Kim Trenbath: Hello, everyone. I'm Kim Trenbath. I am the Group Manager of Communities and Urban Sciences Research at the National Renewable Energy Laboratory. Welcome to the Plug and Process Loads Technology Research Team webinar. This webinar is on "Looking to the Future: Advancing Commercial Building Plug and Process Load Efficiency and Control."

I'll be introducing Amy Van ant a little bit later. And I also want to say that we're getting started right away. As you've heard, the webinar is being recorded. The recording is going to be available on the Better Buildings Solutions Center after the webinar. Give us a couple days for that. And then, also, our slides are going to be available as well. If you have any questions, please type them into the Q&A box. We are going to answer them at the end of the webinar. Next.

We have a great agenda for us today. First, Amy Van Sant is going to give the update for the Plug and Process Loads Technology Research Team. We haven't had one of these webinars in about a year, so we are excited to give you this update. And then, Amy is also going to present on pathways to plug load efficiency and control.

Our next technical presenter is Harold Jepsen from Legrand and he'll be talking about automatic receptacle controls, some of the codes around them, as well as how they can help your building save you energy.

And then, finally, Michael Myer from Pacific Northwest National Laboratory is going to talk about the consistency for automatic receptacle control markets.

After that, we'll have some questions and answers. So, again, if you have questions, please type them into the chat. And Omkar Ghatpande from the NREL team is going to facilitate the Q&A session at the end. Next.

I'm pleased to introduce to everyone the Plug and Process Loads Technology Research Team. There's four of us. I've been the lead for many years and I'm pleased to hand over the lead officially to Amy Van Sant today. Actually, Amy has been in the lead for the PPL team over the past year but we haven't had one of these TRT calls in a long time, so I'm officially making the handoff on the webinar today so that it can get stamped in our webinar history, this handoff.

Other people part of our team is Omkar Ghatpande, our Research Engineer, and Robin Tuttle, our Stakeholder Engagement Manager. You can reach all of us at PPL@NREL.gov.

More on handing off the TRT lead role to Amy: Amy has been part of the PPL team for about five years. She's been leading it for the past year. She works on research related to plug and process loads as well miscellaneous electrical loads. And she also works on work on stock modeling, so one of her recent projects is working on integrating the plug and process loads into our stock modeling efforts.

At this point I'm going to hand it over to Amy to go over the PPL team updates. Thank you.

Amy Van Sant: Great. Thank you, Kim, for the introduction. Hi, everybody. Looking forward to leading this team and looking forward to Kim's continued involvement and contributions on the team.

So, next I will provide a brief update on recent PPL team activities and resources. Next slide, please.

As a reminder, all of our resources and recorded webinars are available on our website on the Better Building Solutions Center. The QR code on the bottom left here will take you to our site. We also have the URL included on the bottom of the slide. Next slide, please.

Speaking of recorded webinars, all of our TRT webinars are recorded and the recordings and slides are posted on our website for on-demand viewing. I've highlighted a couple of our more recent webinars here that are available, one featuring a plug load case study and the other focusing on reduction strategies for larger plug and process loads. But we also have a new report available with findings from our recent study, Pathways to Plug and Process Load Efficiency and Control. I will be presenting this study in a few minutes but we encourage you to check out the report as well. Next slide.

One of our recent research focuses has been medical imaging equipment energy efficiency. We have a couple new resources and reports available on the topic for you all. First, we recently updated our medical imaging equipment energy efficiency fact sheet, linked here at the top. This fact sheet now includes information about why you should meter medical imaging equipment in your facility and how to set up metering, procure equipment to answer

questions around energy consumption of medical imaging equipment in your health care facility.

We also co-published a journal article on the topic of characterizing the energy consumption of MRI systems. And lastly, our team member Omkar Ghatpande presented on a webinar on the topic of medical imaging equipment energy efficiency and metering. The recording is available on the link at the bottom of the slide. Next slide, please.

All right. So, that wraps up our team updates. Next we will move on to the technical presentation portion of the webinar. Next slide.

And then, one more. Thank you. I will be kicking things off with a presentation on "Approaches to Achieving Plug and Process Load Efficiency and Control in Commercial Buildings." Next slide.

So, most of you are probably familiar, but just a refresher, plug and process loads, or PPLs, are plug-in and hardwired loads that are not associated with other major building end uses, like lighting or HVAC. We have some examples here on the screen. You can see that they include a wide range of devices and appliances that have varying levels of energy consumption. We have maybe relatively small consumers like coffeemakers, computer monitors, laptops, all the way up to commercial kitchen and laundry equipment and internal transportation like elevators and escalators. There can be hundreds to thousands of individual plug and process loads in a commercial building and their energy use really adds up. Next.

