Beyond Widgets: Multi-Technology Integration and Connected Systems

Thursday, July 11th, 2019

11:00 am - 12:30 pm

Session Panel

Eliot Crowe

Lawrence Berkeley National Laboratory

Chris Wolgamott

Northwest Energy Efficiency Alliance

Scott Schuetter

Slipstream

Cedar Blazek,
(Moderator)
Department of Energy

Eliot Crowe

Lawrence Berkeley National Laboratory (LBNL)

U.S. DEPARTMENT OF ENERGY

Beyond Widgets: Integrated Building Systems for Building Owners and Operators

Eliot Crowe

Lawrence Berkeley National Laboratory

Adopting Integrated Systems

Opportunity:

- Deeper energy savings
- Enhance comfort.

Challenges:

- Inherently more complex
- Can span multiple building systems
- Require greater levels of design and assessment

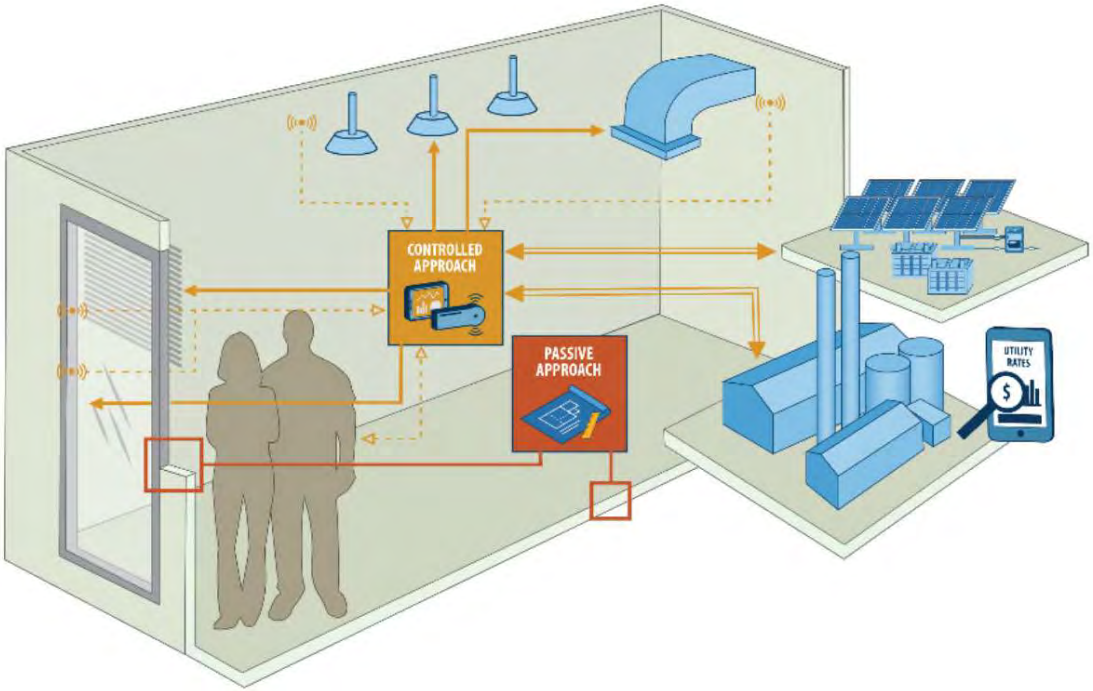


Figure 1 - Systems Opportunities in Buildings Include Combinations of Both Passive and/or Actively Controlled Components, and Include DERs

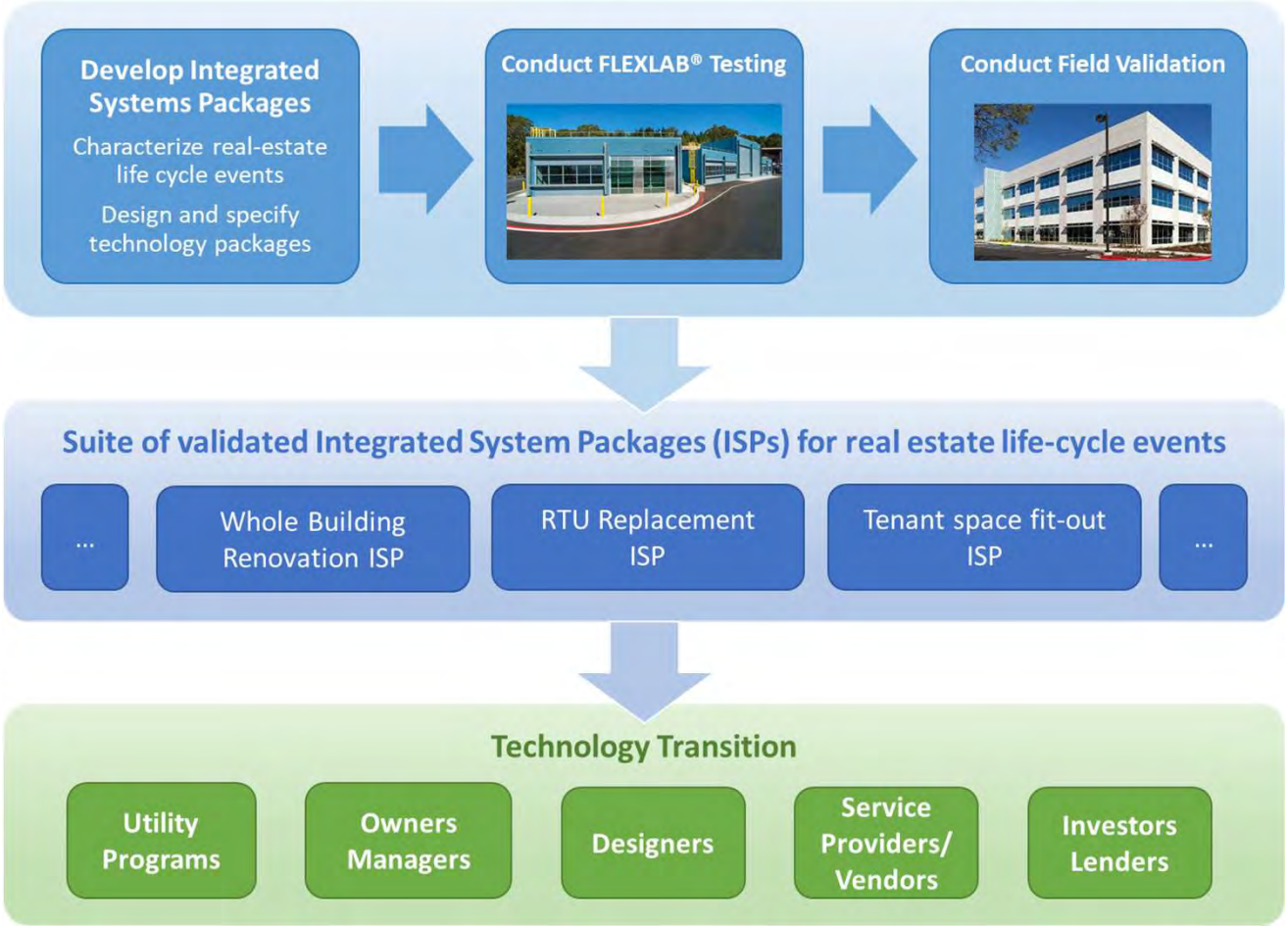
INTEGRATED SYSTEMS PACKAGES FOR COMMERCIAL REAL ESTATE

LBNL project: ISPs optimized for real estate lifecycle

Sponsor:

Demonstration partner:

Research Team:



Who we talked to

- *Owners*
- *Operators*
- *Tenants*
- *Investors*
- *Developers*
- *A/E*
- *Project managers*
- *Lease lawyers*

Stakeholder perspectives: seven themes

Payback is (almost always) still important
3 5 years "if you're lucky"
Can be overridden with other benefits

Packaging and standardization are valuable
Reduction in time, hassle, and risk
What's proven and easy gets done

Lease and ownership structure (and term) matter
Who pays for energy?
What's the "hold period"?

Organizational priorities and practices vary widely
Even within the same organization

Get in the specs
templates, portals, standards, …

Timing matters
"there a 3 4 week window…"

