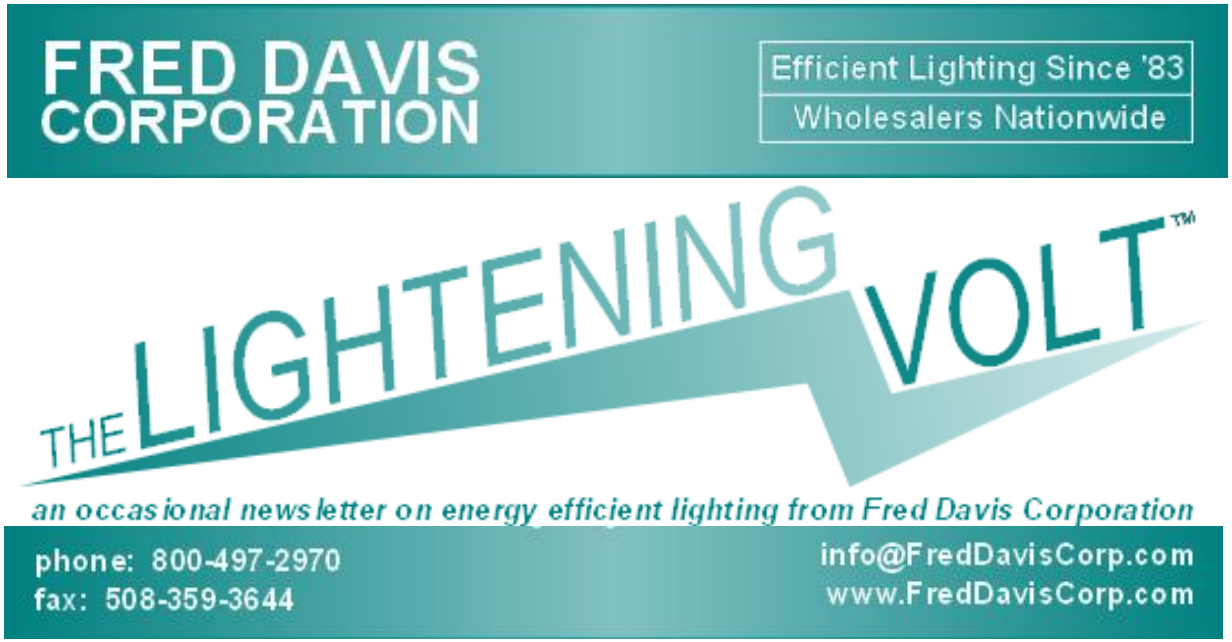
Fred Davis Lighting Sessions Moderator

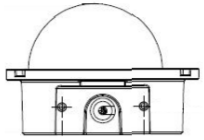
NESEA
BuildingEnergy 2015
WTC, Boston



Please subscribe to our free occasional e-newsletter on developments in efficient lighting

...and stop by our booth.

Introductory Lighting Glossary



L.E.D. = Light Emitting Diode: a semiconductor device, as are computer chip and PV cell.

Lumen = unit of visible light power (output)

Watt = unit of power (input)

LPW = lumen per watt = unit of efficiency (lamp efficacy)

Light bulb =

screw-in bulb
general purpose lamp
A-lamp with medium E26 base or its equivalent

(presume all of these refer more or less to the same thing)

Energy Conservation Measures:

how many do you see?

very-low-carbon ECMs:

timepiece

lapwarmer

very-low-carbon ECMs:

timepiece

lapwarmer

Lighting ECM

location: Eastern Mass.
date: all of February, 2015
available: dawn-dusk daily

light source: diffuse, low-angle
CRI: 100

measure: increase reflectivity
of surround
from ~10% to ~80%
refresh every 2-4 days

turn off electric lights

Price: no-cost

carbon: **zero carbon!**

1987 NESEA Conference

- <u>Some of the names</u>

- Amory Lovins
- Rudy Verderber
- John Fetters
- Jim Grady
- Harvey Bryan
- Ellyn Eder
- Karl Gee
- David Goldstein
- Dennis Mallett
- Lynn Goldfarb
- Steve Nadel
- Glenn Reed
- Robert Sardinsky
- Alex Wilson
- George Wood

<u>Some of the topics</u>

CFLs

Daylighting

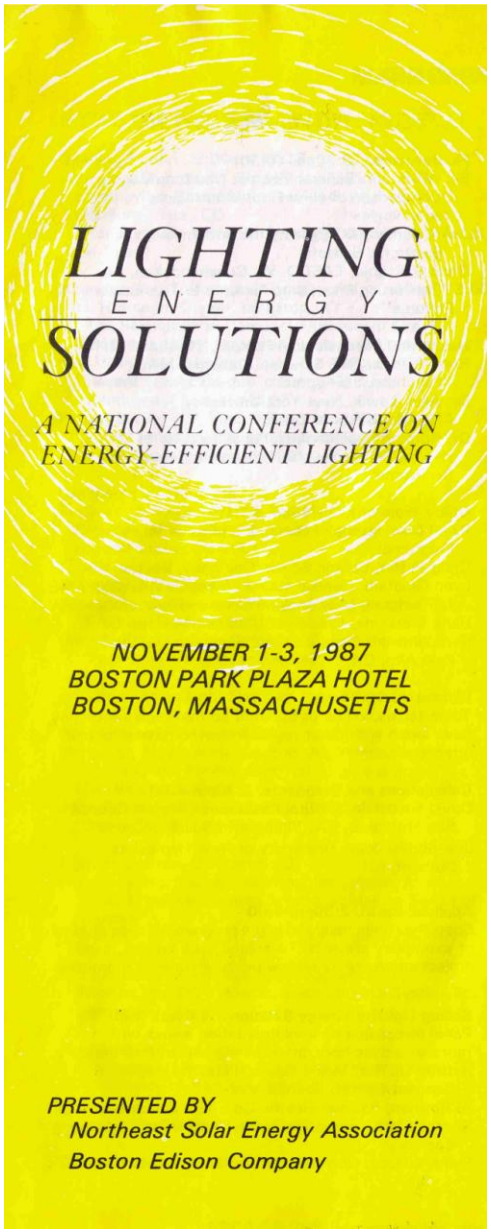
Controls

Electronic Ballasts

Utility Programs

Standards

NOT LEDs!

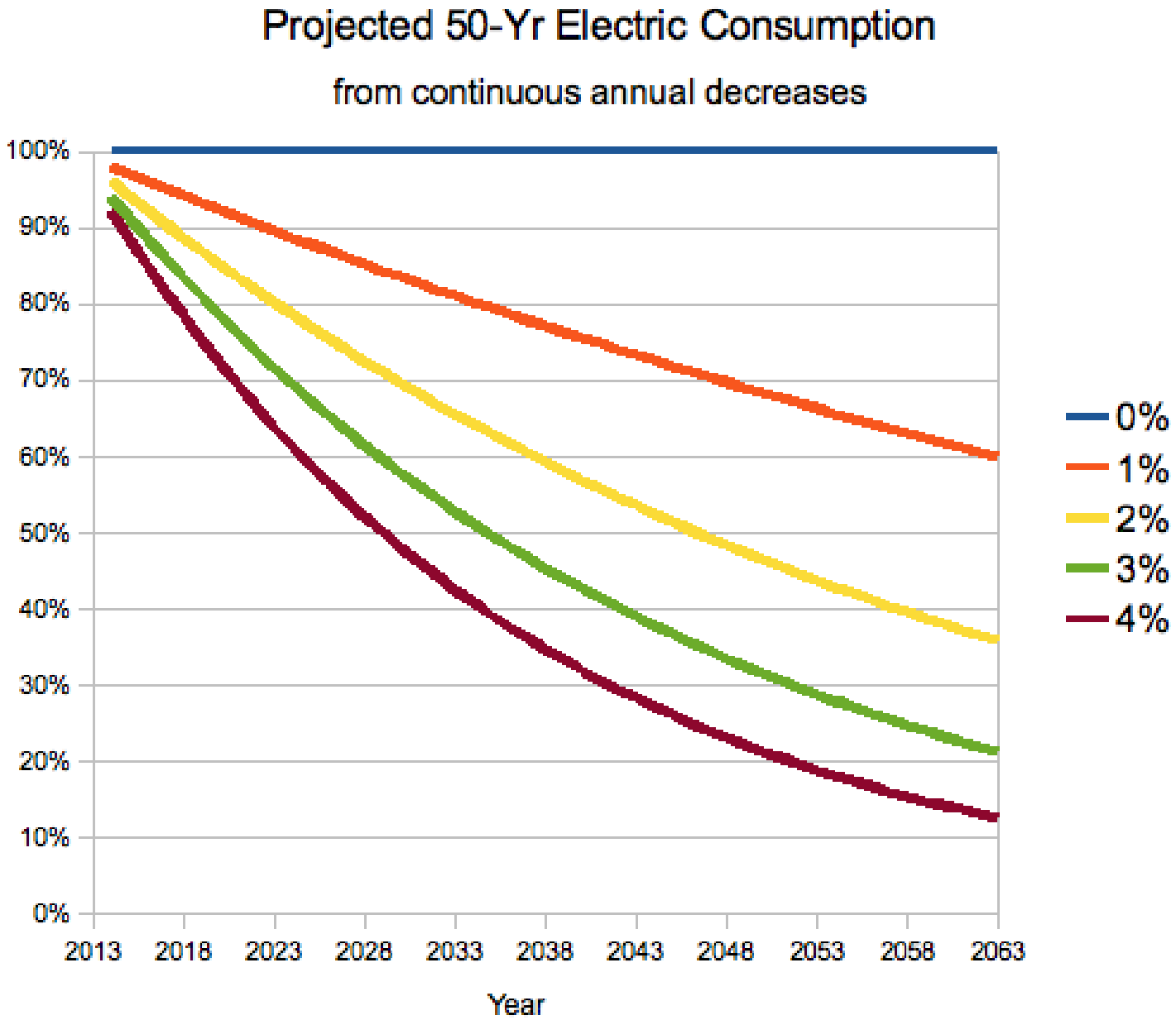


We must reduce use of fossil fuels 80% by 2050.

