



# Illuminating The Future With LLLC

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**Evergreen Energy Partners**



# Today's Session

1. Luminaire Level Lighting Controls (LLLC)
2. LLLC Capabilities and Applications
3. Project Considerations
4. Resources
5. Q&A



# The Future: Smart and Healthy Buildings



# Benefits of Smart and Healthy Buildings

Improved indoor air quality = 8 -11% higher productivity

80% average occupants are dehydrated

Depression reduced by 27% by fruit & vegetables

Views to outdoor environment increases concentration by 15%

Too warm: productivity 4% lower

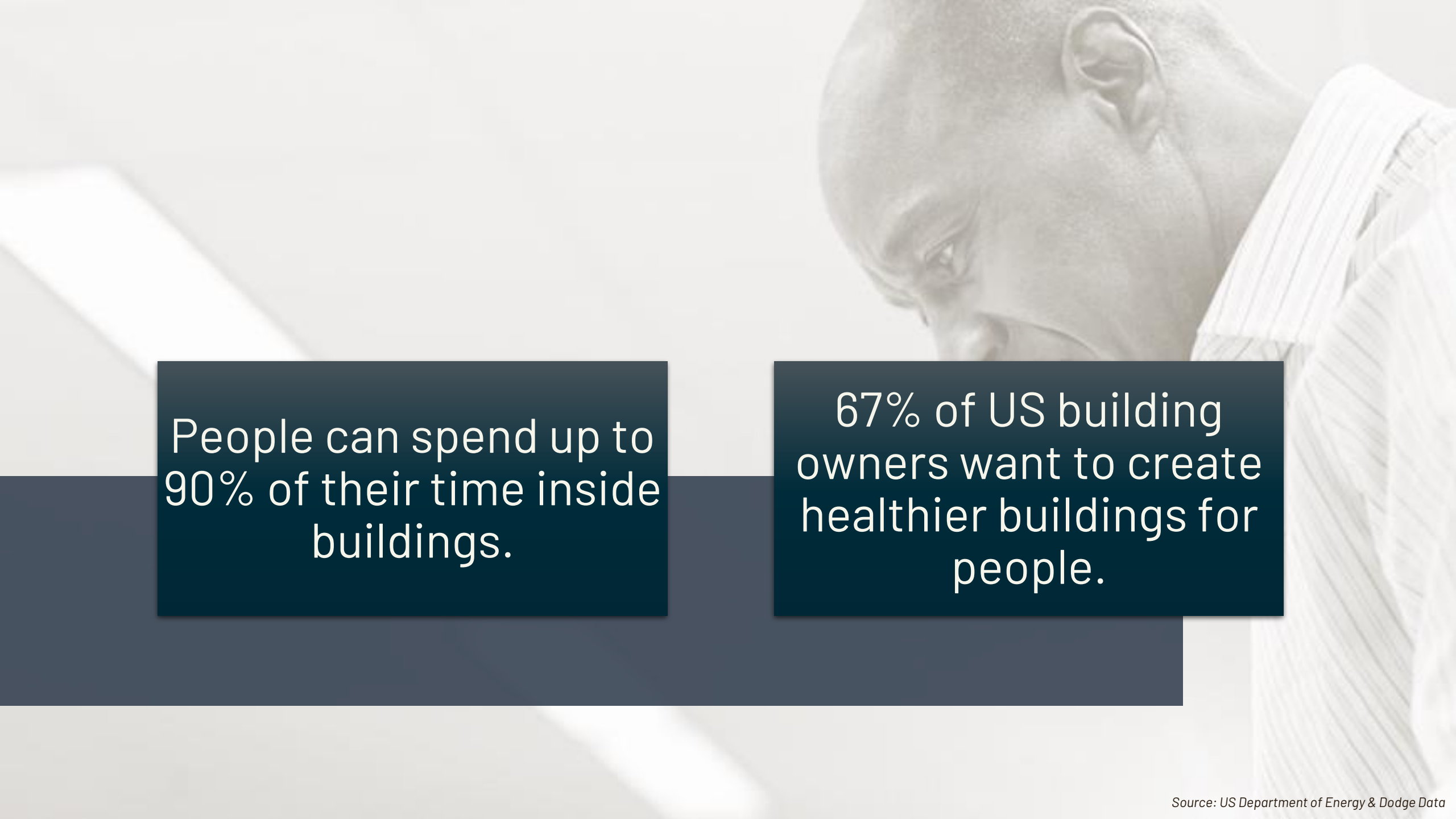
Too cold: productivity 6% lower

Noisy environment reduces concentration by 15%

Concentration increases by 6% with views

Source: Statistics from International WELL Building Institute (IWBI)





People can spend up to  
90% of their time inside  
buildings.

67% of US building  
owners want to create  
healthier buildings for  
people.

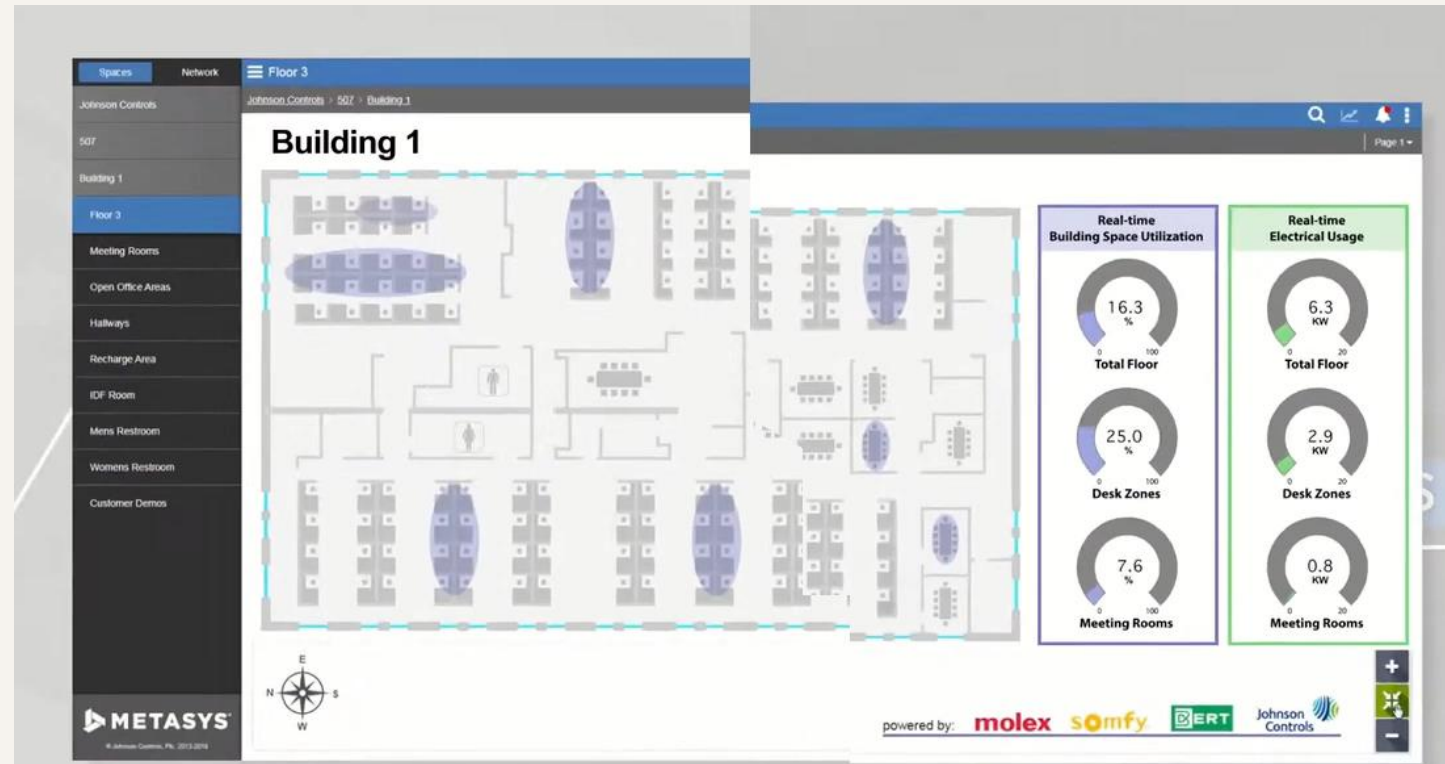


# Harvard Study: 9 Foundations of a Healthy Building

[www.9foundations.forhealth.org](http://www.9foundations.forhealth.org)



# The Future: Smart Buildings with LLLC



# Lighting's Unique Real Estate

The image shows a large, empty auditorium or lecture hall. The room is filled with rows of red upholstered seats with black frames, arranged in a tiered fashion. The ceiling is a white grid with numerous recessed circular lights. The walls are light-colored with a grid pattern of rectangular panels. At the front of the room, there is a stage area with a dark wall, a central doorway, and a small window. A podium is visible on the left side of the stage.

