Axel Pearson: Hi, everyone. I see some folks joining. We're going to give a minute or so for everyone to roll in, but you should see a trivia question pop up as you join. Feel free to answer that while you're waiting. And again, we'll just get started in just about a minute. And no Googling. Honor system on this trivia question.

If you've just joined we're getting started in a minute. Feel free to answer the trivia question. You should see a poll up on your screen. Hang tight. We'll get started in a minute or so.

Okay, I'm seeing the number of participants level off a little bit, so let's go ahead and get started. You still have a chance if you want to answer the trivia question. We'll look at the answer in just a couple minutes. But let's go ahead and get started.

So hello, everyone. Welcome to this Better Buildings webinar, *Advanced Lighting System Solutions: Experiences from the Field and Resources from the Lighting Systems Technology Research Team.* My name is Axel Pearson. I am coming to you live from Salt Lake City, Utah. I'll be your host today. And we have quite a program for you.

We'll hear from a couple recognized participants of the Integrated Lighting campaign, who will tell us about their advanced lighting systems. And then we've also got a number of polls for you to provide your input on how DOE resources can help more buildings install advanced lighting systems and provide the most valuable impact. So thank you so much for taking time out of your day to listen in and participate with us.

I will say slides and recordings are being made, so they will be posted shortly after the webinar.

Next slide.

Okay, let's close that poll, Dana. Here is the trivia question. I hope everyone got a chance to answer. Let's take a look at the results. The correct answer is B, 1962. That was when the LED was invented. And I have a source down at the bottom of that slide if you want to check me on that. Dana, I didn't see the results; maybe you already shared those. Can we see?

Oh, do I have to – maybe I have to answer the poll to see the results. Oh, that's not it. Okay, maybe I'll see that afterwards. But good enough for now.

Okay, let's move on. Next slide, please.

So here's the agenda for today's webinar. We'll spend a little time on welcome and introductions, I'll tell you a little bit about our recent work and some upcoming events that you should be aware of. Then I'll give a little bit of context and background on the Lighting Systems Technology Research Team, and a related program called the Integrated Lighting Campaign that I hope you're familiar with as well.

We'll get to hear from Shanna Olson and Adam Hutchinson, who recently completed some very interesting lighting control projects and were recognized by the Integrated Lighting Campaign last year. So I'll introduce them a little more formally in the next slide. And after they speak we'll talk about Better Buildings resources and I'll ask your input on how best DOE can help the building industry improve their lighting and save energy.

So that's what we've got ahead of us for the next hour or so. If you have questions or comments along the way feel free to enter them into the Q&A box – Q&A pane in Zoom; we'll be keeping an eye on that. I hope we'll have some time at the end of the webinar. If we don't we will definitely follow up with you on your questions and comments. For our speakers, I'll pass it to them as well. And if I can't answer it I will put you in touch with the right person.

All right, next slide.

So here are today's speakers. Yours truly on the left. Again, my name is Axel Pearson; I'm a project manager at the Pacific Northwest National Laboratory. I lead the Integrating Lighting Campaign and the Lighting Systems Technology Research Team and that means I get to put events on like this one and interact with all you good lighting industry folks.

Next we have Shanna Olson. She is IMEG's architectural lighting leader, guiding her team and creating aesthetically pleasing technically versed and sustainable lighting designs. Shanna also endeavors to be at the forefront of new and emerging technologies, trends, and applications, including biophilic design and integration with other design services to optimize user experience of spaces. She has vast experience in corporate, educational, hospitality, healthcare, historic renovation, and retail sectors, employing her client and occupant-centric approach to create curated experiences through visual communication and technical expertise.

We also have Adam Hutchinson, who is an energy professional with 20 years of experience in green building, renewable energy, energy efficiency, and energy management. He serves as the energy management specialist at Denver Water. His responsibilities include organization-wide energy management for approximately 300 facilities with annual use of 60,000 megawatt hours and 700,000 therms. Energy efficiency project development, renewable energy project development, controls administration, sustainability outreach, and producing Denver Water's annual greenhouse gas inventory.

He previously worked at Excel Energy as an energy efficiency engineer, assisting in projects that generated 50 megawatt hours of energy savings annually. He also worked at Anheuser-Busch in bev as the utilities manager of the Fort Collins brewery, where he managed all brewery resource usage, efficiency projects, and helped drive water efficiency initiatives that resulted in record low ratio of water per barrel of beer to 2.3.

His past research includes wood and charcoal cook stove emissions reduction, microgrid simulation and integration, and extracting energy from wastewater.

Awesome. We are honored to have these two industry experts with us today, so thank you so much Shanna and Adam for joining. We'll hear from them in a little bit.

Next slide.

So as I mentioned, I'd like to tell you a bit about some of the recent goings on of the Better Buildings initiative. First I'd like to let you know about the Systems Technology Energy, Equity, and Justice, or ST-EEJ effort that we are taking on to ensure that our efforts around development, deployment, and adoption of clean energy technologies are equitable and just. And that really means that making sure that our resources and assistance reach the people that need it most, and we're not overlooking those often underserved communities.

Next. When working on deployment of a new technology it's always helpful to have examples of real projects with robust measurement and verification to demonstrate the benefits and encourage participation in these market transformation projects. So our lighting teams – and other teams, but our lighting teams specifically are always looking for new candidate sites for evaluation. So if you know of an installation of advanced lighting

controls and would like to get involved, please let us know. Shoot me an e-mail.