It is up to all of us.

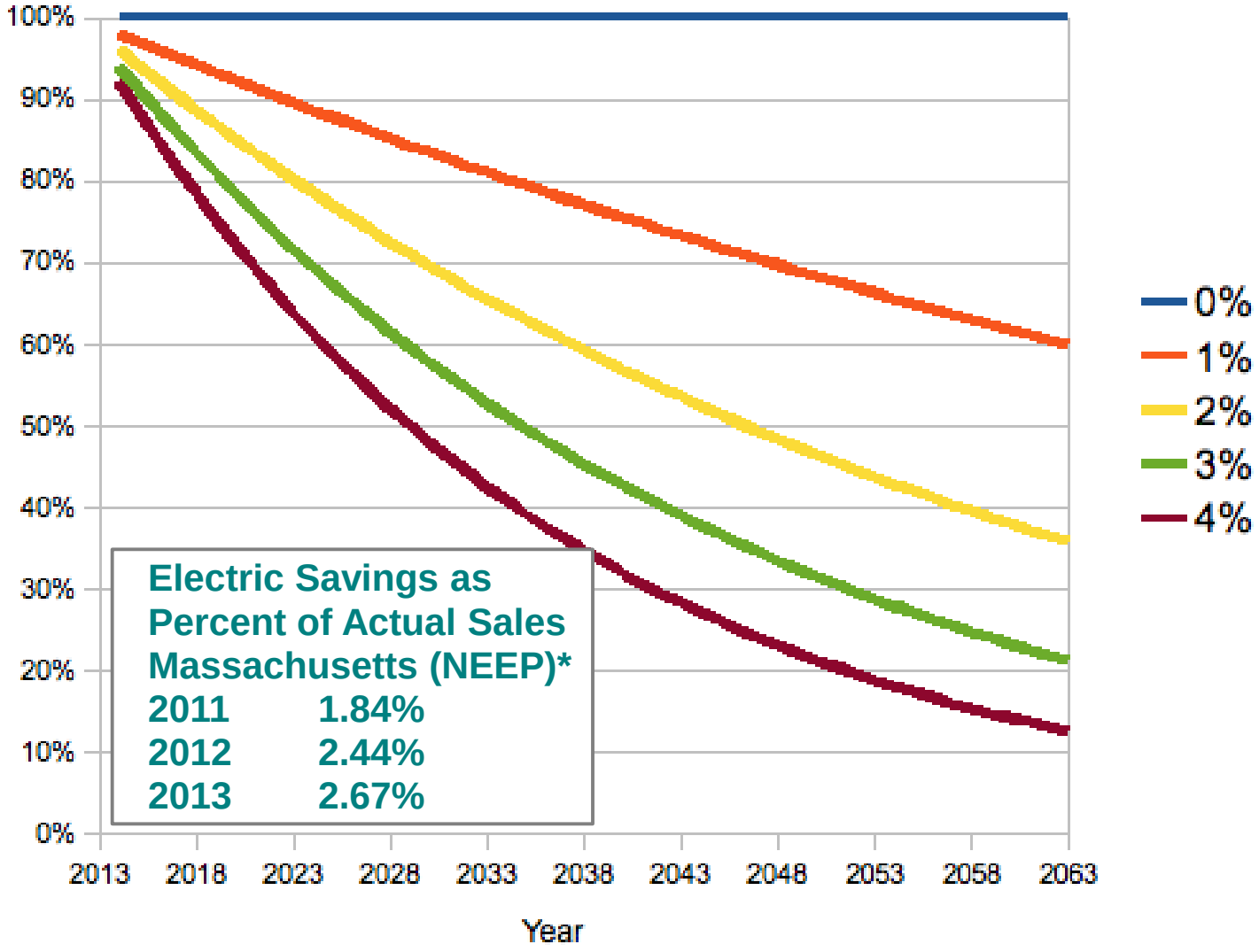
We must save 80% by 2050.

Anyone know how to do that?


Projected 50-Yr Electric Consumption
from continuous annual decreases
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
2013
2018
2023
2028
2033
2038
2043
2048
2053
2058
2063
Year
0%
1%
2%
3%
4%

Projected 50-Yr Electric Consumption

from continuous annual decreases



* Gross Annual Energy Savings Electric Meter Level
Northeast Energy Efficiency Partnerships, Inc. Regional Energy Efficiency Database. Retrieved 2/26/15,from www.neep-reed.org

Fred's Formidable Formula:

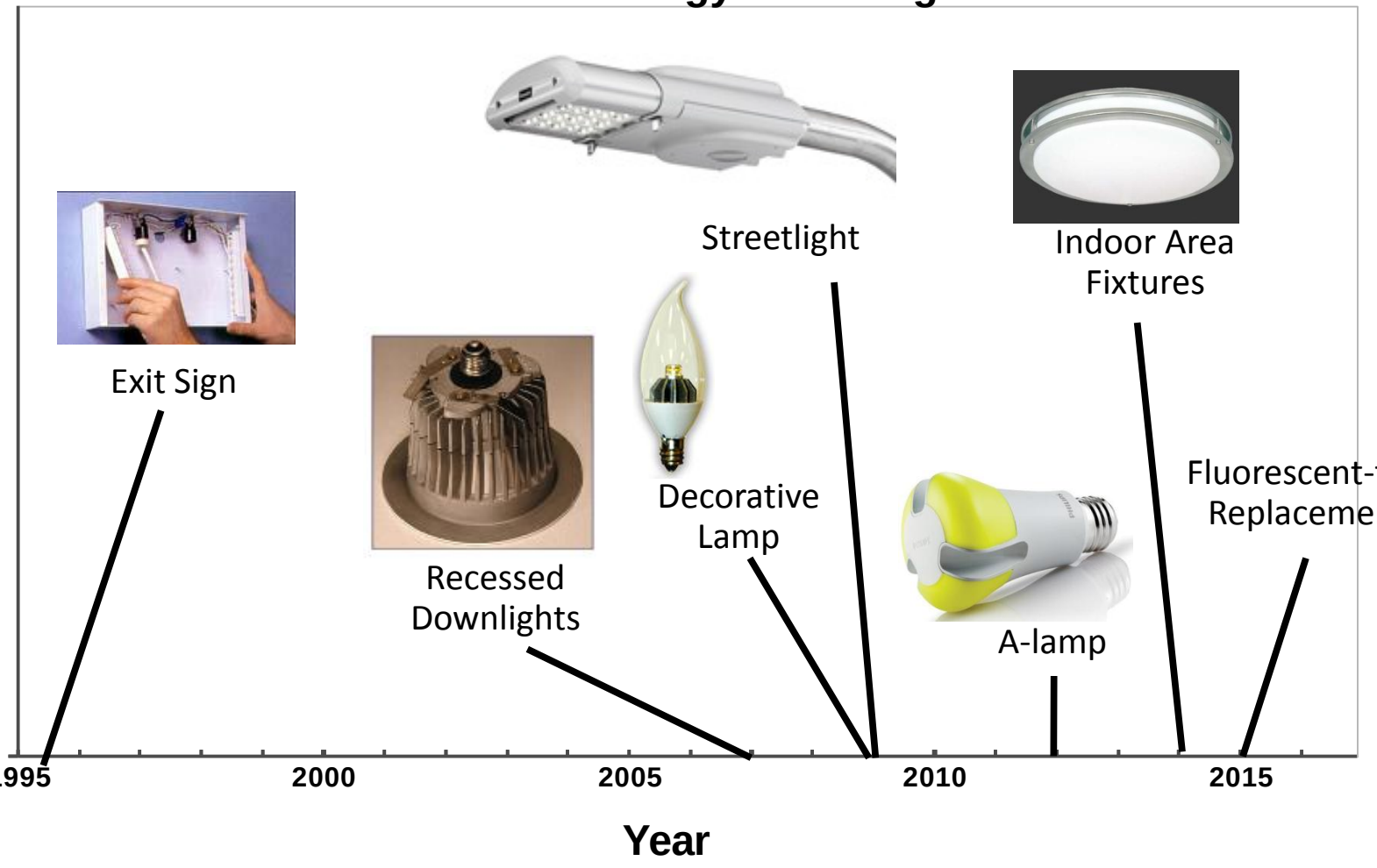
If efficiency doubles,

and amenity halves,

that's a net 75% reduction.

