

Axel Pearson: Good morning, or afternoon, wherever you are. If you're just joining, there is a trivia question on the screen. You're gonna have to go to Slido.com to answer it. We've started a couple minutes early to give you a chance to answer this question and then we'll get started as people roll in. So thanks for joining, and we'll get started in just a minute. While you wait, go to Slido.com, enter the event code #DOE, and answer the trivia question.

[Break in conversation from 0:00:55 to 0:01:16]

Axel Pearson: Again, if you've just joined, welcome. Thank you for coming. We're letting folks trickle in. While you wait, there's a trivia question on your screen. To answer it, go to Slido.com and enter the event code #DOE. You should be able to answer that question.

[Break in conversation from 0:01:35 to 0:01:45]

Axel Pearson: I think I'll give maybe just a minute more for folks to join and then we'll get started, so while you wait, answer the trivia question, test your knowledge. There's also a direct link in the chat to Slido too. Might be easier to use your phone, or if you have a separate screen, pull up Slido. This is not the only question that we'll ask today, so it's not a one-and-done.

[Break in conversation from 0:02:24 to 0:02:39]

Axel Pearson: Okay, we're just about a minute after, so I'm gonna go ahead and get started. Hello, everyone, and welcome to this Lighting Systems Technology Research Team webinar. The title is "How to Weigh Non-Energy Impacts of your Lighting Controls Project." My name is Axel Pearson coming to you live from Salt Lake City, Utah. I will be your host today. Thank you so much for tuning in. If you're not sure what the Lighting Systems Technology Research Team is, not to worry. I will cover that in a bit. And if you're not sure what non-energy impacts are, you are in the right place. You joined the right webinar. Either way, I'm glad you're here. I hope we can share some of our knowledge, help add value to your lighting projects, especially beyond the tried-and-true energy savings of LEDs and controls.

If you joined in time to answer our trivia question and joined Slido, the answer is B, 5 to 6 percent. And this comes from research at MIT. They sampled about 5,000 offices in Manhattan and New York City. Let's see how many people got it right. I actually need to log in. I've got Slido here over on my other screen, and hopefully that'll show us, but can we – ooh, a pretty good spread,

but we tricked you. So the answer is 5 to 6 percent. Many people overestimated the value of daylight when you're renting an office space. Still pretty close, but we are gonna talk about this and other non-energy benefits and impacts a little bit later. So congrats to all of you that you got the impact – got it correct. And if you didn't see how to answer that question, if you're just joining, I'll cover how to use Slido in a couple of slides, and don't worry, there are plenty more questions coming, so keep your finger on the trigger and get ready to answer some polls and give us good input. Ooh, I see people are still answering it. Okay, that's cool. Let's go back to the slide deck.

So first some logistics before we get started. Slides and the recording will be posted shortly after the webinar on the Better Buildings Solution Center. If you'd like to navigate there now, go to betterbuildingsolutioncenter.energy.gov, and then you can hover over events and webinars, and then click on on-demand webinars. From there, you can click on lighting. Under technology, there's a bunch of technologies. Personally, I recommend lighting as the best one to find this webinar and many more that we've done in the past, and we'll also send out an email to all of you that registered letting you know that the slides and webinar posting is available online.

I'm gonna cover questions and answers on the next slide, but you can always reach us at integratedlighting@pnnl.gov. For questions and comments, don't hesitate to shoot an email over there. That one goes directly to my inbox. Happy to help you . I've got a whole bunch of lighting experts at my disposal here at Pacific Northwest National Lab, and they're there to help answer any questions, and I promise you they really like it when we get them.

So if you are just joining, didn't do the trivia question, that's okay. We are going to use Slido for polls and questions and answers, so hopefully you've all used it before. If not, pretty straightforward. Go to Slido.com on your smartphone or a new browser window if you've got a couple of screens, and at the top of the page, you'll just enter DOE into the event code box. And so that's where you can answer our poll questions, and we do have a number of them for you today as well as Q&A, so you can answer your questions, and then we'll take some time at the end to review them. There's a ranking function. You can upvote questions. It's pretty cool. So if we don't get to answer all your questions, we will be sure to follow up with you via email, so keep an eye out for that.

Here is the agenda for today's webinar. I'd like to introduce you to those of us on the webinar today. I'll tell you just briefly about three upcoming events that we're aware of and that we'll be involved with, and hopefully you're aware of. I'm gonna take a little bit of time to give you an update on the integrated lighting campaign, which is a similar DOE lighting program if you're not familiar with it, but I hope you are. So I'll tell you a bit about that and our recognized partners. And then we will get into the main attraction of the webinar, which covers non-energy impacts for lighting controls projects. Okay, that's what we've got ahead of us for the next hour or so. Again, feel free to send in questions via Slido as they come in. I'll flash up my contact information at the end, but again, integratedlighting@pnnl.gov. and with that, I'd like to introduce today's speakers, so we'll go to the next slide.

