*Operator:* The broadcast is now starting. All attendees are in Listen Only mode.

*Cedar Blazek:* Hello, everyone, and thank you for joining our Better Buildings Webinar Series today. We're gonna jump in and get started right away. We have a lot of presenters and a lot of exciting information to present to you.

So, hello, everyone, I'm Cedar Blazek with the U.S. Department of Energy's Better Buildings Initiative. I'd like to welcome you to this December edition of the Better Buildings Webinar Series. In this series, we profile the best practices of Better Buildings Challenge and Alliance partners and other organizations working to improve energy efficiency in buildings. Next slide.

Today, we will hear about the recent work of the Better Buildings Technology Research Teams and how they can benefit your organization. These leaders that are in national research laboratories are working with Better Buildings partners to advance technologies related to space conditioning, lighting, plug loads, building envelope, and energy management information systems.

Before we get started with our presentations, I want to remind our audience that we will hold questions until near the end of the hour. Please send in your questions through the chatbox on your webinar screen throughout this session today and we'll try to get to as many of them as we can. The session will be archived and posted to the web for your reference.

Next slide. So, let me introduce our first presenter today. Dr. Jessica Granderson is a staff scientist and the Deputy of Research Programs for the Building Technology and Urban Systems Division at Lawrence Berkeley National Laboratory. She is a member of the Whole Building Systems Department. Dr. Granderson holds a Ph.D. in Mechanical Engineering from UC Berkeley and an A.B. in Mechanical Engineering from Harvard University. Her research focuses on building energy performance monitoring and diagnostics, advanced measurement and verification and intelligent lighting controls. She is the recipient of the 2015 Clean Energy Education and Empowerment Award for Leadership in Research. And today, she'll be talking about the EMIS Technology Research Team.

Jessica, take it away.

*Dr. Jessica Granderson:* Thank you. So, first, I wanted to start just by defining EMIS for those not familiar with the term. These are a broad family of technologies coupled with services to manage building energy use. They offer, across the board, a mix of capabilities to store, analyze, and display both energy use as well as systems data and in some cases, also provide control. Next slide.

Our driving goal is to conduct R&D that will support the adoption or the expanded use of EMIS. We combine here at the laboratory both our technical expertise and market intelligence to connect utilities, the owner and operator community and vendors of commercial tools. Our work really spans from the development of new analytical approaches all the way into field validation and identification of best practice uses. In that way, we provide knowledge and technology transfer to facilitate market push as well as market pull. Next slide.

Here's some examples of different types of EMIS, just to give a real concrete visual on the technologies of focus for this team. On the upper left, you'll see a screen capture of a monthly utility bill analysis and benchmarking tool. These may be designed for building specific use or for a full portfolio. Moving clockwise, there's an image from a fault detection and diagnostics technology.

These really focus on, usually, HVAC control system and operational data to identify problems with the systems and recommend fixes or responding course of action. Continuing clockwise, the energy information systems are also just meter analytics tools. They usually take a portfolio or a whole building level view using whole building meter data and the incorporation of submeter data. And then on the bottom left, you'll see the kinda workhorse of commercial building operations, the building automation system. So, that's kinda the composition of technologies we're talking about. Next slide, please.

Resources we develop on this team include those that have a kind of document flavor as well as webinars. And I'm listing just a couple of more recent examples. We've characterized the market for automated fault diagnostics tools, defined how we can use the technology to identify the top opportunities for savings in commercial buildings and application examples—one here being from a large corporate enterprise deploying a

Smart Buildings Program across their Global Facilities Webinars that we host featured guests as well as lab researchers. And they cover things like best practice and lessons learned, moving beyond dashboards with our meter analytics and exemplary success stories. Next slide.

In addition to resources that we develop, we conduct targeted investigations. One recent example being an update of a very comprehensive study on the cost effectiveness of commissioning. This is a 10-year-old study that's routinely cited to make the business case for commissioning project implementation or program deployment. We've updated it with new information for projects that have been completed in the last seven years and expanded it to now cover the largest database of cost, benefits, and measures identified almost 1,500 buildings or projects and nearly 400,000,000 square feet encompassed under this study. Next slide, please.

Our main, ongoing activity is the Smart Energy Analytics Campaign. Through the campaign, we provide technical assistance as well as recognition and peer learning to organizations who are either just starting or well underway with their EMIS implementation. This study represents the largest data set that we know on the use of EMIS, the costs of using EMIS, the savings and specific measures that are identified through technology implementation.

We're currently working with 77 organizations who represent over 400,000,000 square feet of install space, and we welcome new participants. I'm providing here on the slide a link, you can peruse the website and see how to get involved. Next slide, please.