History of LED Fixture Advances

Approximately When LED Application First Became Energy-Advantageous



History of LED Fixture Advances

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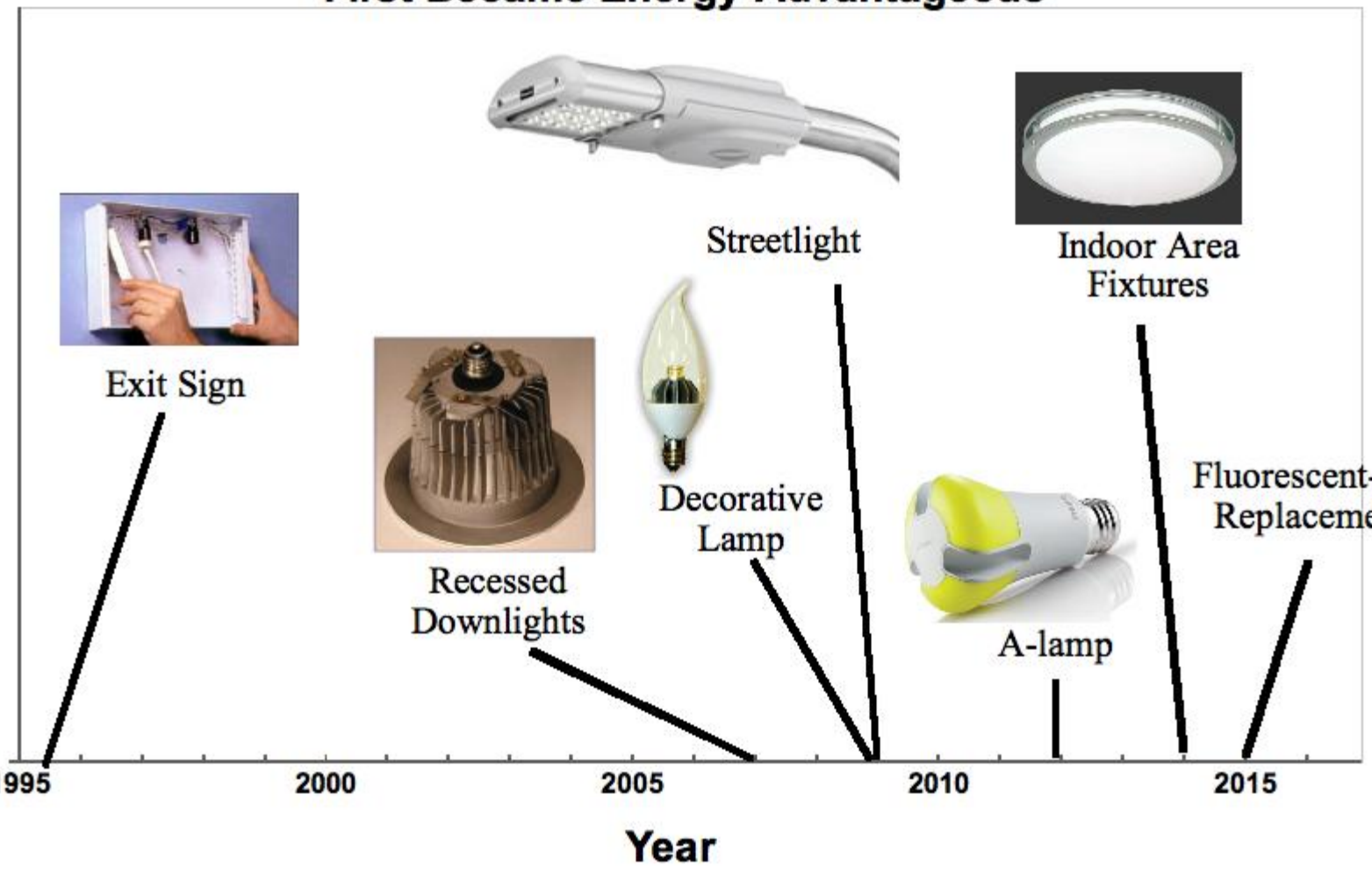
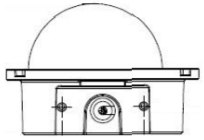


We must reduce use of fossil fuels 80% by 2050.

Let's implement.

Introductory Lighting Glossary



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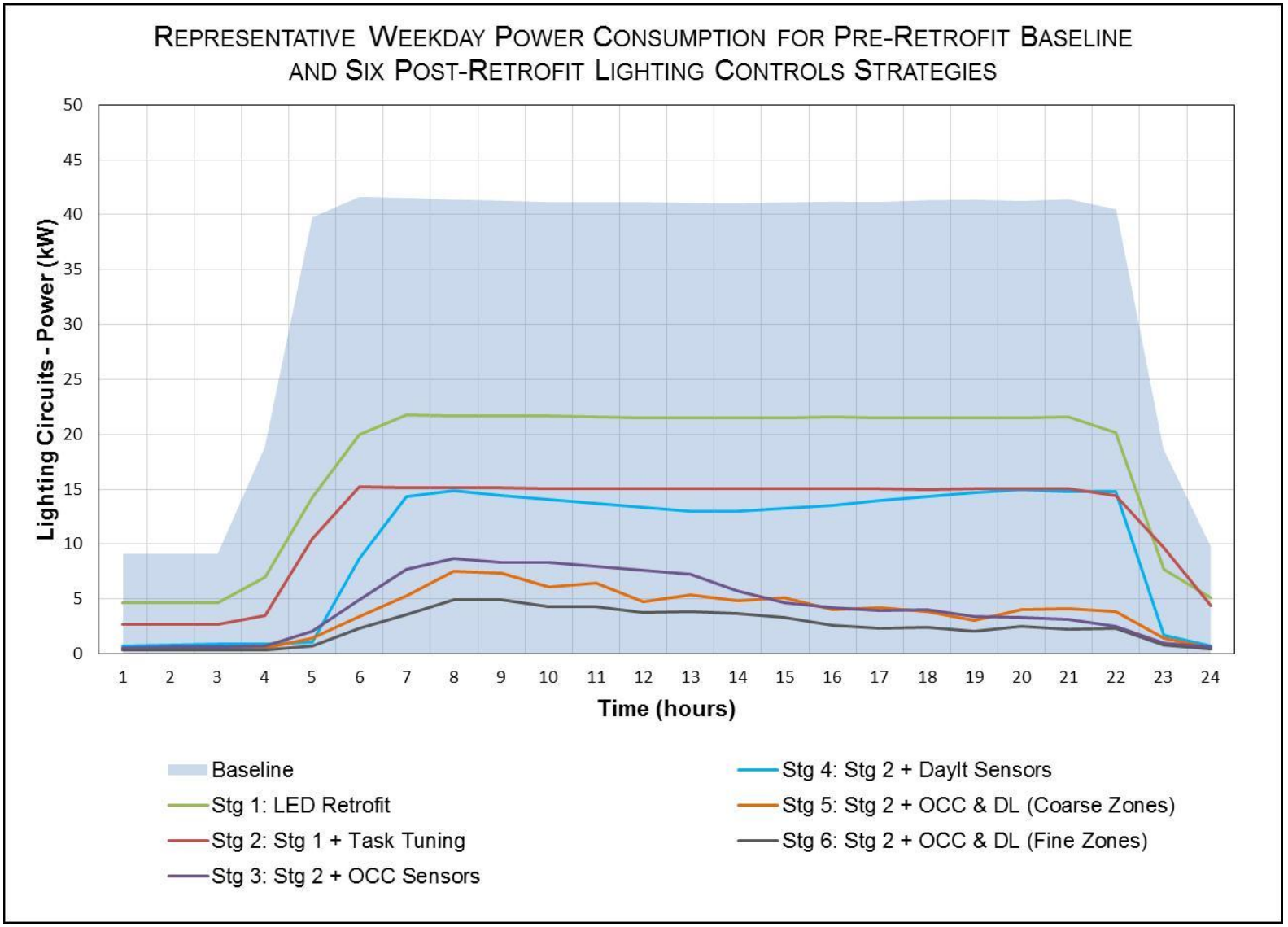
LED Hi-Bay with Controls

LED Hi-Bay with Controls



PG&E Ace Hardware Project, September 2014

LED Hi-Bay with Controls

TABLE OF SIMPLE PAYBACK CALCULATIONS FOR ALL SIX STRATEGIES

	ESTIMATED ANNUAL ENERGY USE (KWH)	ESTIMATED ANNUAL ENERGY COST ($)	SIMPLE PAYBACK (YEARS)	PAYBACK WITH MAINTENANCE ($15,000) (YEARS)
Fully-Operational	254,973	$35,299	---	---
Strategy #1	129,603	$17,942	6.8	3.6
Strategy #2	92,038	$12,742	5.2	3.1
Strategy #3	29,388	$4,068	3.8	2.6
Strategy #4	71,638	$9,918	4.6	2.9
Strategy #5	25,653	$3,551	3.7	2.5
Strategy #6	16,929	$2,344	3.6	2.5

LED Hi-Bay with Controls

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Strategy #1	129,603	$17,942	6.8	3.6	49%
Strategy #2	92,038	$12,742	5.2	3.1	64%
Strategy #3	29,388	$4,068	3.8	2.6	88%
Strategy #4	71,638	$9,918	4.6	2.9	72%
Strategy #5	25,653	$3,551	3.7	2.5	90%
Strategy #6	16,929	$2,344	3.6	2.5	93%