Just two of us here today. I am there on the left. Again, my name is Axel Pearson. I'm a project manager here at the Pacific Northwest National Lab. I lead the integrated lighting campaign and the Lighting Systems Technology Research Team, and I put on events like this one. On the right there is my colleague, Michael Meyer, senior lighting researcher and one of the top lighting nerds here at PNNL, and he'll be covering the non-energy impacts content, and he's gonna ask you for your input along the way. So you're gonna spend the next hour with us. I hope you're ready.

Moving onto what brings us together today, this webinar is a production of the Lighting Systems Technology Research Team. We aim to reduce lighting use by sharing insights and experiences related to emerging lighting and control systems and documenting solutions. We wanna share our work with you and also get your input on how we can help you save energy, improve your buildings, improve your occupants' experience, all through lighting. And this is really intended to be a collaborative effort, and that's why we bring all of us here together and ask you for your input. If there's a topic you're interested in or you want to get involved or you have a question for the lighting experts here at PNNL, let me know, let us know. We'd be happy to talk with you. We love talking lighting. So thank you for joining, and whether you know it or not, thank you for being part of the team.

Just a few events that I wanna let you know about in case you're not aware of these already. We have the IES annual conference coming up in early August. That's held in Schaumburg, Illinois. I personally will be there. I'm gonna tell you a little bit about why in the next slide. And then the next event we have is the Design Lights Consortium's Control Summit. So they gather a bunch of

stakeholders from industry to talk about lighting controls. That will be held in Detroit, Michigan, September 26 and 27. I don't think registration is quite open for that one, but it's opening soon, so if you wanna get involved with that, I encourage you to go to DLC's website. And then finally, IALMCO, which is the International Association of Lighting Management Companies, is holding their 70th annual convention and trade show. That is in Indian Wells, California, just outside of Palm Springs, October 8 through 11. So that will be a good one if you're itching to go to the desert in California. That's the place to be.

I mentioned it, onto the integrated lighting campaign. This is my child. I hope you're all familiar with the campaign. If not, just like the name sounds, the ILC recognizes innovative lighting projects that push the envelope in terms of integration, energy savings, novel capabilities, and non-energy benefits and impacts. So we have just made the determination on our recognized partners for this year, the 2023 campaign year. We are recognizing eleven participants. That means lighting projects and three supporters. We – I'm not gonna announce them today. This is just a teaser. I'm gonna announce them at the IES annual conference that I mentioned last slide. So if you're going to Schaumburg for IES annual, come to our session on Saturday. I'm gonna announce and present on our recognized participants, but we'll also be sending out an announcement via email and promoting them over the next few months, so keep an eye out for that soon. One last note, we will be holding another year of the campaign, so next year, if you have a lighting project that you think would be a good fit for the campaign and you wanna be recognized, please let us know. I'd be happy to get you set up and get you applied for next year.

With that, I am gonna pass it on to my colleague, Michael Meyer, to tell us about non-energy impacts. Take it away, Michael.

Michael Meyer:

Thank you, Axel. And yes, I am a big lighting nerd, or just in general lighting nerd. And this will be pretty interactive today. We are, as Axel alluded to and some of you have already started using, we will be using Slido a fair amount, trying to get some feedback on some data sets and processes. And I did see one or two people ask some questions or raised some comments there, so please push them through as they come in as you see fit so that way when we get toward the end of the hour, we either have some feedback, not just questions. We'd also like to hear some of your opinions on whether or not some of the data sets are okay to use or what concerns you have in processes.

So non-energy impact, non-energy benefit. You've probably heard NEB, which is the abbreviation for non-energy benefit, a little more. The idea there is that we're gonna look at a widget or a process, and how does it affect the building system, or sometimes it's applied to the utility, and what does it give beyond just energy? And often we thought of, well, let's look at the positive aspects of it, so therefore it's a benefit, and let's try to value and realize those value of those benefits. And so that's where the idea of NEB came out of. It's morphed a little more into this term NEI, non-energy impact, and the reason is that not everything has a positive aspect to it, and unfortunately, a simple example is advanced controls, whether or not they be lighting controls or sometimes some advanced mechanical controls, there is an assumption, right or wrong – we can get into that – that it requires more skilled maintenance or it requires more constant maintenance. And as a result, that increased maintenance is going to be a cost, and therefore it is an impact. And so that's where the idea of NEI comes from is that not everything has a benefit. There are some costs that are related to things. So the terms are semi-interchangeable. Again, a lot of shorthand. People use NEB, but then again, there's some new researchers who are looking at this concept of NEI to really realize that.

