

Cooledge Lighting

COOL 500

A Holistic View of Illumination

Presented by [Your Name Here](#)

Date: September xx, 2024



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Course Description

New standards and increased understanding of the impact of design on human well-being are driving changes in what factors must be considered when choosing lighting. This course explores the concept of holistic illumination, focusing on the aspects of lighting and sound that are important for ensuring spaces are supportive of wellness and the requirements for addressing them. In addition, holistic illumination includes the need for various layers of light to be integrated together and explores the role sustainability plays in making design decisions.



Learning Objectives

At the end of this course, participants will be able to:

1. Understand the emerging factors of lighting that require a more holistic view of illumination which includes human well-being, sustainability, and integration
2. Understand the problems associated with human well-being that need to be addressed during design and how luminous ceilings can provide solutions
3. Understand the key metrics used to determine the impact of lighting and acoustics on people and their interaction with each other
4. Understand the current and future state of sustainability in general and specifically as it relates to lighting



“The quality of a visual environment considers a wide range of variables including luminance balance, color appearance, visibility of multiple visual tasks (often accomplished by a layered lighting system), visual comfort, daylight and views, control and finally, user acceptance.”

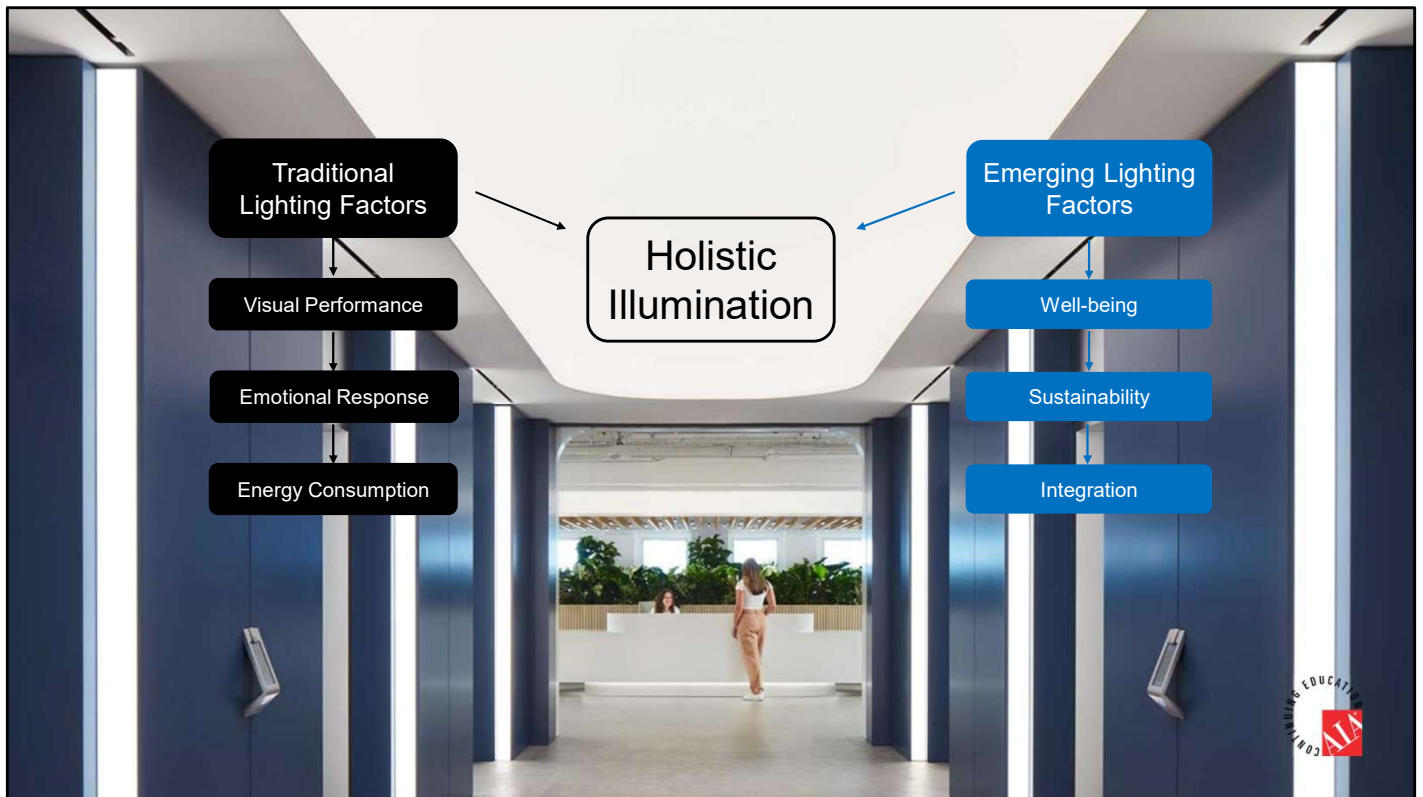
- GSA P100

The Facilities Standards for the Public Buildings Service (P100) establishes mandatory design standards and performance criteria for GSA-owned buildings. Design and construction professionals must abide by the policy and technical criteria in P100.



Speaker Notes:

- General Services Administration P100 requirements apply to federal civilian buildings which provide workspace for 1.1 million federal employees. The GSA is one of the largest real estate holders in the United States.
- The view expressed in the P100 document is an example of taking a more holistic view of lighting.
- In this course, we are going to look at factors beyond even those noted here.



Speaker Notes:

- Light and lighting design has in the past been focused on functionality and creating emotional responses.
- These aspects remain critical to success.
- Ensuring there is an appropriate amount of light for certain tasks or delivering designs that encourage shopping, socializing, or studying are still the primary activities of lighting design.
- However, an additional requirement to consider lighting in the context of well-being is gaining prominence and is likely to become an equal component alongside the others.
- In addition to all of that, design teams are being tasked with ensuring sustainability – whatever that means (More on this later)
- Finally, the complexity of combining all of these aspects of lighting is leading toward a need for more integration especially as it relates to acoustic performance but also the various layers of lighting, controls, and adjacent mechanical systems.

Traditional Lighting Factors: There's Still Work to Do



Visual Performance

Older workforce requires higher light levels

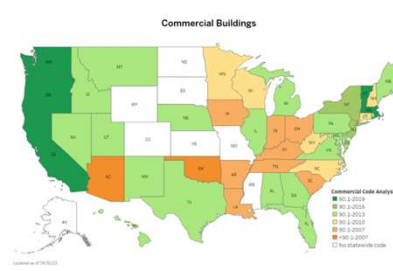
How do we balance the need for more light with ever decreasing allowable energy consumption limits?



Emotional Response

Tunable White illumination is now affordable

How do we take advantage of this feature most effectively?



Energy Codes

LEDs are pretty efficient. What now?

Will ever more stringent codes result in lack of choice or poor quality illumination?

"Importantly, a company, architect, designer, manager or business leader, motivated to create inclusive spaces for all individuals in an office environment, must concern themselves not with an imagined "average" person, but instead with the nuance of individual differences and preferences."

- Tony Esposito, WELL Building Director, Standard Development, Light Concept Lead



Speaker Notes:

- The focus of this course is on those emerging factors but before we go there, I'd like to highlight a few challenges related to what we're calling "traditional" factors that will require more work and more answers on the part of the lighting industry and its partners in design
- The relationship between lighting and visual performance is well understood and has a vast set of metrics to define performance.
- We also know that the population is aging and with it a need for more light. More inclusive approaches to design also recommend creating spaces that cater to the needs of people at the limits of performance rather than the average.
- How will we balance the needs of the people with the desire to reduce energy consumption?
- Are LEDs now an efficient enough light source that we can focus on the type and quality of lighting, or will energy codes eventually restrict lighting to only the most efficient methods even if not the best for the people using the space? *(For reference, the dark green states enforce the most up to date energy codes while the white ones don't have statewide codes at all)*
- Up until recently, tunable white options for LED-based lighting have come with a significant price premium. Now that this is often not the case, how will we best take advantage of this feature to create better lighting experiences?
- As I said, we're not going to try to answer these questions, but they are important enough that they shouldn't get lost and should be considered alongside the emerging factors impacting lighting design.

Emerging Factors: (Acoustic) Lighting for Well-Being

This section will cover:

1. What is Driving the Emergence of Well-being as a Design Factor?
2. What Do People Really Need to Feel Better?
3. The Characteristics of Lighting that are Important for Well-being
4. The Importance of Sound Control and How Luminous Ceilings Make a Difference



Speaker Notes:

- You're likely familiar with most of them but as a starting point, we are going to quickly review the organizations and emerging standards that are driving changes in what aspects of lighting are important
- From there we will look more specifically at how the lighting industry is starting to embrace the idea that lighting has a significant impact on wellness and define what type of lighting is "good for people"
- Now that acoustic lighting is a real thing, we're also going to look at what makes luminous ceilings a better alternative for providing both good lighting and noise reduction

“We now know that developers and architects can be more effective in achieving public health goals than doctors in white coats.”

- Dr. Richard Jackson from the University of California Los Angeles School of Public Health as quoted in Workdesign.com: How Office Design Can Influence Employee Health and Wellness (2022)



Speaker Notes:

- That's a pretty heavy load to carry...

There Are Lots of People Telling You What to Do



Speaker Notes:

- And there are a lot of organizations telling you what to do
- Some like LEED started out focusing on efficiency and have expanded to encompass all aspects of building design.
- Others like WELL – as the name suggests - are specifically targeted at well-being
- Others are even more expansive. LBC regulates the impact on neighboring buildings, who is involved in the construction, and how the building is operated in addition to extraordinary detail about the content of products and where they came from.
- One of the biggest challenges designers face is that these standards are changing rapidly, making it difficult to keep up.
- For example, even as LEED is transitioning from V4.0 to V4.1, they have published V5.0 that contains significant changes in the requirements for points

And There Are Lots of Points to be Scored



Total points achieved	WELL Certification		WELL Core Certification	
	Minimum points per concept	Level of certification	Minimum points per concept	Level of certification
40 pts	0	WELL Bronze	0	WELL Core Bronze
50 pts	1	WELL Silver	0	WELL Core Silver
60 pts	2	WELL Gold	0	WELL Core Gold
80 pts	3	WELL Platinum	0	WELL Core Platinum

35 – 54%



55 – 69%



70 – 84%



85 – 100%



Speaker Notes:

- And there are lots of points to be scored
- A common approach is to award points for specific design features in a variety of categories that when added together will result in a building that addresses the needs of its occupants
- This is a significant added burden on you, the designer.
- (And even moreso on manufacturers, but that is another topic for another day)
- So why bother?

