

## Designers Lighting Forum

### Evaluating Lighting Control Sequence of Operations for High Performing Buildings

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# Evaluating Lighting Control Sequence of Operations for High Performing Buildings



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AIA Provider # J618

AIA Program #

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Questions related to specific materials, methods, and services will be addressed at the conclusion of this presentation.

## Course Description

Every lighting control installation requires a sequence of operation to ensure a code-compliant solution. Assessing the sequence of operation based upon the way occupants interact with lighting controls can increase energy savings and user satisfaction. This course will evaluate common sequence of operations for a variety of applications, provide insight on building usage trends, and offer suggestions on how to maximize energy savings and customer satisfaction with little to no additional hardware investment.

# Learning Objectives

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

- Recognize how Code requirements suggest a typical Sequence of Operation
- Identify how building owners are increasing system savings and usability by broadening the Sequence of Operation
- Describe what system components or features are recommended to benefit from an expanded Sequence of Operation
- Discuss additional measures to enable savings without sacrificing usability

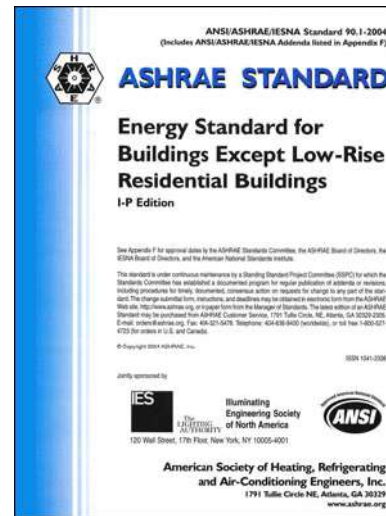


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**Recognize how Code requirements suggest a typical Sequence of Operation**

# Paradigm Shifts

ASHRAE 90.1-2004



2011 First commercially available LED general purpose fixtures



“THE ONLY CONSTANT IN LIFE IS CHANGE”-HERACLITUS

# Energy Saving Strategies



Occupancy Sensors  
20-90% Energy Saving

Time Clock  
15-40% Energy Saving



Daylight Harvesting  
3-60% Energy Saving



# Energy Code Requirements

- Interior and exterior lighting require on/off control in all areas (excluding 24hr and exempted spaces)
- Occupancy sensors required in certain areas
- Areas without occupancy sensors require time-based control
- Light reduction controls are required
  - Dimming or Bi-Level switching
- Daylight responsive controls in areas with windows or skylights
- Exterior lighting must be automated using either photo and/or astronomic time clocks and some codes require light level setbacks
- All systems require basic commissioning, and some require enhanced commissioning to optimize the system



# Sequence of Operation

- A series of events or things that come one after another in a particular order. A set of rules that define how a space will respond to input from a person or another system.

Chart

Narrative

Project Name:																								
Sample Sequence of Operations																								
Date																								
SPACE TYPE OR ROOM	OCCUPANCY SENSOR				TIME CLOCK				WALL SWITCH				DAYLIGHT SENSOR		INTEGRATION POINTS									
	VACANCY MODE (MANUAL ON)	OCCUPANCY MODE (AUTO ON)	SENSOR TIME OUT PERIOD (IN MINUTES)	HIGH LOW OPERATION: OCCUPIED: 100% / VACANT: 30%	SCHEDULED ON AT	SCHEDULED OFF AT	OCCUPIED TIME START	UNOCCUPIED TIME START	AFTER HOURS OVERRIDE SWITCH (2 HOUR)	ON / OFF ONLY	DIMMER SWITCH	KEY SWITCH	SCENE SWITCH	GRAPHICAL WALL STATION	INDOOR - ON / OFF ONLY	INDOOR - DIMMING	LIGHT LEVEL MAINTAINED AT (IN FOOT CANDLES @ 2'-5' A.F.F.)	EXTERIOR PHOTOCELL - ON/OFF	OCCUPANCY STATUS (BINARY INPUT - READ ONLY - OCCUPIED/UNOCCUPIED)	DIMMING OUTPUT LEVEL (ANALOG VALUE - READ/WRITE - 0-100%)	RELAY STATUS (BINARY VALUE - READ/WRITE - ON/OFF)	MEASURED LIGHT LEVEL (ANALOG INPUT - 0-212FC)		
Zones 1, 4 & 5	X		10		8:00 AM	6:00 PM																		
Zones 2, 3 & 6	X		10		8:00 AM	6:00 PM																		
Zones 7 - 9	X		10		8:00 AM	6:00 PM																		
Zone 10							8:00 AM	4:00 PM	X															
Zone 11	X		10				8:00 AM	4:00 PM																
Zone 12	X		10				8:00 AM	4:00 PM																
Zones 13 & 14	X		10		8:00 AM	6:00 PM																		

- Lights shall turn on after manually and stay on until 15 minutes after the space has been vacated. Daylighting controls shall adjust the window adjacent lighting to maintain designed light levels while never dimming occupied lights below 1%

## Sequence of operation can:

- Provide consistency from space to space
- Establish how user interact with the lighting controls
- Increase energy savings



## How users experience controls

- Often perceive lighting controls to complicate how to control the lighting in their space
- Lack of labeling
- Misunderstanding of what lights are controlled by a switch
- Often placed in locations which are not obvious



## User Expectations

- Simplicity – Ease of use
- Predictability
- Located in an obvious place
- Energy Savings



# Our Path to Net Zero – Reduce Greenhouse Gas Emissions

- New Transmission Lines – Updated Grid
- Electric Vehicles
- Smarter Infrastructure
- Carbon Capture
- By 2035, cut emissions, energy costs, and support efficiency upgrades and electrification in buildings

2050



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**Identify how building owners are increasing system savings and usability by broadening the Sequence of Operation**



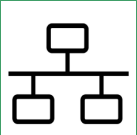
Wired – Devices use Cat 5 or low voltage for the room level interconnections



Wireless – Devices use encrypted wireless for the room level interconnections



Scheduling – Ability to program changes to the lighting



Networked Lighting Control System with a software or cloud front-end



Embedded - Fixture with embedded lighting controls



Integrated - Lighting controls attached to the fixture



Tunable/Dynamic



RGB/Color Changing



ASHRAE



IECC – International Conservation Code



California Title-24

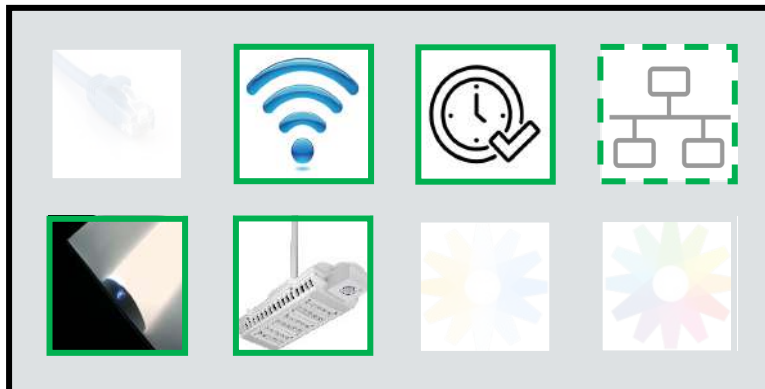


*We choose to go to the Moon... We choose to go to the Moon in this decade and do the other things, not because they are easy, but because they are hard; because that goal will serve to organize and measure the best of our energies and skills, because that challenge is one that we are willing to accept, one we are unwilling to postpone, and one we intend to win, and the others, too.*