So let's talk about that. What does an NEI really mean? What is non-energy? So we're looking at how does, again, the widget or the process improve either operational functions, possibly property values as you saw in that question about daylight and how it affected office premium, and then the holy grail that everybody's desperate to try to figure out is how can we use this widget or process and how does it affect the productivity or the performance of the occupants in the space. Sometimes people try to lump other things into NEIs, and they're really not as accurate, such as grid or demand response. Those are still really ultimately an energy function. If you do a demand-response event, you are saving power and ultimately doing something that's beneficial to the grid, but that's really wrapped up still in that normal energy aspect of it. Similarly, if you're using a lighting system and you're maybe connecting it to the mechanical system to communicate with the mechanical system to set back the temperature or just looking at a reduced cooling load, again, that's really not non-energy; it's just non-lighting energy. So again, it's not really NEI. Those – both examples are energy related. So again, way to think about this, the overall bucket of NEI is how the widget or the process improves the space beyond an energy component, and when we look at that, we're looking at operational, property, or productivity. Those are the three main buckets.

Then we tend to characterize NEIs into three major categories. A fair amount of researchers have looked at this. You typically look at it from a utility point of view, maybe a societal point of view, and then ultimately what they call the participant – I sometimes call it the building level. The idea with the utility is that they might be valuing NEI for different reasons, such as if they reduce energy, that might have secondary benefits to them such as less debt, fewer customer calls, reduced payment arrearages, those type of things. So utility tends to be interested in NEI, and they may actually value an NEI differently to incentivize participation in a program because they're getting benefit utility and at the grid level separate from the building or the participant.

And then you might have what we call the societal ones, so these are greater things than just any of us, and these tend to be the secondary related elements of energy. Maybe it's air quality, so if you have less energy used, your overall air quality tends to be improved depending on the type of power plant that's generating it. You can also have some water quality impacts. So the idea of societal ones – these are again grand NEI aspects and you're now recognizing the externality of that and how it affects maybe employment or reduced coal ash. So those are examples of societal.

I suspect many of you on this call are probably more leaning toward the participant, or what I look at as the building, the owner, the occupant. Why are they choosing to install possibly this more expensive widget to get some additional benefits beyond just energy savings? And so in this case, you might be looking at operations and maintenance, whether or not the – easiest example there is LEDs. They wear longer life, and therefore we have factored that into early cost analysis. It could be something as simple as using lighting controls and a Bluetooth beacon let's say a wheelchair in an airport to help find your equipment. It's reducing the operational cost. So that's an example of operations and maintenance. Could be how you improve property values. The opening slide was about daylight and the effect on rent premium, so in some cases, either the appearance of the light or daylight or some other function might actually increase either the value of the home or the building, and that might be something. Participant health impacts, that typically leans more toward the IEQ side and air quality, comfort, and then again, as many are interested in, how do they make building occupants more productive or improve their performance or those type of things. And there's potential where lighting or other IEQ aspects

could play a role in that aspect, and many people are looking at that. And then again, that health is tied to maybe reduced hospital time. Time in the hospital has been related to daylight exposure in patient rooms. So again, everyone's trying to look at how can we take that information and convert that into a value to make decisions.

Which should be bringing us to our first Slido poll. So this is a whole list of questions that we're asking you. So I just quickly touched base on what are the main categories of NEIs. We're just trying to gauge your interest. What are you here for? Are you here for maybe utility NEI, and then within the utility ranking, which ones are you interested in? Are you here maybe for the greater societal? And now I see people ranking these pretty quickly, so this is exactly the type of response, and this is why we like Slido. So we've got two or three people – and this'll change in real time. So it tends to be many people are here on the participant level, but we do have some societal level. So we have about four or five people ranking, so I'll pause for a second. I think the list is about 16 lists deep. Please scroll all the way down in case you'll find it. The Slido that you're looking at populates the top responses to – moves them to the top for us, so that's why we're seeing them. You're also seeing it while it's recalculating the numbers overall as we're changing. But so far we've had about 11 people respond to the question, so we'll wait about 10, 15 more seconds, hopefully get this number a little higher in our participation.

This is very helpful for us for a couple reasons. One, lets us learn more about you. And then ultimately where we're trying to take some of this research is how do we take your interests and then tailor some of this NEI-related work, maybe in this case let's use comfort as an example. If comfort is a large focus of a number of people who are either attending this presentation or who are interested in NEI in general, that allows us to tailor that research. So we've got about 25 responses. Like I said, I'll wait probably maybe another 10 more seconds. I feel that at this point we're seeing kind of the quick responses where, at a high level, there's a lot of participant level, a few at the societal level of air quality, and someone – a few people are very much interested in some of the benefits on the utility side. I would say the utility side, there's a lot of active interest in that area about utilities and the regulators for these reasons because they like to encourage participation in these programs, and so that's why people are interested in it.

We'll include these – I don't entirely know how the video works, how we'll dump this information when the final tally comes in

'cause you can still vote as long as you want. Some of you may be reading more or less, but at this point we're gonna return back to the presentation and move into the next slide. There'll be a few more polls as we go, so just keep being good Slido participants. Back to the slide.