Designing For The Needs Of People Is Mandatory For Success



Source: 1. PwC CEO Survey 2019

"Wellness in the workplace has emerged as a critical issue because it is simply **too fundamental** to be ignored."

"Bodies of evidence from all parts of the globe prove that **well designed workplaces are critical** for the health and wellbeing of society. The message to the real estate and built environment sector is clear: prioritise health and wellbeing by making spaces human again"

"...More than a 'fad' this is a global socio-political shift – **rue the industry that is not moving to address it.**"

- Cushman Wakefield, Well Work Place: Making Spaces Human Again

"**Wellness** continues to be a **key consideration** for companies and landlords when building or redeveloping office spaces."

- CBRE Online Article 2019

"The workplace is the physical manifestation of your company's culture and core values. By better understanding **the deep connection between the human experience and real estate**, organizations can create more innovative workplaces that drive productivity, experience and business value."

- Ed Nolanm, JLL Workplace Strategy



Speaker Notes:

- It is your clients who recognize the value of designing for wellness, driving changes, and supporting new standards.
- Here we show examples of large property management firms' thoughts prior to 2020. The pandemic has added urgency and created an environment where designing for the needs of workers is no longer an option for companies hoping to attract workers back to the office. It is a mandatory requirement.
- But offices aren't the only places where a wellness focus is at the forefront. Greater awareness by the general public can affect almost any public space.
- Healthcare has always had a focus on the patient experience but struggled to overcome traditional construction practices. The industry will be forced to adopt new ways to address new design requirements
- Hospitality and institutional buildings will also need to cater to people who have gained a sudden awareness and appreciation for spaces that address more than merely functional needs.

New Standards Recognize the Need for Better Environments



AIR



WATER



NOURISHMENT



LIGHT



MOVEMENT

New and emerging building standards recognize the need to provide occupants with environments that have been designed for more than functionality – requiring a number of features be addressed including good lighting and good acoustic performance



THERMAL
COMFORT



SOUND



MATERIALS



MIND



COMMUNITY

WELLv2™



Speaker Notes:

- These new and evolving standards provide a useful framework for defining and rewarding projects that are built with human well-being as a central focus.



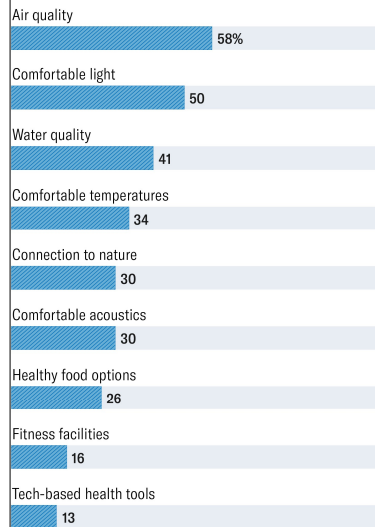
Speaker Notes:

- But realistically, how many of your clients are asking for LEED or WELL or LBC or any of the others? For some of you they may represent the majority – especially if you are involved in a lot publicly funded projects. But for many of you, the certification aspect may not be a consequential part of your business
- However, the goal of designing for human well-being is still a worthy one because for most businesses, whether office-based, retail, hospitality or others, it is their people who are the most important contributor to their success.

But What Do People Actually Need to be Healthy and Productive?

Workplace Wellness Perks That Matter to Employees

A survey of 1,600 workers reveals that air and light matter much more than tech-based health tools.



Source: Future Workplace

HBR

Most Important Design Impacts on Users

- Air
- Light
- Water
- Temperature
- Nature
- Sound

Emotional wellness: Give employees access to natural light, and quiet rooms where they can comfortably focus on their work.

Physical wellness: Provide people with healthy food options, and ergonomically designed workstations.

Environmental wellness: Make sure your workspaces have adequate air quality, light, temperature, and proper acoustics.



Speaker Notes:

- So what do people actually need to be healthy and productive?
- The study cited in the Harvard Business Review article is based on workplaces but again, the results can be applied to most public spaces.
- Designing spaces for humans ultimately comes down to a handful of categories that the design team has control over
- And lighting plays a substantial role in determining whether or not an indoor environment contributes to the health and well-being of its occupants

LIGHT



Speaker Notes:

- As noted previously, ensuring visual requirements are met and creating the desired emotional responses are fundamental to lighting design, however, emerging factors that address a wider segment of the population and consider the physiological impact are gaining in importance and may soon be equally relevant

What's the Problem?

User concerns reported in recent US Department of Energy L-Prize research mirror the latest US Workplace Census reporting.

US 2020 Workplace Census	User Concerns
21% of US Workers experience Vision Difficulty	60% of respondents prioritized “seeing clearly”
12% of US population suffer Migraines, the 2nd most disabling condition after to lower back pain	53% of respondents prioritized preventing headaches.
30% of US Workers experience Ambulatory and Mobility Difficulty	Coexisting disabilities contribute to and exacerbate visual challenges in the workplace.

- A survey of migraineurs and control subjects on triggers for migraine and headache found **light flicker** to be the most cited trigger; it was chosen by 45% of the migraine group compared to only 6% of the control group.
- The same migraine group also identified other visual triggers, such as computer screens, **glare**, abrupt transitions in light conditions, or patterns of stripes

Poor quality lighting can result in significant problems for large proportions of the population



Speaker Notes:

- A workplace census in 2020 highlighted how important having the right lighting can be. Of the problems associated specifically with lighting, having enough light to see properly – especially for those with vision challenges – and poor quality lighting causing headaches and migraines stand out.
- Perceived causes were light flicker – now given the fancy name Temporal Light Modulation – and discomfort glare.
- The solutions to these problems are relatively simple by selecting the correct type of lighting and ensuring the quality of the products selected.

CIE Integrative Lighting: Position Statement

September 2024: The CIE is excited to announce the release of the third edition of its Position Statement on Integrative Lighting - "Recommending Proper Light at the Proper Time."

- **Balanced Lighting Quality:** Emphasizes the need to **harmonize human well-being** in all its aspects with energy, environmental, and architectural considerations.
- **CIE S 026:2018 Compliance:** Characterizing light for integrative effects should adhere to the CIE S 026:2018 standard, the CIE System for Metrology of Optical Radiation for **ipRGC-Influenced Responses** to Light.
- **Guidance on Light Exposure:** International experts meeting in Manchester, UK, recommended **a healthy daily light exposure pattern** for young adults: high light exposure during the day, a much lower level for the three hours before bed, and near-darkness during sleep.
- **Design Considerations:** Urges careful design to **avoid glare** and manage lighting energy use while achieving **high-quality** integrative lighting.
- **Public Guidance:** Today, **we know enough about the effects of lighting on health** to provide general guidance to the public, which the CIE, in collaboration with other international partners, will offer in the coming months.



International Commission on Illumination
Commission Internationale de l'Eclairage
Internationale Beleuchtungskommission

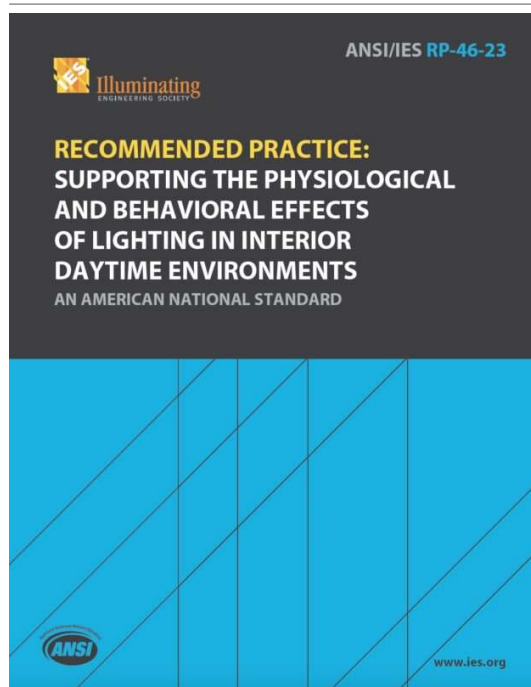
Since its inception in 1913, the CIE has become a professional organization and has been accepted as representing the best authority on the subject and as such is recognized by ISO as an international standardization body.



Speaker Notes:

- Now that LED lighting has addressed energy consumption significantly, the focus of the lighting industry is turning to the impact light has on human well-being and how we can balance all aspects of lighting instead of focusing "blindly" on efficacy, the lighting equivalent of miles per gallon
- The CIE is the global body tasked with providing guidance and standards to the lighting industry. In general, the regional bodies like the Illumination Engineers Society of North America (IESNA) follow the lead of the CIE and incorporate its input into their own standards and design guidance
- In September 2024, the CIE released an updated statement on what they call integrative lighting by which they are meaning, lighting that impacts human physiological responses.
- It calls for the inclusion of well-being as a primary consideration alongside energy, sustainability, and aesthetics in lighting design
- The reference to ipRGC-influenced responses just means that lighting design should take into account physiological effects including circadian impacts – see next
- Managing glare has always been an issue but it now embedded in new standards as is the requirement for high quality lighting in general
- And finally, after years of saying "we're not sure yet" the CIE and other standards bodies think there is enough knowledge available to guide other professionals and the public on the effect lighting has on human well-being

IES RP-46: What Does It Say About Lighting for Well-being?



Healthy daily light exposure pattern

- Large diffuse area lighting
- Indirect lighting with white ceilings
- Wall washing of light-colored surfaces

Temporal Light Modulation (TLM)

- It's talking about flicker
- Known to cause headaches and migraines
- Don't do use products that flicker!

Glare

- Possibly another contributor to headaches, etc.
- Recommendation: "Large number of lower-intensity luminaires can produce physiologically effective light in a workspace more comfortably than a small number of high intensity products"
- Luminous ceilings are this concept at its extreme



Speaker Notes:

- In North America the IES has also recently published guidance on supporting lighting that includes consideration of human physiological responses and best practices for addressing them.
- Ensuring an appropriate level light exposure is recommended with guidance that large diffuse area lighting and/or use of wall surfaces are preferred ways to achieve this
- The Recommended Practice also addresses the need to ensure flicker falls outside the range of human response and that glare is managed – again noting the use of large, diffuse sources as a preferred method

Physiological (Circadian) Impacts

A substantial amount of research in the past decade has determined...