In 2018 plug and process loads accounted for 28 percent of commercial building energy use in the US. We have not seen widespread adoption of efficiency and control technologies and a large part of this is that PPLs are a relatively challenging end use to manage. We've already talked about the volume of individual devices that can be in an individual commercial building. The breadth of types of devices and appliances makes one-size-fits-all strategies often difficult to implement. And then, they're also highly occupant-dependent. So, we see a lot of these devices and appliances being integral to the daily operations of a building and the job function of occupants. To date, there has been little information about what factors influence the adoption of PPL efficiency and control, and so we conducted this study to help address that gap and maybe learn a little bit more about it. Next slide.

So, our methods are summarized here. We really just – our main method was just engaging with stakeholders. We conducted one-on-one interviews and then also hosted a workshop with members of the smart buildings industry. You can see the table on the right, a summary of the participants that we spoke with by category. So, we really covered a broad range of categories and folks that we talked to. We used standardized questions when we were speaking with the stakeholders, the study participants, so as to not influence their responses. Next slide.

These are some examples of questions that we asked. We would ask general questions: How would you reduce the energy use of your PPLs? Are you implementing any of these strategies now? Why or why not? And then, also would ask participant category-specific questions. So, these two here are for the design engineer participant category, to ask what PPL reduction strategies or technologies have been implemented in the buildings you have designed? What is preventing design engineers from reducing a building's plug and process load energy? Next slide.

So, in each of the interviews in the workshop we would generally have one team member asking questions facilitating discussion and then another one taking notes. We took these paraphrased quotes from the notes that we took in these discussions and then through an iterative process categorized the quotes by a theme and subtheme and then also categorized whether the speaker was talking, indicating a driver or barrier to PPL efficiency and control. So, you can see a little snippet of the data there on the right.

And then, we took – once categorized, we took the data and analyzed it by grouping. So, we looked at things like drivers and barriers by theme and subtheme, and then theme and subtheme by participant category. Next slide.

So, I'll dig into a bit of the results now. Next slide.

All right. To start with the drivers: So, this is a bar chart showing the theme and subtheme categories on the left and then the bars indicate the number of mentions for each of these themes and subthemes from those quotes. So, a couple things I want to draw your attention to. One is that building energy codes were the most mentioned driver to PPL efficiency and control. We heard from a number of stakeholders that this was very important for the implementation of control technologies and strategies in commercial buildings.

And then, another key finding is that company goals, especially environmental, social, and governance goals, were a common driver. We heard from participants that companies with clear messaging from leadership about the importance of energy efficiency and sustainability had more success with implementation of PPL reduction strategies and control technologies. Next slide.

Now moving on to the barriers, we have a similar chart here breaking down the theme and subtheme by number of mentions. Some key findings here: One is around awareness. When we're thinking about this in terms of barriers, we're thinking of a lack of awareness. Decision-makers and occupants were the two categories that stakeholders mentioned, decision-makers being people like building owners or facility managers, and then occupants, obviously occupants of the building. So, awareness here being awareness of how much energy plug and process loads consume and why it may be important to address them, understanding what solutions or strategies may already exist out there, and then once installed, how do you interact with the system? How do you contribute to the reduction strategy for energy savings?

A lack of data was also cited as a common barrier, financial data here being return on investment, cost savings, energy savings data from different measures, and then also technical data, which we heard from quite a few design engineers about wanting more information regarding how much energy consumption plug loads are consuming today. What's the device count by type or building type? So, that was another key finding.

And then, lastly here under occupant behavior, without proper implementation occupant pushback can be a barrier. And so, engagement and education of occupants is important. Next slide.

So, we took these drivers and barriers and created five pathways towards greater PPL efficiency and control. The first one involves increasing funding opportunities, specifically some examples include incentives and rebate programs. The second is increasing available case studies and disseminating best practices across the industry. The third is compiling baseline consumption data for PPLs across the whole US commercial building stock. The next is – involves including – continuing to include PPL monitoring and reduction measures in commercial building energy codes. And then, promoting adoption of company goals within companies across the US. Next slide.

All right. So, we have these pathways. Now, how can we start thinking about them? What are ways or approaches that we can take to start achieving these pathways? Next slide.

So, we'll start with the funding pathway. A lot of these approaches involve engagement and promoting awareness of PPL efficiency and control measures. So, here we discuss engaging utilities to showcase potential energy savings and grid interactive capabilities of plug and process load technologies. And then, also engaging them to perhaps include efficiency and control incentives around PPLs. We also mention promoting awareness of these efficiency and control strategies in technologies to REEOs, SEOs, and NASEO, and also with ESCOs. Next slide.