All right, another exciting development, phase two of the L-prize called the Prototype phase, launches today, June 30th. The L-prize is designed to spur groundbreaking innovation for next gen lighting in commercial buildings. With new separate tracks for luminaries and controlled systems, competitors now have more pathways and opportunities to participate and be recognized for innovation and win L-prize awards.

Okay, finally a couple events that you should be aware of if you're not already. The IES annual conference in New Orleans is happening August 18th through the 20th. As always, there's going to be some great lighting topics covered at the event and we will also be there to announce the recognized participants of the 2022 Integrated Lighting Campaign.

Additionally, the ACEEE Summer Study on Energy Efficiency in Buildings falls right after that, August 21st to the 26th in Pacific Grove, California. There will be a number of great presentations and papers on lighting and other building technologies there.

So I hope you can make it to those efforts. If you have any questions about these efforts or events feel free to shoot me an e-mail and I'll put you in touch with the right people.

Without further ado let's get on with today's content. Next slide, please.

So if you're not familiar I want to tell you a bit about the Lighting Systems Technology Research Team, which you might know of as the Lighting and Electrical Team. We narrowed the scope this year to just include lighting; there are some other teams that cover some of the other electrical pieces. So we wanted to focus just on lighting. If you're not familiar with the Better Buildings research teams check out the link at the bottom of this slide to see the website and you can explore those other teams, like there's the Building Envelope Team, the Plug and Process Loads Team, along with the Lighting Systems Team.

These teams analyze the latest research and development on a range of building technologies with the goal of providing market-ready solutions to partners. And just like the name sounds - and this includes you since you are all here today; yes, you are part of

the team – we will focus on lighting. So thank you. I hope you knew that you were joining a team today.

We aim to reduce lighting energy use by sharing insights and experiences related to emerging lighting and control systems and documenting the applications of solutions. This is why we have Shanna and Adam with us today; they are going to share their insights and experiences. And there are also a number of resources available on the website. And we want to develop more, and that's why we're here today as well; we will talk about those resources and developing them at the end of the call. So stay tuned for that.

Next slide, please.

Okay, so I also want to tell you a bit about the Integrated Lighting Campaign since both of our guest speakers are partners of the campaign and will be telling you about their recognized projects. So again, just as the name sounds, the Integrated Lighting Campaign recognizes installations of integrated lighting, which means that the lighting system can communicate and interact with other building systems to enhance the building's performance.

We know that today's lighting has come a long way from basic LED retrofits. It can talk with the rest of the building to achieve those deeper energy savings at the building level, for example, by exchanging information with the HVA C system or controllable plug loads. Lighting and lighting sensors hold some really valuable real estate up in the building's ceilings and they have the ability to relay really useful information to other systems, like occupancy, ambient light, temperature, humidity, and location of assets. And integrated lighting also interacts positively with the occupants through capabilities like tunable lighting for circadian support, visual comfort, acoustic performance.

So while an integrated system's energy benefits can often result in a good ROI, a good return on investment in the form of reduced energy costs and energy savings, it's often those non-energy benefits that might tap into a higher value proposition and further kind of tip the scale in favor of the adoption of these systems.

So we have just made recognitions for the 2002 integrated lighting campaign, but if you're aware of a project that would like to be recognized by DOE and the Better Buildings Initiative next year please let me know; I would be happy to work with you on a submission.

With all that being said we're going to turn it over to our first guest speaker, Shanna Olson. She's going to tell us about the IMEG headquarters in Chicago and the very innovative lighting system installed there. Shanna, take it away. Thanks.

Shanna Olson: Thanks so much. What a great introduction. And I love that that slide came right before mine, because we're going to be talking about so many of those topics here.

So with that let's turn to a case study looking at the lighting design for an engineering firm located right in the Chicago loop. And we're definitely going to be presenting today the project and illustrating the lighting design, but I'd really like to also focus on design recommendations and best practice advice based on my personal and project experience.

So next slide for me.

You could call this project Balance Advancement. And when we thought about the concept we really wanted to apply several advanced lighting strategies, but we wanted them to be in balance. What I mean by this is balanced between health and wellness and sustainability. Also from an aesthetic position we wanted to have a balance composition between warm biophilic design elements and clean geometric forms, which really spoke to the corporate culture of an engineering firm.

Also it was really important for us to give back to the design community and to create a body of evidence-based research. So we've been working directly with PNL to study our circadian support lighting and both mental and physical responses. So the study has been complete and the results will be released later this year.

Next slide for me.

So I mentioned several strategies and circadian support is just one of them. They also include a hospitality-supported workplace, a fractal layout, low UGR, or you can think of these lower glare luminaries using a Dali type 8 driver and dimming protocol integrating with wireless sensors and with acoustics. Now what I'd like to do is give you a tour of our space.

Next slide.

We'll start with our front-facing client spaces. And this is our reception lobby, and it gives you that glimpse into a hospitality-supported workplace and our desire to balance out and incorporate some of those biophilic design elements. So you see that warm wood wall in there, and even the decorated luminary, which I hope you can see there, which is meant to replicate a bird on a branch or bird on a wire, but in a very clean and geometric form factor.

Next slide for me.

