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– everyone. I'm Pam Cole with the Pacific Northwest National Laboratory, and I'd like to welcome you to today's energy code webinar on daylighting controls for commercial buildings. We'll hold the webinar the second Thursday of every month at the same time so you can keep a watch out on the building energy codes training page as topics get added. And if you have any topic suggestions you'd like us to consider, please e-mail them into us using the same e-mail in your webinar reminder messages that you receive for registering for this webinar today. So, our speaker today is Rahul Athalye, and he's also with PNNL, and we really appreciate him taking the time to share information on daylighting control requirements. And Rahul, it's all yours, take it away.

All right. Thank you. Thank you, Pam. So, welcome everyone and thank you for coming to the daylighting controls webinar.

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I'm just going to create a brief background about myself. I'm a mechanical engineer, and I studied daylighting while doing my graduate pieces at NC State University. After graduating I worked at an architecture engineering firm that specialized in designing schools and especially daylighting schools. So, I got to experience some of the basics of daylighting design up close. After coming to PNNL I worked on codes and standards for the last several years and I have participated in the development of daylighting requirements 90.1 in the ICC.

So, that's the background that I'm coming from. My intention with this presentation is to provide an entire view of daylighting and controls.

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So, we start by going over the basics of sidelighting, toplighting, illuminances, and so on. And then go look at some other factors that affect daylighting. From there we go to daylighting controls, see how controls work, how energy savings are realized and what are some other factors that affect energy saving. And finally we'll conclude with the latest requirements and golden standards that are – that following daylighting controls. Right that's a brief overview of the presentation today.

All right. So, let's start with the basics. Why do daylighting in building at all? So, as it turns out and as you can, and as you probably experienced yourself, humans like natural light. Even when we are indoors we want to be – we want to know what's going on outdoors.

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And in fact the lack of natural light can lead to depression and is called the seasonal affective disorder, or SAD or SAD for an acronym. So, we need to be – we definitely need to be indoors to get work done, and at the same time we like natural light. And windows provide that connection for us. Windows provide a way for natural light to enter the space. You can also – bringing light from the top using skylights. But what windows do, they also provide you a sense of connection to the outdoors, which skylights don't. The sole purpose of skylights is to provide natural light and generate energy savings by being able to turn off the artificial light. But as windows also serve as a connection to the outdoors you can have separate clear story windows out at the top of regular windows which are specifically designed for daylighting.

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And here we see what happens when natural light is coming in through a window. The light level near the window is quite high, and as you move inside deeper into the space the light level keeps falling rapidly, almost exponentially. If you increase the head height of the windows, so if you were to make this window higher, or if you were to put more windows at the top here you can probably get more daylight deeper into the space. The decreasing availability of light as you move deeper into the space is a peculiar problem with sidelighting. This is not true in toplighting where you get a more uniform distribution of light level below the skylight.

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You can get an even wider distribution and a more uniform distribution if you were to increase the ceiling height. By increasing the ceiling height you can get both more wider distribution and probably more uniform distribution across the space as well.

So, when we talk about daylighting we often talk about footcandles and lux. And it's important to understand where we – what these units are and what they mean precisely. So, all these terms, footcandles and lux, they're related to illuminance, and if you were to shine a flashlight on a portion of the ground the amount of light falling on the surface would be measured as the illuminance. Whereas the brightness of the surface as perceived by you would be measured as the luminance

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So, the illuminance measure the amount of light falling on a surface. Whereas the luminance measure the amount of light emitted by a source or a surface. And these two quantities have different units. Illuminance is the one that we are all more familiar with probably, especially when it comes to daylighting. It is measured in terms of lumens per meter squared, or lux, and lumens per square feet which is called footcandle. A common conversion between lux and footcandle is about ten, so one footcandle is approximately equal to ten lux.

Here is a logarithmic scale showing illuminances that are commonly found. We start at the very bottom here with moonlight.

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Actually there is a quantity that is even lower, which is still perceived by the human eye, which is starlight. Starlight is even farther below here. And you can still see things under starlight, which is basically just the light from stars. So, we start at the bottom here with moonlight with 0.5 lux, and we can go all the way up to 100,000 lux, which is sunshine, bright sunshine outdoors.

And in the intermediate range we have all these different levels. So, it's five to ten lux is about what you get from streetlight, 200 lux to 2000 lux is the range of illuminance that you will find recommended for office buildings, for schools, for the industry and so on, 10,000 lux is about what you'd see under an overcast sky. But you can see that this is an incredibly wide or large range, and the human eye is able to adapt all the way across the three.

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In fact, you're able to – we are even able to read things under light that is even brighter than sunshine. This is almost a two trillion fold range under which we can still see things.

A lot of research has been done in understanding how much light is required in different spaces and to perform different tasks. For example, if you were to go out to dinner you probably don't need as much light. In fact, you prefer the lights to be dim, from candlelight dinners, I mean, there you go. So, but at the same time if you're repairing a watch, which is a very fine and small task then you probably need a lot of light.

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And so, these recommended illuminance levels, these are from the IES Handbook, the 1998 edition. Since then there have been new additions and the keep changing the recommendations. But the range is approximately, you know, these are approximate ranges. So, as you go down this list you see that there are three main things that are – that determine how much light is needed: the type of the task, the contrast level and how long you need to perform the task.

So, simple tasks like maybe just sitting down in a lobby, they don't require much light. But if you're reading or if you're typing then you start requiring more light. And as you go on increasing the size – or decreasing the size of task, for example, if you were working on jewelry or if you were trying to read fine print you probably need more light. If the contrast level was low, again you need more light.

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As opposed, if you are at the bottom here you have an activity which is performing very special individual tasks of extremely low contrast in small places that has a very high recommendation for illuminance level. All right.

So, when a space is designed with – designed for daylighting, there are several factors involved, and generally start by asking how much light is needed in that space. So, that refers to that previous chart. Daylighting cannot generally supply very high light levels even for certain tasks, such as if you are working with jewelry and so on. But daylighting can really supply ambient levels that are required for moderate office work, just typing, reading, writing and so on.

I don't have a slide in here, but glare is another important consideration when it comes to light and daylighting, actually I should go back to the previous slide.

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Glare is another important consideration when it comes to lighting or daylighting. Glare is when you have an extremely high contrast between the brightest and the darkest part in your field of view. So, this is akin to driving on the road at night when you have other cars, you know, someone is having their full or high-beam on and it shines a bright light in your eyes. But as the rest of your field of view is not as bright, and so that creates a high contrast situation which is called glare.

