that's what a lot of the smart thermostats, that's the sensor, the basis of those. It's just controlling it to only heat or only cool when needed.

So a couple other things here to avoid. Similar to the lighting, we don't want to over light or under light a space. Similarly, on the air handling side or the comfort aspect of things, we don't want to overheat, we don't want to over cool, we don't want to over dehumidifier; so take too much humidification out of the air. And we don't want to over ventilate. So we don't want to have too many air changes per hour in here.

So sticking with these air handling units, a couple standard opportunities. One of them, which is really true for most fluid moving systems whether that's pumps or fans, are VFD's. So being able to have the ability to change the speed of the fan vs. let's say using a damper to either choke down on the airflow coming in or choke down on the air flow coming out of the fan.

Another opportunity is the stand pressure set point reset. And this is really important if you have an air handler that's maybe serving a lot of different offices and in those offices, people are either cranking down on the box. Maybe they have a locally controlled unit that's controlling the airflow into that office, if you get a whole bunch of them closed and gives us an opportunity to then reset the main distribution pressure going out into the space.

So really basic opportunity here is filter maintenance. Similar to your home, you should replace it from time to time because what we are doing is also, we are starving our fan. Another opportunity specifically with these air handling units to look at is this reheat valve leakage. One of the biggest issues typically with air handling units is the fact that you are simultaneously heating and cooling. So your trying to take energy out of the airstream and then you are trying to put energy back into the airstream. By and large, it's done to help control the humidity and that's why we're doing this kind of dual thing. The problem is that if something gets stuck either mechanically or even in the control system, it can be a little bit of a runaway issue where you are starting to cool more so you need to reheat more or you are reheating a little bit too much and you need to cool more. You can see this gradual escalation. In a more simplified approach, the way that some of these things work that maybe relates to your home life, is that when you are driving home, it be like using your gas pedal as well as the brake pedal at the same time to try to go further and further. At some point in there, you want to be able to back off.

And so one of the mechanical issues is in that reheat valve leakage. So it just lets things go. It let some of that hot water or steam constantly go through which then for the most part, were always having to take out. So checking the mechanicals of it. So I would also putting in here checking the controls of some of these units to make sure that you're not always doing both things full blast all the time.

And then the last item, this is obviously a bit more in the cap X, it's just more efficient equipment. So higher energy efficiency ratings or that seasonal energy efficiency rating. If we're going to buy new equipment, do the quick back of the envelope to see whether or not it makes sense to go to the highest level of energy efficiency rating. There's a lot of aspects and things to consider when you have an opportunity to purchase new equipment. But the fact is, most of our equipment sticks in for a long time so if we install the right thing in front, it can make a big impact. And so on that front, here are two more items to consider when you are putting in a new system or revamping a full system. Air economizers and then energy recovery wheels.

Air economizers are actually fairly common although a lot of times, people seem to bypass them. Maybe they have an issue with one of the motor actuators in there and the next thing they know, it's been completely broke or bypassed and it defeats the purpose. These economizers, essentially what they are doing, and this little graphic here if you can follow me here, there are two little dampers on here that are actuated. There's an outside air that's being pulled in or that can be pulled in. And then there's this return air that comes back. Well, depending on the season, it might be more beneficial to take pure outside air and bring that in and then exhaust all our return air outside. Or they might be seasons where it's better to try to recirculate as much of the air from our facility to try to recirculate it as much as possible to make sure that we keep the energy within our facility whether we are taking that out or heating it up. And so there are these different strategies there. And there are these air economizers can have a really massive impact, especially for parts of the country with some of these big seasonal swings. If you are in Ohio, you might have a really comfortable day and a really chilly night. And so these things will want to change throughout the day. That strategy of we want to use more outside air, we want to use more of the indoor air and keep recirculating it. That has a major impact.