The key influencer is … not obvious

ISP design process

Generate list of efficiency measures

↓

Determine applicability for real estate events

↓

Assess potential for standardization

↓

Define core and optional measures for each ISP

↓

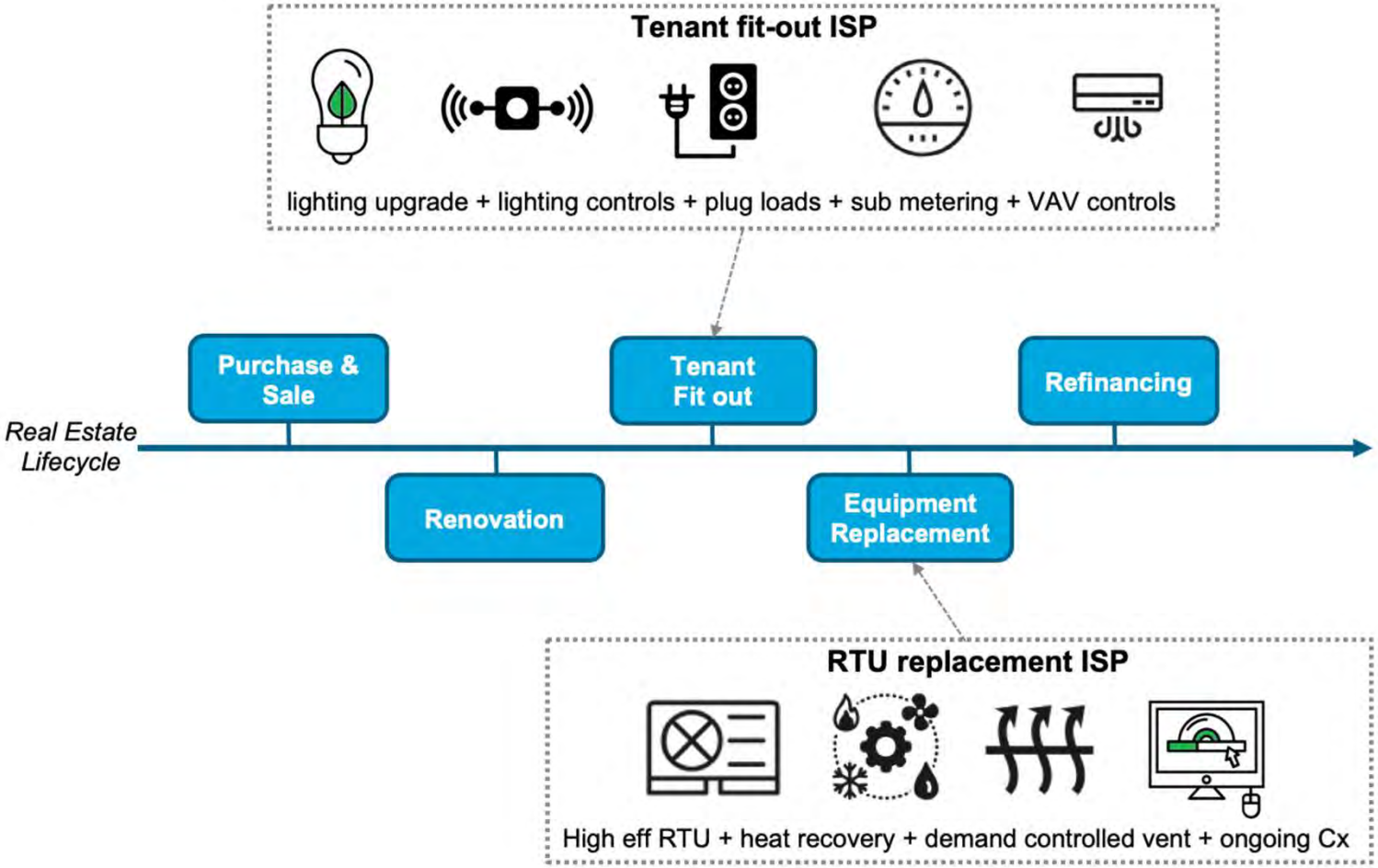
Assess savings range

↓

Revise design as needed → *Start detailed specification*

	Tenant Fit Out Limited	Tenant Fit Out Expanded	Whole Building Renovation	RTU replacement
Lighting Lamp replacement	X	X	X	
Lighting fixture replacement	X	X	X	
Lighting occ controls	X	X	X	
Lighting daylight controls	X	X	X	
Lighting: Networked Lighting Control Sy	X	X	X	
Automated Interior shades	X	X	X	
Exterior shades			X	
Window films			X	X
Secondary Window inserts			X	
Window glazing upgrade			X	
Cool roofs			X	X
Plug load controls		X	X	
RTU upgrade			X	X
RTU upgrade w/ enthalpy recovery			X	X
RTU heat pumps			X	X
VRF RTU heat pump			X	X
VRF RTU heat pump w/ heat recovery			X	X
RTU w/ indirect evap cooling			X	X
VAV min reset	X	X	X	X
Thermafusers		X	X	
Rezoning		X	X	
DCV w/ CO2		X	X	X
DCV w/ occupancy	X	X	X	X
Intermittent ventilation	X	X	X	X
Ceiling fans w/ set point reset		X	X	
RCx incl ASHRAE guideline 36	X	X	X	X
Model predictive control			X	X
Heatpump DHW			X	
Instantaneous DHW			X	
Submetering	X	X	X	
Monitoring based Cx	X		X	X

Illustrative examples



BEYOND WIDGETS FOR UTILITIES

DOE-LBNL 'Beyond Widgets' Project

Building Systems Package

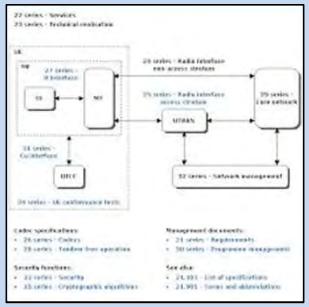
System specifications

Savings & performance metrics

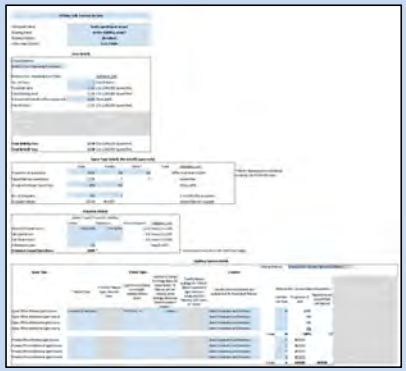
M&V specifications

FLEXLAB-validated Savings

Controlled testing and validation of systems



Implementation & savings persistence guidance



Simplified assessment method

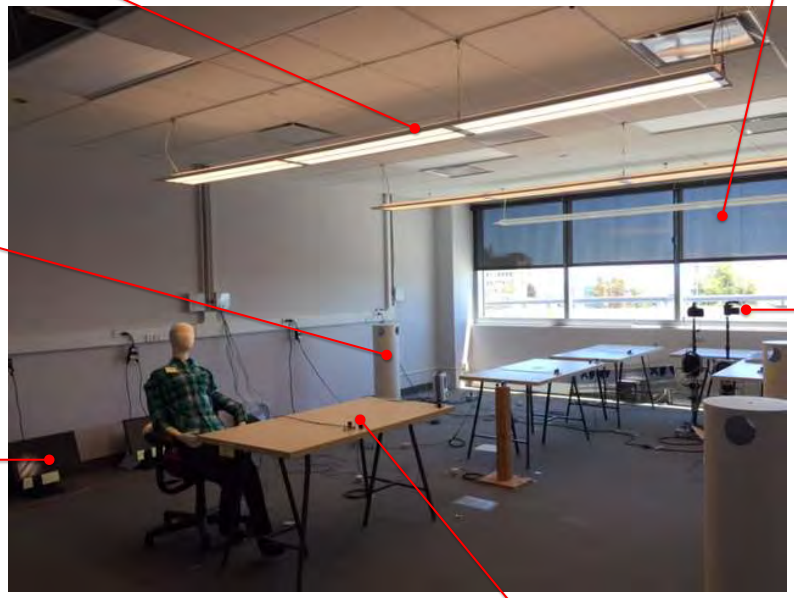
System 1 – Automated Shading, Daylight Dimming

ComEd
An Exelon Company

Market:
Med-large office
K-12 Educational

Simple payback for shading and lighting controls only (no light upgrade) >20 years; simple payback w/ lighting upgrade 10.9 years

Annual Energy Savings Potential:
20%+ Lighting Savings
4-10% Whole Bldg Savings (based on DOE Reference bldgs)



BERKELEY LAB

System 2 – Workstation Specific Lighting, Daylight Dimming

Xcel Energy

Market:
Med-large office

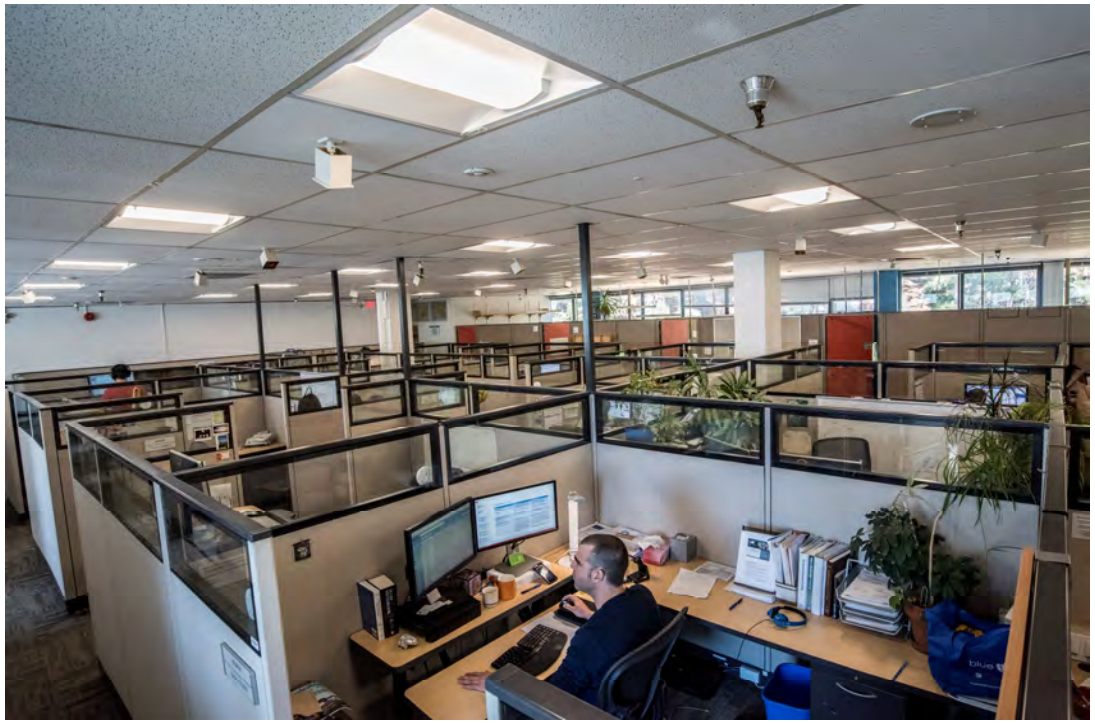
8 to 12 years simple payback at $0.12/kWh

Annual Energy Savings Potential:
90%+ Lighting Savings
5-11% Whole Building Savings (applied S, SW, SE only)