But there is also glare when direct light falls on your computer monitor and of course that's not comfortable at all, but it is also not comfortable to read when there are viewing reflections, so if you're reading off of a shiny piece of paper or something the reflection – if you're reading in direct sunlight and there are reflections that can be uncomfortable as well.

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So, there are some recommendations for glare and contrast. You generally want about a one to ten ratio between the brightest and the darkest object in your field of view. And in general of course in daylighting if you're considering offices and schools then direct light on the work area, work surfaces, of course it's not recommended.

So, again, when it comes to – while we are sort of – so, those are the illuminance levels that are recommended for different tasks. Now, we are looking at the actual – the factors that affect the actual daylighting design. And one of the big ones is where you're located. Across the US of course there is a big change in the latitude as you go from south, the southernmost part to the northernmost part of the country. But also there is a change in the amount of sunshine that you get in different parts of the country.

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For example, if you're in Seattle you get mostly diffused light. You probably need windows with very high visible transmittance, or at least high visible transmittance. So, that means that windows with clear panes of class. Compared to that if you're in Phoenix where there is a lot of sunshine and the light level available outside is very high, you don't need very clear windows. In fact, probably solar heat gain control is very important, actually you want windows with a low SHGC so you can control your solar heating. Most of Europe is also cloudy, and so you can consider the weather in Germany, especially probably similar to that in Seattle.

I mentioned earlier latitude makes a big difference as well. The images here are showing different views in offices under different conditions outside and how that can affect the amount of light you're getting inside.

So the next key variable is orientation. My advisor graduate advisor at NC State, he used to teach a course on daylighting, and he had hammered into to all of us that orientation is the most important factor to consider when doing daylighting design. In fact, if you get the orientation of the building wrong you are pretty much doomed. Everything else is just a Band-Aid. So, these are some rules of thumb here I have at the top. In general if you're glazing faces north you mostly get diffused light, at least in the northern hemisphere. In the southern hemisphere the south and north would be the worst.

But in the northern hemisphere north mostly means diffused light.

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There may be some periods in each summer when the sun will swing to the east and west of north, so you may get some direct let in the late evening or early morning from that. But for most of the time it's diffused light. On the south it's variable. In the summer the sun is high in the sky and so if you put some overhangs you'll probably get mostly diffused light, but then in the winter when the sun is low in the sky you probably get direct light, and you probably want some of that heat as well to heat indoors.

East and west is generally bad orientations to do daylighting. That's because the sun in the evenings is so low in the sky and so head on that almost no solution to control that glare works. It is again – it is akin to driving on the road with your sunglasses.

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I mean, sunglasses are probably the only solution that will work when the sun is facing you straight ahead. So, I took this picture recently when I was in Salt Lake City for a conference. This is a federal courthouse. I think it has been newly designed. It looks like – it is a full glass building, it has glass on all four sides, and it looks like they've attempted to do some kind of shading. I couldn't get very close to the building. This is a picture from across the street, as you can see.

But I was walking back to my hotel in the evening, so I took this picture first and I thought, "Wow. This is quite impressive. They have applied shading to control the direct light from hitting the glass." But then I turned around the corner and of course when you look at it head on it was quite glarey, so I cannot imagine that the solution is working for all periods during the day.

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Maybe it does work for the majority of the day. It's hard to tell without actually being inside the building, but you can see that it's very, very hard to control the direct sun on the east and west orientations.

Okay. So, the next important variable is surface finishes. It can have a large improvement on the perceived brightness of the room. This is a picture that I took off a school which I was studying back when I was doing my graduate pieces. So, these two classrooms are absolutely identical in every way. The only difference being the carpet in one room on the left-hand side and the lack of a carpet in the other room.

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And you can see that there's quite a big difference in the perceived brightness. I mean, both rooms will have enough light to be able to turn the lights off, but the right one just looks a lot more bright and airy compared to the left. So, yeah, surfaces have a big influence, especially the floor and the ceiling tend to have a disproportionate impact on the perceived light level in the room. So that's something to be mindful of if you are doing daylighting design.

And finally, the last, most important factor, humans, those pesky humans. This is again from the same school, and again, see that it's beautifully daylit classroom. It has this light shelf device to device the lighting to the room. But for – in one of the classrooms they wanted to darken the space and the blinds at the top of the clear story were not working.

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So, basically they found a solution to darken the room, and then once the solution went in it stays there forever and that's the end of daylighting savings. So, humans are a very important factor of doing daylighting design. People will figure out a way to make themselves comfortable and all of us have probably, at some point or another, blocked off a diffuser from blowing cold air on our necks. So, we've all been there.

All right. So that was an overview of some of the basics of daylighting and some factors that affect daylighting design. Now we're going to look at how daylighting controls work. The main principle of daylighting controls is pretty straightforward really.

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When the sun shines we get natural light within the space. We've seen how the natural light level falls as we move in tighter spaces. You're looking at sidelighting right now. The natural light level falls inside the space. And in response to that we can turn off the artificial light. So, you can see that this is – these are three-lamp fixtures. You can turn two lamps off in this fixture with this line visible window because you have a higher light level here. And you can just one lamp off in the fixture that is farther away from the window because you need more artificial light in the back of the room.

So, with this situation we might say that the artificial light level looks something like this.

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It's lower near the window and more higher in the back of the room. And the total light level might look something like that. Where there are some slight variations but what all it stays above a target set point, especially if you do the daylighting design right.

So, what constitutes a daylighting control? We have a sensor, obviously, that needs to sense the amount of light either inside the room or the amount of light outside, and we take a look at open loops versus closed loops, enclosed in a minute. So, we have a sensor here. The sensor sends a signal the controller, and then the controller presumably has been calibrated for that particular space and that particular design.

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And based on its internal logic and the signal that it is getting from the sensor it can close ceilings which then communicates to the dimming ballast about how much the light should be turned down. So, this is pretty much how the system works. There are different types of controls, there are closed-loop daylighting controls. The basic philosophy here is that it – the sensor is placed inside the space, so it is able to look at the illuminance on the desk, and by doing that it attempts to keep the – by sensing how much light is falling on the desk it can send a signal back to the controller, and adjust that light, so the amount of light that it is seeing is constant.

So, for example, if you set the tolerance level to 60 footcandles, it receives that there are 60 footcandles that it's receiving within its field of view.

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Then it will send a signal to the controller to turn down the artificial light and get the level back to 60 footcandles. So, that closed loop controls. There are also open loop controls, which don't look at the light level inside the space but instead look at the light level outside the outdoors. These can be useful if you're trying to control a large single room for example where the light level within that room doesn't change drastically. For example, with skylights this may be a valid solution because the light level under the skylight is more uniform compared to a window.