- Elevated above us all the time**
- Distributed across the building**
- Power access at every luminaire**



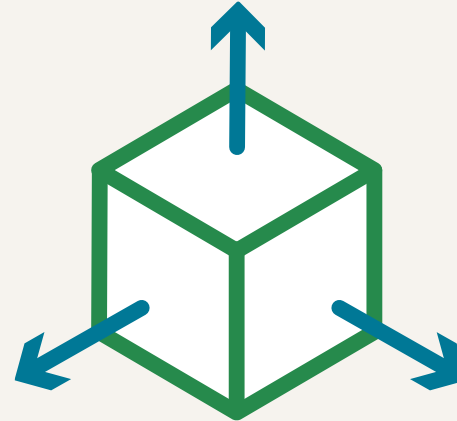
# Why Luminaire Level Lighting Controls?



**Additional  
Energy Savings**



**Occupant  
Comfort and  
Flexibility**



**Occupied  
Space  
Adaptability**



**Energy Code  
Compliance**



# Ameren Illinois LLC Program Offerings & Resources

System Type	Implemented Control Strategies	Incentive per Unit
<b>Interior   Non-LLC</b> installation <i>(Single controller/sensor controls multiple luminaires)</i>	<b>Must include three:</b> <ul style="list-style-type: none"> <li>• Occupancy</li> <li>• Scheduling</li> <li>• High-End Trim</li> <li>• Dimming</li> <li>• Daylighting</li> </ul>	<b>\$0.50/watt</b> controlled <i>(capped at \$75/ fixture)</i>
		<b>SBDI - \$0.60/watt</b> controlled <i>(capped at \$75/ fixture)</i>
<b>Interior   LLC installation</b> (Each luminaire has its own controller/sensors and DLC listing indicates LLC)		<b>\$1.50/watt</b> controlled <i>(capped at \$75/ fixture)</i>
<b>SBDI - \$1.75/watt</b> controlled <i>(capped at \$75/ fixture)</i>		
<b>Exterior   LLC or non-LLC installation</b> (Garage/covered parking areas not eligible)	<b>Must include:</b> <ul style="list-style-type: none"> <li>✓ Occupancy and/or Scheduling</li> <li>✓ Daylight shutoff</li> </ul> <b>Plus, one of:</b> <ul style="list-style-type: none"> <li>• High-End Trim</li> <li>• Dimming</li> <li>• Daylighting</li> </ul>	<b>\$0.50/watt</b> controlled <i>(capped at \$75/fixture)</i>

# Integrated Sensors: Director of Building Communications




# Controls Market Adoption Myths

Controls are too expensive to purchase and install.



Lack of information about how controls can provide a more comfortable, human-centric focused building for owners and occupants.



The systems are complicated to design and take too much time to specify, install and commission.



# LLC Capabilities and Applications

# Simple and Expanded LLC Systems

## Simple

- Comprehensive or Simple Projects
- Minimal Components
- Standard Control Capabilities/Vocabulary
- Standard Configuration On-site



## Expanded

- Larger Projects
- Additional Devices Required
- Optional Control Capabilities
- Third-Party Configuration/Training



# Simple LLC Capabilities

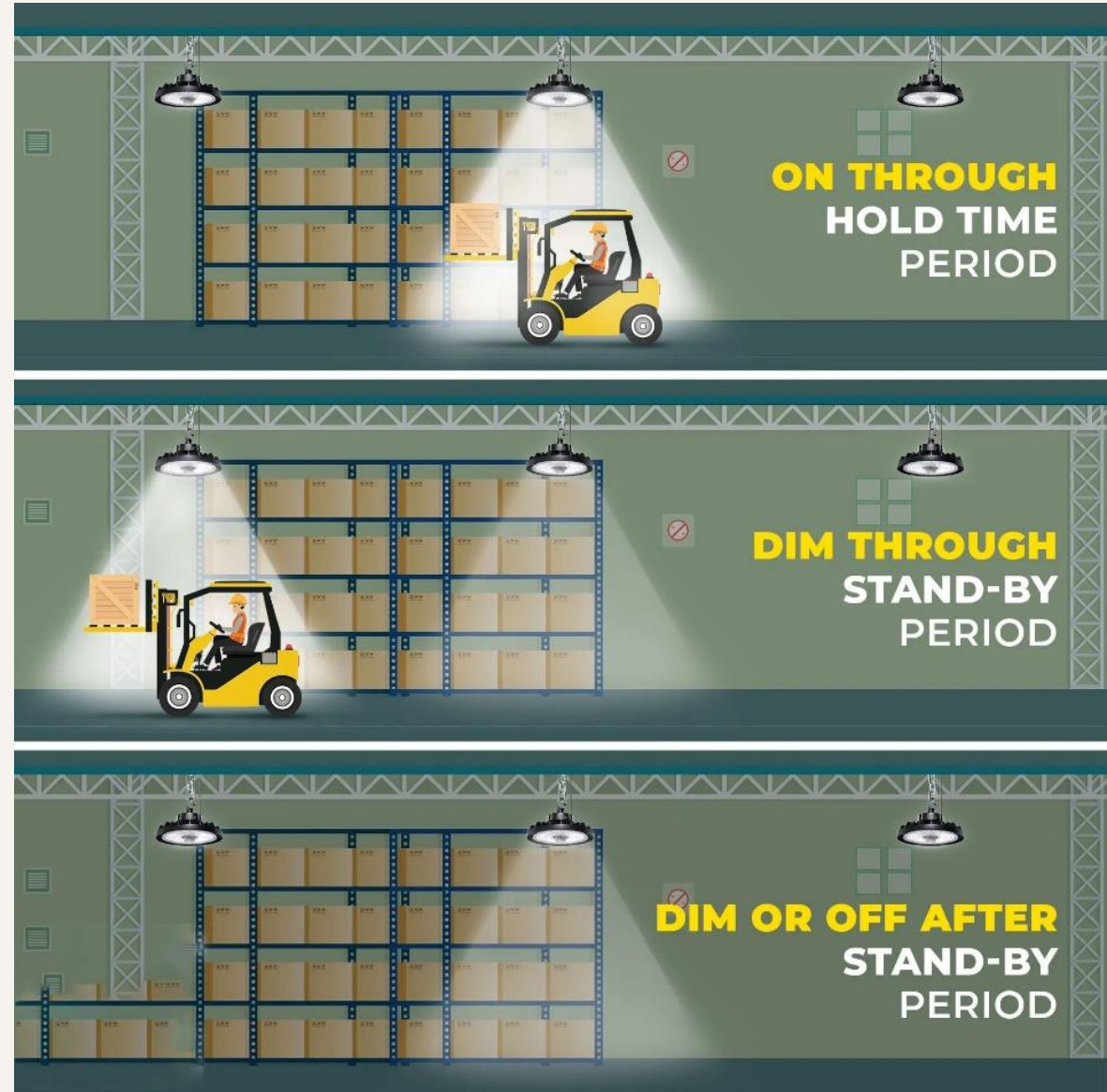


- Occupancy Sensing
- Daylight Harvesting
- Continuous Dimming
- High-End Trim/Task Tuning
- Zoning



# Occupancy Sensors

- Maximize savings during low/no activity periods
- Can provide safety benefits by altering unauthorized occupants
- Incorporate photocell to keep lights off by skylights to increase savings even more!

