Designers Lighting Forum

Demonstrating Interoperability and HVAC Integration: Exploring Open Standards in Action with Wireless LLLC

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Learning Objectives

At the end of this course, participants will:

1. Understand the project, including the technologies being demonstrated as well as the facility characteristics
2. Understand how the project team created the demonstration design, including control strategies, sequences of operations, integration of lighting and HVAC controls.
3. Recognize implementation challenges, after exploring where the key difficulties existed and how the project team overcame them
4. learn the early performance results from the demonstration project; what the initial energy savings were, as well as other non-energy performance goals.

Today's Agenda

- Looking at the what and the why of the demonstration project
- The Why
  - Background of demonstration project
  - Objectives

- The What
  - Project details
  - Early outcomes

Who is NEEA

What is LLLC

NLC

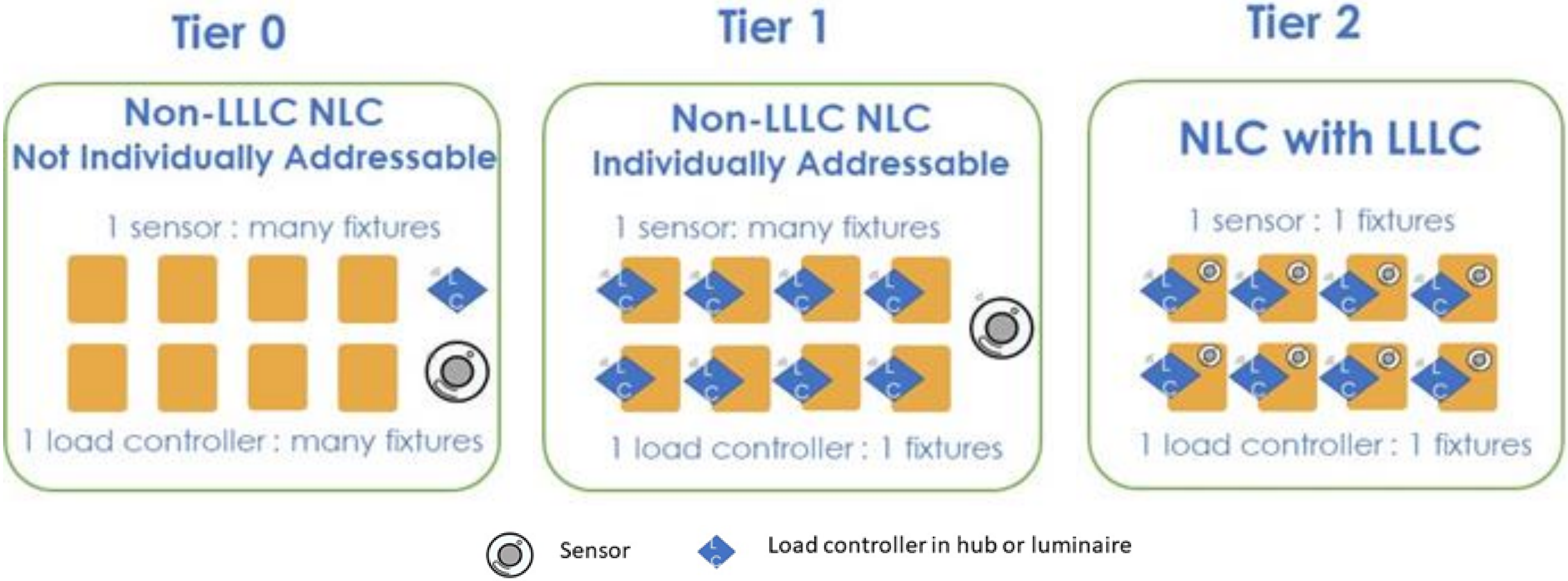
A networked lighting control system consists of an intelligent network of individually addressable luminaires and control devices, allowing for application of multiple control strategies, programmability, building- or enterprise-level control, zoning and rezoning using software, and measuring and monitoring.

LLLC

Luminaire Level Lighting Control, in which **each luminaire has a networked occupancy sensor and ambient light sensor** installed and directly integrated or embedded into the luminaire form factor during the manufacturing process or installed in the field.

Design Lights Consortium - Definitions

3 Tiers for Network Lighting Control Types



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Lighting controls in Commercial