So, what happens here though is that if you were to somehow change the interior light level without changing the exterior light level, –

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there is no way for the system to know that. And so, for example if you were to draw the blinds here the system cannot respond to this change in light level, and what you'd end up with is your sensor is telling you that you have a lot of light outside so it turn off the light, but on the inside you don't have as much light. So, this can be a problematic situation. But of course it works very well with skylights most of the time because we usually don't line the skylights.

Okay. I apologize for the color in these charts. I was playing with this yesterday and trying to make it such that it would be readable. I hope it is easily readable. I'm going to try to explain it. So, light can be dimmed steps.

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We saw in the previous chart light being turned off, individual lamps being turned off. Essentially what we are doing is we're just turning off the light in steps. What happens here is, imagine that the sun starts coming out early in the morning. This yellow piece of the graph shows the natural light. And so the sun starts coming in in the morning. It has still not achieved enough level to be able to turn off half the lights. But at about 25 footcandles there is enough light coming in through the window that you can turn off half the light.

So, your artificial lights are providing 50 footcandles, which is our target footcandle level. When the natural light hits 25 footcandles you can turn off half the lights. And so your artificial light level goes down to about 25 footcandles.

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And then as you start getting more and more natural light during the day your total light level on the workspace goes on increasing until you hit 50 footcandles from natural light in which case you can turn off all the lights, all the artificial lights. But you can see this tooth pattern in the total light that is falling on the work surface. It is more than what the minimum that we need. This is not usually a problem. I mean, 70 footcandles on the work surface is not a problem at all. But there are some opportunities for lost savings here. So, we can probably get most saving if you were to do continuous beaming.

What happens in that case is that once the natural light is above a certain threshold let's say maybe five or ten footcandles, –

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you can continuously turn down the artificial light in response to the natural light and maintain a much more constant target level. This also helps with occupants because what happens in the step system is that the lights can go on and off and there can be drastic changes in the light level. It can be disturbing, and uncomfortable sometimes, and some people may complain about it. But in this system the change in the light level is much more gradual and so this may be preferred by occupants.

You also get more energy savings because the sawtooth piece that we were seeing in the previous graph, they are not there in this graph anymore because you're maintaining a much more constant level here because of the continuous dimming.

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But of course the tradeoff is that continuous dimming is more costly. We have to use tempered ballasts to be able to do continuous dimming and the whole system is more costly in general. But the cost of daylighting controls at the same time it's coming down significantly. So, you're mileage will vary. You may be able to find controls, continuous dimming controls that are comparable in cost to step controls.

Here are some factors that affect daylight control savings. Daylighting controls usually works best in spaces that have regular occupancy during the daytime. So, spaces such as offices, schools, warehouses, even though they don't have occupants, regularly occupied spaces probably they still have lights that need to be on.

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So, they make for good candidates for daylighting. Daylighting that won't work very well in residential spaces, obviously, because there is no one there during the day. And if there is no one there you might as well turn the lights off, so you don't need daylighting controls to do that.

It doesn't work well so much in spaces that need to be darkened. For example, in auditoriums. You can work it into a daylighting design but it's difficult to do as we saw in the classroom. There are some other spaces in which daylighting doesn't work very well. Retail spaces, for example, is an example. The savings also depend on the window size. As you see codes and standards standards usually don't tell you how much windows to put on your façade.

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And so the amount of daylighting that daylight savings that you can generate for the site will depend upon the size of the windows and how much daylight area you have. The window visible light transmittance is also a very important factor. In the southern climates, the current commercial standards require very low SHGC windows and SHGC of 2.5 is required in climate zone one for example. So, the visible light transmittance of most windows is tied to the SHGC. You can of course get high-performance windows where the SHGC is low and the visible light transmittance is high. That's an ideal scenario because then you can get the low SHGC benefits and you can get reduced cooling through that. But at the same time you can get a large amount of light through a single amount of window area and that way you can maximize your daylight savings.

The control type, as we saw, impact how much savings we can generate.

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Continuous beaming can reach high ceilings, but at the same time the off step being able to turn the lights all the way off that was all very important – it's all very important design step that can generate large amounts of savings. If you're not able to turn the lights all the way off then it might be a situation where you have enough daylight when your lights are still on, and that changes actually a lot of things.

The space type or illumination setpoint is also important. For example, if you were to be doing a task which requires a lot of daylight then you may not be able to get all that daylight in there without causing glare and so on. So, if you were targeting a very high – if your task needs a very high setpoint you may not be able to get there all the way with daylighting in.

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So, you may not see as much savings there as you would say, for example, in an office space where you can get all the target elements to daylighting.

Lastly, daylighting controls require calibration, commissioning, and testing. This is very important to realizing the savings in the field. We can do our best daylighting design and specific the best controls, but if they are not communicated, commissioned and tested in the field after installation then they're not going to work or will create an uncomfortable situation and may get disabled. So, this part is very important, and the golden standards are paying attention to this part, so there are requirements in codes and standards to calibrate, commission, and test daylight controls.

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Appropriate sensor location is also very important. Sometimes reflections or of the windows and so on can cause problems. Also direct, indirect standing fixtures can – it's tricky to locate the lighting sensors with. Care must be exercised when locating the sensor. More and more occupancy sensors are required in code now. Most spaces are now required to be controlled by occupancy sensors, and so configuring the occupancy sensors to work with daylighting controls is another important aspect that needs attention rendering the daylighting design.

And finally, training owners, maintenance staff and occupants is vital for daylighting controls to function correctly as we saw on the previous slide. humans will find a way to make themselves comfortable.

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So, if you haven't thought of that in your daylighting design you may not realize all the savings.

All right. So, that was an overview of daylighting controls. Now we are going to look at some of the requirements in the codes and standards. Codes and standards were addressed in daylighting, obviously, because they save energy. But it has been kind of difficult to write language in code, qualified language that can capture the full savings potential of daylight of controls in a systematic manner.

Buildings and spaces come in all shapes and sizes. And it's difficult to write, like, once size fits all solution. But at the same time attempts that we made to incorporate daylighting requirements into the course, starting with the 90.1-2010 version.

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Previous to 90.1-2010 there were no requirements to put daylighting controls into buildings, at least not from code. So, this table shows when requirements were introduced, the types of requirements were introduced and the plus symbol moving back to indicate the stringency of the requirements relative to other standards. So, looking at sidelighting controls, they were first introduced in 90.1-2010 only the primary sidelighting really was required to be controlled. This change to 90.1-2013, so that's why I'm indicating that with the three plus symbols. In the 2012 IECC also for the first time in the IECC 2012 edition highlighting controls were introduced for the first time.