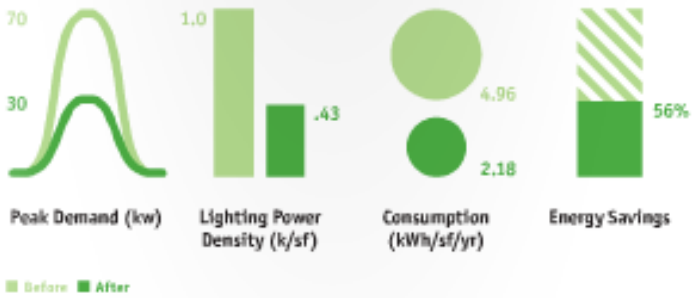
Complicated Office Lighting Retrofit

SAVINGS & STRATEGIES

Project Type	Commercial Interior
Location	Midtown Manhattan, NYC
Year of Project completion	2012
Base building completed	2003
Project Size	70,000 sf
Occupied during the retrofit?	Yes

PRIMARY ENERGY FIGURES

Simple payback: 3.6 years
Annual return on investment: 28%



STRATEGIES

- Addressable, fully dimmable fixtures
- Wireless daylight sensors
- Wireless motions sensors
- Central, web-based control system
- Light tuning capability
- LED downlights (lobbies)
- Fluorescent fixtures (general)

BENEFITS

- Eliminates lighting of unoccupied spaces
- Reduces lighting loads
- Increases occupant comfort
- Lighting dims when daylight is sufficient
- Custom tuning for specific needs
- Centralized, web-based control
- Significant peak demand reductions
- Demand response program eligible

Conclusion

Lighting retrofits are often billed as simple and straightforward, but if Related's experience is a guide they can be complicated and require significant amounts of attention. Despite these challenges the retrofit has resulted in significant energy savings and functionality that has made the effort very much worthwhile.

Less energy, more technicians?

Think Carbon Tax....!

Related Companies Office Lighting Retrofit, May 2014

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Brian Chemel
Founder & CTO

BuildingEnergy Boston – 5 March 2015

Accelerating the LED Revolution

A little bit about me

THE ROBOTICS INSTITUTE
Carnegie Mellon

1996-2000

COLOR KINETICS™

2000-2008

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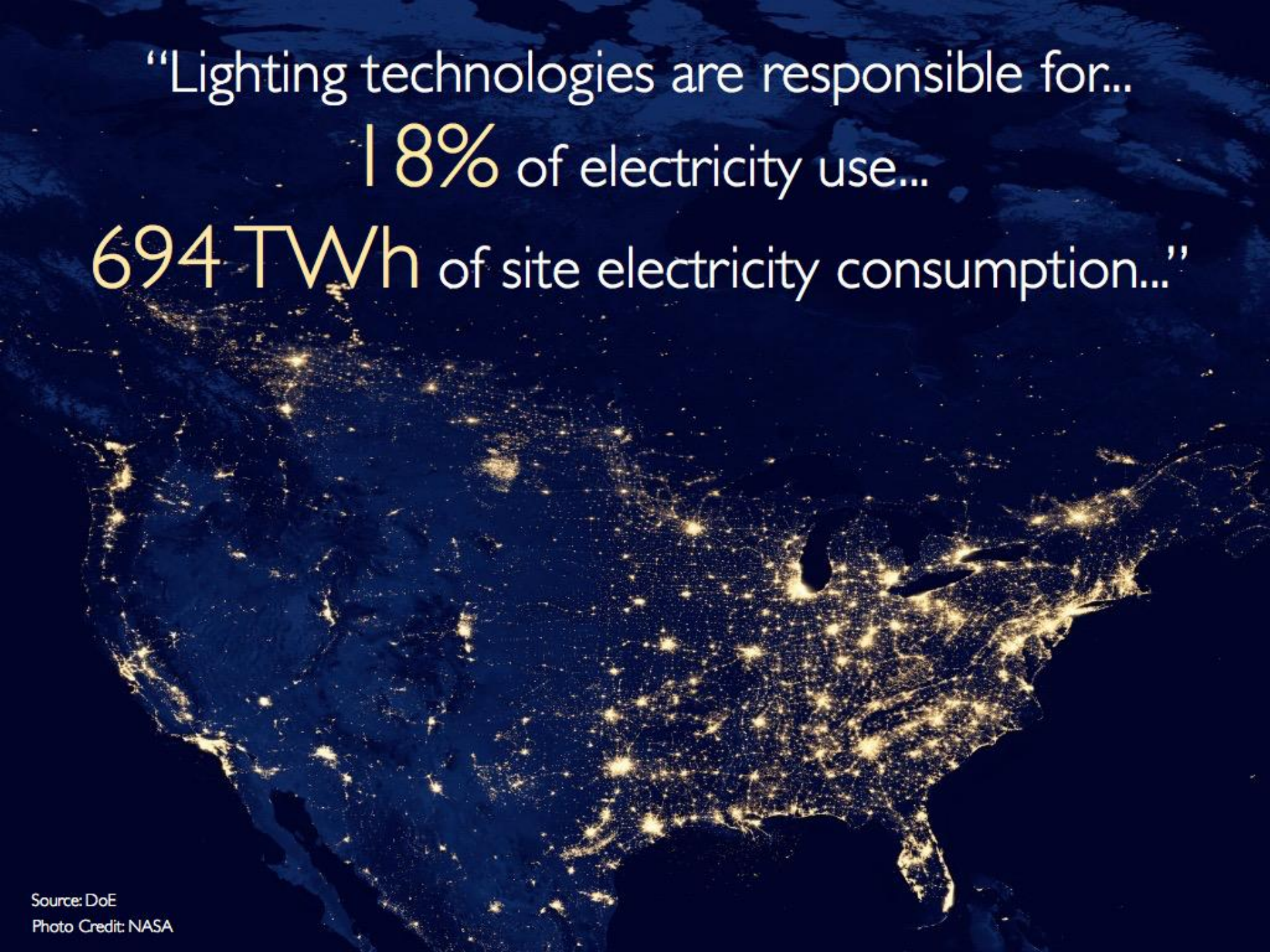
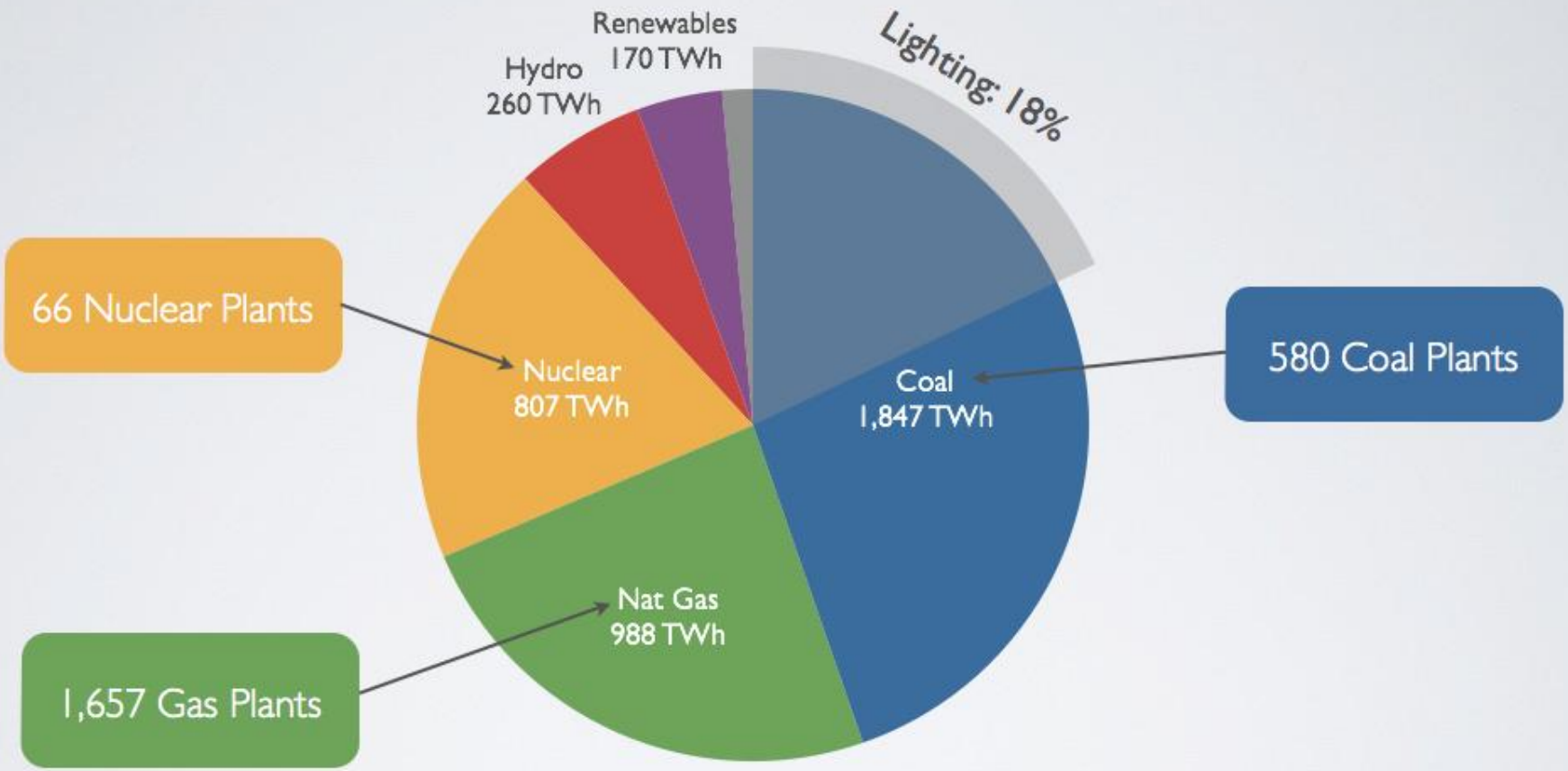
2008-