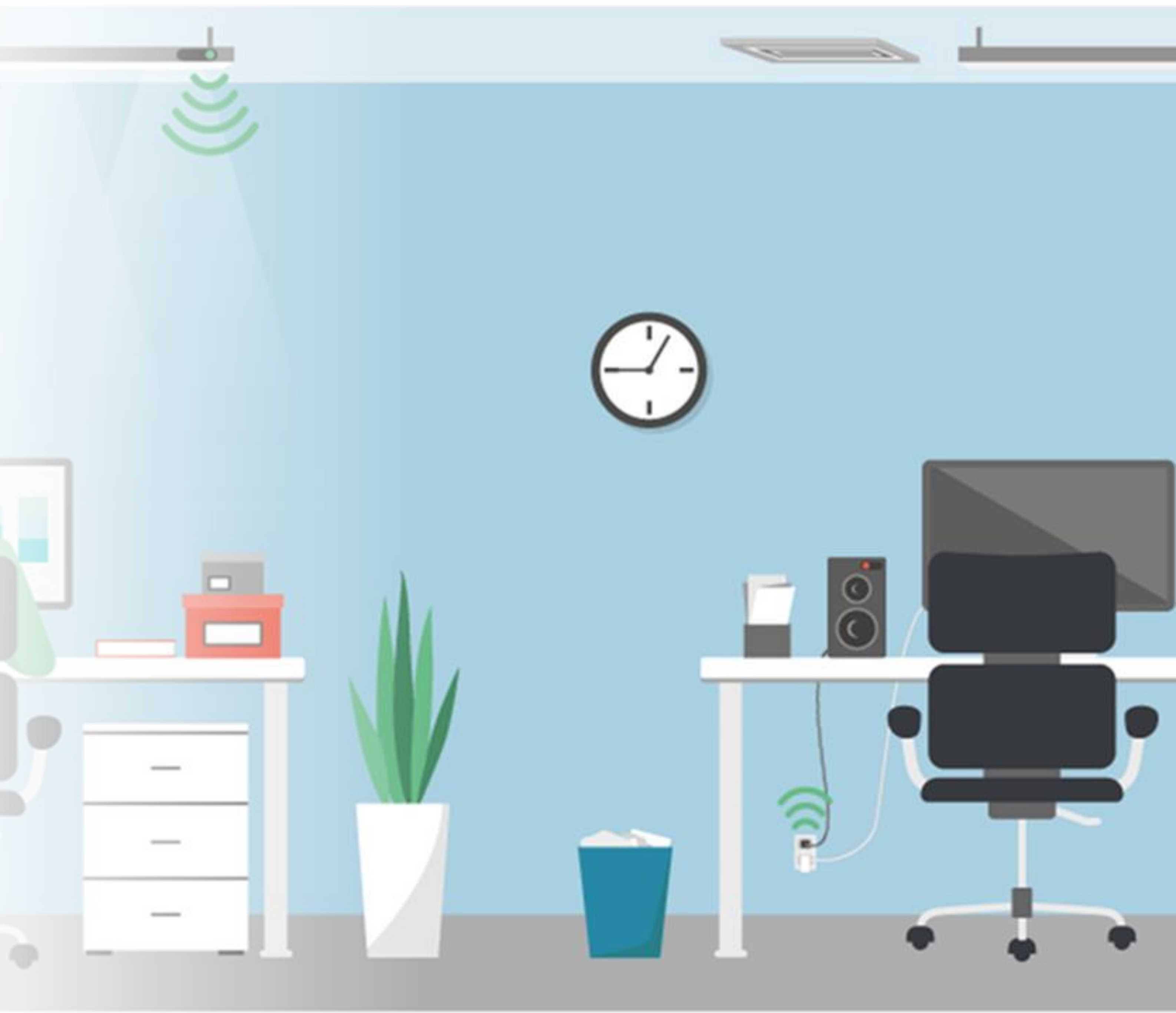
Table 3.25 Prevalence of Lighting Controls in the Commercial Sector by Building Type

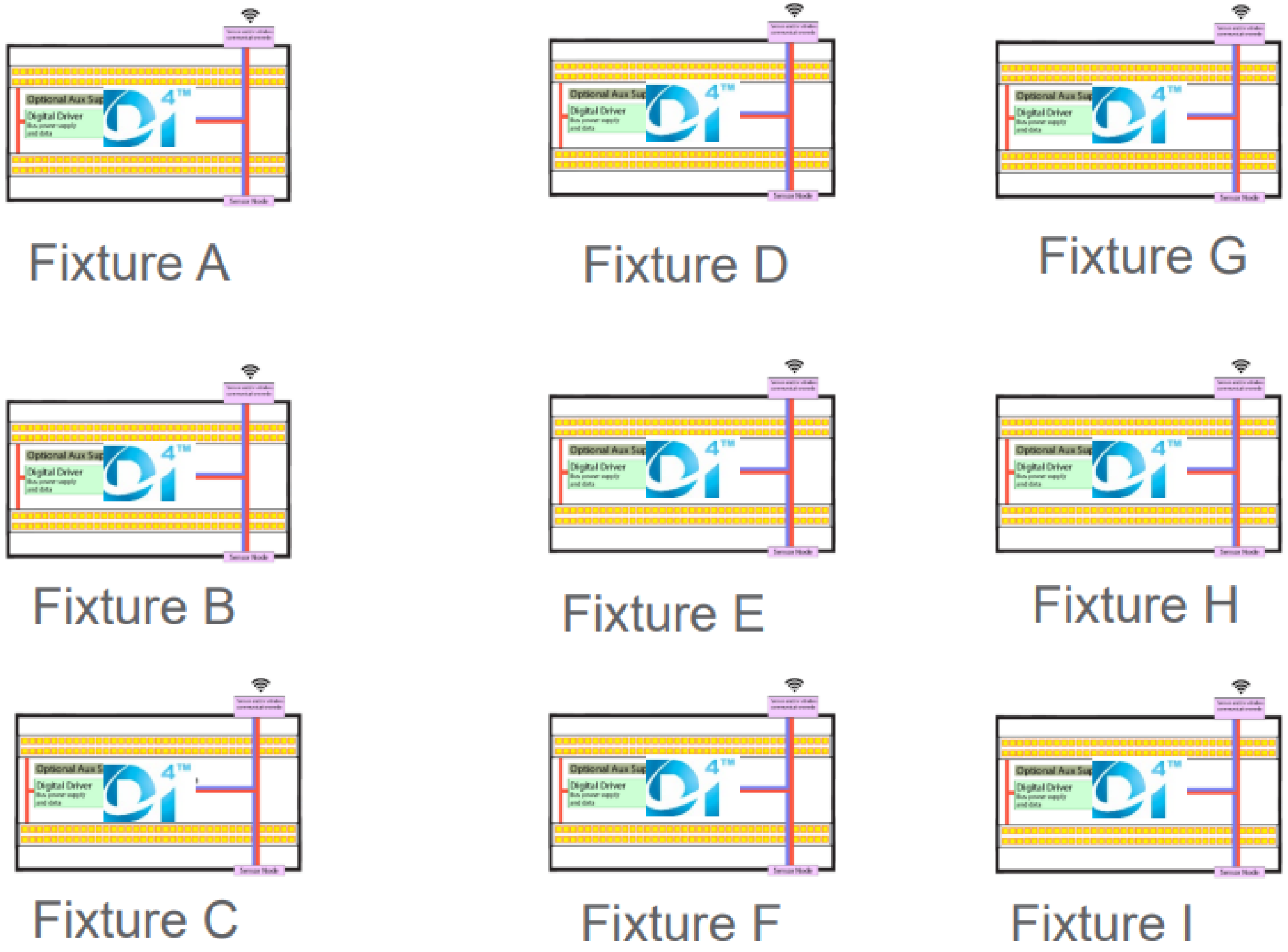
	None	Dimmer	Daylighting	Occupancy Sensor	Timer	EMS	Multi	Total
Education	56%	0%	0%	26%	3%	14%	1%	100%
Food Sales	90%	0%	0%	7%	3%	1%	0%	100%
Food Service	98%	1%	0%	2%	0%	0%	0%	100%
Health Care (Inpatient)	87%	0%	0%	10%	0%	3%	0%	100%
Health Care (Outpatient)	61%	0%	0%	31%	1%	8%	0%	100%
Lodging	91%	0%	1%	5%	2%	1%	0%	100%
Mercantile	55%	1%	0%	3%	28%	13%	0%	100%
Office	73%	0%	0%	23%	1%	2%	0%	100%
Other	90%	1%	0%	6%	2%	0%	0%	100%
Public Assembly	78%	0%	0%	14%	3%	5%	0%	100%
Public Order and Safety	86%	0%	0%	14%	0%	0%	0%	100%
Religious Worship	93%	0%	0%	7%	1%	0%	0%	100%
Service	71%	0%	0%	13%	15%	1%	0%	100%
Warehouse and Storage	51%	2%	0%	31%	3%	0%	13%	100%

