Kim Trenbath: Hi, everyone. Welcome to the Better Buildings Alliance Plug and Process Loads Technology Team webinar. We'll get started in a few seconds.

All right. Well, good afternoon, everybody. I'm Dr. Kim Trenbath. I'm the technical lead for the Better Buildings Alliance Plug and Process Loads Technology Research Team. Welcome to our webinar. We have a great agenda for you today. This webinar focuses on strategies for reducing larger commercial building plug and process loads.

Here's the agenda for today's meeting. We'll give a team update, then we'll talk about our new process loads resource that we recently published and you can access from our website. We have two guest presentations today, one from Brian Turner from CMTA, and one from John Sasser from Sabey Data Centers. We'll save a little bit of time at the end for questions and answers.

I want to remind everybody that this meeting is being recorded and it's going to be archived on our webinar site on the Better Buildings Alliance. And if you have any questions during the webinar, please put them into the Q&A chat function at the bottom. So please use the Q&A button. And the way that we're going to do this is we're going to take all questions at the end. We'll try to get as many questions answered as we can, but if we don't, we'll send out the answers after the call. So a lot of this information will be accessible after the call.

The Plug and Process Loads Technology Research Team works out of the National Renewable Energy Laboratory, and this is based in Golden, Colorado. As you can see there I'm the lead, and our team members include Amy LeBar, who is our mechanical engineer; Omkar Ghatpande, who is our electrical engineer; and Robin Tuttle, who is our stakeholder engagement manager. At any time, you can reach all of us at the following e-mail: ppl@nrel.gov.

So now we'll dig into a little bit of a team update. We haven't talked to you all for almost a year, so we've gotten a lot accomplished since last spring. I also want to highlight our website. You can gain access to all of our resources that we've published from this website, and the link is here. These slides will be accessible after the call, so you can go to the slides and access our website.

Here's some of the presentations that we achieved over the past year. So in May, we presented at the California Plug Load

Research Center, and we talked during their annual workshop on achieving commercial building resiliency through plug load management. In June, we presented at the US DOE-sponsored Miscellaneous Electric Loads roundtable. In July, we presented at the American Society of Healthcare Engineers annual conference. We're actually doing a lot of work right now on medical imaging equipment efficiency, so this was a way to showcase our results. And in August, we convened a group of PPL enthusiasts at the ACEEE Summer Study for Efficiency in Buildings, and we discussed strategies, technologies, and best practices for controlling PPLs in commercial buildings.

I'm also excited to say that we landed our patent for the automatic type and location identification system. We've presented about this before, but our patent finally came through in the fall of this year, and this is a commercial building plug load management system that is plug-and-play and tracks your devices as they move throughout your building, accurately applies controls, and monitors device energy. You can learn about accessing our patent from our lab partnering site, and the link is at the bottom of this page, and learn more about the patent itself through our ATLIS fact sheet, which is on our PPL website.

We also have many new resources that are published on our website. We recently published a conference paper on efficient energy equipment for commercial kitchens. And then we have our PPL TRT fact sheet on automatic receptacle controls. So these ARCs are installed in buildings and they are in code, so this fact sheet should help you understand what the codes are and how to address them by using ARCs in your commercial buildings. And then finally we have new guidance that we're going to talk about later today, and this new guidance document is reducing commercial building process loads and refrigeration unit energy consumption.

I'm please to say that the integrated lighting campaign has a plugs and lights category again this year. This is run by the Pacific Northwest National Laboratory, and our contact is Axel Pearson. We're looking for more participation in this category, so there's a lot of opportunity for you. If you're doing any kind of integration between your plug loads and your lights, please consider applying to the integrated lighting campaign. The links are on this slide, and so is Axel's e-mail.

And we are going to have our summit coming up here in April. This – the Better Buildings Summit is going to be April 11 through 13 in Washington, DC, and registration is open now.

That's all the updates for the PPL team at this time, but we also want to bring in what my colleague, Dr. Tim Laclair from NREL, the Building Energy Sciences Group at NREL, he is the lead for the Stor4Build energy storage consortium. It's a consortium of national laboratories and industry and other organizations, so I'm pleased to turn it over to Tim.

Tim Laclair: Thank you. Thank you for the introduction, Kim. It's my pleasure to be here today. I'm happy to have the opportunity to present to this group and introduce the Stor4Build building energy storage consortium and share what the goals and the expected impacts of the consortium are. Stor4Build is a DOE-sponsored consortium that's led by the National Renewable Energy Laboratory, the Lawrence Berkeley National Lab, or Berkeley Lab, and Oak Ridge National Laboratory for building energy storage. The Pacific Northwest National Laboratory and ACEEE – that's the American Council for Energy Efficient Economy – are also involved in the consortium to support market and policy activities.