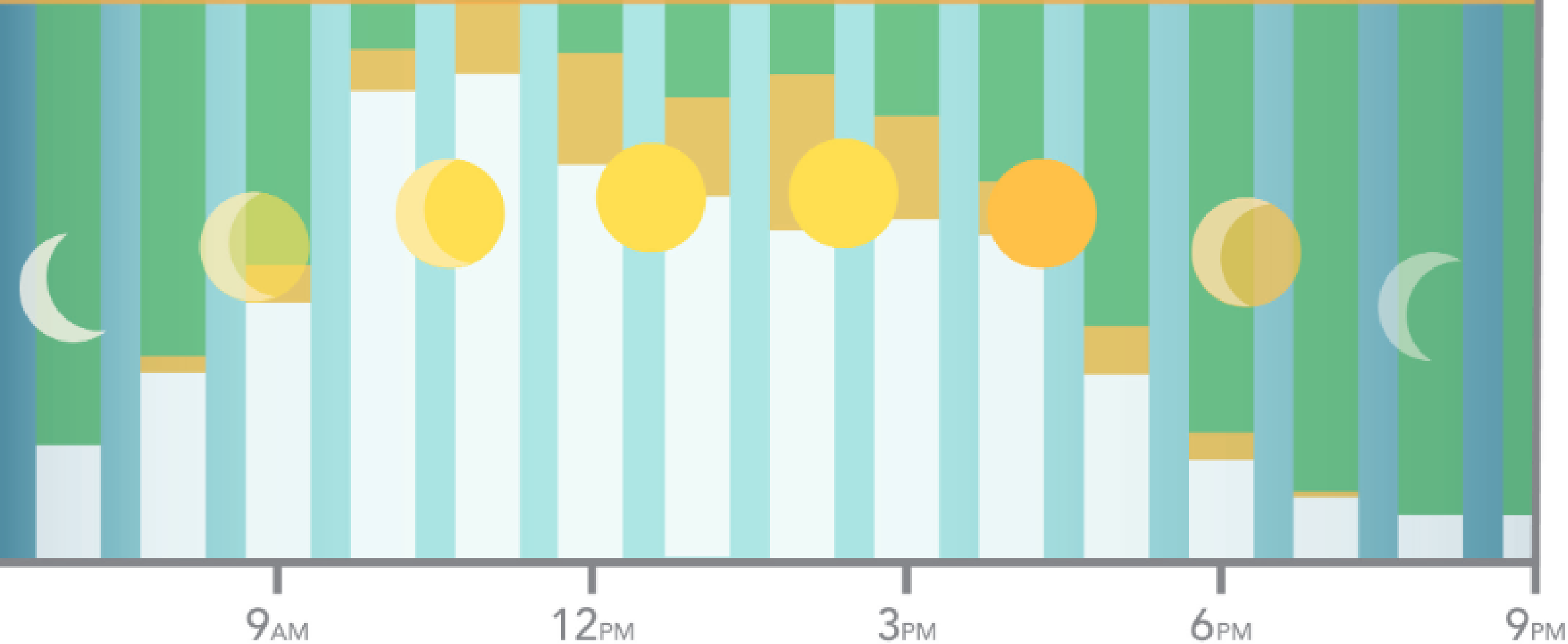




High end trim: reduces light output to the target levels

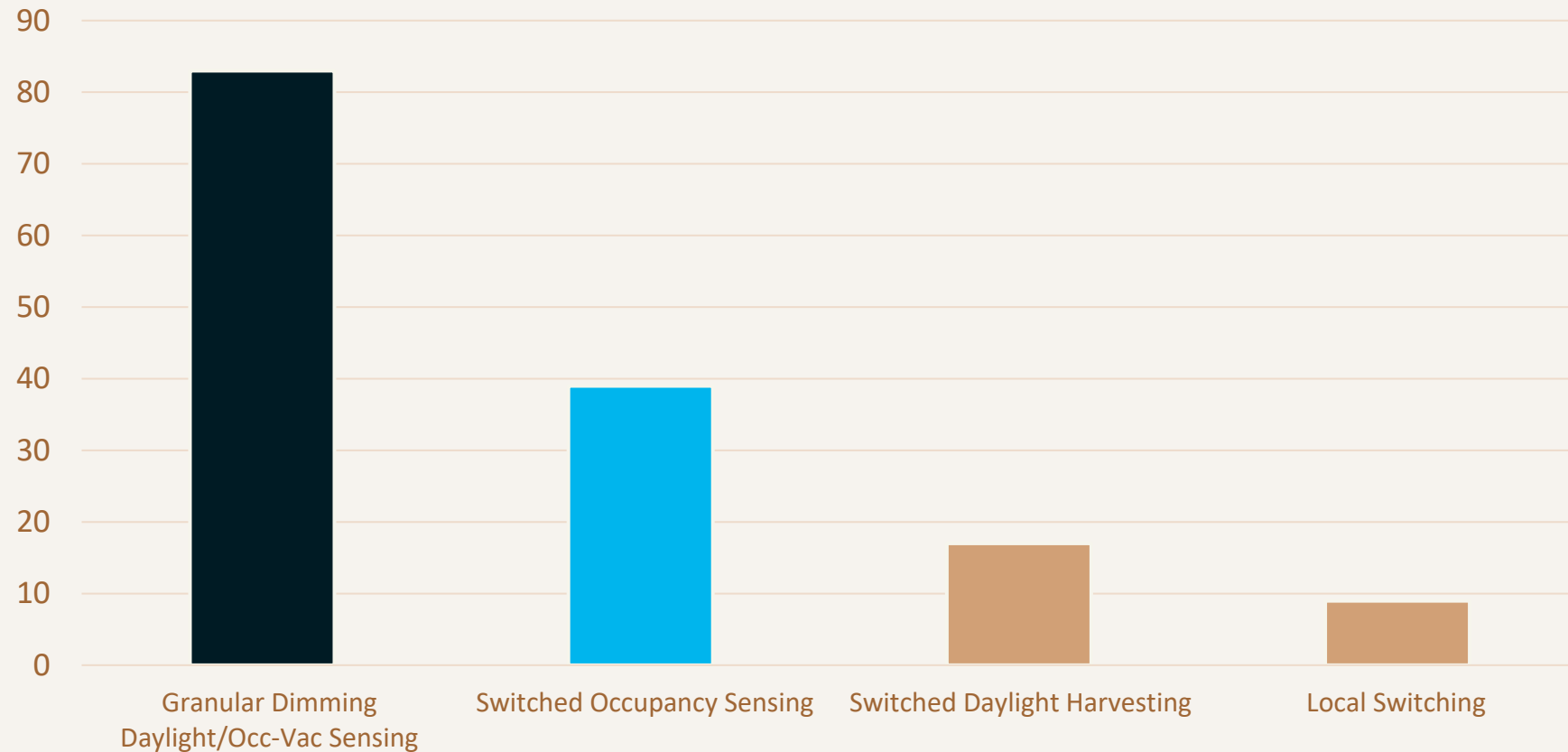
Occupancy Sensing: turns lights off when no one is present