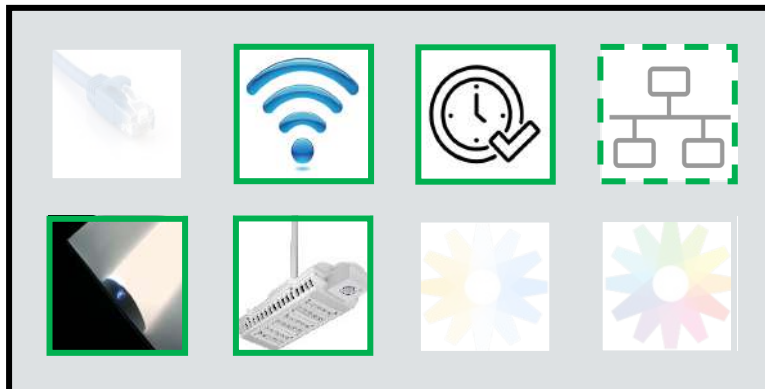
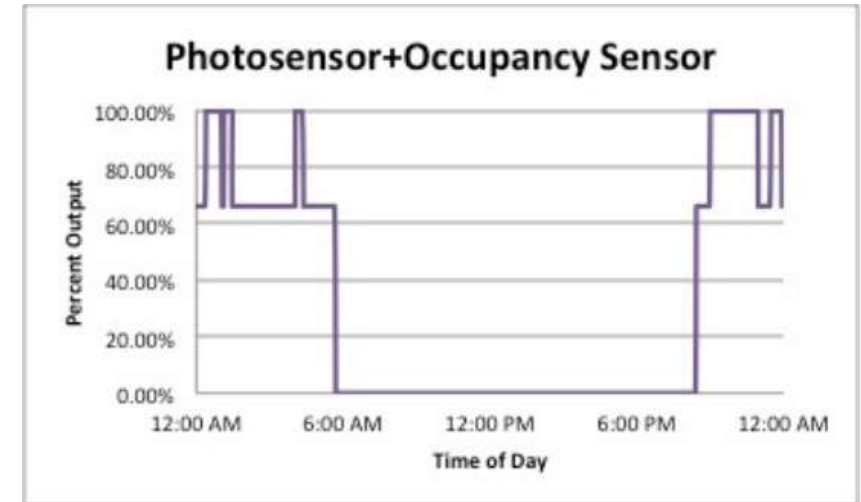
# Roadway and Parking

- IECC 2021 and T24
- Total Wattage reduced by more than 50%
- Lights mounted 24' or less must use occupancy sensor and reduce lighting by more than 50% when unoccupied



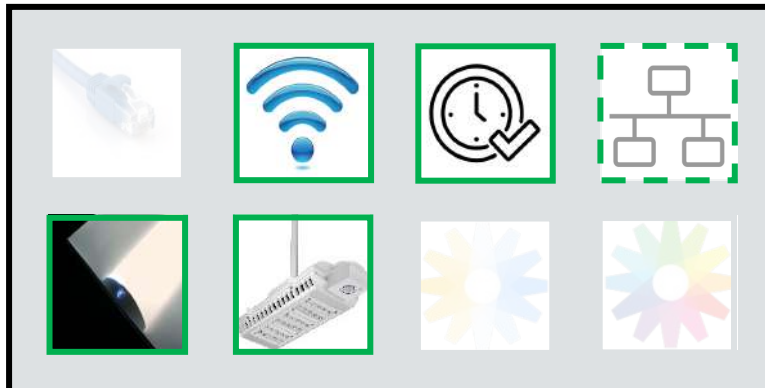
# Parking Garage

- Top deck is designed like a parking lot
- Incorporate Daylighting for additional savings
- Zone Ramps to minimize the number of lights on high
- Overlap zones of lighting control



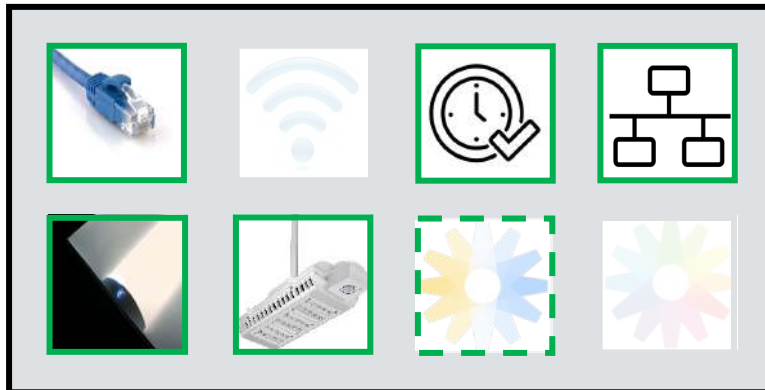
# Car Dealerships

- Street adjacent lighting goes to 100%
- Remaining lighting uses wireless controls to create group lighting response
- Occupancy Sensor highlight movement afterhours