FLEXLAB Setup, Workstation Specific Lighting, 100sf/person

BERKELEY LAB

System 3 – Task/Ambient Lighting with Plug Load Occupancy Controls

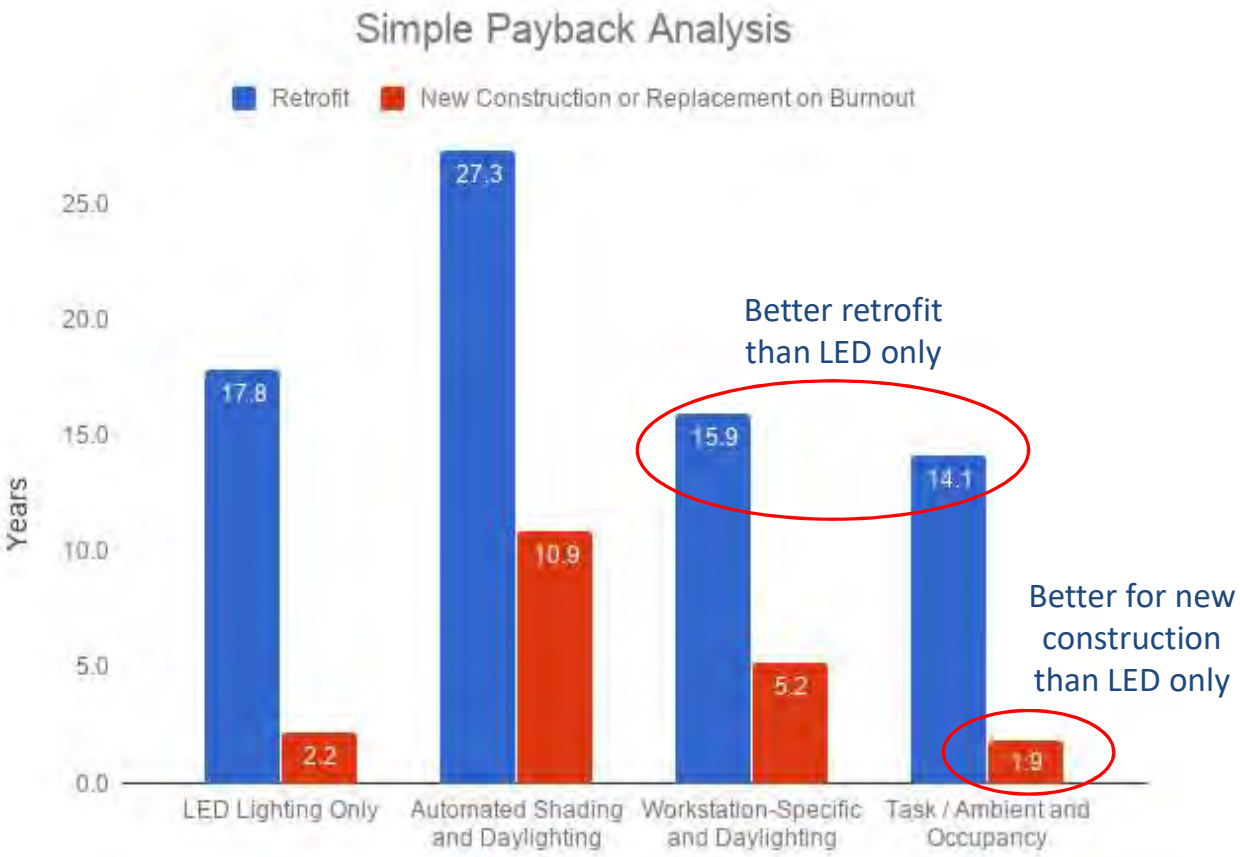


<u>Market:</u>
Small-large office

6-9 years simple payback at $0.16/kWh

<u>Annual Energy Savings Potential:</u>
30%+ Lighting Savings
11-23% Whole Building Savings

Systems Save Over Component Based Upgrades



Baseline: T8 lights, scheduled control.

Further system cost reductions may be possible through simplified approaches to controls integration

Energy and Buildings

Quantifying the benefits of a building retrofit using an integrated system approach: A case study

Cynthia Regnier, Kaiyu Sun, Tianzhen Hong, Mary Ann Piette

ARTICLE INFO

ABSTRACT

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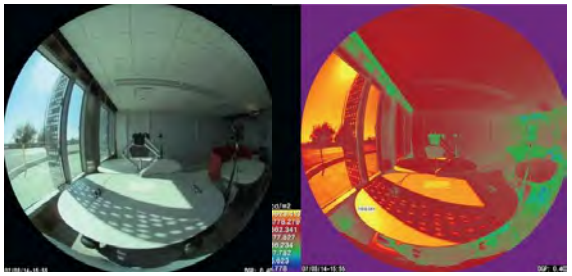


https://buildings.lbl.gov/cbs/commercial-building-systems

Chris Wolgamott

Northwest Energy Efficiency Alliance (NEEA)

U.S. DEPARTMENT OF ENERGY

July 2019

An Integration Case Study: Luminaire Level Lighting Controls + HVAC

Chris Wolgamott, CEM, CDSM
Senior Product Manager

Who is NEEA?

TOGETHER We Are Transforming the Northwest

Luminaire Level Lighting Controls + HVAC + Humans

SIEMENS enlighted

neea

UNIVERSITY OF OREGON

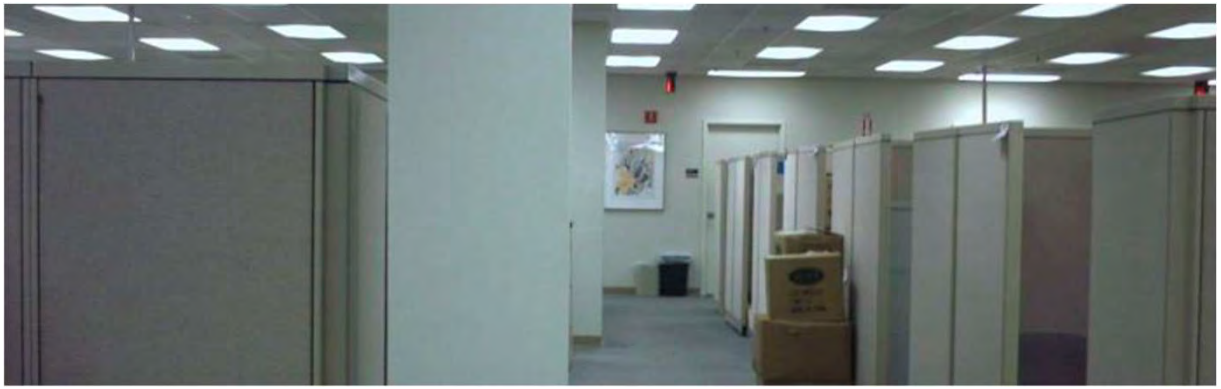
Energy Studies in Buildings Laboratory Institute for Health in the Built Environment

Optimize Health and Balance Energy

Humans spend

~90%

of our time indoors!



Then: Cheap Energy, Productivity and Efficiency

Scene from the 1960 film, “The Apartment”

Now: Occupant Health, Well-Being and Productivity

ehp Environmental Health Perspectives

Research

Open Access

Is CO_2 an Indoor Pollutant? Direct Effects of Low-to-Moderate CO_2 Concentrations on Human Decision-Making Performance

Usha Satish, Mark J. Mendell, Krishnamurthy Shekhar, Toshifumi Hotchi, Douglas Sullivan, Siegfried Streufert, and William J. Fisk

Published: 1 December 2012 | https://doi.org/10.1289/ehp.1104789 | Cited by: 27

ehp Environmental Health Perspectives

Research

Open Access

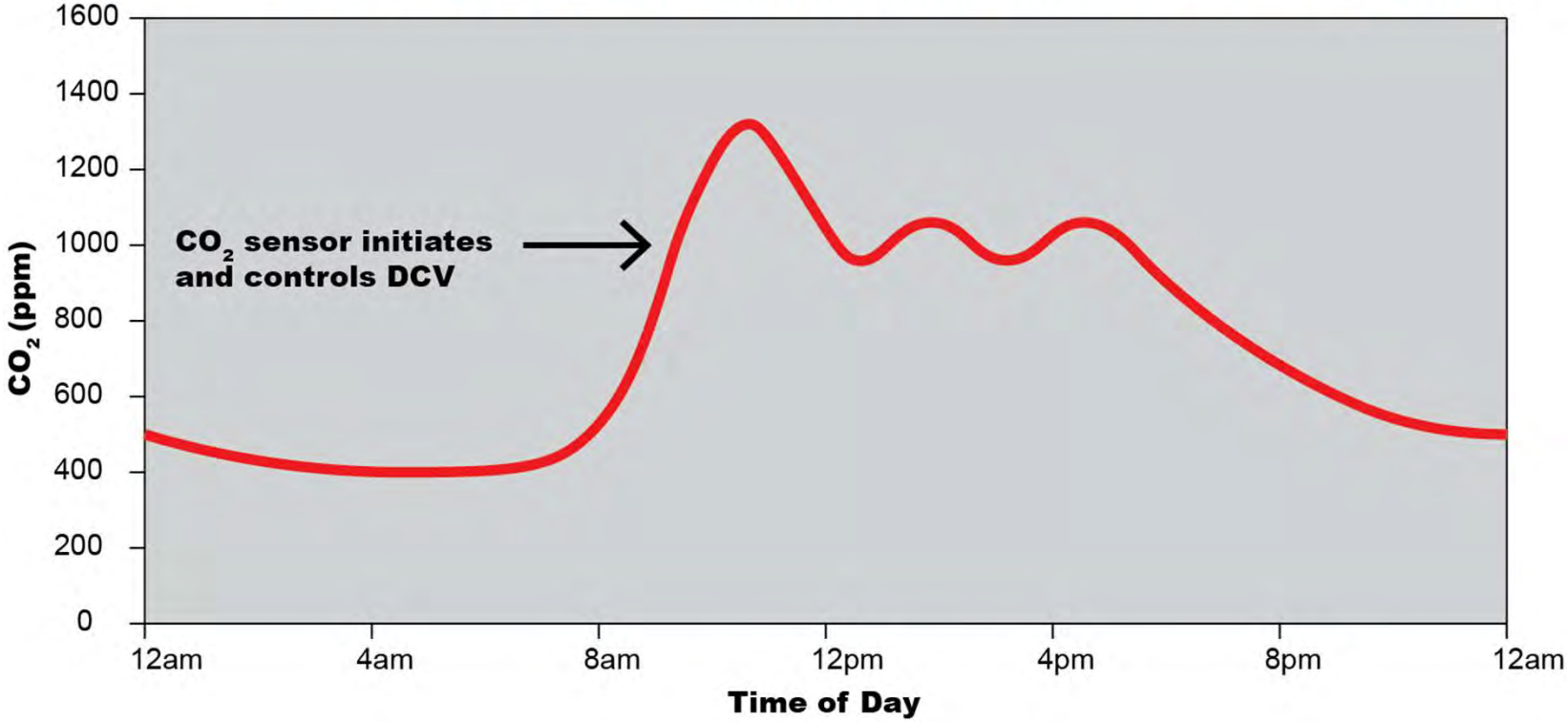
Associations of Cognitive Function Scores with Carbon Dioxide, Ventilation, and Volatile Organic Compound Exposures in Office Workers: A Controlled Exposure Study of Green and Conventional Office Environments

