Bringing Efficiency to Light℠

Advanced Lighting Control System Performance: A Field Evaluation of Five Systems

September 25, 2018

Webinar Logistics

- Slides and recorded webinar will be posted to www.designlights.org after presentation
- All attendees on mute; Please use GoToWebinar Interface (Question pane) to submit questions
- Questions will be answered via follow-up email to webinar attendees
- If you experience any technical issues, use Chat feature to let us know

Speakers

Gabe Arnold
DesignLights Consortium

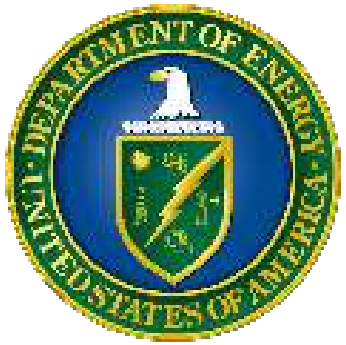
Michael Myer
Pacific Northwest National Laboratory

Agenda

- Introduction
- Findings
- Lessons Learned

Introduction

Thank You to Project Funders



U.S. DEPARTMENT OF ENERGY

nationalgrid

energize CONNECTICUT CT℠

EVERSOURCE

UI

DLC

Project Participants

Specifiers & Installers

- Beacon Electric
- Con-Serv Inc.
- Earthlight LLC
- Engie Services Inc (formerly OpTerra Energy Services)
- Rise Engineering
- Wendel Energy

Manufacturers & Representatives

- Cree
- Digital Lumens
- Enlighted
- Current, Powered by GE
- Langlais Group
- Signify (formerly Philips)

Site Hosts

- M.J. Fish LLC
- Ahold Stop & Shop New England
- Rhode Island Public Utilities Commission
- Two Roads Brewing Company
- Yale University

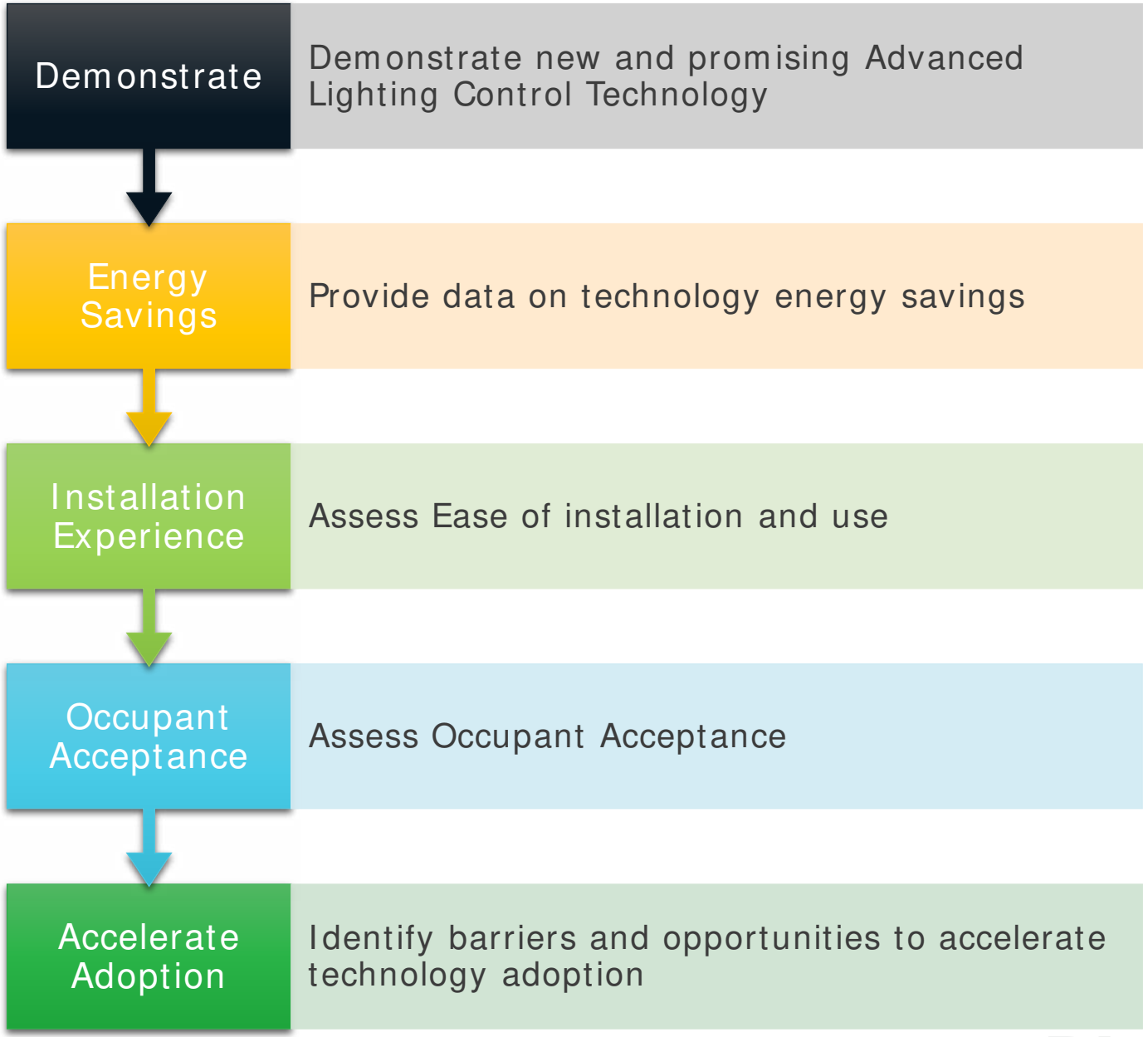
Utilities

- Energize Connecticut
- Eversource
- National Grid
- United Illuminating (subsidiary of Avangrid)

Others

- Cadmus Group (M&V Contractor)
- DesignLights Consortium (DLC)
- Pacific Northwest National Laboratory (PNNL)

Project Objectives



Snapshot, not a deep dive

Energy Savings

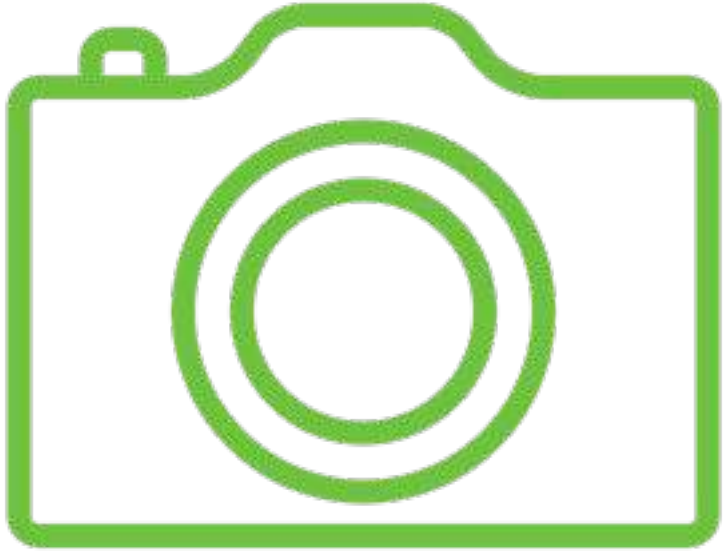
- Pre & Post metering of a subset of lighting
- 2-4 weeks duration of metering
- Extrapolate across facility and year

Occupant Satisfaction

- Pre & Post Written Survey

Installation Experience

- Written Survey



Technology Selection Process

- Technologies selected by RFQ process in 2015
- Scoring Criteria weighted to products that used innovative approaches to overcome technology adoption barriers

Features that were scored highly

“Embedded” or “Integrated” Control & Sensors
Wireless
Open-standards based or as interoperable as possible
Distributed Intelligence
Embedded energy meter
Simple Commissioning
Well-executed programming interface or GUI

Five Projects Selected to Move Forward

Two Roads Brewing Company – Stratford, CT

Rhode Island Public Utilities – Warwick, RI

Multi-Tenant Medical Office Building – Avon, CT

Super Stop & Shop – New Bedford, MA

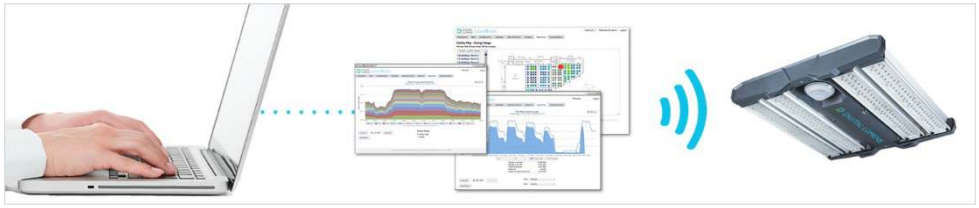
Yale University – New Haven, CT

Site 1: Two Roads Brewing Company

Site Characteristics

- 103,000 ft^2
- Industrial Scale Microbrewery
- Brewing, bottling, retail/tasting room, offices, shipping / receiving, and storage
- Existing Lighting: Fluorescent T8
- Existing Controls: None