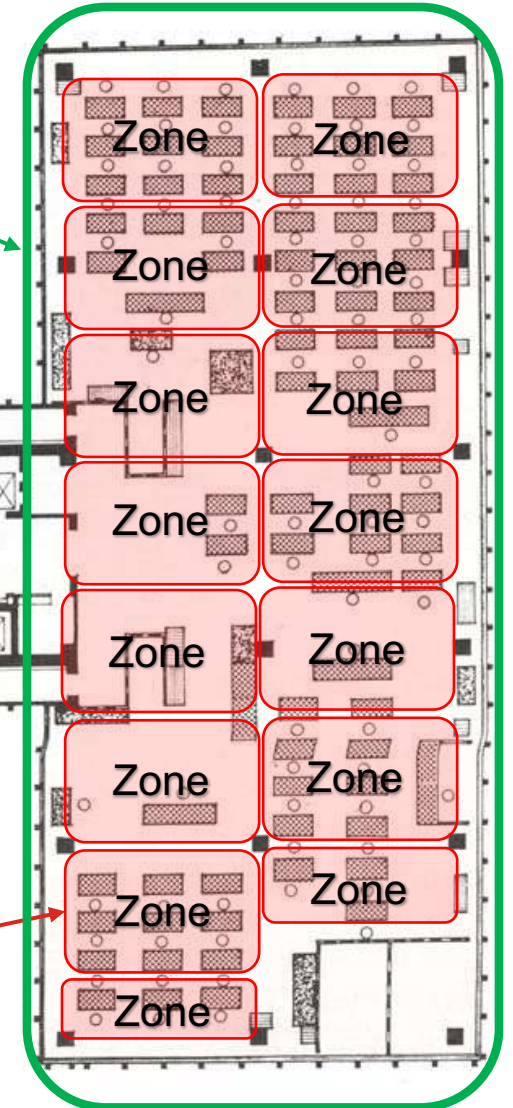
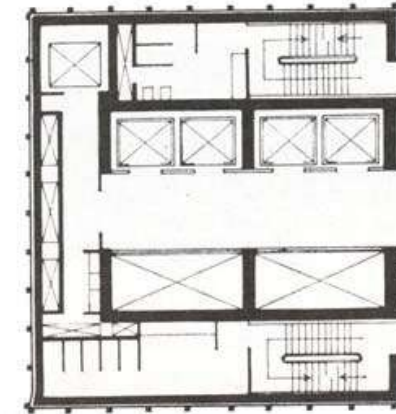


# Office – Support Zones

- Control zones separated into 600sf maximum zones
- Entire space turned off automatically when entire space is unoccupied within 20-minute timeout\*
- Each control zone configured such that lighting power is reduced between 80-100% within 20 minutes of that zone being unoccupied
- Unoccupied zones may only turn on to 20% when other areas are occupied.



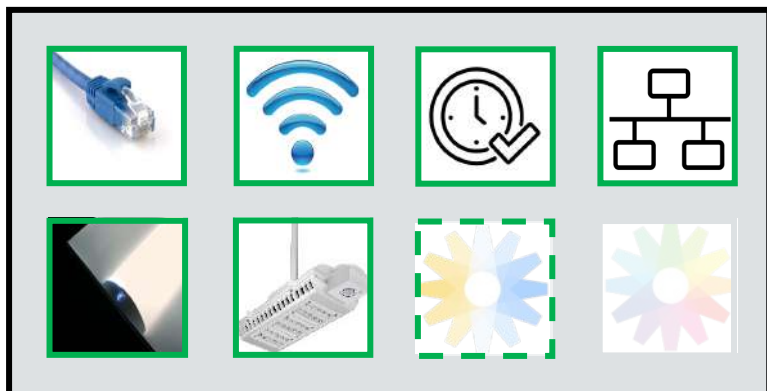
Open office must automatically turn off within 20 minutes when EVERY zone is unoccupied



600sf zone must dim or turn off within 20 minutes of that zone being unoccupied

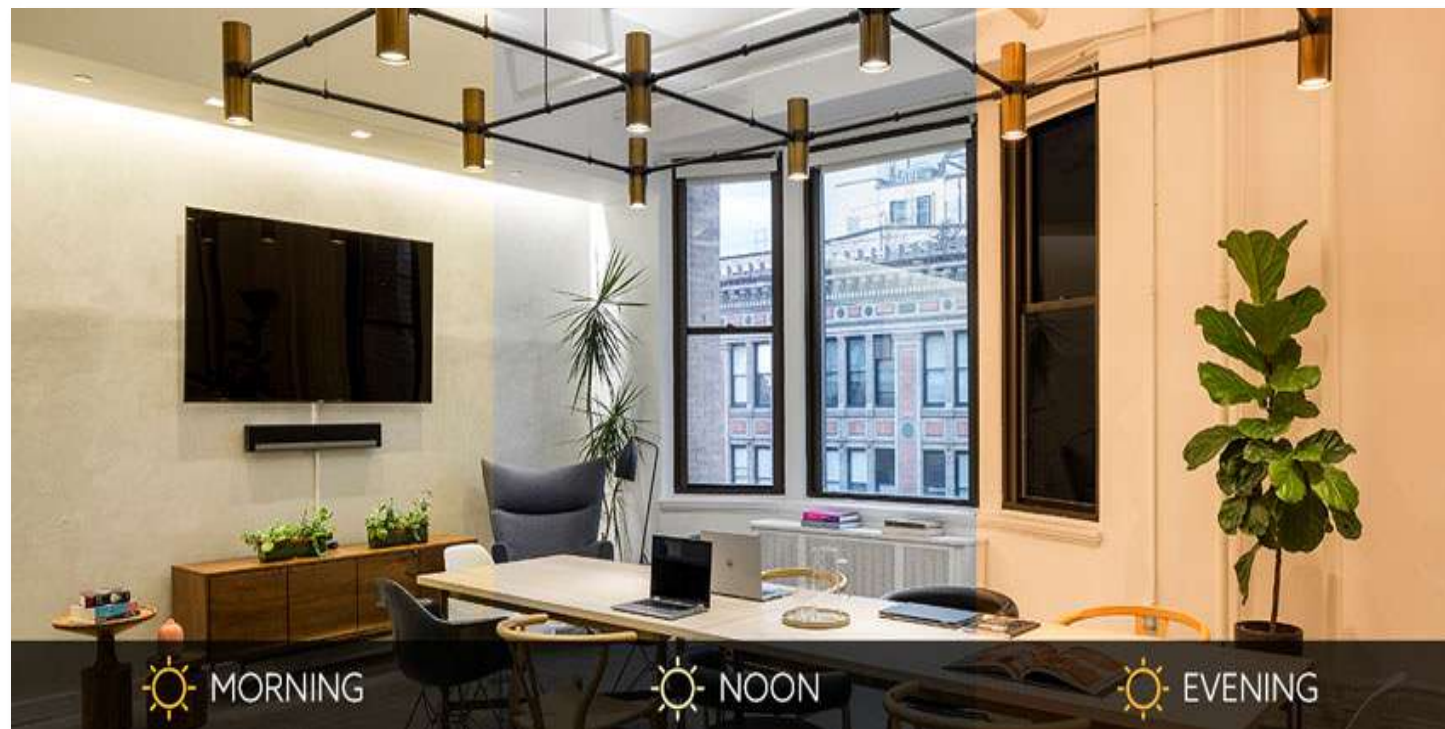
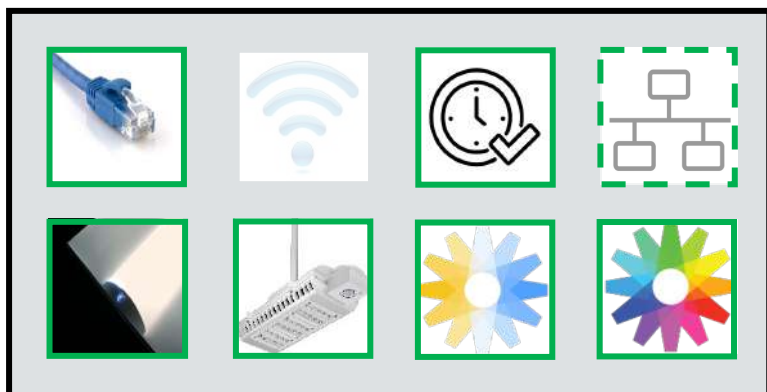
# Rooms with Daylighting