Another way of approaching this, though, are these energy recovery wheels. Sometimes these things can be called enthalpy wheel. Essentially what it is for the most part is a two-way wheel where air might be going past in one direction and maybe that's being exhausted and then on top side, it's coming in. And this wheel right here will slowly rotate around. And so in this case, you've got to use your imagination a little bit because they have this wheel pulled out so typically, I don't think will be shoved in in that manner there. But what will happen is, the exhaust air going out, whether that's warmer or cooler, that will heat up this wheel. Typically that wheel is either made of ceramic. It might be made of metal. But it will heated up to whatever that indoor temperature is. And then as it rotates, the outside air that's being pulled into the facility will get essentially pre-tempered a bit. So some of the energy will get transferred from that outgoing stream to that ingoing stream so if it's really cold, say if it's a wintertime, the air being exhausted from your facility might be really warm. A might be 70°. And if it's wintertime, who knows? Maybe that's 32° air. Okay? Well, wouldn't it be nice to take a little bit of energy from that 70° stream, put it in the 32° stream, that way we can kind of reuse some of the energy that we already had to use earlier to bring the air up to 70°. So that's these energy recovery wheels.

A couple more opportunities specific to some of the various pieces of equipment. So one of them are these exhaust fans. You'll typically see these kinds of all over the place. They might be up in the ceiling area it a lot of times they are on the wall. But they are these really simple fan that might have a little louver on the outside of it. But the big thing with a lot of these is not to run them 24/7. A lot of them have very dumb controls or no controls at all and they are just run literally 24/7 and constantly dumping air or bringing air out of your facility when that's not always needed. There are definitely cases where you need to exhaust air. From an energy standpoint, from a health standpoint, there are cases when you want to do that. But then there are sometimes where we just don't need that at all. And so the opportunity to turn this off or to control them based on a number of strategies is really important.

Installing VFD's not so much on these little guys like this but if you have kind of a much larger exhaust Plenum or fanning your system, there might be opportunities there to install a VFD to then ramp it up, ramp it down to then meet the need of what's required in the space. With the small guys like this that you might see on your wall, one common opportunity is these notched v-belts where there's a little belt that you can just barely see it back here. But there's our motor down here and then it's turning the sprocket up here. Well, there's typically a belt that goes between those two. A slightly more efficient approach and something that you should probably look at stocking in your maintenance closet regardless is a notched v-belt which as the name implies, is just a little belt; it has notches in it instead of being completely smooth, it has these notches which allow it to bend easier. And so that's where the efficiency gain is added. It allows the belt to bend. Not only does it save a little bit of energy, a couple percentage, you know maybe

3% to 5%, but it also can make that belt last much, much longer. So there's some maintenance savings for sure on that stuff.

And then this last point here, this over exhausting really relates back to only delivering what you need to. So don't let it run 24/7. Have the right controls. Understand why you are trying to exhaust.

Another item which are typically super popular in a lot of facilities are these circulating fans. They can be anything from the version I'm showing here on the right or they can be just a little stand up fan that you might have at a little production cell. And you are delivering some cooling for a person that's working. That's fine and well if there are people there but what happens at lunch or what happens when people go home and the shift ends for the full day? We want to be able to turn those off or at least instill the behavior to turn these things off when they are not needed. More advanced approaches are based on temperature and humidity. The ceiling fans can typically be reversed so in the wintertime, they can be wishing hot air to the ground and in the summertime, you reverse it so you are pushing air directly down out to the people to provide that cooling. So recirculation fans, the much bigger ones, you might be able to do VFD's. The smaller ones, not so much. But it's the same deal where you just want to avoid over circulating. Doing too much if you don't know why.

All right. So another one of these and we are getting close to the end here, for this section anyways, our unit heaters. So unit heaters, the most common ones that will typically see look something like this guy down here in the bottom left. Maybe it's driven by steam, maybe it's driven by hot water where it's pumped in there for heating purposes. And there's typically a little fan in there that would pull air through and it heats the air up and for most of the time, it will push the air down just a little bit before that air goes back up. So that's one really common version.

A second one are these infrared heaters. Here's a really simple example where there's typically either a ceramic element in there or it could be natural gas-fired. But it heats a tube in there and that tube gets glowing hot and then radiates the heat away from it. So this is a really simple version. In the picture up here, there's a couple pictures, if you can see my little drawing here, those are infrared heaters that are really high up off the ground. And there are these big U-shaped devices where it's blowing, there's a little burner on one side and it blows the flame down and around and that heats that tube in there to get smoking hot, like red hot. And then it radiates and pushes all the heat all the way to the ground.