Joseph G. Allen, Piers MacNaughton, Usha Satish, Suresh Santanam, Jose Vallarino, and John D. Spengler

Published: 1 June 2016 | https://doi.org/10.1289/ehp.1510037 | Cited by: 31

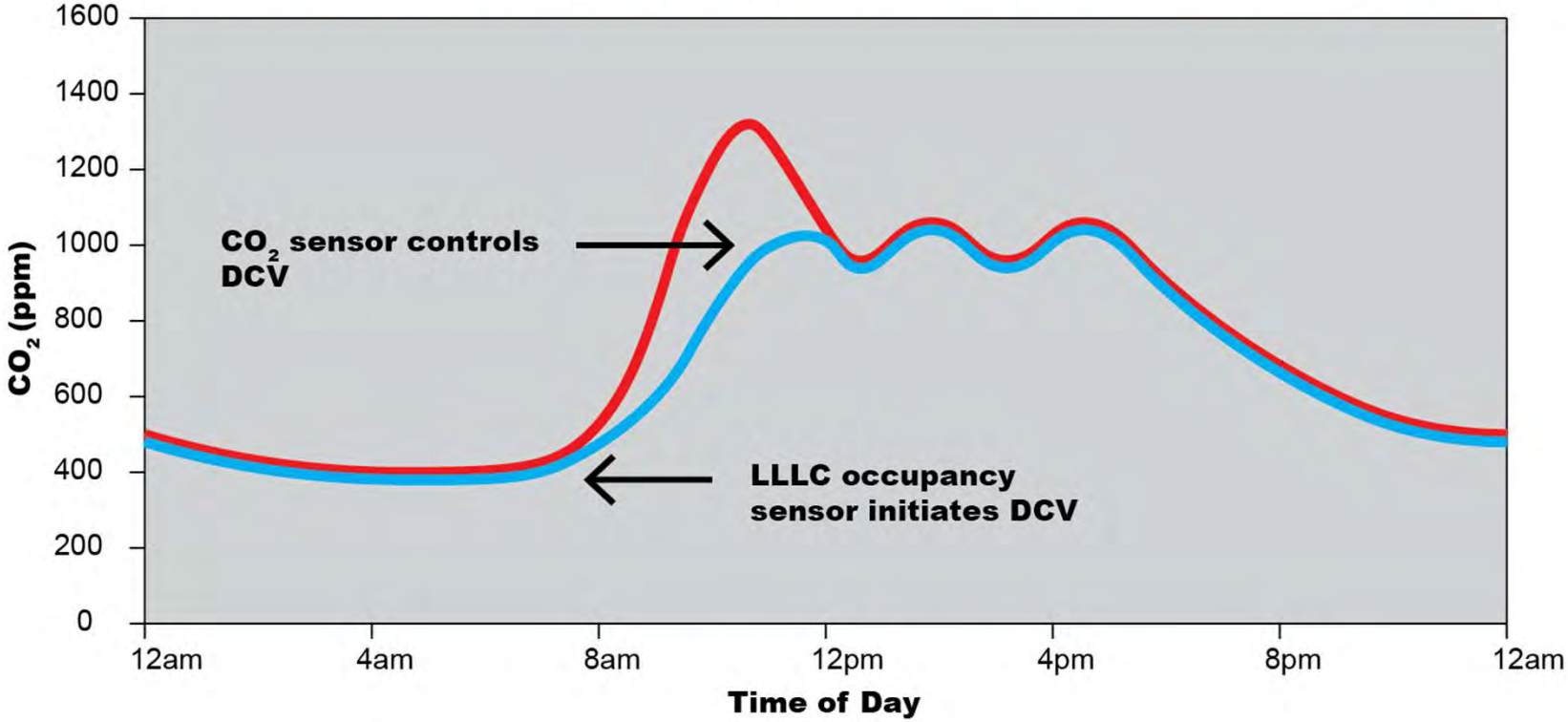
Non-Medical Determinants of Health

LLLC + HVAC can improve indoor environments for occupants



Non-Medical Determinants of Health

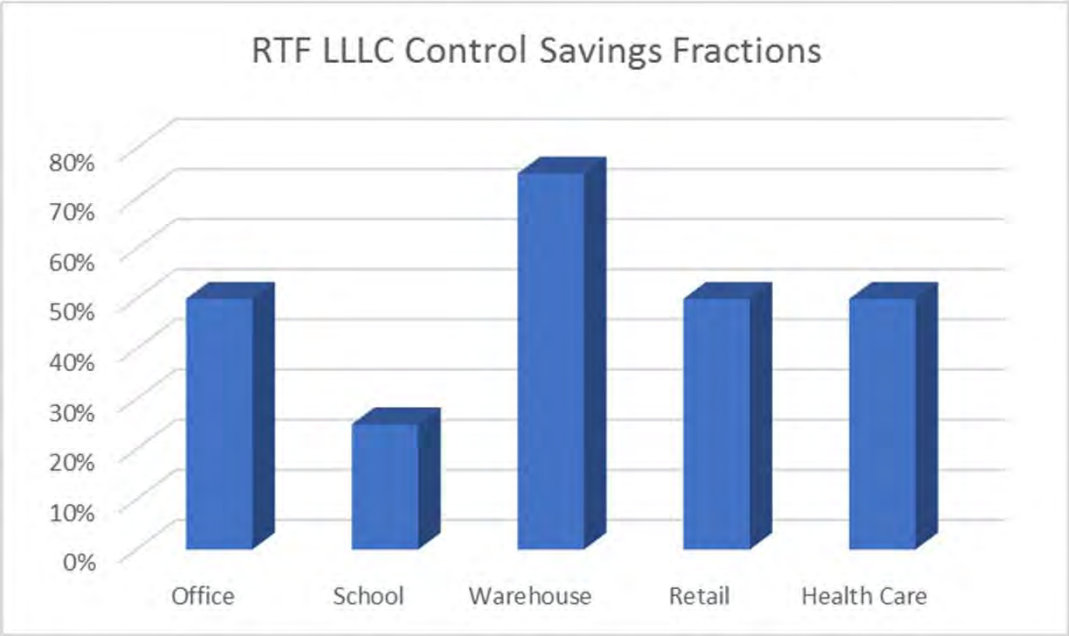
LLLC + HVAC can improve indoor environments for occupants



LLLC Energy Savings (Lighting Only)

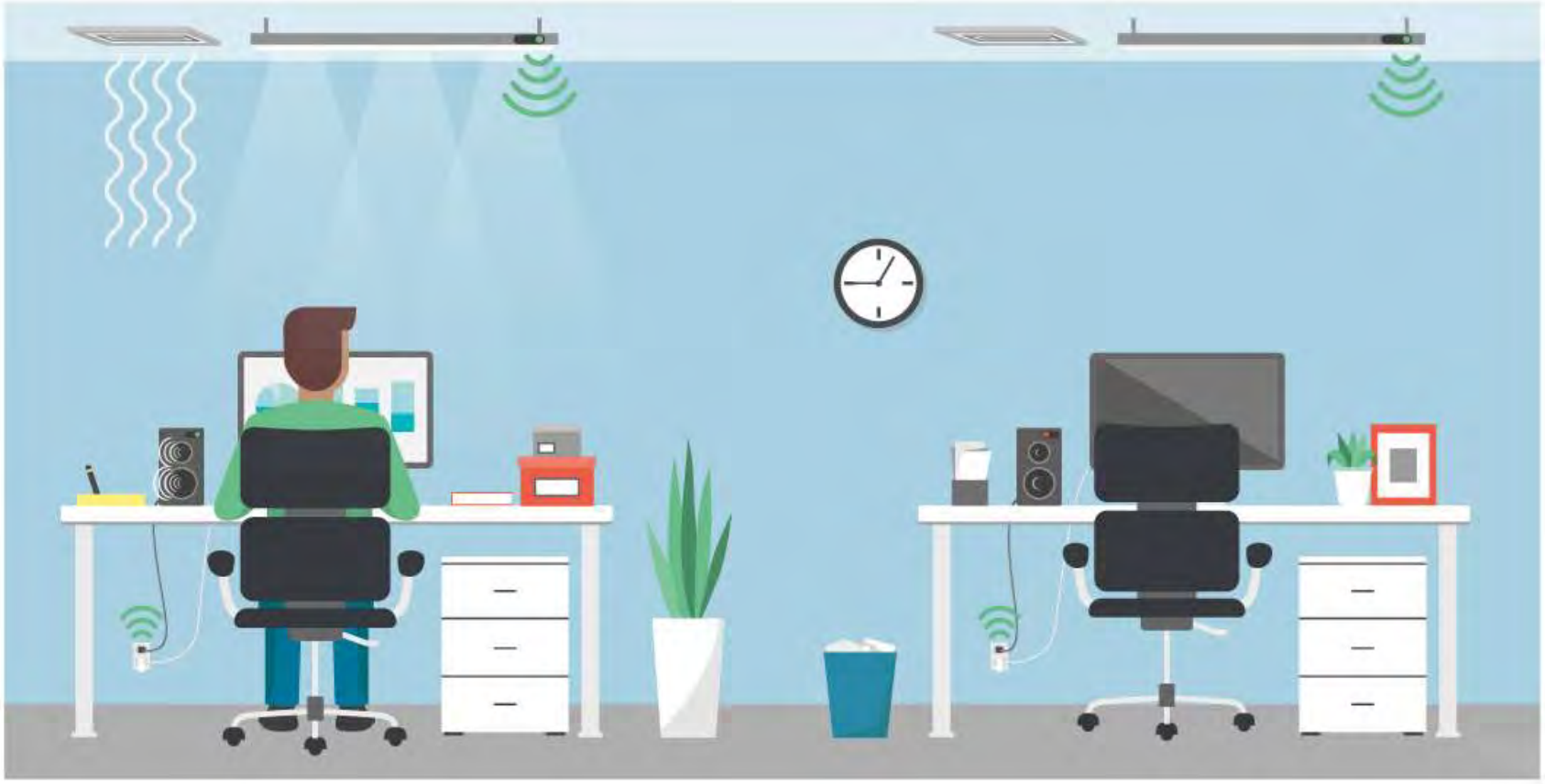
Where do the savings come from?