- Provides incremental energy savings when space is occupied
- Aids in demand reduction



# Color Tuning Applications

- Optimizes the circadian effect within the space
- Improves color quality
- Allows for improved visual performance

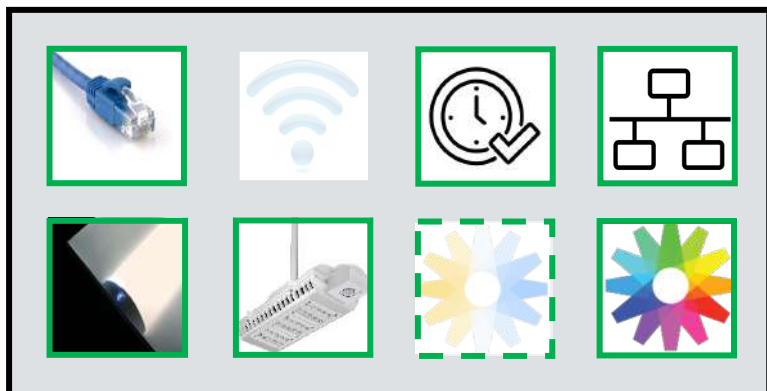


# Spaces with Color

- Color doesn't have to be separated from the code compliant controls

And it shouldn't be...

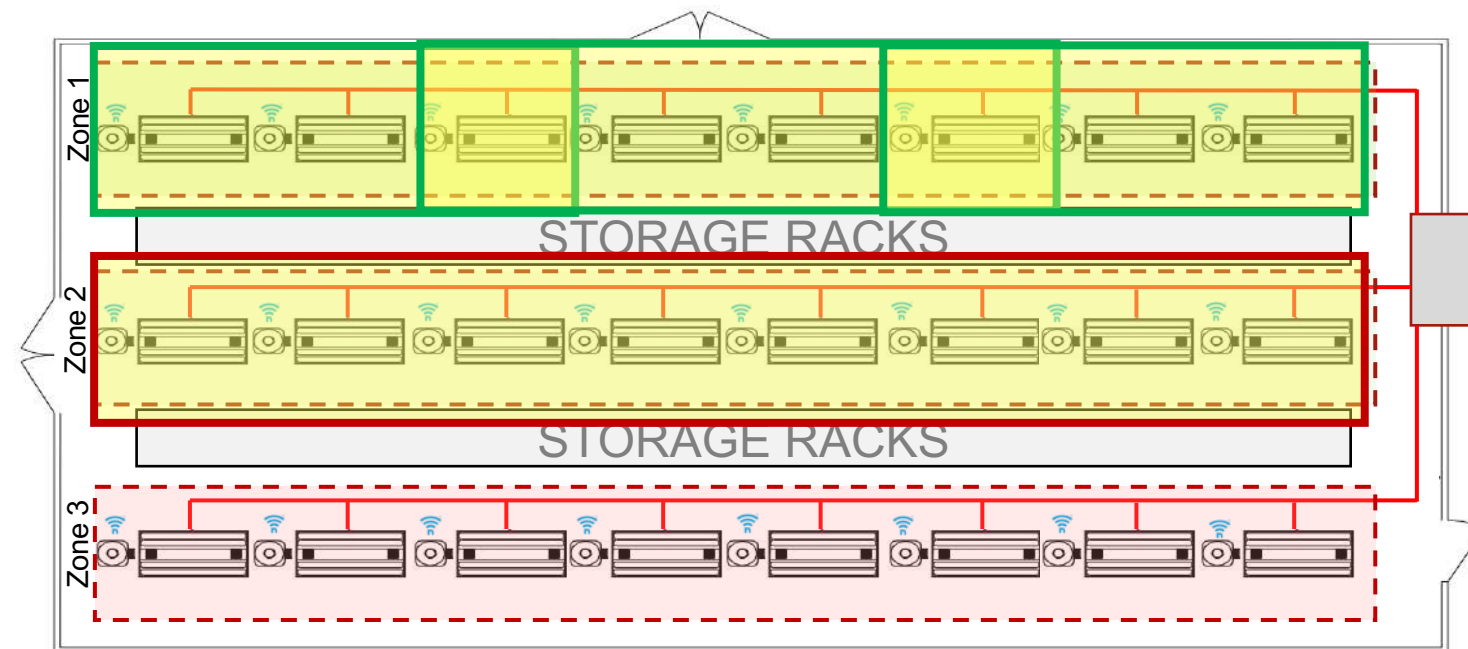
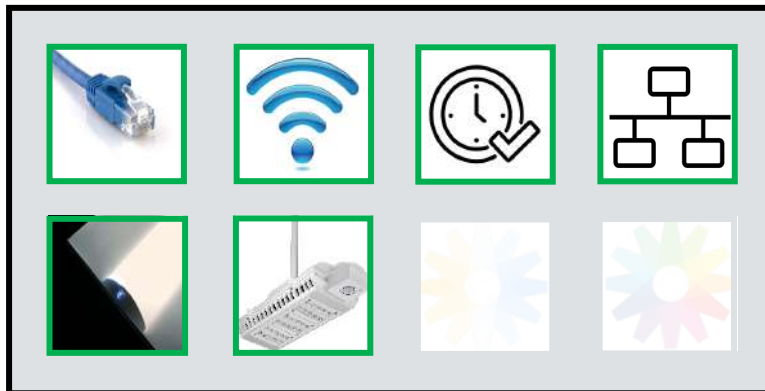
- One central timeclock
- Single Interface
- Manual or Automatic color changing