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And these would be most stringent in the 2015 IECC. Toplighting controls follow a similar story without also requirements for putting in a minimum toplighted area in certain cases. What that means is that not only do you have to have daylighting controls controlling your light, but if you have certain types of spaces, for example, high bay spaces in warehouses you need to put in skylights, which is a component of the envelope so that you have a daylight area in most spaces. And then you have to put controls to control the light in those spaces 'cause there are requirements in that case not just in code but also a requirement in the envelope section.

These daylighting control credits, they are only related to the 90.1 standard.

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What these credits do is they provide a higher LPD if you go beyond the code requirements for daylighting controls. For example, if you were to – in 90.1-2010 if you were to put controls in the secondary sidelighted area, which we describe in a minute. Then you get a credit and you are able to trade that off with a higher LPD, you'll – so those credits exist in 90.1. There are no such credits in the IECC. And finally there are requirements for some testing, which we just talked about. I will look at these in some more detail in subsequent slides.

So, we start with the daylight zone definitions. When you're – all the codes, all the 90.1, all the four codes 90.1-2010, 2013 and with 2012 and 2015 IECC, –

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start with the description of the daylighted area. Once you have a description of the daylighted area you know that there are a certain number of lights in that area and you can have controls for those lights in that area. But it all starts with a description of the daylighted area. So, this figure shows the daylight area under skylights. You can see that this is a description from 90.1-2010. For a skylight the area extends to 27 times the ceiling height. If there are obstructions then the daylight area may be reduced. It depends on how tall your obstructions are. For example, if you have ceiling height partitions, obviously that's a different space.

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But if you have to because when it has certain requirements for how high the partitions can be and how they bound the daylight area. For skylight, if there are no obstruction the daylight area extends to 0.7 times the ceiling height. So, what we see here is what this equation does basically – if you have very tall ceiling height your daylight – your single skylight can cover a large daylight area.

Similar areas are described, or similar definitions pertain for sidelighted areas. Again, this is from 90.1-2010 and you can see that for a window the depth of the primary sidelighted area depends on the head height of the window. So, the primary sidelighted area that I described in 90.1-2010 extends to 1 times the head height.

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So, it is equal to the head height of the window so that the farther the head height of the window the deeper the primary sidelighted area extends into the space. And again, it may be bounded by obstructions in the space. The definition for the 2012 IECC are similar. So, here we looked at the 2010 definition, now we are looking at the 2012 daylight room definition. They are similar but they are slightly different. For example, the floor to ceiling height – sorry, the daylight description, which is based on the floor to ceiling height, 90.1-2010, it is just made equal to the floor to ceiling height in 2012 whereas in 2010 it was 0.7 times the floor to ceiling height. So, it's similar but slightly different. And the same applies to the primary sidelighted area where it was one times the head height in 90.1-2010, but here it is 6 to 15 feet.

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So, if your space – if you have a private office that is only 14 feet deep then it could extend all the way to 14 feet, but if you have an open office that is 20 feet then your daylight zone would extend only up to 15 feet from the perimeter. This is different from 90.1-2010 because generally window head heights are about eight feed typically in office buildings. So, 15 feet would mean that you're almost twice the head height in IECC 2012 compared to 90.1-2010. So, this is something to be aware of.

The descriptions in 90.1-2013 for daylight area did not change. There were some additional things that were added for clarification.

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For example, the overlapping area between primary sidelighted – between sidelighted areas and toplighted areas was – it was clarified that you can't double count this area and also a secondary daylighted area was described in 90.1-2013. So, the primary sidelighted area is one times the head height. The secondary sidelighted area is two times the head height.

All right. So, that was about the daylight zone definitions. Now we are actually moving into the control requirements. So, once you have described the area you can establish sort of requirements based on the area that falls under the daylight zone. The 90.1 follows this methodology. It has a threshold of 250 square feet for sidelighting.

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So, if you have more than 250 square feet in a daylight zone you're required to put sidelighting controls in. The primary sidelighted zone as we saw was one times the head height, and the secondary sidelighted zone that was – it's two times the head height, but you're not required to control that in 90.1-2010. You're only required to put in stepped controls because these are cheaper and some steps are specified. So, you need at least two steps and one step must be below 35 percent of full power and another step can be between 50 percent and 70 percent of full power.

I'm going to jump to 90.1-2013 here because the requirements are similar but there is one major difference between 2010 and 2013. The type of threshold that was present in 2010 was changed in 2013. So, in 2010 we were in an area threshold. In 2013 we are in a controlled threshold.

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What that means is that if you have more than 150 watts in your daylight zone then you're required to put in controls. So, this requirement was not present, or it was differently specified in 2010. In 2010 we had daylight zone itself was 250 square feet you were required to put in controls. So, that's the major difference between 2013 and 2010. Again, the primary and secondary sidelight zone definitions will not change between 2013 and 2010. But the major difference was that our secondary sidelighted zone was also required to be controlled in 2010. And you're required to have an off step in your controls.

So, in 90.1-2010 you could leave 34 percent of the lights on or 35 percent of the lights on. Whereas in 2013 you could not do that. You have to turn the lights all the way off. So that was an additional step that was added that saved a lot of – that generated a significant amount of savings.

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But designers should be warned that turning the lights all the way off can throw some people off. They may think that the lights are not working correctly or it can even create distraction. So, while this requirement is in place it comes with a warning that train – owners and maintenance staff and occupants should be trained to – or should be told that this is how daylighting controls operate and this is normal operation. Yeah.

Okay. So, now looking at the 2012 and the 2015 IECC, as we saw the daylight zone definitions there is just one zone definition that is now primary and secondary **_____** to 15 feet and continuous or step controls are allowed, but they are not required.

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So, you're allowed to do continuous dimming or you're allowed to do step dimming, and there are some specifications for how much full power – for what fraction of full power you must be at when doing continuous and step dimming. But these requirements were not – these were not requirements rather, they're just specifications. You're not required to put in daylighting controls in 2012, but in 2015 you are required to put in step controls and even continuous controls in offices and classrooms. And again, the other difference was in 2012 there was no threshold. You're not required to do anything with the controls and in 2015 we adopt – 2015 IECC adopted the 150 watt threshold in 90.1.

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There are quite a few exceptions to sidelighting controls. I mean, we need to create some exceptions for things like retail spaces for example, as well as for when there is not enough daylight potential even though you may have a daylight zone described by your window you – there may be an external obstruction that is very close to your window, such as buildings, high rises that are next to other buildings, and in that case you may not have enough daylight potential. So, you may not be required to do sidelighting.