The consortium will address energy storage needs in buildings to enable electrification and decarbonization, and we will develop and demonstrate technologies to lay the groundwork for large-scale deployment of energy storage in buildings in the future. We have – the consortium consists of a number of stakeholders.

So what is energy storage in buildings? Why storage in buildings? With electrification of buildings, energy storage is needed to allow for the use of renewable power sources like solar and wind power that are inherently variable. Thermal storage can be integrated with HVAC and other equipment in buildings to provide storage for the heating and cooling needs, which make up about half of all energy loads in buildings. The consortium will do research to develop the needed technologies, address barriers for adoption, and work to accelerate the deployment of the technology in the marketplace. Participants in the consortium include a broad range of stakeholders that include industry, utilities, research organizations, and building owners among others to help ensure that we develop and implement solutions that can work in the real world.

So the national labs will be leading the research and development efforts of the consortium and will be working closely with industry and other stakeholders. The research will include fundamental studies for material development as well as developing and optimizing new components and systems to integrate with heat pumps and other building equipment to enable thermal energy storage in integration with other building systems.

The end goal of Stor4Build is to enable the large-scale implementation of electrification to help achieve net zero emission goals. The consortium is complementary to other DOE initiatives to achieve this goal and will result in more efficient buildings that use energy storage to help respond to grid needs for deployment of renewable power.

So that's it for my overview here. I want to just invite anybody that's interested in receiving updates about Stor4Build and participating in the consortium to please send me an e-mail and we can go ahead and add you to the distribution for e-mail updates. Thank you very much.

Kim Trenbath: Thank you, Tim. Now I'd like to turn it over to Amy LeBar from the NREL PPL team to talk about our new process loads resource.

Amy LeBar: Great. Thank you, Kim. Our team is very excited to share a resource with you all today that we published in January on process loads. So I'm going to do a brief overview of the resource and use it to frame the great presentations we have coming up.

So I want to start by defining commercial building process loads. These are larger commercial building PPLs that also generally perform a process in the building, so they include loads such as elevators and escalators, enterprise servers, commercial kitchen equipment and laundry equipment. Important to note that they can be either plug-in or hard-wired loads, but the key distinguisher is that they are larger loads within the PPL end use.

So in our resource, we focus on five categories of process loads, which is by no means an exhaustive list of these loads, but we tried to capture the most common categories. So we include reduction strategies for food handling, refrigeration, internal mobility, data center and information technology, and water handling categories. This resource is designed to be an introductory guide, so we provide general reduction strategies for each of these categories and then also link to more detailed information if you want to dive deeper.

So just wanted to touch a bit on the contents of the resource. This is the summary table that we have included in there. So on the left you'll see the process load categories that I mentioned previously, and then we go over six common energy-saving strategies which are listed there on the top. So within the resource, we go through each of these strategies, talk about which technologies are available, and some of the best practices for each strategy, and then provide information about how they can be implemented in each of the process load categories. But I think our presenters are going to cover most all of these categories in their presentations, and I'm looking forward to hearing about their experiences with managing these process loads in the field. So yeah, that covers our new resource. If you have any questions about it, please put them in the chat and we can go over them during Q&A. Thanks.

Kim Trenbath: Thank you, Amy. Now on to our technical presentations. I'm pleased to introduce our first presenter, Brian Turner from CMTA. Brian Turner is a partner and electrical engineer at CMTA. He has been designing zero energy buildings at CMTA since 2008. In addition to design and project management, he has performed energy modeling for many of his projects to optimize various building systems' phenomenal performance and value. Brian strongly believes that making zero-carbon strategies affordable is the key to successfully navigating long-term climate challenges. I'm pleased to turn it over to Brian.

Brian Turner: All right. Thanks for that introduction, Kim. Thanks for the invitation to be here today. So as Kim mentioned, we've designed a lot of high energy buildings, and I guess I'll just say up front that there are a lot of ways to improve the efficiency of plug loads, but we don't – fundamentally, we don't design those products. We don't design computers and appliances. There's a lot of gains being made with regard to efficiency in that world, but my presentation's going to be focused on what we as designers and building owners can do within our buildings in order to minimize the process. Next slide please.

So just a brief introduction to why they're important. This is the pie chart, the end use energy pie chart for actually the very first zero-energy school that CMTA designed in 2008, Richardsville Elementary School. And in this case, you can see plug loads are a – plug and process loads are a sizeable portion of the end use energy pie. And this is for a net zero energy school that has very low EUI. It was low EUI buildings. Had we not focused on the plug and process loads as well and drastic energy reduction in those categories, the percentage would actually be much higher than this, so even at the end of the day, it's a sizeable percentage of the energy being consumed.