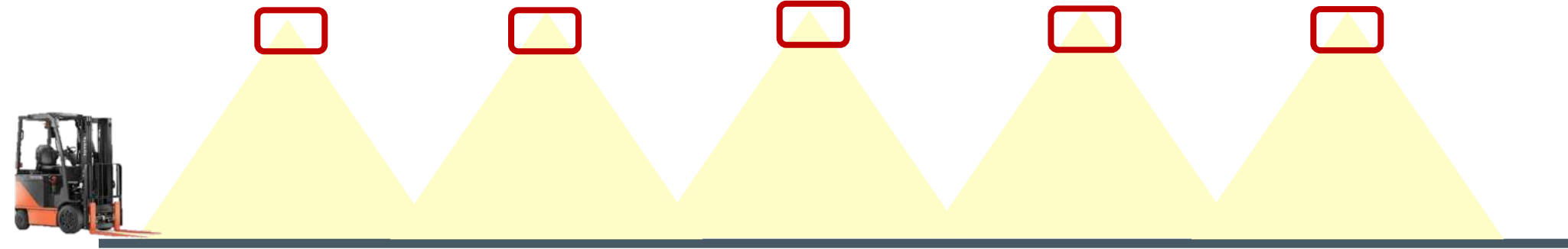
# Warehouse & Manufacturing

- By Code, each Aisle controlled separately
- Reduce lighting power by at least 50% when unoccupied... (dim or turn off)
- Group lights by section instead of Aisle
- Use wireless controls to overlap groups



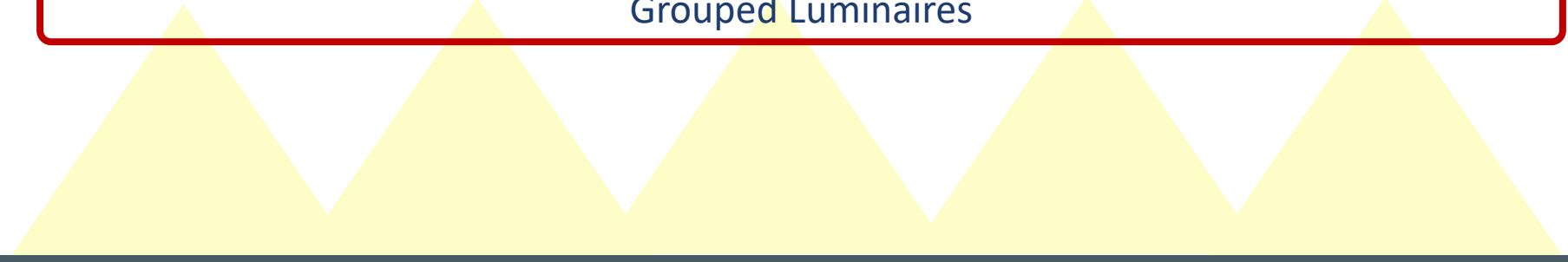
# Warehouse & Manufacturing

Stand-alone Sensor End-User Experience



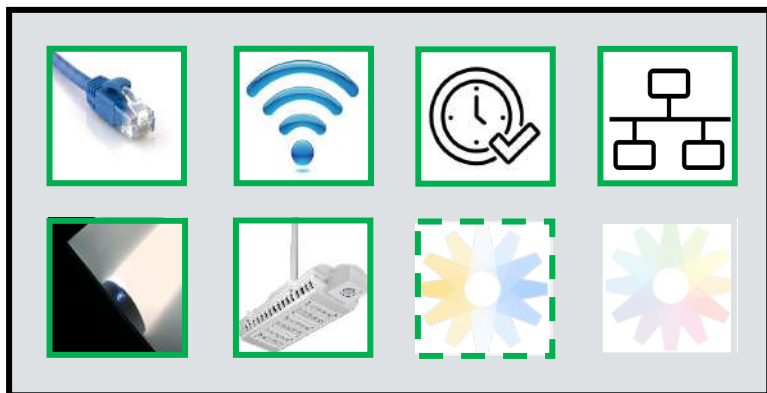
# Warehouse & Manufacturing

Best End-User Experience



# Multi-Use Space

- Electric Vehicle manufacturers are beginning to multi-purpose spaces for high Intensity Inspections along with normal, daily use lighting
- No emissions and quieter cars allow a single space to be used
- Scene controls set lights to the appropriate levels





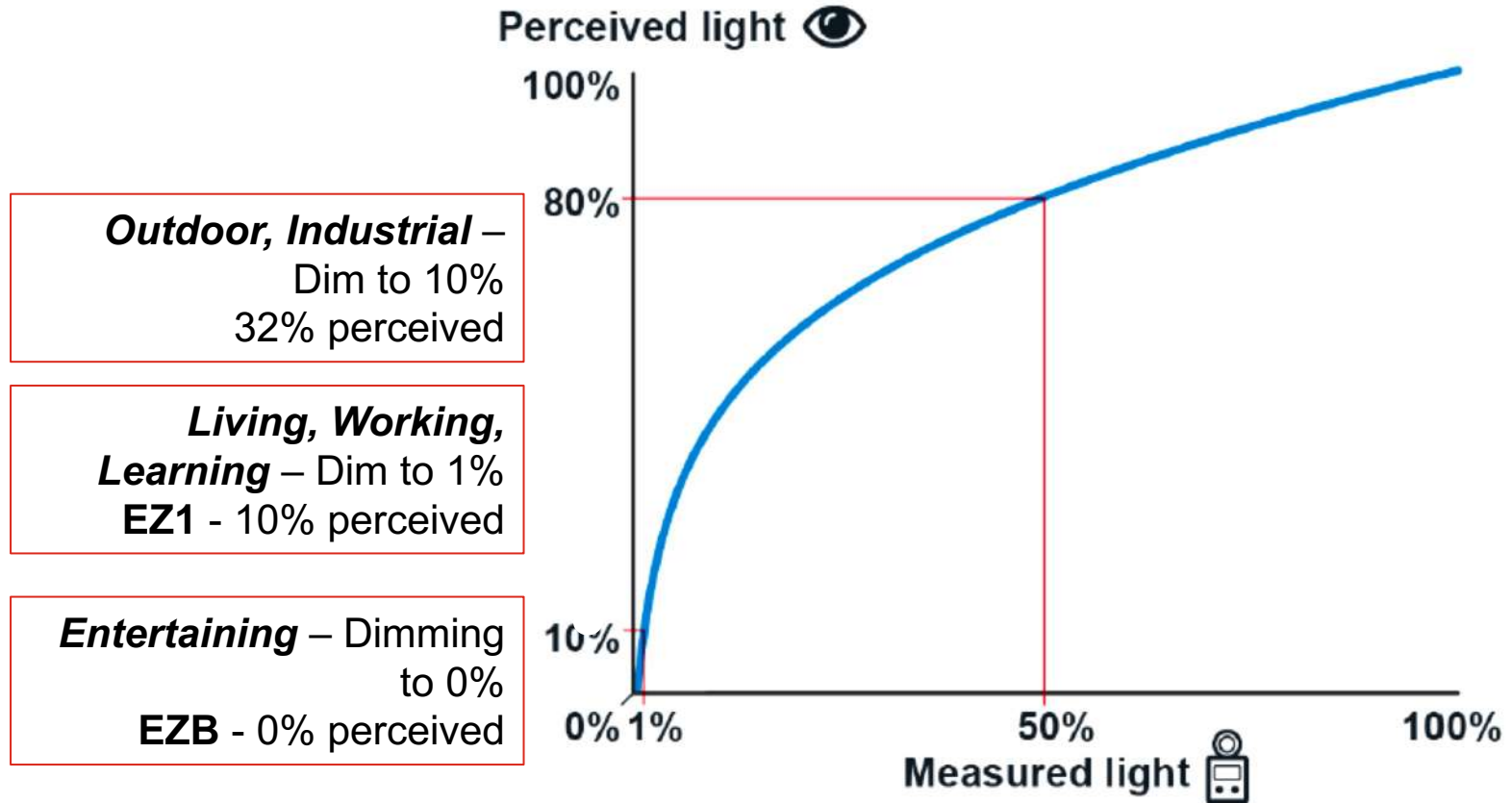
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**Describe what system components or features are recommended to benefit from an expanded Sequence of Operation**