Light exposure has a significant influence on our circadian systems which in turn affects:

- Sleep
- Health
- Alertness

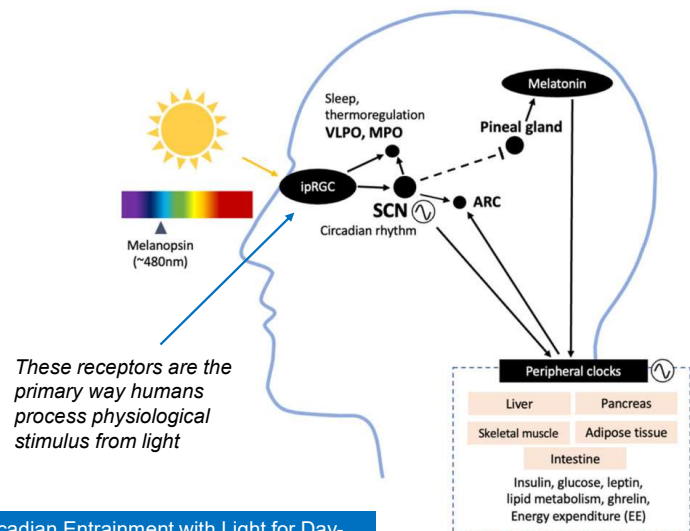
Key Characteristics of Circadian Lighting

- Amount of light at the right time of day
- Spectral qualities of the light
- Illuminance at the eye

In 2020, UL released DG 24480, Design Guideline for Promoting Circadian Entrainment with Light for Day-Active People.

"Lighting isn't just for vision anymore. It's high time we had a valid, agreed-upon metric and some basic guidelines so that healthy lighting can be effectively delivered to benefit society."

- Dr. Mark Rea, Ph.D. Professor of cognitive science at the Lighting Research Center (LRC) at Rensselaer Polytechnic Institute



Speaker Notes:

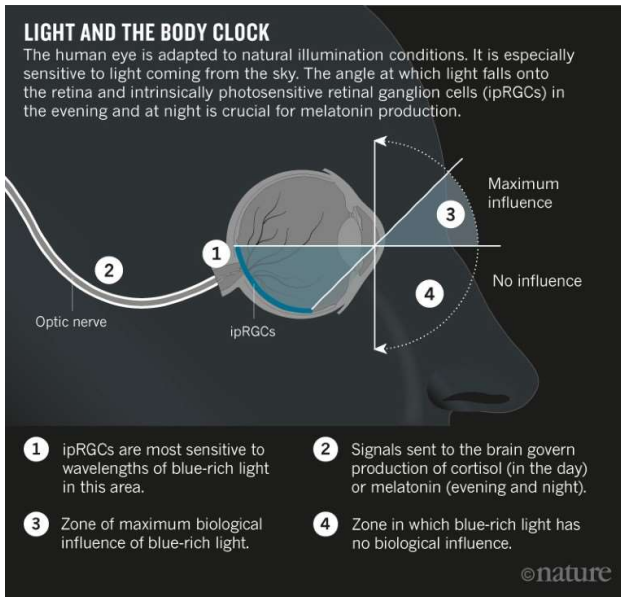
- Both the CIE and IESNA highlight the topic of light exposure.
- The past decade has seen a huge increase in our understanding of the role of light on circadian rhythms and associated health impacts.
- In particular how light exposure patterns affect sleep, overall health, and alertness.
- One of the researchers instrumental in the advancement of our knowledge and helping create design guidelines, Dr. Mark Rhea, states that "*Lighting isn't just for vision anymore*"
- This topic is more suited to a separate, or several separate, CEU presentations, so for the purpose of this one, we will summarize by noting that the key characteristics of circadian lighting or integrative lighting, are

- Ensuring the right amount of light at the right time of the day
- The spectral qualities of the light – meaning how much blue and/or red does the light contain

These are characteristics that fall directly within the expertise of your lighting designer.

- The third one, illuminance at the eye, is also a lighting design issue, but is also highly dependent on the overall design of the room including colors and finishes, and also whether or not traditional forms of lighting are used or alternatively, whether luminous surfaces are incorporated as part of the integrated design.

What Kind of Lighting is Best for People?



- For most of human history, we lived outdoors under a large luminous surface ...the sky
- Our eyes are optimized for this type of illumination
 - ipRGC receptors in the human eye largely responsible for the health benefits of light are widely distributed and located in the lower eye
 - For this reason, they respond better to **large luminous surfaces** – especially located above (eg. luminous ceilings)



Speaker Notes:

- In the early 2000's a new receptor within the eye was discovered and found to be responsible for non-visual responses to light – those that are related to the physiological effects that impact human well-being.
- Unlike the rods & cones that are narrowly distributed at a focal point within the eye to optimize visual tasks, these “ipRGC” receptors are distributed over a wider area and in the lower part of the lining of the eye, indicating that they are designed for receiving light from large areas. This makes sense when you consider that one very large area, the sky, was the primary source of illumination for most of human history.
- Subsequent research has found that to increase the impact of light exposure it is the amount of light reaching these receptors that is critical and that luminous areas in the ceiling or vertical illuminance generated by illuminated walls or walls with diffuse but highly reflective materials are better for this purpose than traditional methods of illumination.

What Kind of Lighting is Best for People?

For workstations used during the daytime, electric lighting is used to achieve the following thresholds:

- a. The following light levels are achieved for at least four hours (beginning by noon at the latest) at a height of 18 in above the work-plane for all workstations in regularly occupied spaces:

Tier	Threshold		Threshold for Projects with Enhanced Daylight	Points
1	At least 150 EML [136 <u>melanopic EDI</u>]	OR	At least 120 EML [109 <u>melanopic EDI</u>] and either L05 Part 1 or L06 Part 1	1
2	At least 275 EML [250 <u>melanopic EDI</u>] ¹¹	OR	At least 180 EML [163 <u>melanopic EDI</u>] and either L05 Part 1 or L06 Part 1	3

- b. The light levels are achieved on the vertical plane at eye level to simulate the light entering the eye of the occupant.

EML = Equivalent Melanopic Lux mEDI = melanopic Equivalent Daylight Illuminance (CIE approved method/RP-46 reference method)

Feature L03: Circadian Lighting Design

This feature requires a calculation of Equivalent Melanopic Lux (EML):
EML = Photopic Lux x Melanopic Ratio

Example of manufacturer data

Melanopic Ratio for FABRILum

	TNW*	3000K	3500K	4000K
Melanopic Ratio**	0.704	0.517	0.620	0.779

*Tunable White: 2700K @ 50% + 5700K @ 50%

**Calculated using the IWBI Melanopic Ratio calculator



Speaker Notes:

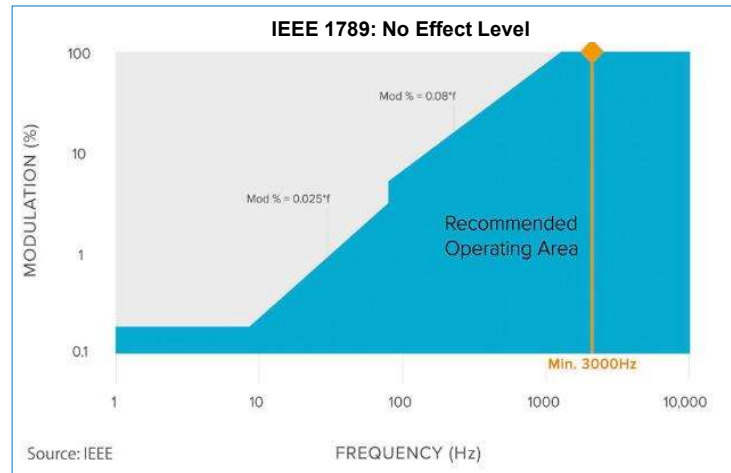
- Luminous surfaces ensure an effective delivery method to the receptors in the eye
- But the other key aspect of lighting for wellness is the spectral characteristics of the light
- Some of the standards such as WELL V2 shown here require calculations of melanopic or daylight illuminance which takes into account the amount of the light received which stimulates a physiological response.
- Again, another topic worthy of its own CEU but the key takeaway is that manufacturers should be able to provide spectral data in a format that can be used in the tools designers have available, or even better provide a ratio that can be applied to regular illuminance values to yield the equivalent.

What Kind of Lighting is Best for People?

Glare evaluation according to UGR												
		70	70	50	50	30	70	70	50	50	30	
p Ceiling		50	30	50	30	30	50	30	50	30	30	
p Walls		20	20	20	20	20	20	20	20	20	20	
p Floor		20	20	20	20	20	20	20	20	20	20	
Room size X Y		Viewing direction at right angles to lamp axis					Viewing direction parallel to lamp axis					
2H	2H	7.8	9.2	8.1	9.4	9.7	8.0	9.4	8.3	9.6	9.8	
	3H	9.4	10.6	9.7	10.9	11.2	9.6	10.8	9.9	11.1	11.4	
	4H	10.0	11.2	10.3	11.4	11.7	10.3	11.4	10.6	11.7	12.0	
	6H	10.5	11.5	10.8	11.9	12.2	10.8	11.9	11.1	12.2	12.5	
	8H	10.6	11.7	11.0	12.0	12.3	10.9	12.0	11.3	12.3	12.6	
4H	12H	10.7	11.7	11.1	12.0	12.4	11.0	12.1	11.4	12.4	12.7	
	2H	8.5	9.7	8.9	10.0	10.3	8.6	9.8	9.0	10.1	10.4	
	3H	10.2	11.2	10.6	11.6	11.9	10.4	11.4	10.8	11.8	12.1	
	4H	11.0	11.9	11.4	12.2	12.6	11.2	12.1	11.6	12.5	12.9	
	6H	11.6	12.4	12.0	12.7	13.1	11.9	12.7	12.3	13.0	13.4	
6H	8H	11.8	12.5	12.2	12.9	13.3	12.1	12.8	12.5	13.2	13.6	
	12H	11.9	12.6	12.4	13.0	13.4	12.2	12.9	12.7	13.3	13.8	
	4H	11.3	12.0	11.7	12.4	12.8	11.5	12.2	11.9	12.6	13.1	
	6H	12.0	12.6	12.5	13.1	13.5	12.3	12.9	12.8	13.3	13.8	
	8H	12.3	12.8	12.8	13.3	13.8	12.6	13.1	13.1	13.6	14.1	
12H	12H	12.5	13.0	13.0	13.4	13.9	12.8	13.3	13.3	13.8	14.3	
	4H	11.3	12.0	11.8	12.4	12.8	11.5	12.2	12.0	12.6	13.0	
	6H	12.1	12.6	12.6	13.1	13.6	12.3	12.9	12.8	13.3	13.8	
8H	12.4	12.9	12.9	13.3	13.8	12.7	13.2	13.2	13.6	14.1		
Variation of the observer position for the luminaire distances S												
S = 1.0H		+0.1 / -0.1					+0.1 / -0.1					
S = 1.5H		+0.2 / -0.3					+0.2 / -0.3					
S = 2.0H		+0.4 / -0.6					+0.3 / -0.6					
Standard table		BK06					BK06					
Correction Summand		-4.8					-4.6					
Corrected glare indices referring to 19689lm Total luminous flux												