Now let's go into our conference room. And this brings me to my first design recommendation. Where you can and where it's appropriate consider illuminating both the ceiling and the walls. This is going to make the space feel much more comfortable, much more open, and especially where we've got a nice, clean ceiling like we do in these spaces here.

Now in this particular instance we chose an atypical mounting, and this created – you can see this, this dynamic play of light and shadow, but it also reduced glare. And in a front-facing client space it looks both forward-thinking and super-comfortable to be under. I'd also like to point out the corridor that's adjacent. You can see that the luminary that we selected here washes both the wall and the ceiling and it makes the space in a corridor feel much more open, much more alive, if you will. And corridors is an often overlooked space, so just consider adding a little bit more pop, adding a little bit more to the walls to make your corridors feel more comfortable and enjoyable to be in.

Next slide for me.

I'm taking you into our break room here and our next design recommendation, and that is that we recommend looking at acoustics in any space you're in and integrating lighting and acoustics where appropriate. You can do this in so many different ways, and if it's something you're interested in I encourage you to check out our recently-released whitepaper from our lighting and our acoustics team called "Lighting and Acoustics in Unison." And I've included the link here, and I think Axel is going to drop it in the Q&A pane for me later.

And in this particular instance we provided integrated acoustic luminaries, and you can see they've got a bold color and a playful layout. I love these fixtures. I love how they feel in a space. I like to think of it as a haptic experience. Or you can think of it as a visual softness. You can see it's a hard surface space and it's a

pretty neutral color palette, and by using these luminaries we both enliven the space and created a little bit of a pop. Now you might think, "Ooh, the color is so bold. How's it going to last? Is it going to get dated?" I actually want to say this is maybe something to think about, but here's our branded color, so I'm thinking it's not going away anytime soon.

Now let's move into our open office and performance space.

Next slide for me. Perfect. Okay.

There's a number of topics I want to talk about in the open office, but the first is biophilic design to through a fractal layout. And when we think about biophilic design a lot of times we think about organic or curve linear, but I will remind you fractals are also found in nature. And when we think about this particular space, we're located on the 27th floor, so when you look out you see architecture, you see buildings, and you can actually see that in the image here. So I thought about these two things and our team looked at this, we wanted to create a push and pull between interiors and the exterior, and we came up with this fractal layout.

The other thing I love about this is let's say I'm sitting here working and I look up, my eye moves across the space and it provides an immediate quietness. It's not distracting; it just provides a moment of calmness.

We also incorporated lower UGR luminaries here. And what's incredible about where we are with lighting today is that we can take something – and you can see the luminaries in the image here, that a vertical lens, but the object control is so great that it's comfortable – at least comfortable for me personally to be under. Love it.

But we didn't just think about light; we also thought about sound and movement. And the other thing you can see in this image, and you can see this in the layout in particular, we've got these soft touchpoints. And so we incorporated a different luminary and we incorporated acoustic baffles. And the differentiation here is both to mitigate a little bit of sun, but really it was to get the idea of a visual cue to get up and move around, and especially after the last couple of years, to be able to reconnect with people.

Next slide for me.

So when you think about that layout you might say to yourself, "Ooh, this is using so much more energy." And we wanted to check ourselves. We actually did a comparison using the same luminary with a parallel layout, getting about the same lumens targets. We actually found that the parallel layout used a little bit more energy than the fractal. So also a little sustainability extra there. And the project overall came in 37-percent below IECC 2018.

Next slide for me.

So we talked briefly about circadian support lighting, and when we think about circadian support I think about five constructs. I have: science, metrics, design, construction, and optimization. And I'd like to talk about each very briefly.

Next slide for me.

So I'm going to give you a quick, quick snapshot of the science behind it. So when we think about light we know that it's made up of multiple different wavelengths and color of light and that the visible spectrum starts in our indigo in around 400 nanometer wavelength and goes up into our red about 700 nanometer wavelength. We also know that our eyes, our rods and our cones see for vision. But what you may not have heard about is there's another receptor in your eye called an intrinsically photosensitive retinal ganglion cell, or thankfully for short, IPRGC. And these communicate with your circadian system, and not just looking at vision, but looking at the wavelength or color of light. And depending on what that wavelength is, what that nanometer range is, it's going to provide signals to our circadian system.

So at about 480-490 nanometers is telling our circadian system and our circadian system is saying provide acute melatonin suppression to help us wake up and potentially be more productive. On the flip side, as we get to those longer wavelengths, those ambers and those reds, it's letting the melatonin come in, putting us in a place where we could fall asleep. So think about that. And that's kind of our basis as we look at circadian support lighting.

Next slide for me.

So much like anything else we talk about these metrics, and it's to help us understand the performance of a lighting system. And so there are many different metrics out there right now. We chose to use Equivalent Melanopic Lux, or EML. And to understand that

take it simply as understanding the amount of light in the space and giving a multiplier for how it's going to impact our circadian system. Now just like there are different metrics there also is nothing in particular in the market that says "This is the exact amount of EML that we need.

But one of the things we looked at was WELL version 2, and there's a one-credit and a three-credit option. And when we looked at these we ended up coming in right at about, well, we'll say two credits, and we did this kind of specifically.

Next slide for me.