Daylight Harvesting: adjusts luminaire output to accommodate natural light



# Deeper Energy Savings

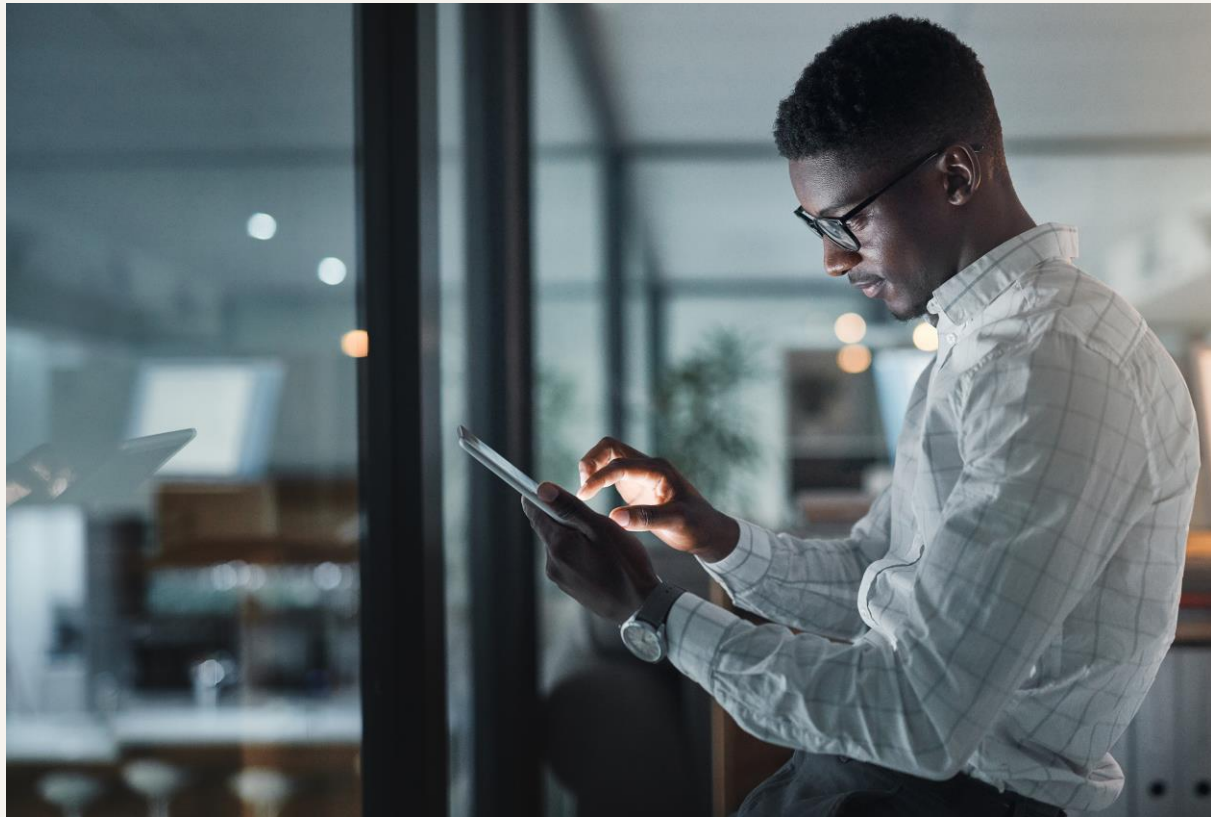
## Compounded Control Schemes



**Industry  
Voices: Chris  
Gilmore**



# Expanded LLC Capabilities



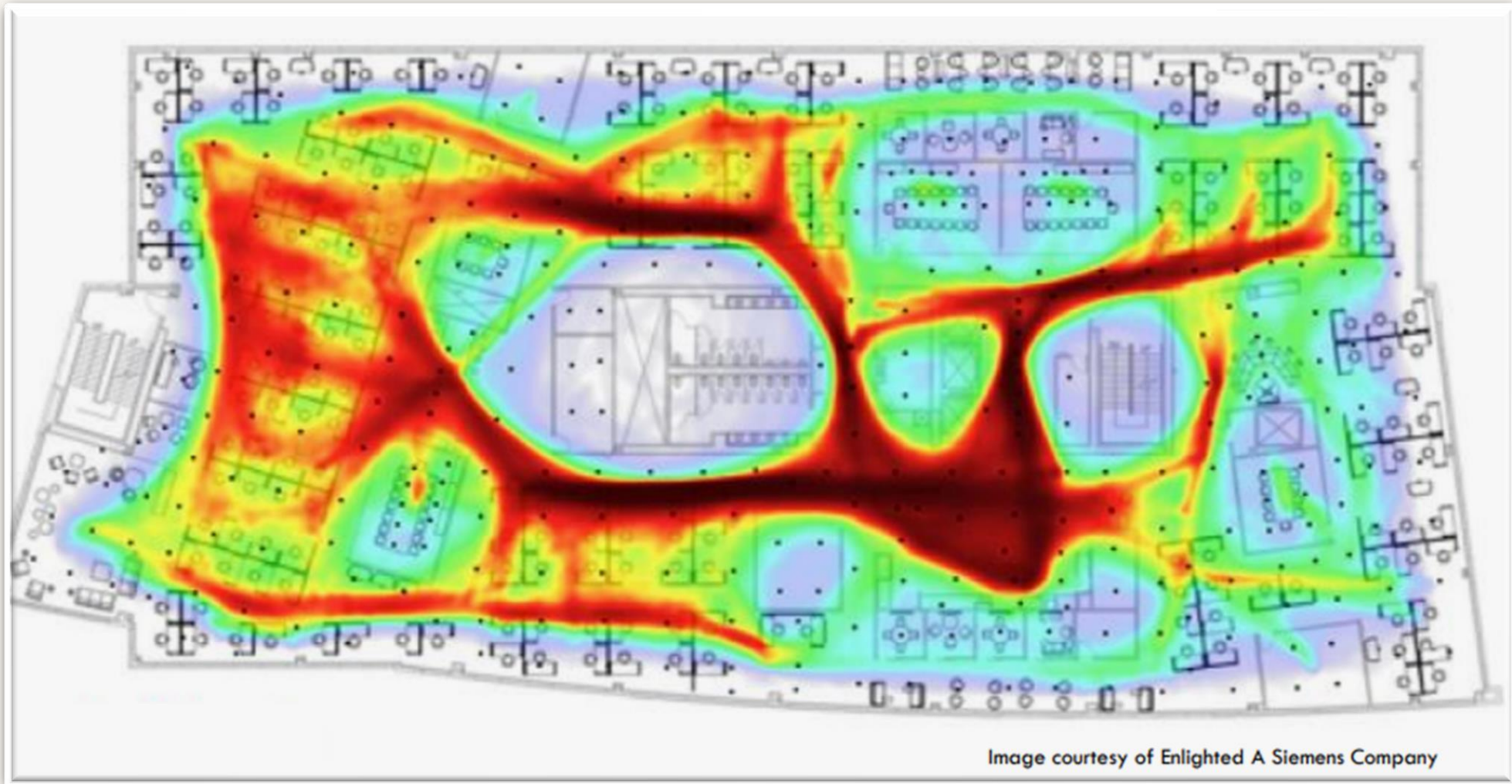
- Asset Tracking
- Space Utilization
- HVAC Integration
- Safety and Security
- Circadian Support