# Enhanced Lighting Control Strategies

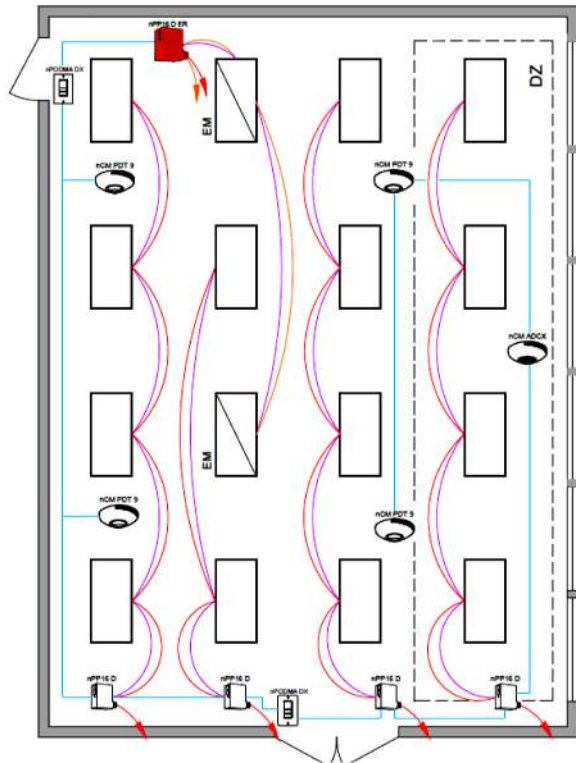
## Task Tuning

- Many Utilities and rebates are requiring the ability to “task tune” the application
- Task tuning is the ability to set the High-End trim of Light Fixture
- Task tuning can increase energy savings without a significant compromise to designed light levels

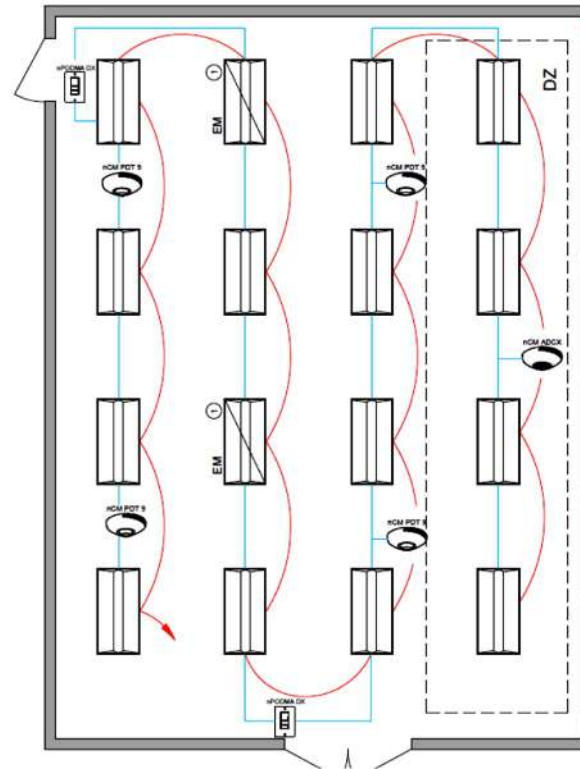


# Embedded Controls

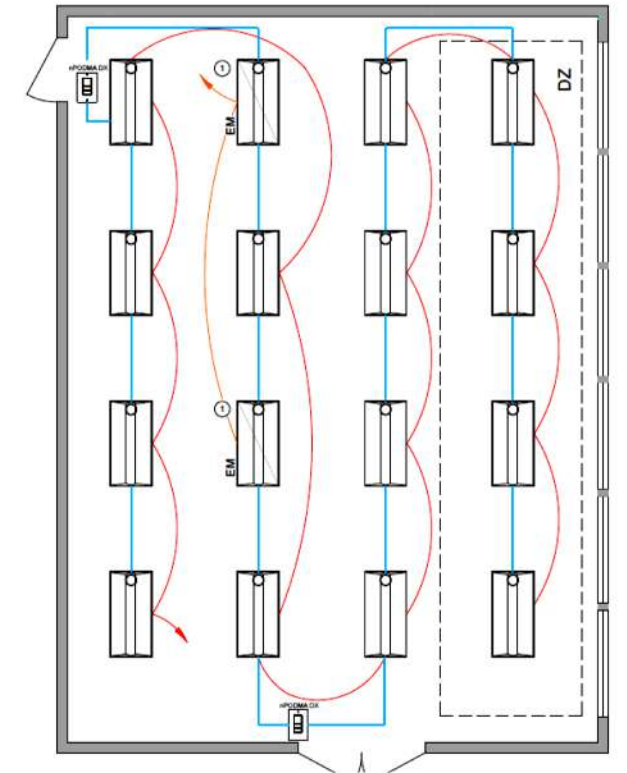
- Instead of using 0-10V or power packs, fixtures use embedded controls to connect to a room network of device