The case studies, we kind of have a two-pronged approach here, the first of which is facilitating implementation so that you have case studies to write about. So, we mention here providing technical assistance to building owners who are interested in controlling and reducing their PPL energy use. Creating a technology campaign or challenge for PPL efficiency and control would be another strategy to increase implementation. And then, of course, there are building owners certainly who are already implementing this in their buildings, so identifying them and collaborating with them to develop case studies.

Once case studies are written, you want to make sure that there's a central location that these can be hosted at so that they're easy to find and then disseminate them, especially to high-potential sectors. We find often K-12 and higher education have high potential for savings in this end use. And then, kind of tying back to the funding pathway, building relationships with organizations that can provide funding can also help with generating case studies. Next slide, please.

All right. On the data front a good first step is to identify the most impactful data. So, what are stakeholders missing? We heard from design engineers that maybe some baseline energy consumption can be helpful. What scale, how much of it do they need? That's an important step. And then, similar to case studies, creating a central location to host all the data will be important, as well as establishing standardized data collection and reporting protocols to make sure that high-quality data is being collected and it's in a similar format so that it can be aggregated easily.

Increasing PPL metering in buildings will be important so you can contribute to the database. Determine data collection sources, building submeters, perhaps device-level meter manufacturers and energy auditors, or third party data providers such as ENERGY STAR Portfolio Manager are some ideas. And then, encourage owner participation to share the data. Next slide.

Energy codes. So, kind of tying back to the case study piece, creating case studies for code-required PPL control technologies can really help get buy-in from designers and building operators as well as codes and standards organization to show the value of these technologies and strategies so that they will hopefully continue to be included in the building energy codes. And then, informing code requirements through research, we're going to have a great presentation by Michael Myer in a bit about some of that research. Next slide.

All right. For company goals, one approach is to communicate the needs for these goals during leader summits. We know peer sharing and friendly competition can encourage the adoption of energy efficiency strategies. Companies often draw on – from each other's trends to stay competitive, so having PPLs as part of that conversation could be a useful approach. Sample language can make it easy for companies to include PPL efficiency and control into their strategy or plan. Green building certification is another approach to promoting adoption of PPL efficiency and control measures. And then, lastly, monetizing ESG goals implemented into companies and buildings is another approach in this area. Next slide.

There are two additional pathways that we thought were important but were not directly mentioned by the participants, one of which is to train the workforce and making sure contractors and folks know how to assess, reduce, and install control technologies. Reduction strategies will be an important aspect for adoption. And then, also interoperability. We know this is very important for building energy management systems and making sure plug load controls are interoperable will be important going forward. Next slide.

All right. So, to close out, PPLs can provide energy and cost savings and emissions reductions through efficiency and control technologies. We have not seen widespread uptake but these approaches offer a starting point toward greater PPL efficiency and control adoption. Next slide.

Thank you so much for your attention. As a reminder, if you have questions, please enter them using the Q&A function and we'll answer all your questions at the end of the presentations. Next slide.

I am pleased to introduce our next presenter, Harold Jepsen. Harold is the Vice President of Standards and Industry Relations for Legrand's Building Controls and Lighting Divisions. A 30-year veteran in the energy, lighting, and building automation industry, he is a licensed electrical engineer and WELL-AP. Harold serves on various committees within NEMA, ASHRAE, IES, and IECC, and other organizations involved in lighting and energy efficiency. Welcome, Harold. I will hand it over to you.

Harold Jepsen: Thanks, Amy. It's good to be here with you today. And I want to be able to share a few things about what the electrical industry has been doing as well as some parts about what the energy efficiency codes have to say about automatic receptacle controls.

And so, I'll start off with just a little bit of clarification here because we use different terminology for what we call automatic receptacle controls. And automatic receptacle controls is actually the technical term that you'll hear in the model codes and standards that are out there, but we also will refer to them as receptacle control, controlled receptacle. I think plug load controls is a broader – kind of a broader group of types of controls that can control plug loads. I think largely what I'm going to talk about specifically are the – those receptacle that can turn on and off and therefore things that are plugged into them will turn on and off. So, that's what I'll go to specifically here. Next slide.

So, a few years ago some industry colleagues and I penned this little article about plug loads and receptacles. And maybe an analogy that each receptacle in a building is an outlet to receive electrical power, essentially an electrical faucet that you can tap power from. Yet, many of these devices we plug in continue to use power whether they are needed or not at that given point in time. And so, electrical receptacles can become leaky energy faucets, if you will. This is where the automatic receptacle controls come in because they turn off power to the receptacles automatically when people no longer need them inside that room or space. Next slide.

Today, automatic receptacle controls are required at many commercial building construction projects. And as Amy mentioned, one of the major drivers of that are the energy efficiency codes and standards that are out there. Automatic

receptacle controls were first introduced into the ASHRAE 90.1 2010 standard. And being that ASHRAE 90.1 is the federal building energy efficiency standard, construction of federal buildings typically require automatic receptacle controls because of ASHRAE 90.1 requirements. Later on, California and other codes, the IECC have adopted automatic receptacle control requirements. It's also required in LEED because to qualify for LEED a prerequisite for that is to follow the ASHRAE 90.1 standard.