- Occupancy Sensing
- Daylighting
- High-end trim/Task Tuning



Regional Technical Forum Non-Residential Lighting Protocols v.4 (2019)

Energy Savings Possibilities: HVAC



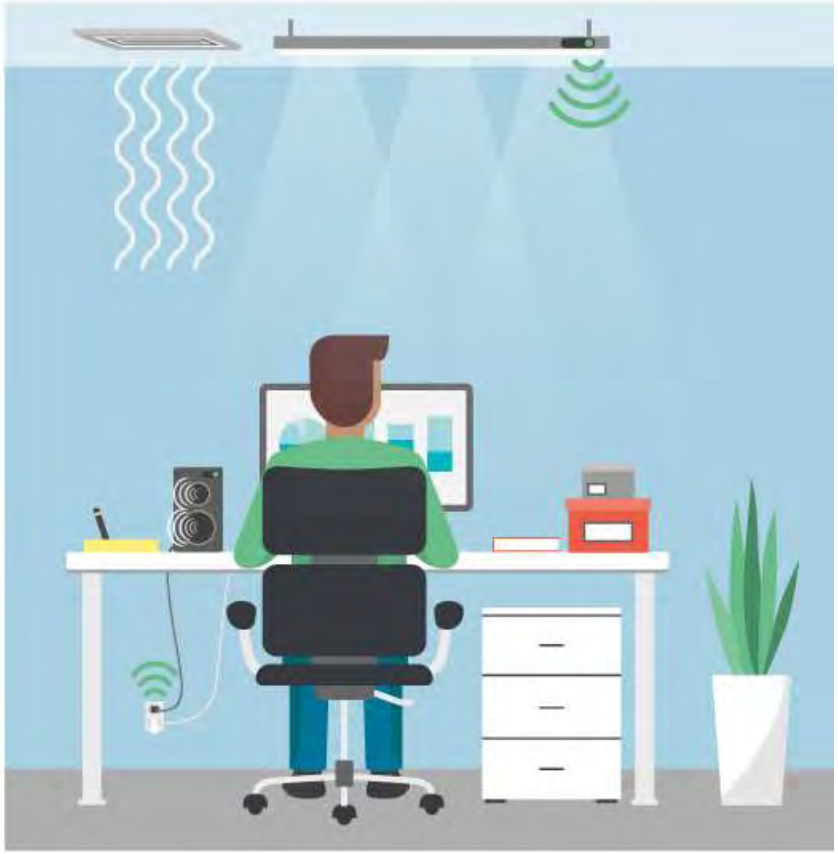
Why could LLLCs be the best option for sensors to control whole building?

- Lights cover most of the building space
- Granularity of sensors
- Power is already available for sensors (no extra wiring)

Energy Savings Possibilities: HVAC

Greater granularity of temperature sensors

- Connect HVAC to better occupancy data and temp data
- Can the new data tell us where/when HVAC calls will happen before it happens?
- Can we look at a space utilization map and correctly size the HVAC units to the space needs?



Energy Savings Possibilities: Plug Load

Two trains of thought:

1. Plug load is down so much that there is no need to control it more
2. We have made good efficiency gains but we are adding more and more to this load that can be controlled

Claims of between 8%-22% savings associated with occupancy controlled plug strips. Could sensors in lighting improve on this? Could it lead to greater persistence of savings?

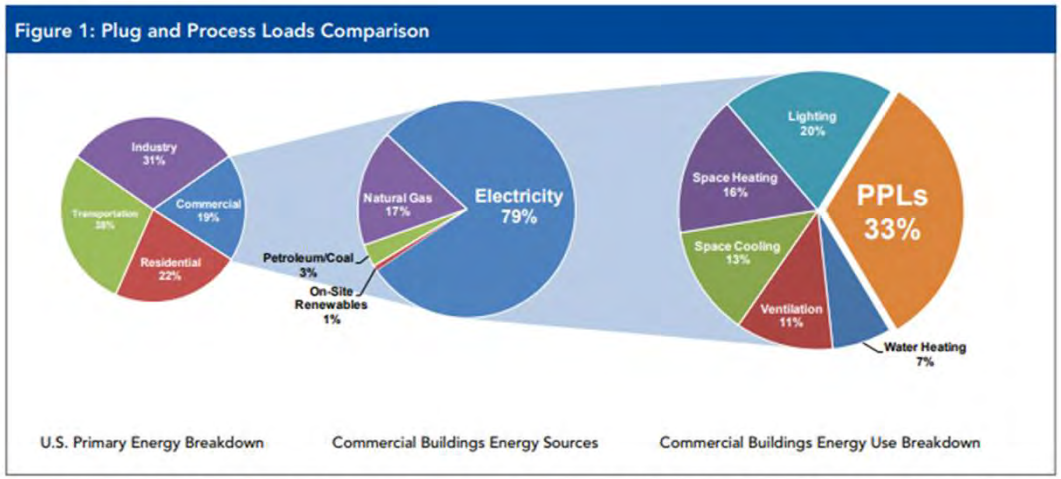


Figure 1. PPLs account for 33% of the total energy consumed by commercial buildings. Graph by Chad Lobato, NREL; Data source: DOE (2010).

Better Buildings Decision Guides for Plug and Process Load Controls DECEMBER 2015

Demonstration Project

Two-story office building located in Portland, Oregon

- Large, rectangular floor plate
- Limited perimeter daylighting
- 30,000 SF each floor
- Primarily open office with cubicles

Recent renovation of ground floor office

- Approximately 400 luminaires
- Enlighted luminaire level lighting control V3 sensors
- Enlighted energy manager

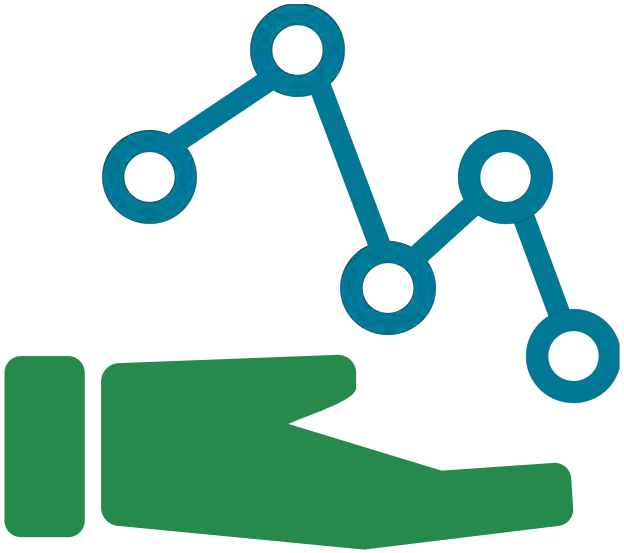
Currently, LLLC system is controlling electric lighting only

Phase One

1. **Establish data acquisition**
   - Enlighted LLLC
   - Plug loads
   - Siemens BAS
   - UO ambient monitoring

2. **Document baseline performance**
   - Lighting
   - Plug loads
   - Key HVAC parameters

3. **Occupant survey**



Phase Two

1. **Install Enlighted Smart Receptacles**

2. **Test different approaches to how temp sensors are used**

3. **Optimize HVAC sequence of operations**
   - Data stream integration of LLLC + BAS
   - Limited by existing HVAC equipment capability

4. **Data analytics on logged data and HVAC intervention**

5. **Occupant survey**

Phase Three (If Feasible)

1. **Implement HVAC equipment upgrades for zonal DCV**
   - Variable frequency drive (VFD) motors for air handlers
   - Variable air volume (VAV) dampers, actuators, controls

Non Energy Future phase*:*

1. **Implement space utilization capability**
   - Enlighted Space app
2. **Implement anonymous occupant tracking**
   - Smartphone or Bluetooth badge trackers
   - Higher resolution DCV + more