We wanted to be in balance, just like anything else, and so when we looked at the luminary, the luminary is available with a range for the tunable system being 2,700 and 6,500. But for me, when I think of about an office, I don't necessarily want to be in that warm or that cool of a color temperature on those range. So we did go between 3,000, 3,500, and 4,000.

The other thing is we really wanted the appropriate amount of illuminance in the space, and so we chose to find a balance between all of those things. And you can see 3,000, 3,500, and 4,000 here, and it's just a subtle shift between those pieces. And we had a slower shift between these, and so they're not even noticeable throughout the day, and it's really quite comfortable.

Next slide for me.

We also thought about the schedule, and what you'll see is commonly when people are looking at circadian support lighting they're following the sun. We wanted to test and add in a little bit of a twist. You can think of this like a cup of coffee after lunch, 'cause I don't know about you guys, but after I eat I get a little bit of tired in the afternoon. So what we did is we boosted the EML for a short period after lunch, with the idea of helping us maybe feel more awake during that timeframe.

Next slide for me.

And this brings me to our design recommendation for design and construction. Now one thing I'd like to point out, with two-channel tunable lighting oftentimes it looks or feels a little bit pink when it gets to the middle color-mixing. And for anyone who's not a lighting geek you're probably not going to notice it in this space,

but if you have a static light next to a tunable you may notice it a little bit.

And so I'm showing you a back-of-house space in our office looking out into our open office. And you can see the one is a static, so it's a little bit more yellow, and the other one's a little bit more pink. And so what I wanted to do as a design recommendation is to think about this as you're designing, do they become all tunable or do you create an architectural or other visual break between your static and your tunable. Just something for consideration.

Next slide for me.

The other thing that I wanted to recommend is optimization and balance. Now this is always a good idea for lighting, but if you have both a circadian system, and especially if you have circadian and fractal it becomes critical.

Next slide for me.

So we accomplished this by having an advanced control system and using a Dali type 8 doing driver and protocol. Now the type 8 is relating to the channel dimming for the tunable and the Dali allows us to have individual control over drivers or lamps or luminaries, depending as you need it. Now look at the layout here. So you can see that with the fractal layout you may have a little bit difference in quantity of luminaire that's over a workstation, so we want to create a balance here; we even out those lighting.

But we actually took it a step further, and that's because it's our team, so we could talk to them. So what we found is our younger team members, those who are more computer-based, really wanted significantly less light than our older team members who are paper-based in their usage. And so we were able to balance it out and make sure it was really comfortable and optimized for our team.

Next slide for me.

The other thing that we had to contend with, as well do, and it's so important, is managing the controls within code. And we were following, again, IECC 2018. And as part of that requirement there's a sensor requirement, a control requirement for the open office, and without getting into all the details of it, what it is is for every 600 square foot of zone, that zone has to be controlled by

sensors. And when you're not in that zone the lighting has to dim down and can be no brighter than 20-percent. Now when all the zones in the space are unoccupied then they all go off. Now on my recommendation here – and you can see this a little bit on the screen by the boxes, is to make sure your furniture, your lighting, and your zones are all coordinated. There would be nothing worse than being at your workstation and half of your luminaire dimming down to 20-percent or potentially turning off. Just not very comfortable to be under. So make sure you're thinking about that as you're working with IECC 2018 or rolling into the new codes.

Next slide for me.

Another thing that I want to point out and recommend is to understand perception of safety. So think about it under the zones that we just talked about. If you're working at night by yourself and all the other zones around you dim down to only 20-percent it can feel a little bit uncomfortable. What we found, and thankfully this worked out really well for us, is remember we have two different luminaire types, we have a direct down with an opaque side and we have the vertical lens product that you see in the forefront here. What we found is that having that vertical lens, having that little bit of light that you see, even on the dimmer setting, felt brighter, felt a little bit more comfortable than the direct-only.

So as we're moving into these code requirements you want to understand perception of safety, how people can feel in this space, especially at night and especially working by themselves.

Next slide for me.

And this brings us into our last set of recommendations here, and these are for how people are going to use this space. My first set of recommendations is to review the clarity of your control systems, make sure it has engraving in there. And you can see that as an example on the buttons here. And make sure it makes sense for everyone.

The other thing I'd like to recommend, and this is just my personal recommendation, is I like to have separate buttons, or it could be sliders, or some other means of indicating that it can dim up and dim down. I just find it to be personally more into it.

I also like to provide, if at hand, both written and short video tutorials for how people use the spaces. Especially when it's a

complex control system it just helps things out. And you can see a very colored base picture of me doing this here with my mask on.

The last thing is if you're writing an RFP for a project consider asking your design and your controls team to come back in after six months or a year, 'cause this is really how long it's going to figure out how you work or possibly live in this space. Have them come back to talk to you about illuminence levels, schedule, your auto shut-off delay, still staying in code, of course. But this is going to help you fine-tune the space and make sure that it works well for you.

And rounding back out here, just as a reminder – the next slide for me. That we did work on a study, it has been completed, and the results will be out later this year. And we look forward to your questions and your feedback.

With that, I appreciate your time and thank you very much.

Axel Pearson: Shanna, thank you so much. That was super-interesting. Thanks for going through that.

Shanna Olson: Excellent. Excellent.

Axel Pearson: Now I'd like to turn it over to Adam Hutchinson, who will tell us about Denver Waters' recent construction of their lead platinum administration building. Adam, take it away.

