Axel Pearson: Hello, everyone. Thank you for joining this webinar. We're gonna give it a couple minutes for folks to join. There is a trivia question on the screen if you wanna answer that while you're waiting. There's a link in the chat or you can go to slido.com and enter the event code, hashtag ILC. We'll get started in just a minute or so. Again, if you've just joined we're giving a couple minutes for folks to trickle in. There is a trivia question up on the screen. Feel free to go to slido.com and enter the event code, ILC and answer that question or there is a link in the chat that will take you right there and you don't have to enter that code.

We'll get started. We'll just give it maybe 30 more seconds and we'll jump right in. Thank you for joining. Okay. There I am. Hi, everyone. We're gonna go ahead and get started. So welcome to this webinar. The title is Demystifying Advanced Lighting Controls. My name is Axel Pearson. I'll be your host today. Thank you so much for tuning in. As many of you know, network lighting control systems can be confusing. Good thing we here at PNNL and DOE have lighting experts with a passion for helping people understand this complex technology. That is just what we're hoping to do today.

We'll talk through things like design objectives and system architecture so we can all understand and maintain these control systems. So thanks again for joining. Let's move on to the next slide. If you joined in time to answer our trivia question the answer is, one more click. There it is. The answer is (A) one to two percent. What percent? That is the percent of US commercial buildings that have advanced lighting controls. Oh, man. I did not stump you at all. Eighty percent of you got it right. It was funny, I asked this of my co-presenter, Ruth, who I'll introduce you to in a second. She said, "Oh, it's one to two percent. The number that never seems to change." That is our motivation for doing what we do.

We are working hard to increase adoption of advanced lighting system and get this number up. So I'm sure we all share that same goal. Thank you for showing this. Some of us were a little optimistic, but yeah. According to DOE's adoption of light emitting diodes and commercial lighting applications, just did that one to two percent. So congrats to all of you that got it correct. If you didn't see how to answer that question, I will cover Slido in a couple of slides and don't worry if you missed it. We've got plenty more questions coming that we would love your input on. So let's switch back to the slide deck.

All right. First some logistics before we get started. Slides and recording will be posted shortly after the webinar as always. That will be on the Better Building Solution Center. If you'd like to navigate there now go to BetterBuildingSolutionCenter.engery.gov, hover over Events and Webinars and then click On Demand Webinars. From there you can click on lighting or any other technology. Personally, I recommend lighting. It's a good one. You can find this webinar, many more that we've done in the past. So check it out. So I mentioned we're gonna use Slido not only for polls, but also Q and A. So hopefully you've all used it before and if not, pretty straight forward. We've got Anna behind the scenes operating Slido and she makes sure that we can receive all your questions and comments as well as answers to our poll questions.

So let's go to the next slide. If you need that information again go to Slido.com or I just saw the link pop up into the chat. So look at the Zoom chat. You can click the link there or go to Slido.com. Enter hashtag ILC and you will enter our Slido room. You can enter your questions and we will take some time at the end of the webinar to review them. If we can't answer them or don't get to all of them in time, I will be sure to follow-up with you via e-mail and get that answered for you. You can always reach out to us at IntergratedLighting@pnnl.gov with questions and other comments. So please don't hesitate to shoot me an e-mail there. It goes right to my inbox.

Next slide, please. Here are today's speakers. I'm there on the left. Again, my name is Axel Pearson. I'm a project manager here at Pacific Northwest National Laboratory. I lead the integrated lighting campaign, which I'll tell you a little bit about in a bit. I work on other lighting related programs. I get to put on events like this one. Hopefully you've attended one before. There on the right is Ruth Taylor. Ruth is also a project manager and a veteran on the advanced lighting team here at PNNL. She's an experienced lighting practitioner and currently manages the next generation lighting systems program, which encourages technical innovation and promotes excellence in the design of energy efficient LED luminaires and connected lighting systems.