DOE 2020 US Lighting Market Characterization

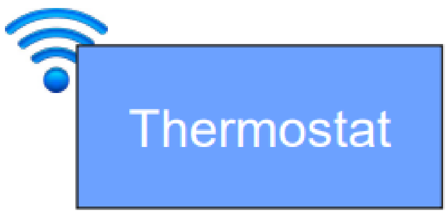
What is (Lighting) LLLC & HVAC integration?

- Occupancy sensors at a granular level (a sensor in every fixture)
- LLLC provides a source of power for the occupancy sensors
- Occupancy signal from lighting can be shared with multiple other building systems, including the HVAC system
- Lighting provides a visual indication the sensor is functioning
- 5-25% energy savings from the mechanical system on top of the 50-65% energy saving from the lighting





# Fixtures	HVAC
7≥ occupancy	Normal
4-6 occupancy	Float 1º
≤3 occupancy	Float 2º



Simple

Limited HVAC changes

Some energy savings

Suited to small buildings (60% of bldgs)

NEEA Field Evaluation

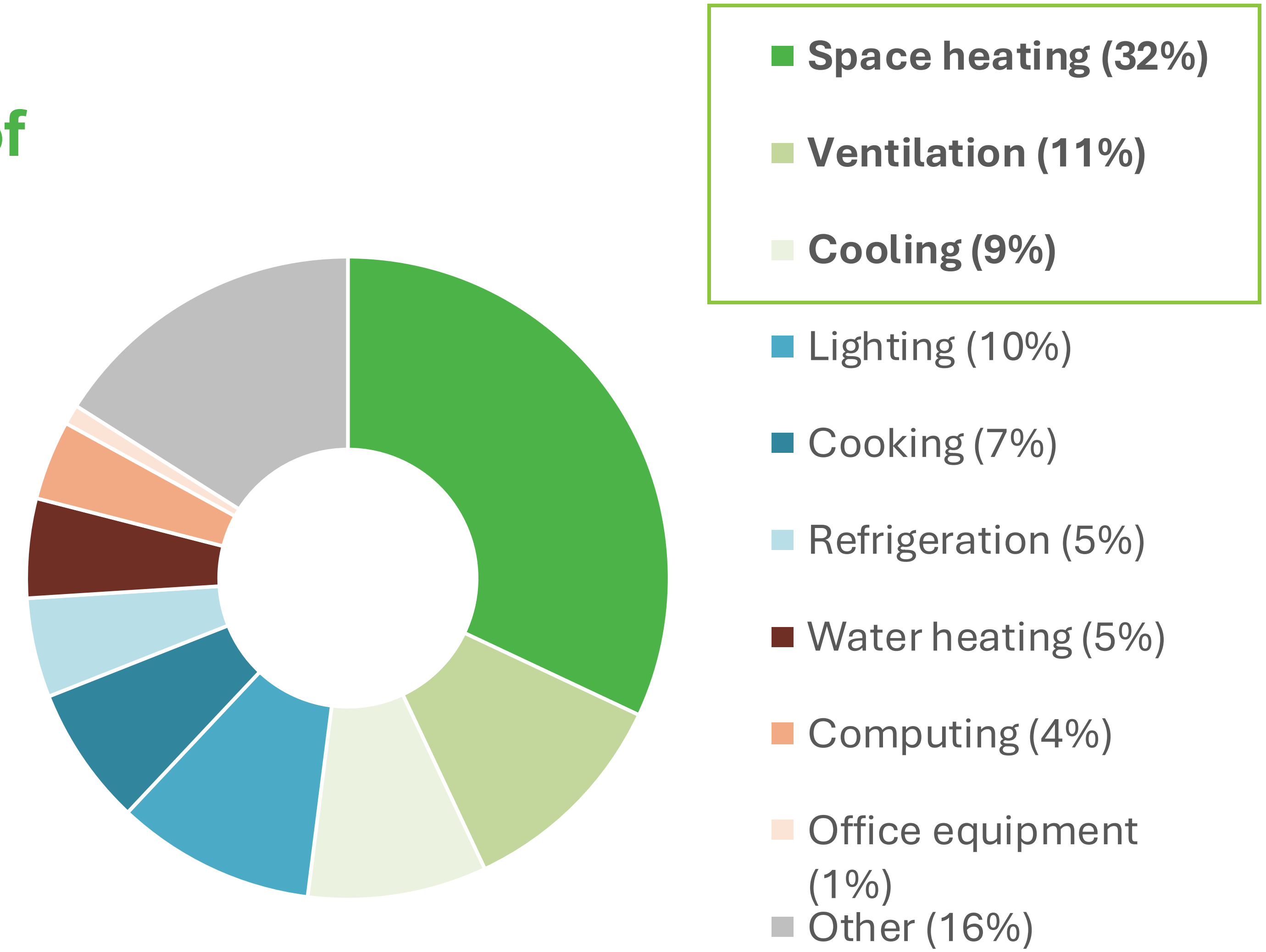
NEEA 2024 LLLC/HVAC Integration Project

Launched in September 2024, the goal of the project is to measure how occupancy data from an integral fixture sensor can inform and optimize HVAC system operation in a typical small/medium commercial building. The field demonstration was deployed in a 12,500 sqft office in Northern California consisting of private offices, conference rooms, open plan, reception and employee lunch/breakroom. The area is served by five thermostatically controlled, single zone, constant volume rooftop HVAC units.