There is an effective aperture requirement as well, or an exception as well. If you effective aperture, which basically ties the size of your windows to the amount of floor area that is daylighted is not above 0.1 you are exempted from the requirement.

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Basically, what that means is you need a certain size of window for a given daylight area, and if you're not meeting that specification then you're exempted from the requirement. There is no bottom threshold for – bottom threshold for minimum lighting power. We'll see in a minute, for toplighting controls type there is a threshold for minimum lighting power. If you are in a warehouse and you have extremely high efficiency lights and you fall below a certain LPD you're not required to do daylighting controls. There's no such threshold for sidelighting. No exemption for climate zones either.

There are some other exemptions. For example, retail spaces are exempted, and there is a general exemption I believe for residential or dwelling units in the lighting section. Similar exemptions are there in 90.1-2013. There is also another exemption for when you have less than 20 square feet of glazing.

[0:49:00]

This sort of puts a bottom threshold on the size of the window. If you have less than 20 square feet of glazing you don't need to worry about daylighting controls. And similar requirements exist in the 2015 IECC. There are no such exemptions in the 2012 IECC because, again, daylighting controls are not required. They only specify the type, for example continuous and step but you're not required to put in daylight controls in 2012 IECC.

Now moving on to toplighting controls. Again, we start with an area threshold in 90.10-2010 in and then we move to controlled power threshold in 90.1-2013 and the 2015 IECC. The requirements are similar, but there are some specific features for skylights.

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For example, if the sunlight access is for 1500 hours between 8:00 AM and 6:00 PM then you don't need to do daylighting. This may be, again, because there are exteriors that are blocking access to the roof, or sunlight access to the roof. There is a minimum lighting power threshold here in 90.1-2010 and 2012 IECC. If you're lighting power density in the spaces below 0.5 watts per square foot you don't need to put in toplighting controls. Similarly there are some exemptions for climate zones. In very cold climate zones, for example in climate zone eight 90.1-2010 and climate zone six through eight in the 2012 IECC you're not required to put in toplighting controls because basically skylights tend to lose a lot of heat in those climate zones. And so, daylighting controls don't become cost effective in that case.

[0:51:00]

And as I mentioned earlier, the sole purpose of skylights is to save energy, and if you're not able to trade off the lighting energy savings with the heat loss then it doesn't make sense to require controls. So, that's why this exemption exists. Similar exemptions exist for 90.1-2013 and the 2015 IECC. But instead of having the minimum lighting power we just have the watts, the control power threshold, so if you have less than 200 watts that are controlled then you're exempt.

This part of requirements is what I was talking about earlier, and it's usually in the envelope section, in fact it is in the envelope section for all these four standards, and it relates to a minimum required toplighted daylight area from skylights.

[0:52:00]

This applies to spaces which are – which tend to be large. For example, the threshold in 90.1-2010 was 5000 square feet. The 2012 IECC 10,000 square feet. And the 2013 90.1 and 2015 IECC it was reduced to 2500 square feet.

So, these are kind of large spaces, and you can see that the gymnasium, convention centers, warehouses, concourses are very large. Open offices probably are large lobbies and atria, these are the types of spaces that are applicable here.

One defining feature of these spaces has to be that the ceiling height has to be at least 15 feet. It then make sense to put skylights in and then to put controls in and it makes sense because controls are able to save lights and they are cost effective.

[0:53:00]

So, not only do you have to have a large space but you also need a certain – a high base ceiling basically or a high base state for this requirement to take effect.

So, there are two parts of the requirement. You can choose either one or two. You must daylight at least half the floor area of the space or the skylight – no, I'm sorry, this is not an either or. This is – both of these are required. You must daylight at least half the floor area of the space and the ratio of skylighted area to daylighted area, this would be greater than three percent. The skylight effective aperture should be greater than one percent.

Basically, these say that for a given amount of daylight area you need a certain amount of skylights to be able to daylight that area properly or sufficiently. That's what this requirement does.

[0:54:00]

Again, you're not required to put in skylights in the cold climate zones and when there are other conditions such as existing structures that block sunlight access you don't need to do that. Again, you're exempted if your interior lighting power density is below a certain threshold. And again, you're exempted if there is other kinds of sidelighting. If you are already – if that part of the daylighted area is already falling under sidelighting you don't need to be additional skylights to daylight that area. Or if you have rooftop monitors and so on then you, again, don't need to put in skylights.

All right. So, those were the requirements related to controls, sidelighting controls, toplighting controls, and then minimum daylight area requirements for skylight. Now we are going to look at alterations.

[0:55:00]

90.1-2010 requires – says that if you have greater than ten percent of the connected lighting load in a space that has been altered then you need to follow the requirements of Chapter 9. So, – and also if your LPD increases when you do the alterations. Only then do you need to follow the requirements.

So, daylighting controls are generally not applicable because only – I'm sorry, I should back up a little bit. This requirement only applies to LPD. So, only the lighting power density must be complied with. Daylighting controls are not applicable to alterations with 90.1-2010. In the IECC, 2012 IECC the lighting controls are not included, therefore they are not applicable.

[0:56:00]

In 90.1-2013, again, the alterations are – you only have to worry about the lighting power density and so again, daylighting controls are not applicable. When we come to the 2015 IECC this is a different scenario. If your alterations going to the lighting chapter when daylighting controls are applicable and in fact you will have to put in daylighting controls in your project.

Finally, functional testing, it's required in 90.1-2010. The requirements are similar, the same are in the 2012 IECC. In 90.1-2013 the requirements were slightly enhanced. We'll go in the details of enhancements here, and in the 2012, 2015 IECC the requirements are the same as in 90.1-2010. So, what are the requirements?

[0:57:00]

The requirements are that the controls must be tested after installation to insure correct operation. It should be confirmed that the daylighting controls actually reduce electric lighting in response to daylight. Placement and sensitivity should be checked. The documentation of tested is required. In 2013 you're also required to put on your plans where the daylight areas are so that a code official can easily identify the daylight areas. And then there should also be third party functional testing and the third party must produce a report that certifies that all the control requirements were met.

These are some of the requirements under functional testing for daylighting controls. A brief summary of control credits for 90.1. I mentioned these earlier.

[0:58:00]

For 2010 there are some credits that basically say that if you have certain controls for example step dimming if you have continuous dimming you get to increase your lighting power allowance by a certain amount, and then if you control the secondary daylight zone then you get to put more lights in basically. That second control credit was removed in 2013 because secondary daylighted areas were required to be controlled in the mandatory provision. So, you would not be able to be credited for it later. So that requirement was removed in 90.1-2013. So, these are just some credits to be aware of using these credits you can get some more toplighting power, if needed.