And so it's using radiation instead of convection to push the heat down. And so there's some really good things here.

With all of these systems, again, you want to try to avoid that manual, let it run 24/7 and try to have some slightly more intelligent with that. So turning it off when not needed, that can be for the most part, accomplished with just basic temperature controls. We want to avoid overheating. And then more and more, especially with manufacturing facilities, looking at these infrared heaters whether it's from spot heating to heat someone at a process or whether it's if you have a facility that looks a lot like this one where there's really high ceilings, we want to be able to push the heat to the people that are on the floor and not just heat the ceiling. And so that's one of the issues typically with traditional unit heaters and that we warm the air up and then as most of us know, warm air rises. So for a lot of our facilities, all of that warm air is going to write up and if you have somebody on the floor, they are not going to reap the benefits of a slightly warmer facility. So that's where infrared heaters are kind of a big win. So this is a case where it's a really good application for these infrared heaters because it's so high of a ceiling that they are pushing the heat all the weight to the ground and the people and then warm up a little bit before that heat then ends up rising. These things are also really popular and really well-suited for dock doors. So if you are loading and unloading, instead of opening the dock door and having a whole bunch of air just got straight through and taking all the hot air with it, these infrared units help push the heat to the people that are working there.

All right. So now we're going to be shifting gears a little bit. We were talking about lighting and then we talked some of the equipment, HVAC-wise. Now we're going to talk a little bit about the building envelope before we wrap up here, okay? So building envelope really just consists of all of the different parts of the building. Everything from our walls, to our roofs, to our windows, exterior doors. It also includes some of the internal structures as well. So if you have a large manufacturing space or you have a warehouse, maybe you have a small office set inside of that warehouse and you don't need to necessarily do everything. You don't necessarily need to heat or cool that entire warehouse. You just want to do the office where people are sitting most of the day or working. So this building envelope does take a number of different forms and fashions.

A couple things to note here is that building envelopes for manufacturing are really, in some cases, very different and in some cases, a little bit different than commercial buildings. Some of the biggest differences that we typically see are that manufacturing facilities in some cases don't require heat. For better or worse, I've been a number of facilities in northern Ohio in the middle of winter and there's not a lick of heat at all. You are just really bundled up. So that is one big aspect to keep in mind.

Another is that not all facilities are cool. If it's not heated, you're darn certain it's not cooled. More often than not, we do see facilities that have some minimum level of heating, maybe no cooling. So maybe if you are far enough north, that might be your facility. That is changing a lot. We are seeing many facilities that are moving towards trying to provide comfort cooling again to cut at that productivity aspect of things. So that is different. And then one thing that typically will be a lot different in our building envelope for manufacturing is just the pure ventilation rates to move air around, to move heat and cooling. One thing that we'll typically see in manufacturers that we won't see in a commercial building is maybe a big heat treat furnace, right, in the middle of your facility. Well, that heat treat furnace is sucking in a lot of air, it's combusting, it's heating our parts. It's heat treating. And then all of that exhaust goes up and out. Well, all that air that gets sucked in for that combustion, it needs to be replaced somewhere else. And so you might notice on the manufacturing site, there's a lot of air being pulled in maybe at the dock doors or you might have a door that won't quite close or it closes with a big slam. And you may not see that if you go to a couple other, maybe a hotel or somewhere else. So these are a couple of the big items I guess to just keep in mind that manufacturing is a little bit different on this building envelope front.

But with that said, there still are some overlaps in terms of the pieces of material, the building construction, things like that that are ubiquitous whether it's commercial, industrial, or even residential. The big one is our insulation. So insulation, when we typically talk insulation, the lingo that we are losing is this R-value. It's just the resistance to heat. So the higher the R-value, the more the thermal resistance. Essentially the better it is at keeping heat in or keeping it where we want it. So the picture appear, this guy is just doing a fiberglass batt insulation. This is obviously a little bit more of a residential picture here but it's the same general theory here. The R-value of all this insulation for the most part, it's determined by the thickness and the type of material that we are using. So a lot of times when we are talking about R-value, the thicker you make the material, the higher the R-value goes. The better the material you maybe put in, the better the R-value gets.