- ***Lighting System Retrofit*** *(88) 3 lamp F32T8 fluorescent parabolic fixtures were renewed with a custom LED retrofit kit that included a certified DALI D4i driver, and an integral D4i and Zhaga Book 20 compatible sensor/controller.*
- ***HVAC Thermostat Retrofit*** *(5) Older programmable thermostats were replaced with state-of-the-art BACnet and Modbus enabled Wi-Fi thermostats.*
- ***Gateway*** *An edge gateway was installed to facilitate local communication with the Wi-Fi thermostats over Modbus TCP, communicate with the Bluetooth Mesh NLC lighting sensors/controllers, and host the evolving LLLC/HVAC setback logic.*
- ***Energy Metering System*** *A commercial grade energy meter/datalogger/web server was installed to measure and log real-time RTU energy usage and support M&V data collection.*

The average commercial building consumes 52% of its energy operating the heating, cooling and ventilation systems.

Major fuels consumption
by end use (2018)



Source: U.S. Energy Information Administration, *Commercial Buildings Energy Consumption Survey*; Note: Btu = British Thermal Units

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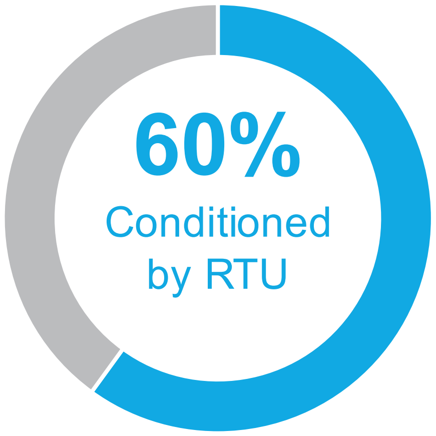
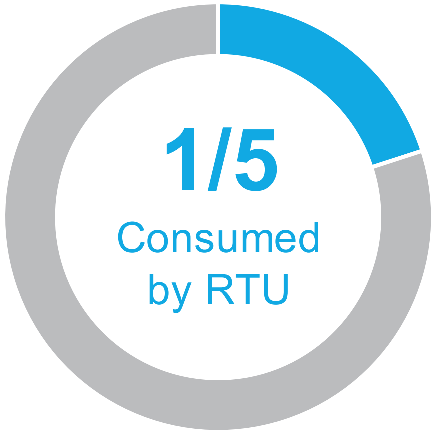
RTUs are a big opportunity for commercial energy savings

