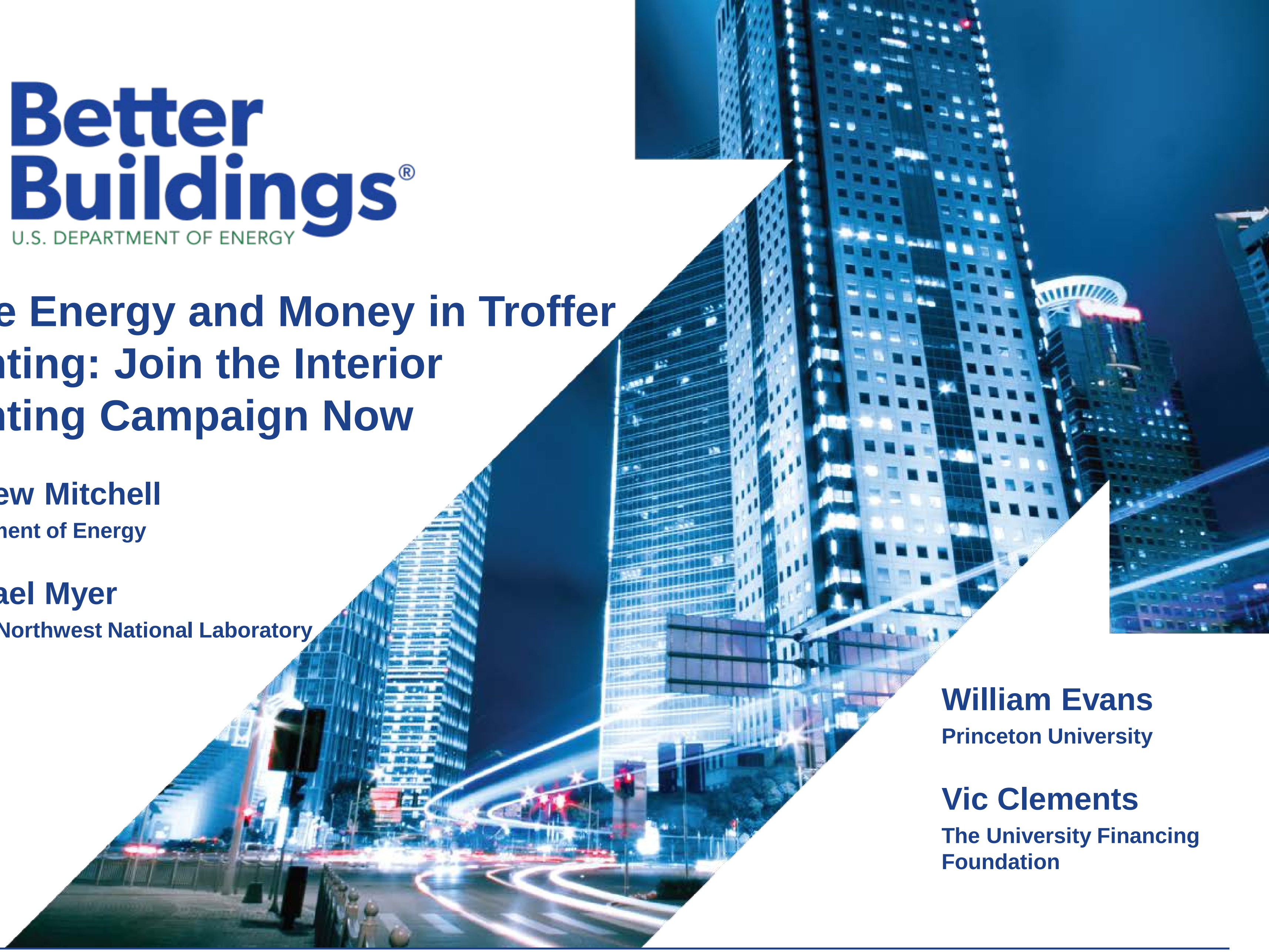
Better Buildings®
U.S. DEPARTMENT OF ENERGY

Save Energy and Money in Troffer Lighting: Join the Interior Lighting Campaign Now



Andrew Mitchell
Department of Energy

Michael Myer
Pacific Northwest National Laboratory

William Evans
Princeton University

Vic Clements
The University Financing Foundation

U.S. DEPARTMENT OF ENERGY

Agenda

- Overview of DOE's Better Building Alliances
- Brief review of troffers and Interior Lighting Campaign
- Princeton University's Icahn Laboratory
- The University Financing Foundation
- Questions and answers

Better Buildings Initiative

Goals:

- Make commercial, industrial buildings & multifamily housing 20%+ more efficient in 10 years
- Save more than $80B+ for US organizations
- Create American jobs; improve energy security
- Mitigate impacts of climate change

How:

✓ Leadership
✓ Results
✓ Transparency
✓ Best Practice Models
✓ Recognition
✓ Catalyzing Action

Launched 2011, Now 250+ Partners & Allies

Commercial, Industrial, Public, Private

Represent:

3.5+ Billion Square Feet
$5+ Billion Private Financing
650+ Manufacturing plants
$4 B Federal Commitment

Better Buildings Challenge Partners and Allies

Why Do Partners Join Better Buildings ?

The Big 3:

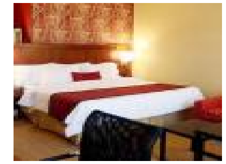
1. Access to experts, tools, and resources
2. Peer to peer learning
3. Public recognition

Better Buildings Alliance: How is it organized?


Commercial Real Estate


Food Service, Retail & Grocery

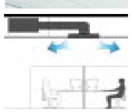
Healthcare


Hospitality


Higher Education

Technology Solutions Teams


Lighting


Space Conditioning


Plug & Process Loads


Refrigeration


Energy Information Systems


Renewables Integration

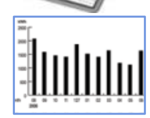
Market Solutions Team


Financing Strategies


Leasing and Tenant Engagement

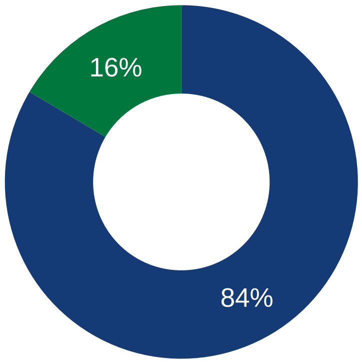

Training / Workforce


Appraisals and Valuation


Data Access

Higher Education Sector

Higher Education Members Compared to Market Floorspace



There are currently 27 members in the Higher Education sector, accounting for over 292 million sq. ft.; about 16% of the sector's floorspace in the U.S. market.