Recognition of our participants' successes is a really important component of the campaign. We confer recognition twice a year through public presentation at industry events. We also document the recognition through case studies and push those publications out to the community at large. Just some examples of the last round of recognition—Clise Properties, Kerry, and Stanford University Dining and Residence. We looked here at very standout applications of meter analytics or fault diagnostics at a single site—in the Stanford case, across a whole portfolio. Next slide, please.

We're expanding our work with two new efforts this year that I wanted to mention just to give a little more example of the

ground that our team covers. So, one effort that I'm really excited for is to work directly with fault diagnostics technology software providers as well as service providers to develop and test automated approaches to correct faults and thereby implement autonomous commissioning.

The second project looks at machine learning combined with unstructured data. So, that's things like images—thermal images or satellite images or things like disclosure records or permitting records—to use those new data sources and machine learning techniques to enhance the energy analytics that we have available to us today in commercial offerings.

So, I really encourage folks to reach out to us with your questions or interests, specifically where your work has strong alignment with our expertise. That's topics like monitoring based commissioning, a meter based savings measurement and verification, operational efficiency very broadly as well as organizational process machine learning and statistics. So, there, I will thank you for your time and look forward to connecting with some of you.

*Cedar Blazek:* Great. Thanks Jessica. And just a note, at the end of the presentation, I will have the e-mails for all of our presenters in case you want to reach out directly.

So, now, we'll hear from our next presenter. Kim Trenbath is an industrial engineer in the Buildings and Thermal Sciences Center at the National Renewable Energy Laboratory. She's a co-lead for the U.S. Department of Energy's Better Buildings Alliance, Plug and Process Loads Technical Team.

Her current research includes plug and process loads in commercial buildings, building fault detection and diagnostics, and zero energy buildings. She is on the management team for the ongoing buildings related JUMP into STEM student competition. Dr. Trenbath is also an adjunct professor at the Colorado School of Mines. Kim, tell us about the latest with the Plug and Process Load Team.

*Dr. Kim Trenbath:* Thanks, Cedar. Hello, everybody. Alright, I'm here to give you an introduction to the resources that we have for plug and process loads, the research that we do, and how these can benefit you.

I'm gonna start out with an introductory question—of all the building end uses, which do you think will use the most energy in 2040? Well, since I have the floor, I'm going to answer my own question, and it is plug and process loads. We'll find out more on the next slide.

So, currently, PPLs—the abbreviation for plug and process loads—make up 40 percent of whole building energy use in U.S. commercial buildings, and this is expected to increase to 49 percent in the year 2040.

So, why the increase? Well, first of all, other building systems such as HVAC, lighting, and building envelope are gonna become more and more efficient, so they're gonna have a smaller slice of the energy use pie. And then we expect more and more plug loads to come online, and these include increases to audio-visual equipment and other plug-in devices such as phones and electronics. So, now may be a good time to start looking into plug and process load efficiencies in addition to your other building end uses. Next slide, please.

So, PPLs include plug-in and hard-wired electric or gas loads that are not associated with HVAC, lighting, water heating, or other major building equipment needed for basic building operations. You can see some examples of these plug and process loads on this slide. Process loads also include equipment for commercial and industrial processes, and an experience of this would be vertical transportation in your commercial building like elevators or escalators.

There’s many, many individual loads, and they are sometimes small, but they are very hard to track and sometimes very hard to control. There are also challenges that relate to human interaction with plug loads that make them hard to deal with if you are a building owner or a manager. These challenges also make this building end use interesting and a good candidate for research and improvement.

The PPL Technical Team has a number of resources that can help you understand the plug loads in your building and how they impact your energy use and strategies that you can employ to be more energy efficient. Next slide, please.

The Plug and Process Load Technical Team is a team of professionals dedicated to finding and improving PPL efficiencies in commercial buildings. This team comes from a

variety of organizations, from technology developers to researchers to building owners. This also includes utilities, regional energy efficiency organizations, and energy efficiency consultants. NREL is the team lead and facilitates the collaboration with the support of our subcontractor, Waypoint Energy. NREL leads a biannual webinar for the Technical Research Team so that they can learn more about current PPL strategies. And we also have a strategic working group which focuses on research, both quantitative energy savings (for example, energy savings from specific strategies) and qualitative (for example, how building occupants interact with PPL control technologies).

And we would love for you to join us, and if you're interested, please sign up by e-mailing Katie Vrabel at the e-mail that you see below. Really, the commitment—there pretty much is no commitment if you sign up. What we're gonna do is, we're gonna send you a little bit of information about our technical team calls and let you know if we have any meetups at any conferences. So, we would love to have you. Next slide, please.

The PPL Technical Research Team works to collaborate with industry professionals focused on PPL efficiency, investigate questions valuable to building owners and industry and communicate knowledge and efficiency strategies through resources and presentations. I'm gonna talk about each of these three things in a little more detail in the following slides. Next slide.