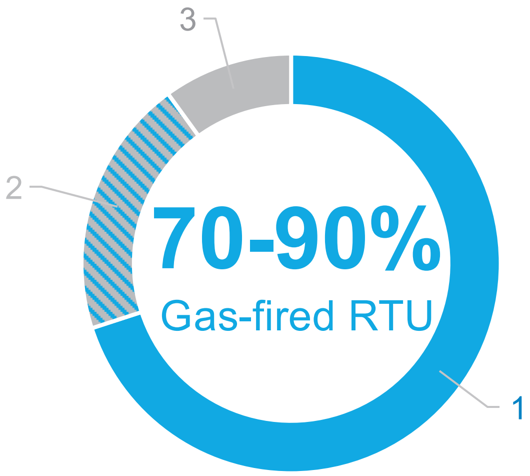
Commercial Floor Area



Commercial Building Energy Use

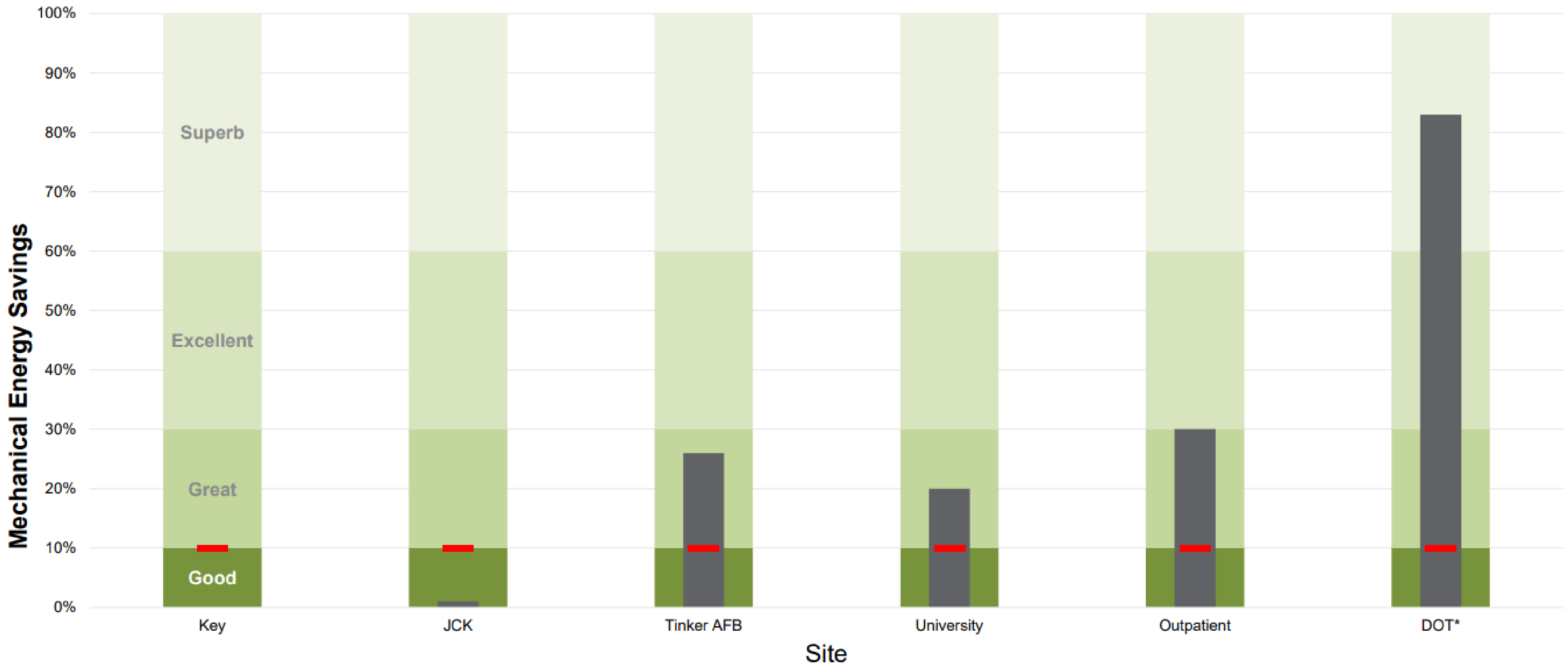


RTU Shipments by Heating Fuel Type



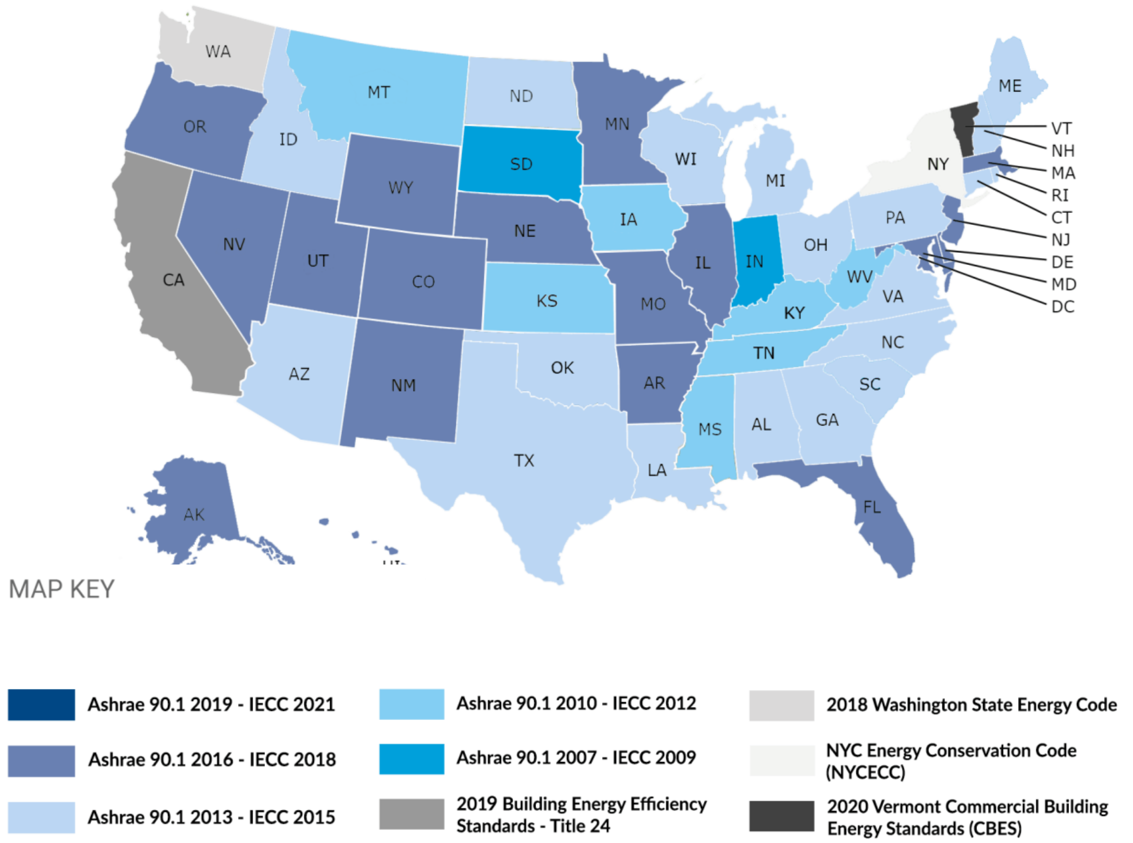
And key energy saving strategies for RTUs are being overlooked

Why Integrate Lighting + HVAC?
5 – 25% energy savings on mechanical system



Red horizontal line indicates targeted savings, black bar indicates achieved savings
* Post data gathering period occurred during COVID pandemic

Energy Codes are primary drivers for Integration



Source: www.cove.tools (2021)

- ...and getting more stringent

- Occupancy Sensors (Lighting & HVAC)
- Occupied Standby (HVAC)
- Plug Load Controls
- Demand Response