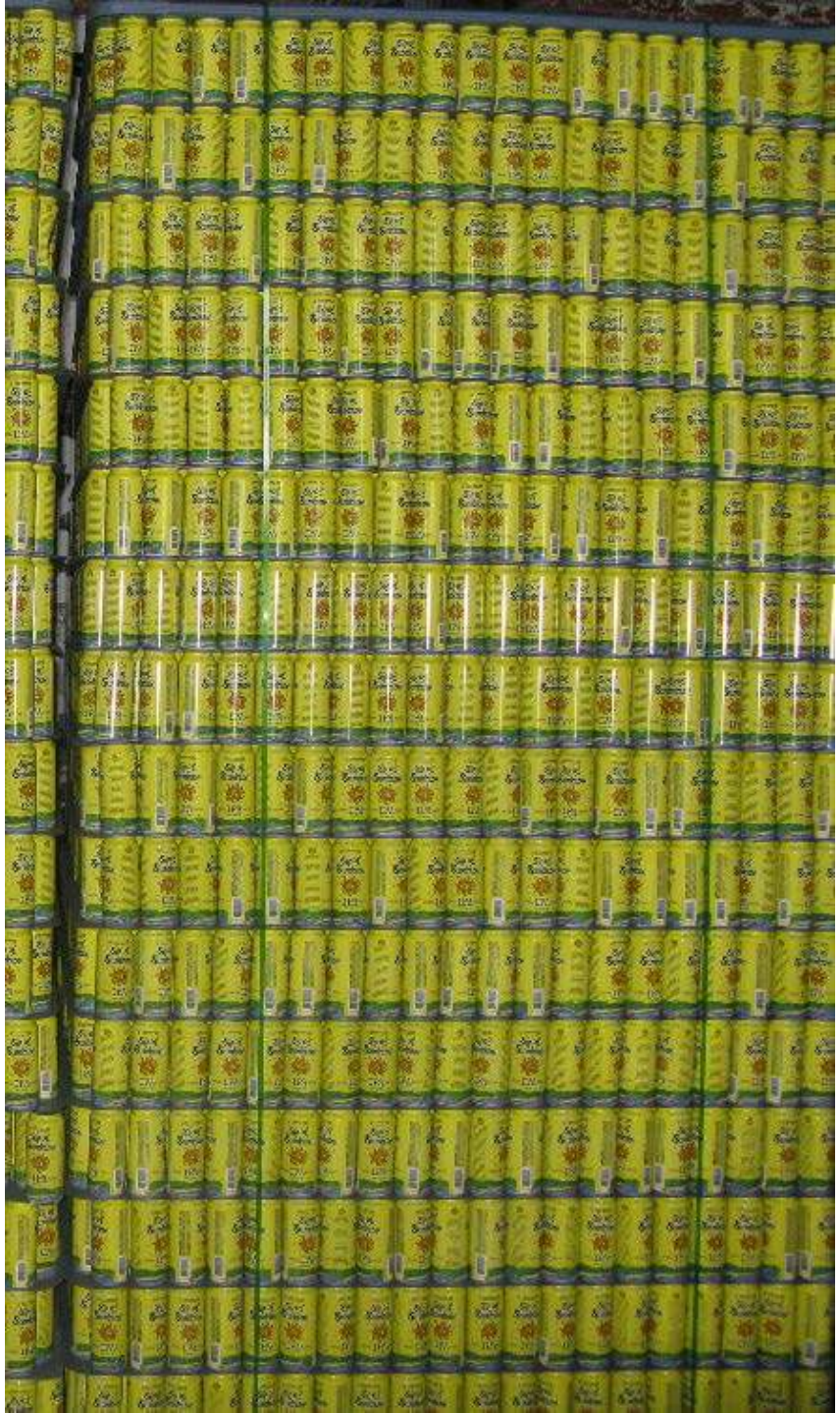
Technology 1: Digital Lumens Intelligent Lighting System



High-Bay Areas

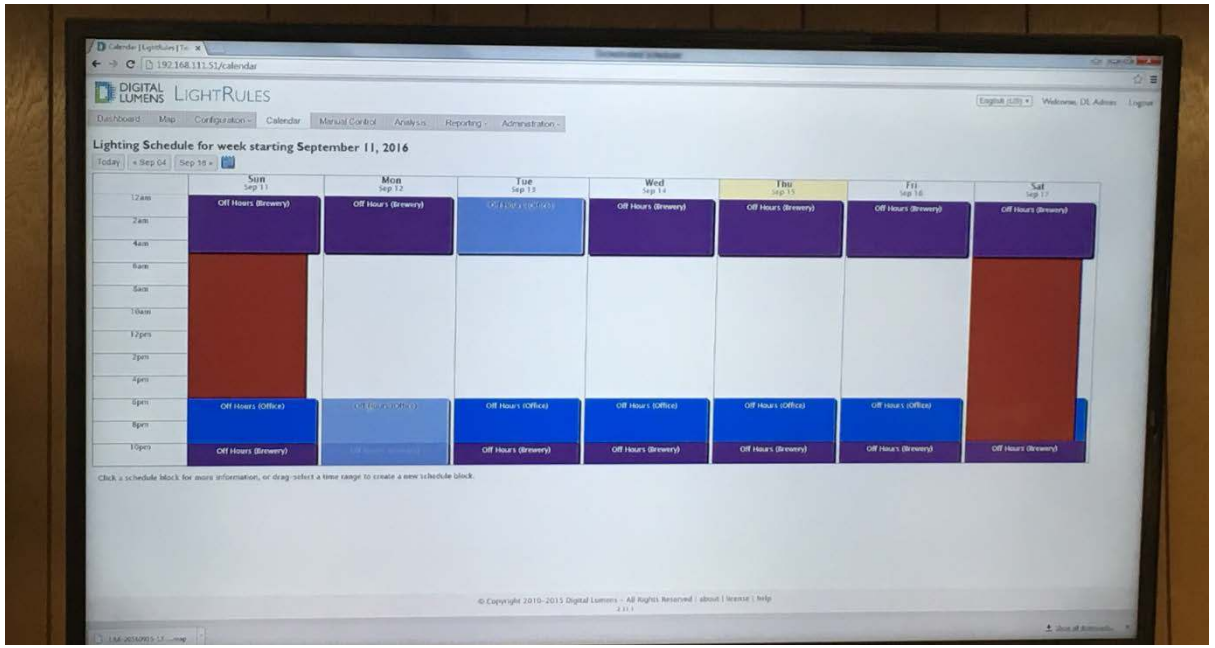
Office Areas (Integrated in Troffers)