Adam Hutchinson: Here we go. All right. I'm live. Excellent. Yeah, thanks, Axel. And yes, Shanna, that was super-impressive. I learned a lot there.

So thanks for having me here today to talk about our integrated lighting controls portion of our main campus redevelopment project. Denver Waters is always happy to share our story and appreciates the platform. I'm going to tell about our journey in sustainability.

Next slide.

Okay, so I want to start with just a brief intro to Denver Water for those of you not familiar with the organization. We're the of course municipal water provider for Denver and about half of the surrounding suburbs. We serve about 1.5 million customers, or really that amounts to about 25-percent of Colorado's population. We have four treatment plants. There's another one slated to start

operation in 2023. And on average we deliver about 190 million gallons of water per day to our customers.

We have a huge watershed, that covers approximately 4,000 square miles. So a lot of different locations throughout the state. There are roughly 1,100 employees at Denver Water, and we're everywhere throughout the state; we're down in the Front-Range, we're in the Denver Metro area, we're up in the mountains, kind of all over the state, so wherever we have property and locations.

Conservation and sustainability are kind of at the core of Denver Water operations. We realize – and this is kind of a catchphrase that we've come up with around here – is that we're inextricably linked to the fragile mountain west environment, and if we don't do our part to take care of the environment we know that we risk not having enough water. So it's critical for us to be a sustainability leader and model not only efficient water use, but also proper storage of the watersheds and ecosystems. We really strive for efficient energy and transportation use throughout our operations and we also are striving for optimal waste and generation and diversion.

Next slide, please.

So the reason I'm here today is to talk about the experience we've had with integrated lighting controls. Lighting controls process is one of many energy saving efforts that was incorporated into Denver Water's operation complex redevelopment. So OCR is what we always called it; I'll try not to use that, but it was a big project here. And the lighting project, the integrated lighting project is kind of a – it's a good microcosm for the whole water redevelopment. It kind of encapsulates the innovative use of technology to enhance the energy efficiency, resiliency, and sustainability of the building and campus in general.

So the lighting project has been recognized for innovative engineering, so I'm going to give a shout out to Shanna here and IMEG; they were actually one of our partners with that operations complex redevelopment and did a great job and it might be interesting to see if you notice some similarities between their building and some of the photos I'll share here.

It's also been recognized for advancing culture of health, innovation, advancing water policy, and water reclamation. And we have a bunch of aspects of warm water on our campus here.

And it's been recognized as a leader in creating sustainable, healthy, equitable, and resilient buildings.

So it's a very large project. It was constructed in two major phases. Construction took five years on the 35-acre campus that we have in kind of Downtown Denver. And the campus remained open during the entirety of construction. So we demolished 15 buildings, constructed 7 new ones, and remodeled 2 existing structures. And the renovations actually included an 1878 pump station that now serves as our conference. So just a little background there on the project itself.

Next slide here.

So as I mentioned as part of redevelopment we built seen new buildings. All the new buildings incorporated had energy efficient design innovative tech specific to their purpose. And for example, I like to note like in our fleet shop we actually painted all the floors white and then installed huge fans, and it's a kind of double-story building. So big open areas, big fans doubled with HVAC, and then the white floors actually it was a design aspect to help with getting a lot of natural daylighting in there, but the white floors actually reflect back up so the mechanics can see underneath the vehicles even better than just using lights that they would normally use.

Another one is in our meter shop, which is used for testing and refurbishing meters. They actually have double-story windows in their testing facility to face east. So they actually work a lot of early hours, and then they also have a kind of gentle light throughout the day. So different energy efficiency ideas very specific to the needs in each building.

Then the building that I'm talking about today is the admin building. It's the largest building on campus, it's 190,000 square feet. And it's the main working location for approximately 600 out of 1,100 water employees.

So from the very beginning our sustainability goals for the project, and especially for the admin building, they're pretty aggressive. So the new admin building was designed to be a lead platinum and achieve net zero energy. So for the goal of achieving net zero energy in this building, first step of course was to design for minimum energy use. You know, if you don't have to use it you don't have to plan for cost saving it. So this is where the integrated

lighting controls come into play, as one of the many design features that can conserve energy in the new building.

Next slide, please.

So here's an overview of the design features that went into the building for energy savings. Hopefully you can kind of read a few of those. And I'll actually go through them here. But first and foremost I just want to go through actually what I'm talking about when I say integrated lighting controls. So this is our building, the admin building – and this is just specific for that building; this is not throughout the main campus. We use a numbered lighting control system, and it's back-integrated with our building automation system and shares real-time status of the lighting system occupancy sensors. And those are located in nearly all spaces of the building.

So it shares that data and to implement energy savings hvac temperature setbacks in unoccupied spaces. We're reducing unnecessary heating, cooling, and ventilation using this. And occupied and unoccupied temperature set points are 68° and 85° for cooling, so pretty extended set points, and then 70° and 60° for heating. And occupancy-based setback measure, it increases the system efficiency, and when I say system efficiency, we actually have a central utility plant, so it's kind of like district heating and cooling here on campus. So it increases that efficiency and also contributes to our ongoing mission of environmental stewardship.