For more information contact:
John Jameson, ICF
Account Manager
303-792-7828
John.jameson@icfi.com

Membership

- Stanford University
- University of California, Irvine
- Loyola University
- University of Hawaii at Manoa
- Grand Valley State University
- University of California, Merced
- Massachusetts Institute of Technology (MIT)
- Arizona State University
- Cornell University
- University of Colorado Boulder
- Michigan State University
- University of Utah
- San Mateo Community College District
- Emory University
- University of South Carolina
- University of Miami
- Portland State University
- Clark Atlanta University
- Tulane University
- University of California, Davis
- University of Massachusetts Medical School
- University of Miami
- Washtenaw Community College
- University of Wisconsin
- University of Maryland
- University of California, Berkeley

NEW! Better Buildings Solution Center

Proven Solutions for:

- Large and small buildings
- All sectors
- Specific building types

Search by:

- Your energy efficiency barrier
- Your sector
- Your city or state

betterbuildingssolutioncenter.energy.gov/

Many ways to stay informed!

Follow us on social media!

Twitter: @BetterBldgsDOE
LinkedIn
YouTube

Sign up for newsletters!

Beat Blog (weekly posts)

- Interviews/Q+As, follow-up pieces from partner events and press releases; solution deeper dive

Bulletin

- Monthly digest of new solutions, partners, news, events

Get Involved

- Monthly call to action email listing events, webinars, ways to participate with Better Buildings

Top-10 Solutions

- Monthly top ten viewed solutions

Participate in monthly webinar series

Check out the newsroom for press on events highlighting partner accomplishments

Better Buildings®
U.S. DEPARTMENT OF ENERGY

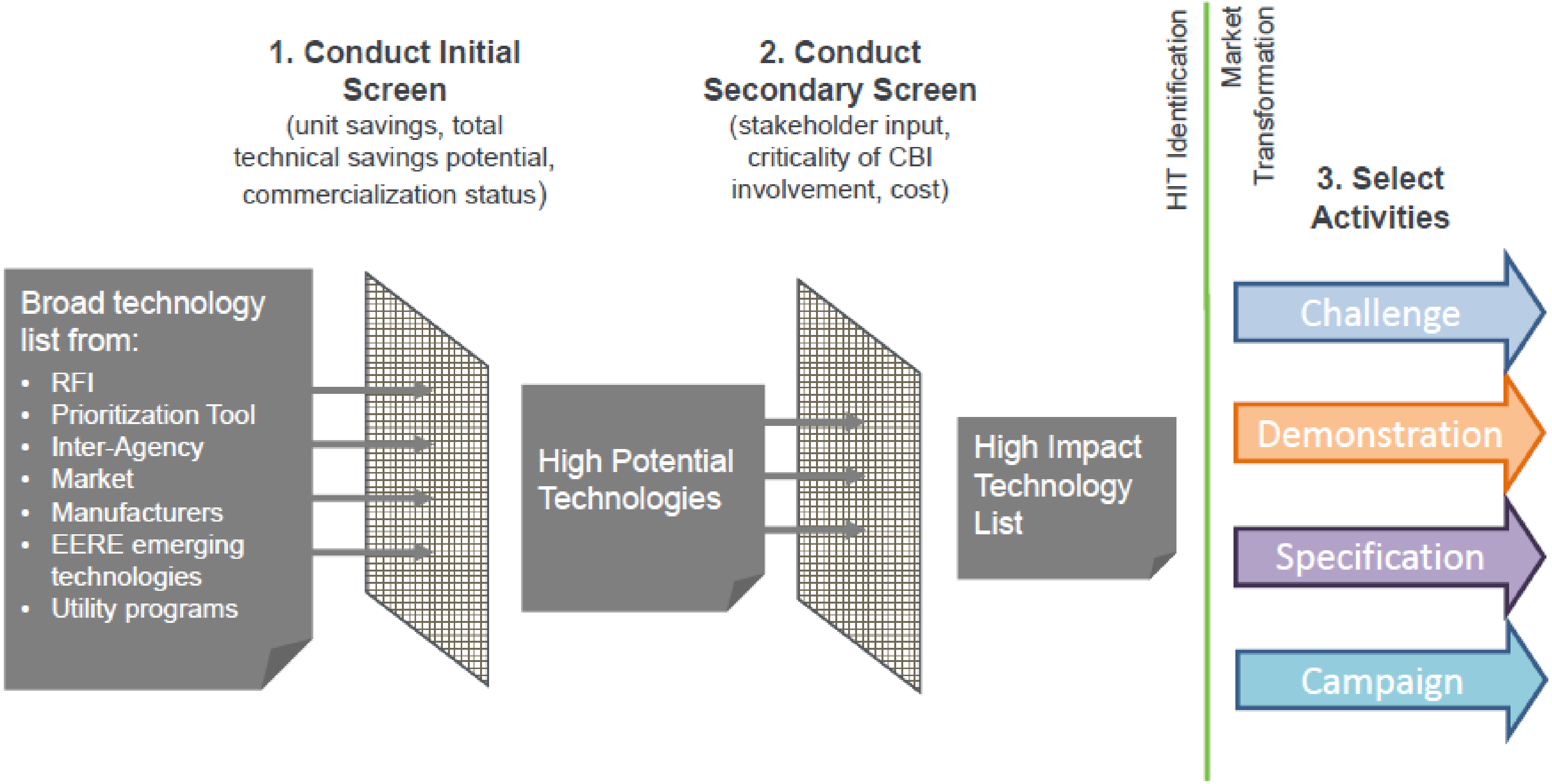
2016
SAVE THE DATE
BETTER BUILDINGS SUMMIT
WASHINGTON, DC ▪ MAY 9–11

U.S. DEPARTMENT OF
ENERGY

How do we Decide what to Focus On?

Identification and Evaluation of HITs

Identify HITs through a rigorous prioritization process; characterize HITs based on their stage in the product life cycle; develop appropriate resources; evaluate and implement the most effective deployment activities.



Other Campaigns: LEEP and ARC

- Lighting Energy Efficiency in Parking (LEEP)

- Advanced Rooftop unit Campaign (ARC)

Interior Lighting Campaign (ILC):

- High Efficiency Troffer Lighting with Controls
- Launched at 2015 Better Buildings Summit
- Goal to replace 1,000,000 standard troffers with high efficiency troffers with controls by May 2016
  - Represents about 60 million kWh savings, worth $6.2m
- Resources include:
  - troffer specification
  - utility incentives database
  - product lists
  - technical reports
  - case studies
  - free technical assistance.