Space Usage Mapping

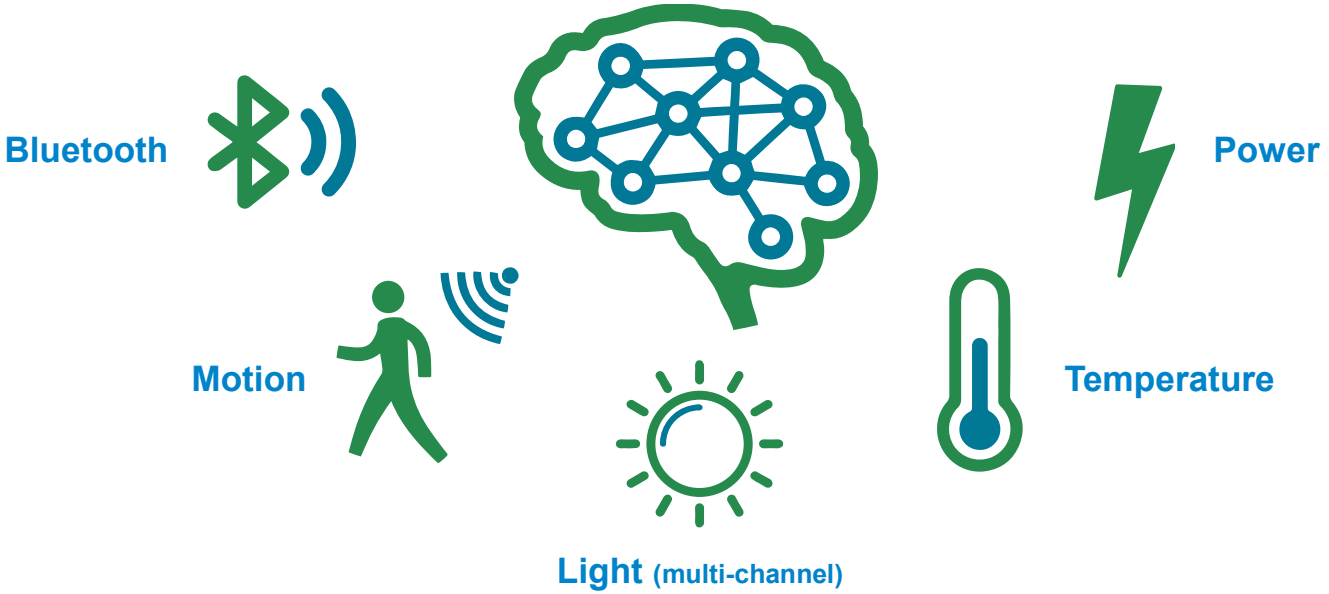
Workflow Optimization

Locate People & Things

Wayfinding

Phase One and Two Project Intent

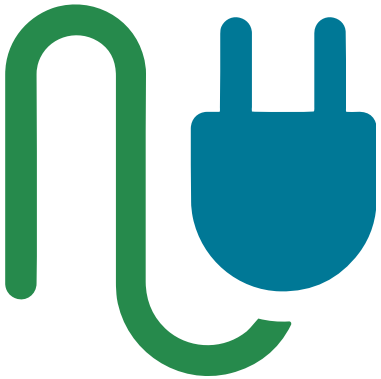
Can LLLC data streams, and the implementation of Smart Receptacles, be used to improve energy efficiency and occupant comfort compared to currently implemented building HVAC and plug load strategies?



Phase One and Two Project Intent

Hypotheses are that implementing Smart Receptacles will:

1. Reduce energy consumption of plugged equipment
2. Better persistence of savings than advanced plug strips or any “plug in” equipment
3. Help define how much plug load is being used in a modern work space



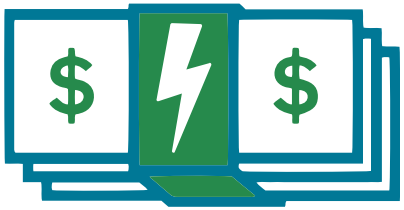
Phase One and Two Project Intent

Hypotheses are that utilizing distributed sensor data from the LLLC will:

1. Improve heating and cooling energy consumption
2. Improve thermal regulation across the floor plate
3. Improve occupant comfort and satisfaction with indoor thermal comfort
4. Provide information to determine if improved HVAC equipment functionality is likely to save additional energy or substantially improve occupant satisfaction

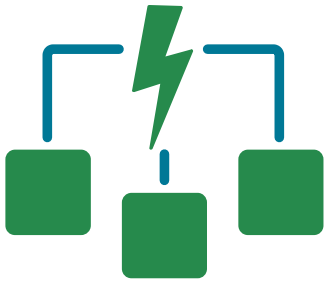
Phase One and Two Project Intent

Hypotheses are that we will find Non-Energy Benefits (NEBs) that help with project ROI including:



NEBs that feed into the $1, $9, $90 rule

Asset tracking



Space utilization
(including hoteling, conference room usage)

Questions?

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TOGETHER We Are Transforming the Northwest

Scott Schuetter

Slipstream

U.S. DEPARTMENT OF ENERGY

Better Buildings, Better Plants Summit
7/11/2019

Beyond Widgets: Multi-Technology Integration and Connected Systems

Integrated Controls Package for High Performance Interior Retrofit

Scott Schuetter

slipstream

Agenda

Integrated Controls Package for High Performance Interior Retrofit

INTEGRATED CONTROLS INTRO → INTEGRATED CONTROLS VALUE → DOE PILOT → NEXT BIG THING → Q & A

Traditional Energy Retrofit

~50% lighting savings

3-8% total building energy savings

Advanced and Networked Lighting Controls

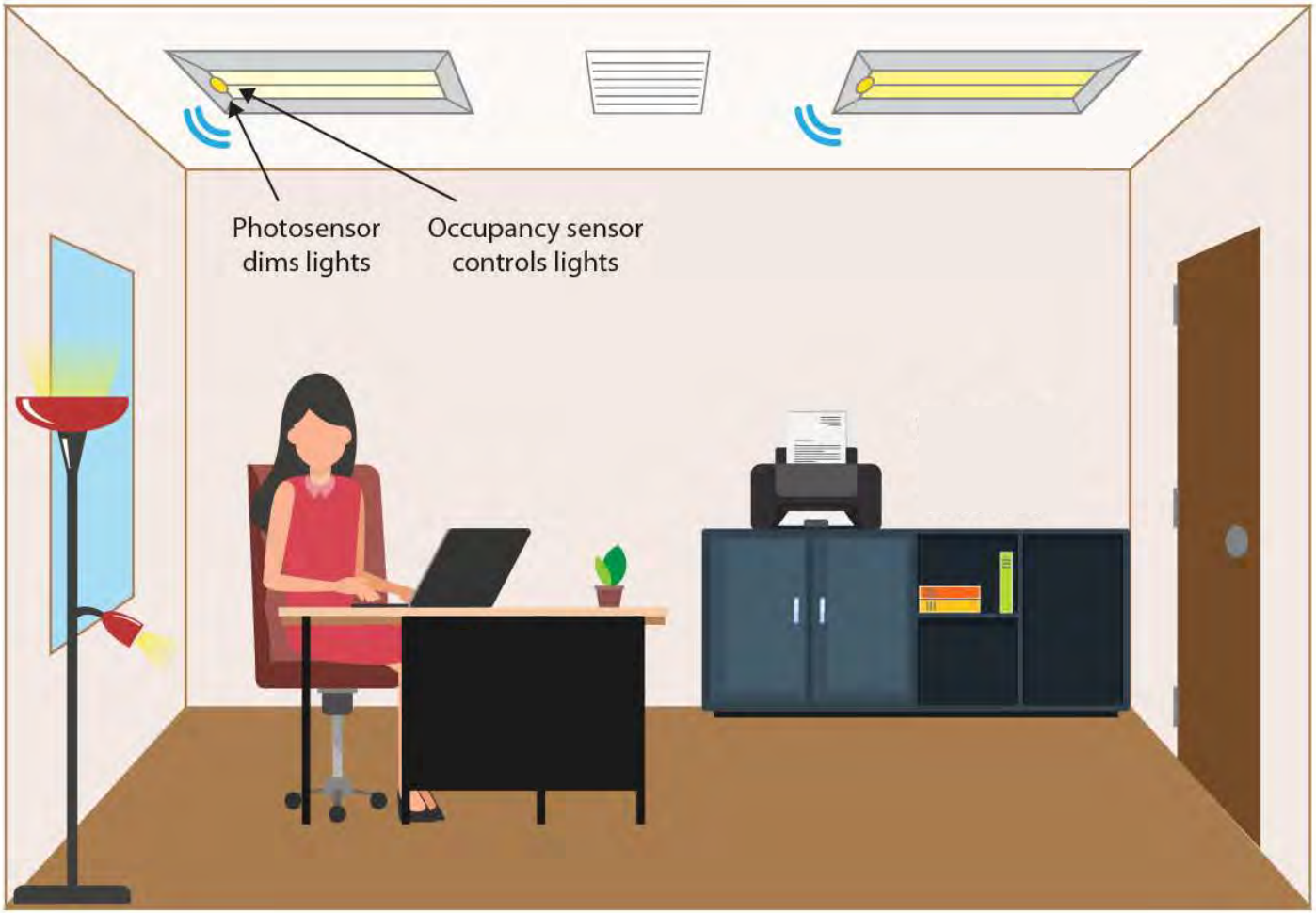
Control	Lighting Savings
Occupancy/Vacancy	24%
Daylighting	28%
Task Tuning	36%
Personal Tuning	31%
Combined	38%

