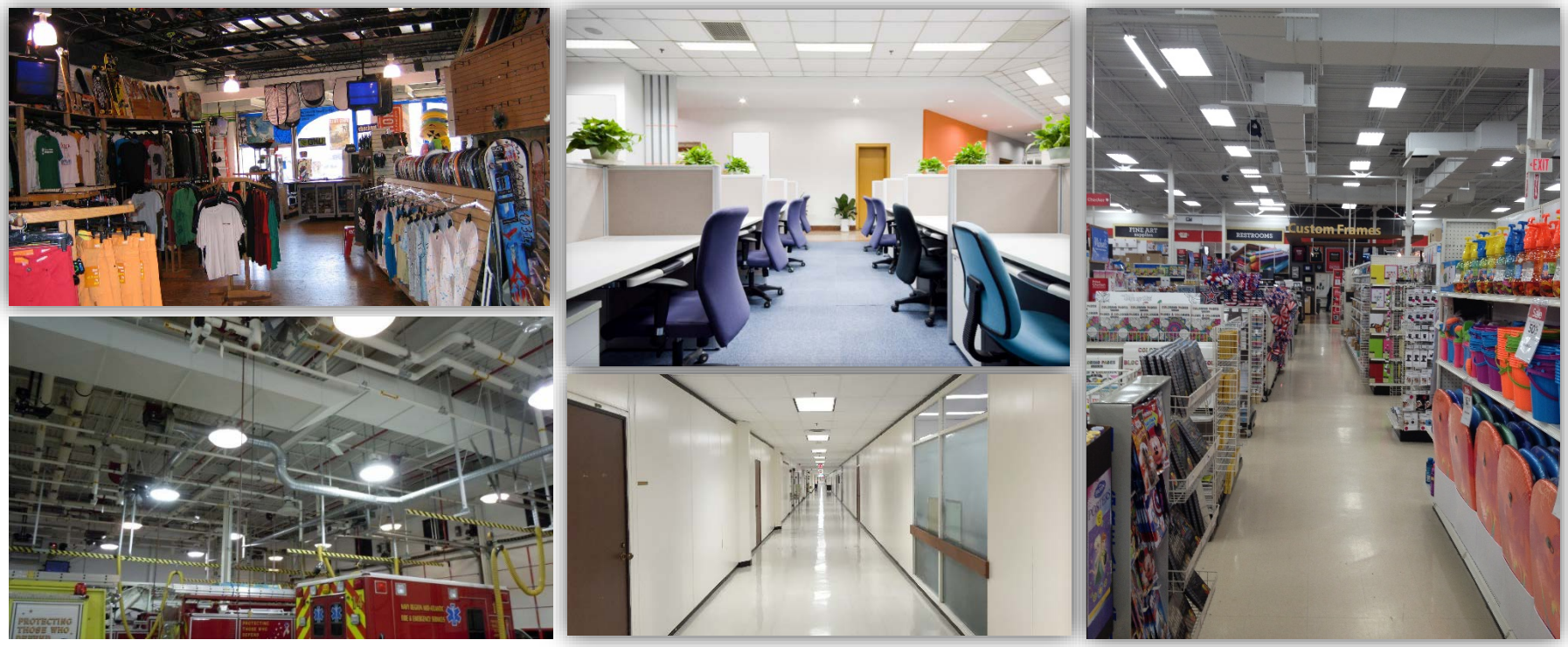
Innovation Challenges:
PNNL – Control-Enabled LED Retrofit Kit

2017 Building Technologies Office Peer Review



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PNNL-SA-124239

Project Summary

Timeline:

Start date: October 2016

Planned end date: April 2017

Key Milestones :

1. Draft spec released for comment; 2/02/2017
2. Comments due from industry; 3/17/2017
3. Final spec released; 3/31/2017

Budget:

Total Project $ to Date:

- DOE: $65K
- Cost Share: No cost share, however our work enables significant industry investment in energy efficiency.

