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C&I Networked Lighting Controls

TECHNOLOGY CAPABILITIES AND ENERGY SAVINGS POTENTIAL

Dan Mellinger, PE LC

September 17, 2019

Contents

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Technology Overview

Lighting Control Descriptions

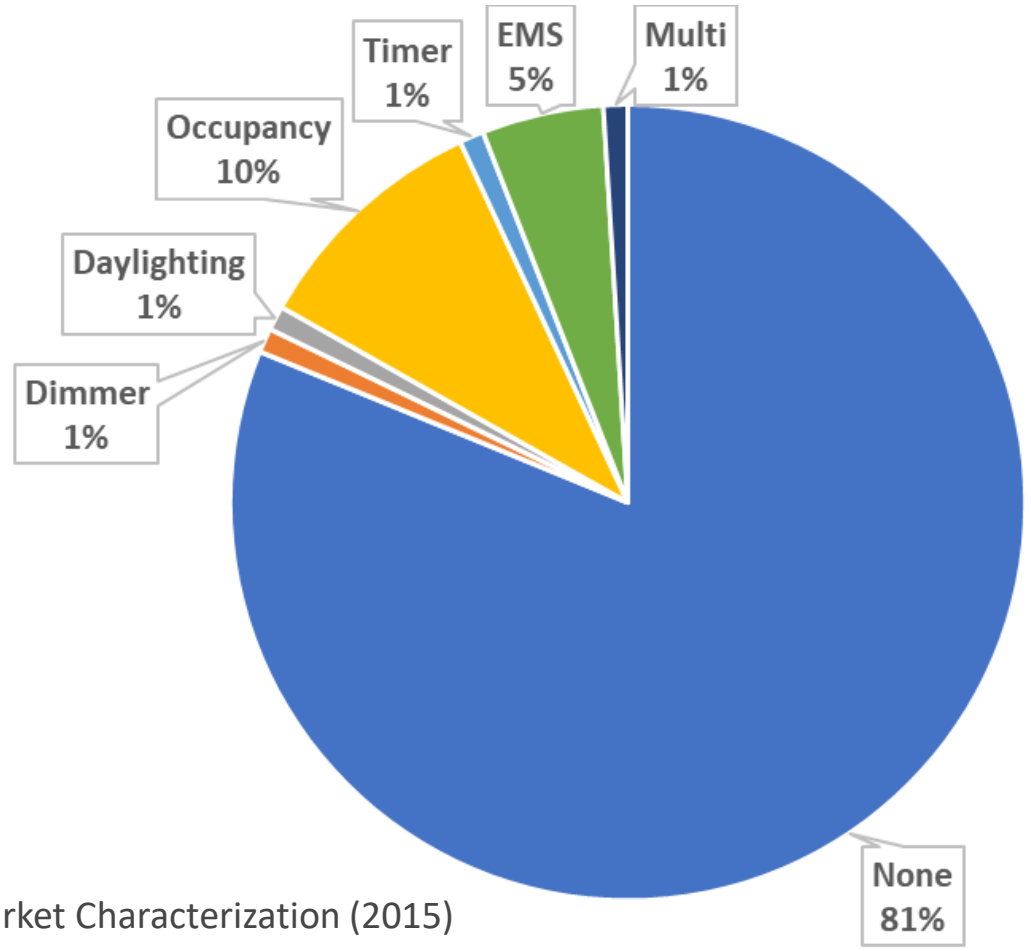
Lighting Control Type	Description
Stand-alone Lighting Controls	Discrete sensors with independent operation.
Integrated Lighting Controls	Sensors embedded within light fixtures; may communicate wirelessly. *Also known as luminaire level lighting controls (LLLC)*
Networked Lighting Controls	Sensors and control hardware connected wired or wirelessly with individual addressability and multi-strategy sensing. May be integrated with other building systems. *Also known as connected lighting or advanced lighting controls.*
Intelligent Lighting	Lighting infrastructure that enables a wide range of valuable new capabilities to create more intelligent buildings and cities. *Also known as smart lighting*

Stand-alone Lighting Controls

- Discrete devices that operate independently and uncoordinated
- Little or no communication among devices
- No data feedback or storage
- Groups/zones are based on power wiring
- Performance is often sub-optimal
- Included as base requirements in most codes
- Despite decades of utility promotion, adoption remains limited




Historical C&I Lighting Control Adoption Rates



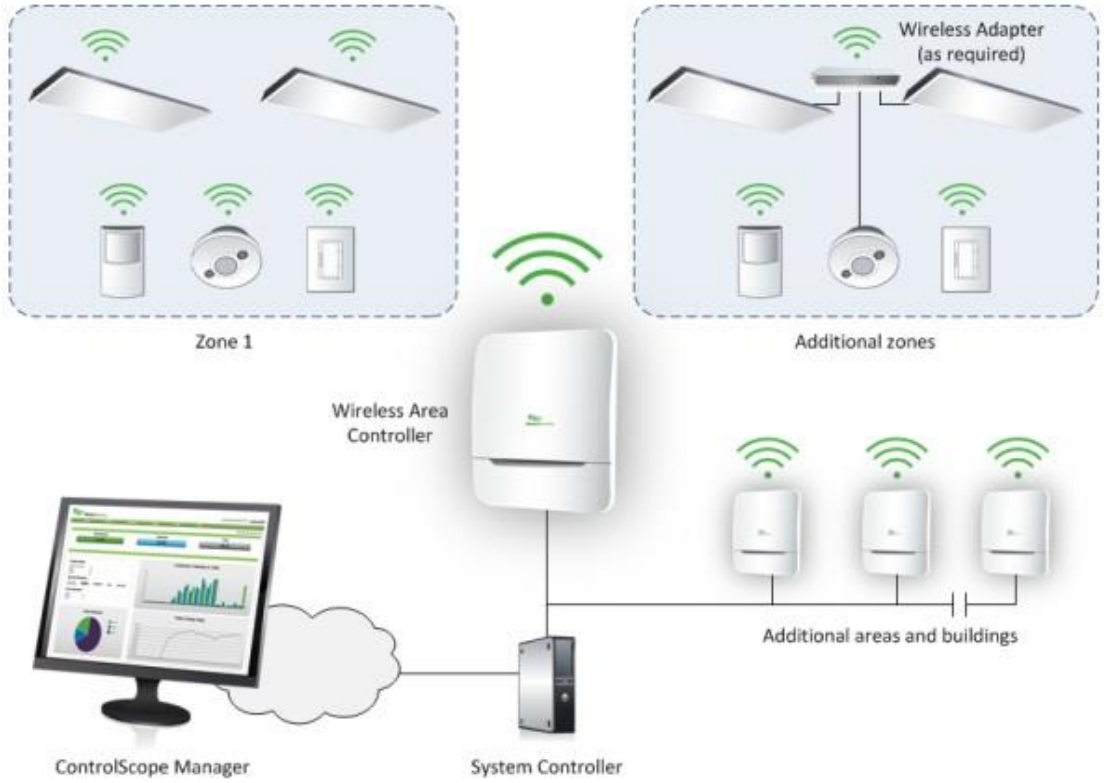
Source: DOE U.S. Lighting Market Characterization (2015)

Integrated Lighting Controls

- Sensors are embedded within light fixtures by the manufacturer
- Some products communicate wirelessly
- Some products provide data feedback
- Custom groups/zones may be possible
- Sensor performance is typically excellent due to granular coverage
- Satisfies nearly all code requirements
- Increasing support among utilities, well suited for mid/upstream programs

Networked Lighting Controls (NLC)