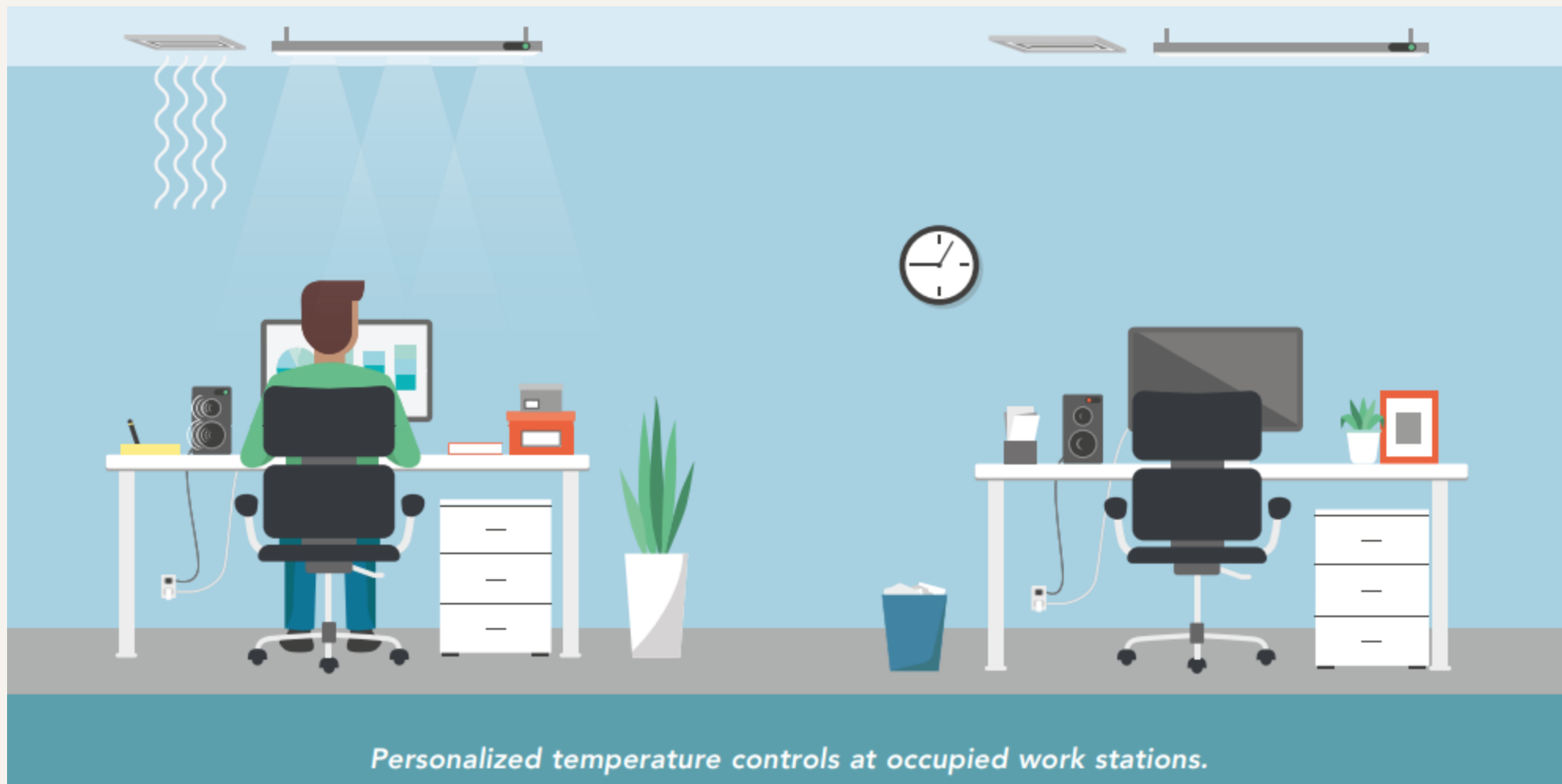
# Asset Tracking



# Space Utilization & Optimization



# Ventilation and Thermal Comfort



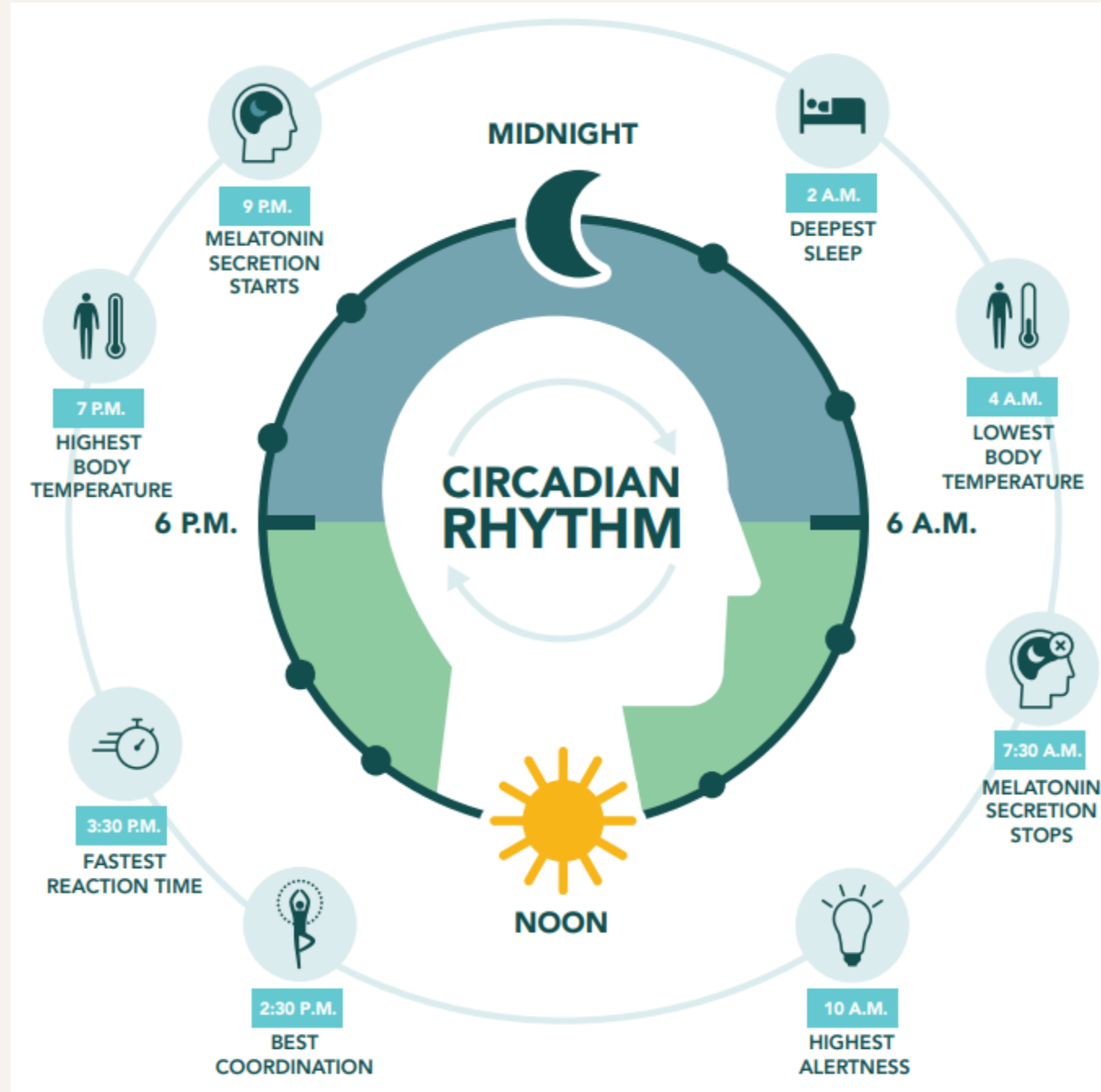
# Safety and Security



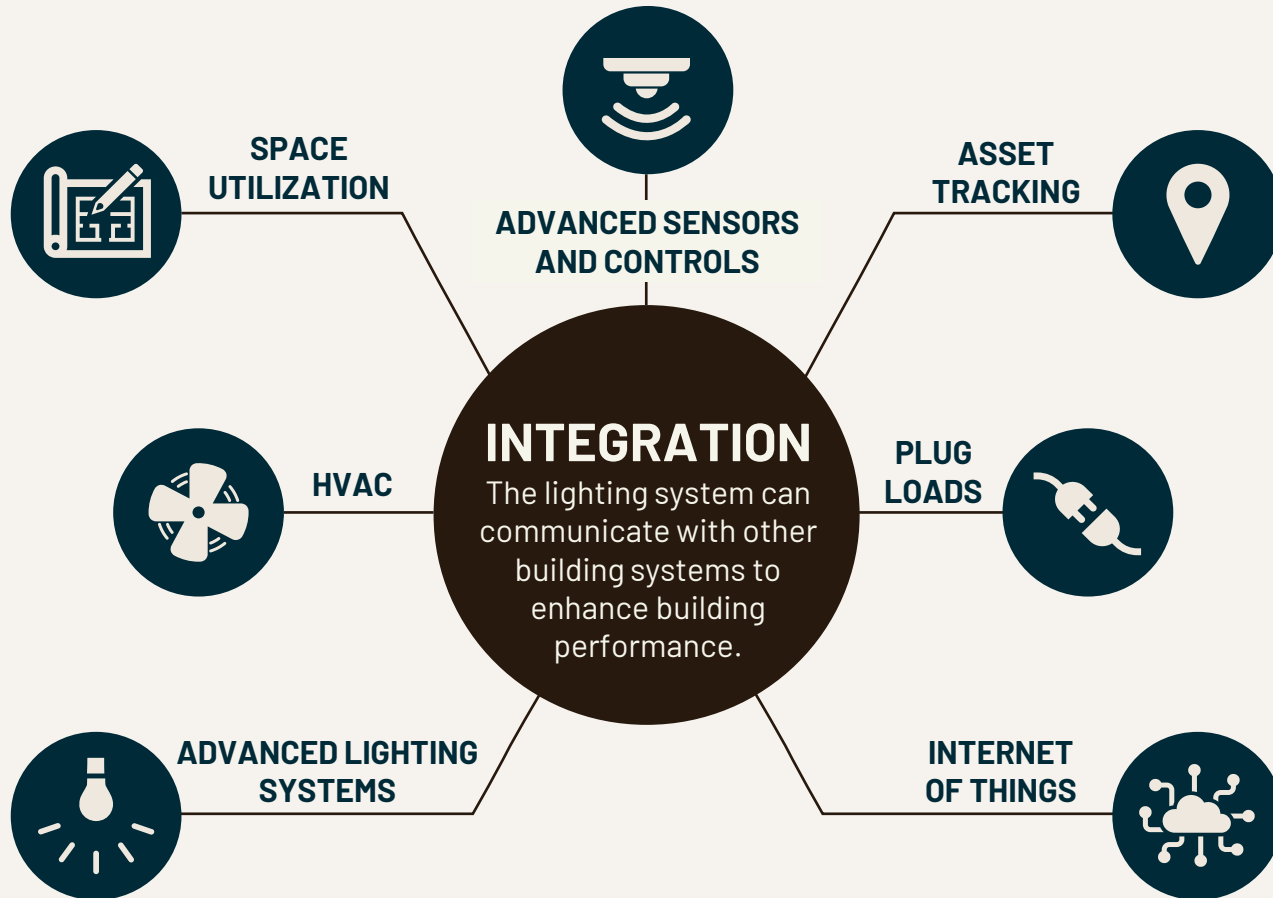


# Circadian

The circadian rhythm is a natural physiological function associated with the human sleep-wake cycle and exposure to light.



# US Department of Energy: Integrated Lighting Campaign



Technology campaigns work with **building owners and managers** who are open to adopting advanced and novel approaches to improve building performance

- Demonstrate **real-world savings and benefits**
- Provide resources that **make it easier for buyers** to consider new or underutilized solutions
- Recognize and celebrate **success!**

Source: Integrated Lighting Campaign



# ILC 2024 Award Winner: Indian Community School



## BUILDING TYPE

Community School



## LOCATION

Franklin, WI