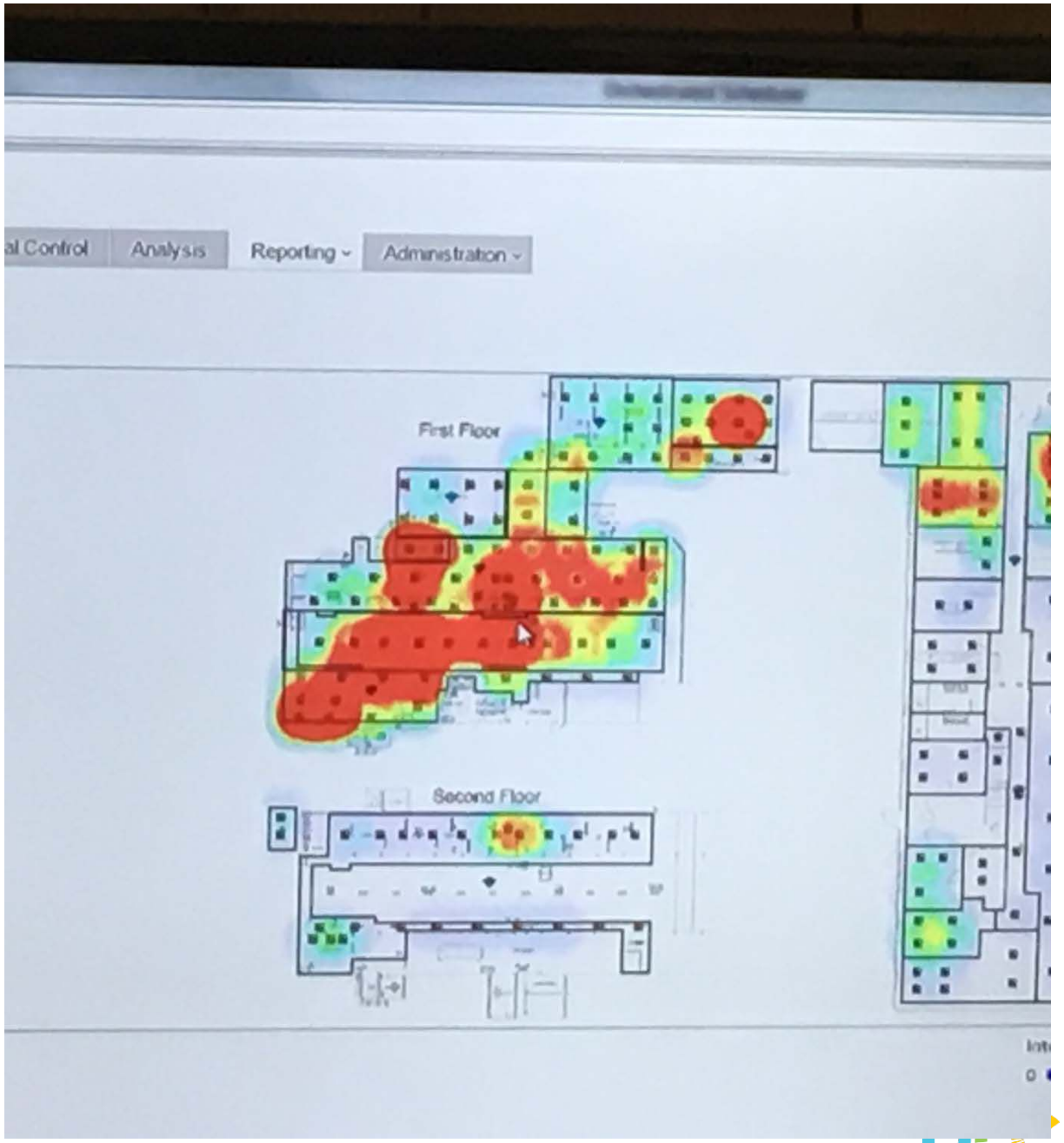
Low-Bay Areas




TWO ROADS BREWING


DIGITAL LUMENS LIGHTRULES
Dashboard
Map
Configuration
Calendar
Manual Control
Analysis
Reporting
Administration
Logout
Battery Backup Test Report


DIGITAL LUMENS LIGHTRULES
Lighting Schedule for week starting September 11, 2016
Sun
Mon
Tue
Wed
Thu
Fri
Sat
Off Hours (Brewery)
Off Hours (Office)


Analysis
Reporting
Administration
First Floor
Second Floor

State of Rhode Island
Division of Public Utilities & Carriers

Site 2: Rhode Island Public Utilities Commission

Site Characteristics

- 19,400 ft^2
- Private Office, Open Office, Conference, and Public Hearing Rooms
- Existing Lighting: Fluorescent T8
- Existing Controls: Occupancy Sensors

Technology 2: Philips SpaceWise


HEARING ROOM A
BENCH
UP
DOWN

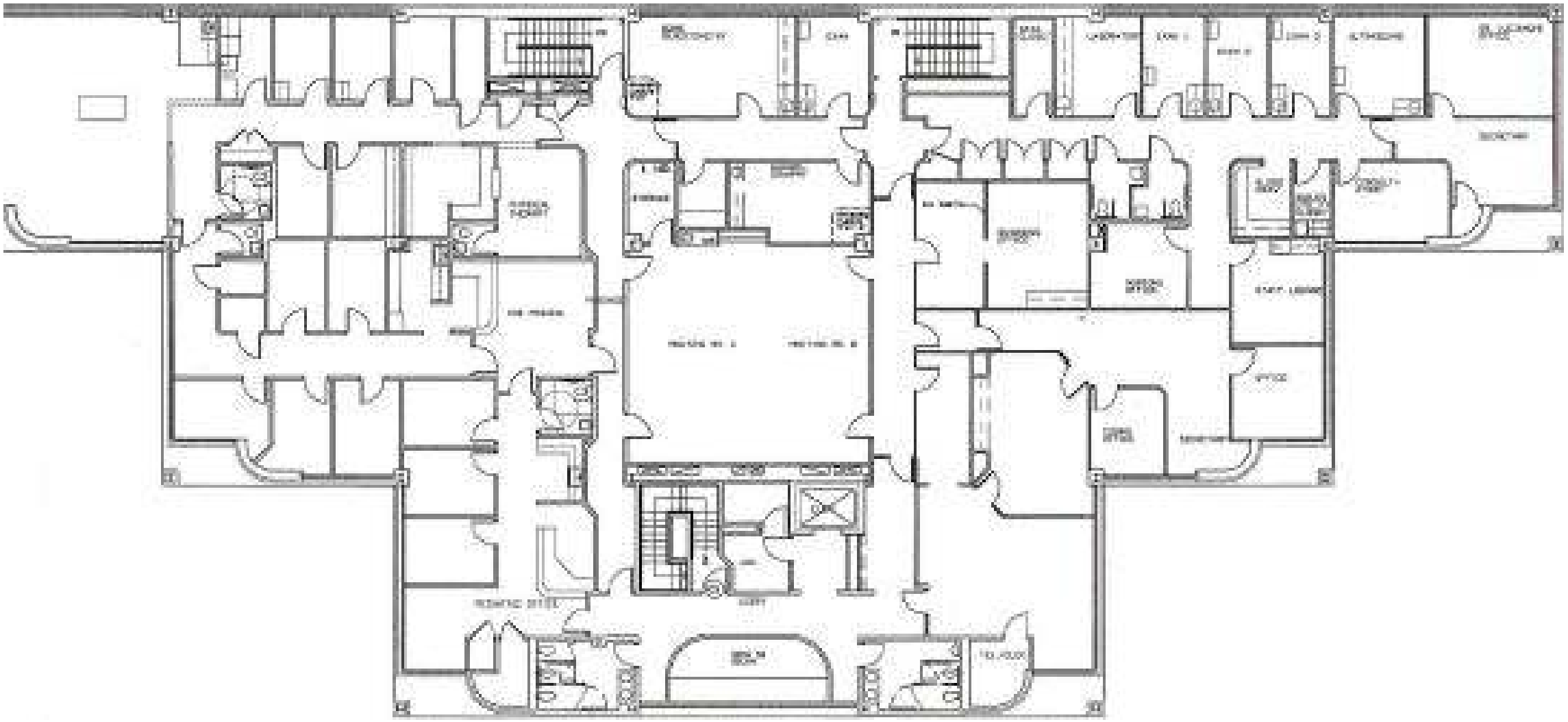

DIVISION OF PUBLIC UTILITIES AND CARRIERS
PUBLIC UTILITIES COMMISSION
STATE OF RHODE ISLAND
Visitor Parking Only
Visitor Parking Only
Visitor Parking Only

Site 3: Multi-Tenant Medical Office Avon, CT

Site Characteristics

- 30,500 ft^2
- 8 Tenants
- Primary Care, Dental, Optometry, Physical Therapy, Psychiatry
- Private Office, Open Office, Conference, Exam Rooms, Workout
- Existing Lighting: Fluorescent T8
- Existing Controls: Occupancy Sensors

Technology 3:
Cree SmartCast Wireless



Site 4: Super Stop & Shop New Bedford, MA

Site Characteristics

- 73,000 ft^2
- Full Service Grocery
- Office, Retail, Shipping / Receiving, Storage
- Existing Lighting: Fluorescent T8
- Existing Controls: None