London Eye photo credit: https://www.flickr.com/photos/ramnaganat


"Lighting technologies are responsible for...
18% of electricity use...
694 TWh of site electricity consumption..."
Source: DoE
Photo Credit: NASA

Lighting has an enormous energy footprint



U.S. Net Electricity Generation by Source, 2010

Source: Energy Information Administration

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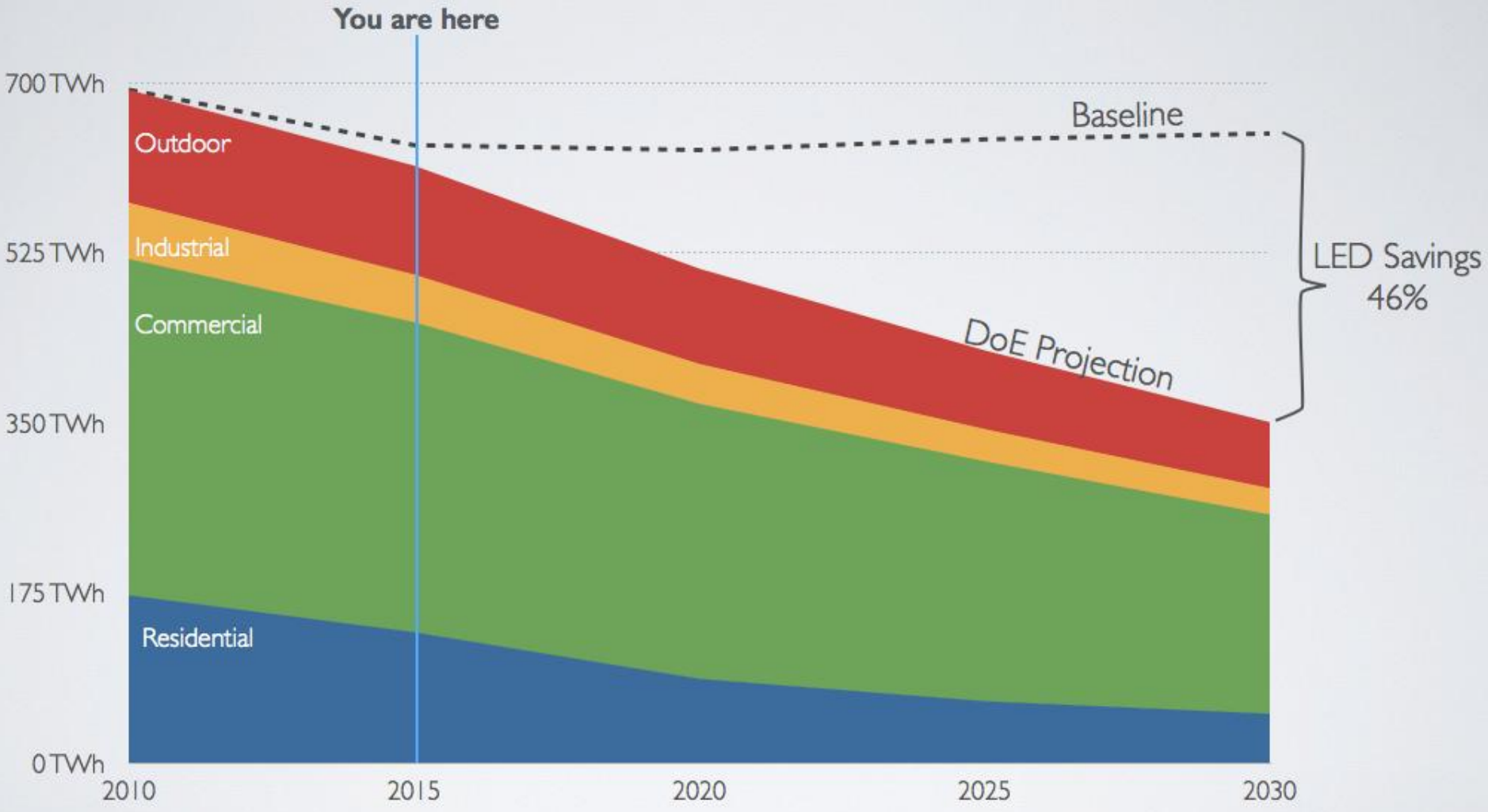
The LED Revolution

- Efficient
- Durable
- Controllable

Photo Credit: https://www.flickr.com/photos/63209717@N05

We're still in the early days of this transformation…



Source: DoE **"Energy Savings Potential of Solid-State Lighting in General Illumination Applications"**, 2012

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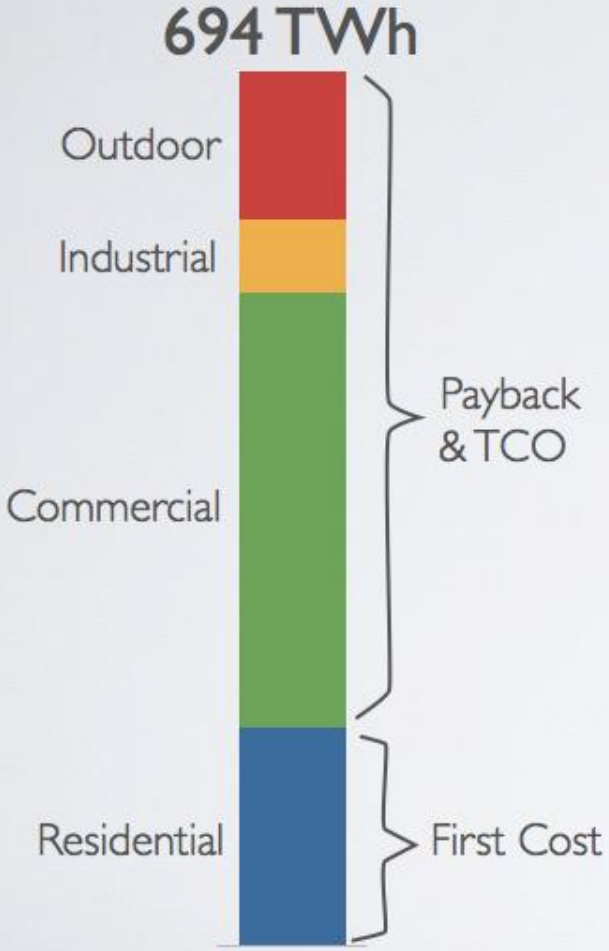
…so how do we make it go faster?



- Sectors with highest consumption are driven by **payback** and **total cost of ownership**, not initial cost
- LEDs remain relatively expensive
- Analysis assumes relatively slow improvements in:
  - $/lm
  - lm/W
  - market acceptance
- Fluorescent is a formidable competitor

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Accelerating the LED revolution

with Intelligent, Connected Lighting

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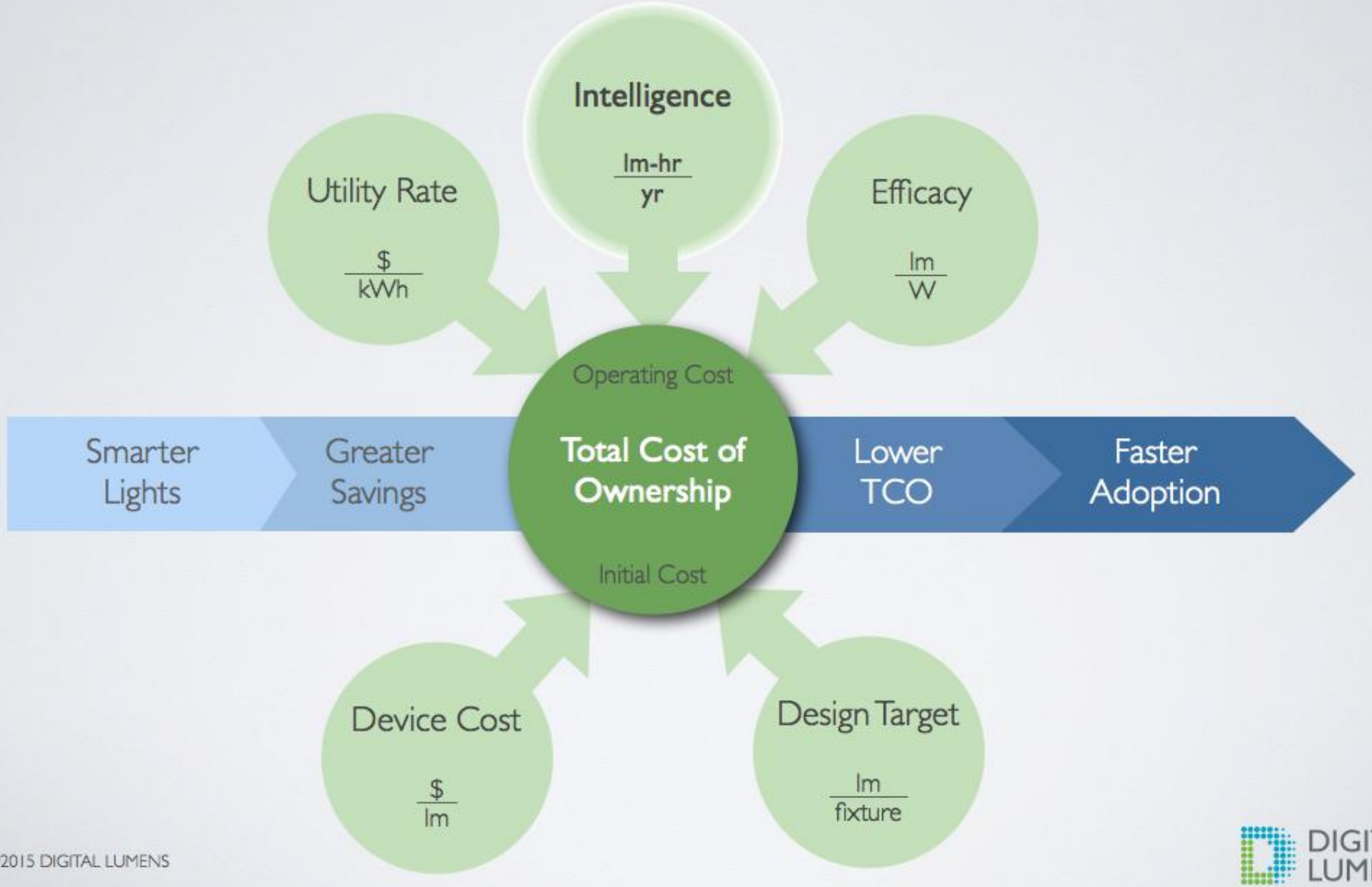