Ruth has also been working on some technical resources focused on connected lighting. That's what she's gonna tell us about shortly. So stay tuned for that. Next slide, please. Here's the agenda for today. I'm gonna tell you a little bit about the integrated lighting campaign, as this is a function of the ILC, and then we will get into the topic of the day, demystifying advanced lighting

controls. Again, Ruth Taylor is gonna walk us through some key parts of advanced lighting control systems and make sure that they're optimized and maintained correctly. Again, we'll have some Q and A at the end. Don't hold your questions to the end. Go to Slido. Enter them in as you think of them and oh, you can also upvote questions in Slido. So if you see one you like, upvote it and it'll bump it higher in the list and we'll answer it sooner.

Next slide, please. So I would like to tell you about the integrated lighting campaign if you haven't heard of it. I hope you have, but really the ILC is a recognition style program from the Department of Energy. It recognizes installation of, you guessed it, integrated lighting. In this sense, the term integrated means that the lighting system can communicate with other building systems to enhance building performance. I'm sure I don't have to tell you all lighting community that lighting has come a long way from basic LED retrofits of the last ten years or so.

Now it can really work with the rest of the building to achieve deeper energy savings at the building level. For example, exchanging information with the HVAC system, maybe controllable plug loads, or even broader than the building level by communicating with the electric grid. Lighting and lighting censors hold some valuable real estate up in the building ceilings and they have this bird's eye view of the space, which is a very useful perspective for collecting data information. They have the ability to relay that useful information to these other building systems like occupancy information, ambient light levels, temperature and humidity, location of assets, anything else that you want to track in your space.

Using that information, the building can again, optimize its performance and save energy. While the ILC is especially interested in these integrated systems, there are still many advanced lighting control systems that we're hoping to capture as well. Advanced lighting systems and controls that improve the performance of the space are definitely of interest. We'd love to hear how systems are going above and beyond simple occupancy, daylight, and scheduling approaches, in particular installations of censors and controls that again, enable those deeper operational savings or create enhanced occupant experience. This could be Luminary Lighting Controls LLLLC, white tunable systems, or those systems that might have a positive effect on the circadian system.

In fact, we recognized some new installations this year on germicidal ultraviolet light. So there's a lot that the ILC is interested in. So we hope to learn about and recognize some of those innovative lighting projects and share their successes with you all. Next slide, please. So the ILC develops and hosts resources as well. This is for the building community to help building owners and managers install advanced lighting control systems, help them feel more comfortable that these things actually work.

Last year we pulled all of you on a similar webinar. You helped us set the priority and inform a lot of Ruth's work, which again, she's gonna tell us about next. So we'd like to ask you another poll question to help continue to guide us. Right now I've got a poll question for you all to help focus the areas of lighting research for future resources and presentations like this, valuable to hear from input like stakeholders like you. So the question is, "What lighting technology areas are you considering or would you value more insights on from lab experts?"

The options are low to no cost lighting upgrades, germicidal ultraviolet, or GUV and commercial buildings, integrated lighting controls like those I mentioned, lighting and HVAC, lighting and plug loads, Internet-of-things lighting systems, sometimes known just as connected or networked where the systems can talk to other parts of the building, nonenergy impact. So those benefits and potential pitfalls of installing advanced lighting controls and systems and buildings. Or we also have another option, if there's something else you wanna learn about, enter it into Slido and we will add that to our results.

So thank you for your input here. Again, this really helps us prioritize and develop resources that are most useful for you. I love watching this graph move. I'm really pleased to see integrated lighting controls taking a commanding lead there, nonenergy impacts. People are still voting. If you haven't voted yet go to Slido.com, hashtag ILC. Looks like there's a QR code you can use. There's a link in the chat. All right. Thank you for that. Let's go ahead and move to the next slide. Thank you for that. I believe this is Ruth's first slide. So Ruth, I'm gonna hand it over to you. I will keep an eye on the questions in the chat for you and with that, I'll let you take it away. Thank you.

Ruth Taylor: Thank you. Welcome, everyone. Thanks, Axel, for having me on today. I thought I'd start the presentation by making you all jealous and putting my background photo as my recent trip to Costa Rica.

I'm gonna be maybe booking a trip when I get off the line here. Let's demystifying advanced lighting control systems and I like that word because as we're talking to people across the country, there are so many parts and pieces and the way systems are put together that it just can get jumbled. So we've really tried to break things apart better and try to get things to a place where they're just better understood and it makes people feel more comfortable.