There are a number of ways that we collaborate. First of all, we have biannual webinars, which I mentioned before. During these biannual webinars, we present on technical topics related to PPL such as strategies, best practices, and new technologies. Past topics on the biannual webinar include building site meetings, site demonstrations, and user interactions with PPL as well as cyber security. You can find recordings of the prior webinars on the BBA website.

We also organize conference get-togethers at conferences such as the ACEEE Summer Study and the Better Buildings Summit. Sometimes we meet for dinner where we are able to casually talk about some of the plug load strategies that we're implementing in our buildings.

We also have one to one calls. If you're interested in getting a little bit more detailed information, we are willing to meet with

you and talk to you about the resources that we have available. We're also interested in finding out about your building's needs and ways that we can collaborate.

One of the ways that we can potentially collaborate are from field study test sites. So, if you have a good site where you're going to implement a PPL control strategy, perhaps we can do a field study with you. Next slide.

We investigate two lines—well, right now, we're investigating two areas of research. One is wireless meter and controls for plug loads or smart outlets. And that's the first column that you see there. We recently released a publication through ACEEE Summer Study proceedings on navigating cyber security implications of smart outlets. And we are about to relate a technical report on the DSA Proving Grounds field study with a wireless meter control and technology from Ibis Networks.

Another line of research that we focus on is integrated controls for meter and control devices. And in this line, we're working on a landscaping study which will be published as an NREL technical report, and it's called Integrating Smart PPL Controls into EMIS Platforms. In this study, we have characterized things that are needed for integration and interoperability of PPL platforms with EMIS platforms and also identify future research needs.

Other areas that we're gonna be working on in the future are in the integrated control space and also on learning behavior algorithm and automatic device identification. Next slide, please.

We've also recently published a paper in *Intelligent Buildings International*, and this is on the energy savings and usability of zero client computing in office settings. We did a study and we looked at zero clients compared to traditional work stations and we found that zero clients use 16 to 31 percent less energy than traditional work stations during occupied hours. However, when you factor in the data center energy use, zero clients use a little bit more energy, but this is specific to one building and also one data center. So, data centers and laptops are becoming more and more efficient, so our findings were a case study, but it will be different for each building. Next slide.

So, we communicate our findings through presentations at conferences such as the Better Buildings Summit, ACEEE, and

Better Plants Day. And we also communicate our findings through resources—and I want to bring your attention to the resources. Look down on the bottom of this slide and you see a web link, and this is a link to our web page associated with the Better Buildings Alliance. On that page, you can find a number of resources that can help you with controlling plug loads in your buildings. Examples include a decision guide for PPL controls by sector, a step by step process for assessing and reducing plug loads in office buildings, and a list of utility incentives related to PPLs. Next slide.

I want to thank you for listening to us today and I want to show you how you can get involved. I've talked about a handful of these things on this slide earlier, but you can get involved by, first of all, joining the Technical Research Team and just e-mail PPL@waypoint-energy.com. Another one I want to bring your attention to is participating in the Interior Lighting Campaign innovation category. You'll hear about the Interior Lighting Campaign later on in this presentation, but they are launching a new category, which is controls for plug loads in addition to lighting together. And so, if you are doing some work in this area for some of your buildings, feel free to apply to the ILC Innovation category.

So, we look forward to hearing from you. Again, PPL@waypoint-energy.com if you're interested in joining, and thank you very much.

*Cedar Blazek:* Thanks so much, Kim. Next slide, please. Next up, we're gonna hear from the Space Conditioning Team. Michael Deru is a Senior Engineer in the Building Energy Science Group at NREL. Michael leads the Space Conditioning Project Team and the Advanced Rooftop Unit Campaign for the Department of Energy and manages projects on the development and testing of novel HVAC systems, building performance simulations, performance metrics for sustainability, source energy and emissions factors, water, and the U.S. Life-Cycle Inventory Database.

Michael Deru holds a Ph.D. in Mechanical Engineering from Colorado State University. Michael, you're up.

*Dr. Michael Deru:* Great. Thanks, Cedar, and hello, everyone.

So, the Space Conditioning Technology Team—first, we're gonna talk about rooftop units and all the work that we do in

that space. So, if you're not aware, there's the Advanced RTU Campaign. That is our campaign to promote all things high efficiency with our rooftop unit. So, high efficiency rooftop unit installations and replacements, advanced control retrofit, quality installation, quality maintenance, and we're gonna talk a little bit more about this down below, but automated fault detection diagnostics and intelligent control.

If you go to advancedRTU.org, there's several resources and information about the campaign, resources for building owners, for contractors for utilities and manufacturers around the technology and the business cases for high efficiency rooftop units. And we are getting ready to announce, in January, we'll be announcing our new round of recognition awards. So, we'll be announcing those winners at the PRSM Conference on April 30th, 2019. And every year—we do this annually, and so, look forward to that announcement coming out soon.