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Combining hardware and software

Intelligent Fixtures

Our custom low-cost, miniaturized control module makes any light intelligent, combining

- autonomous, closed-loop control software
- wireless mesh networking
- occupancy sensing
- daylight harvesting
- power metering
- smooth digital dimming

LightRules Software

A modern, data-driven software architecture combining lighting and energy management, featuring

- wireless mesh facility infrastructure
- sensor data logging
- reporting
- optimization
- scheduling
- automated demand response
- building automation integration
- full-facility energy management

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Connected lighting everywhere

	 Industrial	 Commercial	 Outdoor	 Residential
US Install Base	28B ft^2	55B ft^2	75M fixtures	4.6B lamps
Major Verticals	Manufacturing Warehouse	Office Retail and Hospitality Education and Public Healthcare	Street Lighting Structured Parking Surface Parking	Single Homes Multi-family
Value per Unit	$1 - $2 per ft^2	$0.5 - $2 per ft^2	$250 per fixture	$2.50 per lamp
TAM	$40B	$40B	$18B	$12B
Retrofit @ 5%/yr	$2B	$2B	$1B	$1B
New Build @ 2%/yr	$800M	$800M	$250M	$0.5B
Annual Net Value	$2.8B	$2.8B	$1.25B	$1.5B

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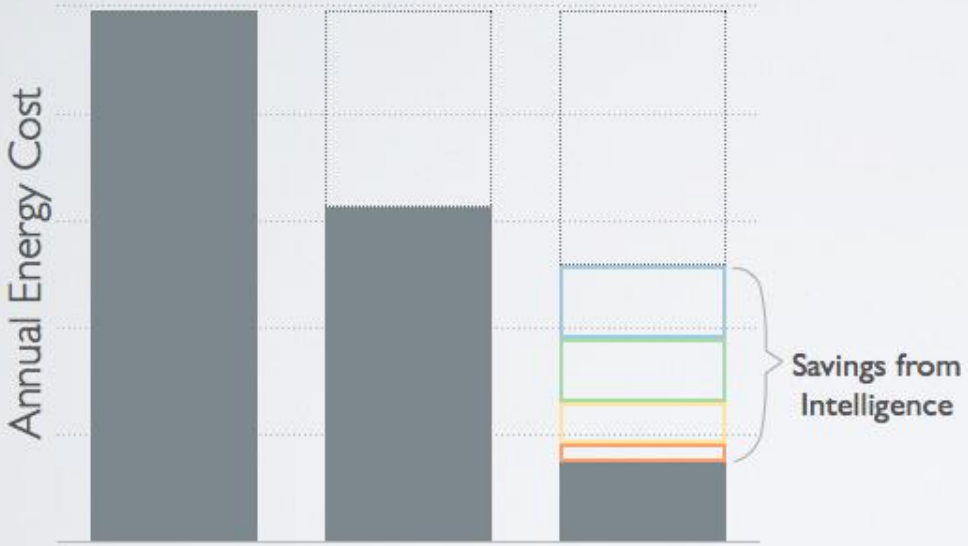
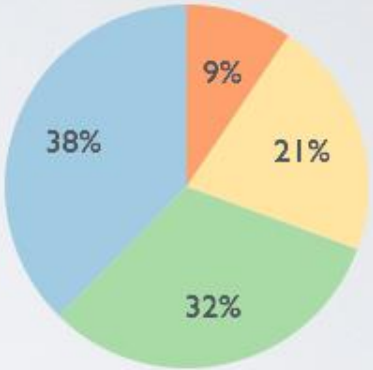
Intelligence shortens payback

Existing Fixtures | "Brand X" LED | Digital Lumens



37%	85%	Total Energy Savings
4.0 yr	1.9 yr	System Payback

Energy Savings by Strategy



- LED Efficacy
- Vacancy
- Scheduling
- Task Tuning
- Daylight Harvesting
- Actual kWh Usage

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The connected lighting value proposition

Hard Economic Savings

- Reduce energy usage by 90%
  (half from LEDs, half from multi-strategy controls)
- Maintenance free with 100,000+ lifetime
- Save $0.50 to $1.00 /sqft/yr
- 2yr project payback

Soft Benefits

- Improved quality and consistency of light
- Fine-grained control at each fixture
- Manage lighting from any browser, anywhere
- Lighting network forms the backbone for additional building system connectivity
  - BMS integration
  - power metering
  - cloud aggregation

Before
8-10fc
$265,000/yr

After
16-18fc
$31,000/yr

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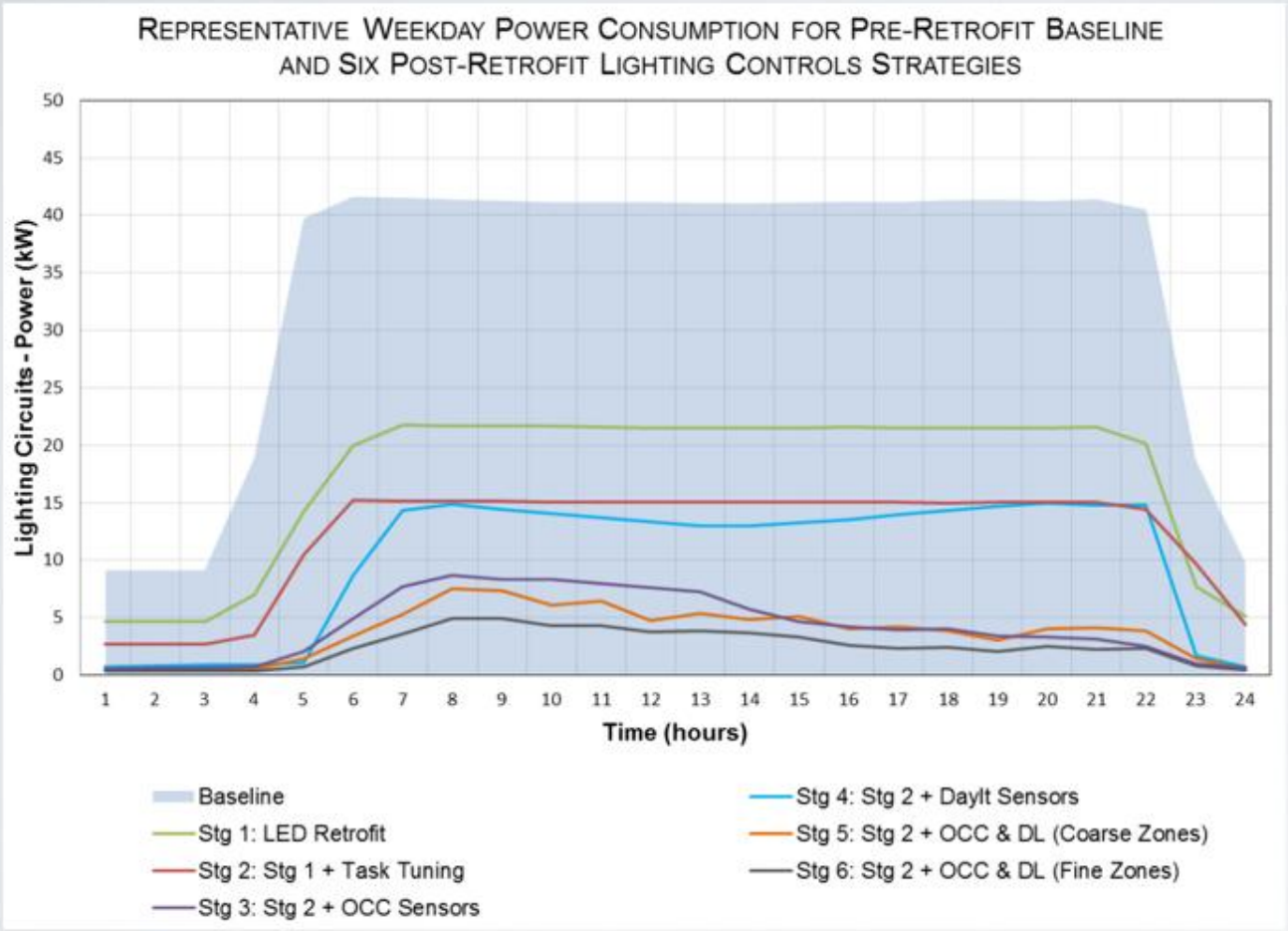
Case Study #1