Let's go to the next slide. So we're gonna walk through today. I'll explain a little more about why we're walking in this way and what this material is built on, but this is the things we'll walk through today. Next slide, please. I wanna start with a couple of poll questions. A lot of my work at the lab is on advanced lighting controls, but the people connection with the controls. So we have living labs in which we watch installers try to get systems installed and configured and all that and really trying to narrow down into what the people issues are.

So these are a couple of questions that I used in my latest IS presentation and I was really curious to see what you guys and gals might think. So where do you think we are with controls and how they compare to where we are with LED luminaires? 'Cause we've come a long way in that arena. Do you feel like it's the Wild, Wild West where we cannot get anything figured out? All the way to the end of this scale that controls are there, man, they're reliable. They're – just everything is where it needs to be. So I think we have that as an Slido. Good. That's fun to see. Everyone is in the middle. I think that rings true. We are making a lot of progress particularly in the last few years, I think. So I think I would probably agree with that 50 percent.

So let's go to the next slide. So do you think – in our work now do you think the difference that it's really the technology that's holding things up that we're just at 50? How do we get to 75 or 90? Is it we just really got to nail down the technology or is it along the continuum is it really the people problem that we need to be? Again, it's a sliding scale there. Man, you guys are all middle of the road. Some of you are more optimistic that technology is close. Thanks for that. I just think it's curious to see where – and just to make us think about that because there are two sides to that equation.

Sometimes we just think, "Well, if technology would just improve," and we forget that it's that people technology connection. So we have been working for the past year, maybe a little longer, of developing a resource that we've called selecting

lighting control systems. I think I've talked about this with this audience before when we were first developing it, but the idea to this document was to help in the selection of the right advanced control system for your particular situation. It was very as a buyer focus.

Let's go to the next slide and I think I can explain this a little more. So we stepped through in this document how to help specifiers work with their owners to determine the best system for their particular project. A lot of it was focused on asking the right questions, understanding enough about how systems were put together that you could understand what your owner was telling you and those kinds of things. So we started by helping designers understand that they needed to really understand what their owners really wanted and to help them to see to get their minds around the risks involved in particular decisions 'cause a lot of folks we talk to it was, "Okay. I think that sounds cool. That sounds cool. Oh, yeah. That really sounds cool, but what's that gonna cost me? What's that gonna cost me in complexity that's gonna take more maintenance down the road?"

There were a lot of intricacies of making those decisions. So we helped step through for designers to see you really need to work with your owner about what do they really need, not just what sounds cool, but what do they really need and then trying to map those needs to capabilities that systems have. Because often – or how it's done now a lot is that designers have a particular product that they're accustomed to using and it's just their go-to product. So they're gonna make that work no matter what because they've got a manufacturer rep that's been good to them and they help them with everything.

So they're just gonna make whatever their owner needs fit into this box because that's what they're familiar with. Often that's not the right mix. If your particular product that you use all the time can't really meet those needs or there's something a little off there, how do you look at other systems? How do you know what to look for? How do you find the right information? Then how do you help your owner then understand the risks involved with that? So we stepped through different – we'll look at some of this today. My reason for max talking through this now is to emphasize how I move things around because my impetus today is to think about it from the facility person's perspective.

Next slide. So today I'm gonna flip it a little bit. So normally we end – in this other document we ended the discussion with you've

walked through, you understand what you need, you've chosen a system. How do you really need to document it in order for this system really to get installed and to work properly? Now we're talking about a situation where you've been handed a system. You're not selecting it. Someone else has already selected it, designed it, and now it's yours to deal with. So we're gonna talk about documentation first so you can – because you've got to understand what you have first. Then we're gonna step through those other steps.

So next slide. So to start, when I first started to think about from the facility manager's perspective what questions need to be answered. First and foremost, what was the system designed to do? Who designed it? Is it doing what it's supposed to do and how do you know? Can you figure out if it's even doing that? Who installed it and configured it and programmed it and commissioned it? All those steps are involved. Did one person do all that? Did – was it handed off to this person and that person? How are upgrades performed? Do they happen automatically? Can you stop those upgrades? If you do that, what are the consequences of that? So there's a lot of additional things as systems get more complex that you need to think about. Just a warning, we're not gonna cover all of this today. We only have a certain amount of time, but they still are important questions to think about from that long term maintenance perspective.