- Sensors can be discrete devices or embedded within light fixtures
- All components must communicate; can be wired or wireless
- Data feedback with dashboard / GUI
- Custom groups/zones are possible
- Sensor performance is typically excellent due to granular coverage and coordination
- Satisfies all code requirements
- Increasing support among utilities, typically custom or hybrid programs



Technology Trends

Expanded capabilities beyond energy

Sensor miniaturization

Controls integration within fixtures

System & building integration

Lack of standardization & compatibility

High cost, but falling

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Lighting Control Capabilities

Stand-alone Lighting Control Capabilities

- **Stand-alone Lighting Controls**
- Integrated Lighting Controls / LLLC
- Networked Lighting Controls
- Connected Lighting
- Intelligent Lighting

Energy

- **Dimming**
- **Occupancy Sensing**
- **Daylight Dimming**
- High-end Trim
- Grouping/Zoning
- Scheduling
- Personal Control
- Energy Monitoring
- Demand Response
- System Integration

Non-Energy

- Color Tuning
- Circadian Wellness
- Space Utilization
- People Counting
- Asset Tracking
- Wayfinding
- IAQ Monitoring
- Emergency Assist
- Building Security
- LiFi

Integrated Lighting Control Capabilities

- Stand-alone Lighting Controls
- **Integrated Lighting Controls / LLLC**
- Networked Lighting Controls
- Connected Lighting
- Intelligent Lighting

* Required by DLC v4.0

Energy

- **Dimming ***
- **Occupancy Sensing ***
- **Daylight Dimming ***
- **High-end Trim ***
- **Grouping/Zoning**
- Scheduling
- Personal Control
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- System Integration

May Be Networked *

Non-Energy

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Networked Lighting Control Capabilities

- Stand-alone Lighting Controls
- Integrated Lighting Controls / LLLC
- **Networked Lighting Controls**
- Connected Lighting
- Intelligent Lighting

* Required by DLC v4.0

Energy

- **Dimming ***
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Networked *

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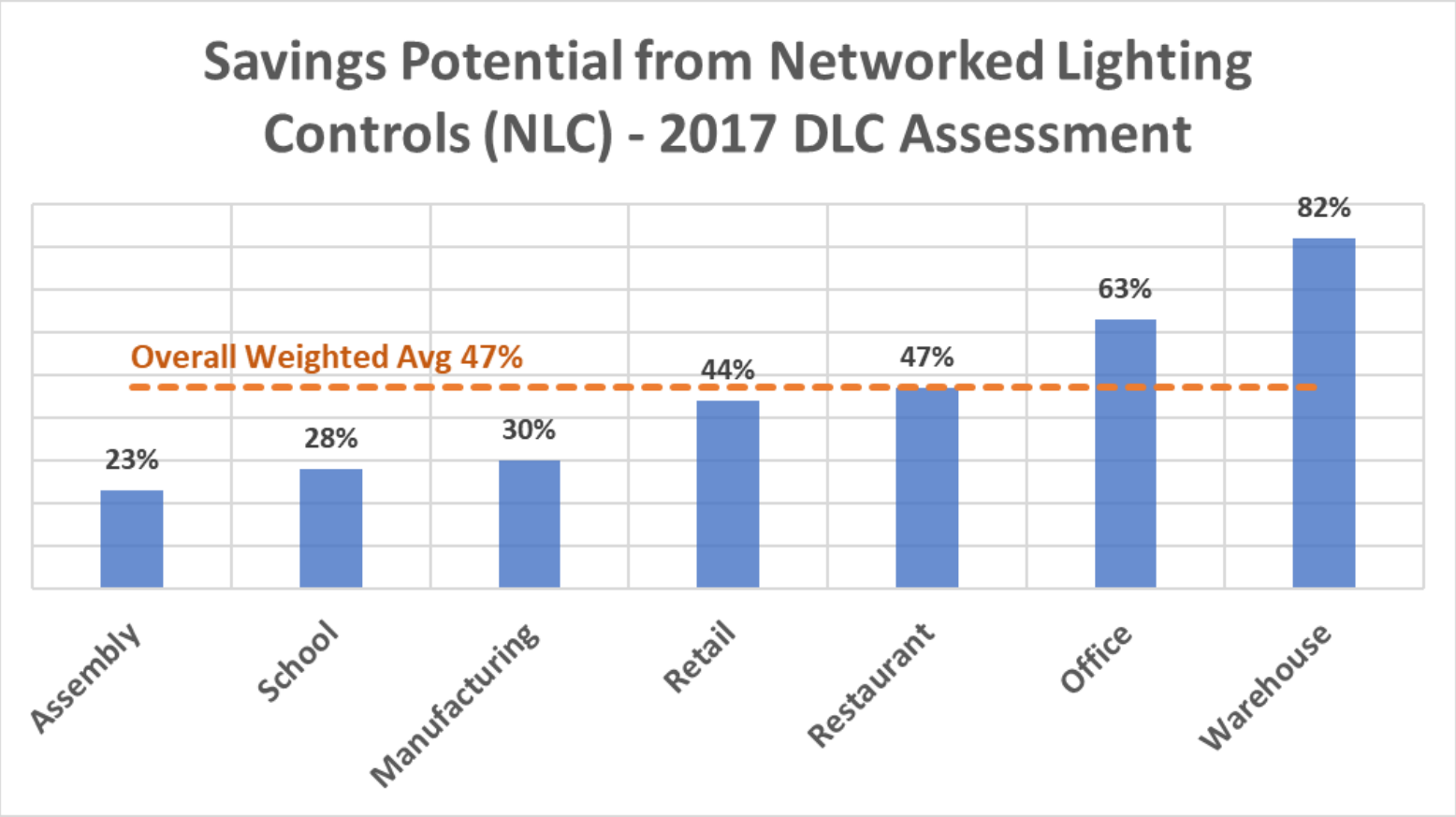
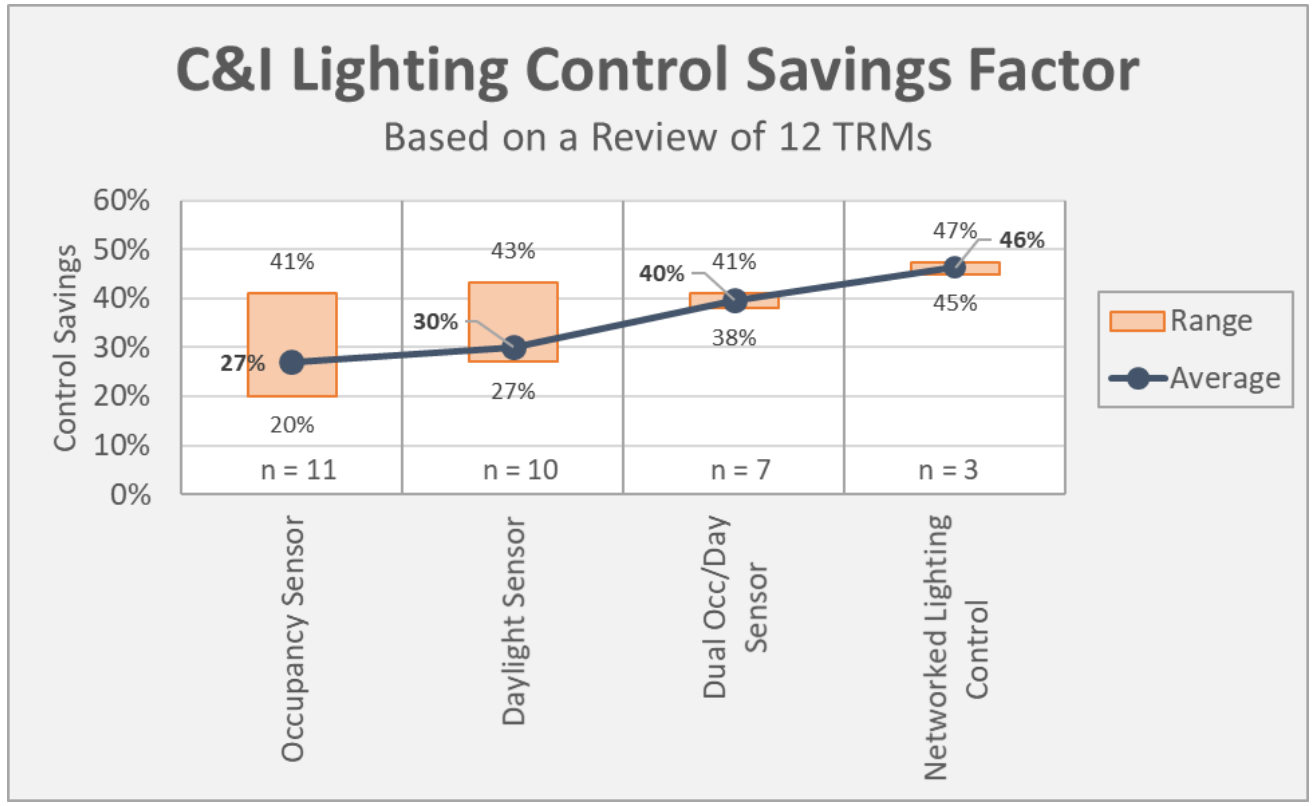
Networked Lighting Control Savings