And through the Advanced Rooftop Unit Campaign, we're also conducting a field study of automated fault detection diagnostics that are being used with rooftop units. And so, we've interviewed several manufacturers and contractors and building owners, and we're still looking for more, especially building owners. If you have rooftop units and you're using AFDD technology, please—and you're interested in participating, please let me know. You can e-mail me and let us know. And then we will be preparing that report soon and having—hopefully, that will be coming out in early 2019.

And then, we're also going to be looking to collect real time data. So, understanding the data that are collected from AFDD systems and how that data are used and hopefully, if you were interested in participating in that, let me know as well.

And then a new project that is related to Advanced Controls is RTU Coordination. So, what that means is, if you—you know, a typical rooftop may have anywhere from 3 to 50 rooftop units. And typically, they are controlled independently and they may be controlled just by a local thermostat, but there's no coordination between the operation of those rooftop units. And so, we see a great opportunity there to optimize that control to minimize energy, minimize the peak demand, provide improved thermal comfort and improve cost savings and reduce cycle time on those rooftop units. So, we'll be starting that with some lab testing this year, or in 2019, and then looking to start some field testing in 2019 and 2020. So, that's

an exciting project we're getting ready to start up. Next slide, please.

And then, on the next slide, we have several technology demonstrations that we'll have reports coming out soon. One is with HVAC air cleaning technology. This is a company called enVerid. And this is not just a typical air cleaning, because this is a gas shift air cleaning. So, it cleans—it removes CO2 and VOCs as well as the particulates. But it's challenging to remove CO2, and this company has a technology that can do that. So, we've completed some field testing and we're writing up that report right now.

And then the next one is a high efficiency smart motor. This is with Software Motor Company, and we did some testing. With this particular testing, it was just—it was on a refrigeration air condenser, so it's replacing the fan motors for the condenser motors. And that report will be coming out as well in 2019.

And then we've completed several studies in different technologies with cooling tower water treatment systems. Most of those were completed with the General Services Administration or the GSA, and then some with DoE. And those, there's several GSA reports that are in the final review before publication. And then the DoE report, we're finalizing the analysis and starting writing that report right now. So, that report will be coming out in the spring of 2019.

A lot of these resources we make available through the HVAC Resource Map. If you're not familiar with that, please go check it out. This is for large HVAC systems—so, central plants with chillers and boilers and so on. And a lot of these resources will be made available there. There's also several other resources there. This is a graphical interface that allows you to zero in on different aspects of your HVAC plan and find out more information. It starts at a high level and then gets down into more details and then provides links to other information. And we're always looking to improve that, so please let me know if you have any suggestions. We'll definitely try to include those.

One thing that we are gonna be doing, based on all those—the cooling tower water treatment system tests and some other water related technologies that we're looking at is developing some more resources around water management and water treatment systems. So, look for those to be coming out this year as well.

And then we have our technology team call, so we'll probably have—right now, they're tentatively scheduled for February and August, and we're always looking for topics of interest to include in those, so please let me know if you have any suggestions. We'd love to include those.

And thank you very much for your time today. That's all I have.

*Cedar Blazek:* Thank you, Michael. Just a quick reminder, everyone, to send in any questions you may have through the webinar chatbox on your screen. We're collecting these for a Q&A period at the end of this session. Now, we'll hear from the latest from our building envelope team.

Melissa Voss Lapsa leads Oak Ridge National Laboratory's support of the DoE Building Technologies Office Commercial Buildings Integration Program, and is Director of ORNL's Building Technologies Research and Integration Center, a DoE National User Facility. She has over 20 years of experience conducting market research, policy analysis, and institutional consumer behavior research aimed at deploying cost effective energy efficient technologies. She also leads ORNL's Sustainable Campus Initiative.

Melissa, take it away.

*Melissa Voss Lapsa:* Thanks, Cedar. So, talking about the building envelope, it's a complicated system, as we all know, and it accounts for 5.81 quads of primary energy use, and it encompasses the walls, windows, roofs, and foundation that forms the primary thermal barrier between the interior and exterior environments.

Envelope technologies account for approximately 30 percent of the primary energy consumed in residential and commercial buildings, playing a key role in determining levels of comfort, natural lighting, ventilation, and how much energy is required to heat and cool a building.

So, our Tech Research Team is really focused on providing information and resources conducting research for building owners and managers of commercial buildings to help them make the best decisions, most cost effective decisions, for high performance envelope designed solutions for space conditioning load reduction and to facilitate the construction of

durable and high performing envelope technologies also addressing retrofit opportunities, how to make those best decisions for envelope technologies. Next slide, please.