## LIGHTING SYSTEM

Upgraded lighting to tunable-white LED fixtures with DALI controls, including dimming, daylight harvesting, and occupancy sensing



## OUTCOMES

- Teachers have more control of learning environment
- Aligns with original lighting design intent
- HVAC setbacks are triggered by lighting system

## Recognition Categories

- Advanced Use of Sensors and Controls for Lighting
- Integrated Controls for HVAC and Lighting Systems
- Energy Justice, Diversity, Equity, and Inclusion in Advanced Lighting

George Lambros Photography



Source: Integrated Lighting Campaign

Project Partners



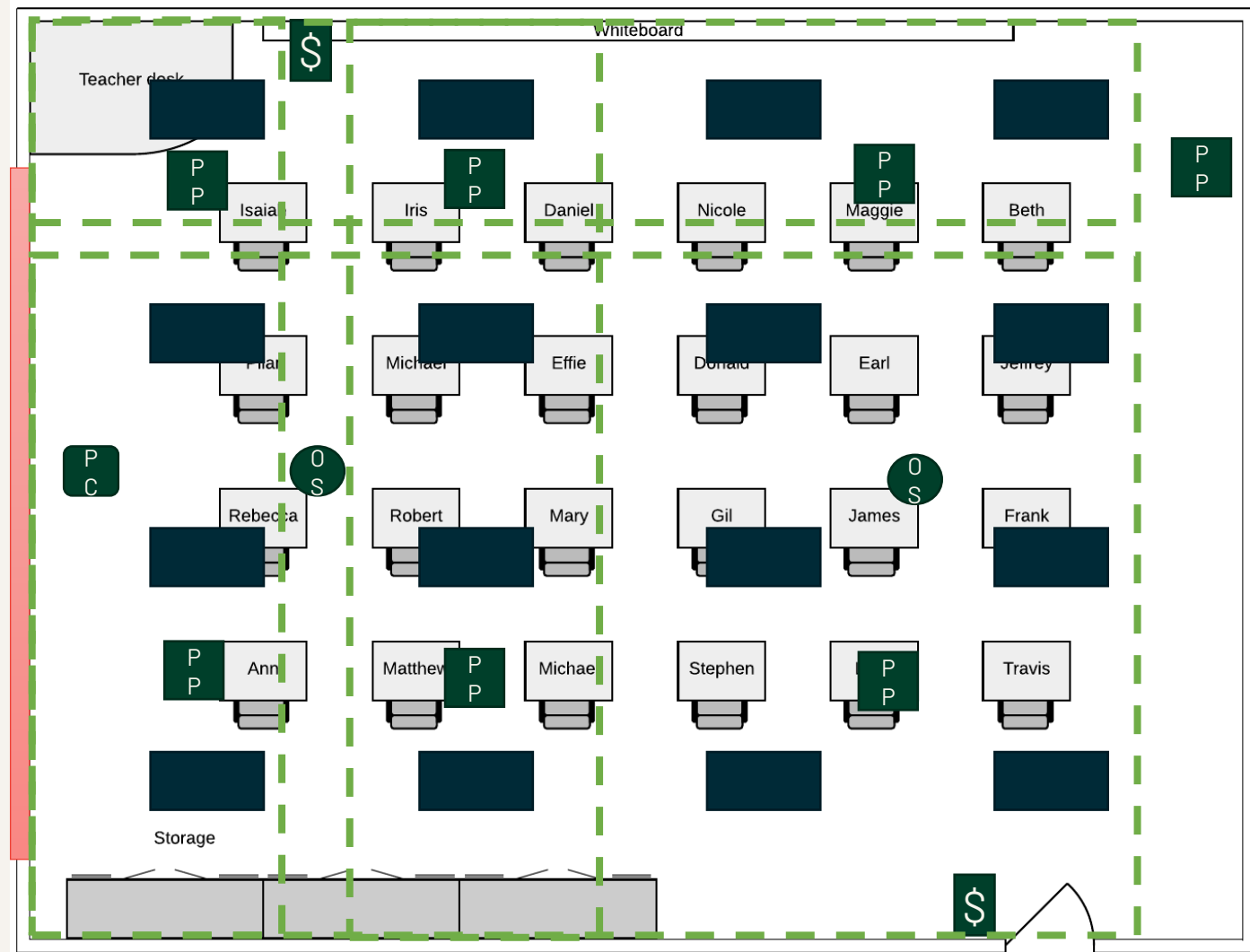


# Project Considerations

# Traditional vs Enabled vs Embedded Control System

## Traditional Lighting Control System

- Switches on the wall
  - On/off at entrance and scene selector at teacher station
- Occupancy sensors
- Photocell
- Power packs (relays) for each zone of lighting and plug load
  