So, we are seeing sporadic adoption throughout the country. This map here is – really doesn't show adoption. What is shows is the stringency of codes throughout the United States with the greenest being the most stringent adopted. And typically, those greener states are the ones where you will see automatic receptacle controls inside the energy efficiency codes that they have adopted. So, next slide.

What are the study benefits of automatic receptacle controls? Well, over the last 10 to 15 years a number of studies have been done to demonstrate the energy savings and the viability of controlling plug loads using automatic receptacle controls. The center study itself was one that supported automatic receptacle control requirements going into California's Title 24 standard over 10 years ago. Next study – I'm sorry, next slide.

These studies largely demonstrate that the energy savings from automatic receptacle controls range from about 19 to 26 percent based on various factors which they studied. Next.

What these controls look like and what's available on the market today for installation in commercial buildings – let's take a look at those. With the first coded option of automatic receptacle controls happening in 2010 a lot of products from a lot of manufacturers have come onto the marketplace in order to support controlling receptacles. What you see here are typically what users will see, and that's the receptacles where things are plugged in. They are marked according to a national electrical code marking requirement. I think Michael will articulate more on that and from some of the study work that he will share with us. These receptacles can be wired or also, like you see with the product on the right side, that's a wireless device that receives a signal to turn on and off the receptacle based on either operational times in the building or maybe by occupancy detection inside of a space where that receptacle exists. Next slide.

Some receptacles have timers built into them like this one, these two you see here on the left side. And another common device is a controllable plug strip. However – next slide – the controllable plug strips, although oftentimes are very good for reducing and shutting off plug loads, they are not code-compliant because they are not permanently connected the building. So, the codes themselves can only have jurisdiction over those things which are permanently installed. Next slide.

Other components that you will find in the ecosystem of automatic receptacle controls are the occupancy sensors that are detecting and will signal when a room becomes unoccupied. Or maybe a time switch, which can be scheduled for when a building is closed or not operating so that receptacles can be turned off. You may also have wall switches as part of that, so that during times when maybe a time control has shut off the automatic receptacles that someone can override them manually through the switch. These could be the same and – one and the same switch as the lighting itself. Next slide.

Other controls that support automatic receptacle controls. Some are more hidden, like these distributed room controllers. These are the devices that actually are turning the power on and off that's wired to those branch circuits. Or it may be done at a centralized panel which may be located back in an electrical room. Next.

So, what are we doing to help owners and building designers, contractors, and end users better understand the use of automatic receptacle controls? Well, I'm part of a small task force within the electrical industry. We are supported by the National Electrical Manufacturers Association, often called NEMA. You may be familiar with some NEMA standards, electrical standards that are out there in the marketplace.

Well – next slide – we've been busy creating a number of things and with some great collaborative help from the Department of Energy's Better Building Plug and Process Load Team have a number of fact sheets, white papers, and guides which are available for free download through the NEMA wiring device white paper webpage. And so, there's a link here. I know you can't access that now but it will be part of the presentation if you decide to download it, or you can just Google "NEMA wiring device white papers" and this page will come up. So, let me walk you through these – several of these guides which we have. Next slide, please.

This one here is our first publication. It's really directed toward building and electrical design professionals. It's a NEMA white paper. It has a big number of BI 50002. It was created in 2022. But what this paper has and outlines and – it focuses on how automatic receptacle controls are required in the energy codes. It provides an overview of their use, their benefits, and it largely – the main piece is that it's really good design guidance on how to apply and comply with the code requirements in a building's electrical design.

Next is – this is a short automatic receptacle control fact sheet. This was done by and produced by NREL's PPL team. The NEMA task force provided some input to it. It's meant largely for those who are considering adopting energy code requirements or who might influence energy code adoption. And this provides a brief overview of what automatic receptacle controls and why they are important in the energy efficiency codes.

Okay. Next.

This is a compliance and inspection guide for building officials. It's a simple two-pager. It gives an overview of automatic receptacle control code requirements, how to inspect for them, and a number of further references helpful for the building officials, their departments, and inspectors as they go on to projects that have or are reviewing plans with automatic receptacle controls as part of that. Next.

This one really is to address what Amy mentioned about the importance of the engagement and behavior of users inside of the buildings. This is an end user guide. It's a simple one-page. It's designed to inform end users what automatic receptacle controls do, how to identify them, and what should or should not be plugged into a controlled receptacle. Next one.