Another common project type that we work on is office context, which can be a little bit trickier because we see a lot of the process and plug load energy tends to be in distributed computers. This is the energy data for one of our headquarters buildings in Louisville, Kentucky, and again very low EUI, but at the time at least, we used all desktop computers for Revit and AutoCAD workstations, and they consume a huge amount of power and tend to be very difficult to schedule off when you're not using them. So as a result, we saw a very high percentage of plug load computer use in that example.

CMTA doesn't do a lot of industrial design. Every now and then we have some project come along. This is kind of an extreme example of a new bourbon distillery that I'll touch on later, but process and plug loads absolutely dominate the end use energy usage in that building.

So in addition to the amount of energy that's being consumed by process and plug loads, I think it's also important to point out that when that energy's being consumed has a big effect as well, and particularly as the grid continues to electrify and decarbonize. That aspect is going to play a larger and larger role. So again, this is Richardsville Elementary School, a typical year in terms of peak electric demand. It's an all-electric school. What we actually see is that the annual peak happens in January. It doesn't necessarily correspond to that hot weather. So interestingly, when you look at the day that that peak occurs, it is the food service program that is really firing up in the morning that is overlapping with what is still a cold day early in the morning and all heat pump zones are running. And that overlap is what's causing the peak for that building. So in part it's really driven by plug loads. That typical wintertime day shown below, I think one thing that's important to note is that plug loads, especially in a very efficient building that shuts down after hours to a high degree, a lot of that energy that's being used in the after-hours scenario are plug loads, plug and process loads, and often that is the dirtiest energy, especially as we continue to decarbonize grid electricity, it'll often be the dirtiest energy moving forward.

So we touched on it already briefly, what are common plug and process loads. Again, essentially anything that is not an HVAC end use for lights or water heating. In our buildings particularly, these are the categories that we see as big users: central and distributed computing and anything to do with food service.

So briefly touching on IT and central computing, in most of our buildings these are the MDF rooms, the IDF rooms. Servers can use an enormous amount of energy, but they essentially run 24/7. You can't just schedule these off. The interesting thing, though, about most servers and centralized HVAC equipment is they use almost as much energy when they're doing nothing and idling at 1:00 AM as they do 12 hours later when they're experiencing a lot of traffic and a lot of activity. So one technique to minimizing server energy usage is to virtualize those servers and migrate them to – and consolidate the virtual servers on fewer pieces of hardware. That way you can shut down other pieces of hardware that aren't being used after hours. That is still a somewhat sophisticated strategy, and that is something that is not necessarily going to be done on a lot of buildings at the small and medium commercial scale.

So one of the solutions that we often turn to is send it offsite. For a lot of owners, there's an enormous amount of server functionalities that can just be sent to the cloud, and we like to stress you don't have to feel guilty about doing this because Amazon and Microsoft and Google, they can manage their data centers much more efficiently than you can as a building owner. And the vast majority of time, they are powered by renewable energy, often unmatched renewable energy.

Another big user, you know, once you have sent everything to the cloud, wi-fi has access points. You know, schools or office buildings might have hundreds of these, and modern wi-fi access points typically have multiple antennas, and what they – there's a new feature – it's not new. It's probably been around for ten years. It's just not always activated, and that's one important thing. Make sure the box is checked so that low power listening has been activated through your wi-fi system. What it will do, each of the antennas will basically listen for traffic, and if they don't see packets going back and forth, they'll power down. This is a feature that can save a lot of energy in wi-fi use systems, again, if it's enabled.

So moving on to the distributed computers, again, these are desktop workstations, computers that occupants in the building are going to be directly interacting with. Again, huge energy user on our projects. One strategy is an end client approach where essentially all of the horsepower for those computers lives in the server room, and on the desks you've just got monitors and keyboards, and it really helps to improve efficiency but also makes sure that you're able to power down after hours in a much more efficient manner. Again, this is the strategy that isn't common for small and medium commercial projects, and there's a sense of scale that you really have to hit before this becomes a really compelling option.

Our typical strategy is go mobile. If at all possible, replace that desktop computer with a laptop or a tablet. Not only do they use a fraction of the power that a desktop computer does, they are much easier to schedule off. You don’t have to schedule them off. They turn off. It's kind of like an electric car. An electric car has to be eight to ten times more efficient than a gas car by necessity. Laptops have to be designed to be very power efficient or else they wouldn't be very useful. So if you can switch all the desktop computers to laptops, even if it's a laptop that's going to stay on that desk over the long run, it will be way more efficient. So that's a strategy that we have seen in most if not all of our zero energy projects.