Credit: Energywise.co

BOMA International
IFMA International Facility Management Association
IES Illuminating Engineering Society
Better Buildings U.S. Department of Energy

Why Do Participants Join ILC?

The Big 3:

1. Access to experts, tools, and resources
2. Peer to peer learning
3. Public recognition

Example: UC Davis

CALIFORNIA LIGHTING TECHNOLOGY CENTER

UCDAVIS
UNIVERSITY OF CALIFORNIA

Indoor Lighting

Working at the edge of design theory and technology, CLTC produces indoor lighting innovations that save energy while enhancing human health and comfort. Advanced control systems developed at the center integrate daylighting and electric lighting, reduce peak demand and electricity consumption, and tailor light levels and distribution to occupants' needs.

Many resources Available a cltc.ucdavis.edu:

- Case Study on adaptive Corridors, UC San Francisco
- Video on UC Davis 2012 lighting project

Example: Towson University

- Stephen Kolb, Energy manager at Towson spoke on our September Lighting team call. “2014 TU Standardizes on LED---everywhere!”

- Towson’s BBC Partner Profile on the [Solution Center]

Recognition: ILC Awards at BOMA 2016!

BOMA 2016

INTERNATIONAL CONFERENCE & EXPO

Presented by BOMA International and BUILDINGS

GAYLORD NATIONAL RESORT & CONVENTION CENTER

JUNE 25–28, 2016 | WASHINGTON, DC

Interior Lighting

- 2004 estimated that colleges and universities in the U.S. spend an average of $1.10 per sf on electricity[1]
- In typical higher education buildings, lighting represents 31% of energy use[1]
- Troffers make up the majority of installed light fixtures

1. nationalgrid / E Source "Managing Energy Costs in Colleges and Universities" https://www.nationalgridus.com/non_html/shared_energyeff_college.pdf

U.S. DEPARTMENT OF ENERGY

Troffers by the Numbers

- Estimated 367 million troffers in the US
- ≈1 troffer for every 240 square feet
- ≈1 troffer per person in the U.S.

/

Troffer Conundrum
What do I do?

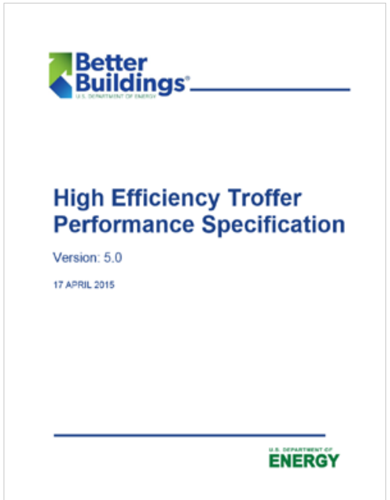
Option	Action	Light Source	Risk	Controls	Energy Savings Potential
1	Do nothing	Fluorescent	---	OS or dimming w/ new ballast	
2	Replace lamps	Long life fluorescent	---	OS or dimming w/ new ballast	
3	Replace lamps	TLED+FL ballast on existing socket	●●	OS	☼
4	Replace lamps	TLED on mains voltage in existing socket	●●	Yes w/ paired controls	☼ ☼
5	Replace lamps	TLED (hybrid) mains or ballast in existing socket	●●	OS or if ballast replaced	☼ ☼
6	Replace lamps	TLED w/ proprietary power supply in existing socket	●●	Yes paired w/ controls	☼ ☼
7	Retrofit Kit	Fluorescent or LED	●●	Many options	☼ ☼ ☼
8	New Fixture	Fluorescent or LED	●	Most options	☼ ☼ ☼ ☼

OS = Occupancy Sensor

Interior Lighting Campaign Goal

- 1,000,000 troffers either retrofit (tubes, kits, or new fixtures) or new construction by May 2016
- Awards for both new construction and retrofits
- Technical assistance
- Participants
  - Entities that are end users are eligible to be participants
  - Participants can be building owners, building managements, and tenants
- Supporters
  - Anyone not directly related to the operation / management of the lighting system(s)
  - Supporters are designers, engineers, architects, energy efficiency organizations, utilities, and manufacturers

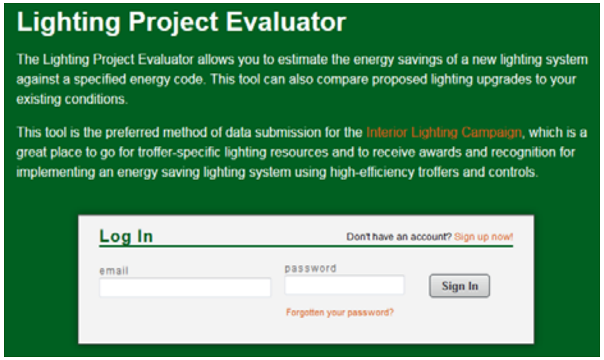
Interior Lighting Campaign Resources



Specifications

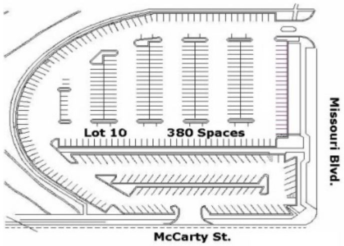
Reports

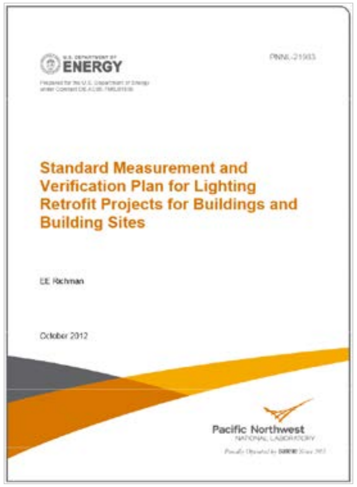
Fact Sheets



Energy Estimator to compare against code

Technical Assistance (limited)





M&V guidance

DSIRE®

NC CLEAN ENERGY TECHNOLOGY CENTER

LED lighting facts®
A Program of the U.S. DOE

Indoor Lighting - Troffers (incl retrofit kits), Controls

Utility	State	Technology	Product
PPL Electric	PA	Controls	Occupancy S
PPL Electric	PA	Fluorescent	High Perforn
PPL Electric	PA	LED	High Perforn