Typical Application



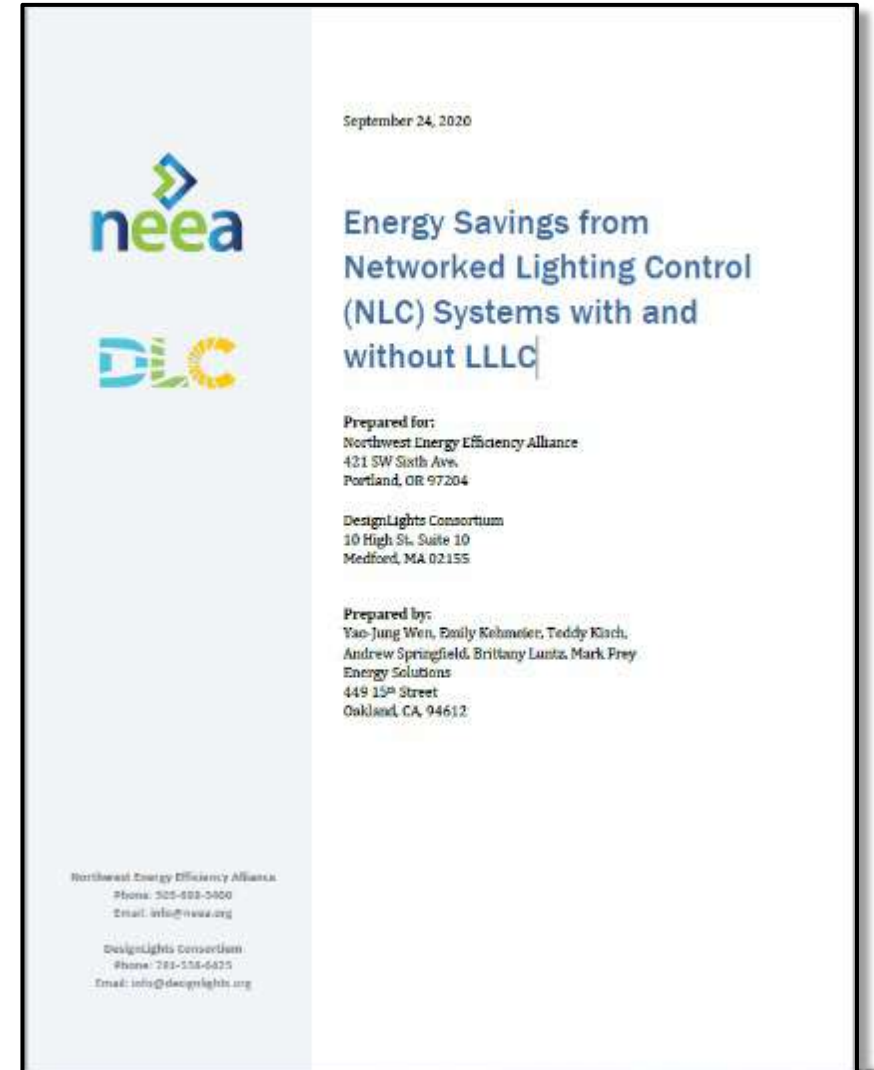
Embedded Controls  
w/sensors



Embedded Sensors

# Network Lighting Controls

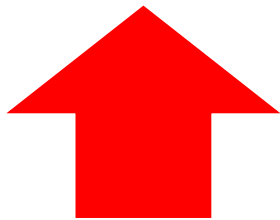
- DesignLights Consortium's (DLC) new report, Energy Savings from Networked lighting Control (NLC) Systems, estimates average lighting energy savings of 49% resulting from installation of network lighting controls



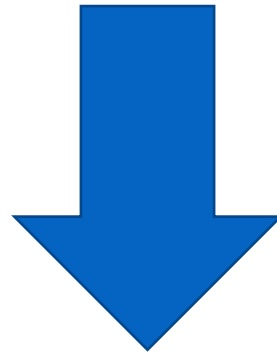


## Network Lighting Controls

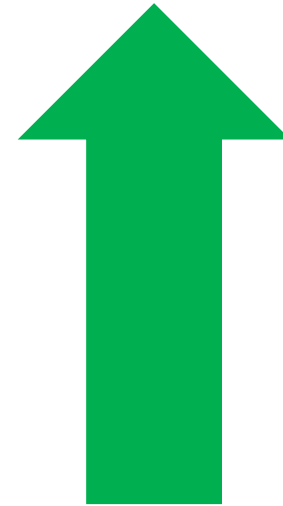
- Backbone Hardware adds around 5.6% additional cost to the job
- Allows startup to take less time reducing startup by around 16.3% which provides an additional savings of 16.3% over a stand-alone project
- Considering the increase in hardware cost and the decrease in labor, on average a network backbone will add about 3.3% to the overall lighting controls budget



Hardware Cost



Startup Cost and Time



System functionality,  
reconfigurability and usability

# Building Management System (BMS) Integration

- **Single IP platform for Lighting and HVAC:** Critical systems don't need complicated and custom integration
- **One Visualization Tool:** Provide robust site visualization of critical systems that can be monitored and controlled from any device
- **Accelerate ROI:** Reduce integration costs, leverage sensors for HVAC and lighting control, reduce site management costs
- **Performance and Security:** BACnet BTL certified, 3rd party security audit, faster demand response
- **Smart Building Ready:** Seamless integration into BACnet systems and designed for future technology integration



## GUV – Germicidal Systems

- UL 8802 – requires Occupancy sensor and manual override to prevent exposure to certain UV (Ultraviolet) wavelengths
- GUV solutions have on-board Occupancy Sensors but have limited coverage of space
- Overlapping GUV controls with general room controls can promote safety to the occupant

Safe UV Wavelengths with  
occupants present

Filtered 222 UVC  
Near UV 405 nm



Unsafe UV Wavelengths with  
occupants present

254 nm UVC  
Broadbands (UVC, UVB, UVA)



## GUV in High Performing Buildings

- CARES Act – ESSER Funds provided increased ventilation process and cleaning protocols for K-12 schools
- Currently, UV is not addressed as part of the energy code
  - Technology is not based on LED sources
  - Wattage varies from 15-150W per device
- It's not new but it's a current trend
- What does control look like for “safe” disinfection of a space?
  - Disinfection in process
  - Disinfected space
  - Space requiring disinfection
- How will this technology evolve over the next 6-10 years?

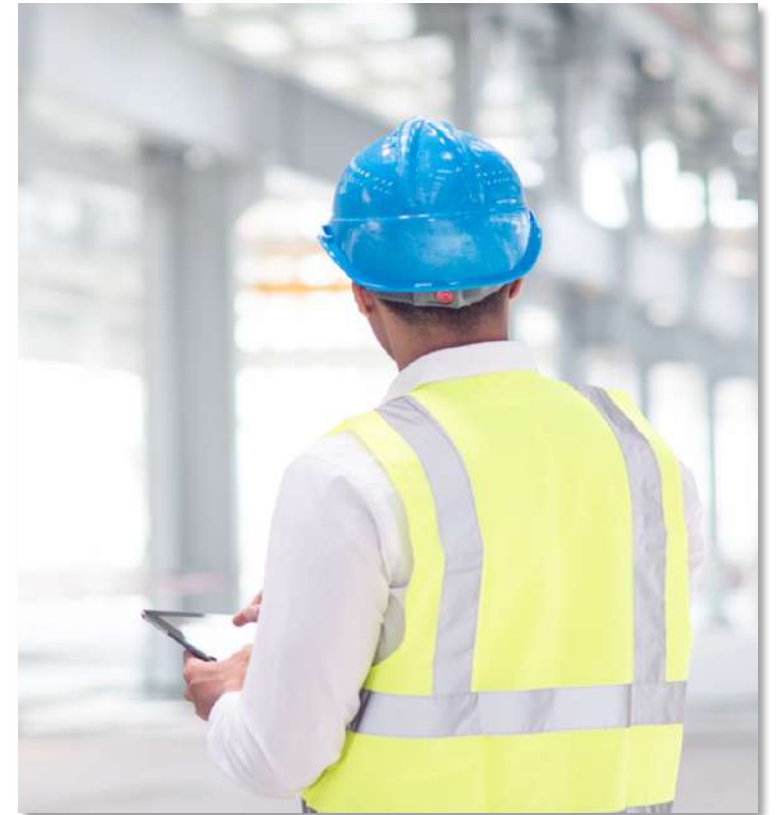


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**Discuss additional measures to enable savings without sacrificing usability**