So a quick thought experiment. Sometimes vampire or phantom loads get a lot of attention. With the PD designs, vampire power and electric power consumed while appliances are switched off or in standby mode. Personally, I think there's a lot of conflation with vampire loads and computer loads that are just idling after hours because they weren't turned off or shut down or put into sleep mode. A typical desktop computer, when it's doing something very graphically intense, let's say, might be using about 145 watts between monitor and PC. When it's doing nothing, it'll use slightly less energy. When you put it to sleep, it might use 3 watts, but that's about how much it's going to use even if it's off. You have to unplug it to have it use no power. So if you're going out hunting vampire loads, now there is a little bit of energy you can save there, but honestly it's not that much in a lot of cases, particularly in the case of computers and distributed computing. You really want to make sure these computers get shut down after hours. There's nothing worse than going into an owner's building and seeing a computer lab with 40 computers in it, nobody in it, and every one of those computers is running and you know they've been running for the last two weeks straight. Again, go mobile when possible.

So moving on to food service, this is data from the Food Service Technology Center, and it's a little bit dated now, but the lighting category is probably a little bit lower than 13 percent at this point. But you can see most of the energy usage in a commercial food service operation is in the cooking appliances and the HVAC and exhaust to deal with those cooking appliances.

So when it comes to the cooking appliances, there are some pretty simple heuristics that you can follow to reduce energy. One's electrifiable. We'll go over that here shortly, but the types of equipment that end up under the hood say a lot about how efficient a kitchen's going to be. If I see a brand-new kitchen design and I see that we've got fryers, we've got ranges, we've got a lot of open cooking equipment, it's usually not a good sign for how efficient that kitchen's going to be. It might make great food, but what we've seen is there is also a correlation between the healthier the food is in kitchens, that kitchen tends to be more energy efficient as well, so appliances like combi ovens and convection steamers, fully-enclosed cooking appliances, those are the ones that are going to be the most efficient, require the least amount of exhaust, the least amount of makeup air, which can be very energy intensive. If you do need open cooking equipment like a range, go electric induction if at all possible, and there are huge savings for an induction range, as everybody probably knows, compared to a traditional natural gas range.

So this is a quick case study, again by the Food Service Technology Center. This is a commercial kitchen in NorCal, and it kind of shows you that a little bit unintuitively you often see that in order to take a kitchen electric, sometimes you'll even see that the connected load's a little bit higher, but the actual energy usage, especially if you really pay attention to the efficiency of the equipment, the actual energy use is going to be much lower. A lot of times the big difference between a piece of efficient food service equipment is how many BTUs is it using when it's idling, when the piece of equipment is not in use. Does it really go into a low-energy use mode or is it kind of like the computers, it's almost using as much energy as when you're actively cooking something? A lot of time in a commercial kitchen, the cooks are going to come in and they fire everything up and it kind of runs until they're done cooking and it's ready to clean up. So a lot of energy can get used in that idle mode for this equipment.

Moving on to sanitation, again, enormous amount of energy for dishwashing. There are strategies to mitigate that. There are a lot of ventless dishwashers now that incorporate integral drain heat recovery. We have been burned by that, I'll say. They're fantastic. They save a lot of energy, but you really have to pay attention to how you're designing the room and the heat recovery because they can let out an enormous amount of steam at the end of a cycle when you open them, and if the exhaust rates haven't accounted for that, can have an angry owner. So there's a tradeoff there where you don't want to too heavily exhaust the dish machine room, so you really need to pay attention to what are those air change rates versus how much energy you're saving with that ventless dishwasher. Again, the nice thing is you don't need the exhaust. That saves some more cost in terms of construction.

One other strategy that we've seen, if you can maintain your water temperature at 120 degrees instead of 140 degrees in your water heater, you can save energy in that way, but you will need to upsize the booster heater in the heater because they generally run 180 degrees. Again, there are huge discrepancies in the flow rates for pre-rinse heads. Typically you're going to use the pre-rinse function for dishware before you put it in the dish machine, and that can have a big effect on the amount of hot water that's being used for these processes.

Refrigeration is another topic. It is kind of down at the end of the list in terms of energy consumption for food service, but this can be very – this can be widely variable. A lot of times we'll see a food service design that's got refrigerators all over the place. So one strategy that can be very effective here is to consolidate that equipment. Why do we have ten distributed reach-in refrigerators if we can better position and get by with only three? One thing that we see is that when you reduce the number of compressors that you have in your refrigeration system, you tend to save a lot of energy. If you can have one walk-in cooler that's twice the size of two smaller ones with separate compressors, you're going to save more energy in that scenario.

Another strategy for a lot of our zero energy projects and high-performance projects, we've got water source loops for the cooling. Often it's a heat pump loop so it's neutral temperature water. You can use water source compressors for a lot of refrigeration, not just walk-in coolers but even smaller reach-in coolers, ice machines, even serving equipment. And if you put those on a geothermal loop, they can reject their heat to the geothermal loop where it can be recovered to be used for things like water heating.