For systems that include:

- Networking
- Occupancy sensing
- Daylight dimming
- High-end trim
- Zoning

Lighting Control TRM Savings Assumptions



Illinois TRM v7.0 (2019)

Lighting Control Type	Energy Savings Factor771
Wall Switch Occupancy Sensor	24%
Fixture-Mounted Occupancy Sensor	24%
Remote or Wall-Mounted Occupancy Sensor	24%
Fixture-Mounted Daylight Sensor	28%
Remote or Wall-Mounted Daylight Sensor	28%
Integrated Occupancy for LED Interior Fixtures < 10,000 Lumens	24%
Integrated Occupancy for LED Interior Fixtures >= 10,000 Lumens	24%
Integrated Dual Occupancy & Daylight Sensor for LED Interior Fixtures < 10,000 Lumens	38%
Integrated Dual Occupancy & Daylight Sensor for LED Interior Fixtures >= 10,000 Lumens	38%
Fixture-Mounted Dual Occupancy & Daylight Sensor for LED Interior Fixtures < 10,000 Lumens	38%
Fixture-Mounted Dual Occupancy & Daylight Sensor for LED Interior Fixtures >= 10,000 Lumens	38%
Exterior Occupancy Sensor	41%

Connected Lighting Capabilities

- Stand-alone Lighting Controls
- Integrated Lighting Controls / LLLC
- Networked Lighting Controls
- **Connected Lighting**
- Intelligent Lighting

* Required by DLC v4.0

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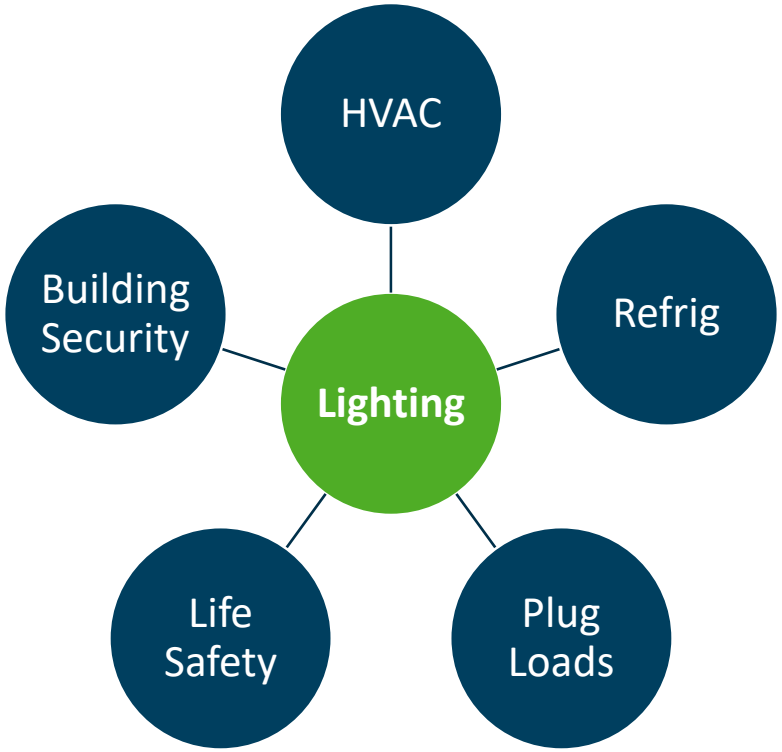
Lighting as a Backbone

Lighting is well suited to host this connected infrastructure since it is **ubiquitous and uniform throughout our buildings**, and **already has power**.



Connected Lighting Capabilities

- Connected lighting adds communication with non-lighting systems to unlock additional energy savings
- Optimize operation of other building systems (HVAC, refrigeration, plug loads) based on occupancy, daylight, schedule, temperature
- Enables auto demand response of the lighting and/or intelligent demand response of other building
- Handful of utilities are piloting connected lighting (lighting + HVAC) programs

Connected Lighting DR Example

- Demand Response decisions based on information provided by lighting system

DR Strategy	Sensor Info	Possible DR Actions
Typical	Occupancy Temperature	• Turn off lights • Adjust temperature set point
Intelligent	Occupancy Temperature People Count Schedule Electricity Price	• Dim lighting (or turn off if unoccupied) • Close window shades • Adjust temperature set point dynamically based on occupancy and schedule • Minimize ventilation rate based on people count

Intelligent Lighting Capabilities

- Stand-alone Lighting Controls
- Integrated Lighting Controls / LLLC
- Networked Lighting Controls
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* Required by DLC v4.0

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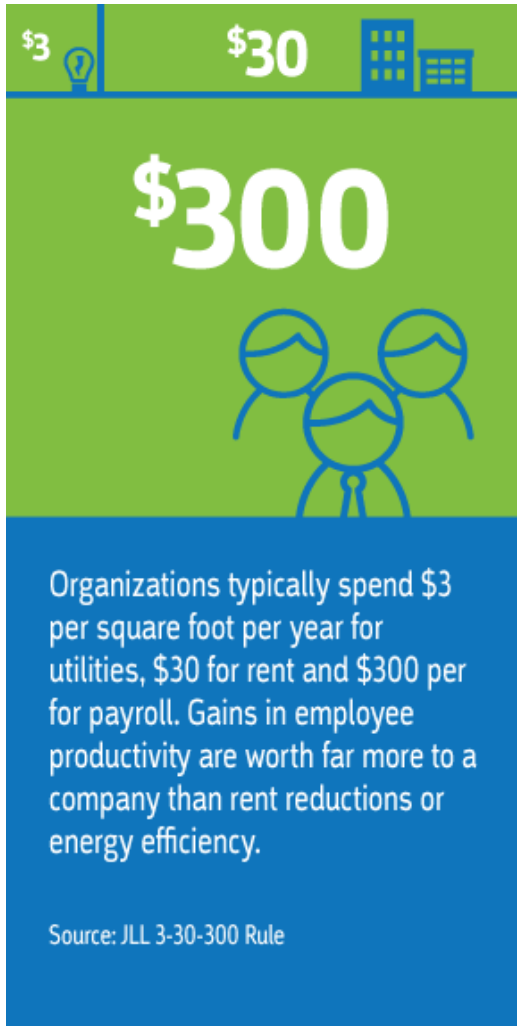
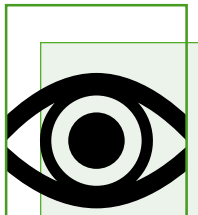
Why Intelligent Lighting Matters