Total Project $:

- DOE: $65K
- Cost Share: $0

Key Partners:

Better Buildings Lighting & Electrical Team
Interior Lighting Campaign Partners
U.S. General Services Administration
Next Generation Luminaire Systems Design Competition
Walmart

Project Outcome:

Focus: Partner with potential end-users (owner/customers) to develop a performance specification that signals technology developers of an unmet market need.

Driving Adoption of Technology Solutions MYPP Goal #2: *Partner with market leaders to drive the adoption of HIT applications capable of reducing building energy consumption by 10%.*

Purpose and Objectives

Problem Statement: Although replacing fluorescent tubes with TLEDs can save energy and is a least first-cost option, performance, control, and longevity can be disappointing. An LED retrofit kit that offers controllability and quick installation could address most challenges at a reasonable cost point, however no such products exist with the desired performance levels desired by many large end users.

Target Market and Audience: Commercial building lighting uses ~4.0 quads of primary energy annually. Over 75% of these lighting systems use linear fluorescent lamps. These are the systems we target since < 5% use have transitioned to high efficiency LED systems. Audiences targeted:

- Building owners/managers who make decisions related to commercial building lighting system retrofits, to help define the specification and to express purchasing interests.
- Lighting equipment manufacturers to help define the specification and to produce products that meet it.

Purpose and Objective

Purpose:

Encourage development of a control-enabled LED retrofit kit for converting existing systems used in troffer, suspended, low bay, and high bay applications

- *Note: From a program design perspective this is more cost-effective than direct R&D investment IF there is buy-in from manufacturers and end users*

UL Type A LED Tubes

- Good for:
  - Energy savings
  - Least first-cost
  - No add-on labor cost
- Challenges
  - Control compatibility
  - Energy savings left on table
  - Dated luminaire