Okay, so back to another question. So here's the second question. What is the estimated breakdown of workplace costs by salaries, benefit, rent, and utilities? So you have three categories – salaries, rent, and benefit. What are your percentage breakdowns? Let's go back to the Slido poll. So we have some responses coming in. This'll be a good lead-in question to our next slide so we get a sense of kind of where all these break down, though I feel that we're getting some consensus opinions here. I really do like the Slido process because you get to see the real-time response where all the – how we're all coming in and the numbering process. I wanna pause while you're doing that. Please keep the questions coming in. If you have webinar-related questions, you can use the Q&A pane. I see someone asking about where the deck will be located, and we'll follow up later with that one. If you have general NEI questions, you can always use the Slido Q&A pane if you have any questions come in. We've got about 32 responses, so I would say looking at this we have two – one main answer, but second runner-up. Most people think that it's about a 75 percent salaries, 15 percent is rent, and 6 percent utilities, and a close second is 90 percent in salaries.

So many of you probably are attending this have heard kind of that famous 3-30-300 rule that was really popularized by La Salle. They're a commercial real estate building company. Now, they tend to think of things in a per-square-foot basis because that's how real estate works, and it makes a lot of sense to talk in that sense. And so they set up that simple scale where essentially utilities are your smallest portion, which was the same in the slides that we showed you, and then you have essentially a ten-factor cost increase for rent, and then they suggested they have another ten-factor increase for salaries. Or the distance between your salaries and your utilities is essentially 100-to-1 ratio. CBIESE, which is out of Europe, in 2005 did a slightly different approach, and the reason I like this one is that it gives you a percentage of cost of an organization. You as a company or you as an organization probably know what your budget is, and you may think about it in terms of this is how much our operating is and this is how much money we bring in or our budget. And it's easier to break it down into these percentages rather than trying to understand what the per-square-foot relationship is at Lasalle.

Now, what you'll notice between these two completely done independent processes is that you're seeing about the rent-to-utility relationship is about 10-to-1. Then you're also seeing – then what you're seeing is essentially, in this case, the rent-to-salaries on the left-hand side is essentially about an 8-to-1 relationship, and then from the utilities to salaries is essentially 185 percent. So the relationship magnitudes are similar, but I like the one on the left because it allows CFOs and others who know their budget rather than thinking about per square foot how to break it down quickly. And again, I think these numbers probably have dwarfed a little bit post-pandemic in the restructured work, for certain building sectors. There are probably people who are now more on salary, less on rent, and so it'd be interesting to see where this number is in 2024 being ten years after the major point of the pandemic.

Why does this matter? Probably you know this, but let's talk about it anyway. Utility costs are a small portion, so everyone's trying to think about how can we tap into that greater value potential, whether or not it be rent or whether or not it be payroll.

So let's get into the process. Here's a series of about nine different studies that were done, different places, different locations, using house premiums on the green high-performance metrics. So you can see over here on the left what the sales price premium is and what the ranges are. You can see that we provide the study name, and then these were done in different locations across the domestic United States. Some are national studies; some are regional studies. And you can see that they've been done over the last 20 years. It's a very tight average, though. And the reason I like this is that when we think about NEIs at the building level, they tend to give you more consistent answers than when we get to that human aspect, and the reason is that there's many factors that are going to affect your human performance or productivity, and the ranges tend – the numbers tend to be pretty broad ranges. And they also tend to be very hard to monetize. So I like thinking about if we're going to prioritize our NEI work area, looking at that first – that middle band as a starting point is probably the best place to look at is how can we perform – improve on the building operations or the building value for consistent. But we also have to build up this data set of where are we getting this data from and how are we calculating it and how are we using it.

So this is a slightly different – the previous slide was residential, this is now rental commercial buildings. Again, you can see over

on the left, the perceived rental premium as a result of the building, whether or not it being LEED or a few other variations depending on the certification system. Again, these have been done over the last 20 years by different studies. Again, nice consistent range. I know real estate has some different ranges. You're always going to have whether or not via a downturn in the economy, location, those type of things. But again, you can see kind of this next clustering of prices are of premiums, again, related to the building level. We have consistent data, and it's easy when we look at those type of things. It gets really hard when we start looking at the performance of humans and all the variables that affect them.

The other thing that I think is important is to gauge your poll, and people are already responding, so thank you. How many data points? So in those two previous examples I showed you, roughly ten studies that would show you what the premium would be, whether or not you're doing a study on residential or commercial buildings on a high-performance certification of that dwelling and then you'd be able to make a representation about the value that that certification gets. So we're here asking you how many – what would be enough to establish a trend. And this is important because as we start trying to build out this NEI model, which you'll see again in a little bit, this is gonna factor into the workflow as well as the data sets. When we first asked this question, as many as I could get got a lotta votes. Now we're seeing that people really need to see five, ten studies before they would consider that a valid data set to consider how the appropriate approximate NEI for that building. And so this is very informative, again, as we are building out this process to know, okay, we need to focus maybe on certain NEIs to see if we can get this number higher if this is what's goinna be the minimum acceptance or comfort level for a data point.