- Lighting controls as an energy-savings option have decades of low adoption
  - Poor performance
  - Low perceived value (especially once lighting is LED)
  - Complexity
- Energy alone isn't a sufficient driver
  - 3/30/300 Rule
- Intelligent lighting capabilities can unlock energy savings potential
  - Increase value proposition
  - Create "bottom-up" demand at the customer level

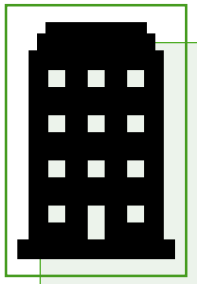


Intelligent Lighting Examples



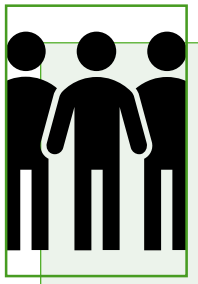
Color Tuning/Circadian Wellness

- Improve occupant alertness, performance, and well-being
- Comfort and productivity



Space Utilization

- Optimize office space
- Flex desking
- Space analytics



People Counting

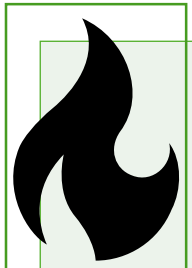
- Precise HVAC control
- Space planning

Asset Tracking

- Wheel chairs
- Medical equipment (e.g. ultrasound)
- Staff badge tracking

Wayfinding

- (Office) Find an open conference room
- (Airport) Quickest route to gate
- (Retail) Shopper traffic patterns



Emergency Assist

- Dynamic path of egress based on occupant & hazard location
- Location of people in building

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Energy Savings Potential

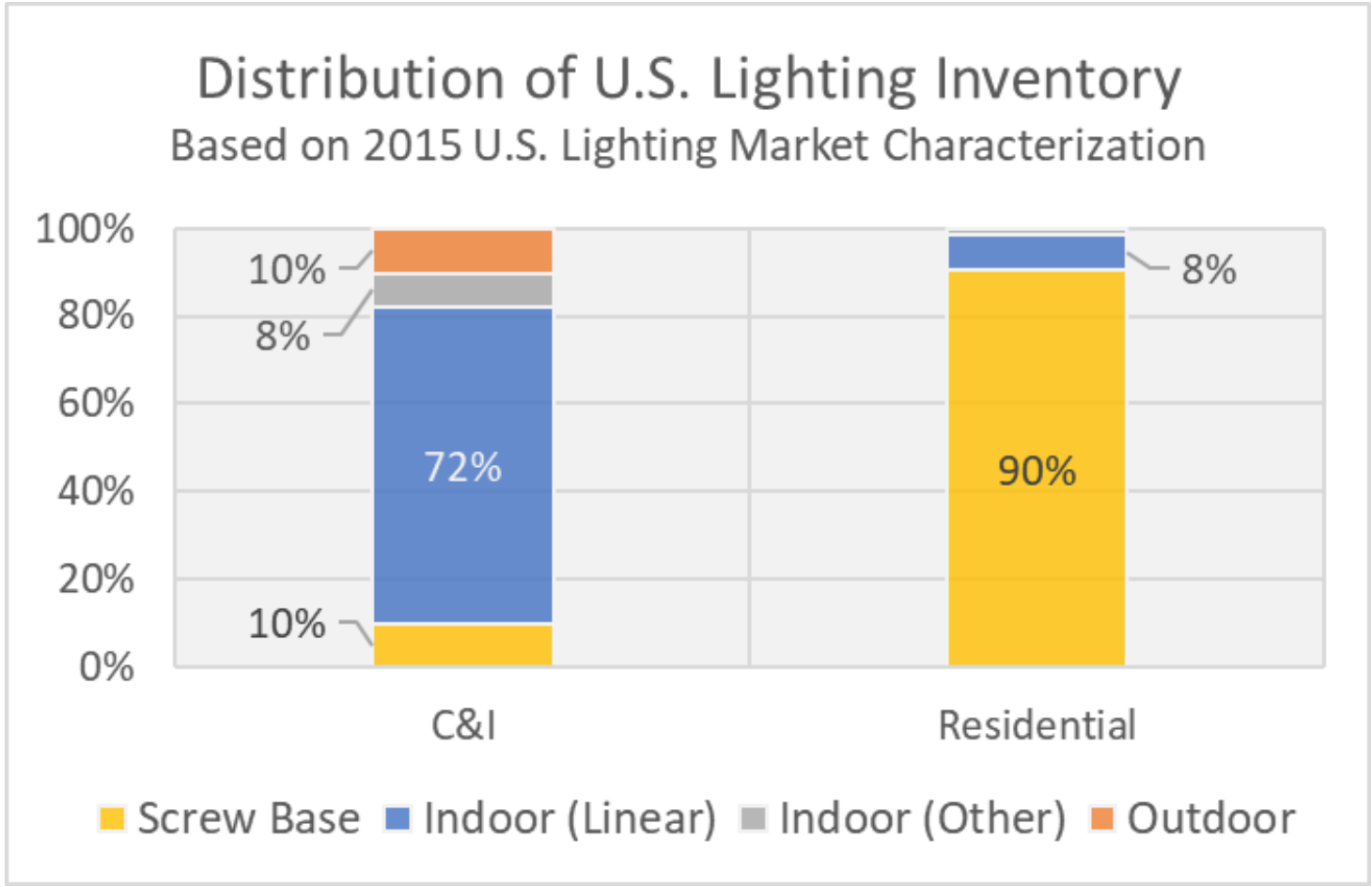
C&I Lighting Energy Savings Forecast

Completed for DLC in 2018 with the intent to:

- Evaluate the long-term potential of C&I lighting savings
- Quantify the potential savings from Networked Lighting Controls
- Estimate the timeframe C&I lighting portfolios can be sustained
- Understand regional differences in adoption and savings