List of utility incentives

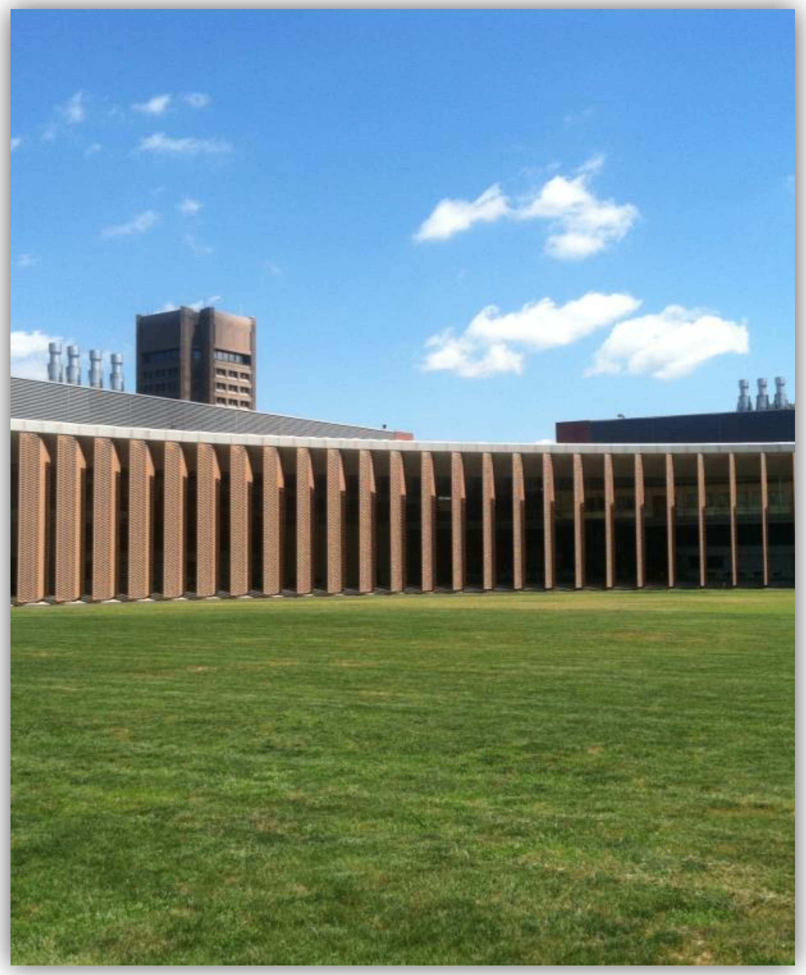
Princeton University

Icahn Laboratory Troffer Retrofit
CFL Downlight LED Retrofit

U.S. DEPARTMENT OF ENERGY

Carl Icahn Laboratory of the Lewis-Sigler Institute for Integrative Genomics

- 98,000 sq ft overall
- 35,000 sq ft of labs; 2 floors
- 150 person capacity
- Central glass atrium and 2 story curving glass wall joining them
- Glass wall is shielded by 31 external 40ft vertical aluminum louvers that rotate with the sun to maximize shade, minimize thermal loading
- **First building-wide interior LED project on campus**



Carl Icahn Laboratory of the Lewis-Sigler Institute for Integrative Genomics

- Annual lighting energy use
  - 564,000 kWh
  - $50,000 annual cost
- Lab and office space lighting
  - 815 recessed 2ft x 2ft luminaires
  - each use (2) 31W T8 fluorescent U-lamps
  - acrylic prismatic lens, draw 59 Watts of power
  - operate an estimated 5,000 hours per year
  - 240,425 kWh annually, or about 43% of the facilities annual lighting energy use

Carl Icahn Laboratory of the Lewis-Sigler Institute for Integrative Genomics

The Issues

- Removal of existing fixtures and replacement with new was not cost competitive, due to the amount of labor required
- Based on past experience with lab users on campus, a simple on/off type occupancy sensor configuration was considered to be a nuisance by users and had a history of being deactivated

Carl Icahn Laboratory of the Lewis-Sigler Institute for Integrative Genomics

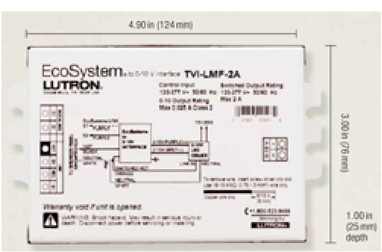
The Troffer Lighting Solution

- LED pan type Retrofit kits from Maxlite
  - 3,315 lumens
  - 45 Watt power input
  - CCT of 4,100K
  - Minimum CRI of 82
  - 0-0-10V Control (off at 0V)
  - Safety Certification from ETL
  - Design Lights Consortium's Qualified Products List member (QPL)
  - Yields over 57,000 kWh in annual energy savings, before controls

Carl Icahn Laboratory of the Lewis-Sigler Institute for Integrative Genomics

The Controls Solution

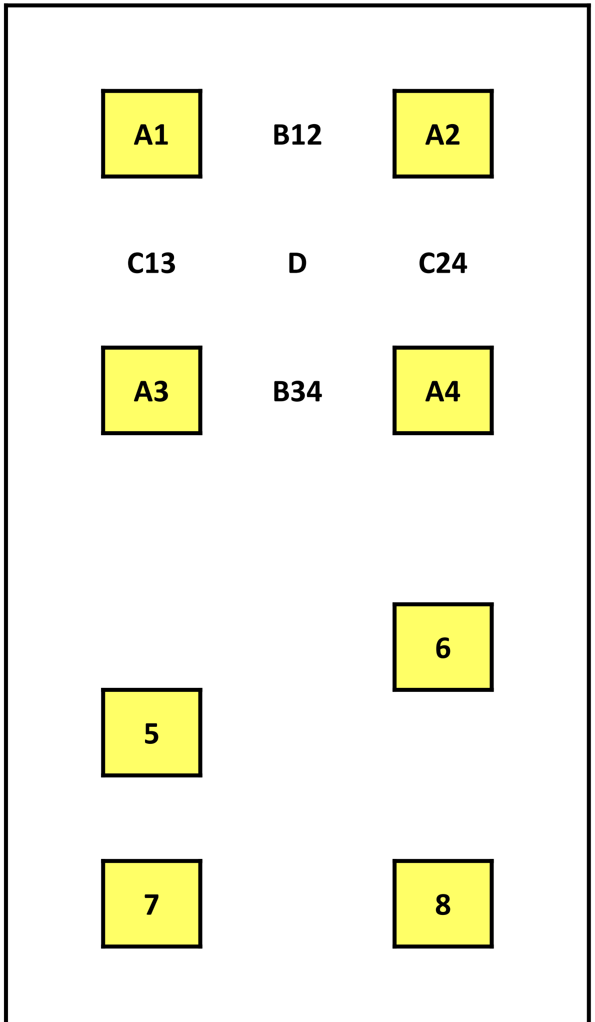
- Lutron Quantum Ecosystem with 0-10V-to-Ecosystem converters to drive groups of fixtures
- Lutron Wireless Motion and Daylight Sensors
- Lutron Pico Wireless Dimmer Switches
- Bi-level dimming philosophy in lab areas