Next. So understanding expectations is really important to understand what you have. I like this cartoon because the designer needs to understand that in order to design a system correctly, but a facility's person needs to understand what the users of the system are expecting. That makes a big difference. You have the grandma on the right there that's just as accustomed to a light switch. You have the owner in the middle that's just expecting magic. You've got the crazy haired kid who's everything is on the phone. There's just a lot of different angles that people will come to and from when they're using a control system and to understand that is important. Ask for clarification. There's many issues that come up with communication and with incomplete documentation.

Next. So we're gonna talk a little bit about documentation and about these three documents that are typical. I'm not gonna spend a lot of time on this, but it is important to understand what's in these documents and how that could help you really understand what you're – this is answering the question what is your system even supposed to do, much less what it's actually doing, but do you know what it's even supposed to do?

Next. So the designer's role is to translate the owner's request into the lighting system. So it's important to know who did that design and a lot of those decisions that were made in that process effect what you have now to work with. Now the control intent narrative is – you have your owner's requirements and then you have an intent narrative that usually is a written form. It's in plain language so everyone can understand it. It clearly communicates the intent of the system.

Next slide. Now the next step to that is the sequence of operations and it's an extremely important document. Thank goodness there's a lot more emphasis on it now. There's an LP-16 that came out in '22 that is helping designers know the language that they need to use, but it is legally enforceable document. It is what the system programmer and commissioner are looking at to know. It's got set points. It has various – it is very precise as to exactly what this system is supposed to do.

So from what we hear, a lot of people – they're not necessarily using this document and probably from a facility manager's standpoint you wouldn't have access to that. I would say ask for it. It will be the document that will tell you exactly what the system is supposed to do. So especially if you have problems, your system is not performing right, you're getting complaints or whatever it might be, in order to fix things you need to know how it's programmed now and what it was even supposed to do. So important part of the process.

Next. So manufacturer – hopefully you have documentation from your manufacturers as well. Often they can be confusing. We'll talk about this quite a bit more later. One of the main things is inconsistent language. All the parts and pieces of your system are called different things, the way systems are put together. All of that can be different from manufacturer to manufacturer. So it's important when you get your system to look at that information and to realize that if you're familiar with another system that might not translate exactly the same to the system you have here. So it's important to read through things carefully and to ask the questions you need to ask.

Next slide. A lot of what goes into this and we spent a lot of time with our materials for designers talking about proprietary systems and how they are different. So it's just important to understand that, that they're gonna be done in a different way and you need to – that's one of my main purposes for this presentation and for these

resources is to try to look at these systems in a more generic way. That's – when we installed 14 systems at Parsons School of Design in the NGL's living lab there, that was one of the things that such an eye opener was how different each of the systems approached things and we were able to explain those in more detail. It helped people get a basic feel for how manufacturers were approaching the problem.

Next. So let's talk a little bit about objectives, how you maybe describe those objectives, what your system was supposed to do, and then how you connect those dots to the capabilities that systems have. Each system is a little different. They have a little different secret sauce and all that, but to be able to draw those connections is important.

Next slide. All right. We have some animations here. So we tried to – to start getting our brains around objectives and what systems are really trying to do to group into four main use cases. Now there's nothing magical about these. Not everyone – every system will probably have some combination of this that's not exactly in these buckets, but I think it helps us to bucket them so that you get a feel for how to commonly put together. So the first is just code compliance. That's gonna be different in every jurisdiction, state, all of that. Just basic code compliance. Everyone has got to do that and we'll build upon that.

Next. So the next use case we're just called advanced lighting performance. So that's thing like tuneability and dimming and just the things that are related to the lighting that enhance the performance of the system. Next. Then we have things that are more directed towards the energy base. So this is above codes, but there's other energy management, energy reporting, those kinds of things, demand response. Those kinds of things that are very specific to energy that are packaged in that way because that's the owner's highest interest.