ACE Hardware Distribution Center



1M sq.ft. warehouse
1,653 T5 & MH fixtures

Full facility retrofit with intelligent system
Multi-strategy approach to control
Securely managed and configured from any browser

>3x light level increase
81% overall energy savings (93% vs. MH)

PG&E formal report available

PG&E Study Details: http://www.etcc-ca.com/reports/led-high-bay-lighting-and-controls-project

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Case Study #2

Stone Brewing Company

LEED Silver bottling & kegging facility

high-resolution daylight harvesting
profiles matched to production schedules

86% Energy Reduction (vs. T8)
1.77 year payback

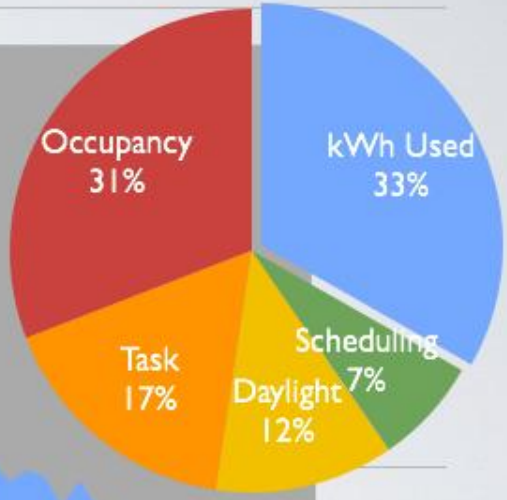
Case Study: http://www.digitallumens.com/case-study/stone-brewing/

Case Study #3

Open-Plan Office Space

Digital Light Agent
Wireless Multi-Strategy
Control Module

LED Troffer
25.0 kWh/year
40 month Payback vs. T8



"Smart" LED Troffer
8.3 kWh/year
67% Savings
27 month Payback vs. T8

00:00 01:00 02:00 03:00 04:00 05:00 06:00 07:00 08:00 09:00 10:00 11:00 12:00 13:00 14:00 15:00 16:00 17:00 18:00 19:00 20:00 21:00 22:00 23:00

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Characteristics of successful projects

Operating Hours	4,380 - 8,760 hr/yr
kWh Rate	$0.05 - 0.15 / kWh
Existing Lighting	T5 - T8 - T12 - Metal Halide
Utility Incentive	0 - 50% of project cost
Sustainability Focus	Goals - Accountability
Facility Size	100,000 - 1M+ ft^2

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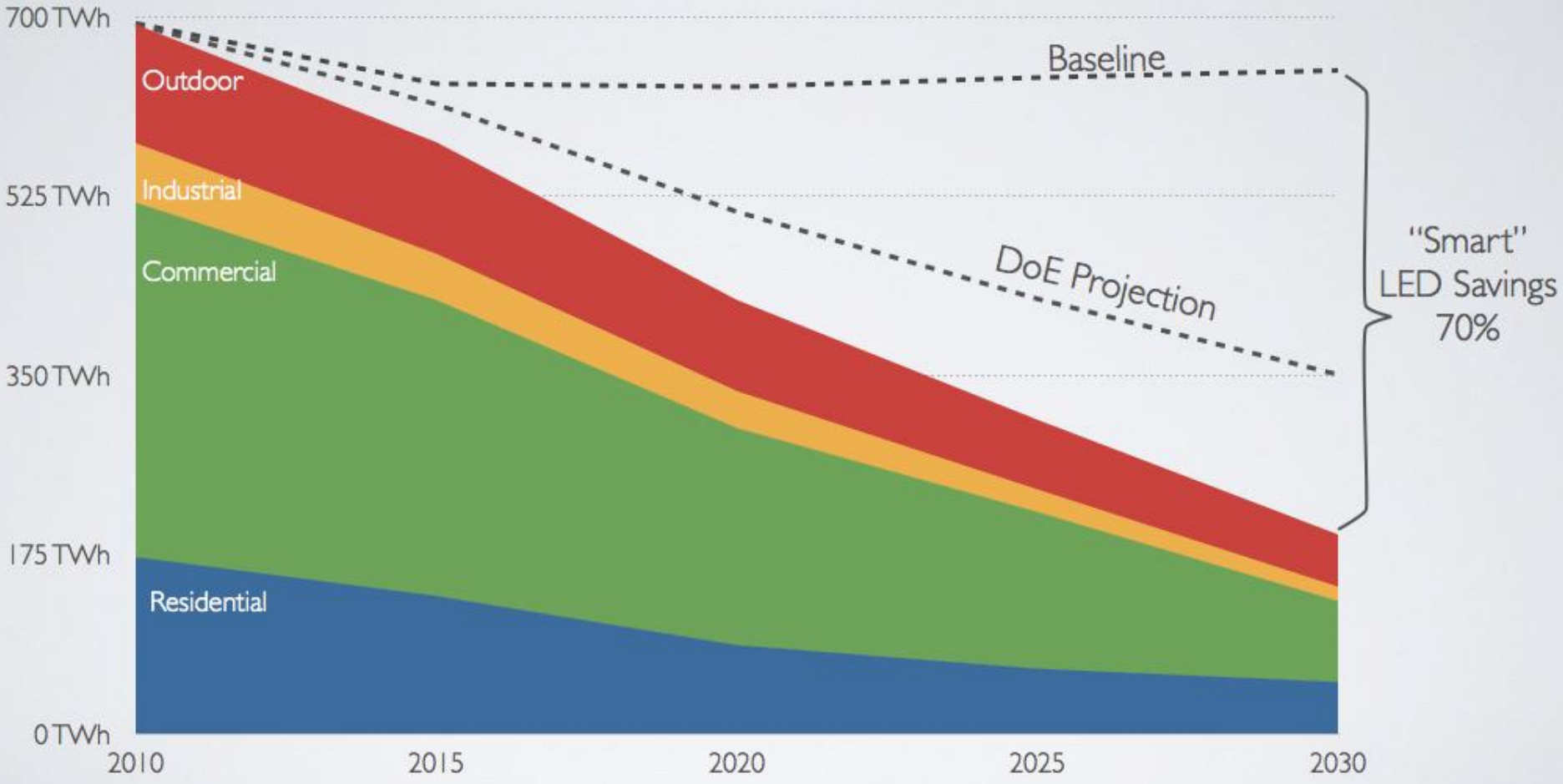
Driving accelerated energy savings



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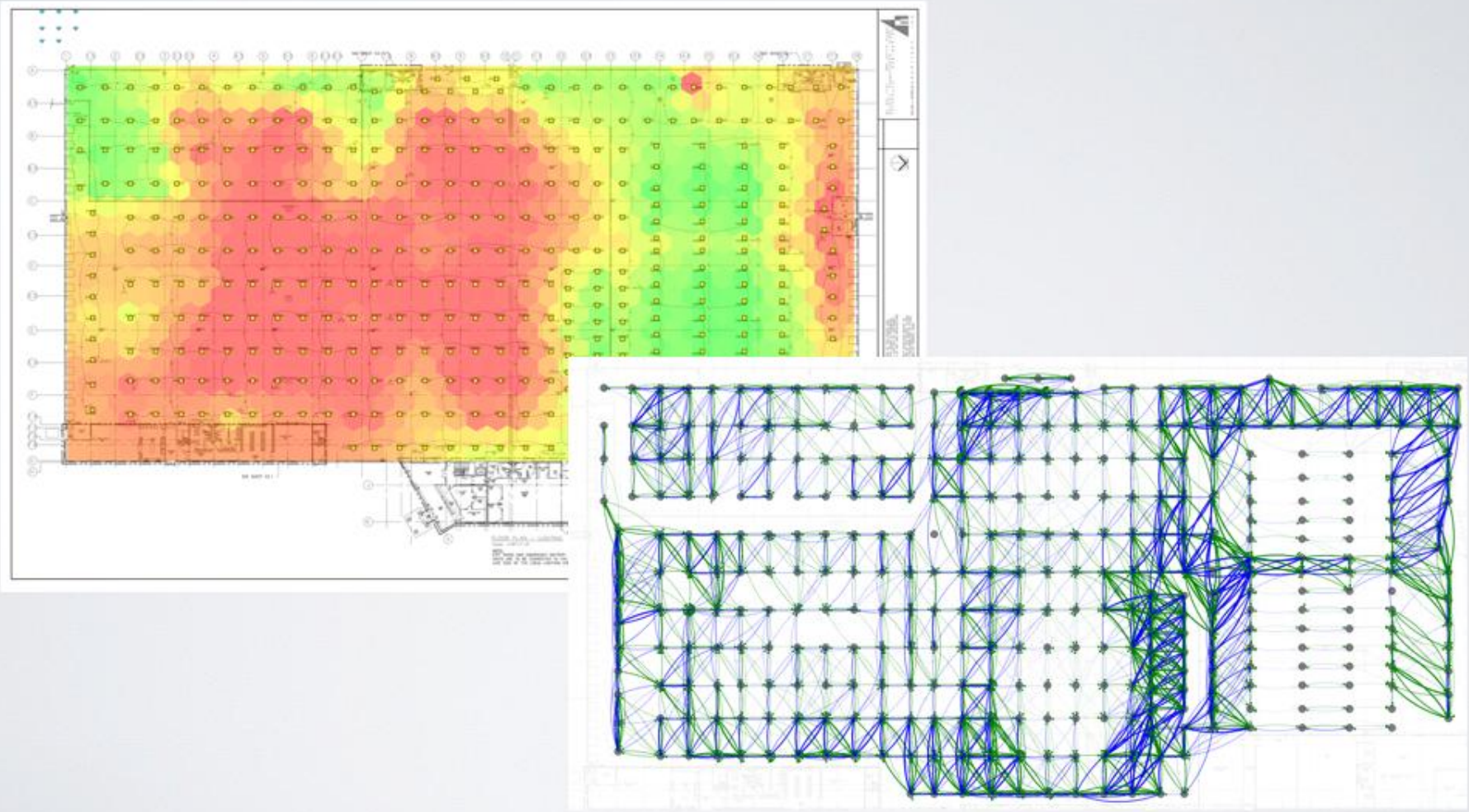
What's next?