Williams et al. 2012

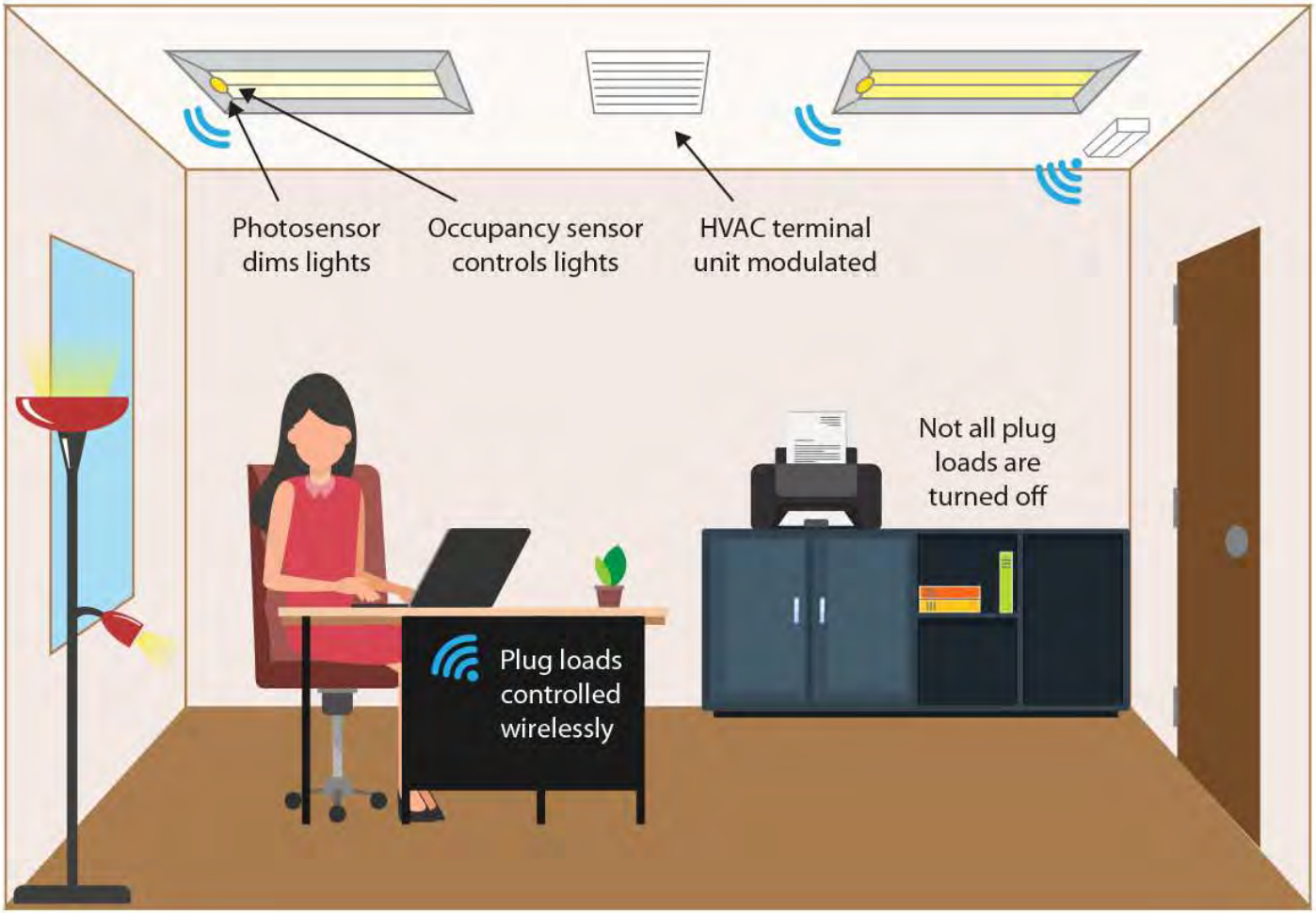
5-12% total building energy savings

designlights.org/lighting-controls/

Luminaire Level Lighting Controls (DOD project)



Integrated Controls (DOE project)



15-32% total building energy savings

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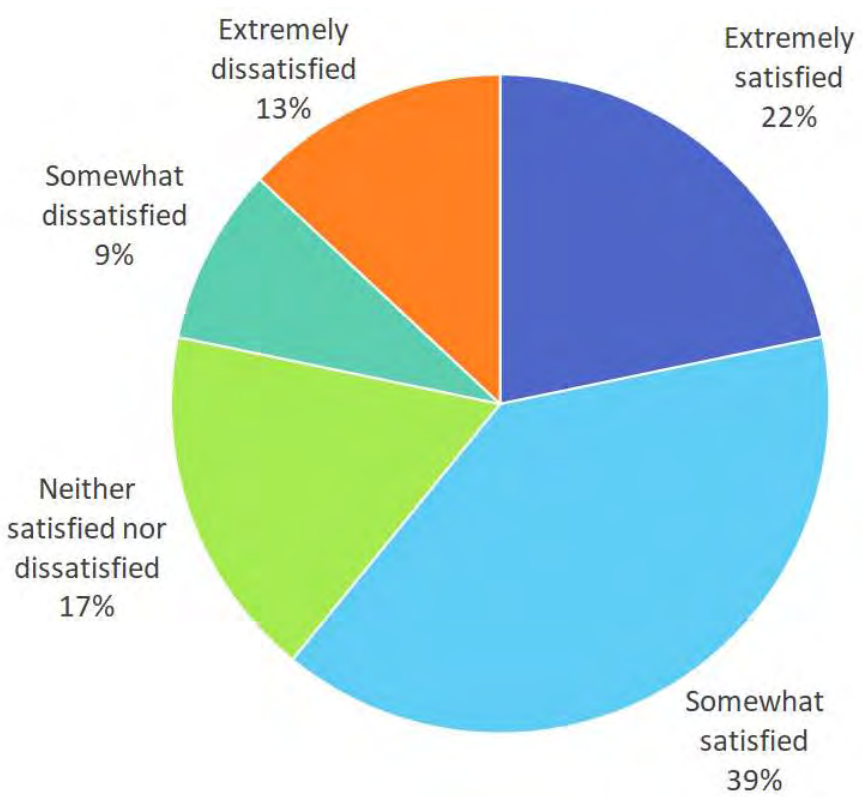
Integrated Controls Package for High Performance Interior Retrofit

Savings Streams

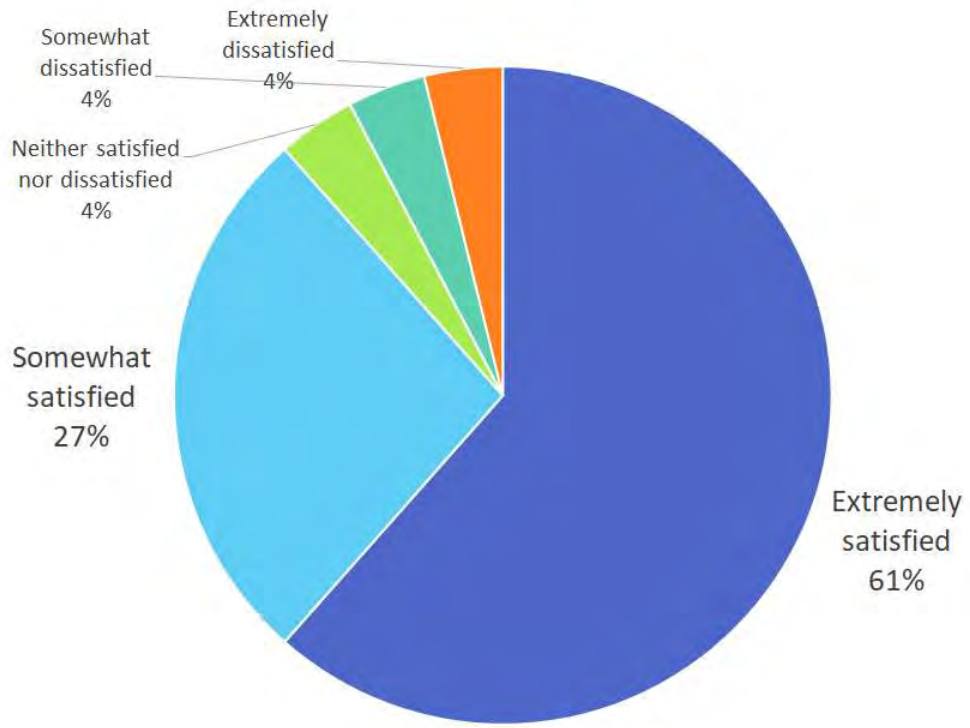
Type	Measure
Traditional Lighting Retrofit	Efficient LED Lighting
Advanced Lighting Control	Occupancy / Vacancy
	Daylighting
	Task Tuning
	Personal Tuning
Integrated Control - Plug	Workstation Plug Load Control
	Common Area Equipment Control
Integrated Control - HVAC	Thermostat Setback (Airside, Waterside, Baseboard)
	VAV Box Turndown (including off)
	Aggressive Pressure/Temperature Reset
	Ventilation Reset
	Demand Control Ventilation

Non-Energy Benefits: Occupant Satisfaction - Lighting

Pre-Retrofit



Post-Retrofit



Overall score improved from 2.5 to 1.6
(1 = Extremely Satisfied, 5 = Extremely Dissatisfied)

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Non-Energy Benefits: Continued

- Improved IEQ and health
- Simplified maintenance
- Better space utilization

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Integrated Controls Package for High Performance Interior Retrofit

INTEGRATED CONTROLS INTRO → INTEGRATED CONTROLS VALUE → DOE PILOT → NEXT BIG THING → Q & A

DOE Project Overview

Timeline: 9/2017 – 6/2020

Project Objectives

1. Inspire the retrofit market to go beyond simple light fixture replacement
2. Demonstrate energy savings and barriers at 5 sites
3. Create a replicable utility program design with appropriate incentives
4. Begin to transform the market for wide-scale adoption

Key Partners

Xcel Energy® RESPONSIBLE BY NATURE™

CREE™

legrand®

Pacific Northwest NATIONAL LABORATORY

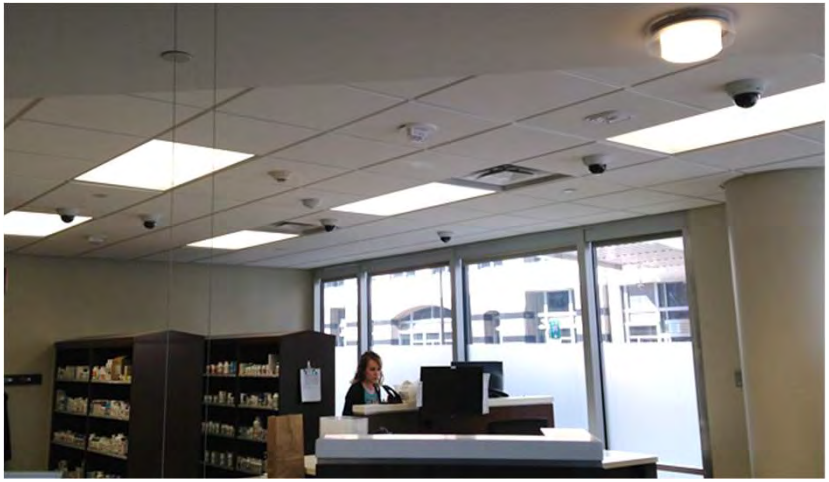
Hennepin County, Minnesota
City of St. Paul, Minnesota
University of Minnesota
CentraCare