Then the last bucket, which relates the most to the integrated lighting campaign and probably what you guys are interested in based on your poll and questions. We described it as facility productivity, but it's asset tracking and people counting and those kinds of things and integrating with other building systems. So those kind of things we would put into that bucket. Next slide. All right. So here's our spaghetti slide. I'm gonna walk through this, but I wanted you to have a big picture idea of where we're going with this. So the task was once you know what your owner wants and needs, whether it's one of these specific use cases, typically

not. It's gonna be a combination of these somehow, but how do you know what capabilities facilitate that? So let's step through each of these.

Next slide. So first we have just basic energy code compliance, scheduling, and occupancy sensing and daylighting. Like I said, it depends on your jurisdiction as to what will be required. The circles over to the right – I'm not gonna talk a lot about this in this presentation, but in our document that these materials are based on we talked a lot about risk. So these little circles represent risk and an empty circle means low risk. We base those on the availability of the products. Is it something – our technologies, our capabilities, is it new or is it something that's been around for a long time? People have figured it out. That was one dynamic in that.

Then the other was communication that's used 'cause a lot of complexity is introduced when there's a complex communication protocols required and necessary for the capability to work. So those two factors usually will add cost or they're – add complexity that may make maintenance more expensive or difficult. So that's how we rank those. Like I said, not gonna talk a lot about that, but that's what those green dots represent.

Next slide. So now we get to enhanced lighting performance. Like I said, it's things like task teaming and seeing control. Both energy code compliance and enhanced lighting performance need dimming. So this is where you see the overlap and the spaghetti diagram coming in. You also can see on the circles on the right how some of these capabilities, tunable white and task tuning introduce a little more risk. So it's just a way to gauge those things in that discussion.

Next slide. So when you look at energy management you can see some overlaps there. So you can see how task tuning, something you would need in energy management, but it's also something that's an enhanced lighting performance and you also can see that we're inducing more risk. These risk assessments are pretty subjective. We did our best to rank them and they will probably change over time. Like I said, the two criteria we used were how common a capability was and how much communication it typically needs.

Next slide. Then we get into what we term enhanced facility productivity. This is where we're definitely introducing more complexity and more risk. It includes things like asset tracking, like I said, and indoor positioning and external system integration,

those kind of things. So as you're stepping through these use cases and the capabilities on the right, there is an increased complexity and therefore typically risk.

Next slide. So let's talk about the architecture a little bit. I think that's a really important part, particularly from the facility perspective, to understand what goes into these systems and how these systems are typically put together. Next slide. So the capabilities and the requirements influence decisions. So the scale of your system, the intelligence of your system, and then how your system communicates. We'll talk about each of these separately.

Next slide. So the scale. Now in this instance, you've got what you've got. Just having that in mind can help you see whether I've just got my one building that I'm dealing with. I've got a whole portfolio. I'm managing campus. That really can make a big difference in what's gonna go into these systems, what kind of capabilities it's gonna have and what architecture and communication it's gonna require.

Next slide. Also the system intelligence, whether it is a central processor that's used or whether it's distributed intelligence. And that could make – just understanding how it's doing that is an important part of what you need to know. There's no right or wrong with this. We'll look a little more detail about getting to the distributed intelligence and LLLC and all that. Understanding how the intelligence is distributed. Is there a main brain that everything is going through that's a service system or is it like an LLLC where you've got a censor in every single luminaire and that kind of thing? So it's important to keep that in mind.

Next slide. How your system is wired and how it's communicating is extremely important obviously and how that affects – this table at the bottom you can see how data is exchanged. An analog system that is only – there's only one way. They're not communicating back and forth. So you need to understand that's what's going on and what you need – how you would troubleshoot that. Digital is a two way. Digital can have luminaire addressability and zoning flexibility obviously is one of the main reasons to go digital. Whether you've got a situation where everything is hardwired or it’s a combination of wireless and hardwired and all of that, just to understand what you've got is important.

Next slide. So that preview, overview to architectural will set us up to talking about the details. This is where I think things get confusing or at least I'll speak for myself. When I was first trying

to understand all this, all the parts and pieces and different manufacturers call things – have different labels for them. They can – some functions are separate devices. Some can be combined in one device, all of that. It's a really important thing to understand to know what to even look for when you're trying to figure out what's going on. Let's step through these.