[0:59:00]

That's all I have. I'm going to summarize quickly about all the things I talked about. I've been talking for an hour, so it's good to do a summary. We started with a brief overview of daylighting basics. We looked at illuminances. We looked at what sidelighting is, toplighting is, then we went onto some of the factors that are important for all daylighting design, such as sunlight availability in interior surfaces, the human factor and so on. From there we moved onto daylighting controls, how they work, what are open-looped controls, closed-loop controls and how daylighting savings are achieved. What the differences are between continuous and step building controls.

And the last section that we talked about was the requirements in the different back codes and standards. So, that's what we covered today.

[1:00:00]

I hope you were able to get some information out of the webinar, and I hope that you learned something new. If you have questions you can send them to Pam, or you can type those in the chat box. And Pam, do you want to go over these last few slides?

Pam Cole: Sure. Thank you Rahul. That was a great presentation. Before we get into the question and answers, a flight on resources that are out on energycodes.gov, a couple things. We do have compliance software for commercial energy code compliance, COMcheck-web, there's a screenshot of it there. We also have technical supports, so we do have a help desk. If you have energy code related questions or questions related to the software COMcheck or REScheck for residential energy code compliance. There are code notes that are available on specific code requirements that we have out under resources on the website.

[1:01:00]

Specific publications, energy cost analysis and so forth that you might be interested in. Some resource guides and our training materials. We have the full set that we actually do for all of the main IECC and 90.1. If you're a trainer that's great material to go grab. You don't have to pay anything. This is all free material.

Take it, use it, customize it to your liking. But those materials are available for all the main baseline codes for ASHRAE and IECC. And if you're not a trainer it's good information to go out there and take a look and see what's actually in all the codes 'cause it does have every code section in there and does have some speaker notes as well.

That's all available out there on energycodes.gov. There's more information, so if you haven't played around with the website it's a good time to go do it. And I also want to mention yet again, we are looking for more training topics. There was a couple questions that came in, asked about if there's any other daylighting software or daylighting training that's available.

[1:02:00]

We don't have any specific daylighting training that we have geared up to do in the near future, but if you have some suggestions on other topics even related to daylighting or other type of lighting controls or anything to do with energy codes in general to do with commercial or residential buildings we want your topic ideas.

You can submit them through the help desk, you can submit them through the link that you were provided to the webinar today and so there are some different avenues that you can go to and submit us your topic ideas. We are interested. So, again, Rahul, you did an awesome job. There are so many questions. We had a really large audience today.

And I'm going to go ahead and start just addressing question to you, Rahul, and then you can answer them as we go along, and if time permits we will try to get through all the questions that have been submitted and ones that we don't, if your question doesn't get answered, again, you can submit them through our help desk and feel free to do so.

[1:03:00]

So, let's start off with the first question. So, Rahul, how do the savings in natural light compare with the increased cost of air conditioning?

That's a good question.

Pam Cole: I thought I would just start off with a tough question.

That's a good question. So, actually, when you have daylighting savings they come from turning the lights off in the space, and so what you would see if your cooling load would actually decrease because the lights are putting out some heat together with the light. And so when you turn the lights off you have less heat, and so your cooling load goes down. But you do see an increase in the heating load and as we saw in some of the requirements in the codes, skylights are not required in climate zones six through eight, which is basically the really cold climate zones, climate zone eight is Alaska.

[1:04:00]

So, in those climates the tradeoff doesn't really work. You save some energy from the lights, but you're losing so much heat from the skylights and also – yeah, you're losing so much heat from the skylights that tradeoff doesn't work anymore. But generally, for sidelighting and for skylights most – in many parts of the continent in the US it should work. It is a positive tradeoff.

Pam Cole: Great.

I hope that answers the question.

Pam Cole: How does one deal with the veiled reflectance at very high lux levels? So, veiled reflectance at very high lux levels.

Could you repeat that? Sorry.

[1:05:00]

Pam Cole: So, it's, how does one deal with veiled: V-E-I-L-E-D, reflectance at very high lux levels?

Yeah. I mean, there is – you can't really deal with it. You have to do something about it, I guess. If you're getting that in the space then – I mean, I'm trying to imagine how in an office if you're getting that you're probably getting direct sunlight deflecting off some surface or many it's in an adjoining building which has a really reflective glass. And you will be getting a reflection from that. I mean, that can be really annoying and I guess you need blinds or some mechanism to control that. And if you don't have that that can become really problematic.

Pam Cole: Okay. Next question, LED won't operate with ballast. Does the driver in LED lighting control the artificial light?

[1:06:00]

Yes. That's right. So, there is a whole – PNNL we have a solid state research program with PNNL and we are engaged in understanding how LEDs react to dimming. So, not all LED lights are capable of dimming and even some of those that are capable don't do it very well. So you can get flicker and you can get premature burn out and so on when the lights are dim. So, you need to get drivers that are compatible with dimming. But, yeah, but they are available and they should be commonly available, and LEDs are actually great for dimming because you can control them really, really precisely and quite easily and they are more amenable to dimming than say, fluorescents.

[1:07:00]

Pam Cole: Okay. So, while we're still talking about LEDs and we've not specified fluorescents in years and it was a comment that came in and at this point was there an update coming for LED fixtures? Some of this no longer pertains and I think was in your beginning slides that you had when you had the table up. So, the question is, is there going to be an update for LED fixtures for specifications?

Yes. I mean, I'm just the question. So, in general LEDs are moving at a very rapid pace right now. There are rapid improvements of the efficiency and the cost is coming down quickly too. So, in the next round of 90.1, which is 90.1-2016 and probably the 2018 IECC we'll see new lower LPDs that are based off of LED products, –

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especially 90.1 I know that the company has looked at what is available today and what is likely available to be in the future. And there are some conservative updates to the lighting part entity. So, the lighting part entities are moving downward to follow the penetration of the LEDs in the market.

Pam Cole: Okay. Next question, using dimming ballasts in the fixture, what is the range of the dimming ballasts to be used?

I don't know if I can answer that question. I don't know. I would probably need more information to answer that. To be fully honest, to provide some background, I have not been a practitioner for, like, several years I've worked in codes and standards. So, I wouldn't be able to answer that question.

[1:09:00]

But I can – if given more information I can probably take a shot at it.

Pam Cole: Okay. Sounds good. What is driving the reduction in cost for daylighting systems?