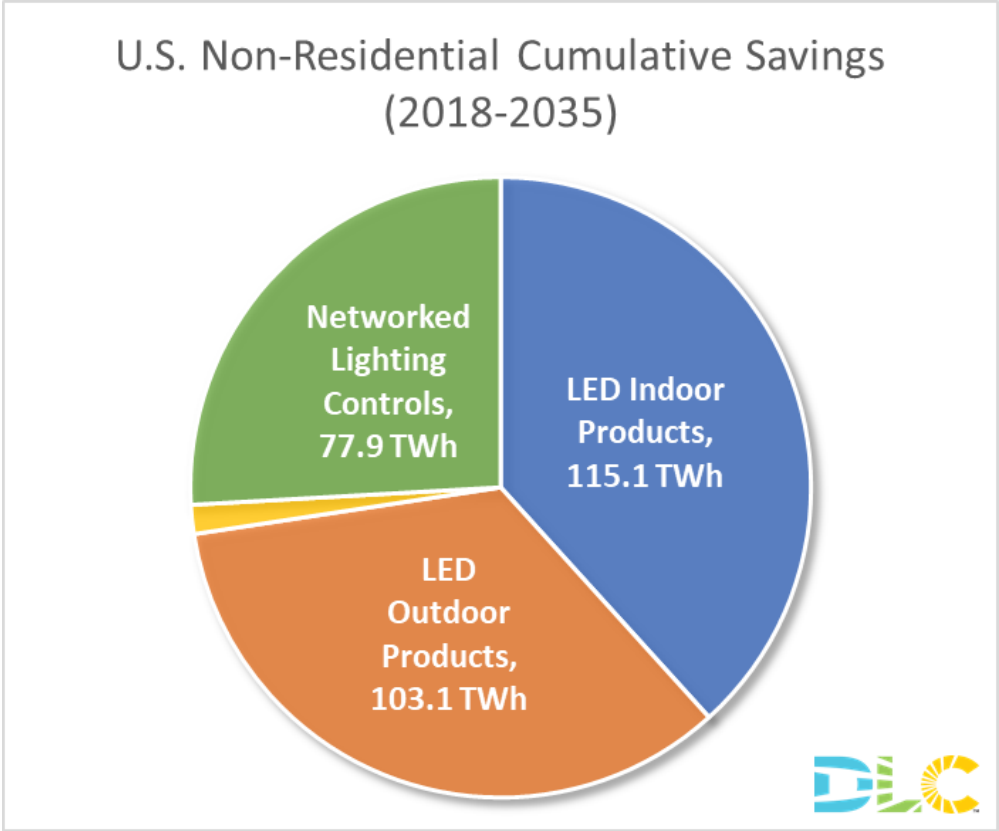
Residential ≠ C&I

- EISA impact to C&I sector will be far less pronounced than resi
- The vast majority of C&I installed inventory consists of linear lamps & fixtures (72% nationally)
- Within C&I screw base products, a high share have already been converted to LED



National Savings Potential from NLC

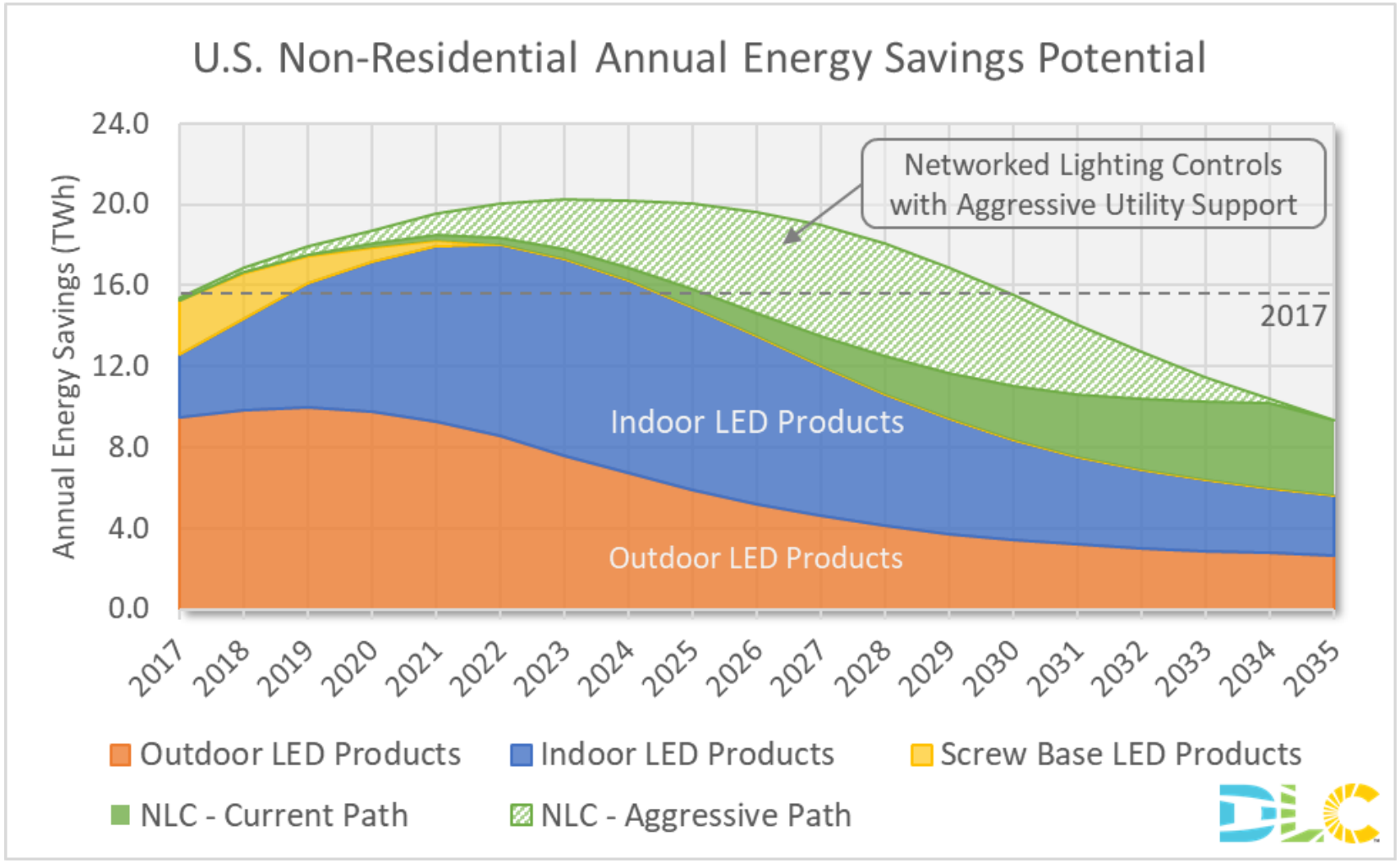
- Significant NLC savings potential, but can it be realized?
  - Historical lighting control adoption rates suggest otherwise
- Will require market transformation through new utility program designs, training, and education



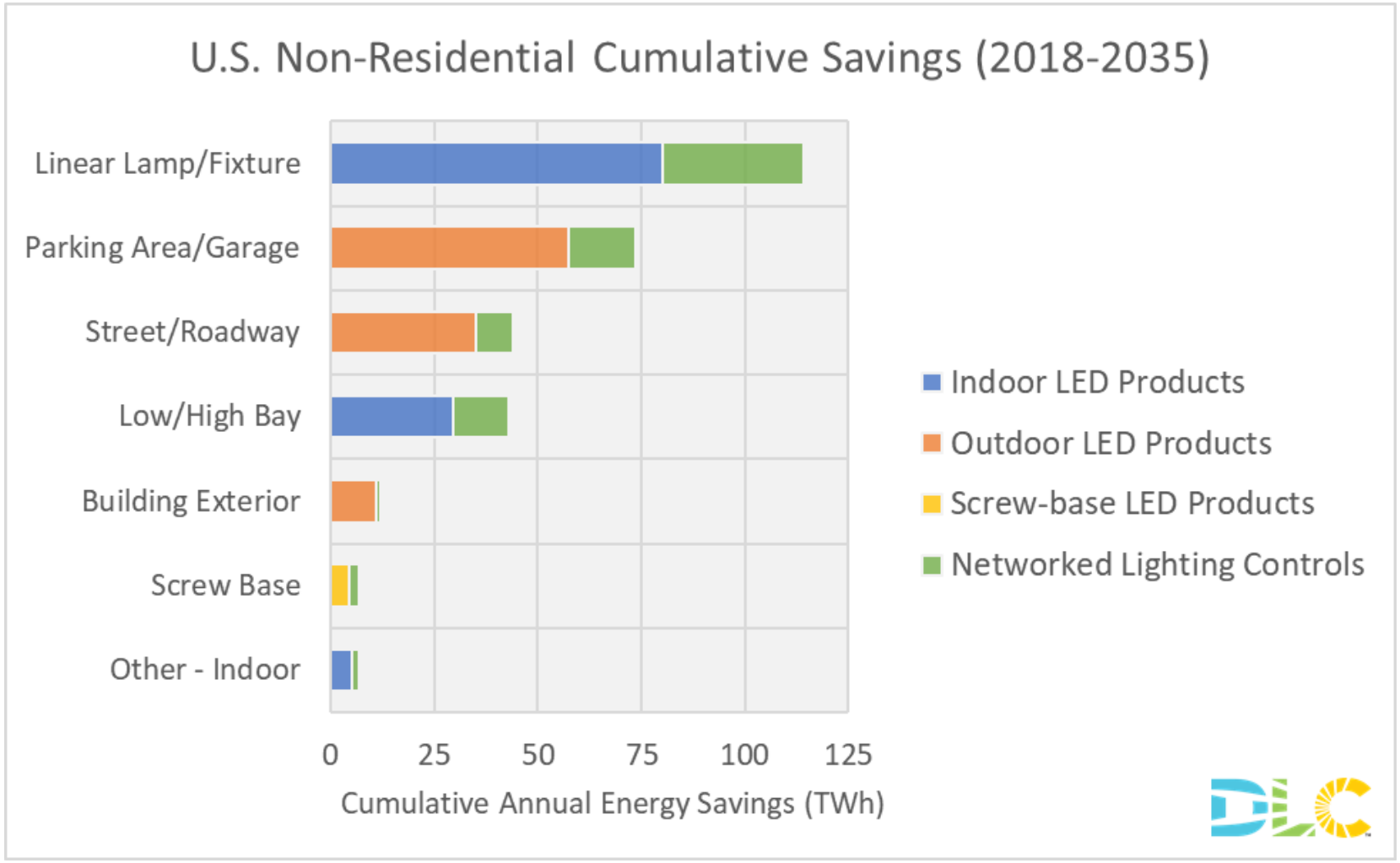
Forecast assumes:

- Installed lighting stock per DOE U.S. Lighting Market Characterization
- Efficacy improvement per DOE forecast
- LED adoption levels reach 83% (indoor) and 90% (outdoor) by 2035
- Utilities and industry aggressively promote NLC to achieve adoption levels of 58% (indoor) and 65% (outdoor) by 2035

Annual Savings Potential for C&I Lighting

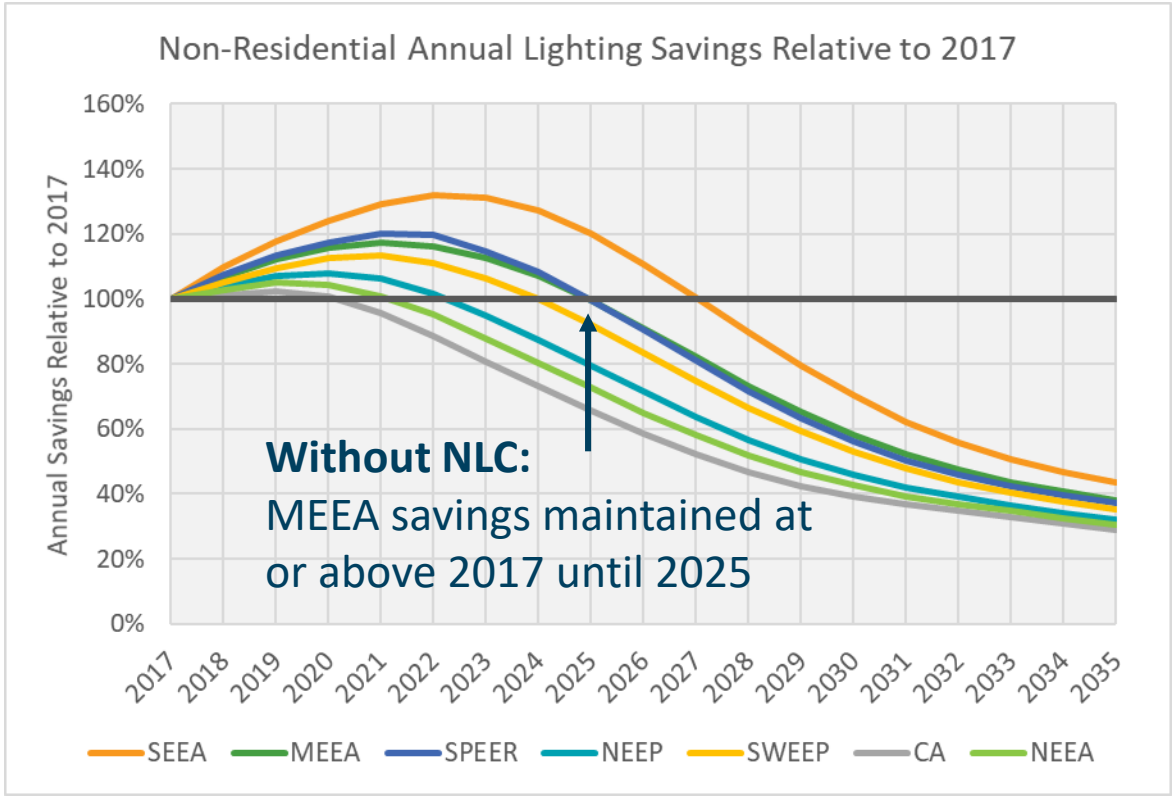


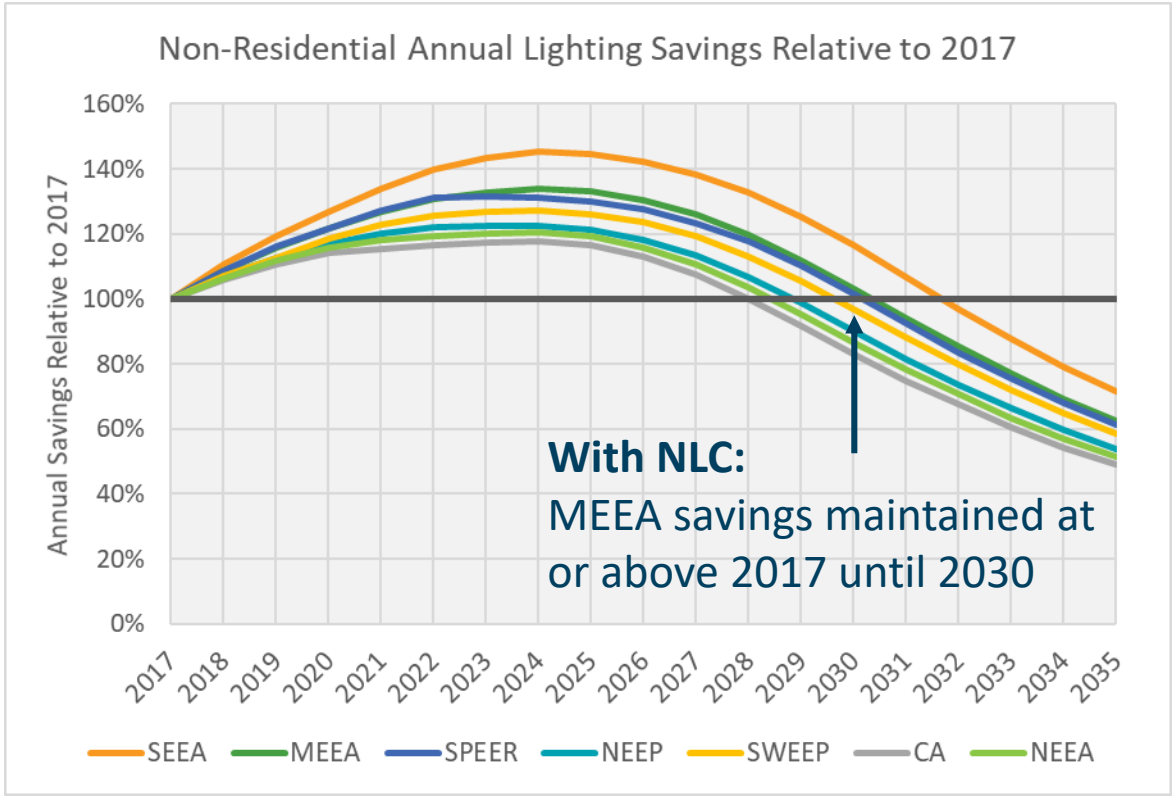
Cumulative Annual Savings Potential for C&I Lighting