A quick little anecdote, again back to Richardsville Elementary School, about six months after that project opened, we did a post-occupancy walkthrough just to kind of see what was working and what wasn't and how the building was being used. So again, this is a school that performed at an 18 EUI, and one thing that we noticed was there was a very old Good Humor ice cream cooler plugged in in the kitchen by the serving line. And it was visibly very old, didn't seem to shut off while we were there, so I put a kilowatt meter on it and left it on it for a couple hours while we were there. We checked it before we left and was able to confirm that the compressors in that unit never turned off, not once. So that one little ice cream cooler was adding about a half of an EUI to this 75,000-square-foot building for about 3 percent of the total energy of the building. You can't plan for that. The food service operator brought it in after the building was occupied, and honestly it wasn't on the design drawings, but if you're going to control process and plug loads, you have to be wary of things like that particularly really old equipment.

Just to touch back on the potential sources of energy recovery, particularly with refrigeration but not just refrigeration. So most commercial kitchens are going to have a lot of refrigeration needs, so they're constantly rejecting heat. If you can reject that heat to a water loop where it can be recovered, that heat could be used for a lot of things, not just hot water at sinks, but it can feed dish machines. It could even potentially feed a hot well on the serving line. So you can sort of create this closed loop where the devices that need hot water and devices that are constantly rejecting heat are just in a circular pattern trading heat back and forth within a kitchen. Also helps reduce the number of geothermal wells or tonnage of cooling power you might need outside for HVAC.

So moving on to a lot of common miscellaneous plug and process loads throughout these types of buildings, in general we do everything we can to stay away from projectors. There are some newer LED type projectors that are more energy efficient, but still many of the projectors use 300-watt incandescent bulbs. They're very energy intense. They often stay on for long amounts of time, so compared to a 30-watt video display, often these are touchscreen and they're very easy to schedule off when they're not in use.

Coffee pots. This touches back on the theme of consolidation. There's no reason for every office or every classroom to have a personal coffee pot. If you can centralize these amenities, and particularly in the case of a coffee pot, if you use the type that use thermal carafes instead of burners, which in my opinion just burn the coffee anyway, you can save a lot of energy in that way through consolidation and just more efficient coffee machines.

Printers. Again, we’ve seen a lot of buildings and a lot of owners that like to have kind of a personal printer on every desk regardless of the cost of doing that. It can be very wasteful, particularly if those are laser printers. The heating elements in laser printers can be very energy intense, so it's either inkjet printers in a distributed fashion, there's probably not a ton of energy being wasted there, but again, anytime you can consolidate and kind of move these amenities to central locations within the building, there's opportunity to save energy there.

Same with refrigerators. Again, just reducing numbers of compressors. We'll get the same volume of refrigerated space and save energy by using a single compressor. This is another quick example in our office building in Louisville. We had a vending service briefly, and they brought in the oldest Pepsi machine I think I'd ever seen before. It was at least from the '80s, and it also seemed to run nonstop, made a lot of noise, generated a lot of heat in our breakroom, and seemed to just ever turn off. So again, I put a kilowatt meter on it once. I came back a couple days later and confirmed that this Pepsi machine never turned off its compressor in something like 72 hours. We got rid of it shortly afterward, after we went away from the old model which we should have done long before that. But the better alternative there is an energy-efficient, Energy Star rated vending machine, essentially with an add-on VendingMiser which adds occupancy controls to it so that you can get some savings in after-hours situations and still take care of the product.

This one's half joking. One strategy to make sure you don't have space heaters everywhere is to wear a sweater, but really that's not the solution. The solution is that mechanical engineers and architects need to design comfortable spaces where people don't feel like they're being freezed out. There's nothing that hurts me worse than walking into a building after occupancy and seeing space heaters under desks. That's a failing on our part, so we need to make comfortable spaces so that we don't see that.

Touching briefly on transformers, anyone that's familiar with Ohms Law knows that you can transmit power more efficiently with less loss the higher the voltage of electricity. So one common approach to designing building electrical systems for commercial buildings is we're going to bring the power in a high voltage, usually for rebate and then we'll distribute transformers all over the building, kind of different trunks in different neighborhoods, and then we'll transform down to 122 for those computer loads and those small plug and process loads. What we've found is that strategy usually puts an enormous amount of transformer capacity into buildings. Particularly in school, if you've got six or seven or eight of these small step-down transformers, if you go and put a meter on each one of them, you'll see that they're very lightly loaded because those plug and process loads have come down over the years. We've seen on some of our earlier designs that they're only loaded to 2 percent. And even though transformer efficiency has come up over the years, what you see is when they're very lightly loaded, the efficiency of that transformer plummets. So we have actually changed our typical design approach so that we're using larger, more central transformers, even though we're distributing at a lower voltage because we can keep those transformers more highly loaded and get the higher efficiency.