So as an example here, a 1 inch of a solid wood, so maybe this is relating to our picture here, that has an R-value of one whereas if we look at a blown cellulose, so this is typically what you might see it in your house, the R-value of the blown cellulose might be somewhere in the 3-4 range. So quite a bit better. And this is typically in a per inch. So an R-value is typically per inch type of rating. And then we just figure out what thickness of insulation we have and then that gives us our total R rating.

This example here in the bottom right-hand corner is a little bit more relevant for our industrial facilities where you – this is more the roofing installation for a lot of our manufacturing sites where there is a metal deck and then there's maybe some insulation in between. There might be a hard insulation board perhaps finally finished off with metal roofing on the top. In some cases, you might even put some dirt and some plants and some other things and you call it a green roof. That is seeming to take effect in some cities more and more but these are all different approaches and provide some different benefits.

For all of our insulation, regardless if it's our walls or our ceiling, one really good activity to keep in mind is do and insulation assessment from time to time. For the most part, there's a lot of equipment that's out there that you can use. Here's an example. This is just an infrared camera. If you are a Better Plants partner, we have several. We have some really fancy ones here that we will loan out for free. We will give them to you, just don't break them. And these things are great at doing a lot of different things. One, obviously, you can check insulation levels. You can see where you are either losing heat or heat is coming through. But it also gives us some better ways of seeing maybe some of the construction defects that might have happened. So here's a couple of different examples over on the right-hand side. It gives you that x-ray vision into a wall. In some cases, you might just see where water leakage is coming into a wall. These things, and I think we will probably touch on it in a future session here, these infrared cameras can be used for pieces of equipment. So checking insulation in a furnace or our steam system. But they can also be used on our electrical systems, to, so to identify bad connections in our switchgear. So some really good stuff there, a really important piece of equipment.

So that's kind of our roofs and walls. The next big one is in our windows. So windows, there's a couple main types of lingo that we use here. The big one for windows is not an R rating like we do for insulation, it's a U factor. And the two are essentially just the inverse of one another. Just purely the inverse of one another. The second item on here is this HSGC, it’s the solar heat gain coefficient. Essentially what that is is the lower the number is, the less heat that were picking up from the sunlight and coming in. And so that’s an important factor if we have let’s say Eastern and Western facing windows or maybe if we have southern facing windows with zero shading at all in the summer. It just means that there will be much more heat coming in our facility. And then these next two, this visible transmittance, the amount of light that comes in and then the air leakage. It’s just literally the amount of air seepage through the window frame construction.

So here is an example of some of these typical window ratings and how you might see them if you were ever going to buy them. And what we are looking at is the frame types in the first column. You have a glazing type, essentially the number of pains, windowpanes in here. You can see they are single vs. double, even a triple in here. And then over here on the right-hand side is the rating criteria. We have clear glass and then there’s tinted glass. So the You factor for these guys, this is like that R rating. This is the heat conductance through a window. You can see what some of the numbers are the general trend, if you look down through there. The single glass, it’s worse than a triple pane glass. So the lower the number, the better.

The solar heat gang coefficient, this is again for our clear glass, if you contrast that with tinted glass over here, that’s where these numbers are a little bit different. So let’s say a double pane glass might be .59 whereas that tinted glass because it’s not letting in all the sunrays, it’s not bringing in all the heat as well, so the solar heat gang coefficient is a little bit less. And then that last one is VLT. This is the visible light transmittance, so how much light is actually coming through and coming into our facility. Similar to that solar heat gain coefficient, same general things are going on here where the clear glass is a bit higher than the tinted glass.

So really putting some of this stuff together, ASHRAE has some building requirements for all different types of buildings. We talked about ASHRAE a little bit during last week’s session. So ASHRAE 90.1 really provides the standards, the framework, kind of the base and minimum of what’s considered good practice. And so they have really all this information listed out by building type as well as by climate zone. So depending on where you live or where your facility might be located, you’re going to want to build it in slightly different ways to really maximize the efficiency of it. And so ASHRAE is really a great reference point. You can see in here; they have things specified for let's say roofs and what the minimum R-value should be. And they have it for nonresidential; in this case, I'm showing nonresidential vs. residential and the semi-heated facilities.