Icahn Lab: Room 222

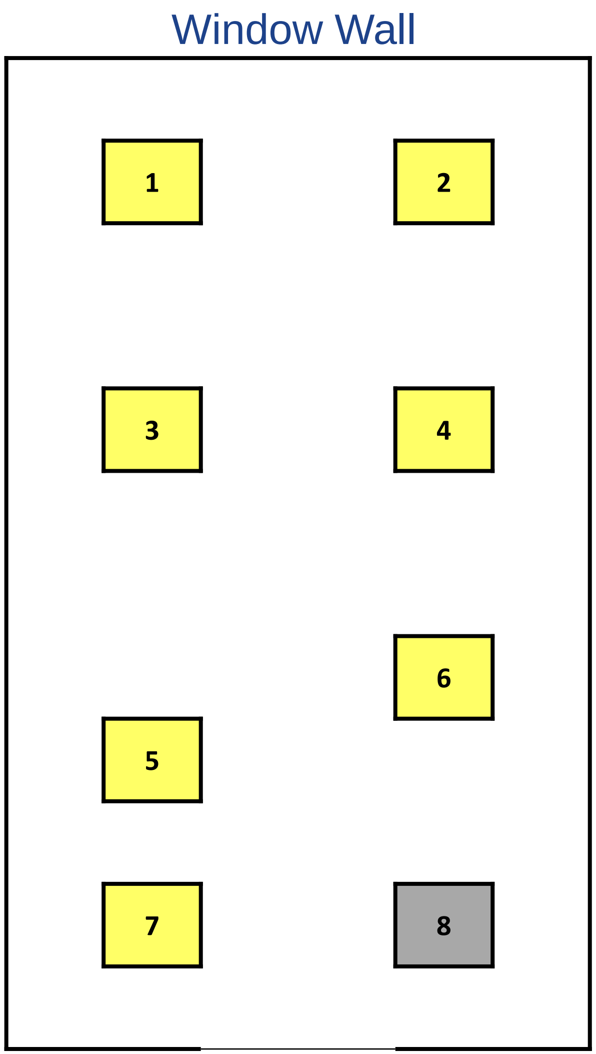
Icahn Lab: Room 222

Window Wall



ILLUM (HOR) AT COUNTER HEIGHT			
	FC FL	FC LED	LED/FL
AVE	62.2	103.6	1.67
MAX:MIN	1.34	1.36	
ILLUM (VERT) AT WINDOW TOP			
AVE	56.5	86.1	1.52
ILLUM (HOR) AT TOP SHELF			
AVE	91.9	149.3	1.62
ILLUM (VERT) AT TOP SHELF			
AVE	40.9	65.9	1.61

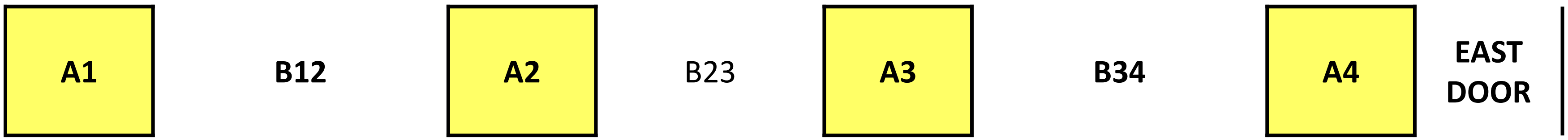
Icahn Lab: Room 222



COLOR MEASUREMENTS				
FIXTURE	**FL CCT**	**FL CRI**	**LED CCT**	**LED CRI**
1	3715	81	4304	85
3	2842	86	4323	85
5	3746	78	4311	85
7	3158	78	4299	85
2	3169	77	4336	85
4	3747	78	4303	85
6	3750	78	4313	85
MAX	3750	86	4336	85
MIN	2842	77	4299	85

Icahn Lab: Corridor 233

Icahn Lab: Corridor 233



- Horizontal illuminances measured at 3’ AFF centered under fixture row
- Vertical illuminances measured at 5’ AFF along south wall, aligned with horizontal measurement locations

	FL-HOR	LED-HOR	LED/FL
MEAN	53.0	96.8	1.83
MAX:MIN	1.19	1.24	
	FL-VERT	**LED-VERT**	**LED/FL**
MEAN	30.4	53.5	1.76
MAX:MIN	1.34	1.16	

Icahn Lab: Open Lab area

Icahn Lab: Open Lab area

- Horizontal illuminances measured along the counter at 2’ intervals
- Point 0 is at window end of bench; point 14 at end near inner wall

POINT	FC - FL	FC - LED	LED/FL
0	44.9	72.7	1.62
2	47.5	76.3	1.61
4	52.9	78.3	1.48
6	56.1	76.5	1.36
8	57.5	89.0	1.55
10	57.9	94.8	1.64
12	59.0	98.7	1.67
14	65.1	111.8	1.72
MEAN	55.1	87.3	1.58
MAX:MIN	1.45	1.54	

Icahn Lab: CFL Downlight LED Retrofits

The Downlight Solution:

LED downlight retrofit kits from Terralux

- 60,000+ hour L70 lifetime
- 80+ CRI
- 92 Lumens/watt
- Energy Star

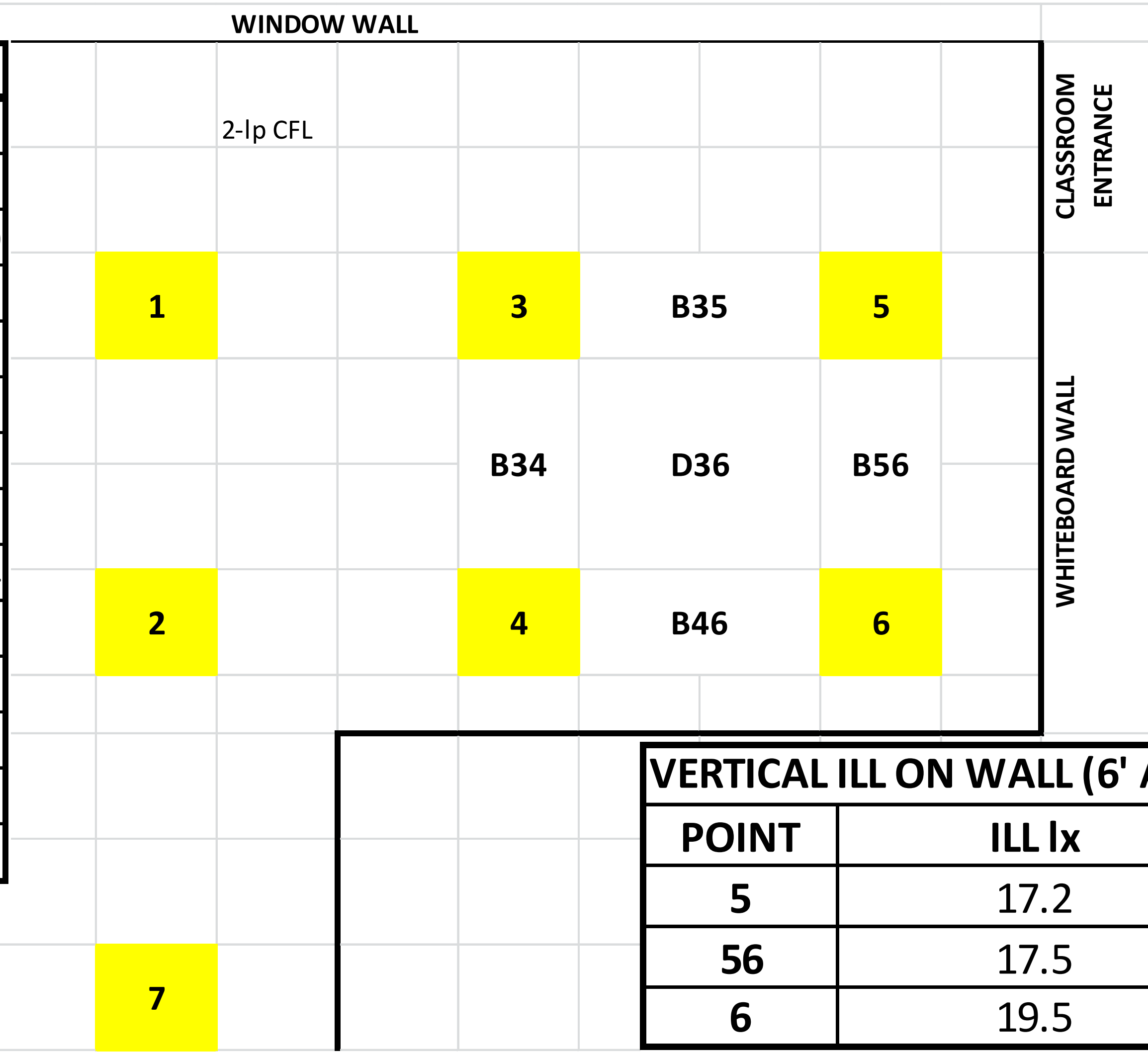
Icahn Lab: CFL Downlight LED retrofits

Better Buildings
U.S. DEPARTMENT OF ENERGY

U.S. DEPARTMENT OF ENERGY

Icahn Lab: CFL Downlight LED retrofits

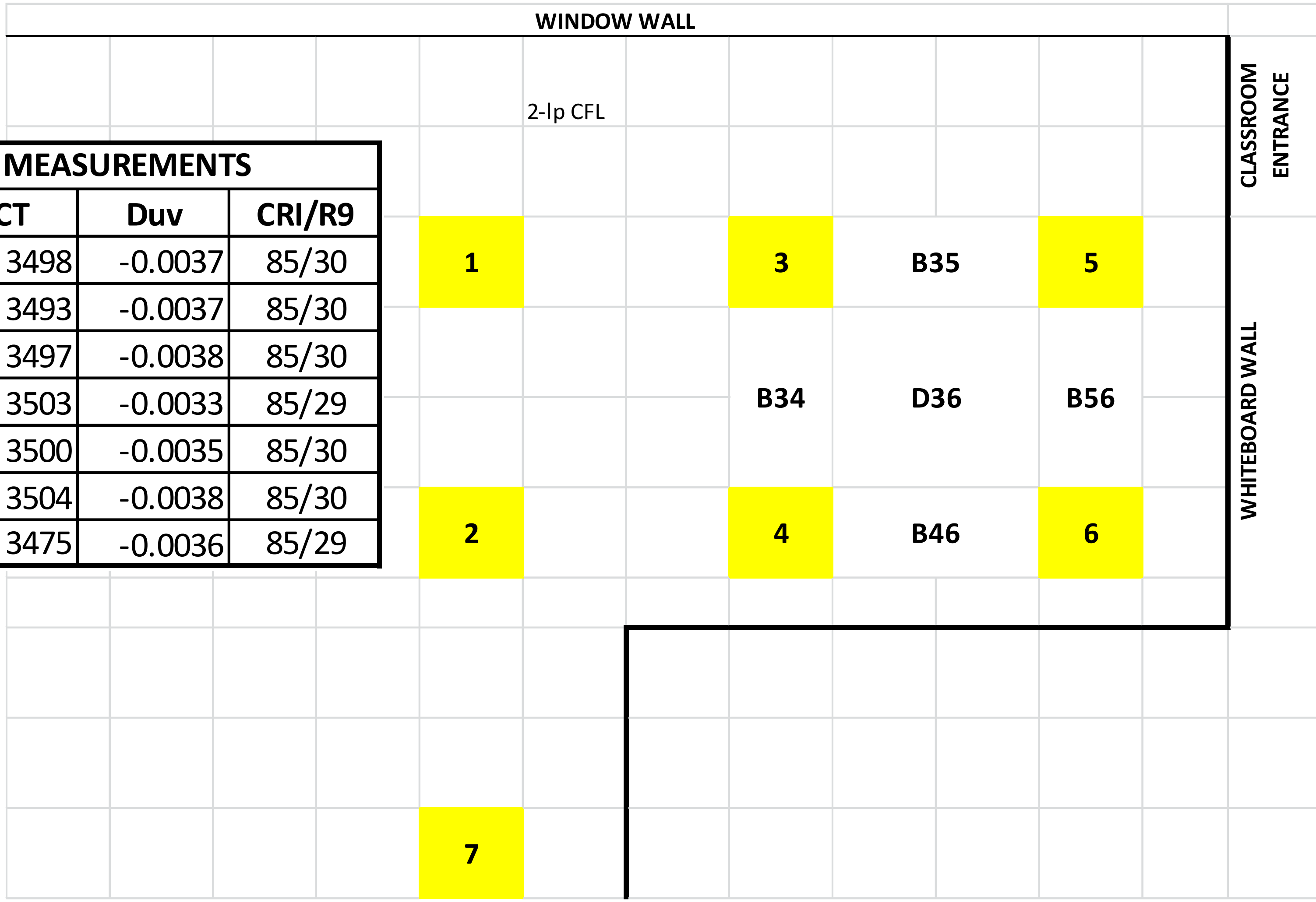
LED ILLUMINANCES		
POINT	**HOR fc**	**VERT fc**
A3	58.8	19.5
A4	54.9	19.0
A5	46.9	17.2
A6	47.8	17.9
B34	61.2	16.9
B35	54.1	17.5
B46	52.8	17.9
B56	53.5	19.4
D36	58.4	NA
MEAN	54.3	18.2
MAX	61.2	19.5
MIN	46.9	16.9
MAX:MIN	1.3	1.2