Kim Trenbath: Brian, so I think we have to move on. Do you want to take 30 seconds to say a few more words?

Brian Turner: I will probably go ahead and skip the elevators because they're not as interesting as some others. Compressed air, don't use compressed air. There are much better electric options, and it's very wasteful. We'll skip those industrial sort of applications.

Okay, the fun one. The bourbon distillery that I promised we'd touch on at some point. I don't know if anybody's familiar with Kentucky, but the emissions intensity in Kentucky are very high, over 1,700 pounds and its equivalency of 1730+ megawatt hours. So we do have a project that the steam generators for the boilers for the bourbon still is the vast majority of energy usage on that site, so the options are you can electrify. You can go with an electrode boiler, but at that emissions intensity, that is the dirtiest thing you could possibly do unless you immediately pair it with tens of megawatts of solar, which can be done. Another option is a traditional natural gas boiler method. Again, very carbon intense, especially if you use methane. Heat pump boilers, this is something that's been very common in the US. That was an option.

What we found using biogas with a traditional natural gas boiler was by far the best option. So a biogas digester is being placed onsite, and it's being fed from local agricultural waste products, essentially, and it generates its own natural gas onsite to feed the natural gas boilers. The reason it can be such a great thing is because all of that agricultural waste would otherwise be emitting methane directly to the atmosphere, so again this was a great solution in that case. All right, I'm out of time. I will go. Thank you, Kim.

Kim Trenbath: Thank you, Brian, so much for your presentation. It was extremely interesting and entertaining at the same time, but we do have to move on. I would like to introduce our second speaker, John Sasser. As Chief Technology Officer of Sabey Data Centers, John

Sasser is responsible for leading operations, designing construction, security, and IT systems for the company. Mr. Sasser has over 30 years of operations and engineering experience and has been with the Sabey Data Centers for over 19 years in roles of increasing responsibility. Prior to employment with Sabey, he served in various facility operations and management roles for Capital One, Disney, and the US Navy. Mr. Sasser graduated from Auburn University with a BS in civil engineering. I'll turn it over to John.

John Sasser: Thanks, Kim. Sabey Data Centers is a colocation company. We're headquartered in Seattle, Washington. This shows where some of our campuses are. I'm just going to tell you what a colocation data center company is real quickly because it's a business-to-business service, and a lot of people are not familiar with it. So Brian mentioned cloud companies. Cloud companies are large companies where they host their servers in their facilities and customers come in and use their servers. Another traditional practice is to have a company own its own servers and place it in their facility. A colocation company is one in which the customer buys the server and network equipment and then puts it in the colocation company's facility. We operate the facility, the customer operates their IT equipment, and it does offer some advantages.

So this is a shot of our campuses, and as you can see, they're fairly large facilities, and in most cases they're very specialized, intended primarily for the data center use. Some ancillary office and storage use, but really it's largely data halls and equipment use.

So I'm going to talk a little bit about data center processes. I included this very broadly, so the main process, of course, is the IT equipment. So we have computers, servers, we have storage equipment, and network equipment. On the facility side, we have three main categories. One is electrical losses. Brian mentioned transformers. We also have uninterruptable power supplies. Those condition the equipment and make sure that there's storage for any sort of brief interruption of power. We have cooling and humidity control. In data centers, it's really constant rejection of heat. You have very little heating required. The servers provide their own heat, so what you're trying to do is get it out of the facility so you're maintaining appropriate environmental conditions within those data halls. And then finally you have lighting and miscellaneous other loads within the data center.

So just to give you a sense of how those loads compare, power usage effectiveness is a very common measurement of data center facility efficiency. It's actually the inverse of efficiency. By definition, it's the total energy used in the building divided by the IT energy. So if you look at this pie chart here, the dark blue is the IT equipment. By definition, that's one. The next largest category typically is the cooling equipment, the HVAC, which in this 1.56 PUE data center, which is fairly typical across – on average across the industry, HVAC is probably 0.5. So about one-third of the total energy is HVAC, and about two-thirds is the IT equipment. Electrical losses is the next larges category, largely in the UPS that I mentioned, but still a fairly small category.

So I mentioned a PUE of 1.55 being industry average. That's according to the Uptime Institute. So Brian again touched on, hey, put it in a cloud facility. I'd also say another option is put it in a colocation facility. The cloud facilities are highly efficient, so I can't speak to the veracity of it, but I think it's credible to say that they are – they've published PUEs of less than 1.1, and in a lot of cases I think that's highly credible. They have some advantages. They work very closely with the server manufacturers to build their servers in certain ways, and often they have flexibility in how they condition those servers, so they may operate those servers at very high temperatures and high humidities, which many customers of ours would not allow. Still, in modern colocation facilities, an average annual PUE of 1.3 is very common, and we have some that are much more efficient. Our average PUE across our portfolio is 1.23, and we have some that are 1.15. There are other benefits of scale. You can usually achieve lower unitary costs, higher reliability, and more convenience. You don't have to operate your own data center.