I think we kinda get the flow there. Again, it seems to be that a lotta people want somewhere between – more than five, a lot would prefer at least ten, and then some of us love the more the merrier. Going back to the slides, please.

Okay, so let's talk about some of the studies that we looked at and their processes, and then we'll get into our process in a second. So this is DNV. They're a utility third-party group. They did this work for Puget Sound, which is out of the Northwest. They established a methodology. What they did is they reviewed the published NEI studies. So again, one of the challenges with an NEI process and how you value it is you've got to go out and gather all of those NEI studies so you can document what the numbers are. I showed you

those. They developed weights based on confidence factor and plausibility, which you're gonna see in the next slide. Confidence is a series of questions related to the level of review document. So one of the challenges we have with these NEIs are someone publishes a report, but it may be limited to the Northwest, or it may be limited to primary education, and you're now trying to extrapolate those results. So the idea with a confidence score is how can that research that I've read, how can I weight that now to apply that to a grander process or to my specific location. Plausibility is a similar idea. Here they're looking at maybe the report was published five years ago. What has changed in those five years, either through technology or to practices, and would I now weight that differently? As well as they include in the plausibility factor some things related to the technology changes and other factors.

So this is kind of a quick snapshot of some of the underworkings of their slides – of their methodology. So here you can see the confidence factor over there. So what they do is they ask the reviewer when they're calculating this NEI process, they ask them these five questions, and each question gets a certain level score from zero to three, and then you combine them and you get a weight. And then essentially – so you can see is the measure specific? How was it done? Was it done using a statistical method? Because some of the data we have on NEIs can be really deep into a scientific process with good statistics. Some of it can be pretty broad and just be kind of near saying this NEI improved performance and not provide a lot of technical background on how it did it or statistical rigor of showing what it was. So here you can weight it. Each question has a different series value, then you sum those up, and then ultimately you would multiply that times the NEI that was reported in the calculation below. Similarly, they have a series of questions related to their plausibility factor here. And here you can see where they're gonna ask about the age of the study. So in their model of the older the study, the less weight they give it, ideally the newer, more fresh research is gonna give a higher score because it's hopefully gonna be germane to what we've been doing in society at the time, so that's gonna build into it. They also looked at what has happened to that technology since it was published. Has it improved itself and, therefore, maybe you should weight it less as a result of that?

So the reason I'm trying to show you is that the NEI process involves lots of subcalculations and lots of questions. you need to evaluate every NEI that you're reviewing and then come up with a weighting factor for each of them. So in this case, D&D's process

is you would take the NEI that was found in the previous report, then you would multiply it by a confidence factor that would be determined by you, your site-specific confidence in that report, then you'd multiply it by your plausibility factor. How much do I think that this accounts for – this new report is based on where we are today based on what I know about it? And then they also had an economic adjustment where maybe that NEI had a lot of value because it was in, let's say, New York City, and the example that we showed with rent, but where you're located in Manhattan, Kansas, it has a different economic value, so you'd scale that way. And that's how they got to their NEI process.

Another example is the study of summary of study of IEQ studies and productivity. And this is definitely what I've been trying to slow down on, and this is where I think those plausibility and confidence scores really are going to become a question, and that's gonna be one of our next poll questions in a second. There's a wide range in productivity. To think that either temperature control or lighting or improved IEQ can boost your performance by 10 to 40 percent, I'd be very concerned about that analysis because then either was the sample size small, was it a short duration analysis, or other factor? What would make someone's productivity increase by a factor of 40 percent just by having access to temperature? Unless it's a really horribly hot space or cold space, productivity tends to be, again, multivariable, and so you wanna limit that. But you can see the wide range of the studies. Because the values on humans, everybody looks there, but again, this is where we need to put the most caution and look at how do we evaluate each of these studies individually and weight them appropriately?

So then this is another analysis. This was published in '23 at the start of the year. This is a survey-based approach. This was done by the DesignLights Consortium. They hired a third-party group who's very versed in NEI research. There they found that utility programs that value NEIs and cost benefits essentially 2.3 times. That's good. That's what we like to see. That means for every \$1 you're putting in, you're getting about \$2.30 back, and that's our value. And they also found that NEIs value at approximately 11 percent of full-time staff maintenance. And then they also found building occupants' self reported productivity improved through network lighting controls. Now, the only caution I would have with this approach is that this is a survey-based approach, and so what they're doing is they're saying if this control went in, how much would it improve your performance, and you as the building occupant or building manager would respond, oh, I think this would have more time or less time for maintenance or my

productivity would be better if I had this control or not. So it is not quantitatively assessed through a rigorous analysis of how much work did we produce over the year. This is a qualitative process where I subjectively determine how much I would be improved through its mechanism. Would lighting controls make me more productive? And that's how I assessed it. And so that's a different way to do it. So I just wanted to touch base on this approach.