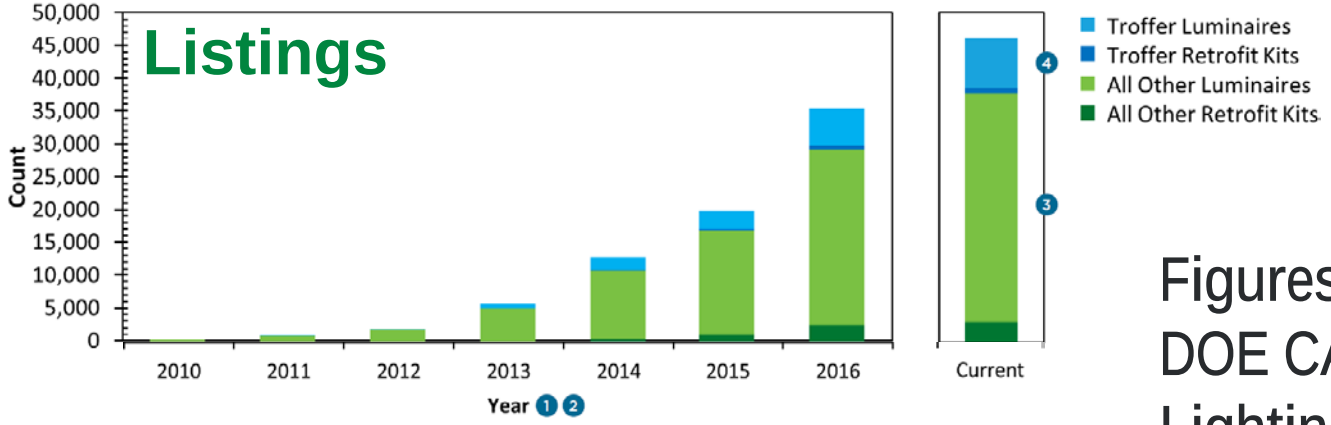
Retrofit Kits

Luminaires

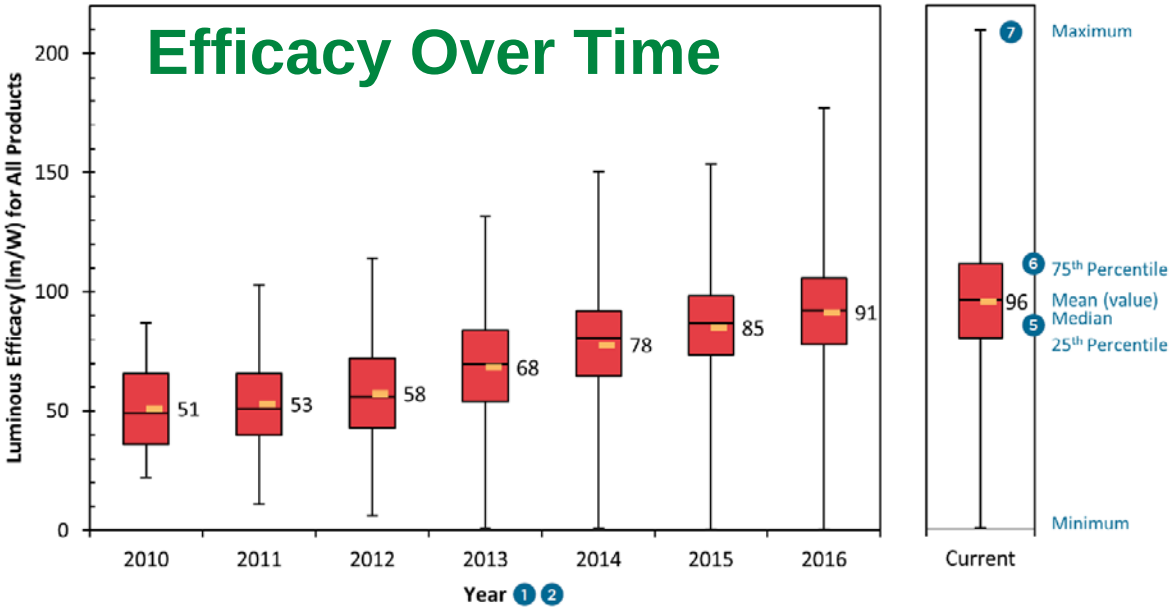
- Good for:
  - Best energy savings
  - Control options
  - Longest life
  - Mostly maintenance- free
- Challenges
  - High first cost
  - Labor cost to install

Purpose and Objective

All Products **Listings & Efficacy Over Time**



Figures from the Dec. 2016 DOE CALiPER analysis of Lighting Facts data



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Purpose and Objectives (continued)

Planned Project Impact

Contribution to Energy Efficiency:

- By adopting this specification for retrofit kits, building owners can save more than 50% of the energy on a one-for-one basis; up to 80% with controls
- $15.77 billion annual SAVINGS, based on 150 billion annual kWh saved if applicable non-LED luminaires in the nation were retrofit to this specification

Outputs

- **New specification-compliant products that meet owner/end-user demand and are ready for purchase through normal purchase channels**
- A Control-Enabled LED Retrofit Kit Specification for adoption by industry and use in purchasing by end-users/owners
- Demonstration project to show real-world performance

Purpose and Objectives (continued)

Innovation Challenge MYPP Goal #2: Driving Adoption of Technology Solutions

2016 BTO MYPP, pg. 157

Measuring Impact Toward BTO MYPP Goals:

- **Measuring contributions:**
  - Near-term outcomes:
    - Release of draft and final Challenge specifications
    - Next Generation Lighting System (NGLS) demonstration utilizes specification as the basis for technical requirements of an upcoming NGLS evaluation of troffer lighting systems.
    - Number of participating manufacturer and building owners/managers
  - Intermediate outcomes:
    - One or more new-to-market products that meet the Controls-enabled LED Retrofit Kit Specification
    - Commercial building owner/managers use the products in their facilities
  - Long-term outcomes
    - Control-enabled retrofit kit use increases in the market as a retrofit strategy, improving the energy savings and cost-effectiveness of controls-enabled solutions
    - New Interior Lighting Campaign recognition category tied to greatest percent savings for a tube/kit/troffer

Approach

DOE and PNNL convene industry and private sector partners to encourage development and use of a new-to-market controls-enabled LED retrofit kit

- Build upon existing connections with commercial building sector (e.g., Better Buildings) and lighting manufacturers (e.g., Interior Lighting Campaign and NGLS contacts) for input/buy-in
  - Integrate with existing resources
  - Peer exchange of information
  - Partners help test and refine design of new retrofit kits
- Demonstrate it is possible and cost-effective to save energy using LED retrofit kits equipped with lighting controls
- Leverage support of and coordinate with other federal agencies with major purchasing power

Innovation Challenge Triggers product development where the market has not met building owner and designer demands for more efficient products.