And then they go through all the different building construction components. So there's roofs, there's walls, there's doors, there's glazing. So this glazing for windows. So they have all the stuff located in here. So it's a nice one stop shop if you are really doing some new construction. This is kind of that threshold, hey, this is what I wanted to be built to at the minimum. You might want to do a little bit more.

And the way a lot of that is based is really on these climate zones. And so right now, the US has seven climate zones. There are more in this world depending on if you are higher or lower. But these climate zones essentially help us dictate what type of building construction you might want to consider because each one of these zones will receive a very or experience a very similar climate. So for some of you, you might be up here in Ohio and climate five whereas – and the construction there would be radically different than let's say if you are building maybe out in Los Angeles or down in Miami, Florida. The construction techniques that you want to use or follow are going to be significantly different because there's just a wildly different climate zone difference with those and what they experience.

So a couple things to really keep in mind here when it comes to building envelope. So the big one is really our exterior walls and roofs and building those correctly in such a way that you make them pretty tight. Tight and insulated. And so in the case of this guy on the right, he is spraying on this foam. I've seen this in a number of manufacturing facilities, not necessarily spraying on to what looks like plywood and two by sixes there, but onto metal framework. You spray this and not only can it provide pretty good insulation from stopping thermal conductance through the building but it also provides an airtightness. It provides a barrier, a solid barrier so that air doesn't come in and out of our facilities. We want to only have the right amount of air similar to maybe the items we were talking throughout the presentation. We want the right amount of air so we want to know the purpose of that. Typically we don't want a hole in the side of our wall, we don't want a hole in the side of our house. Same thing with our building envelope. So with our exterior walls and our roofs, more insulation, the better insulation, the better airtightness we can get. Obviously, the better for our walls, kind of a standard might be and

R-13 with 7.5 continuous insulation where we don't have it broken up across say the different trusses they are or support beams.

On our roofs, it one thing you might want to consider depending on where you're at, is a cool roof where a lot of times more and more you'll see that they put down kind of a white rubber roof and that white reflects the sunlight. So instead of the sun coming up in the middle of the day in the middle of July and heating your roof up to crazy temperatures, it reflects a lot of that light out and doesn't let that seep into your facility. So there are some opportunities for cool roofs. You can see there's a little bit higher level of insulation that's called for, continuous insulation.

But beyond that, there's also these other opportunities in other system areas. So windows having a window film or shading, especially if you have Eastern, Western or Southern exposures of your facility. Having shading approaches and that could be something such as a fenestration, it could be blinds, it could be just having trees planted out in front of those. If it's kind of an aesthetic thing, there are window films that can help with the solar heat gain and really reduce that. So that is a big thing for the insulation purposes. Getting a double pane or a double layer window or higher is typically the most efficient aspect.

And then getting into these last two, really these exterior doors and even interior doors. Ultimately, we want to try to reduce the amount of airflow through these guys when it's not needed. And one of the really common opportunities here are these high-speed rolling doors, so that's this picture over here on the right-hand side. As you get close to it, that thing zips up in the course of ½ a second. And then as soon as you might drive a forklift through it, the thing comes back down. And so the thing comes back down. And so the purpose really of all of our doors and even on the interior side, we want to just try as much as possible to separate unconditioned from conditioned spaces. So if your whole building is conditioned, we want solid doors. We want quick-acting doors. Protecting your insight from your outside. But even on the inside, if you have air years of your facility that need to be heated and cooled whereas they might be storage facilities that don't need to be heated and cooled at all. We want some type of physical separation of those two. And it does make a pretty big difference.

-you're not off the hook, you all have homework again. So similar to last week, this is not painful homework but these are simple things that hopefully all of you can do after today's session. So number one, what I want you to do is try to list the types of lights used in your facility. So that's going back to what we were talking about incandescent, metal halide, maybe you have the florescence. Maybe you have LEDs. So what types of lights are you using in your facility? And the bonus on that one really is identifying the number of each one of those types. Or around about, give it the old college try. You don't all need to be professors but give it the old college try to see roundabout. Are we talking five metal halide or are we talking 500 metal halides?