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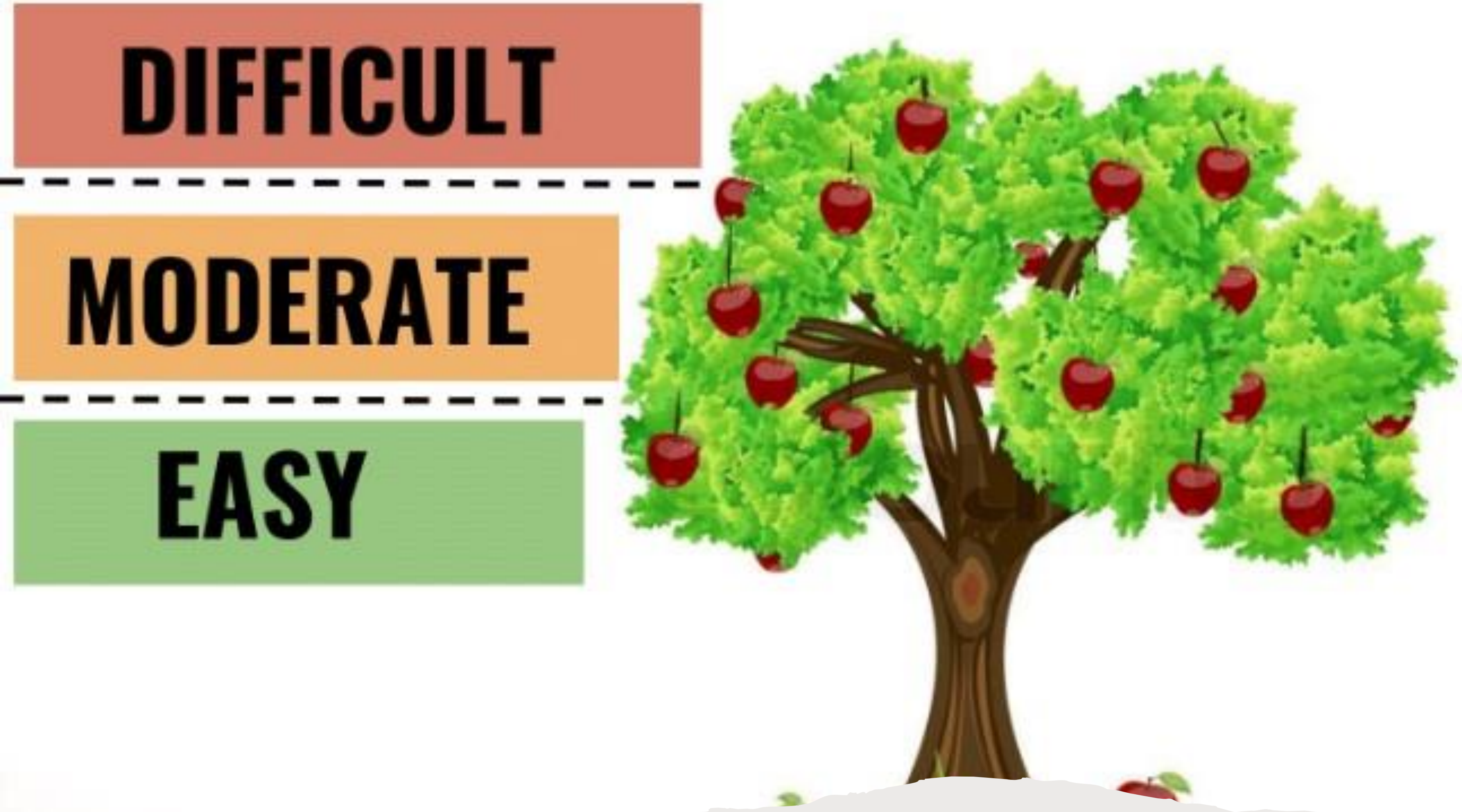
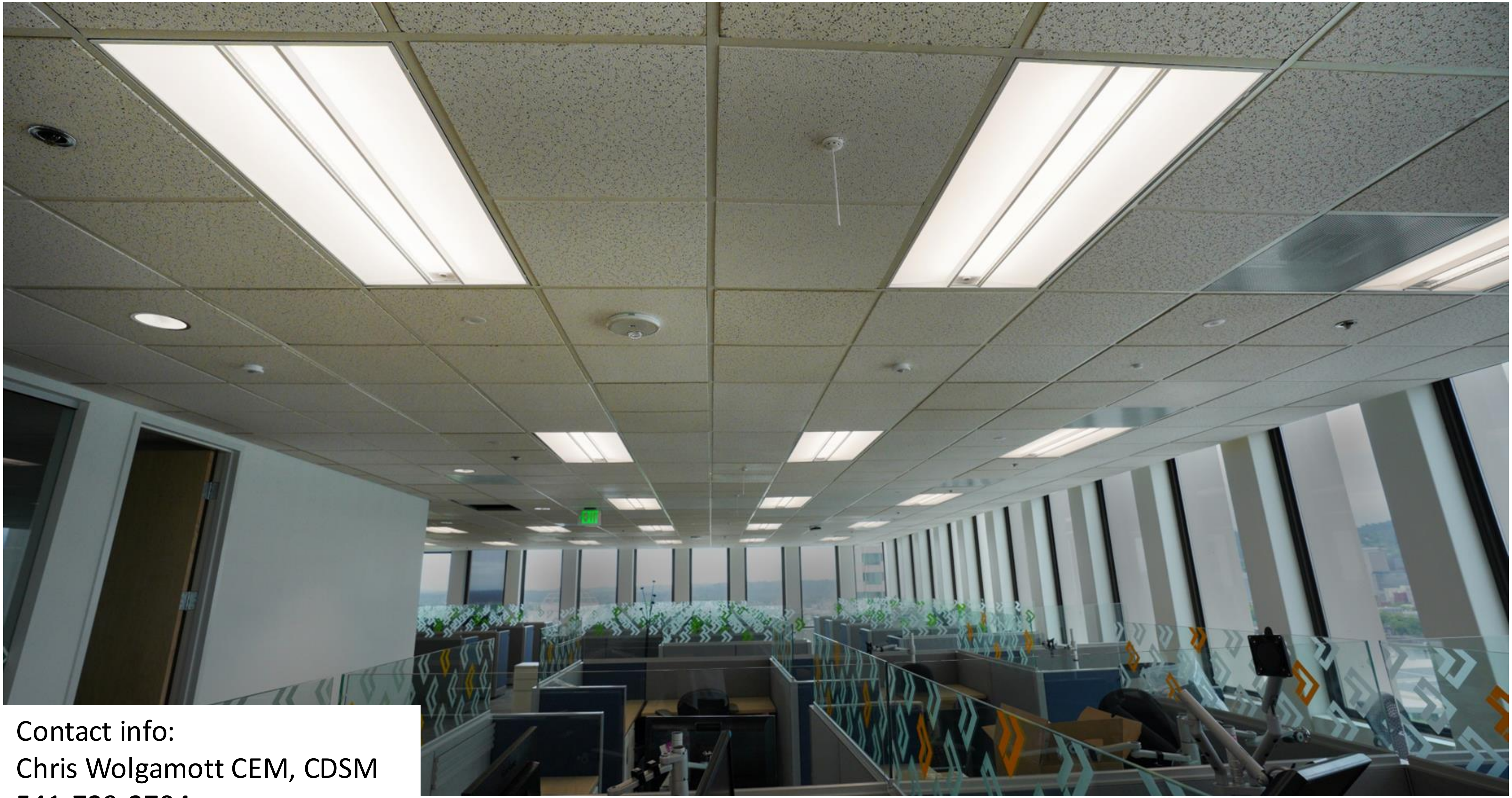


The Low Hanging Fruit is gone!