Technology 4: Daintree Enterprise Wireless Solution

current
powered by GE

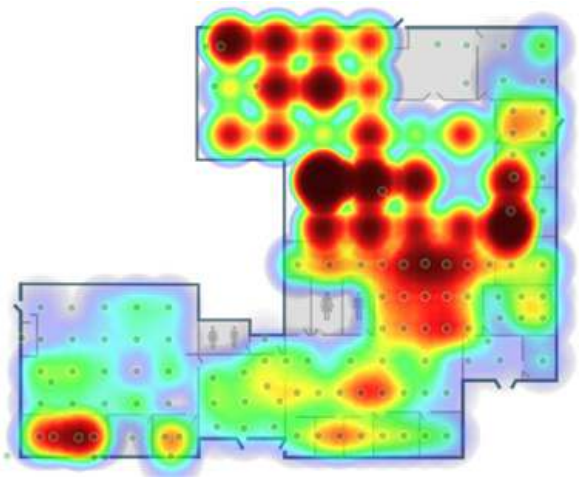

FRESH FRUIT
snacks
meals


Stop&Shop
great food

Site 5: Yale University Administration Building New Haven, CT

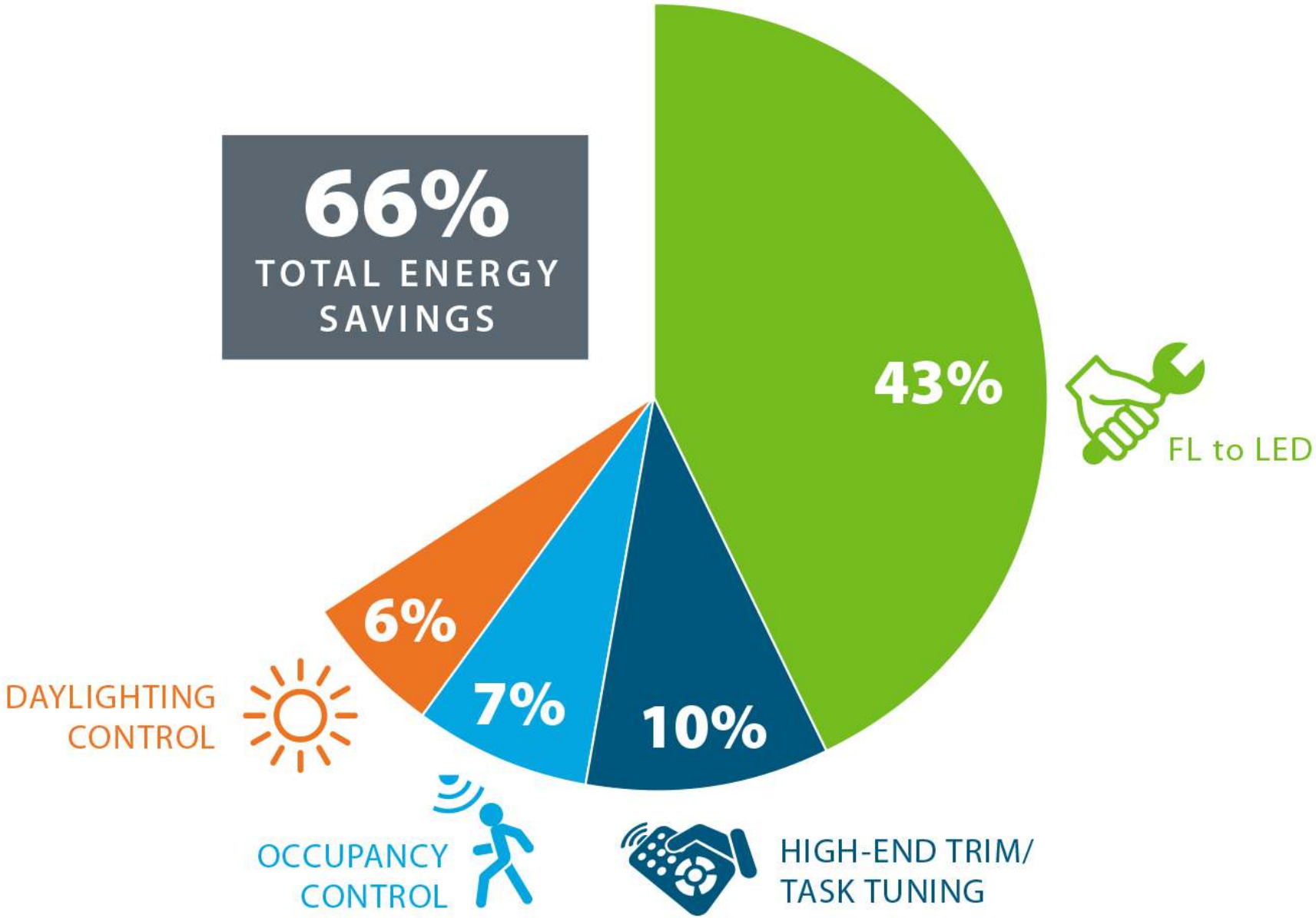
Project Characteristics

- 25,000 ft^2
- Human Resources
- Private Office, Open Office, Conference, Corridor
- Existing Lighting: Fluorescent T8
- Existing Controls: Occupancy Sensors



Technology 5: Enlighted

Findings


66%
TOTAL ENERGY SAVINGS
43%
FL to LED
6%
DAYLIGHTING CONTROL
7%
OCCUPANCY CONTROL
10%
HIGH-END TRIM/ TASK TUNING

Lighting Controls

High-End Trim / Task Tuning

31% personal tuning
36% institutional tuning

Occupancy-based

24% average energy savings

Daylight harvesting

28% average energy savings

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Lighting Controls in Commercial Buildings

Alison Williams[1*], Barbara Atkinson PE[1], Karina Garbesi PhD[1], Erik Page PE[2], and Francis Rubinstein FIES[1]

Abstract—Researchers have been quantifying energy savings from lighting controls in commercial buildings for more than 30 years. This study provides a meta-analysis of lighting energy savings identified in the literature—240 savings estimates from 88 papers and case studies, categorized into daylighting strategies, occupancy strategies, personal tuning, and institutional tuning. Beginning with an overall average of savings estimates by control strategy, successive analytical filters are added to identify potential biases introduced to the estimates by different analytical approaches. Based on this meta-analysis, the best estimates of average lighting energy savings potential are 24 percent for occupancy, 28 percent for daylighting, 31 percent for personal tuning, 36 percent for institutional tuning, and 38 percent for multiple approaches. The results also suggest that simulations significantly overestimate (by at least 10 percent) the average savings obtainable from daylighting in actual buildings.

Keywords—Energy, daylighting, occupancy sensors, controls, tuning.

1 INTRODUCTION

Lighting systems have the largest potential of any known appliance to reduce United States energy use [Desroches and Garbesi 2011]. Lighting represents approximately one-third of electricity use in commercial buildings and more than one-half in lodging and retail [DOE 2003]. As a result, there is significant interest in reducing lighting energy use through more efficient lighting systems, including controls. The National Electrical Manufacturers Association (NEMA) has argued that controls have greater potential for energy savings in major applications than do increases in source efficacies [DOE 2011b]. However, lighting controls are not incorporated in federal energy conservation standards and are only partially incorporated through state and local building codes.[†] While energy savings from some system components, such as replacing T12s with T8s, can be fairly easily quantified and guaranteed, savings from controls that turn lights off or down when not needed depend on numerous factors

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40%
TOTAL ENERGY SAVINGS
TUNING
OCCUPANCY CONTROL
DAYLIGHT

Site 1 - Brewery

	Pre-Retrofit (fc)	Post-Retrofit (fc)	Change
Site 1 (Brewery)			
Waiting Lounge	35	56	59%
Exterior Covered Storage	36	21	-41%
Front Lower Mezzanine	9	53	496%
Lunchroom	42	54	31%
Outer Office	51	55	7%
Rear Lower Mezzanine	38	55	45%
High Bay Production	13	37	188%

No tuning

Site 2 - Office

	Pre-Retrofit (fc)	Post-Retrofit (fc)	Change
Site 2 (Office)			
Open Hallway	47	38	-18%
Elevator Lobby	36	30	-18%
Open Hallway	38	32	-16%
Enclosed Hallway	11	26	147%
Lobby	19	36	85%

Tuning Energy Savings 12%

Site 3 – Medical Office

	Pre-Retrofit (fc)	Post-Retrofit (fc)	Change
Site 3 (Medical Office)			
Suite 304	63	25	-61%
Hallway	56	15	-74%
Suite 204	49	29	-40%

Tuning Energy Savings 6%

Site 4 – Retail / Grocery

	Pre-Retrofit (fc)	Post-Retrofit (fc)	Change
Site 4 (Retail/Grocery)			
Conference/Lunchroom	23	18	-23%
Floral Shop	64	33	-49%
Central Storage	18	15	-15%
Cracker/Juice Aisle	46	39	-15%
Juice Shelves (vertical)	38	41	7%