This one here is not quite out yet but it – this is the latest one that we've created. This is really what Amy talked about, showing the value, that's what this guide is intended to do, is it speaks directly to building owners and designers about the energy saving benefits of automatic receptacle controls. It talks to the value proposition, how they work, how to apply them generally, and is loaded with references for them so that they can understand even better how to deploy them inside their building and their benefit that they provide. Next.

So, I thought what might be kind of nice is to take a little look at how these things are actually applied inside of a building. And so,

let's take a look at it in a design. This is basically from the electrical plans – this is a layout of a classroom, if you will. Go ahead and click. And so, what you see here circled in green are the receptacles inside the room. In the energy codes automatic receptacle controls are required in certain building spaces. A classroom would be one of those space types. And so, what you would expect to see here are controlled receptacles that have the control marking on them installed here. Typically, there would be a controlled receptacle and an uncontrolled receptacle, both in either the same duplex outlet or maybe side to side. Go ahead and click again.

What's actually controlling these is this plug load controller. This is showing one that would be mounted maybe up in the ceiling or somewhere out inside the space. If you notice the blue diamond there, there are some other blue diamonds there as well, those are actually the load controllers for the lighting. And so, if – in this particular method of installation, the control of the automatic receptacle controls is combined with the control of the lightning inside the space. So, next slide.

And you can directly see that, that these occupancy sensors that are located in the center of the classroom and are detecting when the space becomes vacant, those are the same sensors that are doing the lighting shutoff and then additionally will shut off the receptacles which are controlled inside the space. So, there's a good benefit to do that. Tying those together is a great cost benefit.

So, back up to – my next slide there is the last. This is kind of my wrap up. And so, my general summary here is that energy codes call them automatic receptacle controls, although there's other terminology that's out there. There have been quite a few reports and studies done to demonstrate the energy savings that come from automatic receptacle controls. We are seeing them increasingly used in buildings as they come online and are complying with the newer energy codes that have these requirements in them. There are many readily available products and ways to install them inside of buildings. So, leave the preference up to the designers to decide what works best for any given building design. We invite you all to access that NEMA wiring device white paper webpage and take advantage of the resources that are there.

And lastly, what I want to say is let's all work together here to stop the leaky electrical faucet in commercial buildings, and automatic receptacle controls is a great way to be able to help do that. So, with that, that wraps up my section. Back to you, Amy.

Amy Van Sant: Great. Thank you, Harold, for your great presentation. As a reminder, please enter questions for Harold using the Q&A function and we will answer all questions at the end. Next slide, please.

I'm pleased to introduce our next presenter, Michael Myer. Michael is a senior researcher at Pacific Northwest National Laboratory. Michael's work at PNNL focuses on decarbonizing commercial buildings via a combination of market transformation activities. Experience from a field evaluation of automatic receptacle controls and Michael's work on energy codes prompted research into user behavior of automatic receptacle controls. Welcome, Michael. I will hand it over to you.

Michael Myer: Thank you, Amy. Next slide, please.

And just recapping what Amy mentioned, we'll be talking about user behavior. And next slide, please.

We've alluded to this a little bit. There's been a low use of plug load control. So, this is a graph from CBECS, which is the Commercial Building Energy Consumption Survey, from 2018 showing different measures that are typical. The ones that I've highlighted here in the two red arrows are lighting occupancy sensors and scheduling. The reason why is those kind of function similar to how automatic receptacle controls would be. They would turn off when a space is unoccupied. And they have pretty good exception penetration. However, plug load control is very low at the bottom. And so, that's just kind of a reminder that it's still not being picked up by the industry. And we tried to explore some of those reasons and ultimately wanted to move into why the behavior of users are. Next slide, please.

So, one of the things we did is a visual-based survey. We use what's called Amazon Mechanical Turk. This is a service that Amazon offers where people can sign up and be compensated to do surveys. And we gave them a visual-based survey of different images. You can see the nine different devices that we showed them. And there we asked them – essentially, they were given two different receptacles, ne that's always on, which is the typical receptacle most people are familiar with, and then what we would call the automatic receptacle control. And we asked them for the nine devices which receptacle would they choose to power their devices. The brown or gold color here is the ARC. And you can see for the most part about 47 to 61 percent or an average of about

50 percent of the responses, people would use the ARC. And we asked a variety of other demographic questions and a majority of these people were focused on saving energy in their spaces. So, that kind of – it helps, but ultimately it didn't matter who responded. It was about 50 percent of the responses would use an ARC. So, that's somewhat helpful. It's good to know that they're considering them and that number could be much worse. So, it's helpful to see these percentages. Next slide, please.