So just to give you a rundown here. So that's just innovative lighting controls portion of it, but we also had implemented a very efficient building envelope, natural daylighting, full self-controlled window blinds, of course everything is 100-percent LED lighting, and then we have occupancy vacancy sensors that control lights, plug loads as well, as well as HVAC set points. We use radiant heating and cooling, and as I mentioned before, we have a central utility plan, which really makes everything more efficient.

Next slide, please.

So as I mentioned, this was a long process. There's a lot of feedback from employees on campus with our design team – internal design team, and then also with all of our partners on the project. There was a lot of back and forth on what was possible and how much innovation energy conservation Denver Water wanted to incorporate into the building.

So as you can see here, this is kind of the process of, you know, you can see – hopefully you can see this, but the conceptual design phase, you know, through schematic and kind of go back up for the construction design whenever we find permanent feed estimate for energy use. So it was pretty impressive. I actually – I didn't start with Denver Water until we were into the construction phase, so I was kind of brought in and just really impressed with just the amount of innovation and energy savings that was actually decided on. So I thought it was pretty cool.

And you can see here with radiant cooling – so like I mentioned before, radiant cooling and heating, the occupied set points are pushed a little bit higher and a little bit lower, and this was kind of deemed impossible because the field rating and how it conditions is basing those for those lower and higher set points while still maintaining an optimum comfort. So then I can just tell you from experience, you know, we actually have a setting of 76° for cooling. There's a lot of occupants in this building that actually think it's a little bit too cold, so, you know, that's the number we're looking at as we continue to live and work in this building.

So you can see the final energy summary before design is complete and construction started. This was actually the set points that were adjusted during this phase for the very last modeled here, and then also the public spaces and office spaces, all office spaces had a schedule – time schedule set to 6:00 AM to 6:00 PM. And you can see that we landed on an energy model here that said it was going to be 22 kBtu per square foot per year.

Next slide.

Excellent. So I've included this energy summary. So this kind of was in the same reports as previous summary. And I've included this just to give you an idea of the layout in terms of spaces on each floor. And I'll just kind of – don't strain your eyes too much here, but the top picture there is kind of a rendering of the building from outside. Level one is the middle kind of floor plan there, and then the bottom floor plan is level six. And I'll just tell you that the bright blue color, that's open office space. And then the bright pink or bright fuchsia is closed office space. I just wanted to give you an idea of what kind of spaces are we dealing with throughout the building.

Level one is a little bit unique because it houses our cafeteria and our public lobby and also has a walkway through it that isn't represented there in this upper space. And then level six is more of

a typical floor and that's what it looks like throughout the rest of the building. So pretty much all the spaces use integrated lighting controls, the open spaces, the closed spaces. The ones that don't are the mechanical rooms as well as idf and it rooms.

And also I don't know if you can see this or not, but the lighting density for the location was 0.52 watts per square foot, and that's something that we're continuing to fine-tune as we kind of work on the building to increase energy savings. So that's something we have to keep building that's to increase light levels, decrease light levels, and do all sorts of different things, kind of like what Shanna was talking about with, you know, kind of living and adapting to different needs of occupants.

Next slide, please.

All right, our controls here. So while the concept of using the lighting controls system aux sensors for HVAC settings seems pretty straightforward, it's pretty much like, "Okay, you have the Ox censor," but that tells us the – whatever the set point is for temperature. Pretty straightforward. But the lighting controls themselves and tying everything together with programming and schedules is a little bit more complicated. And I just wanted to give you an example of the variation in designing for all lighting within the building.

So you can see here, you know, the first design intent – control intent here was a1 and one other in a6. There's actually – we didn't go a1 to all, you know, a1 through a6 or whatever. There's 16 different control concepts that's lighting throughout the building, and here you can see, I mean lots of different things were tying in here. We have timing switches or timing touch screens, we have aux sensors, we have photosensors, we have time schedules. So there's a lot of stuff that's going on here. It's actually pretty cool and intricate system, so I just kind of wanted to share that with you.

Next slide, please.

So and now I just want to talk on the actual control systems we're using for lighting and the HVAC. And these are just screenshots of actually the software interface and we use reliable controls for the building automation system, and that's for the HVAC system and it does connect to the lighting system. And then we're using Polaris Lighting Control System from lighting management system for lighting controls. So they've both been very effective and easy to

use. My personal experience falls more into the lighting system controls, 'cause I get calls about different light settings and things aren't coming on or things are turning off on people or aux sensors aren't working. I kind of have been designated to help our electrical team do a lot of troubleshooting through the software. And then I also like to deal with just the energy savings I get from dimming at certain times of the day or certain times of the year.

And then our internal plumbing and HVAC team, they kind of own the RC controls. And they're in their daily monitoring subpoints, flows, and they use the system to troubleshoot any issues that they come across.

And then the screenshot on the right, there's kind of three little pictures there. I just wanted to put that in there 'cause that shows how occupancy is presented as lighting controls. So right there you can kind of see the purple spaces are unoccupied, the orange space is occupied, and the white space is actually being controlled by a set schedule, so that's that 6:00 AM to 6:00 PM lights on on campus Monday through Friday kind of schedule.

But I also want to note that even though the lighting and the white space is being controlled by a time schedule, there are occupancy sensors in those spaces that can be used for HVAC settings.