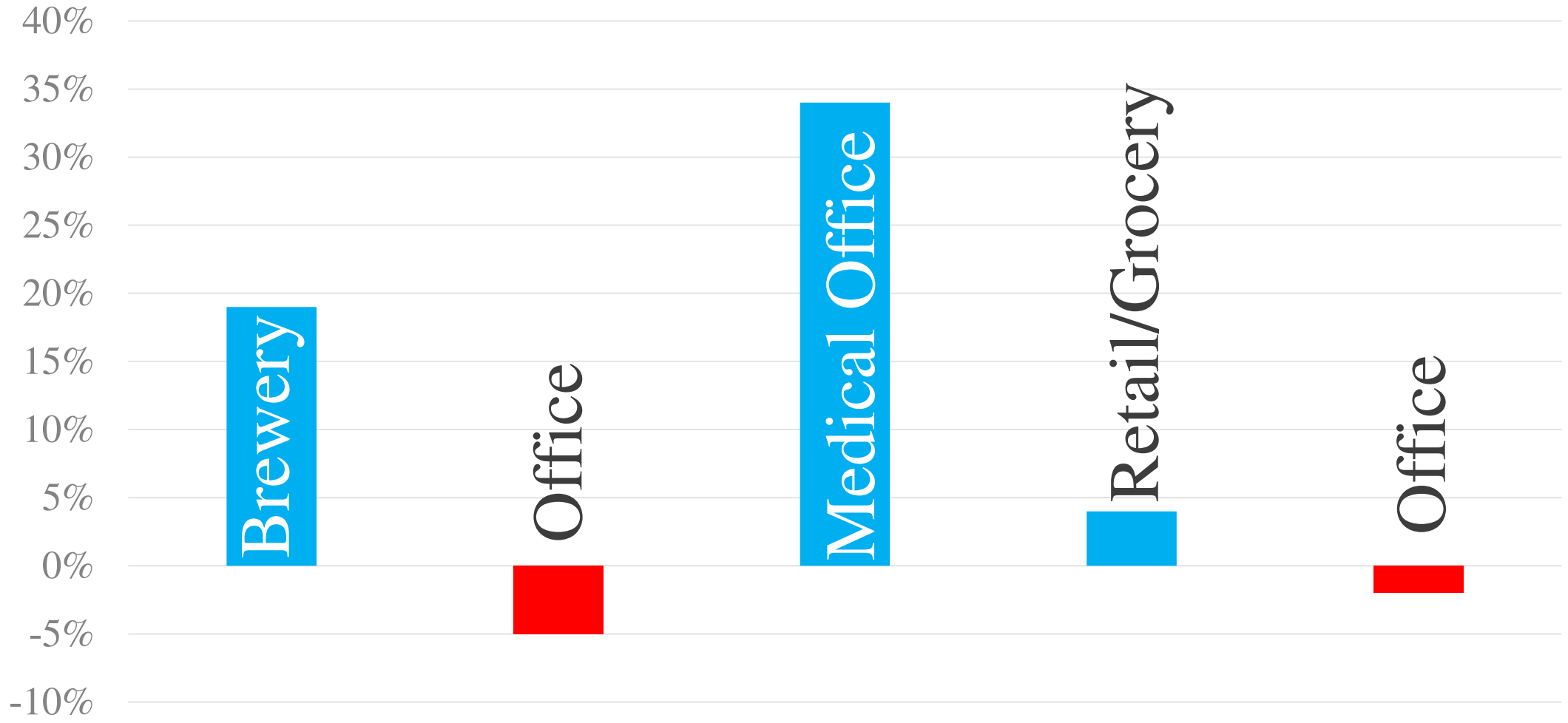
Tuning Energy Savings 47%

Site 5 – Office

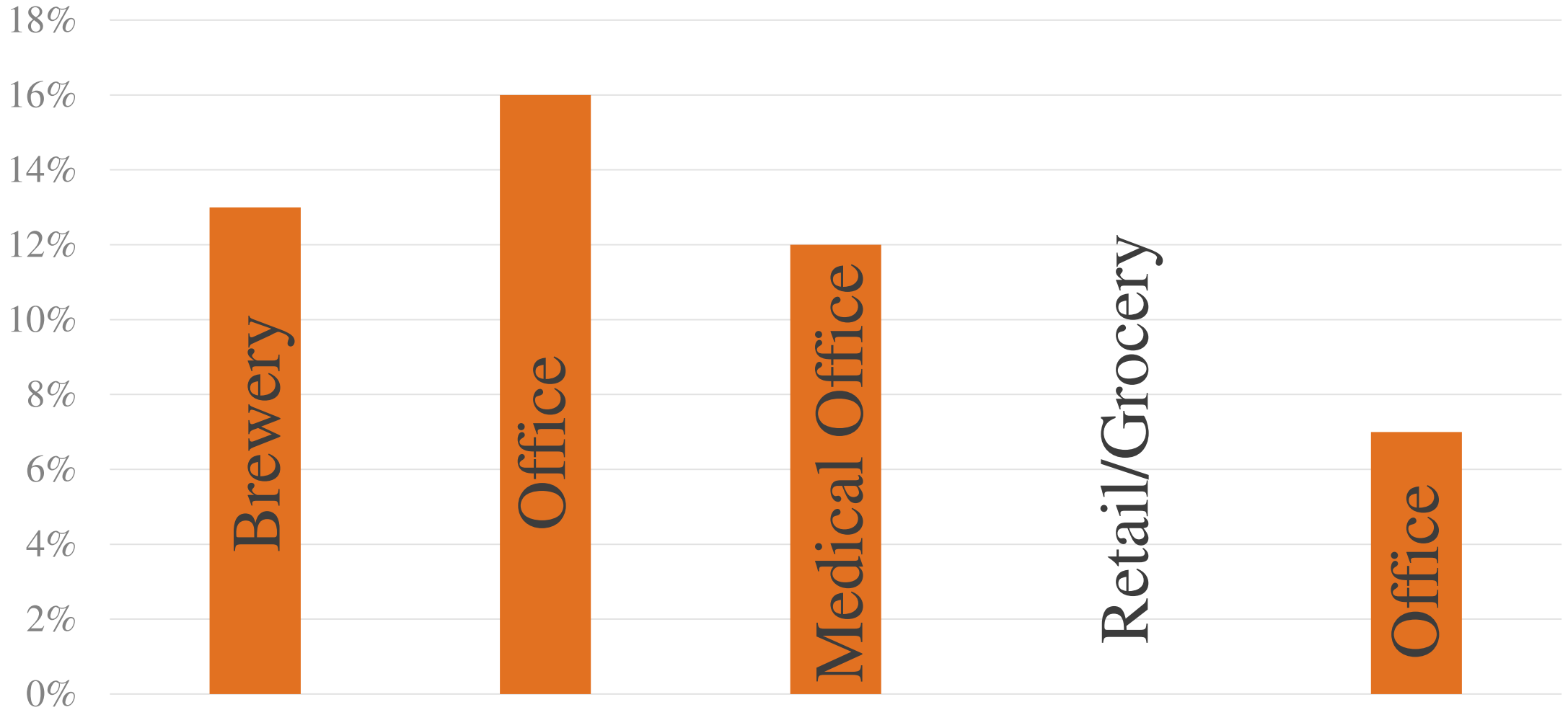
	Pre-Retrofit (fc)	Post-Retrofit (fc)	Change
Site 5 (Office)			
Open Office	32	44	38%
Meeting Room	62	45	-27%