So I'm going to talk a little bit about IT equipment best practices. And again, we don't own the IT equipment in our facilities. Our customers own that. But there are some fairly straightforward practices you can use not just in a colocation facility but in any facility to try to reduce that IT equipment load, which is again typically the largest load that you're going to have in a data center or computer closet or what have you. So the first – and I'd say arguably the most important – is to manage your server storage and applications. So Brian talked about vampire plug loads. Another load out there is zombie servers. So the zombie server is a server that's sitting there running but it's not actually doing anything useful.

The Uptime Institute again did a study on this some years ago and found that there's a significant number of applications where servers that are running an application, especially if it's not a virtualized server and the application is not actually being used. People just forget to turn them off. And so it's – one of the best practices is to actually manage those applications, understand what you're running, and when it's no longer needed, turn it off. Another is buy Energy Star servers. I think that's fairly straightforward. And then this goes along the lines of what Brian had mentioned before. A lot of times, power management is available on servers but it is disabled. So where possible, enable that power management. I think it's gotten a lot better than it used to be. Similar to your workstation where you want to turn it on and in the old days it wouldn't respond for some minutes, that has improved. And then Brian also covered virtualizing. I won't say any more about that, but you certainly should virtualize applications where possible.

I'm going to talk a little bit more about cooling. I know earlier in the deck, HVAC was not defined as a process load. I'm going to cover it here because I think there's some crossover between IT equipment and HVAC, and certainly given that it's really – it's different than comfort cooling. In a data center, really it's mostly about heat rejection and maintaining a stable environment. So there's a number of best practices to doing cooling in data centers. The first, and I'd say arguably the most important for air-cooled servers, is airflow management and containment. So you want to physically separate the cold air from the hot air, and what that allows you to do is a couple of things. One is it significantly reduces fan energy, and secondly it also extends economizer hours so the amount of time that you don't actually have to run the mechanical cooling because you're able to increase the discharge temperature of the air handlers. We'll cover that a little bit more in a later slide.

I mentioned economizers. So economizer, there are a lot of case – a lot of the time – and we have some facilities where we're running mechanical cooling less than 5 percent of the year just for those warmest temperature days, and you can achieve that especially in certain climates by use of various forms of economizer coolant. The third cooling is liquid cooling. So we're starting to see a lot of this on the data center side. Mostly a lot of conversations around that, although there are some, especially high-performance computing and crypto, that are actively in that liquid cooling space. It allows a lot of opportunities in terms of less fan energy use both for the facility and the server plus elevated temperatures. And finally I'm going to talk a little bit about mixed-use facilities.

This is a non-contained environment, really common around 2000 to call it 2010. At least in this case, you've got the hot air facing each other, but what you're going to see where that guy is standing is you're doing a lot of mixing of air, and what that means is you have to provide cooler air through that floor tile – very common to have it less than 60 degrees – and you're going to run more fan energy. By contrast, in this slide you see a contained environment where you're physically separating the cool air from the warm air, and that means that cool air, instead of being sub-60 is often above 70 degrees Fahrenheit, and you're using less fan energy, and it allows for, again, that higher economizer because since you're trying to achieve 70-some-odd-degree air, you can do – you can expand your economizer hours. This is just a couple of pictures of some of that containment, some pods.

And this is a shot of our facility in Quincy, Washington. Our PUE there is average annual less than 1.15. this is indirect evaporative cooling, which has three modes of cooling. When it's cold enough outside, we just cool via air-to-air heat exchanger, no water use, no mechanical refrigeration. When it warms up a bit, you have to evaporatively cool the outside air stream and again use that air-to-air heat exchanger, but you're not using any mechanical refrigeration. And it's only on the hottest summer afternoons where we actually turn on the mechanical refrigeration cooling. So again, that's one form of economizer. There's also direct outside air economizer, and there's water side economizer and refrigerant-based economizers, so there's a number of strategies to allow you to avoid using that mechanical cooling. Again, one way to think about economizer is opening the windows versus turning on that window air conditioning in a comfort cooling situation. If you're not running those compressors, you use a lot less energy.

This is some of the liquid cooling that I mentioned. This is an immersion-based liquid cooling. So in this case, the servers are actually submerged in a dielectric fluid, and so they have no server fans. The dielectric fluid rejects its heat via heat exchanger to a facility water loop, and then it's taken care of. This is direct to chip liquid cooling, so this is a little different. You see the tubes going into the servers. Those actually go to a cold plate right next to a CPU, and about 70 to 80 percent of the heat is rejected via the liquid with about 20 percent still rejected via air.