Next slide. So this is the big picture. I'm gonna step through this one thing at a time, but a couple of things I wanna call to your attention as we start to do that. Next slide. I would say this one part of – at least for me, personally, getting into my head, this concept was the most important for me. The idea is, is something in the luminaire? Is it always in the luminaire or it's in the space or it's in the building or it could be maybe in this system it's in the luminaire. Oh, but this other system it's in the space. Oh, this – it's conceptually understanding that one fact helped me get in my head and understand when I was looking at a manufacturer's product trying to understand what they were telling me and how their system worked.

The other thing I want you to pay attention to, next slide, is that direction of the arrows. Because we use this to indicate when devices communicate with each other, arrows on either side or when that communication is just one direction. Here's the first example. Analog is only one way. Digital is both. So when you look at your user interface, your wall controls, or your censors they are feeding information to that load controller or the gateway, but not both. So this is – we'll talk a minute about how some of these ideas get tweaked a little bit when you're talking about just a root-based system or the LLLC or all that. This is a very high level look at that. So let's step through it one thing at a time.

Next slide. So we've got our luminaire, the LED module. We've got the luminaire driver. It's always in the luminaire obviously. The driver is sending information to that LED module to tell it what to do. You need to – there's all kinds of things to worry about in terms of what that luminaire is doing and how it's programmed and all of that. This is just generic high level.

Next slide. The load controller. I'm admitting too many things in this, but I had a hard time understanding what a load controller was when we were first looking at all of this. Part of what complicates that is that it can be called a power pack or relay or manufacturers can call it different things and it can be in the luminaire or it can be in the space. Basically all it's doing is sending and receiving, can do either, a command to execute for the lighting to do something.

So it's very generic and different manufacturers do it in different ways, but it's an important part of the system.

Next slide. Now we've got the gateway. Now see where the gateway is. The gateway can be in the building. It can serve a number of rooms. It can be hard level. It communicates with the load controller. I should say it can be in the space too. All of our systems at Parsons, because they were individual rooms, those that used gateways, they each had to have a gateway in that room. Often it was definitely overkill. You don't need a gateway in every single room typically. It's important to know how is your system done. Do they want – how many spaces can it serve? Is it in the building or just in the space?

That communication between the gateway and the load controller can be wired or wireless and it's both ways and – I always have to look at my notes – it can be called a hub, a bridge, a central processor. So when you're looking at manufacturer information or looking at your specs, it might not be called a gateway. So you need to know that there's different ways to refer to that. Next slide. Then we've got the parts and pieces that are in the room. Now this is not for LLLC. We'll talk about that in a minute.

You've got sometimes a central sensor in the room, sometimes you've got the other part of luminaire and then you've got the user interface. They are giving – they're telling the load controller and/or the gateway what they want done based on, "There's people in the room, turn the lights on," those kinds of things, which I'm sure we all understand.

Next slide. Then we've got the server. Now the server is in the building or in a campus situation maybe it's for the whole campus. It communicates with the gateway. It can be wired or wireless. So these are the basic components in a generic way. Each system is different. Each manufacturer does it different, but in a generic way, these are the pieces and the way things communicate. So let's look quickly.

Next slide. So in the document itself we have diagrams like this that not only give – show what each of these architectures light look like, but what kind of communication you could likely see. It could be Zigbee. It could be Thread, all these kinds of things that help so you can know what to look for. This is the simplest. You just got one space and it's got a sensor in the room. It's giving direction to that load controller. And the user interface does the same, but this is just a diagram of the simplest room-based system.

Next slide. Then this is essentially what we looked at in the generic one that I stepped through already. This is a more centralized system. You do have a server that's connected to the Internet and giving commands there. You've got some sort of software that you can control everything, but essentially the things we've already talked about there. Then we've got LLLC, the next slide. So with the LLLC you have a sensor in every single luminaire. So they're on that part of the diagram. It's feeding information into that driver and to the load controller.

Then you've got a user interface in the room that's feeding information to the load controller or to the gateway. The key to LLLC is that you've got that sensor in each luminaire. So it gives you a lot of flexibility with your zoning and all of that. Otherwise, the system is similar. It's just the location of that particular device or capability of where it's located in this kind of system.