Tuning Energy Savings 43%

Occupancy Sensor Savings



Daylighting Savings

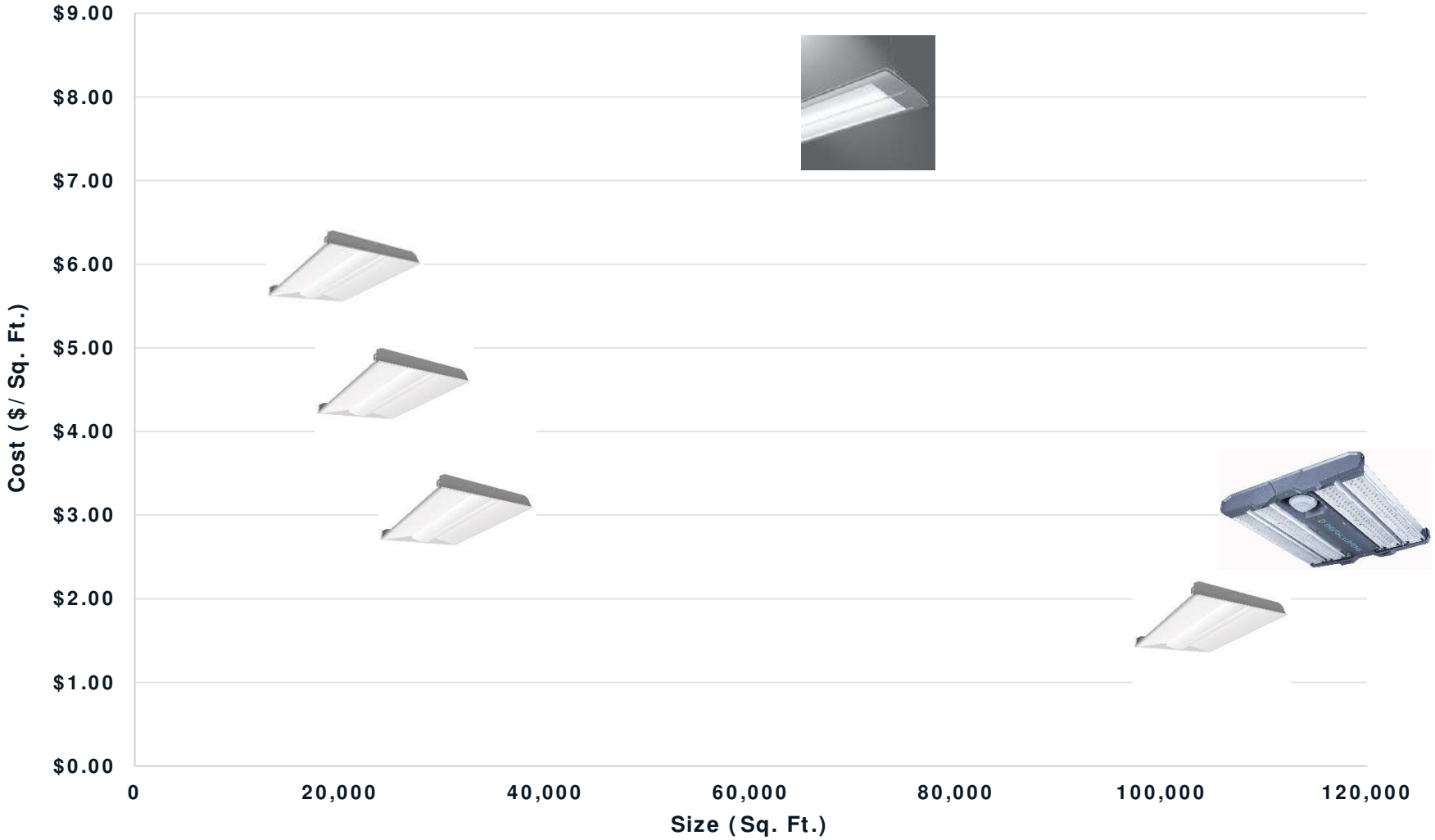


Daylighting Savings

Cost Effectiveness

Site	Fixture Type	Site Size (sq. ft.)	Installed Cost Without Rebate		Installed Cost With Rebate	
			Total	Per Sq. Ft	Total	Per Sq. Ft
1 – Brewery	High bays and troffers	103,000	$158,489	$1.54	$95,093	$0.92
2 – Office	Troffers	19,400	$110,900	$5.72	$69,900	$3.60
3 – Medical Office	Troffers	30,500	$92,500	$3.03	$54,550	$1.79
4 – Retail/ Grocery	Linear direct/indirect pendants	73,000	$583,061	$7.99	$490,808	$6.72
5 – Office	Troffers	25,000	$116,600	$4.66	$67,600	$2.70

Cost Effectiveness



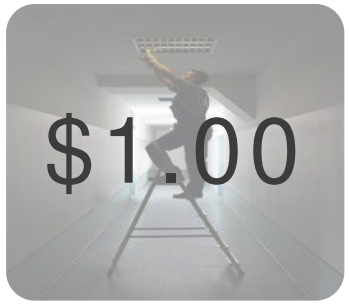
Cost Effectiveness

Site	Annual Energy Savings		SPB/ SIR Without Rebate		Product Life	SPB/ SIR With Rebate	
	(kWh)	$	SPB (years)	SIR	Years	SPB (years)	SIR
1 – Brewery	95,000	$13,800	11.5	1.74	20.0	6.9	2.90
2 – Office	39,500	$4,700	23.6	0.85	20.0	14.9	1.34
3 – Medical Office	69,000	$8,200	11.3	1.77	20.0	6.7	3.01
4 – Retail/ Grocery	439,300	$65,985	8.8	2.26	20.0	7.4	2.69
5 – Office	34,600	$5,190	22.5	0.89	20.0	13.0	1.54

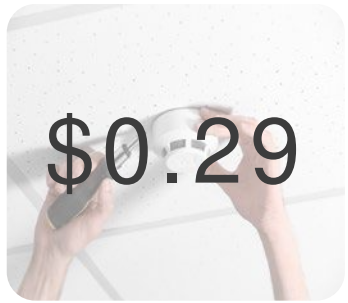
Cost Effectiveness – Site 2 Office

$5.72 /sq. ft

Fixture



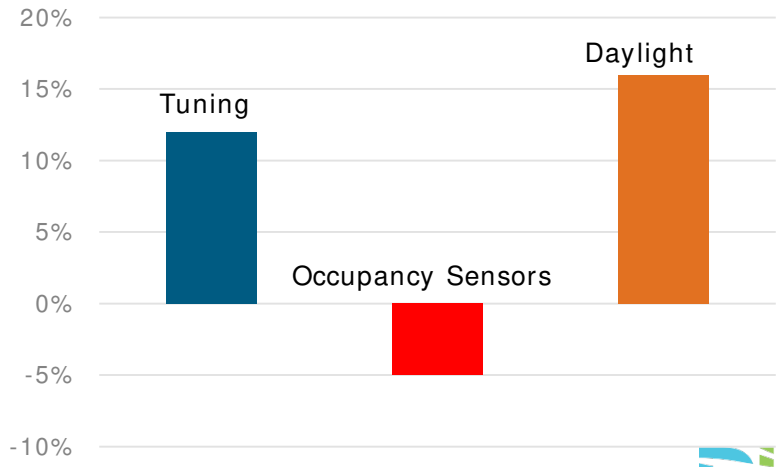
Controls



$4,700 energy savings
$4,512 lighting
$188 controls

$8,467 Controls
(materials and labor)

45 years simple payback



Cost Effectiveness – Site 3 Medical Office

$3.03 /sq. ft.

Fixture

$2.80

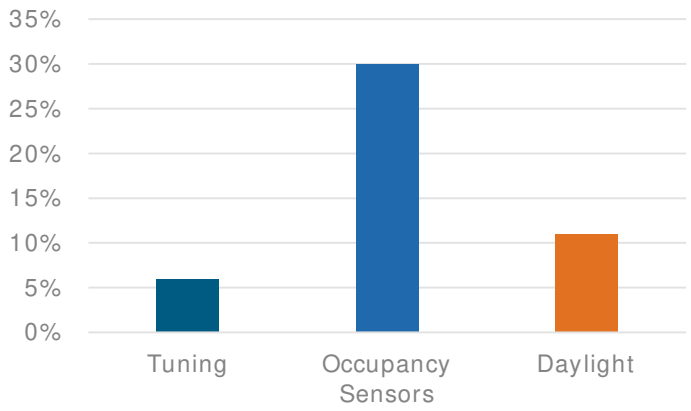
Controls

$0.23

$8,200 energy savings
- $3,840 lighting
- $4,370 controls

$6,423 Controls 1st Cost (materials and labor)

1.5 years simple payback for the controls



Cost Effectiveness – Site 4 Retail/ Grocery

$7.99 /sq. ft.