UGR Values for a Typical Luminous (Stretch) Ceiling
(values are generally in the "barely perceptible" range)

Luminous Ceilings are Low Glare



No Effect Flicker



Speaker Notes:

- A more direct factor required for suitable lighting is to ensure that glare and flicker are reduced to the point where they are not a factor.
- Glare is inherently an issue with LED-based fixtures because LEDs are themselves small, very bright sources of light.
- Traditional linear, troffer, and point source fixtures have to be properly designed to ensure they minimize glare
- In addition to being an ideal way to improve receptivity to circadian effects, because of their diffuse nature, large luminous surfaces are inherently low glare.
- A metric used to measure glare is the Unified Glare Rating, or UGR. A value in the range <17-19 is considered the borderline of acceptability. The chart shown here shows that a typical luminous ceiling generally falls within the "barely perceptible glare" range

Light and Color

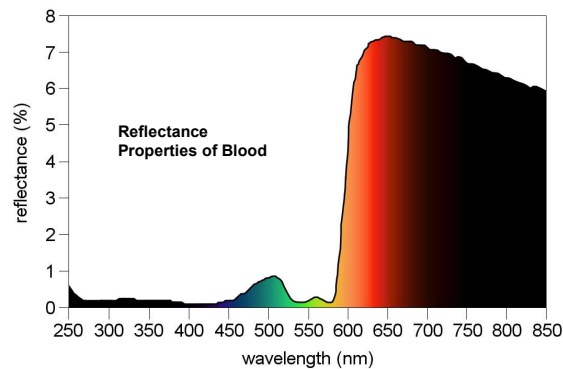
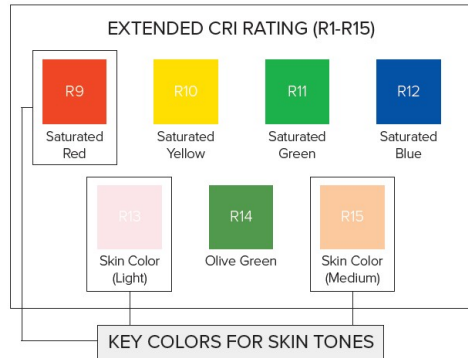


- It is well known that colors have specific influences on moods and emotions
- It is the **job of the designer** to determine the appropriate colors for the space
- It is the **job of the lighting** within the space to accurately render the desired color and provide the appropriate level of warmth`

Speaker Notes:

- As designers you are well aware that color can play a significant role in enhancing the design vision but also how people perceive and experience a space.
- It is the expertise of the design team that will ensure an appropriate palette.
- Critical to success however will be in choosing lighting that faithfully renders that palette and sets the baseline level of warmth depending on the desired mood or atmosphere required
- Where change is required, whether daylight cycles, seasonal cycles, or the ability to switch from work to socializing, tunable white options are common and generally not as cost prohibitive as once perceived.

Light and Color



Fun Fact:
Sea water filters out red, so if you are diving at deep levels and cut yourself, your blood will actually look green.

- LED-based sources are notorious for having low R9 values
- High blue & green content in LEDs can make skin look greenish and unhealthy if enough red is not available

COLOR RENDERING INDEX DETAILS

Reference	Value	Reference	Value
R1	95	R9	94
R2	95	R10	92
R3	98	R11	98
R4	97	R12	77
R5	95	R13	95
R6	92	R14	99
R7	95	R15	94
R8	96		



Speaker Notes:

- Generally, discussions about color rendering, whether CRI or new metrics, revolve around making objects look better. For example, the red apple or the blue car look better when you use a high CRI light source.
- High CRI sources tend to be those optimized for selling merchandise
- Very much related but not as much of a consideration is the color rendering of people by the general lighting in the space
- LEDs are notorious for not rendering saturated red very well as measured by the R9 color rendering value and for retail and related applications designers generally consider the R9 value. There are two other R values, R13 and R15 that are associated with skin color.
- Interestingly, R9 is also important for making people appear healthy because that is partly based on being able to highlight the blood in the skin. Without red in the light, people will appear a little grey.

In Summary: The Kind of Lighting That is Best for People is...

- Light that enhances human physiological responses
- Light that has low glare
- Light that does not flicker
- Light that renders color well and is the correct color temperature for the desired outcome

In other words:

Luminous ceilings with good color rendering characteristics, no perceptible flicker, and suitable spectral content



Speaker Notes:

- And so the answer to what kind of lighting is best for people...
- Is large luminous surfaces to optimize the response of the eye's receptors that have been designed to deliver the right amount of light at the right time of the day
- Light that has low glare
- Light that doesn't flicker
- And finally, lighting that faithfully renders the designer's color palette, desired ambiance, and the appearance of the people using the space
- A very good option is to use luminous ceilings and as an added bonus, they can also contribute in a meaningful way to solving another problem: Noise



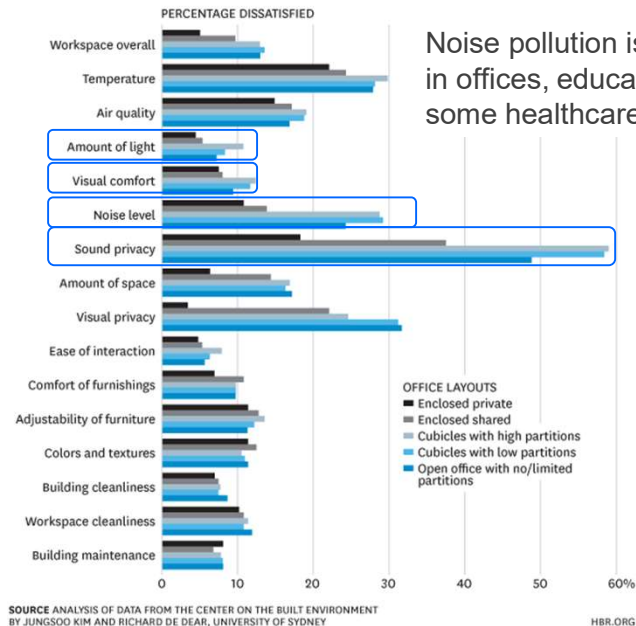
Speaker Notes:

- Just as the impact of lighting on human wellness is becoming a key consideration for building design, the focus on improving the acoustic performance of public spaces is increasing

What's the Problem?

EVERYONE CAN HEAR YOU, NOW

Lack of sound privacy is the biggest frustration we have with our cubicles.



"Studies indicate that approximately **80 percent of office workers** believe that their productivity would increase if their working environment was more acoustically private."

"A **300 percent increase in perceived 'worker satisfaction'** was reported as a result of the reduction in noise levels from conversational noise. In addition, a measured **20% increase in sales productivity** was recorded at the end of the six months following the refurbishment."

American Society of Interior Designers; Armstrong World Industries, Inc.; DynaSound, Inc.; Milliken and Co.; Steelcase, Inc. 2005.

Speaker Notes:

- Yet another study done in conjunction with association of interior designers found that sound issues were ranked as THE most important sources of dissatisfaction in workplaces and was able to demonstrate increases in satisfaction and productivity when the noise levels were reduced.
- Again, while this study focuses on the workplace, the issue of noise pollution is a problem found in almost any public space

What's the Problem?

“Evidence has shown that noise, especially sound with information, such as human voices, can significantly affect office employees' cognitive performance and subjective feelings. Another study found that office noise may cause harm to human health.”

Effects of acoustic environment on design work performance based on multitask visual cognitive performance in office space (2021)

GROWING EVIDENCE THAT NOISE IS BAD FOR YOUR HEALTH



Speaker Notes:

- Not only does noise decrease satisfaction and productivity, there is evidence to suggest that it also has a more direct negative effect on health.
- The quote mentions office employees, but imagine the impact in a classroom setting where students face a barrage of unwanted noise, often continuously
- Or a crowded museum space where the distraction of noise might significantly reduce the enjoyment of the experience

Sometimes the Soundscape is About More Than Comfort

"Most retail sound is inappropriate and accidental, even hostile, and it has a dramatic effect on sales"
- Julian Treasure*



He references studies showing that the right "soundscape" in a retail store can increase sales up to 38%.



Conversely, inappropriate soundscapes filled with unwanted noise can decrease sales by 28%.

*Julian Treasure is a sound and communications expert whose TED talks have been viewed over 100M times.



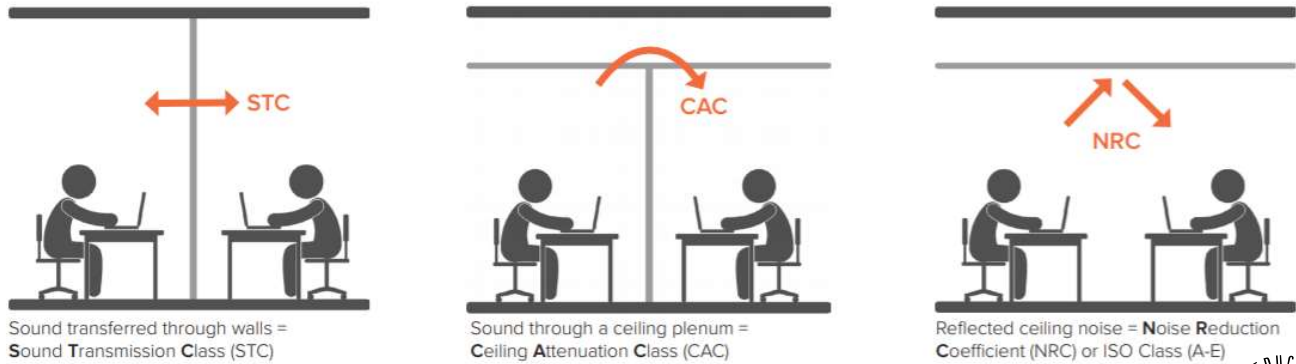
Speaker Notes:

- The ability to design for sound is not just about health. In retail applications it can have a huge impact on sales – both positively and negatively
- Julien Treasure is an expert on sound and communications.
- He sites research that demonstrates that designing a positive soundscape can dramatically increase sales.
- But,.. he also has found that most sound is not controlled with the result that noise can reduce sales almost as dramatically.
- The key takeaway from all these studies seems to be that ensuring your space has good acoustic performance is high on the list of requirements

3 Types of Noise Problems

There are 3 types of noise problems:

1. Sound that is transferred through walls/barriers
2. Sound that travels from one room to the next through the ceiling plenum
3. Sound that bounces off the ceiling and reflects back into the space



Speaker Notes:

- There are three ways that sound may be propagated to increase noise:
 - Through the walls
 - Through a ceiling plenum that acts as a sound conduit
 - Or by reflections off of the ceiling
- Managing sound that is transferred through walls is more of a structural design challenge outside of the scope of this discussion.
- Ceiling attenuation might be improved using some of the techniques we touch on here, but our main focus is on absorbing noise that reaches the ceiling so that it is not reflected back into the space
- To ensure better acoustic performance, taking advantage of as much of the surface area of the ceiling as possible seems like a logical approach

Acoustic Lighting: Size Matters

Acoustic engineers use a metric called a “sabin” to quantify sound absorption.