2016 BTO MYPP, pg. 157

Note: this approach is modeled after the successful Innovation Challenge specification for LED parking lot lighting, initially released in 2012

Approach (continued)

Key Issues:

- Determining how far to push efficacy in Challenge spec requirements while still maintaining cost effectiveness and other key performance features
- Extent to which lighting manufacturers will introduce new products remains to be seen (not guaranteed)

Distinctive Characteristics:

- Collaborative effort with industry and other DOE programs
- DOE, with input from building owner/operators, defines performance to meet unmet market demands
- Building owner/managers partnering with DOE provide indication of interest in new product, encouraging industry innovation

Progress and Accomplishments

Near-term Progress Against Milestones

Key Activity	Milestone/Deliverable					
	Oct 16	Nov	Dec	Jan 17	Feb	Mar
Prepare Project Plan for spec development			X			
Develop draft specification - Define: criteria, projected energy savings, fixture categories, optional features						
Spec overview to Better Buildings Lighting Team (webinar)				X		
Release draft specification to manufacturers				X		
Solicit/document industry feedback						
Webinar: Spec overview and Q&A to industry						X
Comments due on draft spec						X
Develop spec demo evaluation plan and site criteria						X

Complete
Underway

Progress and Accomplishments (continued)

Upcoming Activities: April 2017 – September 2017

Key Activity	Milestone/Deliverable								
	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Release final Challenge specification	X								
Intent to submit product due from manufacturers.		X							
Manufacturers notified of product eligibility based on *Intent to Submit* submission		X							
Prototype products submitted to PNNL (date subject to change based on manufacturer timelines for product development)				X					
CBI demonstrations: - Set demonstration requirements - Candidate demonstration site(s) selected - Select product(s) for demo			X	X	X				
Next Generation Lighting Systems* Demos: - Sets performance criteria for demo - Select products for demo					X X				
Demonstration results complete, documenting in-the-field performance									X
Track specification uptake (e.g. through ILC and partner utilities)									

Complete

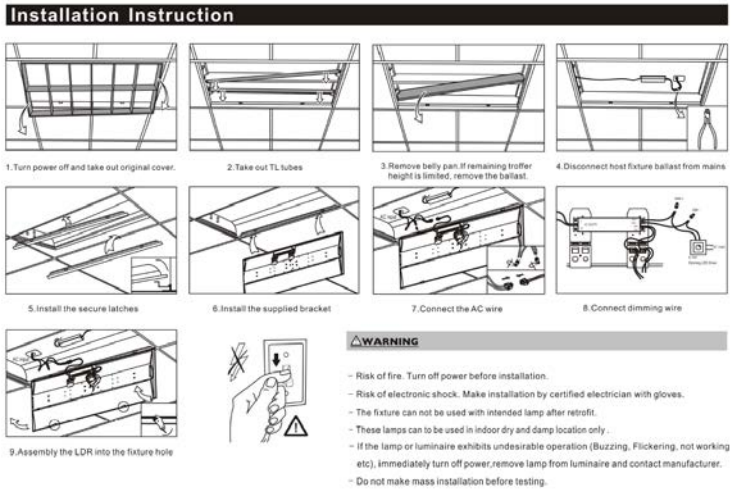
Underway

*Separate project managed by the DOE SSL Program

Controls-Enabled LED Retrofit Kit Performance Spec – draft spec performance level highlights (for comment)

- Focus on troffers, linear suspended fixtures, high and low bay fixtures
- High efficacy: **140 lm/W current target**
  - Conventional fixtures 50 – 80 lm/W
  - 40 – 60% energy savings
- 7-year warranty
- Long life (70,000 hours)
- Good color requirements
- Focus on distribution requirements
- Focus on controls
  - Kits work well with lighting controls
  - Beyond lighting controls (e.g., Bluetooth / location sensors)