Fixture

$3.42

$3.22

Controls

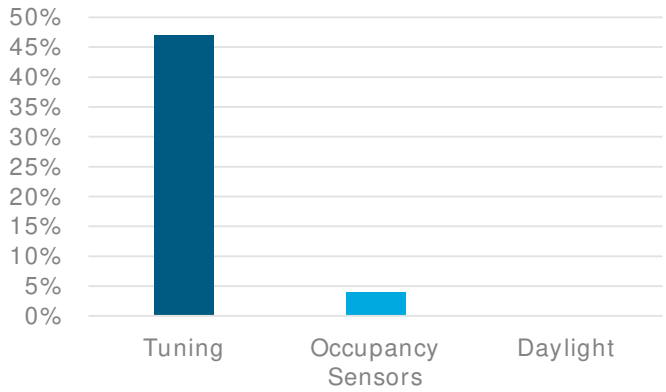
$1.03

$0.31

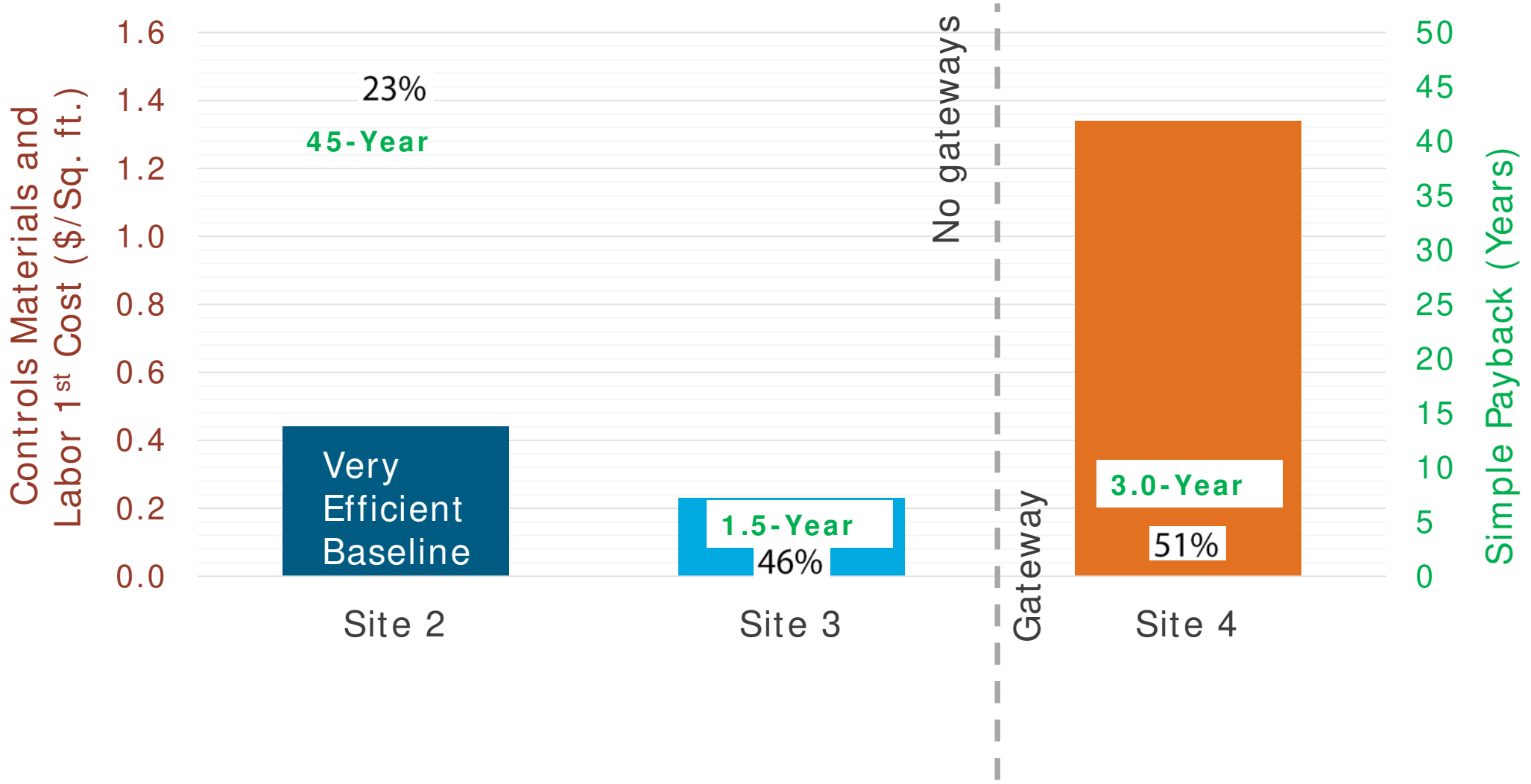
$65,985 energy savings
$30,353 lighting
$35,991 controls

$108,603 Controls
(materials and labor)

3 years simple payback



1st Costs, Simple Payback, & Energy Savings



Lighting during Time-of-Day

Site	Lighting Condition	Morning lighting is too bright or too dim at times.	Afternoon lighting is too bright or too dim at times.	Nighttime lighting is too bright or too dim at times.
1 – Brewery	Before	26%	15%	28%
	After	0%	0%	11%
2 – Office	Before	26%	23%	---
	After	22%	17%	---
3 – Medical Office	Before	---	---	---
	After	21%	21%	---
4 – Retail/ Grocery	Before	---	---	---
	After	---	---	---
5 – Office	Before	24%	29%	---
	After	38%	21%	---
Weighted (by response)	Before	26%	22%	28%
Average	After	22%	18%	11%

Lighting Conditions

Site	Lighting Condition	Neutral or very satisfied with brightness of lighting.	Neutral or very satisfied with automatic control of lighting.	Neutral or very satisfied with overall lighting conditions.
1 – Brewery	Before	81%	81%	85%
	After	89%	89%	100%
2 – Office	Before	78%	59%	89%
	After	100%	87%	96%
3 – Medical Office	Before	---	---	---
	After	89%	86%	86%
4 – Retail/ Grocery	Before	---	---	---
	After	---	---	---
5 – Office	Before	89%	85%	100%
	After	79%	71%	85%
Weighted (by response)	Before	82%	72%	90%
Average	After	91%	84%	90%

Lessons Learned

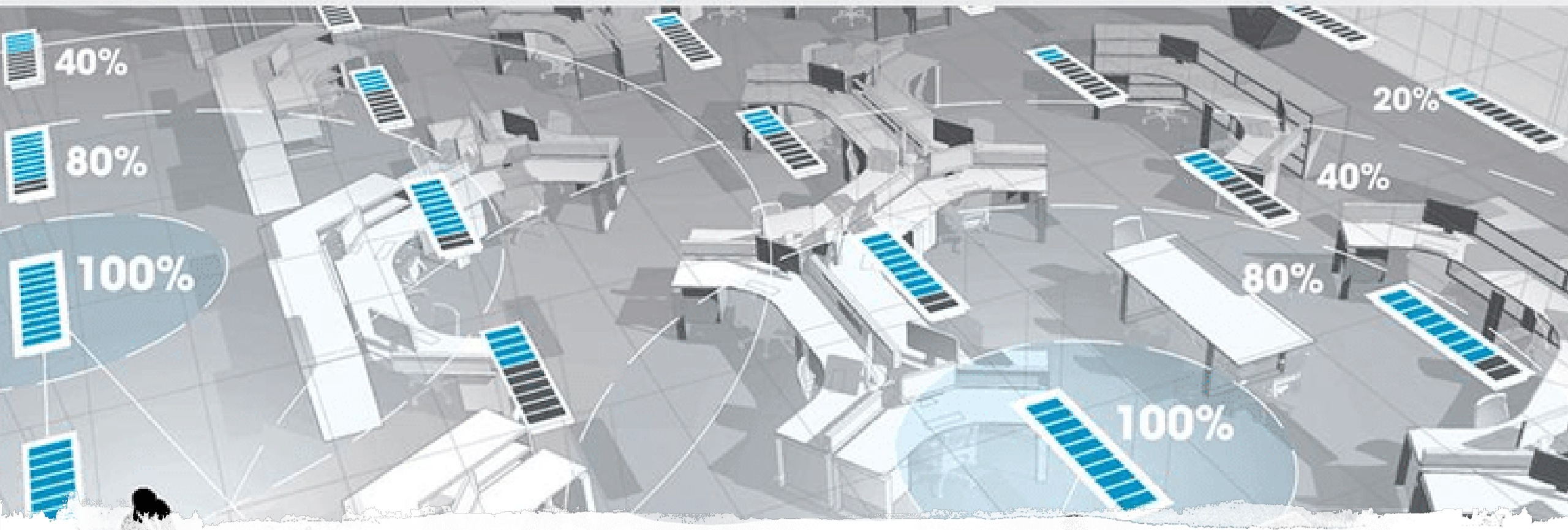


Image Credit: organic response by ORTechnologies

Occupancy Sensors

New operational profiles with advanced digital controls may *increase* energy use relative to traditional occupancy sensors – but may improve occupant satisfaction

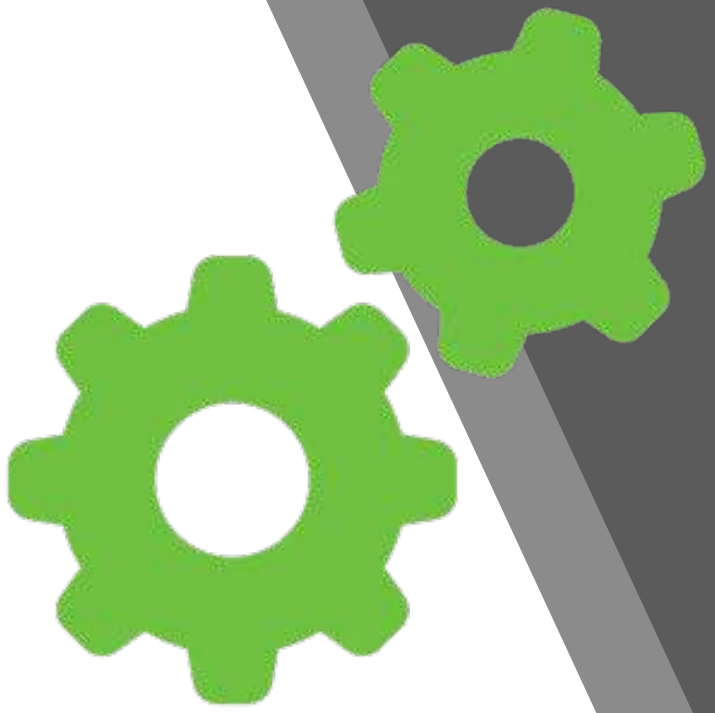
Occupancy Sensors

Some users prefer or need manual control of lighting. With integrated sensor solutions, additional wireless switches or other methods to enable occupant control should be considered.