We then asked them a second question. So, our first question gave them no information about it, just a simple device – a picture and a name. So, in this case, a laptop and that. Then we did a second round of questions where we gave them information about the devices to see if that would affect their choice. Would the power drawn by the table lamp, either at nine watts or 40 watts, would that affect their choice? Would maybe the startup time of a printer – we thought that might affect their choice. Again, we explained to them ahead of time that these would turn off once the space was occupied and they turn on before the space was occupied again, trying to set some of those tones. So, we gave them this more information and asked them again the same set of questions: Which device would you use? Next slide, please.

So, in this slide, you'll see a series of examples. So, in this case, we asked about startup time and we only isolated three devices with startup time. We had the laptop, the personal printer, and then the network printer. Here, always on is red; the black is the automatic receptacle control. The results are a little mixed. What you see is that depending on which device, they didn't change too much from the no information situation to the other options, but they varied. So, for instance, when they were given no information about the laptop, 56 percent of the people opted for the ARC. When they saw it was a short startup time of 15 seconds, it went down. And then, when it was a longer startup time of 44 seconds, it went down further. So, you might have this idea of, oh, well, as startup time increased, maybe fewer people or a lower percentage would select the ARC.

However, when you look at the personal printer, the logic is completely opposite. You can see that they progress. And in fact, when you look at the network printer, we see the – kind of the most contradictory evidence there, that as it gets to the longest startup time, more people selected for the ARC. So, the key takeaway here really was – and these results were similar for whatever information we provided, whether it be startup time, energy savings mode, or power. The results were, I would say,

somewhat inconclusive or muddled. And that's actually helpful. That really tells us that they're still going to be pretty consistent in their choices, whether or not they know a lot of information about the device, or they know nothing about the device. And the reason we ask that, again, is that maybe when people are plugging things in, they may not be thinking about these things or know where to find this information. And so, it was very helpful to see that the results were pretty consistent, regardless of what information we gave them. Next slide, please.

So, overall takeaway here is that, again, we asked them a couple of questions ahead of time about their demographics and we found about 50 percent of our user base who took our survey considered themselves concerned or very concerned about their energy usage. Of the entire population, so people who were not concerned at all, to mildly concerned, to very concerned, of that entire population, 50 percent would consider using an ARC. So, that's helpful, knowing that it really doesn't matter if you're super concerned or not concerned at all, people are going to consistently appear to use ARC – choose to use an ARC for the different devices. Also, a nice takeaway here is that information did not really affect their choice. And that's helpful because a lot of this information is not readily available when they're choosing to plug something in. So, these are pretty good takeaways from this survey. Next slide, please.

We also did another type of visual-based survey. Again, same process with the Amazon Mechanical Turk. As Harold mentioned, these are all receptacles that are covered by the National Electric Code. All the National Electric Code says when you have an automatic receptacle control is that it has to be labeled with the word "control" and it has to have that power symbol, which is the circle with a line through it. It doesn't say anything else about either color, contrast, other markings.

So, you can see a wide range of – these are all commercially available receptacles. You can see in – the third one in the top row, third one from the top left, the contrast there is rather low. It does say "controlled" and show the power symbol. Similarly, the second from the right just shows – actually, that's an embossed power symbol. So, you can see a range. And then in some cases, they have dashes or borders around them. So, we use this as a – what's all available on the market. Next slide.

And we then showed them side-by-side versions of the cartoon versions down below. So, we created a generic version so that the

survey respondents saw identical versions of every option they could have and then we actually ranked them side by side and said which one was more obvious, which one was the single ARC? And in this case, single ARC just means that one of the two receptacles is controlled. You can see the overwhelming results is option F. In this case, that is a receptacle with a border around the controlled receptacle. The word "controlled "is written horizontally, and you have the power symbol. And then you can see G and H with similar results – again, the border, but in this case, the word "controlled" is oriented vertically.

What the interesting takeaway from this is, is that if you compare letters A and letters F, they are the same in that the word "controlled" is in the same orientation and the power symbol is in the same spot. However, fewer people selected A as more obvious. Similarly, if you compare B and G and C and H, same thing, where the word "controlled" is in the same orientation and the power symbol is in the same place; however, C and H – I'm sorry, G and H have that border, whereas B and C don't have that border. Overwhelming, what this tells us is that the respondents liked the border as well as where the words were located, compared to, say, D, where the word "controlled" and the power symbol was between the two receptacles.

So, the takeaway is while the NDC says it has to say the word "controlled" and have the power symbol, the border was a helpful thing. And we've tried to share this with manufacturers and others, because while the NDC does not require this, it does show that respondents found it more obvious and that was the preferred market. Overwhelmingly, they also liked high contrast. We don't include that example here, but about 75 percent of all respondents like the high-contrast versus the low-contrast options. Next slide, please.

So, then – oh, this is the contrast option that I was just mentioning. I got ahead of myself. My apologies. So, you can see the two. Both of these are side by side. The low contrast on the right, it does say the word "controlled" there, but it's only about a 30 percent contrast. So, it's a little hard to see, and that's understanding why they like the high-contrast option. Next slide, please.