I showed you this already, which already had the IEQ studies and productivity. I just wanted to kinda mention most of these are done through the quantitative approach where they're essentially measuring how you perform and what the outcomes are.

So then this gets into, again, that qualitative approach or survey approach. What level of comfort are you gonna have? So here is five, six studies that show a wide range of output, but here's the thing that we need to think about. These studies go back as far as 1980, to essentially the year after I was born. What has changed since then? The way we work, the lighting situations, everything about that. So how much stock would you put into a data report from 1980 that was done with a duration of two days? Would you put more stock in a report, let's say, that was done in 2014 that had a participant size of 49? Or conversely, would you put more stock in a 2002 report but it had 290 participants that went on for two months? So again, the challenge we have is we can find examples of NEIs over time from different sectors using different technologies, but then we have to – we can't just take that number and say, well, this report found an 8 percent improvement in productivity, which is what that lighting productivity gain found, by increasing the illuminance without pausing and saying, wait a minute, what has changed since 1980. The answer is everything. So how much stock do we put in that answer? That's where the weights come in, that's the idea of the plausibility factor, and that's the idea of confidence factor that you have to build into this NEI calculation.

So we're now asking a poll. We're trying to understand – again, this is for us to improve the methodology and help us get rid of certain data inputs. As we're reviewing NEI data inputs, what is your preferred rank of, whether it be a survey-based approach, maybe a manufacturer case study, maybe a third-party case study, or do you think – do you prefer it to be a structured journal article that looked at qualitative methodology where they do a pre and a post, they measure everything? So again, the idea here is showing you all kind of the different data set examples. I get out there and explain to you some of the concerns that other NEIs have looked at

of how do you weight the confidence of it or the plausibility of it. Now you as potential buildings or utilities or others who might be implementing an NEI into your value calculation if you knew that the underlying data was X, how would that affect your answer? And so we're seeing that overwhelmingly it appears – we've got about 22 responses – most people have said they want that third-party review data and then maybe – I'm sorry, I said third-party but I really meant peer review is what I meant to say. And then they ranked it second by third-party case studies, and it appears that the least comfortable or least ranked data there would be manufacturer-based case studies. And so this'll help us as we build our NEI database know what to factor into.

So then we have a second question is can you also rank the data set by importance? So I showed you – our last question was all about how accurate or who did the data set of the NEI. Now, as they start sharing this data, do you consider participant size important or duration or the age of the study or the metric? And the metric could be whether or not they're using illuminates as a proxy for circadian health. Or maybe they're using temperature for a proxy for IEQ. That's the idea here. So again, this helps us as we build out this overall process as well as our NEI data set to then maybe skew certain inputs related to, this case, studies that only have a sufficient participant size or younger or newer, I guess, studies versus older studies. Seems duration right now is less of a concern. So more important it seems that if we test this on 100 people but only over two days, people seem to be more comfortable with that than maybe saying testing it on ten people over 20 days. That'd be an example of this ranking, so I appreciate that. I'm keeping an eye on time as well, and I think we're done with that question.

So we're moving to the final steps. So this is where we're getting to, and this is kinda where we need your help, and this is what we're looking for. So we have started working on building up this data set of NEIs. We're looking at them. In this case, we tracked – here's a simple example, rent and minimum daylight spatial autonomy. So that was what that first slide was about, was what is, if we increase the daylight in a space, what does your rent premium look like? So that's the type of things that would be captured from a journal article and measured and built into an overall data set so then we could build this into the calculation. So then we found _____ capture the magnitude of the NEI. This in case would be a 6 percent rent pricing premium. You could also capture this with, let's say, IEQ, lower CO2 levels have an improved employee productivity of 4 percent, whatever the number is. But here you're not only documenting what happened

but also what the outcome was. So in this case, the benefit being a rent pricing premium. So then we've answered almost all of our questions for Number 3, so weight the data set based on, from what we heard, you want – prefer a third party, you prefer a large participant size, and a few other data sets, and we'll build that into our process there.

Once you've weighted it, you then identify a representative cost. So in this case, I live in Albany, New York, so I picked the average rent in my location, and so the average current office rent is \$19.62 per square foot. So then I would multiply it by 1.06 percent, which is my rent increase. And then I showed you these weighting factors, one, two, three, and N, and that's what we're gonna hopefully finalize in what these weights actually look like based on the feedback you just gave us. And so their idea there is we'd come up with a standardized process that you would walk through and you would answer questions of did the NEI that we're using have four reports that showed similar results. Do they have – can we weight those reports based on age and sample size and those type of things? So you answer those questions and that's how we would develop those weights. In this hypothetical scenario, I said all those weights reduced to 0.97. So then you can see that in this scenario, if I had a rent – an office in Albany, New York, that met a 55 percent spatial daylight autonomy, you should be able to actually get a rent premium of \$20.17. Now, that is less than a 6 percent increase, but again, that's the whole point of these weights is that the reference document gave us one number, but that number is only applicable to really that report, that one point in time, and then you build all your weights to factor in how to either change location or change all the variables that you need to change, and then you get essentially the cost for your location or the benefits for your staff or what the improvement in X would be.