Occupancy tracking and path reconstruction



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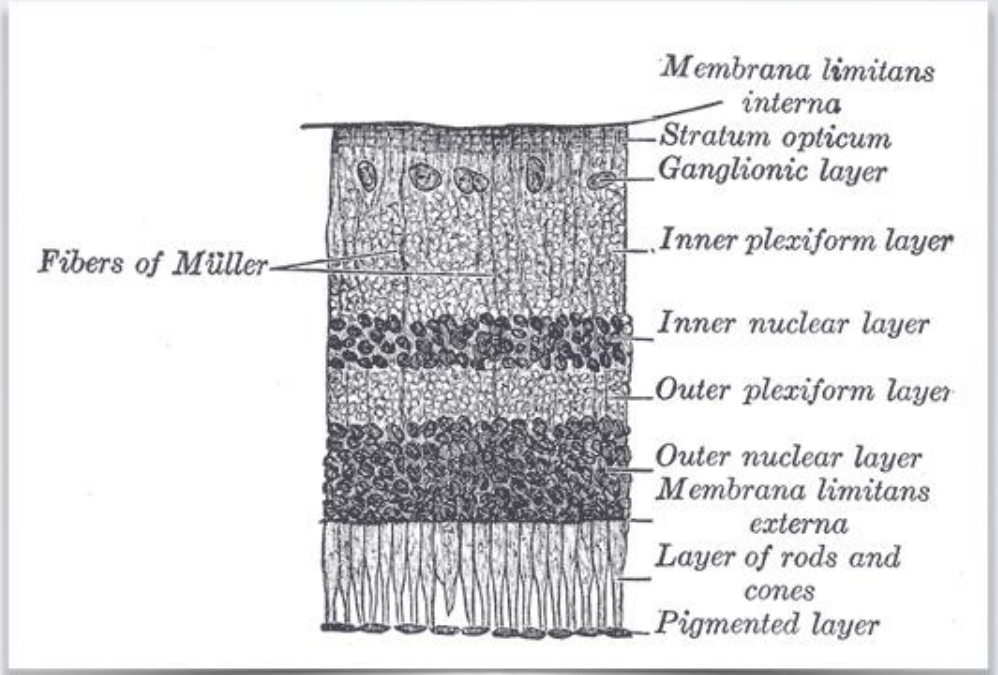
What's next?

Spectral control for health and wellness

- Photosensitive retinal ganglion cells affect melatonin levels
- They are spectrally sensitive - the "color" of light matters
- By carefully controlling spectral profile, we may be able to:
  - sleep better at night
  - be more alert in the morning
  - heal faster in the hospital



Retinal Structure

Gray's Anatomy of the Human Body, 1918

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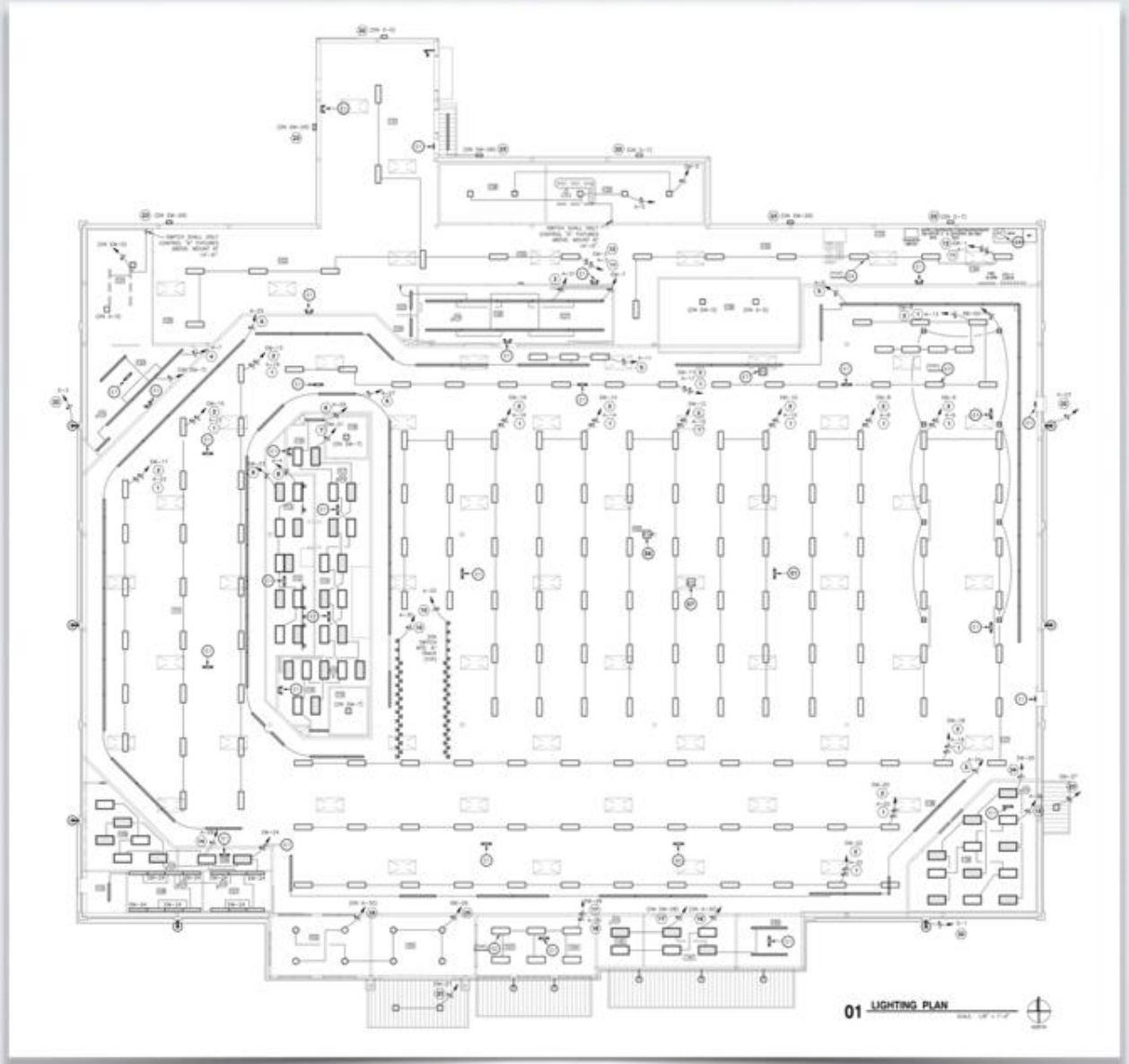
What's next?

Lighting as trojan horse for building management



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Thank You!

Email: bchemel@digitallumens.com

 : @bchemel

Accelerating the LED Revolution

OUTDOOR LED LIGHTING

ON THE BRINK OF PARADIGM CHANGE

INTRODUCTION

THE PARIDIGM

- **ROADWAY LIGHTING FOR NIGHTTIME VISIBILITY**

VS

- **PLATFORM FOR SMART CITIES**

- **OBJECTIVES for TODAY**
  - **Evolution of LED Outdoor Lighting**

Los Angeles Project - La Brea Avenue 200w HPS

Los Angeles La Brea Avenue 64w LED

EVOLUTION

Last Three Years

- **Price has dropped by >50%**
- **New England Utilities Allow LED Lighting**
- **Efficacy has increased by 35% to as much as 69%**
- **Control/Metering Technology**

CONTROLS WILL DRIVE THE PARADIGM

- Manufacturers are Anticipating the Market
  - ANSI 136.41 receptacle
  - Dimming Drivers
- Many flavors-point to point, mesh, Zigby, 2.4 GHz, 502 MHz, Proprietary, Non proprietary etc.
- Evolving Standards for metering and Interoperability
  - ANSI 136 Group
  - TALQ

WHAT IS THE LANDSCAPE

- Metered Lighting
  - DOT
  - Parking Lots
  - Shopping Malls, Auto Dealerships, Sports Venues
- Unmetered Lighting
  - Tariffs
  - Customer owned
  - Utility Owned
  - Muni's

WHO IS COVERED

- Massachusetts
- Rhode Island
- Connecticut in NU Service Territory
- Maine-Pending

- Prime Candidates
  - New York
  - Pennsylvania
  - Maryland
  - New Jersey
  - California

GEORGE WOODBURY
LIGHTSMART@TDS.NET

CELL 603-321-0212 FAX 910-814-1266
HM/OFFICE 910-814-2342

THANK YOU.