Regional C&I Lighting Savings Potential (relative to 2017)

Networked lighting controls play a critical roll in sustaining C&I lighting programs

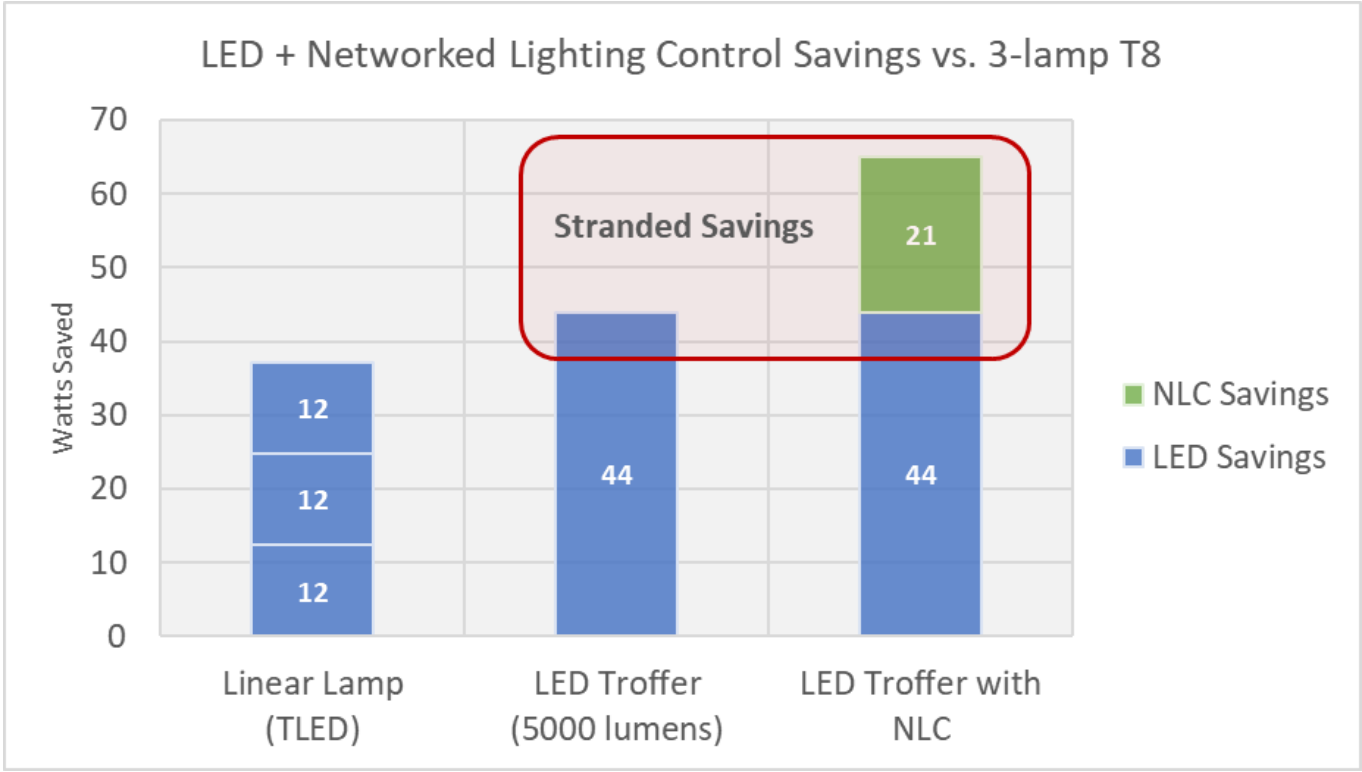




* This analysis does not account for net savings adjustments

Risk of Stranded Savings

- Every time a linear replacement lamp (TLED) is installed, deeper savings potential becomes stranded
  - Fixtures deliver greater savings per unit
  - Networked Lighting Controls can't (typically) be used with TLEDs



Risk of Stranded Savings

Illinois Linear Lamp/Troffer Savings Potential	3-lamp TLED	LED Troffer (3-lamp equivalent)	LED Troffer with NLC
TRM Delta Watts	37.2	43.9	65.0
Unit Savings (kWh)	125.7	148.3	219.5
Average Annual Savings, 2020-2029 (kWh)	160,550,434	189,466,776	280,341,774
Cumulative Annual Savings, 2020-2029 (kWh)	1,605,504,340	1,894,667,756	2,803,417,739
% Increased Savings vs. TLED		18%	75%
Stranded Savings, 2020-2029 (kWh)	1,197,913,399	908,749,983	

Assumes TRM “Commercial (unknown)” hours of 3379; 73.6% LED penetration by 2029; does NOT adjust for expected efficacy improvement; does not account for net savings adjustments

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Program Design Considerations

Challenges

Technology

- Lack of standards
- Proprietary hardware
- Cybersecurity threats
- High cost

Installation

- Complexity
- Need for training
- Commissioning
- Lack of interoperability

Historical Bias

- Negative perception regarding controls
- Contractor disinterest in controls
- Energy savings not a sufficient motivator

System Integration

- Involves players that cross supply chains
- Contractors are often siloed (electrical, HVAC, refrigeration, etc.)

Program Design

- “Widget” based rebates don’t fit well
- TRMs treat lighting fixtures & controls independently
- Savings from integrated systems and NEBs difficult to quantify

Program Design Strategies

Education, Training, and Outreach	• System installation and commissioning • Supply chain development • Reframe value proposition for customers, contractors
TRM Updates	• Include networked lighting controls • Develop LED + NLC characterizations as a system • Characterize integrated building systems (e.g. lighting + HVAC) • Quantify NEBs for measure and program BCR
Revise Rebate Strategies	• Reduce or discontinue TLED rebates • Bundle LED & control rebates (or devalue uncontrolled LED) • Use a hybrid program approach in place of custom/calculated • Leverage breadth (midstream) and depth (hybrid/performance)
Promote Products with Energy Monitoring	• Increase savings accuracy and aid evaluation • Enable pay-for-performance programs
Lighting as a Service (LaaS)	• Overcomes cost and complexity hurdles • Addresses owner/tenant split incentive • Off balance sheet = operating expense rather than capital expense

NLC Program Spotlight

Hybrid

Wisconsin Focus on Energy

- $/SF NLC rebate with TRM-based savings
- Up to $0.25/SF
- Bonus for energy monitoring

Prescriptive

Bonneville Power Authority

- $/unit “kicker” rebate for NLC
- Indoor LED fixtures and highbay
- $40-100 adder

Breadth & Depth

MassSave and National Grid RI

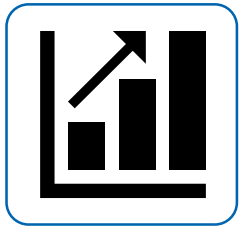
- Midstream $40-45 adder for LED troffers with integrated NLC
- Performance Lighting Plus program
- Significant education efforts
- Lighting + HVAC and LaaS pilots (2020)

NLC Program Spotlight

energize CONNECTICUT

Tier	Lighting Tier	Requirements	Incentive
Best	High Performance Lighting	LED + Networked Lighting Controls	65% - $0.65/kWh
Better	Enhanced Performance Lighting	LED + Controls (2 per project, 1 per fixture)	45% - $0.45/kWh
Good	Standard Lighting	LED	25% - $0.25/kWh