The Changing world of Utility Incentives

- LED Fixture incentives shrinking or disappearing
- Control Incentives still available
- Systems becoming more valuable than Widgets
- HVAC energy savings much greater than lighting incentives
- Flex Load (Demand Response) becoming very important



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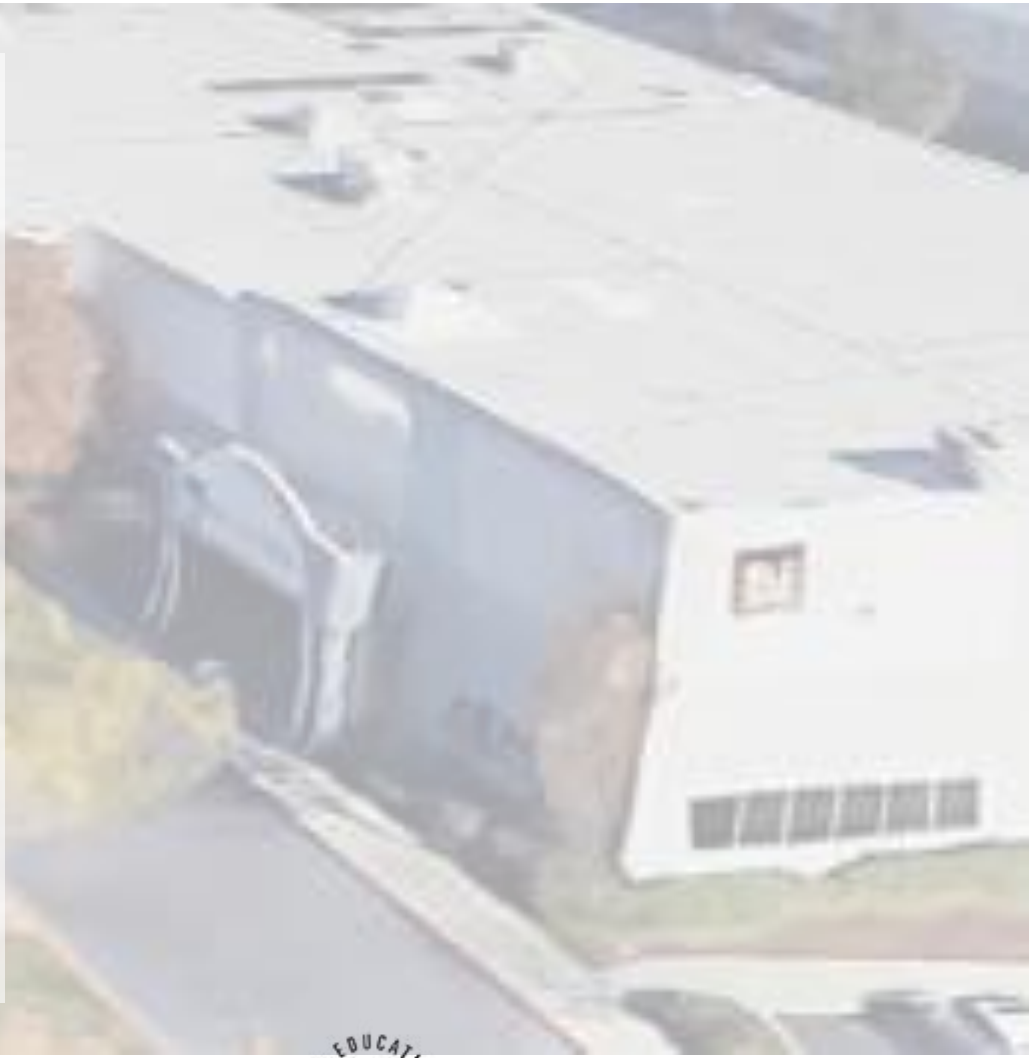
What is the Project?

- **Retrofit a medium-sized commercial space with LED lighting, advanced mesh-based controls and HVAC integration**
- **Location: Sacramento California**

What is the Project?

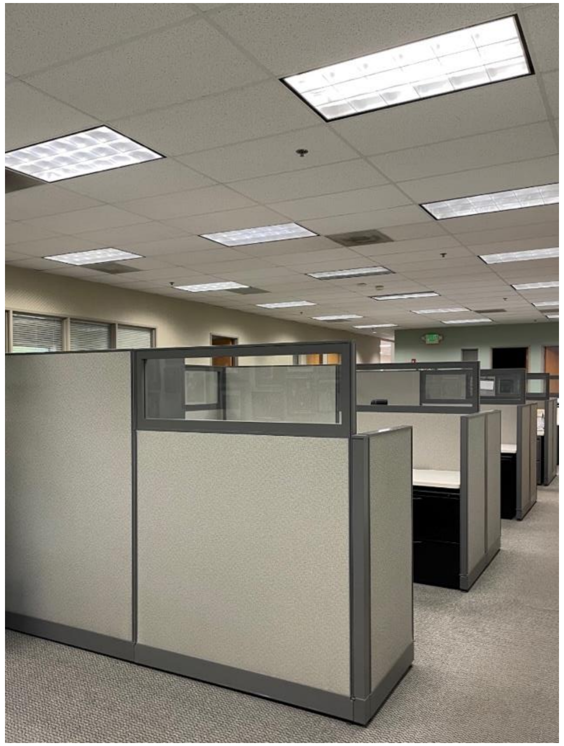
- **Physical characteristics:**
  - **Mid-size commercial facility (25,000 ft^2)**
    - **10,000 ft^2 of offices, conference rooms, lunch/break room**
    - **15,000 ft^2 of warehouse and production space**
  - **Building vintage: 2001**
- **Project duration:**
  - **Installation and commissioning Q3 2024**
  - **Data Gathering began late Q4 2024**



Project Lighting and HVAC Characteristics

- Variety of light sources
  - fluorescent, LED, CFL, halogen, and incandescent lighting
- Variety of lighting controls
  - Stand-alone occupancy sensors and switches
  - Small mesh networks
- Original HVAC system
  - 5 rooftop units (RTU)
  - Hardwired thermostats