Next slide. So here I'm not expecting you to read all these, but this was an exercise we went through that was really interesting because we took six different products from six different manufacturers here and we diagramed, in our generic way, we diagramed their systems. So this just gives you a feel for how each manufacturer does things in a slightly different way. I think this was probably the one thing that causes people the most confusion.

We did some workshops at Light Fair and at IES in which we instructed attendees to take the system architectures and I think we started with their capability system. But they had their design in place and we gave them a whole stack of product literature from different manufacturers and we said, "Find the product that can do that. Which one would you pick and how would you know? How would you pick it?" It was really hard. It was really hard because they – 'cause not only are different words used, like I talked about. You got power packs and load controllers and bridges and gateways and all of that, but what a device does is different.

For this manufacturer that does device does two things and for this manufacturer it's separated and for this manufacturer they put it in the luminaire. This manufacturer they put it in – it's not – once you know it, once you get the concept, it's not so bad. If you're trying to just go through materials and compare apples to apples between manufacturers, how in the heck do you figure that out if you don't get your head around it generically? So that's really what this whole presentation is about from – like I said, from the beginning, not from the designing the system or choosing a system, but just

figuring out what you have so that you can maintain it properly and all of that.

So next slide. Here's an example of things you might find in product literature. So they'll have cool diagrams and show what their system looks like and how they are putting things together. Again, when you're trying to compare one to another, can you correct those dots correctly? Like I said, what does each component do? What is it called? All those kinds of things is important to understand. Next slide. So how does this help with maintenance? I'm gonna wrap up here and go to questions, but the main point is to know what to look for and to know how to ask the right questions.

Then there's lots of things we could go over and talk about down the road I could talk about on that first slide about upgrades and all those kinds of things, how do you reprogram something, who do you – there's lots of things around that, but just generically from the beginning if you can get your mind around these basic ideas I think will take you a long way in trying to ask those right questions and understand what you have. So that's all I have today. So good. We've got – must be fast. We've got some time for questions.

Axel Pearson: Awesome. Thanks, Ruth. Sorry. Make sure I was off mute. Thank you for that. Yes. We do have some questions that came in. So give us just a moment and I will take a look at the Slido side of things and pass some questions and comments on to you. So I've been keeping an eye on it and there's been a few that have come in around communication standards. So I'll start with a couple of comments that came in and then a question. So one comment is, "Key issues are end to end device integration and ensuring there are common communication standards between manufacturers comprising the network system and ensuring cybersecurity exists throughout all the devices to the connected network."

Another comment is, "Most manufacturers don't have solid enterprise solutions on the server software side. This needs to be improved for customer adoption. We've been led down dead ends and disappointing. There should be more standardizations like in BAS." So the question here is, "Is there any organization that is looking into standardizing the language and terminology around lighting systems to minimize this confusion?"

Ruth Taylor: I talk about this so much. Yes. This is what I spent a lot of time talking about it at Light Fair and IS and those venues. It's hard. It's harder than you think. When we first came into this I was like,

"Man, the lowest hanging fruit is vocabulary. Come on. Let's just all use the same words." But when you talk to manufacturers and dig into it, you see they're point. They're like, "Fine. I don't care what you call my stuff, but you tell me exactly what to call it and who's gonna decide?"

When I do – when we do decide, ten years later as the standards group figures it out or whatever, I've got to change that how many places? How many PDF documents do I have? How many websites? It's not a simple ask necessarily just to change what would be the simplest thing. For sure we are working on that. I think since we spend a lot of time talking to specifiers on this, I think they are beginning to understand the, maybe power is not the right word, but the influence they have on manufacturers to say, "This has got to happen. If things do not become more standardized we just can't use it."

So I am on several standards committees, as painful as it is on trying to get wall controls consistent. Just wall controls people cannot figure out how to use them. How would you know? They're a different symbol for everything or they don't do anything. There's no labeling on them and those kind of things. Configuration and reporting and interoperability. I know I'm preaching to the choir here. Yes. It is the number one thing, but it's the slowest and most frustrating thing. So we need – the entire industry has got to come together and start really putting the pressure on 'cause it just is a very slow, slow process. I'm not sure I answered the question. I got on my soapbox.