Summary



Significant energy savings potential remains within C&I lighting, particularly with NLCs

Intelligent lighting can unlock energy savings that may not be captured through traditional or even networked lighting control measures

Programs can deliver greater value to customers while obtaining deeper energy savings

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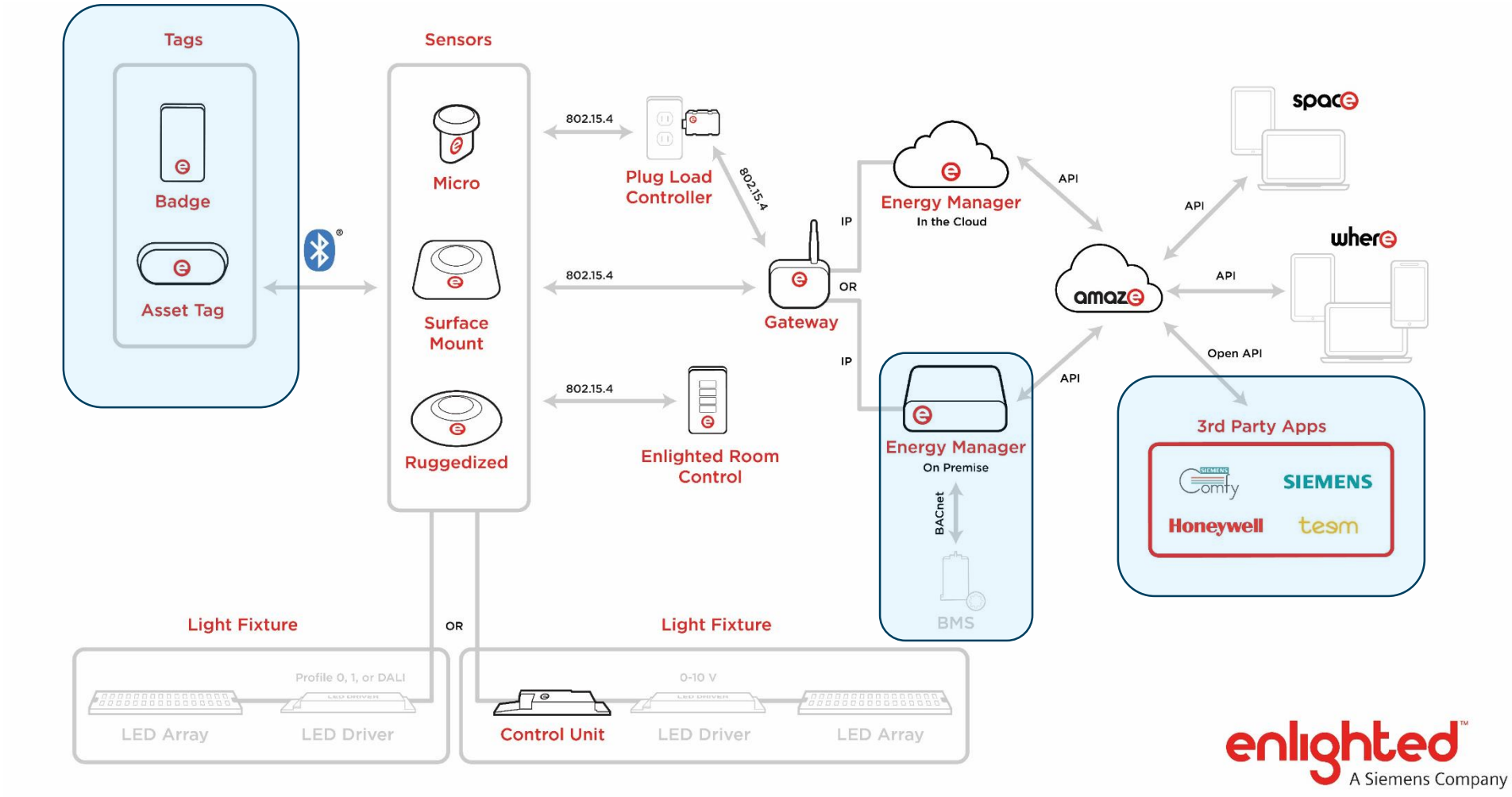
Appendix

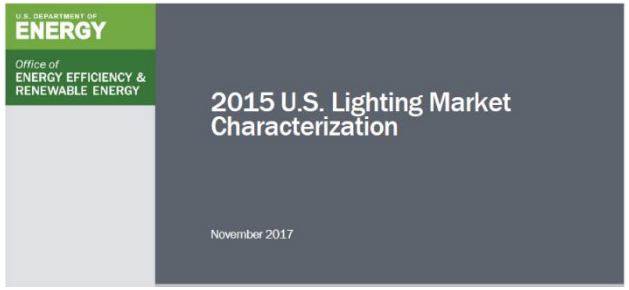
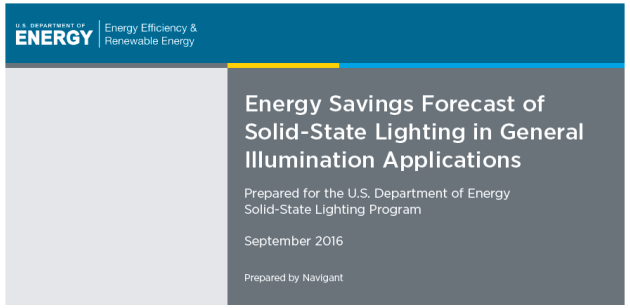
Intelligent Lighting Architecture Example



DLC Networked Lighting Controls v4.0

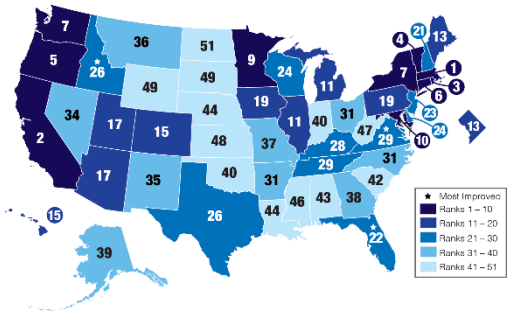
'Required' Interior System Capabilities	'Reported' Interior System Capabilities
•Networking of Luminaires and Devices •Occupancy Sensing •Daylight Harvesting / Photocell Control •High-End Trim •Zoning •Individual Addressability •Continuous Dimming •Energy Monitoring	•Control Persistence •Scheduling •Device Monitoring / Remote Diagnostics •Type of User Interface •Luminaire Level Lighting Control (LLLC, integrated) •Personal Control •Load Shedding (DR) •Plug Load Control •External Systems Integration •Emergency Lighting •Cybersecurity •Color Changing / Tuning •Ease of Implementation •Scene Control

National C&I Lighting Forecast

	2015 U.S. Lighting Market Characterization (U.S. DOE, 2017)	• C&I lighting inventories • C&I LED market penetration • Baseline technology characteristics
	Energy Savings Forecast of Solid-State Lighting in General Illumination Applications (U.S. DOE, 2016)	• LED adoption rates • LED efficacy forecast • NLC adoption rates • NLC savings estimate (2035)
	Energy Savings from Networked Lighting Control Systems (DLC, 2017)	• NLC savings estimate (2017)

Regional C&I Lighting Forecast

National analysis results plus:

	2017 State Energy Efficiency Scorecard (ACEEE, 2017)	• State scores for utility programs and building energy efficiency policies • Used for moving states up/down the LED & NLC adoption curves and adjusting baselines
CBECS	Commercial Building Energy Consumption Survey (EIA, 2012)	• Commercial building floorspace by census region • Used for scaling national results

LED Adoption Forecast