The second one, this one is super simple. You should know it right away. Is your space conditioned? Yes or no? Whether you've been complaining because it is or is not, a little too much or not enough, you should know this one. So the tougher part of this question is what are the two types of equipment that are used – what are the two most prominent or largest? Is it a chiller system? Is it an air handling unit system? Is it a little space heater? List those out.

And then the third thing here, are they are any opportunities or are there any openings in the building envelope? Or opportunities for quick doors? You have dock doors that are wide open all the time. Do you have maybe other openings or holes that are just kind of always on. Maybe you have exhaust pans that are going all the time. I don't know, I don't know. Think about that one. If there is an opportunity, take a picture of it.

So those are your three homework activities for this week. And with that, I'll ask are there any questions for today?

Eli

Go to Webinar software and I did see that some folks have sent in a couple questions as we were stepping through things but do try to type them in if you can think of any additional questions. Alternatively, you can try to virtually raise your hand here in the software and we can try to unmute you and hopefully that's not the most catastrophic thing ever. But with that, I think I will step through just a couple of the questions. And Marissa, if you can, you can feel free to read off any that I may miss in here that are coming in.

But a couple of things, though. Where do I start here? So actually, before I even jump into the questions, I do want to throw out one maybe two items here especially as it relates to just the general pandemic, the COVID craziness that is going on and some things that I didn't mention. But one is just an anecdote from one of our Better Plants partners and it's on a technology related to our HVAC system that I did not mention today. But I think for all of us, it could be applicable.

So within HVAC systems, one technology that you might really want to think about in today's world, especially with maybe sending people home to work, are our demand ventilation sensors. So really sensors to monitor our CO2 levels typically within office or commercial settings that would allow the system to ramp down. And I will say that the anecdote because I was just talking to one of our partners here last week, is Raytheon. Raytheon, they were just looking at the data. They implemented the CO2 demand sensors that one of their facilities over the past year and they were looking at their data just recently and wondering wow, why is my one facility staggeringly better than some of my other facilities when more or less, everyone is being sent home? And in large part, the big aspect of that is as we are sending more people to work from a telework type of the scenario, though CO2 demand sensors that are controlling our HVAC supply air, it allows the system to back down. If you don't have as many people in the office space, similar to turning off your lighting, it allows your HVAC system to ramp down. So that's one thing.

A second item, and this actually does relate to one of the questions we did get in here is asking about using UV in our HVAC systems to help with the COVID situation and may be disinfected. So I think there's a longer maybe explanation here of sorts but within HVAC, UV can be used within some of those but I would really caution with the COVID, specifically, there's still studies coming out showing or investigating the potential for using UV to kill COVID, the COVID virus. And I think the latest one that I saw was it does, it can kill COVID. However, in the studies, they had to use the most extreme, highest level of UV in order to kill the virus. And so by no means don't take my word as gospel here. It is something that you can look into as an option, putting a UV light in the HVAC unit to help disinfect some of the air it's being recirculated in your facility. But caution you, the UV and specially those UV lights that kill germs, it's a special type of UV, it's UVC, UVC, right, and it's extremely dangerous to humans. It's not something that we are accustomed to so it's not good stuff. So just be really careful. But alternatively, at least in today's times, I think one of the more prominent strategies is that you use dedicated outdoor air. So you use a lot of outdoor air to really help flush the systems. So if and where possible, you have people coming back to work, really utilizing maybe 100% outdoor makeup air where and when possible. So that is maybe another strategy that's not necessarily saving us the most energy but certainly is much more important on the health of all of our workers certainly ask companies start to come back and reopen facilities, ramp facilities back up, trying to follow CDC requirements. Okay.

So those are definitely two things here. So a couple other items here and give me a second, as I'm looking into some of these questions that are coming in. So I think one of them – Angel sent something in asking about tracking energy consumption in our chillers. Is it feasible? Does it make sense to correlate our energy consumption for our chillers to the cooling degree days question mark or should she be using the building energy consumption? Really on that, I would say yeah, if you can look at, and I've seen this simple scatter plots, right, where you have the energy consumption of chillers maybe on the Y axis and the cooling degree days on the X axis or as a proxy for cooling degree days, maybe you use the average outdoor air temperature. And those are – that's a really simple, simplistic way of cutting at those trends to see how much energy your chiller plant uses. So really effective, good way to go about doing that.