Axel Pearson: That works too. Another comment that came in and one I'm sure that you'll agree with. I do. "One of the most important aspects that we've been trying to address is documenting explicitly the nonenergy benefits or NEB's. We call it NEI's, nonenergy impacts associated with integrating lighting controls at CEA. And I think this is the California Energy Alliance has been trying to incorporate that into cost effectiveness metrics for codes." That is just a great point. Like I said, we're working on it here at PNNL to identify nonenergy benefits and potential pitfalls, but really you know that much of the efficiency as far as watt saved is gained through the LED light themselves and then you're controlling a lower number of watts with a very expensive control system.

So you – but it also does offer so many more benefits and potential energy savings when you integrate it with systems that quantifying those nonenergy benefits are definitely key to improving those cost effectiveness especially when it comes to adopting them in codes,

which have pretty strict cost effectiveness thresholds to meet. So definitely agree with that one. Michael Meyer on our team here at PNNL is working on that. So keep an eye out for more to come on that one.

Ruth Taylor: Well, and I think I would add to that helping owners understand those benefits, but also the impetus for our original document is understanding what you really need and the risks – the complexity involved and is it worth it 'cause not everything is worth that and then you get people who are very dissatisfied. They get a system that just has everything, all these bells and whistles that sounded cool, but it added way too many layers of complexity that they didn't really need and they would have been much more satisfied and everyone like, "Yes, this is the thing to do," when it's really narrowed in to meeting their specific needs.

So really tailoring things around that and understanding those business decisions so that you can help the owner see, "No, no. This is a no brainer, man. This is a no brainer. This one over here, be realistic. This one over here is gonna add complexity and you probably need to add some money to maintain that. Are you good with that?" So they're not – don't pretend it's not gonna happen because then they're really mad that nobody told them and they have this big burden that nobody told them about. Then they're telling all their friends, "Don't do that. That looks crazy," blah, blah, blah. So we need to be more – we don't need to be one extreme or the other. Don't do anything 'cause – or do everything. It's all great. Be very targeted in what you help – the decisions you're helping folks make.

Axel Pearson: Well, I think that I really like the way that your spaghetti slides, you called them, narrow in what someone wants as a capability and what that translates to as a component or a function of the control system. We did drop the link into the chat, by the way, for that resource. So it's called selecting lighting control systems. So if you haven't taken a look at that PDF, that one is linked in the chat. Take a look and that really helps. If you really aren't sure what you need or what your – or you know what your goal is for a lighting control system, like you just wanna meet code, that's a great resource to follow the lines and say, "This is – these are the functions that I need," and like Ruth said, really narrowing it down and tailoring it to what the building owner needs. Let's take one more. "Are there resources or examples of connected lighting configuration reports? I'm curious if there are standards or suggested templates to use?"

Ruth Taylor: What a great question 'cause I'm on that committee. We are making some good progress on that. So it's – we're zeroing in on what utilities need first to be able to – they've given these incentives for control system and then it's been commissioned or whatever. When they go in to verify that can you get an actual read out from the system that says, "This is exactly how it was programmed and configured and all that," and you can verify it.

The other thing – what – I'm interested in that, but I'm really interested in when a commissioner comes in or something has gone wrong with the system and you're trying to figure out what in the heck is going on back to what was it even thinking it was supposed to do. That's really hard to figure out. If you have something, a report that comes directly out of the system that says, "Well, this is what I think I'm doing and is that what you wanted?" It will save a ton of time to just figure that out. We are working specifically on a template and I think we're bringing that next week, I think, to the big group to get feedback on. So that is actually making some – it's a small committee and we're making pretty good progress on that.

Axel Pearson: Great. Awesome.

Ruth Taylor: Thanks for that question.

Axel Pearson: Yeah. All right. So that brings us with just one minute left, I think. So note the e-mail down here at the bottom of this slide. If you have other questions or comments, we love to talk about this stuff, IntergratedLighting@pnnl.gov. Is there one more? I think maybe just a thank you slide. Yes. Thank you. There's the e-mail there again. Thank you for your time today. Really enjoyed talking with Ruth and getting these questions in. Thanks again for your input and helping us prioritize where we need to go and help increase those – the penetration of advanced lighting control in commercial building. So thanks again. Have a good rest of the day.

Ruth Taylor: Thank you.

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