That's a good question. I mean, in general the cost of sensors and controls are – is going down. Sensors are becoming much cheaper, and it is also – with LED lights it's also easier to control LED lights, as I was mentioning earlier. Yeah. I mean, basically just the cost of the sensor and the controls are going down. The cost of the wiring and the commissioning and installation that may still exist, but there are some ways around that too. I mean, not only as you get wireless sensors which are more expensive to begin with, but they're much easier to commission. s the tradeoff then is that wireless means there are more things that can fail, and there are more things that you may have to maintain.

[1:10:00]

So, it's a tradeoff, but traditionally, traditional sensors and controls or controllers are coming down in cost that's just driven by technology I'm guessing.

Pam Cole: Okay. And in 2012 is there something that distinguishes the sidelighting provisions from the toplighting provisions? Is it just daylighting control? Can you confirm? So, is there – I would have to say distinct – pure distinct – I can't even say it. Where it's distinguishing between the sidelighting provisions versus the toplighting provisions in the 2012 IECC versus 90.1? Can you go into more detail about that? You might want to go over that in the slide where you have the toplighting and sidelighting.

[1:11:00]

Yeah. I mean, there are some differences. The main thing I would say is that the 2012 IECC does not have requirements for daylighting controls. I mean, it prescribes things such as if you want to do daylighting controls you must have these – you must have continuous controls or you must have step dimming controls. I'm sorry. I'm just going to go back to my final slide. It does prescribe the types of controls, but I don't think that they are required. You're not required to install controls. There may be some requirements tied to the envelope section where if you do – I'll have to look in detail, if you do certain higher window to wall ratio you will be required to put in controls or if you have skylights in a zone and so on you may be required to put controls.

[1:12:00]

But it is in the lighting chapter. The daylighting controls are not required. They are optional.

Pam Cole: In the 2012 IECC for daylighting controls, or you know, all the provisions you talked about. In the 2012 is commissioning and testing required?

Yes. Yes it is.

Pam Cole: So, this has to do with sidelighted zones and the one times the head height and the secondary head heights, Rahul, so 90.1 over 2013, the secondary sidelighted zones are only one by the head height and depth, but extend that depth beyond the primary sidelight zone. Isn't the two times the head height a misnomer to the depth of the space?

[1:13:00]

Right. That's true. Though, let's see, do I have that graph here? Yeah. Let's try this one. So, yeah, you can see that it is a misnomer. Yeah. The secondary sidelighted area does not start until the end of the primary sidelighted area. So, it is one times the head height, but it starts at the end of the primary sidelighted area. So, yeah, I guess in my slides where I say twice the head height I could change this to say it is one times the head height beginning at the end of the primary sidelighted area. So, yes that is true.

Pam Cole: Okay. Keeping on this slide, there was one about the wattage that I'm going to ask next. Yes, right here. So, one of the questions was, control power 150 watts for a lighting area what is the wattage referring to?

[1:14:00]

It refers to the lights that are placed in that area. So, for example, if you were to look at a drawing of the lighting system and you have certain luminaires in your – let's take the example of a perimeter office of a private office. You may have, say, six or four, two by four fixtures in there, and you will have a certain amount of lighting power in that private office. And if that private office constitutes the primary sidelighted area then you have a certain amount of power in that primary sidelighted area. If that power exceeds 150 watts basically you're required to put controls in. That's how it works.

[1:15:00]

Yeah, so it might happen that your daylighted, you know, in a large or in an open office it might happen that your daylight area extends up to a – extends a certain amount, and there is just one fixture, like half of the fixtures that fall in there which makes you go with the pressure. There may be some situations like that. But they should be rare and they should be explainable with the cone of vision.

Pam Cole: So, I'm going to try and combine a couple questions here and maybe you can touch on this or summarize this, Rahul. So, there have been questions that have come in, a variety, on alterations. So, if we have an existing building, I'm remodeling it, and this I think is going to be code dependent, does daylighting controls come into play? And let's say if you were doing a lighting retrofit that's 100 percent of an actual space. Or can you talk more on the requirements for alterations on an existing building, and you have the slide up.

[1:16:00]

So, I think this might address some of the questions that have come in. and what path is this? Is it very prescriptive? Meaning if you are doing alterations and you're looking at daylighting controls, is this very prescriptive or can you look at other methods of compliance when it has to come to these requirements for daylighting.

Okay. I'll answer the first part first. So, I just quickly – I think I was not clear when I explained the slide probably. So, for these – whoops. So, for 90.1-2010, 2012 IECC and 90.1-2013 daylighting controls just don't come into the picture because the only things that are affected by operations are the lighting power density, the interior lighting power density. So, if you're doing alterations all you have to worry about is the interior lighting power density. Daylighting controls are not in the picture at all.

[1:17:00]

The 2015 IECC, they are in the picture, so if you are altering more than ten percent of luminaires in the space and your LPD is increased then daylighting controls are in the picture and you may have to put those in. but if you're not altering – if you're altering less than ten percent of the luminaires or if you're not increasing the LPD, again, you're okay. So, will then max the requirement.

The second part of the question was whether the performance part of some other parts would be explored. And I would have to refer back to the code before answering that question. I don't want to say something that may be incorrect. So, if they want to – if the person asking the question wants to contact us later I can probably look into the code or the code or the codes and try to answer that.

[1:18:00]

I'm not sure how the parts work and where alterations fall in the different parts because there is a prescriptive part, there is a performance part, there is maybe tradeoff approaches, so I like to look at that before answering that question.

Pam Cole: I answered a couple questions. You have some slides for – you had a table with VT, visible transmittance, and it was asked what VT was meant. So, I'm wondering if you could touch on VT. Go to the slide that had visible transmittance and the variables around VT and this will answer a couple of questions that have came in about visible transmittance.

Right. I think there's –

Pam Cole: There's on retail spaces right there. Can you touch on VT a little bit? That might help answer some of the questions related to VT.

Sure. Yeah. So, VT is basically the visible light transmittance. That is the total light transmittance coming through the window including the frame.

[1:19:00]

So, there are certain exceptions here. VT also ties into the effective aperture. So, the effective aperture includes the effect of the size of the window as well as the transmittance of the window. Basically, that just means how clear your window is very clear window you can get a lot of lighting, whereas if you have a dark window you may not be getting as much light in. Essentially that is what we categorize – visible transmittance categorizes.

So, what the effective aperture says is that if your window is either too small or too dark to create enough daylighting, then you're not required to provide controls. It's the same with – yeah, and it's the same with skylights too. If the VT is below a certain threshold then again you're not required to provide controls. But, I would suggest looking at the requirements in detail because there are certain exceptions, there are certain other requirements too.