- (16) fixtures to install
- (12) control devices to install
- (6) pairs of 0-10V wires to install
- CAT5 cabling between devices

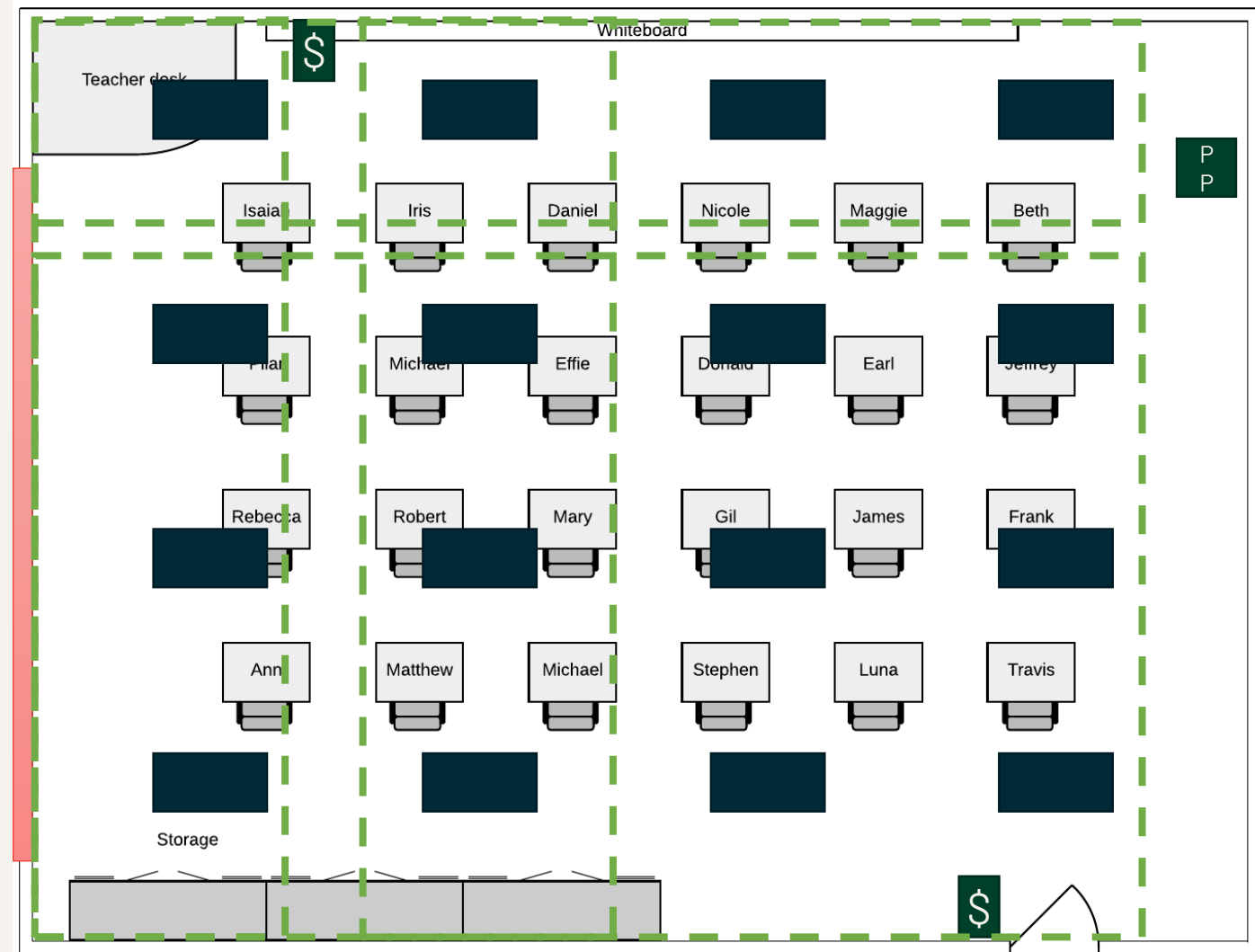


# Traditional vs Embedded Control System

## Embedded Lighting Control System

- Switches on the wall
  - On/off at entrance and scene selector at teacher station
- No occupancy sensors required
- No photocell required
- (1) Plug Load power pack required. All other zoning created through programming
  
- (16) LLLC fixtures to install (wireless )
- (2) control devices to install
- (0) pairs of 0-10V wires to install
- CAT5 cabling between devices and fixtures, or use line voltage for power

Code Compliance through configuration!



# Office Lighting And Lighting Control



# Scheduling Success: Sequence of Operation Plans

- What are the overall project goals?
- What is the need in each space?
- How can we utilize control strategies to meet these needs?
- Are there any modifications needed?

		MANUAL ON	MANUAL OFF	DIMMING SWITCH	OVERRIDE SWITCH	MULTI ZONE SWITCH	KEY SWITCH	TIME CLOCK ON
SPACE TYPE	ROOM NUMBER							
Open Offices	1001, 1002, 2001, 2002	X			X			
Private Offices	505, 506, 507	X						
Meeting Rooms	etc.	X	X	X		X		
Break Rooms	etc.	X						
Kitchen	etc.	X			X			
Pantry	etc.	X						
Cafeteria	etc.	X						
Corridors	etc.					X	X	X
Restrooms	etc.						X	
Storage Rooms	etc.							
Ground Floor Lobby/Reception Area	etc.	X	X			X	X	X
Main Floor Lobbies/Reception Areas	etc.	X	X			X	X	X
Electrical/Mechanical Room	etc.	X	X					
Exterior Parking Lot Lighting	etc.					X		X
Exterior Grounds Lighting	etc.					X		X
Exterior Security Lighting	etc.							



# Value for Everyone



## TENANTS

*Living with the system*

- Easier way to interface with the building
- Increase in comfort and productivity
- Increased lighting quality and space appearance
- More personal and flexible way to control lighting



## BUILDING OPERATORS

*Leveraging the system*

- Easier way to interface with the building
- Reduced maintenance time and cost
- Monitor, dashboard, and control system as needed
- Extended luminaire and system life
- Integration to other building systems



## CONTRACTORS/ INSTALLERS

*Implementing the system*

- Simplified installation and maintenance
- Allows for more flexible designs
- Create longstanding relationship through consistent optimization
- Platform for additional value-adding services



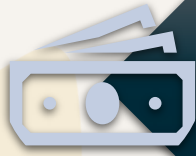
## OWNERS

*Investing in the system*

- Flexibility for future space changes
- Meet code or certification requirements
- Reduced operating costs
- Future proofing the building with tomorrow's NLC features



# Summary



LLLC can be the most cost-effective option and easier to purchase and install.



LLLC can provide a future-proofed building for owners and occupants.



The systems can be simple to design and commission.



There are resources available to help you with every project type.



# Resources

# Resources: Design to Installation

- Simplified Systems
- Factory Commissioning Tools
- Remote Access
- Owner/Occupant Education



# Utilize Local Resources

“With LLLC, not only do we offer load shedding capabilities, but we also provide monthly reports. This gives them insights into lighting as well as other systems, for example, their HVAC system. It’s a transformative conversation that needs to happen at the decision-maker level.”