So, we have, in our national use facility here, we have a lot of envelope experts. And so, we have put together on our website toolkits with a lot of information on different technologies, information on air barriers, the best practice guidance, and we also provide technical expertise. Next slide, please.

We also—I won't mention all those names, but we'll keep going. We have 29 members of our Technology Research Team of building owners, managers, architects, engineers, including Legacy Health, Newmark Grubb Knight Frank, Turner Construction and others. We also have another, over 30 members who are affiliated with us that make up the manufacturer, trade association, energy service providers. So, collectively, we can share a lot of best practices and also find out where those gaps are for information and technology needs that we can provide. And the goal is to basically have those high performance envelope solutions being deployed in new construction and retrofit opportunities. Next slide, please.

So, our current activities across our envelope team is that we've heard from our team members that they would like to have more information on commissioning, and specifically on closure commissioning. Best practices, case studies—so, we've been working with a lot of different associations and information providers to pull this information together. We've also been working on a building enclosure performance metric, and I'll speak a bit about that on the next slide. We're looking at wall systems and looking at where that information gap is, and we're also analyzing that to see where the opportunities are for active controllable wall systems.

We're doing research on composite walls, looking at a multi-functional composite panel for an envelope retrofit that would be cost effective that will combine heat, air, and moisture barrier with the cladding system. And we're also working on window attachments, looking—collaborating with the Attachment Energy Rating Council. Next slide, please.

So, speaking about this performance metric—and we have a lot of information about this put together, there's a link at the bottom, so I won't dive into a lot of detail given our time constraint. But I will mention that an analogy is miles per

gallon with your vehicle. We wanted to—we heard from our team members that they're looking for how do I evaluate the effective performance of my enclosure. We all know that it's more than the R value. We need to take a lot more into consideration. And so, we are pulling this information together and we are working with our partners, we're doing a lot of research with other national labs, with industry associations, but we're also getting input from some of our building owner managers providing real world building data. So, it's an opportunity for them to be a part of this process of our research and then they can utilize the results for their—making their energy efficient, cost effective decisions. Next slide, please.

Regarding the passive walls, we are, again, doing our research in our national use facility, but we're also getting input from our partners on their wall performance data so that we can basically have cutting edge information and be able to see where the gaps are, categorizing common commercial wall assemblies, identifying simulation model deficiencies, and conducting sensitivity analysis. And all of this will be publicly available information that we will post on our website and do a webinar to showcase the results. Next slide, please.

So, some of the items that are on our website are linked here in these slides. We do have webinars about once a quarter where we bring in experts to talk about the latest energy efficient, cost effective envelope technologies. We've had recent ones on windows and air barrier technologies, enclosure systems, and also window attachments, and those are all available online. We have had a half day workshop at the Better Buildings Summit on going deep on enclosure commissioning, and we're adding information on that based on some publications and articles that we've recently released, and we also have ACEEE Summer Study results on air tightness of commercial buildings and a new calculator that's available on our website. Next slide, please.

So, in closing, I'd like to just reiterate that we have a lot of partners, about over 60 members and affiliate members of our Tech Research Team. Our job is really to help provide best practices, package information that helps building owners and managers make quick decisions on where to invest in this complicated building envelope system and enable engagement on the research to enable advancing the deployment of energy saving solutions. So, I would encourage anyone who would

like to get involved with our team to reach out and e-mail me and we will be able to add you to our team.

That's it! Thanks, Cedar.

*Cedar Blazek:* Thank you, Melissa. Finally, let's hear from our Lighting and Electrical Team. Michael Myer is a lighting analyst and joined the Pacific Northwest National Laboratory in 2007. At PNNL, he supports the Interior Lighting Campaign, and the Lighting and Energy Efficiency and Parking Campaign. Beyond these campaigns, Michael supports commercial and federal building projects on lighting needs. In addition to commercial support, Michael has provided technical analysis related to energy codes and appliance standards. Prior to joining PNNL, Michael was an architectural lighting designer.

Michael, the floor is yours.

*Michael Myer:* Thank you. So, I guess I should provide some context, here. Lighting is about 10 to 20 percent of the electricity use in your building. It all depends on the age of your building and, as we learned with plug loads, some of those loads are now outpacing the lighting. Significant inroads have been made in energy efficiency and lighting in the last five years. That's why that number has gone down, coupled with other loads increasing. But it is a constant need and something that many of you are working on.

It's also, of the building systems that we've mentioned on this phone call, one of the easier ones to retrofit in an existing building that can be done sometimes overnight or over a weekend, so the construction delays are limited.