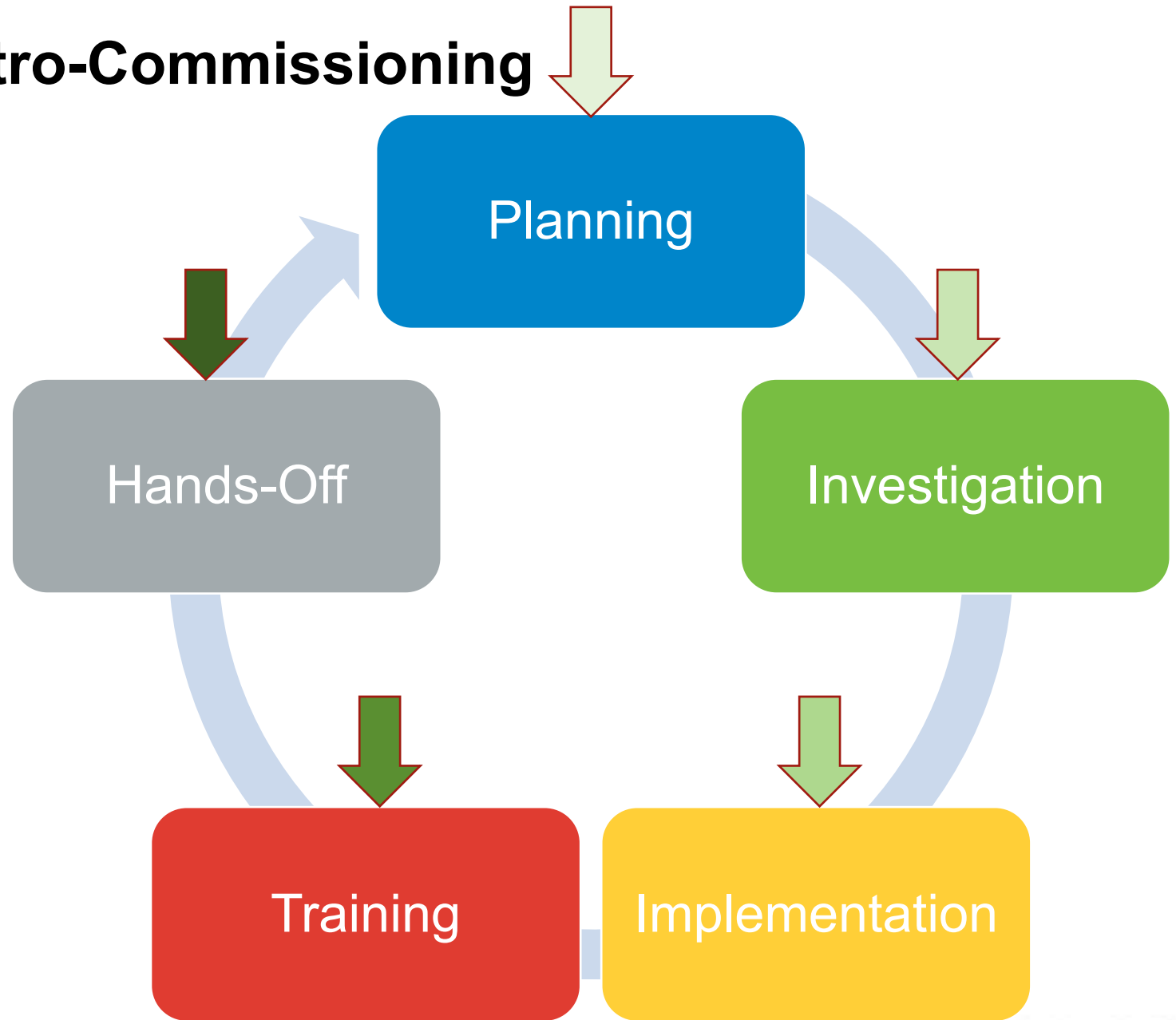
## Retro-Commissioning

- Multiple studies have shown that commissioned buildings have energy saving opportunities due to improper commissioning
  
- Factors for Retro-Commissioning
  - ❑ Devices can fall off-line
  - ❑ Floorplans change
  - ❑ Change in hours of operation
  - ❑ Sensors not detecting
  - ❑ Daylight calibration
  - ❑ Areas where sensors are false tripping
  - ❑ Lighting/controls retrofits or additions



## Retro-Commissioning

- Annual or biennial system re-evaluation
- Evaluate issues (known and unknown)
- Review System Diagnostics
- Assess zoning and the need to regroup spaces
- Validate Daylighting performance
- Optimize Settings
- Update schedules



## Service Plans

- Onsite and remote diagnostic plans to enable configuration changes and allow the user to maintain a high performing system
- Minimize budgetary surprises
- Reduce system downtime
- Optimize energy savings
- Partner for future retro-commissioning/renovation opportunities





## Creating a Unified BMS Plan

- Single user interface for all using viewing the entire system
- Common timeclock
- Increased operational and energy savings advantages
- Occupancy Sensors can provide logic to the HVAC system for establishing when space are occupied or unoccupied
- Increase occupant comfort
- Building maintenance
- Covid Solutions





5

**Conclusion**

## Takeaways

- Technology is accelerating the introduction of new products and features
- Code requires the use of energy controls
- Following code creates a minimum sequence of operation
- Users desire consistency in function and how the lighting controls work from space to space
- The Path to Net Zero will require new design techniques and products
- Typical applications can benefit from layering control strategies
- New technology like tunable white and dynamic colors should be installed as part of the lighting control solution and not a disparate system

## Takeaways

- Evaluate areas for use of overlapping controls to maintain safety and security (warehouses, stairwells, hallways)
- Networking lighting controls is inexpensive, and it will greatly increase the capability of the system
- GUV will challenge our traditional Sequence of Operation in the years to come
- Retro-Commissioning can increase energy savings in installed facilities
- Integrate BMS and Lighting Controls

This concludes The American Institute of Architects Continuing  
Education Systems Course