VERTICAL ILL ON WALL (6' AFF)	
POINT	**ILL lx**
5	17.2
56	17.5
6	19.5

Icahn Lab: CFL Downlight LED retrofits

COLOR MEASUREMENTS			
FIXTURE	**CCT**	**Duv**	**CRI/R9**
1	3498	-0.0037	85/30
2	3493	-0.0037	85/30
3	3497	-0.0038	85/30
4	3503	-0.0033	85/29
5	3500	-0.0035	85/30
6	3504	-0.0038	85/30
7	3475	-0.0036	85/29



Icahn Lab

Icahn Lab

Icahn Lab

Icahn Lab

Icahn Lab

Icahn Lab

Summary of Princeton Experience

- 24% energy savings (before lighting controls)
- High-level trim and Bi-level motion sensing allows additional savings
- Light levels and color temperature consistency improved
- Lower maintenance costs expected thanks to increased time between failure of fixtures

What came before?

Military Jet Propulsion Technology…

Lockheed F-117 Nighthawk

McDonnell Douglas F/A-18 Hornet

What came before?

…was turned into a 15MW Cogeneration Facility with up to an 80% energy conversion efficiency!

What comes next?

Low Voltage DC Distribution deserves consideration:

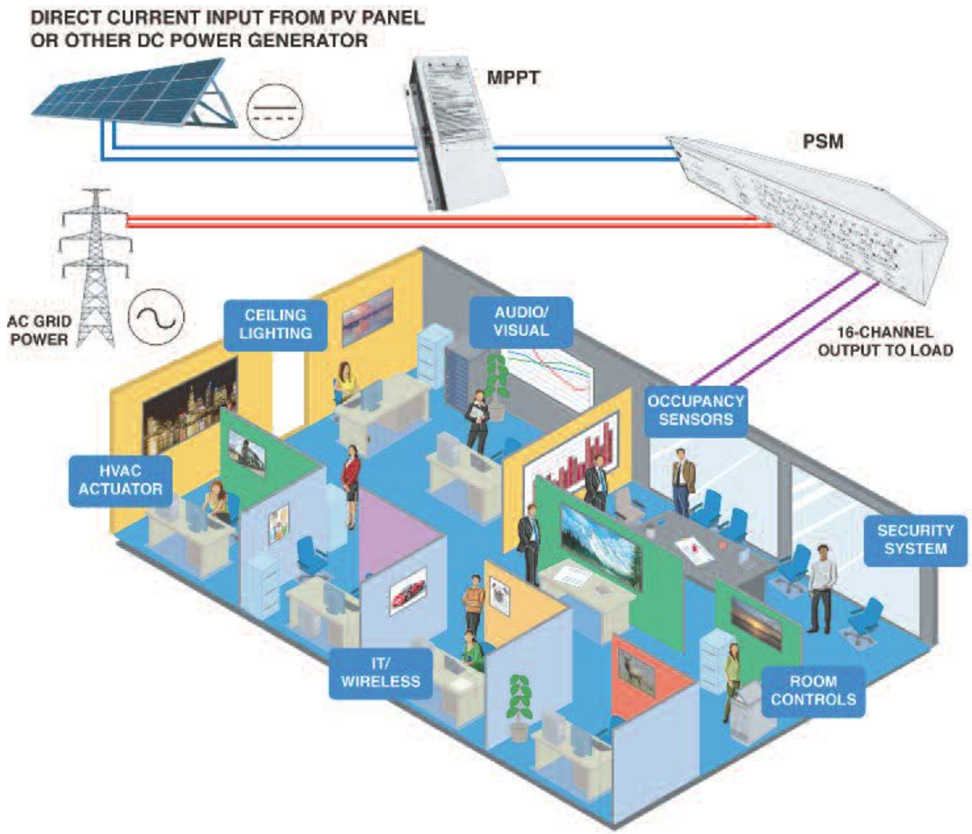
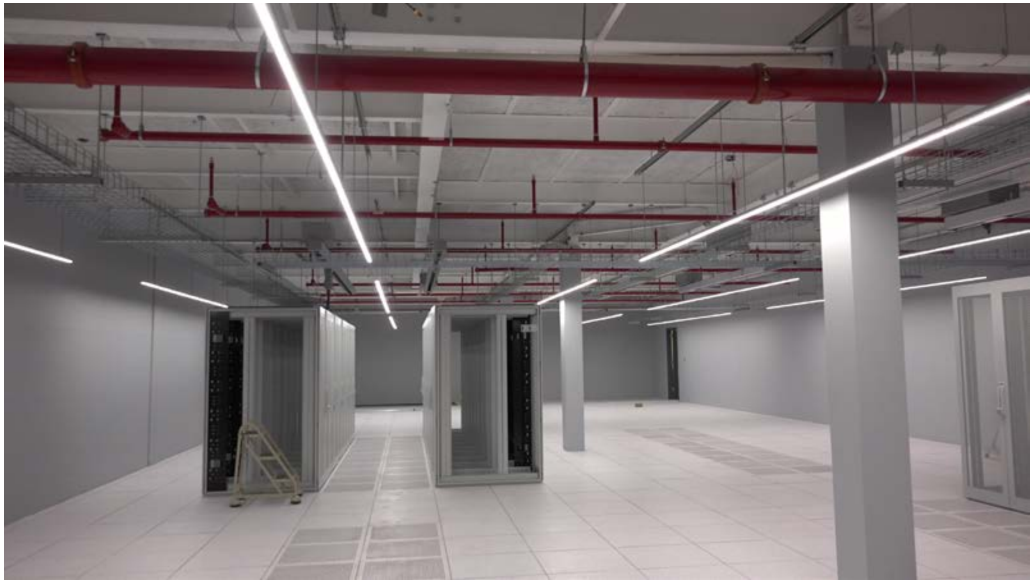