Retrofit Project Details: LLLC with Open Standards



- Space types:
  - Executive private offices
  - Accounting, administration, sales private offices
  - Lunch/break room
  - Open office area with cubicles
  - Conference rooms
- Each LED luminaire contains:
  - DALI D4i driver
  - embedded Bluetooth NLC-qualified sensor-controller for LLLC
- Wireless kinetic wall switches in some spaces, 4-button wall controllers in other spaces

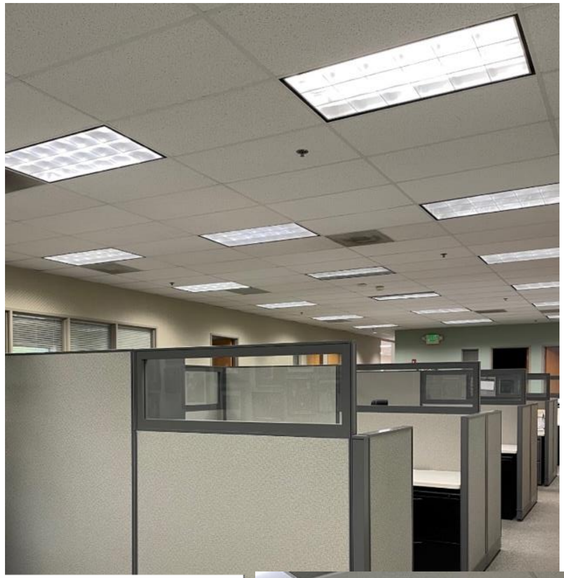
Retrofit Project Details: HVAC Integration

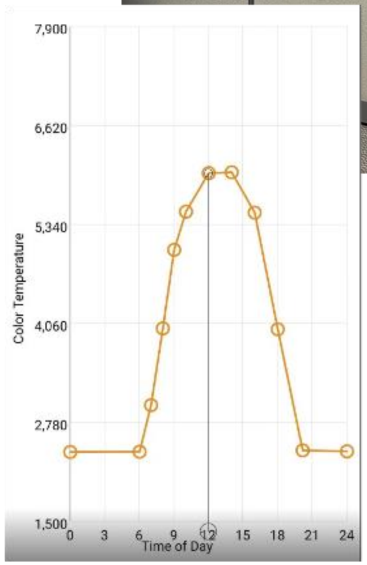
- Hardwired thermostats replaced with wireless mesh enabled models and connected to edge gateway

- Created 5 HVAC zones
  - RTU #1: Accounting, Administration, Sales, Open Plan East, Open Plan West, OPEE, PC, Library
  - RTU #2: Executive #1, Executive #2, Executive #3, Conference room
  - RTU #3 Kitchen, Dining, Lounge, Restrooms
  - RTU #4 & 5 not participating in demonstration

LLLC Control Highlights

- Private offices, break room, foyer, and open floor plan areas
- High end trim (70% output)
- Dimming level of 55% when occupied
- Perimeter space with large windows and daylight contribution:
  - Zones with daylighting + occupancy
  - Zones with occupancy
- Circadian profile for conference room
  - Occupancy sensing + daylighting
  - 2400K CCT at 6 am, transitions to 6000K CCT through mid-afternoon, then transitions back to 2400K by 8 PM and automatic shutoff
- Tunable white for spaces without windows





HVAC Integration Highlights

- Legacy "Set Point" approach (weekday and weekend settings only) updated to capture data from occupancy sensors
  - "Cascade" set point program
  - "Occupied/Business hours" and "Occupied/ Non-business hours" spectrum

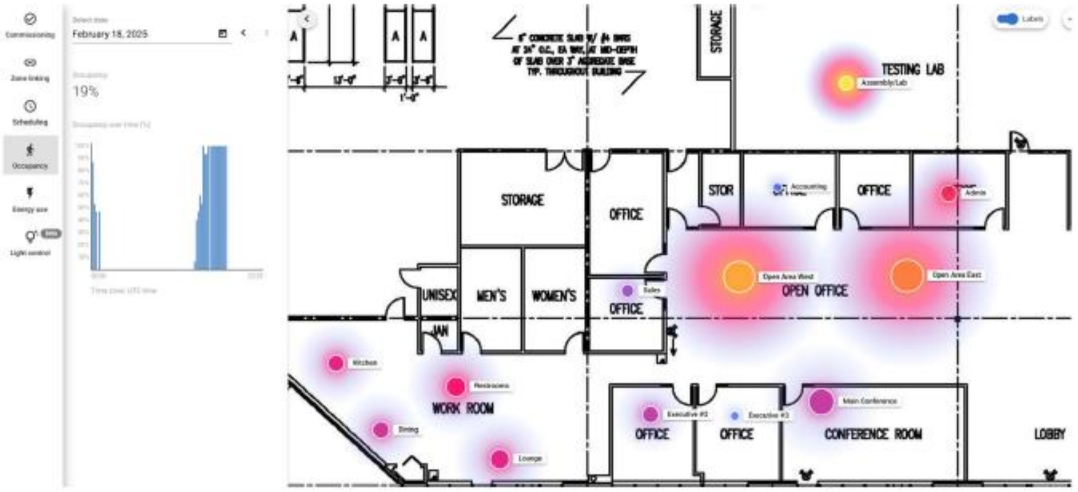
HVAC Zone	Occup + Cool	Occup + Heat	Non-Occup Cool	Non-Occup Heat
RTU #1	75	70	78	67
RTU #2	75	72	78	69
RTU #3	75	72	78	69
RTU #4	Not part of demonstration			
RTU #5				

Project Implementation Challenges & Early Learnings

- Multiple wireless communication protocols
- Thermostat installation: Initial power requirement issues; hidden default settings
- Sufficient Wi-Fi to facilitate Modbus communication between edge device and thermostats
- Programming challenges associated with edge device integration algorithms
- Hardware/software challenges with capture of multiple data streams

Early Project Outcomes

- 69% reduction in energy consumption from lighting and controls retrofit
  - Legacy lighting/control systems averaged 8280 watts
  - Post-retrofit, lighting/control systems average 2588 watts
- HVAC performance:
  - Winter project start means less electricity (cooling) savings
  - Holidays = more variable occupancy data
  - Increased vacancy = thermostat setpoint adjustments
  - Preliminary projected results = 5-10% energy savings (gas and electricity)



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