And before we move on to the next slide I just want to give a little bit of a timeline of our building completion and occupancy kind of as it pertains to COVID, just because – well, I'll give you the timeline. *[Laughs]* So substantial completion of the admin building was in November of 2019. So all Denver Water employees that reported to the main admin building moved November 2019, moved to the new one. We were only in the building for about three months and then in March of 2020, because of COVID, we had a majority of doing remote work. So over the next year occupancy increased back in the building. Of course we were – had different people reporting to different locations, different people had different schedules, but most of them are hybrid schedules and were in place during that time and actually they currently are as well.

So we really didn't have most employees come back to the building until 2021. And I think June 2021 was when we started and then I think most employees are back to the full hybrid schedule as of 2021.

So even though we moved in in 2019 we're still learning a lot about living and working in the building and we're still learning to make a lot of adjustments to be documented, expectations that come from those.

Next slide, please.

Okay, I'm getting close on time here, so I'm going to speed it up here a little bit. So this is kind of a one operating insight. So right there we're really talking about taking advantage of the energy savings in the occupied buildings. So one of the tools that we used after we moved in was monitor-based commissioning. And I'm not sure that a lot of you are familiar with this, but really it's basically just real-time commissioning of the building. We had one of our partners set this up for a year after construction was completed. So like I said, before we were in November 2019 we actually didn't start the monitor-based commissioning until I believe February of 2020.

So the monitor-based commissioning software and proprietary software package is attached to both the lighting control system and the building automation system, collects and analyzes thousands of data points. We're talking flow rates, temperatures, valve positions, light levels, occupancy, daylight readings, pretty much all that information. And right here I just have two examples of findings that were pertaining directly to the integrated lighting controls. So, I'm sorry, I actually need to speed it up a little bit. *[Laughs]*

So you can see here one of them is occupancy mode, flexibility schedules instead of occupancy sensors, which actually was the design intended to those spaces. So it was a finding, but it was something we used to actually think about actually switching that to be the – not all spaces are reflecting set points based on time schedules, but they can be – more of them can be integrated into using the occupancy of the certain space for sub-temperatures.

And then the second one just in this for the monitor based commissioning was some of the AVs were never actually going into occupied mode. So they were actually set to look at a different point in the lighting control system, and it was just something that we went to commissioning it actually seemed like it was working, but then when we did this monitor based commissioning we actually found that they were looking at the wrong inputs. So easy fix, and we're pointing towards looking at occupancy and then that was right.

So next slide, please.

So real quick I'm just going to talk about some other insights. So we had monitor based commissioning in place, and that spawned a lot of things, but then of course you have a lot of occupant input on what's going on. So when our – I guess I'm just going to say there was one big main finding and it happened to be because of our reporting, it's a unique situation, 'cause when it's occupied it's full – instantly full. Lots of people come into the boardroom, so we noticed that it was just getting too hot as soon as they were occupied and the setbacks were not keeping up. So first we were discussing about using the 6:00 to 6:00 schedule so that there was always a setback temperature in there, but then we kind of came up to we knew that we could adjust the actual setback temperatures for both heating and cooling to adjust the actual setback temperatures in that room. So really that's what we did in general, instead of going to the 6:00 to 6:00 we tried to maintain our actual energy savings and just redid some of those set points in there.

One last thing – I know we're getting close here – I'd like to make note is that, like I said, we're learning a lot and adapting to the process of dealing with the maintenance of these systems. You know, before completion of this new redevelopment of the campus and the new building we didn't have a specific team or process for dealing with facility requests. You know, people would make phone calls, they'd stop electricians when they saw them for lights out, you know, there wasn't really a process in place.

So now with these new systems and the connections between them we're noticing that we're getting duplicate work orders, so, you know, electricians might get a call, HVAC guys might get a call, sometimes the construction shop gets a call, all for kind of the same issue. So this whole integration and working with these systems has kind of driven us to come up with a facilities maintenance team, which I think has been a really interesting kind of outcome of using the systems.

And it's not because the systems aren't working; they actually work great. And we actually thought we kind of had everything dialed in, where we had all the people in place to take care of the systems. You know, we have a electrical workshop, we have HVAC shop, we have plumbing, we have sustainability, and we've just found that these systems, so many people are interacting with them that we really need to kind of focus and centralize in one location for the maintenance of all these systems.

Next slide.

And I'll just talk real quick here about, you know, this, is it working? And we are saying yes, it's definitely working. So this is a scorecard from Denver City and County that we got for 2020 and this is the main campus. This is the entire campus, our main campus is the 21.3 kBtu per square foot. So that's the – the energy module actually before was actually for the admin building. This is the entire campus. So this is an extremely efficient campus. We don't have the 2021 scorecard yet; that actually comes out in July, 'cause the deadline is in June. I've done calculations earlier this year for 2021 and I just did it for the admin building, and we are actually at that 21.3 kBtu per square feet – we're actually 21.27; I'm rounding up.

So yes, we're getting savings. We actually believe that – I'm attributing probably 40 to 50000 to just kph to just interview lighting controls. I think there's ways of actually even getting more efficient. I'm talking solar seasons and some other adjustments that we can make. So I'm really excited about it.

Next slide, please.

So just overall operating insights. The system, it doesn't – it's amazing. It's working. We've seen the results here. Adaptability is key. Of course the system is working great, the adaptability of systems, kind of like I mentioned with our boardroom. That really allows us to kind of attack our energy goals but also maintain comfort. Establish ownership and governance, that's kind of what I mentioned about we didn't have a team specific for these systems before and now we are developing one.