QA/ QC and Compatibility Testing

- Two projects experienced technical issues after the installation that eventually required replacement of drivers
- Traced to 2 problems:
  - Manufacturing defects in driver/control connections
  - Substituted drivers contributed electrical “noise” that caused problems with the control system

What we can do



Manufacturers

- Improve QA/QC of products to address manufacturing defects
- Improve compatibility testing of control and luminaire components

Lighting Industry

- Develop and support industry standards to ensure compatibility and interoperability

Cost-Effectiveness

While these projects are not necessarily representative of typical costs today…

- 2-3 years ago, brand new technology
- Not competitively bid
- Contractors unfamiliar with systems

…we need to continue to tackle cost barriers and better communicate the value proposition of networked lighting controls

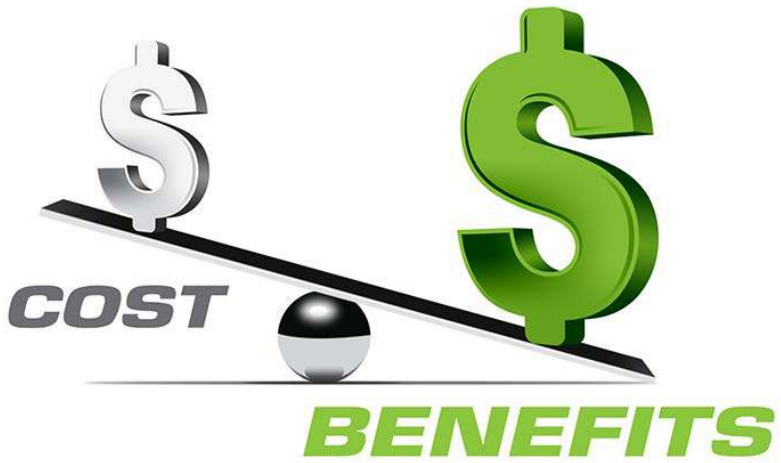
Cost-Effectiveness

What we can do

- Integrated or Pre-Installed Controls to reduce installation costs
- Standards and Standardization to reduce hardware and installation costs
- Education & training of installers to reduce installation costs

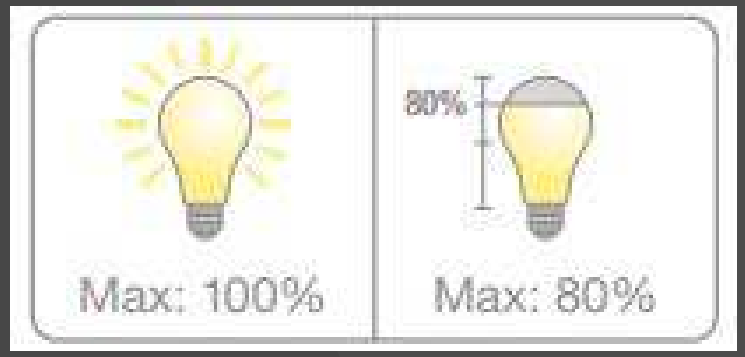
Cost-Effectiveness – What we can do

- Quantify, communicate, and sell other benefits
  - Networked lighting controls can improve lighting quality
  - Better lighting quality can improve productivity, wellbeing; create better environments for employees and customers
  - Smarter management of system, buildings, processes, and people



Graphic courtesy of Sieben Energy Associates

Task Tuning / High-End Trim



- LEDs paired with advanced controls brings ability to tune lighting to occupant or task needs
- Can save significant energy while improving quality of light
- Tuning of lighting at the time of installation is a new practice that is not widely implemented

Task Tuning / High-End Trim

What we can do

Manufacturers

- Incorporate this task tuning as standard step into your configuration apps and software

Contractors

- Include task tuning as standard step of installation – don't forget your light meter

Specifiers, Procurement, End-users

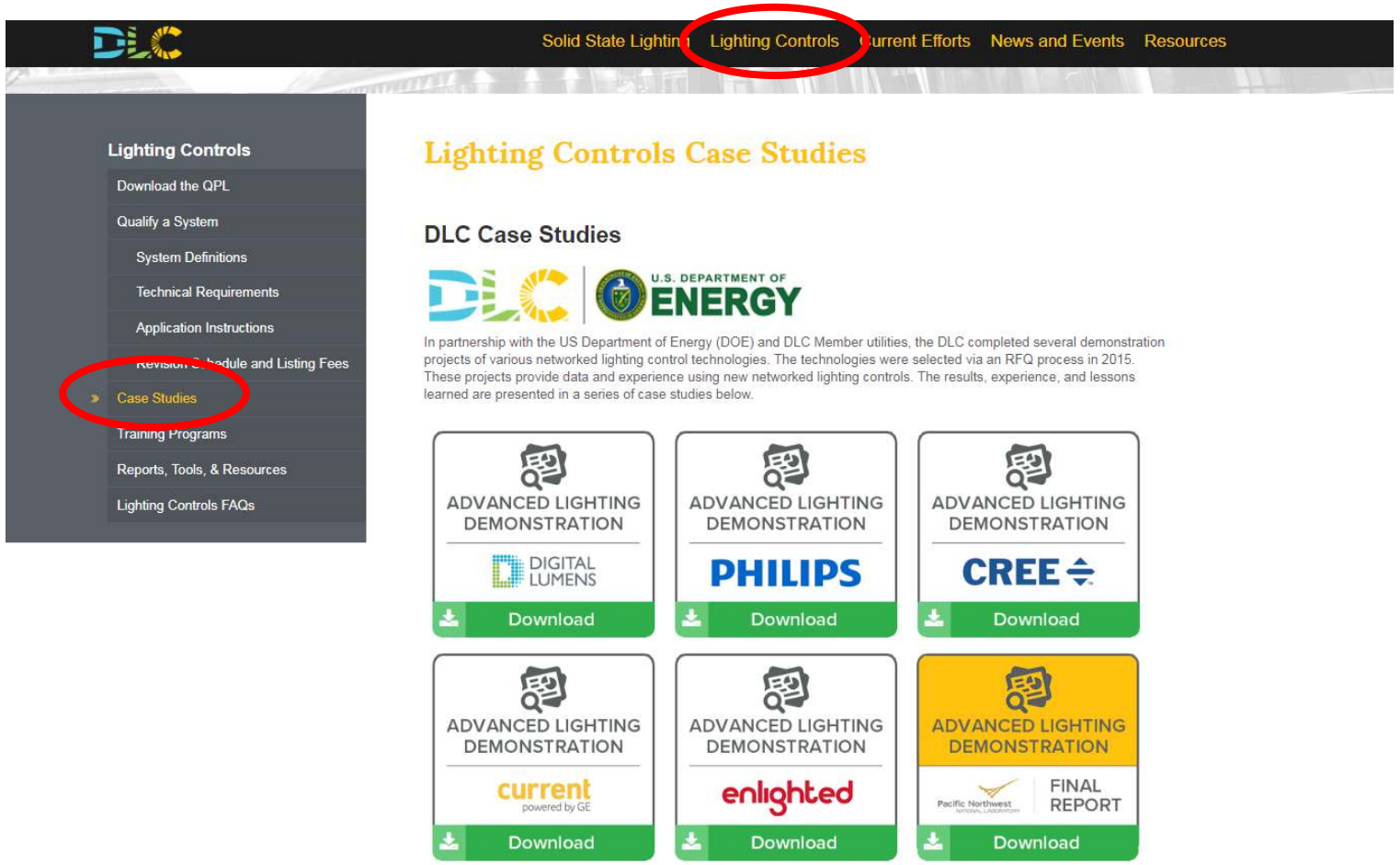
- Require task tuning in your specs, include in punchlists

Utilities

- Support task tuning in your programs, consider providing rebates or financial incentives for implementation of task tuning

Where to Find the Report

www.designlights.org



Q&A