As I've mentioned, this is where no one has cued into the Q&A and discussion, but we'd love to hear your thoughts here. These are our kind of next big hurdles that we're locking into is determining the weighting factors and the ranges. How many questions should we ask? What would be an acceptable number? Is five weights acceptable or do people think that, hey, I can only spend ten minutes on this task, we can only ask three questions, and what would they be? I've talked about the polls, which you guys have helped and we're gonna take and we're gonna build into our process. What did we miss? What type of things do you think should be considered? We talked about the size of the study, the type of the NEI that we found, the number of reports that showed that same value, we talked about duration, we talked about the

methodology. What did we miss? I see some questions coming in here, so I'll look at those, so thank you for those questions.

What applications should we be looking at? Now again, we went really high level with this presentation. We talked about rent and we talked about loosely on productivity and student performance. We gave an example of wheelchairs and the lighting centers. What types of applications are people looking for? Where do they feel the NEI is either ready to be grabbed and we just need to build it out? Or is an untouched area that hasn't been looked at? And then finally the question that we're desperate to get someone to answer is we've built this methodology out, we're building it out even better. How would your organization, your utility, your building, your school build this into a financial calculation? So if I'm gonna put a color tuning system into a classroom, how did you get your school district CFO or whoever the correct person is to approve spending more money than a standard lighting system because you said here's the benefit. We showed you the calculation, now we want you to spend a little more money 'cause we're gonna get this value. But it's hard to translate value to real dollars to financial people. So the question is how would your organization do that? We're desperate for that feedback.

While we've got some questions, I'm gonna look over here. Would it be possible to build this proposed process into a calculator to be used in evaluating design options? I think that's an interesting question. I think we could develop concept and then maybe a modular aspect that would allow for it. And then I think, Axel, the next slide is a discussion panel so I should invite you in. I just get so enthused by Q&A and I just jumped into it. I apologize.

Axel Pearson:

Yeah, no worries. Yeah, you are right on. Yeah, thank you, Michael, that was great. Yeah, so we are now in the question-and-answer phase, so Michael, you answered one, but now is the time if you've been holding a question, go ahead and enter it into Slido.com. Again, if you still need to get there, you can use that QR code. You can go to Slido.com and then enter the participant code DOE. There are links in the Zoom chat sent by our tech support, Anna. So yeah, go for it. And it also doesn't have to be a question. If you have some input to some of those questions that Michael was just asking on those discussion points, the last slide, just throw it in there and we can discuss. I know that these webinars don't give us a really good way for two-way communication, but we will use Slido as best we can. So with that, let's go into the next question. Are there certain regions of the US that have more NEI studies than others, Michael?

Michael Meyer:

I'm gonna answer that in one second, Axel. I would like to say, though, could we also go back to that other question 'cause I'd like to expand on the calculator question to the audience. In terms of NEI studies, yes, there are more regions. I feel that the Northwest has done a little more work in this area. I think the real question is we need to get specific on the NEI study. When you say more NEI studies, are you talking specifically, let's say, about lighting? Or are you talking more specifically the utility level or the building level? Residential, again, as I showed you all those examples, those tend to be populated a little more on the East Coast. That's 'cause some of the certification organizations related to residential tend to be located out here, and they've also got some other reasons why they did it just because of geography.

But in terms of utility level, we've spent a fair amount of time in this area. I do tend to see, again, more on the East Coast and the Northwest who are looking into it. I think some of that's trying to increase their participation in their existing programs, and I think that relates to some regulatory reasons. But then if you want – again, when you say NEI studies, those things that I'm referencing, a lot of those are really related to the valuation of the NEI. If you're just looking at a high-level question of what NEI data research exists, that tends to be across the country where people looked at whether it be how many days in a hospital does someone stay because of daylight, those tend to be more regional based on where they're located and things like that. There is a plethora of studies out there in the IEQ world that have looked at what are the benefit or the impacts of the non-energy impacts. The valuation's still the thing that's not standardized.

It would be really helpful to capture quantify the productivity loss associated with poorly implemented lighting control systems. Yeah, I mean, in general, when we get into productivity, everyone should get a sense in their head that you're talking small numbers. You're talking 1 to 10 to 15 percent. Anything beyond that, you've got a bigger problem. I mean, we know from vision science that you can do a fair amount of performance under low light, so that's where that is, as well as we know there's a huge number of factors that affect performance and productivity, and one of the challenges with productivity research and why I'm always nervous to approach it is – it's twofold is that, unless you can show a true rigid output of I sew this many shirts an hour, it's hard to convert that into office settings or teaching settings. You can't really say teachers teach more in good lighting or a lawyer can write more briefs in good lighting. So you run into how do you – they tend to

use secondary metrics of in this lighting condition, people were able to do word searches faster or number cross-checks faster, and while that is an easy-to-do research, it is very hard to take that example and extrapolate that out to your normal job.