We have three calls scheduled, they're on the upper right hand corner for those dates, if you're interested. We always try to spend a portion of the call talking about some of the current activities which we're working on, which we'll talk about shortly. Recent ones we talked about were lighting as a service. I assume many of you have heard about these, but these are—there's new as a service models. The concept is that rather than burning your capital expenditures, you essentially are entering into a different type of ownership and lighting as a service is an example of that.

We're also working on some Internet of Things research related to lighting. Internet of Things is using smarter devices. The

easiest one to think of is your home devices such as the AI and Alexa and the Amazon devices or even Siri and asking them to do things. Now, you can use sensors and light fixtures to possibly interface with how often a space is used or other types of beacons. We'll talk more about that in a second as well.

We also use a portion of these conference calls for what we call cross talk for members. The idea here is that one member might be looking for a solution or having a challenge. A quite recent example shows a hospital was using bi-level lighting controls in a corridor or stairwell, and they were asking how their other members had dealt with that type of code issue before, and they were also able to explain—other members were able to explain how they were able to deal with it. So, it's valuable information. It's not just one way, it's very much two way as much as possible.

It is a PNNL primarily supported program through the Department of Energy. Also, we work on individual requests. Most recently, a retailer had some issues with a color product in their lighting in a store and we were able to help them—after they asked us some questions, we were able to provide them some feedback on things they should consider. Similarly, we were able to provide information about downlights and other products.

Typically, what ends up happening is, a member will say, "I'm looking at this product, this is what I'm hearing—how does this match up?" And we provide them just unbiased technical information as well as resources they can find. Next slide, please.

As mentioned in the previous programs, we also have a campaign, you heard about it briefly, the Interior Lighting Campaign. We have a 2019 recognition event. Most recently, in 2018, we recognized 15 organizations at the Illuminating Engineering Society, their conference in Boston. We have a similar event in the works for 2019. The concept this year with the campaign is that projects that are significant energy savings and good programs, they can be recognized. We have a submittal process. It's open now, but we really push that in the new calendar year. And as mentioned previously, we are also looking to expand beyond just focusing on lighting but how lighting is now interfacing with both HVAC and plug load interactions. By integrating sensors directly on the light fixture, the light fixture occupancy sensor can not only reduce—turn

off the light fixture when it's no longer occupied, but also reduce the plug load or the HVAC as well.

We have many resources on our website for the Interior Lighting Campaign and we update them regularly—specifications, utility incentive database, case studies. We recently had a related webinar about a K-12 lighting toolkit, and that's about to be posted there as well. We also have resources on the L&E page. Next slide, please.

As I mentioned previously, we are working on the Internet of Things and lighting. This seems to be where a lot of interest is right now, and lighting is a mechanism to bring in IoT into the space because it's a mounting platform as well as provides power. We found that some of the challenges related to IoT relate to the lack of awareness of some of the benefits. Cyber security is always an ongoing challenge that has to be addressed, cost as well as interoperability. Next steps—we are working on a challenge related to the IoT as well as some ongoing research. Next slide, please.

So, the idea of this is a forthcoming challenge. We are looking for partners and we'll be reaching out to see if end users are interested in it. The idea is looking at a product, either a Luminaire or a retrofit kit, that had connectivity and upgradeability into the future. The idea is that, later in the future, when the product is ready, you could install a sensor—both a light sensor as well as an IoT device that might be able to do future applications. And then they would also have to demonstrate how it would work. But we'll follow up more with that in the next call. Next slide, please.

We are also in the process of doing a number of field evaluations. This is taking equipment out of the lab and actually demonstrating to see how it works. As I mentioned previously, we are doing one with lighting and HVAC. This is a federal building using smart sensors and, again, reducing the HVAC through the occupancy sensor in the lighting fixture. We're also doing another one in Minnesota with four LED retrofits, both with HVAC and occupancy sensors.

But I also wanted to take advantage of everyone on this phone call to also mention two field evaluations that we're currently working on. Next slide, please. One relates to a tuning of an LED system, the other one relates to PV. We'll talk about that one in a second.

So, tuning—the idea here is that you can modulate the color temperature, that's the appearance of the light source. So, over on the right, we call that cool source. That's kind of a whiter, bluer light source over on the left. You'll see more of the warmer tones. Next slide, please.

And by modulating color temperature throughout the day, as shown in this type of clock with midnight at the top and through the progression of the slide, we have found that—next slide, please—that by modulating color and temperature throughout the day, we can have different effects on the body, both perceived mood as well as some performance. So, this is an example of it in a classroom where they had different types of, again, color temperature, so it's the different appearance of the light source that can be changed to a different day when they were maybe teaching a different subject or wanted to draw attention. Next slide, please.

And so, we are looking to seek out partners who might be interested in doing a tuning evaluation in an office setting. It would require some consent to participating in the field evaluation, just because we'd be seeking their feedback on how they liked working under this type of lighting that would change the color temperature throughout the day. Ideal building would have duplicate floors so it could be segregated, also a standardized work shift with limited travel. And we'd be asking questions about different energy savings of the different systems, the user's perspective.