Let's see here. Another question asking about the RY of combining spark controls with LED lights in manufacturing settings. As I mentioned during the presentation, that LEDs are probably the technology you should be thinking about. I'm not a salesman but certainly that's the most effective technology of today. But the real beauty is when combine the LEDs with the smart controls that let's say you maybe set up zones, maybe lets you turn things on and off automatically so as people are coming in, it can help you turn things on or turn them off. Certainly, this is very popular within office environments and I think I even made a mention that some of the smart controls even let you essentially dim or brighten the room with LEDs so you can ramp it up. Maybe you want to track the lighting levels of the sun to help with our natural circadian rhythms. And so there's a really big impact not only switching to technology but adding those smart controls. I think we even have a couple write ups within our Better Buildings Solution Center where some partners have made the switch. One of them I think that maybe came to mind for me is in our, I think it's Steelcase made a big retrofit and they had something on the order of 60% to 70% savings by switching not only their lighting systems but implementing these smart controls. Okay. So really big things.

Had another question it looks like come in from Kurt asking about the refrigeration tonnage in one of the conversion units that I had on one of those and whether, I guess it's just a conversion unit. He was asking is the value of 3.517 kW dependent upon equipment performance? And Kurt, if I could pull up the slide here for you, I would. But the answer is it is not dependent on equipment performance. It's just a way of talking or it's an equivalency, right, of one tonnage of cooling equals 12,000 BTUs which equals 3.517 kW. So really, it's equipment performance agnostic.

Okay, so a couple more here. Marissa, I might need your help here because it looks like there's even more coming in. Maybe for the sake of time, we will just go for a couple more and for some of these, maybe I'll take them offline and I'll try to get back to folks a little bit later.

Marissa Schatz: Hey, Tom. Do you want me to help you with moderating by reading some off for you? Will that help?

Tom Wenning: Oh, please.

Marissa Schatz: Okay, yeah, totally. So I'll just jump right off of where you left off and I think this one is from Dominic. The next one is is Energy Star/EER only a United States-based program?

Tom Wenning: Yeah. So Dominic, the Energy Star program is really a rating program that's specific to the US. But I can tell you that Energy Star which is run by our colleagues over at the Energy Protection Agency, the EPA or the Environmental Protection Agency, there we go. They do have sister programs around the world. So there are other standards for most other countries around the world. So it is kind of regionally dependent, Energy Star and that Energy Star rating that I was showing in there really is US Pacific but with that said, the Energy Efficiency Rating or the Seasonal Energy Efficiency Rating, really, that can be applied around the world because that's just a way that we can rates equipment and it's not necessarily specific to the US. Marissa, are there other ones?

Marissa Schatz: Yeah. Let me see if I can pull up some other ones. How about, and just let me know if you don't want to answer any of these. In a zone one, (high temp/high RH) should I use the supply air temperature to control the AHU or should I control with the return air temperature? And this one is from Angel.

Tom Wenning: Oh, okay. So let me break this down for everyone just real quick. So Angel, who's in zone one, so if we remember those ASHRAE climate zones, so probably down in maybe the Miami region, right? So high temperature, high relative humidity. Should she be using the supply air can temperature to control the air handling unit? Or what should she be controlling the unit on?

So for that, Angel, I guess best case scenario for most of our facilities is to control on that return air temperature. So that way we know what is ultimately being supplied in that room and what is being delivered to the occupants in that room. So typically the way a lot of these air handling units are set to operate is that the temperature of the air, the supply air is controlled by a chilled water valve that is somewhat separate from the amount of air that's being delivered into the room. So typically, the fan, the supply air fan will be controlled by that return air temperature and then the supply air temperature will be controlled. In most facilities, it's just trying to be held at a specific temperature. Maybe it's 55°. Maybe it's a little bit lower than that for you. And so it's trying to typically just hold a supplier temperature and then it allowed, the system allows that control valve to actuate so that it can maintain that supplier temperature but ultimately, the air flow and then the load is then controlled by that return air temperature.

Let's see, a couple others here. Marissa?