A higher sabin value means more sound absorption... equals less noise.

$$\text{Sabin} = \text{Absorption} \times \text{Area}$$

The noise reduction capability of a light fixture is dependent on TWO equally important characteristics:

1. Absorption Characteristics (often approximated by NRC)
AND
2. Absorption Area



Whole Roll = More Sabins

VS



Single Sheet = Less Sabins

The paper towels to the left have the same absorption characteristics

Noise reduction requires good sound absorption properties **AND** a large surface area to deliver useful noise reduction and create a comfortable environment



Speaker Notes:

- It's often the case when we are talking about acoustic performance of light fixtures that we focus on the absorption characteristics of the materials that will be used.
- For example, looking at NRC or more intentionally the specific sound absorption properties across the relevant frequencies
- But equally important is the amount of area dedicated to sound absorption
- A single sheet of paper towel has the same absorption properties as the whole roll. But how much liquid does it absorb in comparison?

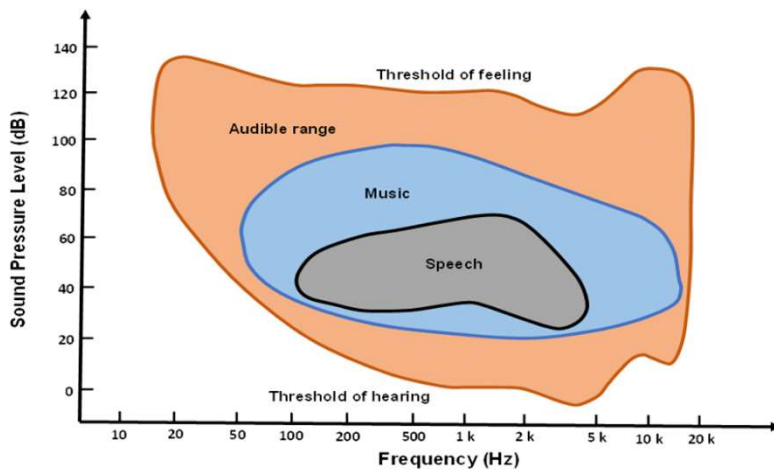
Acoustic Lighting: Size Matters



Speaker Notes:

- Acoustic luminous ceilings are the roll whereas typical pendants and similar solutions are more like the single sheet of paper towel.
- Both incorporate sound absorbing materials but only a luminous ceiling has the ability to have a meaningful amount of noise reduction without adding passive acoustic elements.
- And if you think about it, having to add those additional elements sort of negates the purpose of using acoustic lighting

Why the Frequency of Absorption is Important



Source: International Commission for Acoustics

Acoustic Design Requires a Detailed Understanding of Absorption at Different Sound Frequencies

- Different materials absorb sound at different frequencies
- Two materials could have the same NRC value but absorb sound very differently
- Most architectural spaces are concerned with the ability to hear speech – e.g. “speech intelligibility”
- As shown, the frequencies of interest are those between ~100Hz – 4000Hz



Speaker Notes:

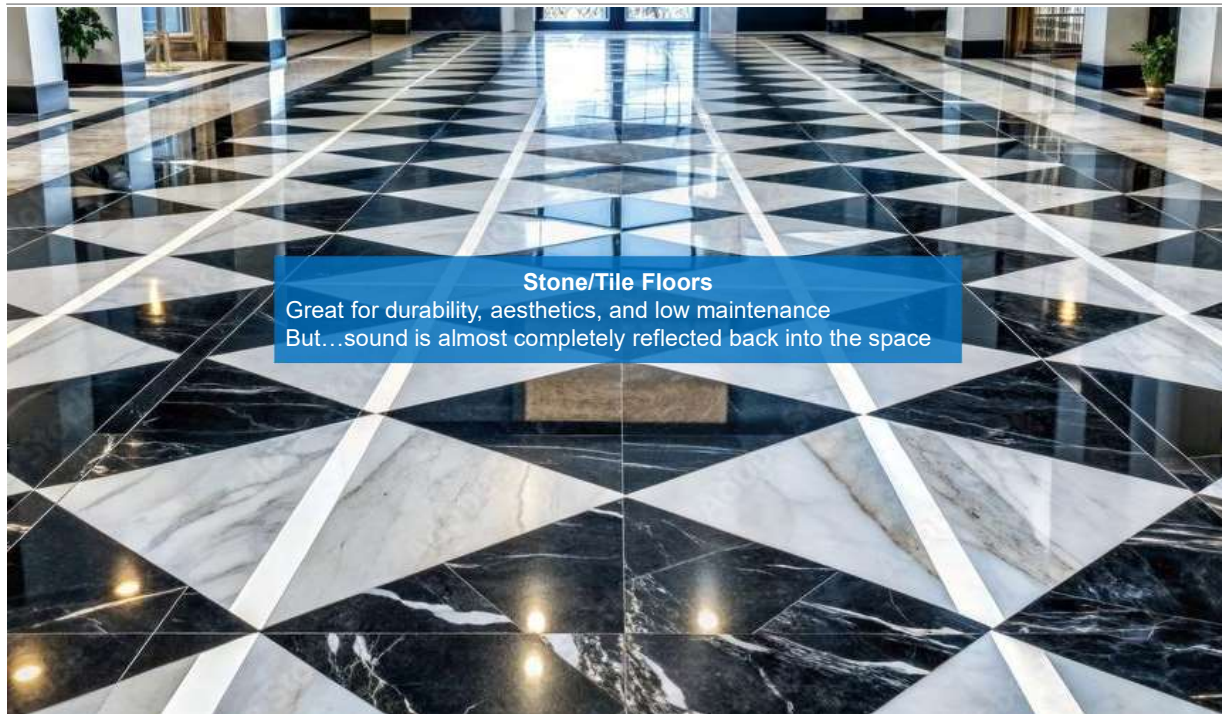
- While the surface area dedicated to acoustic materials is critical, that does not mean we should ignore the properties of those materials.
- NRC values can give you an idea about the average material properties, but they are not used by acoustic designers who are more interested in the absorption characteristics across a range of sound frequencies.
- For architectural acoustic design, the frequencies most of interest are those associated with human speech - which determines the speech intelligibility of a space. Or in other words, how clearly you can hear someone speaking to you against a background of noise that is most often the sound of other people speaking.
- For these applications, it is the ability of materials to absorb sound in the range of 100Hz to 4000Hz that is of interest.



Speaker Notes:

- This short example attempts to demonstrate the impact of using acoustic materials in a space.
- Acoustic performance is generally measured using reverberation time with a lower value indicating quieter space.
- Speech intelligibility is an indicator of how well a person can comprehend what another is saying and is generally better within a quieter space.
- In this simulation, the addition of a luminous ceiling decreases reverberation time significantly
- Adding acoustic materials to the walls reduces the time even further to make a once loud room into a quiet space

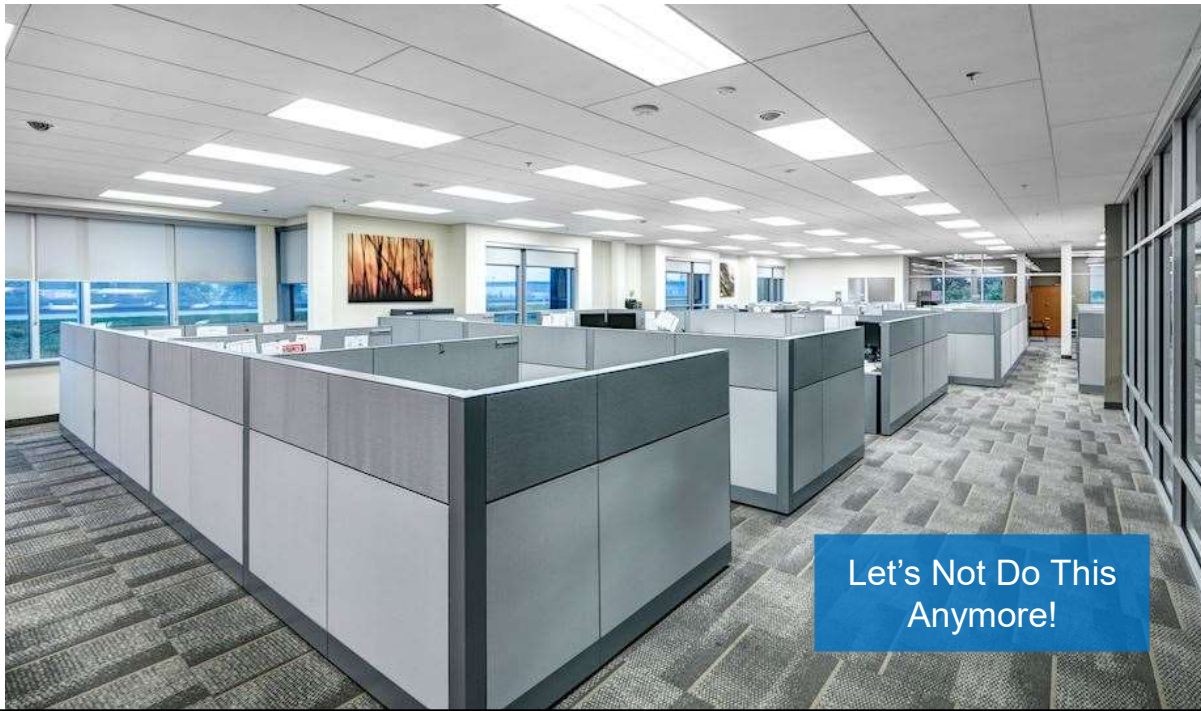
Large Area Acoustic Lighting Enables More Interesting Designs



Speaker Notes:

- Incorporating large area acoustic lighting in the ceilings of your spaces offers plenty of area to create a comfortable soundscape and frees you up to use great looking, highly durable floors even though they can be some of the worst materials acoustically speaking

Large Area Acoustic Lighting Enables More Interesting Designs



Speaker Notes:

- Incorporating acoustic luminous surfaces allows you to create spaces that don't have to rely on traditional design staples like carpeting, ceiling tiles, troffers, drywall, etc.