So, then we did – so, takeaways there, again, are contrast is critical and receptacles with borders. Those were the preferred options. Next slide, please.

So, while we were doing a field evaluation, we noticed that there's a lot of similar looking receptacles out there. So, in this example, the two on the left, the one furthest on the left is a controlled receptacle. The one in the center is what's called the GFCI. These are near water. They have a quick fault if there's an issue for safety reasons. However, if you look at the two of them, they both have LED lights in similar locations. They both have a center button and those type of things. In fact, we actually were asking one of our measurement team to take some photos for us, and they actually captured the center photo, thinking it was one of the receptacles, and that's how we discovered, oh, maybe there's some confusion out there.

Similarly, the image on the right, that's what's called a quad box. So, there's four receptacles there. The two on the right, that's called the D style, what you might see typically in your house. The one on the left is the controlled receptacle. In this case, the top one is the controlled receptacle. But the example here is that when you're given the option of four receptacles side by side, how easy would respondents be able to identify the correct receptacle? So, that's what we did in our survey. Next slide, please.

So, we came up with a number of different options you might see out in the wild, as we say, or in reality: a standard one, a tamper-resistant version, a hospital grade – these have a green circle on them, isolated ground – these have an orange triangle, and then the GFCI, which has the test buttons. So, these are all receptacles that are very common, that can be found in different applications, and then we showed them the different options from that previous survey about markings to compare them to. Next slide, please.

So, this is where we get into some results. About a third of users could correctly identify the ARC. And what that means is that in the top two left images, we asked them "Of these options, A, B, C, and D, being top, bottom left, and C being top right, and D being bottom right, and then E, none of the above, which one is the controlled receptacle?" So, when they were comparing the two left images, the only option they could pick in this case that would be correct is A. So, overwhelming, you see what the response was, was about 39 percent of people could find it when we actually told them.

So, we did two versions of the survey. Survey one, we just showed them the two side-by-side images, and then in survey two, we said the controlled receptacle will say the word "controlled" on it, it will have the power symbol, so they were knowing what to look

for. And you can see when we gave them that information in the B survey, they only did marginally better most of the time. So, the takeaway here is that when they're given multiple receptacles, which is what they would experience in reality, only about a third of the time could they identify which of the options was the controlled receptacle. Next slide, please.

So, the takeaway there is when using the highest rating – so, this was the receptacle from our marketing survey that people liked the most, we only got about a third, 32 to 39 percent of surveys to be able to correctly identify it when compared to other ones. And then, again, that marginally only improved when we told you ahead of time it would be controlled. Now, that's not helpful that it only marginally improved because you may not have someone in your office or your school telling you "Hey, the controlled receptacle is going to say the word 'controlled.'" You may have to have an information sheet that you at least know to look at, but when we're going to plug things in, we may forget or they may not have it in the right location. So, it's important to understand that while it's helpful and it does improve people knowing that it's controlled, it did not significantly change the results. Next slide.

So, when you combine all these, we know that users are the critical point in this. They are the ones who are choosing which devices to plug in. They are the ones who are also choosing which receptacles they're going to plug that device into. So, user behavior is critical here. But as we talked about in the first survey, that 50 percent of our respondent base, over 100 people, chose the ARC. And then in our third survey, we showed only 33 percent of them could correctly identify the ARC.

So, when you combine the 50 percent to the – and the 33 percent, it suggests that about a 17 percent success rate from ARCs. And a lot of that stems from, again, user behavior. And that 17 percent is a high number because we know that 33 percent came from using the best marked receptacle. And we know there's a number of different receptacle options out there, so, that number could be even lower. Our recommendations are better ARC markings, consistent ARC markings. One of the challenges is that an ARC and a switched plug strip don't always have the same markings, and that might cause some user confusion. We'd also like to encourage maybe some use of color to help reinforce that. Standardization might be a way to help users, so they always knew the top one was the controlled one. And then, also possibly

consider how energy codes could make some changes as well. Next slide, please.

And I now turn it back to the entire team.

Amy Van Sant: Thank you, Michael, for your presentation. Really appreciate both you and Harold being here today. So, next we will move to the Q&A portion of the webinar. Again, please enter questions for any of the presenters using the Q&A function. And I'll hand it over to Omkar to facilitate.

Omkar Ghatpande: Thanks, Amy. Yeah, I would like to take a moment to express gratitude to today's presenters for their insightful and engaging presentations on the future of commercial building plug and process load efficiency and control. Thanks for sharing your valuable knowledge with us today. On to the first question to Amy: "Where should I start if I want to reduce plug and process load energy in my buildings?"