Marissa Schatz: All right. How about what is the current payback on typical energy reduction projects?

Tom Wenning: Holy smokes. That is really wide. So I'm going to dance and jive a little bit here because that is a really wide-ranging question. So what's the typical current payback on energy reduction projects? Honestly, it's all over the board. I will maybe point you to two different things, two different potential resources here. So one is the Department of Energy's Industrial Assessment Center program. So the DoE's IAC program. They provide no cost energy assessments to small and midsize manufacturers. And as part of that program, they take all the recommendations that they've ever given to a manufacturer and they put it into an open public database. So this is fantastic. And it's fantastic because it allows all the rest of us to go in and look and see what are the opportunities that have been found maybe in my specific sector, for my specific type of manufacturing facility. And that database will tell you what the opportunity was as well as what the typical cost is, what the typical savings has been, what the implementation rate has been, what the simple payback is. And so you can really dive into some pretty deep things. Okay, so that's one. The Industrial Assessment Center database. And just Google it, it should pop up to the top of your list. But it's a really valuable resource for us out there.

The second thing that I will mention is that through our Better Plants program, we do our Energy Treasure Hunts. Right now, if you are able to get into a facility, if your facility is still operating, maybe there's an opportunity where you can do a treasure hunt like, maybe it's just you. I know the folks at Nissan have taken the Energy Treasure Hunt and I think they made their own little kind of smaller, condensed version where maybe it's just the maintenance guy or two that walks through the facility and looks for pieces of equipment that can potentially be shut off. And so these treasure hunts that we run our really geared towards low cost/no cost opportunities and by and large, when we've run these, the average identified savings is somewhere in the 5% to 10% of the facilities footprint. So it's not small savings. A 5% to 10% savings or low cost/no cost opportunities. Okay. So that's another thing maybe to keep in the back of your head.

And then at least anecdotally right now, the typical implementation that we've seen on a lot of those is right around 50%. So 50% of the opportunities identified on these treasure hunts get implemented. So maybe that's somewhere probably the 3% to 5% savings range for our facilities. So, Marissa, are there others?

Marissa Schatz: Yeah, I think I found a good one to end on if you're cool with one more.

Tom Wenning: Yeah, yeah, yeah.

Marissa Schatz: Okay. So this one is can we use your recording for our internal training or communication, so to play your recording to our energy team members?

Tom Wenning: Oh, *[laughing]* that is a perfect one to end on. Oh, excellent. Send me your address, I'll send you the five dollars. Okay. So yes. The answer is yes. Everything that at least I have ever presented, all the material that we've come out with through the Better Plants program, feel free to use it. It will all be available. I know the recordings for all of these are being placed upon the DoE's website. If you – I think the slides are being placed up there as well as a transcript of everything. So hopefully I didn't say anything to stupid through all this because it will be recorded for posterity. But absolutely. If you want these recordings for your energy teams, 100%. I made this note last week. I had a fantastic mentor long ago who one of his sayings was plagiarism saves time. And at least in the real world, in this energy world that we are living in, I believe wholeheartedly in that. Feel free to steal anything that I put out, use it, make it your own, do as you see fit. Okay.

So Marissa, with that, I think maybe we end on the Q&A and maybe do a quick preview because next week, we are going to be continuing this webinar series and we are going to have some friends over at the USDA talking about their rural energy programs as well as the Department of Commerce. We have some folks coming in, talking about their manufacturing extension partnership programs. Really, some additional just great resources that are out there that you might be able to plug into. So please be sure to join us for that one.

And then after that, we have a couple more coming up, at least for this initial set of webinars. But as Eli mentioned at the very beginning, please, please, please send some thoughts, send comments if you like these, if you want to hear some other topics. Send that stuff in. We are contemplating and debating how far out we extend this. Do we extend it? What do you want to hear about? What are you interested in? And see if we can pull in the right folks or other companies to tell their story.

So with that, Eli, I don’t know if you want to close it here and say some parting words?

Eli Levine: I think you said everything I wanted to say but I wanted to just continue to thank everyone for being a part of us and please send feedback so we can continue to customize these to your needs.

Tom Wenning: All right. Fantastic, thank everyone. Stay healthy. Stay safe.