Why this is interesting is that there's often what we call the post lunch dip where people are a little tired after lunch—the whole point of the siesta. And by maybe modulating the color temperature and making it a little bluer or higher color temperature in the afternoon, we'd be able to increase alertness. And there are government programs as well as private programs that are interested in this type of research. Next slide, please.

We are also doing another one related to different technology. This one is photovoltaics with direct LED lighting and battery storage. I apologize. I think it's going to the next slide, but my Internet connection is becoming slower and slower as this goes on, so I have a limited idea of what I'm seeing at the moment.

The concept here is that we would use photovoltaics connected to a direct current in the building, then direct current LED lighting in the ceiling and on site battery storage. The interest here is that, some resilient aspects to why buildings as well as, obviously, energy efficiency every time you convert between DC and AC, there is efficiency losses, and LED lighting is really ripe for it since it's already a direct current technology at the end source, and so you can pick up some savings here, as well. Next slide, please.

So, similarly, we'd be looking for—seeking partners for this. We don't entirely know the ideal building type, but small commercial is what we are looking for. But they would have to have an interest in DC power, most likely new construction as a result. Also, some limit effects on staff, and we'd be looking at both energy savings as well as how hard and the design challenge. So, if you're interested, please follow up either of these demonstrations. Next slide, please.

So, these are the many resources, I think, available across the different programs.

*Cedar Blazek:* Yes. Thank you, Michael. So, that wraps up our Technology Team presentations. These are just a few specific resources provided by each of our presenters, which you can access any time for your use. These links will remain active in the slide deck on the Better Buildings Solutions Center. Next slide.

Alright, so now we're gonna move into the Q&A session. Please remember, if you have questions, you can put them into your chatbox now. We've had some questions come in, so, I'm gonna go ahead and get started with answering them.

So, the first question is for Michael Deru. One of our attendees wanted to know which company makes the HVAC air cleaning technology. I'll answer that quickly—the company is enVerid, but they also wanted to know, is there any more information you can share about the enVerid air cleaning, recycling, and smart motors project specifically? Any details about the technologies and their case study pilots NRES is reviewing as well as what NREL is reviewing for these two projects?

*Dr. Michael Deru:* Great. So, that's a long question, and I'll try to answer as much of that as I can, thank you. And so, the enVerid testing, we tested in Miami and Houston and Arkansas and New York _____ in different office buildings and those locations. And

then we have—we'll be sharing that technology or those results in our report that will be coming out, as I said, in early 2019.

And then, as far as recycling, I'm not sure what you mean by that. Those cartridges that contain the absorbent material are—right now, they're scheduling the replacement of those cartridges annually. That's all I know about that part.

The smart motor technology, as I said earlier, we're testing that. We tested it in a refrigeration air cooled condenser replacement. We're also under—so, that's what we'll be reporting. We're also doing some testing in our laboratory in a separate program with a rooftop air conditioning unit. That's all I have.

*Cedar Blazek:* Great. Thanks, Michael. I have a question now for Michael Myer. Michael, it was mentioned that there is interest for a partner to study tunable LEDs in commercial settings, and do you have any existing partners already for this project? If so, is there interest in partner organizations beyond the business organization you already have?

*Michael Myer:* We are in initial conversations, and if anything has proven out, having multiple potential partners is the best way to go, just as we get down the line, we often find out their building doesn't work or their organization decides not to. So, we'd like to have, in the initial stages, as many conversations as we can. So, yes, we'd be very interested in speaking to other interested parties.

*Cedar Blazek:* Thanks, Michael. And so, for that, if you are interested in that study, Michael's e-mail will be at the end of this presentation, and you should be able to just reach out to him directly.

Melissa Lapsa, I wanted to see if you can tell us a little bit more about the benefits of envelope commissioning. I'll stop there. Just describe them in a little bit more depth.

*Melissa Voss Lapsa:* Sure. The envelope commissioning is really just looking at the performance of the system as a whole. So, you know, looking more than just the R value of the building, but on our website, we have a lot of information that we've pooled together on commissioning and what the benefits and the cost and—you know, it really is something that we're trying to put a metric around to really look at all the different aspects of it and look at location and other elements regarding that performance to see how can we cost effectively assess the performance of a

commercial building so that we can know where we need to make those investments cost effectively. But I'd be happy to—as I mentioned, we've got links on our website with more detail and be able to answer any specific questions about it if there was additional need there.

*Cedar Blazek:* Great. Thanks so much, Melissa. Kim, this is a question for you. The respondee noted that 40 percent of commercial building use is for plug and process loads. Do you know how much goes towards plug loads and how much towards process loads?