In Summary...

- Noise reduces productivity and satisfaction and may negatively impact health
- Noise can reduce sales
- Sound absorption relies on area and so acoustic lighting should be applied to large areas of the ceiling
- Using the ceiling as the primary sound absorbing surface enables better alternatives for the floors and walls

In other words:

Reducing noise is important for well-being and to maximize the effectiveness of acoustic lighting, large area sources should be used



Speaker Notes:

- To summarize...
- Noise reduces productivity and satisfaction, and studies indicate that it probably is bad for our health
- If you're doing a retail store design, keep in mind that sound can be good... but often it is very bad
- Take advantage of the entire area of the ceiling to increase the acoustic comfort in your space
- Try new things. They may surprise you.

Applications Where Lighting for Well-being is Important

This section will cover:

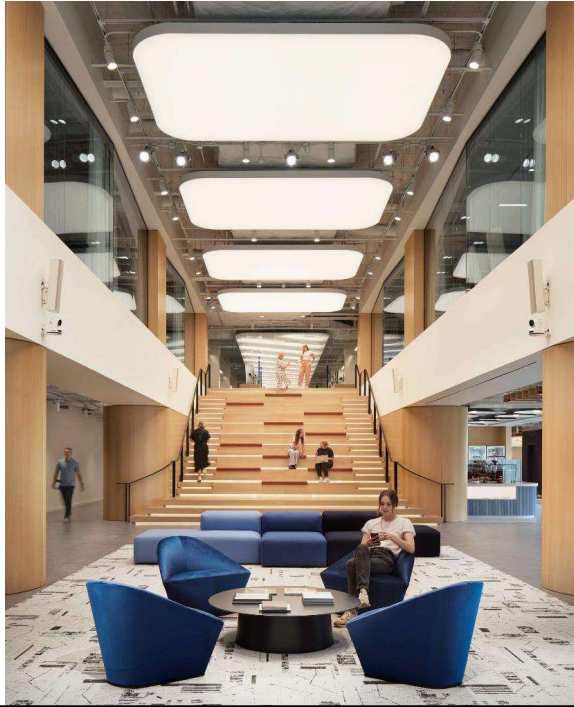
1. A Few Examples of Applications Where Lighting for Well-being is an Important Consideration



Speaker Notes:

- The next few slides are some examples where the wellness aspects of lighting may be more important than in other applications.

Applications Where Lighting for Well-Being Matters: Workplaces



Luminous surfaces deliver comfort with high levels of low glare illumination...*sometimes mimicking nature itself*



Speaker Notes:

- Most of the data we have looked at was based on workplaces and since so many people spend a significant amount of their time at their workplace it seems self evident that some consideration for their well-being is warranted.
- Recently there has been a move by some of the famously large companies to reduce or eliminate working from home, so having the right kind of illumination may grow in importance

Applications Where Lighting for Well-Being Matters: Workplaces



Taking advantage of tunable white lighting enables workplaces to match daily rhythms



Speaker Notes:

- Tunable white lighting generally no longer comes with the large price premiums of the past and offers the option of creating office environments that match the natural daily rhythms.

Applications Where Lighting for Well-Being Matters: Libraries



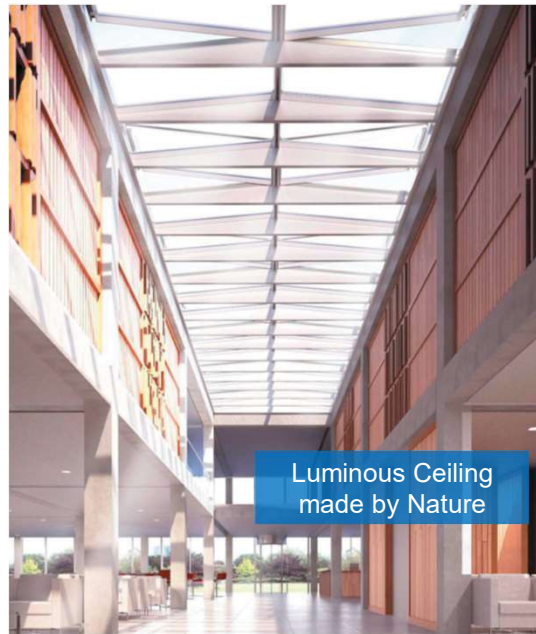
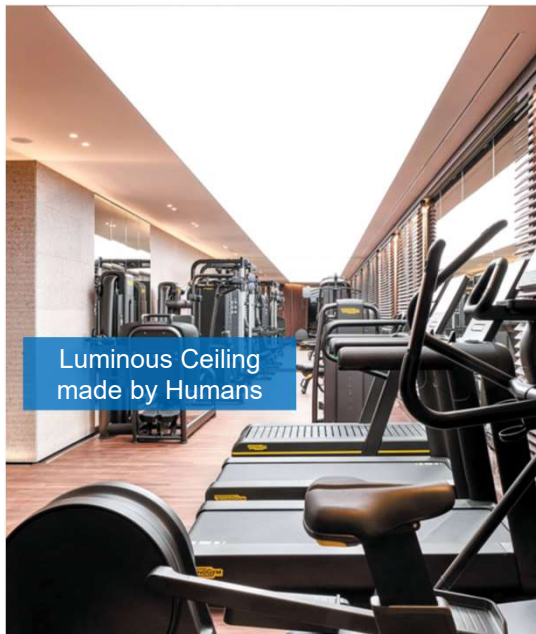
Meeting the visual needs of people in libraries is a no-brainer but bookworms need healthy daily light exposure too. And aren't libraries supposed to be quiet? Lighting that absorbs a lot of sabins will help.



Speaker Notes:

➤ *Read the slide...*

Applications Where Lighting for Well-Being Matters: Fitness Facilities



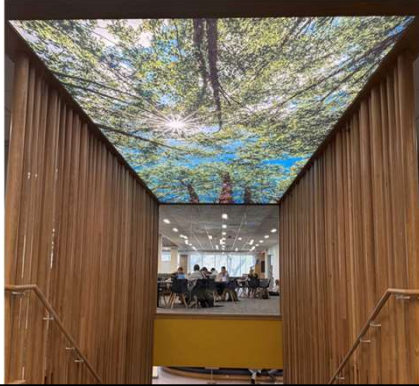
Wellness is a huge part of the fitness experience – the right kind of illumination makes a significant contribution



Speaker Notes:

- Fitness facilities are another application where impact of the lighting has the potential to enhance or detract from the experience.
- While dynamic color lighting and loud music are appealing for certain fitness facilities, the ability to bring the feeling of nature to workout and yoga areas can be a big selling feature for operators

Applications Where Lighting for Well-Being Matters: Education



Providing the right kind of illumination has been linked to increases in alertness and productivity. Acoustic luminous ceilings can provide this and help keep the noise down at the same time.



Speaker Notes:

- Similar to the importance of workplaces, schools would seem to be one of the critical applications for implementing lighting that supports wellness.
- A holistic approach to illumination would by definition, contribute to less noise, better conditions for learning, and the opportunity to improve the wellness of young people.

Designing for Well-being in Education: Another Certification



"Thanks to CHPS hundreds of schools in our district serving thousands of students deliver healthier indoor environments, better daylighting and acoustics, and are more comfortable. These factors make a big difference in how students perform in the classroom and boosts their overall wellbeing when they are at school."

— Christos Chrysiliou, Director of Architectural and Engineering Services for the Facilities Services Division of the LA Unified School District and CHPS Board Member

School facilities received a D+ on the Report Card for America's Infrastructure, and it's estimated that 53% of public schools need to invest in repairs, renovations, and modernizations now to put buildings in good overall condition

- Collaborative for High Performance Schools

CHPS **DESIGNED**™ schools

CHPS Designed™ is a voluntary, self-certification system that helps school districts and design teams accomplish high-performance schools built according to CHPS criteria.

CHPS **VERIFIED**™ schools

CHPS Verified™ is a recognition program for school projects that have integrated the required high performance features to realize the associated benefits including improved health, productivity and student performance, decreased operating costs, and increased energy savings.

MINOR RENOVATIONS program

CHPS has [launched a Minor Renovations Program](#) with the backing of government partner [Sourcewell](#) to provide the timely support millions of school districts need to improve the performance of their existing facilities and systems and is actively seeking partners and [sponsors](#) join us.



Speaker Notes:

- And because there aren't enough organizations and certifications to worry about, here's another.
- This one does have the worthy cause of trying make school buildings better for all students and provides a framework for doing so.

Sustainability: A Growing Part of Holistic Illumination

This section will cover:

1. What does sustainability mean in practice?
2. Considerations for the future



Speaker Notes:

- We are going to explore each of air, light, sound, and nature to look at what aspects of each are relevant to designing for human well-being and why
- We'll also look at the design requirements and suggest some alternative solutions that address problems and also add value that isn't included in traditional approaches

Sustainability: What Does It Mean?