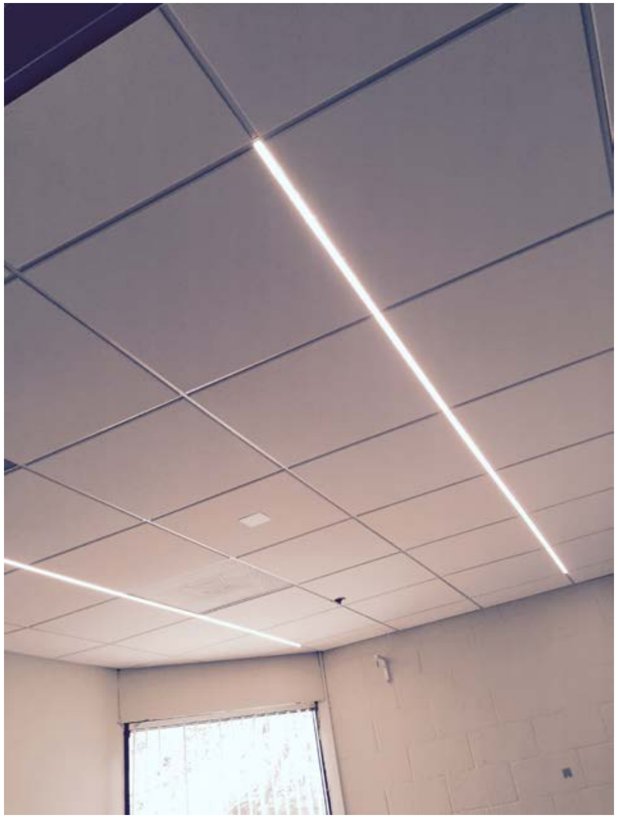
*Illustration Courtesy of Nextek Power Systems

What else comes next?

What happens when we think outside the traditional ceiling troffer?

- 24 VDC LED grid lighting





*Photos Courtesy of Steel Orca and Goldeneye

Thank you!

The path to enlightenment begins with a walk around the block.

- Philip Delves Broughton

The University Financing Foundation, Inc

The University Financing Foundation, Inc.

Who is TUFF?

- Non-profit, 501(c)3 private operating foundation formed in 1982
- Mission to assist education and research institutions in obtaining facilities and equipment at below market prices
- Often invited into the early decision making process when an Institution's President says "I have a dilemma that I need your help solving"
- Objective is to provide turn-key facilities, equipment and renovation and energy efficiency projects faster and at a lower overall cost than institutional development methods
- Participant, supporter and sponsor of Better Buildings Challenge since its inception in 2011
- Over $1 billion in development project financings and loans
- Visit our website at www.tuff.org

THE UNIVERSITY FINANCING FOUNDATION, INC.

What is TUFF?

We are not-

- a speculative developer (i.e. Place Properties, Ambling, American Campus Communities).
- an energy services company (Siemens, Energy Systems Group, Johnson Controls, Schneider).
- a vendor (general contractor, engineer, product supplier).

We are-

- a partner- We sit down with the institutional leadership to understand your desires and needs.
- an advisor- We bring an independent, realistic view of the market from both a financing and cost perspective.
- an accelerator- We are nimble and can provide upfront equity. We assume construction risk, interest rate risk and execution risk.
- an innovator- Lead “activation” of projects to create community.

THE UNIVERSITY FINANCING FOUNDATION, INC.

Financial Structuring Alternatives

- **FASB 13 Operating lease financing (Off Balance Sheet)-** Developed and financed approximately $60 million of student housing, life sciences, food service, parking and aquatic facilities for the Florida Institute of Technology. We structured the lease as an operating lease which results in those assets and liabilities not being included on the balance sheet of the school.

- **Energy Services Agreement-** Developed, renovated and financed a $12 million central utility plant and later completed a $4 million expansion, that services approximate 39 buildings (and goring) on the campuses of Clark Atlanta University and Spelman College. The Energy Services Agreements provide that the schools purchase the output of chilled water, hot water and steam generated by the central utility plant based on the relative usage by each school. Neither the asset or liability related to this financing are reflected on the balance sheet of either institution.

- **Off-Balance Sheet not Off-Credit-** To avoid any confusion, while both of the above examples reflect off-balance sheet financing, that does not mean that the rating agencies do not allocate some or all of the underlying debt when considering the rating of the institutions involved in the above arrangements. Also, proposed changes in accounting rules may change the reporting for these structures in the future.

GTRI Cobb Research Campus

$14 million renovation of 160,000 sq. ft. research facility on 52 acres

Deep energy retrofit and renovation

Reduced annual energy costs in excess of 40%

Energy, capital repairs & annual maintenance by over $800,000

Lease costs are fully reimbursable under research grants

Clark/Spelman Central Utility Plant

$12 million renovation and later a $4 million expansion
Chilled water, hot water and steam to 39+ buildings
15,109,080 kwh annual savings of electricity or 27% reduction
Equivalent to CO2 emissions from 1555 homes of electricity use per year

CENTERGY ONE

Numerous small projects performed with in-house engineering staff at a capital cost of less than $150,000

*Re-lamped building (12,000 lamps)

*Changed exterior lighting to CFL and LED

*Lighting controls

*Day cleaning

*Continuous commissioning

Decreased utility consumption by over 26% Netting annual savings in excess of $350,000

TECHNOLOGY SQUARE RESEARCH BUILDING

NUMEROUS PROJECTS PERFORMED WITH A COMBINATION OF THIRD-PARTY AND IN-HOUSE ENGINEERING STAFF AT A CAPITAL COST OF $265,000.

DECREASED UTILITY USAGE BY OVER 31.6%; NETTING ANNUAL SAVINGS IN EXCESS OF $177,000

*PARTICIPATED IN PNNL/DOE BUILDING WIDE BAS AUDIT

*INSTALLED LINE REACTOR CAPACITORS TO MITIGATE REACTIVE POWER AT END USE DEVICES

*LIGHTING RETROFIT THAT ALLOWED REMOVAL OF 1/3 OF LAMPS

*INSTALLED CO2 SENSORS INTEGRATED INTO VENTILATION DEMAND CONTROLS

*INSTALLED WIRELESS SUB-METERS WITH OVER 60 ACCESS POINTS FOR BETTER CONTROL OF ALLOCATION AND DEMAND

*INSTALLED REAL-TIME ENERGY AND WATER USAGE DASHBOARD IN LOBBY

Contact information:

Vic Clements

The University Financing Foundation, Inc.

Phone: 404-214-9200

Direct: 404-214-9445

Email: vic@tuff.org

Website: www.tuff.org

Summit: www.tuffsummit.org

Questions?

- http://www.interiorlightingcampaign.org/
- #IntLtgCampaign

U.S. DEPARTMENT OF ENERGY