Twin Cities Retrofit Sites

Owner	Building (Space Types)	Retrofit Area (ft^2)	Hours of Occupancy	HVAC	Plug Loads Controlled
University of Minnesota	Office/Education (office, classroom, comp lab, lounges)	11,563	6 am – 9 pm; M-F (variable Saturday)	VAV, steam, HW reheat, CHW	Workstations, printers, computer labs
Hennepin County	Mixed Use (clinic, fitness center)	7,320	6 am – 6 pm; M-F (fitness = variable 24/7)	VAV, HW, HW reheat, CHW	Fitness equipment, workstations
City of St. Paul	Office/Service (office, conf, break, locker, vehicle repair, storage)	13,100	7:30 am – 4:30 pm; M-F	Dual-duct CAV, DX, RTU, HW radiators	Computer, copier, printer, furniture feed
Public Works Agency	Office/Service (conference, offices, lunch, locker, storage)	11,300	24/7 mostly in winter. People come in and out.	AHU, VAV	Design in progress
CentraCare	Outpatient Clinic (reception, offices, exam rooms, labs, break)	12,364	8:00 am - 5:00pm; M-F	RTU, VAV (no reheat), FCU	Design in progress

Design and Integration – Lessons Learned

- Work with controls contractor familiar with building
  - Gauge cost-optimal level of control sophistication
- Many critical steps in system integration
  - Developing a template checklist as DOE project deliverable
- Maintain one-for-one fixture replacement
  - Hard and soft cost savings



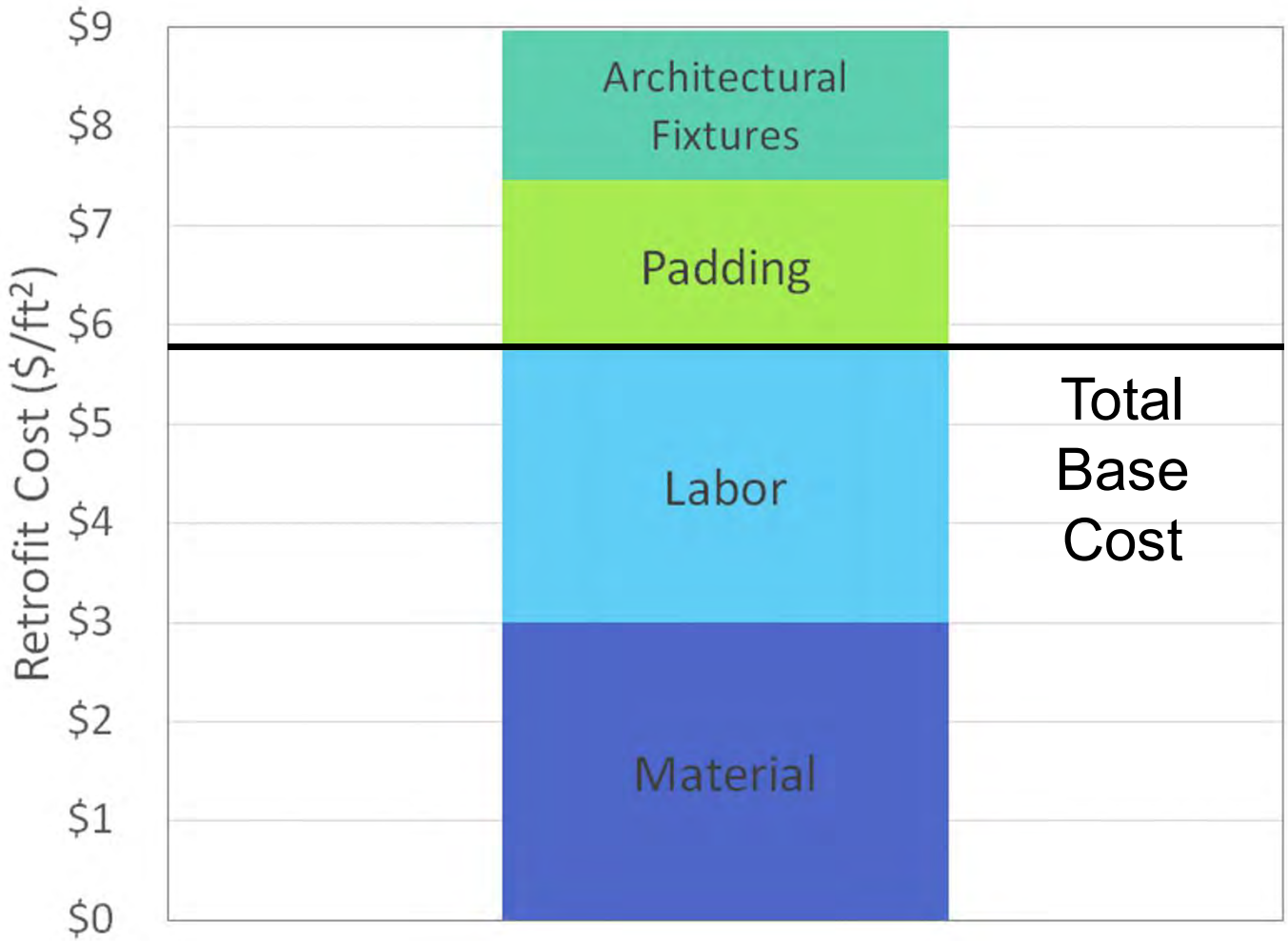
Design and Integration – Lessons Learned

- Create a control parameter plan together with office manager
- Time the commissioning of lighting to avoid long uncontrolled periods
- Educating occupants is important
  - Reduce complaints, disabled systems; office manager is important resource

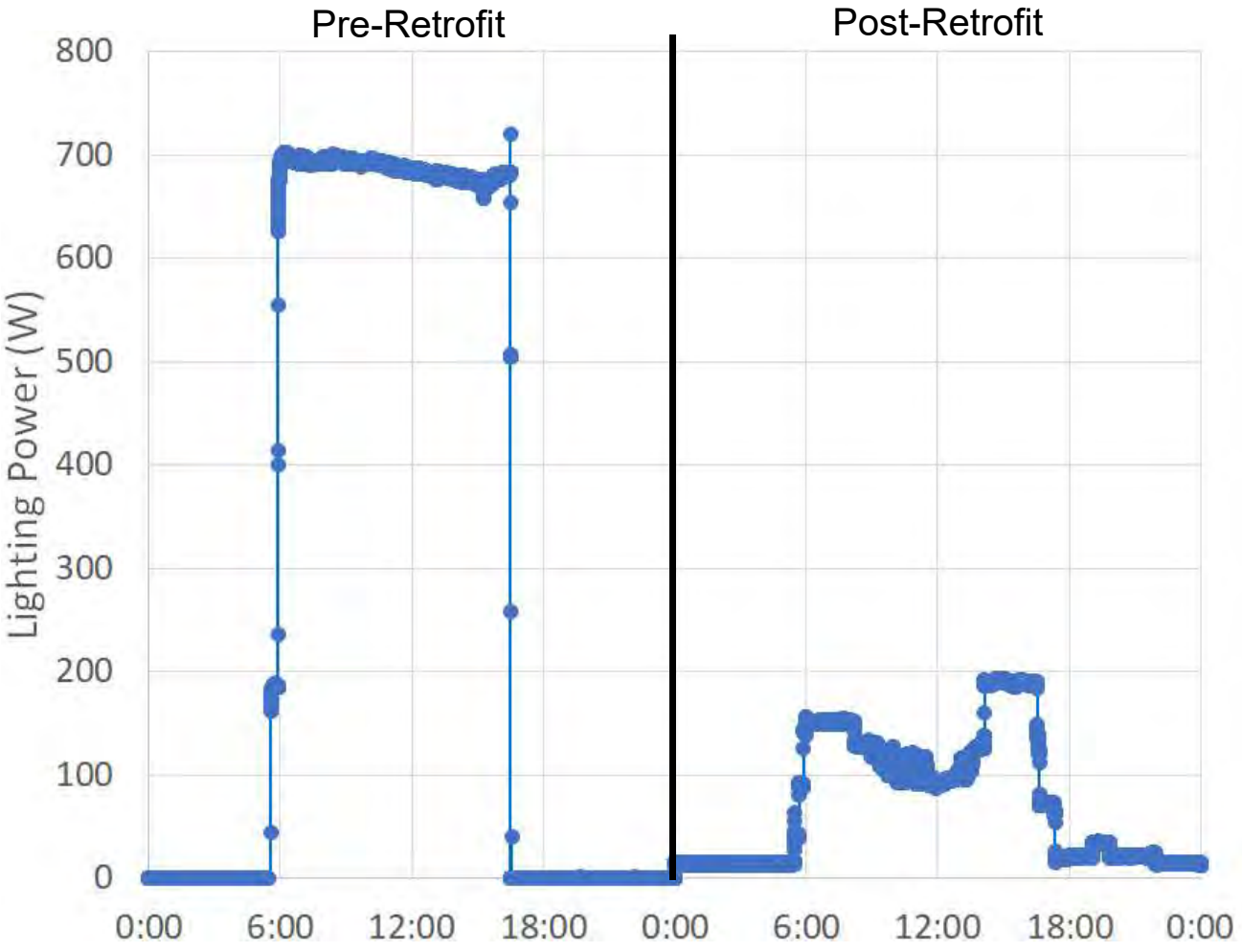
Design and Integration - Challenges

- Complexity
  - HVAC: system specific, contractor sophistication (Guideline 36?)
  - Open Office: plug load circuits, associating lighting occupancy zones
- Contractor familiarity with these systems
  - Affects install quality and cost
- Plug load savings comparatively small, need better integration
- Care needed to ensure occupant satisfaction
  - Light levels, computer/printer availability, temperature recovery
- Cybersecurity

Preliminary Cost Data



Preliminary Results: Lighting Power for Typical Weekday



Agenda

Integrated Controls Package for High Performance Interior Retrofit

Next Big Thing

- Paybacks are currently a challenge; though HVAC and plug load integration help
- Capturing additional non-energy benefits will improve economics through value stacking
  1. Asset Tracking
  2. Space Utilization
  3. Security
  4. Demand Response and Load Shedding

Agenda

Integrated Controls Package for High Performance Interior Retrofit

INTEGRATED CONTROLS INTRO → INTEGRATED CONTROLS VALUE → DOE PILOT → NEXT BIG THING → Q & A

Q & A

Thank you!

slipstream

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Questions?

U.S. DEPARTMENT OF
ENERGY

Thank You!

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