[1:20:00]

So, yeah, I would suggest looking at the requirements in detail when it comes to VT. There is a thing called the haze value as well. That applies to skylights. I don't think I have it here. So, what the haze means is that the skylights need to be – you don't want to let direct light in through the skylights. You want diffused to fall through the skylight. And so, the skylights are fitted or they are sort of hazy in terms of the texture or how they look. Basically, that diffuses the light coming into the skylight. So, that is a requirement in the standard for that too. And that's sort of related to VT.

Pam Cole: Great. Next question.

[1:21:00]

Are there any standards in the IECC for K temperature, Kelvin temperature, mixture of artificial versus natural light? Is there any reference standards?

Could you repeat that again?

Pam Cole: Are there any standards or reference standards in the IECC for K temperature mix of artificial versus natural light or natural light? I don't think there is.

I don't believe there is. No. So, the IECC and even 90.1, they're primarily concerned with energy savings, and I guess what this is getting at is the color of the light. I'm not – I don't have the question in front of me and we can't talk with the commentor, so I don't know what the question precisely means, but if it refers to color then, no.

[1:22:00]

There is no guidance or a requirement for the IECC for that. But I would look for the IES – you know, the IES handbook or one of the recommendations or the – I don't know what they call them, but the standards to IES standards for that information.

Pam Cole: Okay. Great. This is back on the visible light transmittance and then I'm not sure that there's an answer for this, but I'm going to ask you anyway. Is there a visible light transmittance value that will reduce the potential for glare or eliminate glare?

That's a good question. Yeah. So, I mean, you can put dark windows in there, darker definitely reduce the amount of light coming in, and so if you are wearing sunglasses, for example, you can probably look straight into the sun as well. Probably not but sometime maybe.

[1:23:00]

So, you can get tinted windows, dark windows that will probably help with the glare, but I don't think that's good daylighting design. I think the way to do it would be to have clear windows so that your occupants have a view to the outside, and then you should have blinds on the inside so that the occupants have control. So that when there are situations where there is glare they have the ability to control that environment and avoid the glare. Also, with some overhangs you can generally avoid some of the direct sunlight in most parts of the country. So, there are some other ways to avoid glare I would say. Definitely blinds are probably the best way.

[1:24:00]

Pam Cole: Okay. I'm kind of going through some of these questions. We've answered some of them 'cause they've been multiple together. But there was a question, Rahul, on slide ten, and it had to do with if you could further define the sky types A, B, and C. And the map that you've referenced what was – the reference that you've shown on the map.

Yeah. I think this is from the IDCC. The IDCC, I don't remember which year, but this is from one of the IDCC standard, which is a green standard or an advanced standard. An advanced version of the IECC. But it really comes from NOAA, and it's a chart showing the annual mean sunshine. There is a legend here which I edited out.

[1:25:00]

But basically it talks about the amount of sunshine that is available in different parts of the country. I mean, in most parts there is enough sunshine available, it differs of course. But you have to be very – you have Seattle and probably along the coast here in some of the more cloudy regions that may warrant a different daylighting design where you probably have for most parts of the year you have diffused light and that will affect your daylighting design. The size of the windows, for example, and what strategy you use to control glare and direct light. Those are the sort of things that would be affected.

Pam Cole: Okay. So, there's been some questions that have came in about states and who adopts daylighting controls and so forth, and I'll address that then I have one question left for you, Rahul. And then we will wrap it up.

[1:26:00]

If you could put it on that last slide again. And again, if we didn't address your question send it in through our help desk. The link is also provided on this slide here. So, there were a couple questions that came in and said, "Well, who has these daylighting controls and where are they enforced? And what states have adopted them?" And so forth.

There was a question that came in on an older code, the 2009 IECC. States adopt different versions of the codes throughout the entire US. Some are still on the 2009, some are on the 2015 IECC and some directly enforce 90.1-2013 and vice versa. A good resource to go to to see what state has adopted what code, you can go out to energycodes.gov and you can click on adoption and there is a dropdown of every state, and you can click on the state and see what the active effective energy code is in that state.

[1:27:00]

And as Rahul has talked about today he was referencing the most recent two versions of the 2012 and 2015 IECC and ASHRAE 90.1-2010 and 2013. That doesn't mean that these are the only codes that are effective in certain states, and in some states are home rule and they adopt by local jurisdictions. So, if you're a designer and you're not sure first place maybe go look at the state level and secondly you might want to work with your local jurisdiction to see what they're enforcing in their municipality.

And last question to you, Rahul, is where do you see the future of daylighting controls going? To sum it up.

Last one, that's a great question. I am not the expert or anything, I've just been – I've been familiar with these things, but I'm definitely not an expert, but definitely really they're proliferating rapidly into the market and the lighting part entities are going down too.

[1:28:00]

I see at the same time there are phenomenal progress – there is phenomenal progress happening in technology especially in the field of sensors and integration of different technologies. So, I think that luminaries, LED luminaires the integrated sensors that are able to with the logic encoded in them to automatically to sense the lighting, automatically reduce the lighting – automatically reduce the light leveling response for that light. I mean, I think that is probably where we're headed eventually. These things do exist right now. You do get luminaire living degraded sensors and controls. They are expensive though. Although, I don't know, maybe the cost has come down, but definitely that's some place that is likely where we are headed.

[1:29:00]

And I'd also like to add a little bit to what Pam said, the 2009 IECC and the 90.1-2007 do not have any daylighting control requirements.

So, if your state is on, or if your jurisdiction is on those codes there are no daylighting control requirements. And the second thing is there can be amendments. So, even if your state adopted the 2015 IECC they may have amended the daylighting control requirements. So there is always that. So, you should refer to what your state has adopted for the code.

Pam Cole: That's exactly right. I was just going to make that point. Some states do modify and have amendments to the codes and some states have their own state-specific code. So you really need to pay attention to what's happening within the state, the best resource to go to is go take a look at those state pages out on the building and energy code DOE's website and there is links out to even the state pages and resources if you want additional information on what's happening with their codes and their adoption of codes. And if you want to look at lighting in particular there's committees you can get more interest in if you want to. There's an ASHRAE lighting committee.

[1:30:00]

There's lots of good resources out there that are available. And again, if you have questions and you need additional information send it into our help desk. Well, thank you, Rahul, for taking the time. This was a great webinar that you presented today. There was a lot of questions that came in, a lot of really good questions. And we do appreciate taking the time.

Again, send us in your topics. We are looking for additional topics. We want to know what you're interested in when it's related to energy codes for training. We will be doing training every month the same time, second Thursday, so pay attention to out on the website for upcoming training webinar events as well. And everyone, thank you for participating today and you can disconnect.

[1:30:48]

[End of Audio]