**EFFICIENT AND HEALTHY SCHOOLS**

Lighting Retrofits for Schools

Holt Public Schools: Recognized ILC Participant

- Project Stats:**
  - 9 schools, 5,000 students
  - 145 Campus, 340,000 sq ft
  - 10,000+ LED fixtures
  - 8,000+ Bluetooth communicating devices
  - 2,000+ Bluetooth devices in the Holt High School alone in a single mesh network
- Benefits:**
  - 44% energy savings over previous fluorescent-based
  - Energy monitoring allowed for greater utility visibility
  - Integration with the BMS creates potential for better architecture HVAC savings and coordination of control platforms

**Better Buildings**

Integrated Controls for Plug Loads and Lighting Systems

CASE STUDY: Minnesota DOT Cedar Avenue Truck Station

NOT YOUR GARDEN VARIETY GROW SPACE. INTEGRATED LIGHTING IN GREENHOUSES

**INTEGRATED CONTROL SYSTEM**

Pinva System utilized in this facility

- Detects internal and external climate data through sensors
- Storage and app can run Light Hvac, and irrigation processes, responds in real time to data, and was responsive to change
- Interdependence of control parameters (light, CO2, temperature, humidity, and nutrient) requires this type of advanced control systems

**Better Buildings**

Higher Education Buildings Recognized for Integrated Controls for HVAC and Lighting Systems

CASE STUDY: California State University Dominguez Hills and University of Minnesota

About the Participant

The University of Minnesota, Department of Transportation (DOT) more than 7,000 buildings with 1.67 billion square feet of floor space in the MNDOT Cedar Avenue in downtown Minneapolis, Minnesota, provides critical services to the state. The MNDOT provides critical services to the state, and the Cedar Avenue Truck Station is a key facility for the state's transportation system.

**Project Goals**

Cal State Dominguez Hills:

- Save 16,000 sq ft
- Year Built: 2007

University of Minnesota:

- Location: Minneapolis, Minnesota
- Size: 25,000 sq ft
- Year Built: 1970

**Better Buildings**

Technology Campaigns: Adapting Commercial Building Strategies to the Residential Sector

Felipe Loan, Linda Sandahl, Christian Valeria, Alegra Steensma

Pacific Northwest National Laboratory

**Abstract**

The Department of Energy is committed to helping residential building owners and managers to improve their energy efficiency. This campaign is designed to help residential building owners and managers to improve their energy efficiency. The campaign is designed to help residential building owners and managers to improve their energy efficiency.

**Better Buildings**

Connected Lighting Systems in Smart Buildings: Findings and Lessons Learned from the U.S. Department of Energy Integrated Lighting Campaign and Multiple Field Evaluations

C. Asst Professor, Pacific Northwest National Laboratory  
Michael Meyer, Pacific Northwest National Laboratory  
Linda Sandahl, Pacific Northwest National Laboratory  
Cedar Blazek, U.S. Department of Energy

**ABSTRACT**

Commercial buildings are making great strides in transitioning to high efficiency lighting, with light-emitting diode (LED) – the predominant fixture type in commercial spaces – more than doubling its penetration of linear fixtures in a 2-year time span to over 20% of installed base (DOE 2020a). Although the energy savings from LEDs are a great energy success story, commercial spaces can save more by adopting connected lighting controls in their lighting systems. The energy savings potential of connected controls can be significant for lighting systems, and additional energy savings exist with other building systems. Despite this potential, connected lighting systems account for only 1% of the LED market (DOE 2020a), leaving a tremendous amount of energy savings on the table and, worse, foregoing the opportunities sensor data from these lighting systems can afford smart buildings.

Between 2016 and 2020, there were multiple field evaluations completed on these systems that demonstrated 60% lighting energy savings, greater than 80% plug load savings, and greater than 20% heating, ventilation, and air conditioning savings. The Integrated Lighting Campaign was launched in 2020 with an aim to share the benefits of these systems. This paper will present the findings from projects that were recognized in the inaugural year of the Integrated Lighting Campaign for exemplary performance related to the associated use of sensors and controls in lighting, as well as the integration of lighting systems with other building and business systems. Benefits afforded to building owners will be presented, along with best practices and lessons learned from the installation and operation of these systems.

**Introduction**

Light emitting diodes (LEDs) have upended the lighting industry in less than 10 years and are expected to grow in market share, approaching saturation in most lighting applications by 2035 (DOE 2019). If LED adoption continues as projected through 2035, an estimated cumulative lighting energy savings of 67 quadrillion British thermal units (quads) of primary energy would be saved (DOE 2019). Department of Energy (DOE) estimates an additional 16 quads of savings is possible from the use of controls and connected systems (DOE 2019).<sup>1</sup>

LED retrofit kits and new luminaires typically yield 30% energy savings compared to incumbent fluorescent and high-pressure sodium technologies, and this is before the inclusion

<sup>1</sup>ILC's average annual energy usage (water (e.g., transportation, buildings, etc.) is roughly 100 quads annually. This is 100 times more than the cumulative savings from lighting energy from 2016-2035.

## Recorded Webinars

Chicago Smart Lighting Program: ILC 2...

Watch later Share

1:03 / 2:28

Northwest Energy Efficiency Alliance: IL...

Watch later Share

0:09 / 3:19

## Participant Videos

## Case Studies

## Infographics

**2022 RECOGNIZED PARTICIPANT**

**CHICAGO SMART LIGHTING PROGRAM (CSLP)**

- Converted more than 390,000 high-pressure sodium streetlights to high-efficiency LEDs with smart Lighting Management System.
- Achieved \$8.7 million (45%) in annual energy savings.
- Resulted in improved and more responsive operations of lighting infrastructure.

Location: Chicago, Illinois  
Recognition Category: Other Integrated Systems and Lighting  
Building Type: Street Lighting

Project Partners: AMERESCO

FOR MORE INFO, CONTACT US AT: INTEGRATEDLIGHTING@PNNL.GOV

## Journal Publications

Source: Integrated Lighting Campaign



# NXT Level 1 and 2 – Fully Online

[www.nxtleveltraining.com](http://www.nxtleveltraining.com)



## NXT Level 1 Training

Advance your career with the latest lighting techniques and technologies.



### No Cost

Free of cost thanks to your local utility



### On-Demand

Web-based and available whenever you are



### Increase Exposure

Join the exclusive NXT Level Designation List



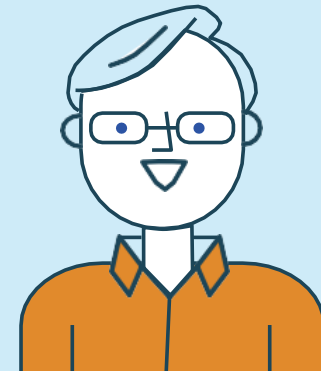
### Access Incentives

Align projects with utility incentives, where applicable



### CEUs

Earn up to 8 continued education units



## What is Energy Harvesting?

EnOcean is an energy harvesting technology that powers devices through either kinetic energy (the physical act of pushing a button), micro solar, or both.

This technology uses such little power that no battery is required. To achieve this, EnOcean has developed a proprietary protocol available for license.

Recently, both BLE and Zigbee updated their standards to require interoperability with EnOcean devices. This effectively means that BLE and Zigbee lighting systems can offer wireless lighting systems that will be compatible with EnOcean devices that will be compatible with EnOcean devices.



BetterBricks Industry Voices: Novanta

**Ken Packwood**  
Facility Administrator  
Novanta

0:09 / 2:29

YouTube



## LUMINAIRE LEVEL LIGHTING CONTROLS

- Simple Installation**  
Sensors and control programming are integrated into fixtures for straightforward setup out of the box.
- Occupant Comfort**  
With the ability to adjust each individual fixture, LLCs boost occupant comfort and productivity.
- Savings**  
Energy savings of 25 to 75%, and decreased installation and maintenance costs.
- Building Improvement**  
LLCs can enable emergency lighting, demand response, asset tracking and integrate with other building systems.
- Better Lighting**  
Overall light quality is improved with LED fixtures.
- Flexible Control**  
Capable for changes in space and reduce cost of new occupants.



# Ameren Illinois LLC Program Offerings & Resources

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<b>Exterior   LLC or non-LLC installation</b> <i>(Garage/covered parking areas not eligible)</i>		<b>SBDI - \$1.75/watt</b> controlled <i>(capped at \$75/fixture)</i>
	<b>\$0.50/watt</b> controlled <i>(capped at \$75/fixture)</i>	



Q&A



# Thank You!

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