Corporate Level

- Focused on Sustainable Business Practices
- Limited Demand for Certification



Product Level

- Focused on Specific Properties of Products
- Vast Variety of Demand for Certification



BREEAM®

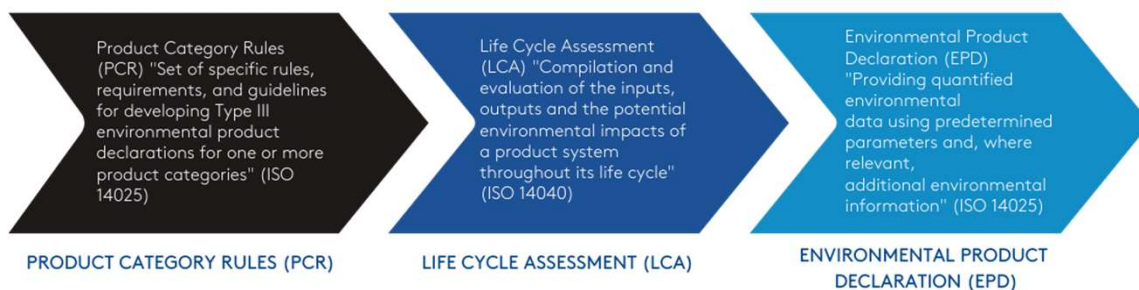


Speaker Notes:

- There are two levels of sustainability.
- The first occurs at the corporate level and looks at the business practices of the manufacturer to determine if it is operated in a sustainable and responsible manner covering environmental footprint and sustainable sourcing but also ethics and treatment of its employees.
- It has been our experience that certification at this level has almost no influence on whether products are specified.
- The other level focused on the specific properties of products is much more prevalent in the building products market with a large number of organizations offering their own guidelines and certifications.

Sustainability: What Does It Mean?

- LEED and others offer points for submitting a minimum number of EPDs for products that are specified
- Specifiers ask for EPDs from manufacturers as a way to score points for their clients' projects where building certification is a requirement
- EPDs offer the opportunity to standardize documentation requests
- Follows a standard format (ISO 14025) for creating an EPD based on product information.
- 3 elements required to create an EPD
 1. Product Category Rule (PCR)
 2. Life Cycle Assessment (LCA)
 3. Environmental Product Declaration (EPD)



Speaker Notes:

- The industry seems to be converging on using Environmental Product Declarations or EPDs as proof of sustainability.
- LEED in particular seems to be a big driver of this approach.
- For those of you not aware of how EPDs are created, it is a 3-step process based on ISO standards that define the required methods and contents.
- The first step is to establish a Product Category Rule that is applicable to a specific type of product and defines the inputs and outputs that must be included
- The second step is a Life Cycle Assessment that generally includes a calculation of embedded carbon including transport from suppliers to factories and delivery to customers
- The third step is the creation of the EPD document itself which can be done by the manufacturer but scores more points if done by an accredited 3rd party

Sustainability: What Does It Mean for Lighting Today?



- "An EPD reports a specific set of environmental results, which can only be created after a full LCA is conducted. Common impact categories include: global warming potential (GWP), ozone depletion potential, acidification potential, eutrophication potential, smog formation potential, and primary energy use."
- "Environmental Product Declarations (EPDs) are a way for manufacturers to take comprehensive, third-party-verified LCAs, which are quite complex, and turn them into standardized declaration labels for their products."
- "An EPD will have certain characteristics:
 - Compliance with ISO standards
 - Adherence to the appropriate industry-standard **PCR**
 - Third party certification of the LCA process
 - A clear description of the functional unit
 - A list of the life cycle stages considered in the analysis"

Status Product Category Rule for Luminaires as of October 2024

Part B PCR for Luminaires (North America)

ISO 14025 and IEC 63366

In development



Speaker Notes:

- The idea behind EPDs is that they will standardize the sustainability information provided by manufacturers to enable specifiers and customers to compare products.
- As it relates specifically to lighting here are some challenges to be aware of.
- Lighting manufacturers are being asked for EPDs more frequently however, the Product Category Rule on which they should be based is still in development. That means that any EPD supplied a by a lighting manufacturer is necessarily based on their own assumptions about what should be included.
- A second challenge that may extend beyond lighting is that there do not appear to be any correct answers. For example, how much embedded carbon is too much? Should it be measured per lumen? Per area? Etc
- While requiring an EPD from a lighting manufacturer is perhaps premature, it is not unreasonable to ask for product composition data or for a manufacturer to address specific questions you may have.

Sustainability: Where is it Going?

Figure 1. Optimized Product Valuation by Eligible Product Documentation

A	Optimized Product Impact Areas (Multi-Attribute Score)					
	B	C	D	E	F	
	Climate Health	Human Health	Ecosystem Health	Social Health & Equity	Circular Economy	
Eligible Product Documentation						
Multi-attribute Certifications						
Cradle to Cradle: Bronze	0.5	0.5	0.5	0.5		
Cradle to Cradle: Silver	0.5	1	1	0.5	0.5	
Cradle to Cradle: Gold or Pt.	1	1	1	1	1	
BIFMA e3 / level		0.5	0.5			
Living Product Challenge	1	1				
Living Product Challenge w/ MHI	1	2	1			
FSC Certified			1.5	1		
SFI Chain of Custody			1	0.5		
Reused materials			1		1	
Single Attributes						
Industrywide EPD	0.5					
Product-Specific Type III EPD	1					
Optimized EPD, Tier 1 (15% better)	1.5					
Optimized EPD, Tier 2 (30% better)	2					
HPD: pre-checked for LEED		0.5				
HPD: third party verified		1				
Optimized HPD with verification		2				
Declare		0.5				
Declare: third party verified		1				
Global Green TAG PhD		0.5				
Product Lens		1				
Green Seal Certified		1.5				
GreenCircle Closed-Loop certified						2
TRUE Zero Waste manufacturer						1
EPR: carpet, gyp.board, furniture, ceilings						1
Recycled content						%
Biobased - nonwood						%

EPDs are one way of many to provide sustainability documentation



LEED V5.0

Released for Public Comment in April 2024

- Requirements are bundled into broader categories with more ways to achieve them
- Larger selection of documentation and certification
- More products will be required to have documentation/certification
- Requirements only apply to non-structural materials



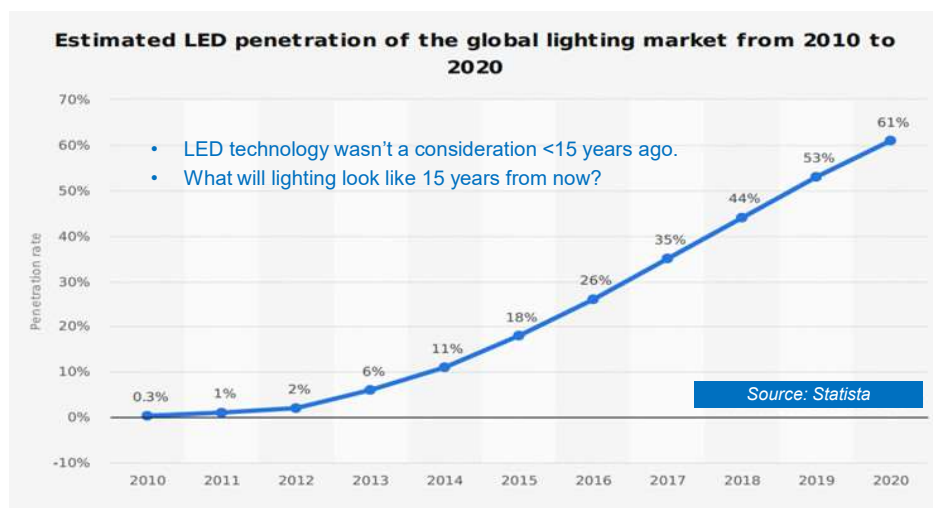
Speaker Notes:

- While the PCR that enables lighting EPDs is still in development, LEED appears to be expanding the type of documents and certification that will score points.
- The table shown here is from V5.0 that was released in April for public comment.
- So, while everyone agrees that sustainability is part of the consideration for inclusion in specifications, the regulatory framework for lighting is still in development and the overall regulatory environment is changing rapidly.

Sustainability: What Does It Mean for Lighting in the Future?

Today there is a big focus on product recyclability at end of life
And for some segments where the useful life of the space is 7-10 years that is a good conversation
But...

- Most LED-based lighting products have a useful life measured in decades
- What does “recyclable” look like in 20 or 30 years?
- In 2010, was anyone thinking about what to do with LEDs?



Speaker Notes:

- One last thought about the topic of sustainability
- Under the category of sustainability there has been a lot discussion about recyclability.
- This makes a lot of sense for spaces with a comparatively short lifespan – retail and office TI's come to mind.
- As a manufacturer, however, committing to recyclability for products that may be installed for 20 or 30 years is a challenge.
- For reference, most lighting products on the market today are based on LED technology that from a market perspective really didn't even exist less than 15 years ago.
- The takeaway here is not so much about facts as something to ponder if you find yourself in a discussion about what happens at the end of the product life.

In Summary...

- There are two levels of sustainability assessment: corporate and product
- Environmental Product Declarations (EPDs) are becoming the default assessment tool for sustainability.
- The Product Category Rule (PCR) for lighting is still in development
- Everyone agrees that sustainability is a requirement (and hence part of a holistic view of illumination), however, measurement and enforcement are very much a work in progress

In other words:

A holistic view also looks at the manufacturer as well as the product and while sustainability is desirable, evaluating it is a challenge for specifiers and manufacturers alike



Speaker Notes:

- To summarize...
- *Read the bullets as they appear*

Integration: Achieving Holistic Illumination

This section will cover:

1. What does integration mean in the context of holistic illumination?
2. What are the elements of an integrated system?



Speaker Notes:

- Earlier we reviewed recent statements by the CIE about “integrative lighting” by which they mean the physiological element of lighting.
- We are using the term “integration” in a much broader sense.
- It is the idea that in order to achieve all of the goals of holistic illumination including both visual performance and well-being, a new integrated approach to lighting will be required.

Integration: Combining Existing Functions into One



The most successful technology of today is the integration of many earlier successful technologies



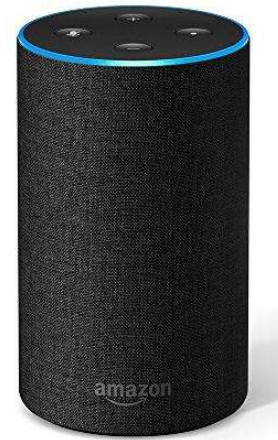
Speaker Notes:

- Historically, the idea of combining several technologies that were successful on their own together into a single solution has proven to be a revolutionary way to advance the way we live and do things
- Check your pocket – or your hand – for the most obvious example

Integration: Combining Existing Functions into One



The most successful technologies are the combination of many earlier successful technologies



Speaker Notes:

- Or this one...

Integration: Combining Existing Functions into One

What is integration in the context of holistic illumination?