And I would say the other challenge with productivity is how do you monetize 3 percent of someone's job. How do we say, in this example, poor lighting design, whether it be contrast or glare, resulted in a 7 percent reduction in productivity. Seven percent is a small number, so it's not like you can really eliminate an employee or add an employee, so how do you monetize those type of things is still the question. Again, we can do it mathematically. We can take your salary, we can do all those, and we can say based on this, this poor lighting is costing you \$12,000. You can do it algebraically, it's not hard, but then how does your CFO appreciate that is the question with some of these productivity numbers?

What top three NEB control strategies are being adopted across the country by vertical market or segment? I don't know if we have good data on what strategies are being adopted. From a lighting control point of view, really the lights are everywhere, so everyone is really trying to tap into the space utilization and little less so now with COVID concerns being different that they are. There was kind of some of the contact tracing. I would say schools are very interested pretty much across the country in different reported of color tuning, whether or not it being – it's good for conditioning children in bright light we do this, low light, and maybe low color is when we kind of are relaxing. So I know at least three different school projects. I think two of them that Axel shared with me of schools looking at color tuning, and again more for – not for an improvement in educational performance but more of a conditioning of the students know when the lighting system is this they can be loud and boisterous, and when it's a lower light shows bright and warmer tone, they know it's quiet meditation, reading kind of phase. So I would say that's an example. Color tuning I would say by far is really in the educational setting.

Color tuning's got limited uptake in the office setting, but from a controls point of view, really what else can you do with those sensors, whether or not the asset tracking or space utilization. The space utilization from the office sectors I've met with and chatted with is the data is confusing what to do with. They make decisions kind of long-term, three, four years, and having that space utilization data now is not when they make their decisions. And so how do they build that process out? I think that's the best answer.

It's a good question. It's worth asking about, looking into a little more, so thank you.

Wouldn't a simple payback with NEI and illustrating a shortened payback be a good addition to gaining confidence? So the person who asked this question about an NEI with a simple payback, I agree. Again, the challenge is that most financial people – energy is a cost. I can point to where it's saved. Staff FTE time in maintenance because of – for mechanical equipment like AFDD through that, you can point to where we have four service calls, with automatic fault detection we had two service calls. You can monetize that and you can point to that easier. Where you start running into some of the challenges with NEIs are how – do you have the data on what is the cost of finding wheelchairs in an airport? We know it helps, but has anyone actually figured out what that actually costs to a CFO? Or as I say, when you get to that actual true performance and we say, well this improved productivity, how do you monetize a small portion of someone's salary? That's where the CFOs tend to get into less confidence, but that's what we're looking from you. Tell us what your organization – how would they treat this data, and how would they build that new calculation?

Do studies typically take into account just one perspective, or should they ideally weigh each? For example, an 8% increase in rent means 8% in pocket for owner and perhaps 10-15% out of pocket for tenant? I'm sorry, I read that quietly to myself. I think that's a great question, and I think that's a prime example of why it's called an NEI that I didn't think about of, yes, this example of rent, the owner's getting – could get more money. The tenant is now paying more money, and you could conversely say are we seeing an increase in performance because of daylight in those spaces? So I think that's a good question. No. Typically, most studies tend to look only at a population and not looking at the flip side of who may be possibly other effected. That's not always – the studies don't always do that, but the valuation could possibly look at how it affects both sides. But that's a really good question. Thank you for asking it.

Another concern is the monetization of working populations relative to productivity. There must be a way to diversify or partition worker pool rather than simply aggregating them is a single example. Better your problem than mine.

Yeah, productivity in lighting, we could go all the way back to the '20s and Hawthorne. It's something that lighting has been looking

at in productivity, honestly, for 100 years. It is – this person highlights at least one if not many of the problems related to it. A true productivity study really needs to have separated groups, longitudinal. There's a lotta things there, and again, suggest that lighting controls or quality of lighting are gonna have a major improvement on productivity, and I gotta say major, 10, 15 percent or more. The lighting conditions have to be pretty poor because, again, there's so many other factors in productivity. But productivity studies are really hard.

Axel Pearson:

Awesome. That is just about perfect timing. We are out of questions now, but if you still have a question that you haven't had a chance to ask or maybe you're noodling on this a little bit later, feel free to shoot me an email. There is my email on the screen. Also integratedlighting@pnnl.gov all goes to the same place. I will get in touch with Michael, and we'll get back to you with an answer to your question. But now I think I'm proud to wrap it up at this point. Michael, thank you so much for your time and expertise on this fascinating presentation. Thank you all for your great questions. That was a great discussion session at the end. If you can't tell, Michael likes talking about this stuff. If you wanna get in touch, please do so. So with that, I will just go ahead and say thank you so much for your time. Keep an eye out for more webinars from our Technology Research Team, and we'll keep this going. Thanks very much. Have a good rest of the day.

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