Commissioning, of course or original commissioning very important; everything was working as its intended. But something to mention too is, you know, coming back in for a year or six months or some sort of checkup, we're finding a lot of little hidden treasures that we can get more energy savings and still maintain health and comfort.

And then also the employees, you know, we really try to engage our employees on everything. I'm just going to move down to the Denver Water continuous improvement team. It's an internal team that strives to eliminate a lot of rework and streamline processes. So we've found that the dedicated facilities and maintenance team

has been going to be created to take more advantage of these systems and conserving capabilities. So sorry, Axel.

Last slide.

Really it's just a thank you. I appreciate you guys' time. Thanks to the Building Initiative that allowed us to speak here today. So back to you, Axel.

Axel Pearson: Awesome. Thank you, Adam. Very well done.

Okay, so I'm going to take us home. I hope we can still get through some polls, and I'm going to move pretty quickly, so let's go to the next slide.

So both of these projects are documented as case studies from the ILC, the Integrated Lighting Campaign, and that's really a key goal of the campaign and the Better Buildings Initiative as a whole, to really create this body of knowledge of these best practices in educational materials and other resources to share these insights and experiences. And we have more resources, so let's take a look at the next slide.

There's decision documents that help building owners understand key aspects of choosing the lighting control system that will meet their needs and their end users.

Next slide.

We also have fact sheets on specific applications, like the one you see is on parking structure lighting and technologies like upgrading troffers to LED. May; types of fact sheets – and this brings us to our first poll.

Next slide.

We know that fact sheets and two-pagers are not for everyone or every application where technical assistance is needed, so we'd like your input. What is your preferred – oh, I mixed these up. So this is a different – let's keep this poll. What challenges do you encounter when in your work and where do you think technical assistance will help?

I was going to ask you about your preferred form of technical assistance, but we'll get to that one next. So if you have a minute to answer this one: what challenges do you encounter where you

think technical assistance will help? Is it lighting sources? Lighting controls? Integration of lighting and other building systems? Utility incentives? Or other/I'll tell you in the question and answer pane?

So feel free to answer one and get specific in the chat. We'd welcome your input there.

So just a few more seconds to answer this one.

Okay, let's go ahead and close that one.

Awesome. Lighting controls it looks like is the bulk, and that's good; that's where we're focusing a lot of time. Integration of lighting and other building systems coming in second. Awesome. Thank you so much.

Let's close that poll and let's move on to the next one. So again, we know that fact sheets and two-pagers are not for everyone. What is your preferred type of technical assistance? Do you like the fact sheets about webinars like this one? Short recorded videos? Maybe one-on-one conversations with experts? Diving a little bit deeper into your project, or again, that fifth option, other/I'll tell you in the Q&A pane. Again, I don't think the chat works, so sorry. Go ahead and put that into the Q&A pane.

Okay, let's go ahead and close that one.

Oh, pretty evenly split. Fact sheets, webinars, one-on-one conversations, and to a lesser extent short video. Okay. Awesome. We'll keep that in mind.

So you can tell that – and I mentioned this – we want to develop these resources, so that's why we ask you these questions. What types of resources do you like? What are the challenges that you're seeing? And of course we want to get more specific to develop specific topics like many of you said, lighting controls. Is it system selection? Is it interoperability? So we want to know more. So please let us know. Put it in the chat, send me an e-mail.

And there's another way you can get involved. So next slide.

So once we nail down the type of resource, the technical assistance, we want to start developing these resources for the lighting industry. And that is, again, really the goal of the lighting systems technology research team. And we want to use the broad

experience of the lighting industry, you all. So we are looking to convene a technical working group that will take some specific topics highlighted by the larger group and work with us to develop targeted guidance. We will let you know what topics we hear and reach out to you again and say, "Okay, we are doing a resource on interoperability or something of lighting controls."

If you're interested in participating in a technical working group more broadly please send me an e-mail; I'd be happy to give you more info what we're thinking on time commitments and that type of thing.

Okay, one last poll before we move on and wrap up. So another key question is about the audience of the resources. We want to know in your experience what sectors or building types do you think are most relevant to prioritize in terms of developing these resources? Another way to think about this is where is the greatest need. Not just where you work, but where you've seen areas that could use assistance more than others.

So office buildings, K-12 schools, retail, healthcare, those are the ones that we kind of came up with as maybe the top, but another other option. So if you see another area where we should focus and create that more specific guidance let us know.

Okay, let's close that one and take a look.

All right, office buildings, healthcare, K-12 schools. And to a lesser extent retail and other/tell us in the chat. So please, if you have some time tell us in the chat; we'd be happy to hear it.

Okay, so I do some questions that came into the Q&A pane. I want to respect your time; we're right at the hour. As I mentioned, we will follow up with those folk on the questions and I will pass them on to the relevant folks. And feel free if you have any more questions or comments, discussion, shoot me an e-mail and I'm happy to talk and I'll put you in touch with the right person if I can't help.

And again, slides and the recording will be posted on the technology research team page and the Better Buildings Initiative website. So thank you again so much for joining. Thank you for your time, expertise. Keep an eye out for our next meeting, hopefully in the early, early fall. We'll see you again.

All right. Thanks, everyone. Take care.

[End of Audio]