Richard Kelly

To supply a complete lighting solution, an integrated ceiling must provide the “three elemental kinds of light effect”

- Focal Glow
- Play of Brilliants
- Ambient Luminescence



Speaker Notes:

- So what does that mean for lighting?
- Richard Kelly is regarded as one of the founders of modern lighting design. He defined the “three elemental kinds of light” which are often implemented as “layers of lighting”

Integration: Luminous Ceilings ARE Ambient Luminescence



" Ambient luminescence produces shadowless illumination. It minimizes form and bulk. It minimizes the importance of all things and people. It suggests the freedom of space and can suggest infinity. It is usually reassuring. It quiets the nerves and is restful" – Richard Kelly (1952)

Luminous Ceilings deliver...

- Light that enhances human physiological responses
- Light that has low glare
- Light that does not flicker
- Light that renders color well and is the correct color temperature for the desired outcome

The Kind of Lighting That is Best for People



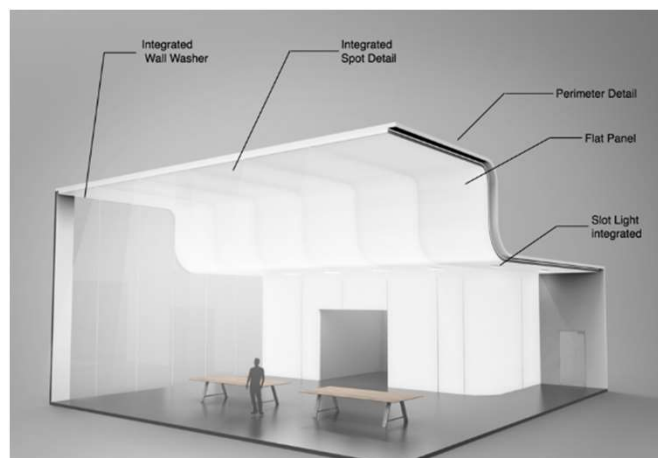
Speaker Notes:

- Ambient luminescence is the background general lighting that as Kelly defines as shadowless and suggesting a freedom of space
- Luminous ceilings are the very embodiment of the concept of the natural ambient luminescence on which he based his definition
- As summarized earlier, luminous ceilings have the ability to enhance human responses, and deliver the comfortable, reassuring light that quiets the nerves and is restful
- In other words, the kind of lighting that is best for people.

Integration: Adding Focal Glow & the Play of Brilliants

What are the important factors?

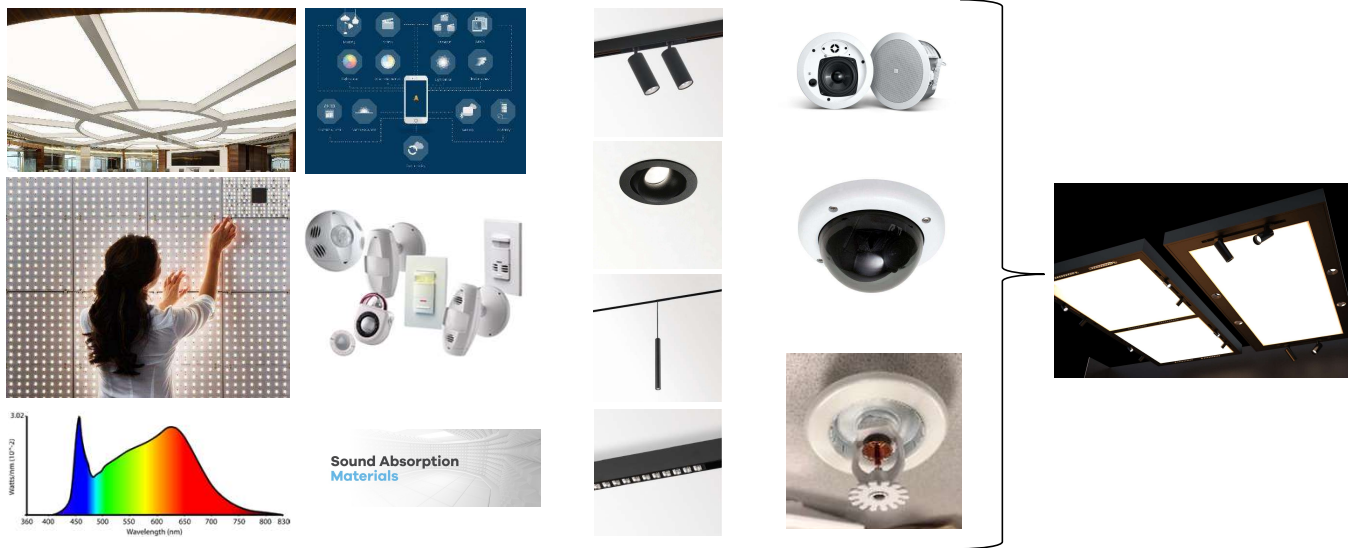
- Ability to support a variety of linear and point source lighting types: spots, floods, wallwashers, grazers, linear, etc.
- Minimizing the intrusion into space >> e.g. seamless/hidden visual appearance
- Mechanical integration
- Wiring simplification
- Accommodation for site variances
- Integrated Controls



Speaker Notes:

- But spaces would be very dull if we didn't add the other two elements of light: the focal glow and the play of brilliants
- Or in more straightforward terms accent lighting and/or decorative lighting
- An integrated lighting solution is one that combines the three elements or layers into a single solution that includes control and takes advantage of unique properties of each type of lighting
- Such a system would also enable simpler wiring and ideally minimize the intrusion into space by creating a more seamless visual appearance

Integration: Combining Existing Functions into One



The next revolution in lighting will be the integration of many earlier successful technologies



Speaker Notes:

- An integrated solution then starts with a luminous ceiling incorporating the best lighting technology and sound absorption for wellness along with controls
- Additional accent lighting is then added
- But why stop at lighting? Other ceiling elements can be incorporated such as speakers, security cameras, sensors, and as already done with stretch ceilings, fire suppression sprinklers
- Like the smartphone and smart speaker the result is a solution that represents a leap forward in the art and science of lighting

Integration



CORPORATE RESPONSIBILITY



PRODUCT SUSTAINABILITY



Speaker Notes:

- But to truly achieve holistic illumination, an integrated luminous ceiling system must also meet the needs of the people and the planet
- Holistic illumination also means sourcing from companies that meet a high standard for sustainable practices
- And products that are sustainable – however that is defined.



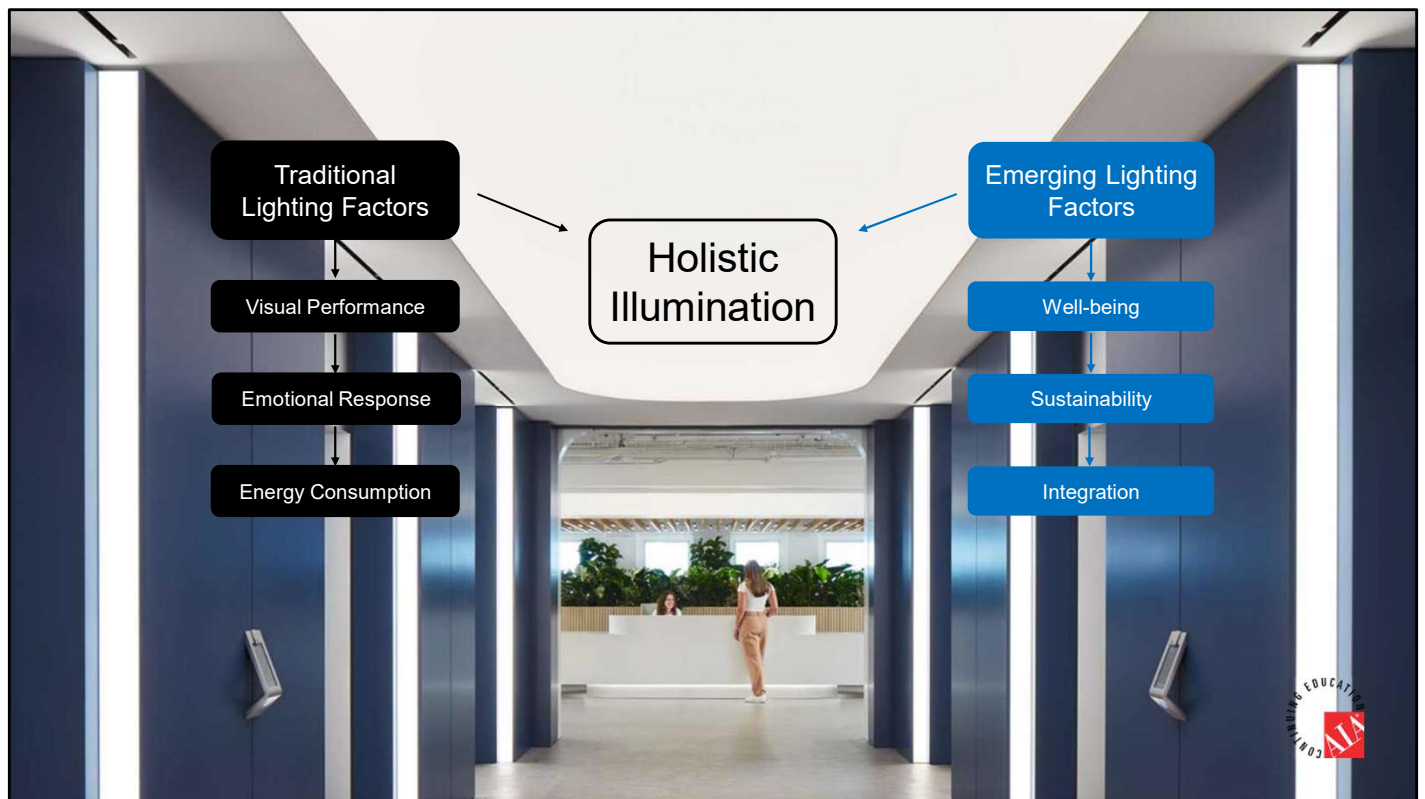
Speaker Notes:

- Integrated luminous ceilings might be used to enhance public spaces in the workplace or hospitality



Speaker Notes:

- Or provide a full lighting solution for retailers looking to create immersive experiences for their customers.



Speaker Notes:

- We started out defining holistic illumination as a combination of traditional and emerging lighting factors
- Holistic illumination is not a new thing....It's the next thing.



This concludes The American Institute of Architects
Continuing Education Systems Course

Contact: [*Presenter Name*](#)



Speaker Notes:

- Thank you.