Amy Van Sant: Yeah, great question. Really, starting with assessing what plug and process loads already exist. So, doing a walkthrough and an inventory, looking at both device type and then also the quantity can help you identify strategies for reduction and maybe high energy users as well. It's also important to establish a plug and process load champion. So, this would be the person that can help initiate reduction measures, energy efficiency strategies and help with the process of any procurement, getting buy-in from leadership, and then also ensuring success of the implementation throughout its life and making sure that building occupants are getting educated and then that they continue to get educated as new folks enter the building.

Omkar Ghatpande: Thanks, Amy. Now on to the second question to Harold. "What can energy codes do to encourage more plug load controls in buildings?"

Harold Jepsen: Well, I mean, I think overall energy codes have already done a lot. But as you could – you saw from Michael's chart, we know that from Amy's side it's a driver, but from Michael's chart there's not a lot of knowledge about them. We're not – we don't have the familiarity out there. And so, I don't think it's so much that the energy codes need to do more. I think if what is in the energy codes is applied inside buildings and if we do a better job of educating the end users, the people that are – the facility managers in buildings about them, and what things should be plugged into them, that would go an awful long way. So, I'm not so sure that

updating and making it more stringent, because I think the code already has some really good requirements today. So…

Omkar Ghatpande: Thanks. Thanks, Harold. I'll move on to the next question to Michael. "Related to the behavioral study, do any of your studies show that competitions between groups' floor organizations have an impact on plug and process load?"

Michael Myer: I'm going to repeat what I heard. Related to the behavioral, was that competition was the question?

Omkar Ghatpande: Sorry, I think I mixed up the two questions. So, let me repeat the question. There are two separate questions. I'll go on to the second one later. But related to the behavioral study, did the study ask users about their role within their organization in terms of leadership, entry level, middle, or senior level? Or did the study ask about individuals' age demographics?

Michael Myer: We did ask age demographics question. We also asked questions about how many hours of the week – how often do they typically work in an office place setting? We also suggested, regardless of that number, please assume you're working in an office for this many hours a week. We did not ask what their role was within their organization. It's an interesting question to see how that would have affected our results.

Omkar Ghatpande: Thanks, Michael. Now on to the next question to Amy. "Do you have any studies showing that competitions between groups' floor organizations have an impact on plug and process loads?"

Amy Van Sant: Yeah, another great question. We have seen studies using gamification. So, competitions, oftentimes this involves an app where the user can actively engage with the challenge or competition for reducing plug load energy in their building or their space. I don't have numbers off the top of my head for what the savings were, but I knew that there were savings that were achieved. So, yeah, that is definitely a strategy, again, speaking to the importance of occupant engagement in the space.

Omkar Ghatpande: Thanks, Amy. Now on to the question to Harold. "You mentioned some of the materials in your presentation. So, how will NEMA communication materials be shared and where can we get that material?"

Harold Jepsen: Yeah, so the NEMA wiring device web page – and a wiring device is what we consider in the electrical industry is like a plug. It's like

a switch. It's those things that we tend to interact with. They have a web page. And if you just type in Google, "NEMA wiring device, white papers" is the web page that those are actually located. You can just download them for free there. There's that. There's a couple of other documents there that are not related to automatic receptacle controls that are wiring device-related. But you can grab all of them there. And I think we even have a link to the NREL publication. The fact sheet is also on our web page as well. And so that's probably the easiest way to get access to them.

Omkar Ghatpande: Thanks, Harold. Now on to the next question to Michael. "Were any of the participants informed about how to reactivate the automatic receptacle controls if they needed it back on?"

Michael Myer: Great question. So, it depends on our survey. So, in one of our surveys where we asked them which device they would use, we told them just to understand that it would turn off an hour after they left and an hour beforehand. We did not want to get into the different control mechanisms to see how that would affect. It's actually additional research that we wondered about if you had those different mechanisms. So, in this case, we told them it was just going to turn off on a time clock and it would turn back on a time clock an hour after work was over and an hour before everyone showed up. And we gave them some time examples on that.

And in the other survey, no, we just said that it would turn off when the occupancy was out of the room for a period of time. We did not try to get into some of the nuances. So, yeah, for the device selection one, that's when we just said it would turn off based on a certain schedule that was after – so no one would be affected by it.

Omkar Ghatpande: Thanks, Michael. I think we are just about time. So, I'll hand it over to Amy.

Amy Van Sant: Great. Well, thank you, everyone, for joining today. I would like to thank our speakers again, Harold Jepsen and Michael Myer, for joining us and sharing their insights on plug and process loads today. We really appreciate it. This webinar is recorded and the recording and slides will be available on the Better Buildings Solutions Center. So, be sure to check that out and please email our team at PPL.NREL.gov if you have questions about plug and process loads in your buildings or would like to share. Thank you all very much. Have a great day.

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