*Dr. Kim Trenbath:* Oh, yeah, thanks. Great question. Actually—so, there's not enough good data for us to know the breakout at this time. And, if we did break it out, we would have to break it out by building type as well, because if you think about process loads and you think about vertical transportation like an elevator, you'd probably have more elevators than, say, certain hotels versus a school building.

So, I think that's my best answer at this time, that we would love to look into this a little bit further, but I don't know—I don't have the specific breakout at this time.

*Cedar Blazek:* Great. Thanks, Kim. Michael Deru, there's another question for you—are the energy savings associated with RTU controller technology mainly fan electric savings? Are the energy savings opportunities similar in cold climates, especially if electric savings also include compressor energy savings?

*Dr. Michael Deru:* So, yes, the majority of the energy savings are from the fan energy savings. So, the fan in a rooftop unit, typically in a commercial building, runs continuously at 100 percent. And so, with the advanced controller, you put in a variable speed drive or a step speed drive and slow that down during ventilation and then cooling one and then heating one and so on. And so, that's where, probably, 75 percent of the energy savings comes from.

And then there's additional energy savings potentially associated with other advanced control, like demand control ventilation or integrated economizer controlling. There's usually not much, maybe a little bit of energy savings from these technologies on the compressor side.

So, in a heating dominated climate, you are gonna see energy savings from the fan, because you know, you're not gonna be

heating all the time, but there's usually a lot of time where you're just ventilating, and so, you actually have a lot of energy savings there. That's where most of the energy savings comes from.

And then, if you're in heating mode, oftentimes, you don't need to run that fan at 100 percent. So, you'd be running it at a slightly lower speed. Now, there are some technologies that provide variable speed compressor saving, or control, as well. There's only this limited actual energy savings from most buildings, depending on your load and the climate.

*Cedar Blazek:* Great. Thanks, Michael. I have one last question, and this one is for Melissa. How much flexibility do I have in improving my envelopes for an existing building?

*Melissa Voss Lapsa:* That's a great question, Cedar. And, you know, this is at the heart of what we're doing on our Envelope Tech Research Team. You know, we're focused on these specific technology options that are cost effective and efficient for windows, walls, roofs—but most importantly, how the system works as a whole in a whole building context.

So, it really depends on a lot of things, looking at a commercial building—the size, use, location, et cetera. But specifically, if you're willing to change your façade or your roof materials, you're gonna have significantly more options for improving your performance of your envelope. So, if there's a specific question, feel free to reach out to me and we will get our technology experts engaged to answer that for a particular commercial building.

*Cedar Blazek:* Thanks, Melissa. So, we did have one last question that I wanted to address. If we're taking an integrated approach to energy efficiency in our buildings, what's the best way to get involved?

I'm gonna take that one. I would say join the Better Buildings Initiative. You've seen today a number of ways to get involved, joining any number of our Technology Research Teams, applying for recognition and joining one of our campaigns. So, joining the Better Buildings Alliance, or committing your organization to the Better Buildings Challenge—reducing your energy usage 20 percent over 10 years.

So, with that, we'll go to the next slide, please. We hope you'll plan to attend the next Better Buildings Webinar on Tuesday, January 8th from 3 to 4 p.m. titled Prioritizing Laboratories to Meet Your Energy Goal. This webinar will focus on the Department of Energy Smart Labs Accelerator Program and the first steps for incorporating Smart Labs methodology into your organization's current management plan. Using lessons learned and experts in the field, this webinar was set up to _____ for creating a Smart Labs program. Prioritizing energy efficiency and labs can help organizations quickly meet their energy savings goals. Next slide.

Additionally, we hope you'll join us for the remainder of the Better Buildings Webinar Series, where we will be taking on the most pressing topics facing energy professionals with new experts leading the conversations on proven best practices, cost effective strategies, and innovative new ways to approach sustainability and energy performance. Next slide.

I also very excited to announce that the 2019 Better Buildings Summit has been confirmed for July 10th and 11th in Arlington, Virginia, which is located just outside of Washington, D.C. Please save the date in your calendars now and be on the lookout for more information coming soon. You can stay up to date by following the 2019 Summit link on this page, as well as our Twitter. We look forward to seeing you in Virginia. Next slide.

With that, I'd like to extend a big thank you to our panelists today for taking the time to be with us. Feel free to contact our presenters directly with any additional questions or if we weren't able to get to your question during the Q&A period. If you'd like to learn more about the Better Buildings Challenge or Alliance, please check out our website or feel free to contact myself, Cedar Blazek, or my colleague, Kendall Sanderson, directly at the e-mails shown. I encourage you to follow the Better Buildings Initiative on Twitter for all the latest news.

You will receive an e-mail notice when the archive of this session is available online. Thank you for attending, everyone.

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