And then I mentioned mixed-use facilities. Brian had in his slide a heat pump. Another option is variable refrigerant flow. We've got to keep in mind in a mixed-use facility that you're always going to be cooling those computer spaces while you may be heating an office space, and this allows for some heat reuse within the facility. And that concludes my presentation and look forward to any questions. Thank you.

Kim Trenbath: Excellent. Thanks, John. We really appreciate your presentation. So now we have five minutes to have some questions and answers, and please type your questions in to the chat. I'm going to call Brian and John back up to the stage for them to answer some of the questions that have come through. So my first question is for Brian. You presented a lot of great ideas for reducing process load energy consumption. How should owners/operators of existing buildings identify and prioritize which process loads to target for reduction?

Brian Turner: Simplest way to answer that is probably use the 80/20 rule. How can we have the biggest effect with the least amount of effort? There are certain things that you can do to save energy on plug loads that are very difficult to implement and to keep working over time. There's some things like simply choosing laptops over desktop computers. That simple choice, it's made once, it sticks, it's durable, and has a large impact. So it's kind of like we always use the approach of follow the energy. We're going to follow the biggest pieces of the pie and go from there. Often, in our buildings at least, that is computing.

Kim Trenbath: Thanks, Brian. The next question is for John. How expensive are retrofits required for implementing cooling best practices on existing data centers? I have follow-up questions as well, but we'll start with there.

John Sasser: So obviously it depends on the size of the facility and that sort of thing. We've found, in a lot of cases, that especially if you don't own the facility, if you can think about migrating to a colocation facility, that it's going to be much more cost effective to simply migrate your servers to a colocation facility or migrate your application to a cloud facility rather than to try to update an existing facility to be more efficient. It tends to be a lot more cost-effective to build the facility efficiently to start with.

Kim Trenbath: And then two follow-up questions. Is this a cost-effective option for improving data center PUE?

John Sasser: Again, it's usually best to start new. I mean, we have done retrofits and made incremental improvements, but we still do operate some older facilities that operate at 1.6 to 1.8 PUE. If you start with a new one, it's sub-1.3 is not difficult to achieve.

Kim Trenbath: Thanks, John. And are there any other reduction strategies that are cost effective?

John Sasser: I'd encourage people to move to a newer colocation facility or the cloud.

Kim Trenbath: Great. Thank you. All right, another question for Brian. How does energy consumption of a laptop compare to a desktop when you add in a docking station and multiple external monitors?

Brian Turner: Still very favorable. The docking stations are going to use a little bit of power, but it's less than 10 watts generally. That can vary. Multiple monitors, if you want an entire wall of monitors, that will add up. They're 15 to 20 watts depending on size typically, but most typical applications, no matter how many monitors you use, reasonably a laptop's going to be a better option than a desktop approach.

Kim Trenbath: Thanks, Brian. I have another question for you, Brian. How does dryer exhaust heat recovery work? Is that an off-the-shelf product or does the mechanical engineer design it out?

Brian Turner: So there are a few updryers. Again, something that's been in Europe for decades and is now starting to get some traction in the US over the last couple years. Typically updryers are ventless, so you automatically get the heat recovery because their exhaust leaves the space with a little extra filtration. So that's one option that is off the shelf. Beyond that, really doing heat recovery on dryer exhaust probably doesn't make sense until you get to a bit of scale. So we've done projects, particularly testing facilities, that have dozens of dryers running and exhausting to common exhausts. And in that case, basically a runaround loop or a heat recovery coil in that exhaust. Again, you have to make sure that it doesn't immediately get full of lint, so there's some extra filtration steps that are required to make that practical and sustainable, but there's enormous amount of heat that can be recovered that can be used elsewhere in that scenario.

Kim Trenbath: Thank you. And I have one more question for Brian cause he has one more minute. Do you ever experience pushback from clients when recommending these process load reduction strategies? How do you overcome it?

Brian Turner: You get in early and you have targeted charettes and meetings that are going to chew on those topics. You get the right stakeholders in the room. You bring in the IT department leader to explain what they're doing. They might already be doing a lot of these things. Food service, choose food service designers that are – there are a lot of great food service designers that are well versed at low-energy kitchen design, but honestly that's probably 20 percent of them if that. So who you choose to work with and how receptive they are to these sort of ideas that come from an engineer or not staying in our lane, that often is just the willingness to try something new is our experience.

Kim Trenbath: Excellent. Thanks, Brian. Thanks, John. Thank you both for your excellent presentation. It's the top of the hour so now I'd like to wrap up the call. Thank you very much to all those who attended. If you have any additional questions, feel free to e-mail me. My e-mail is right there. And at any time, if you're interested in learning more about PPLs, come and join our – go to the PPL website online, and we'll send out these slides – a link to these slides a couple days after this call. Thank you all.

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