- Why Kits?
  - Lower 1st cost → short install time (less than 10 minutes)
  - Cost is slightly more than TLED, but less than a new fixture
  - Intersection of low initial costs + high energy savings + long life
- Focus on installation instructions



See reference slides for more details

Progress and Accomplishments (continued)

Activities underway to solicit feedback

- Challenge spec featured prominently on ILC web site
- Request for feedback distributed via email to over 100 lighting manufacturer and utility/energy efficiency group contacts
  - Individuals who commented on past DOE specifications
  - Current ILC Supporters
  - ILC listserv
  - ILC HighLIGHTs newsletter list
  - Next Generation Lighting Systems Design Competition participating manufacturers
  - Better Buildings Newsletter
- Presentation at Midwest Energy Solutions Conference, 2/22/2017
- March 2, 2017 webinar invitations distributed to:
  - Better Buildings Newsletter
  - Better Buildings Lighting & Electrical Team listserv
  - DOE SSL Program listserv

Progress and Accomplishments

Initial Feedback

- Deltavation
- Silver Spark Lighting
- Beimini Sustainable Resources, LLC

Feedback as of February 2017

- *I was given a copy of your initiative and found it to be a remarkable program. The guidance can certainly help get everyone moving in the same direction.* *Lighting Manufacturer, 2/3/2017*

- *Everybody SHOULD be going LED, as fluorescents are energy wasters, and this technology [can be made] for less than THE ENERGY SAVINGS alone!* *Lighting Manufacturer, 2/6/2017*

- *…we were able to de-lamp by 40 to 50% of the existing light fixtures due to the robustness of the LED panels and the wider beam angle. That coupled with your efforts on LED changeover and controls will assist you to make even better energy savings claims.* *Lighting Manufacturer, 2/15/2017*

Project Integration and Collaboration

Broad collaboration and coordination

- Better Buildings
  - Lighting & Electrical Technology Solution Team - > 90 organizations; > 160 people on listserv; ~15 regular participants
  - Walmart played key role in draft spec development
- Interior Lighting Campaign
  - Specification integrated into project plan, included on website
  - Partners will review spec/provide feedback; assist with outreach
- Federal Energy Management Program
  - Recent LED retrofit kit guide helps agencies decide between TLED vs. retrofit kit vs. new luminaire decisions; shared agency requirements

Proud Participant of the
INTERIOR LIGHTING CAMPAIGN

BOMA International

IFMA™ International Facility Management Association

IES Illuminating Engineering Society

FEMP Federal Energy Management Program

Walmart Save money. Live better.

Project Integration and Collaboration

Broad collaboration and coordination

- U.S. General Services Administration
  - Green Proving Ground demos help show innovative LED troffer system performance in real world buildings
- Next Generation Lighting Systems (NGLS)
  - Will use spec as performance target for upcoming demonstration
- DesignLights Consortium™
  - Advanced lighting controls demonstrations lead to body of knowledge
- Utility, efficiency groups
  - Serve as ILC Supporters; help recruit ILC Participants
  - Share utility incentive program information, share project data

GSA U.S. General Services Administration

MEEA Midwest Energy Efficiency Alliance
The Source On Energy Efficiency

DLC

Next Generation LIGHTING SYSTEMS

nep

The University Financing Foundation, Inc.

Franklin Energy
Experience. Delivery. Results.

ComEd. An Exelon Company
powering lives

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Next Steps and Future Plans

Next Steps

- Address questions and comments on the specification
- Determine final performance requirements based on feedback; release final specification
- Coordinate with Next Generation Lighting Systems demonstration; encourage other demonstration projects; share results
- Track introduction of products that meet the specification requirements; encourage their use
- Integrate challenge specification support into the Interior Lighting Campaign
- Assess/review success of this Innovation Challenge

Future Plans

- Consider other emerging technologies for additional innovation challenges

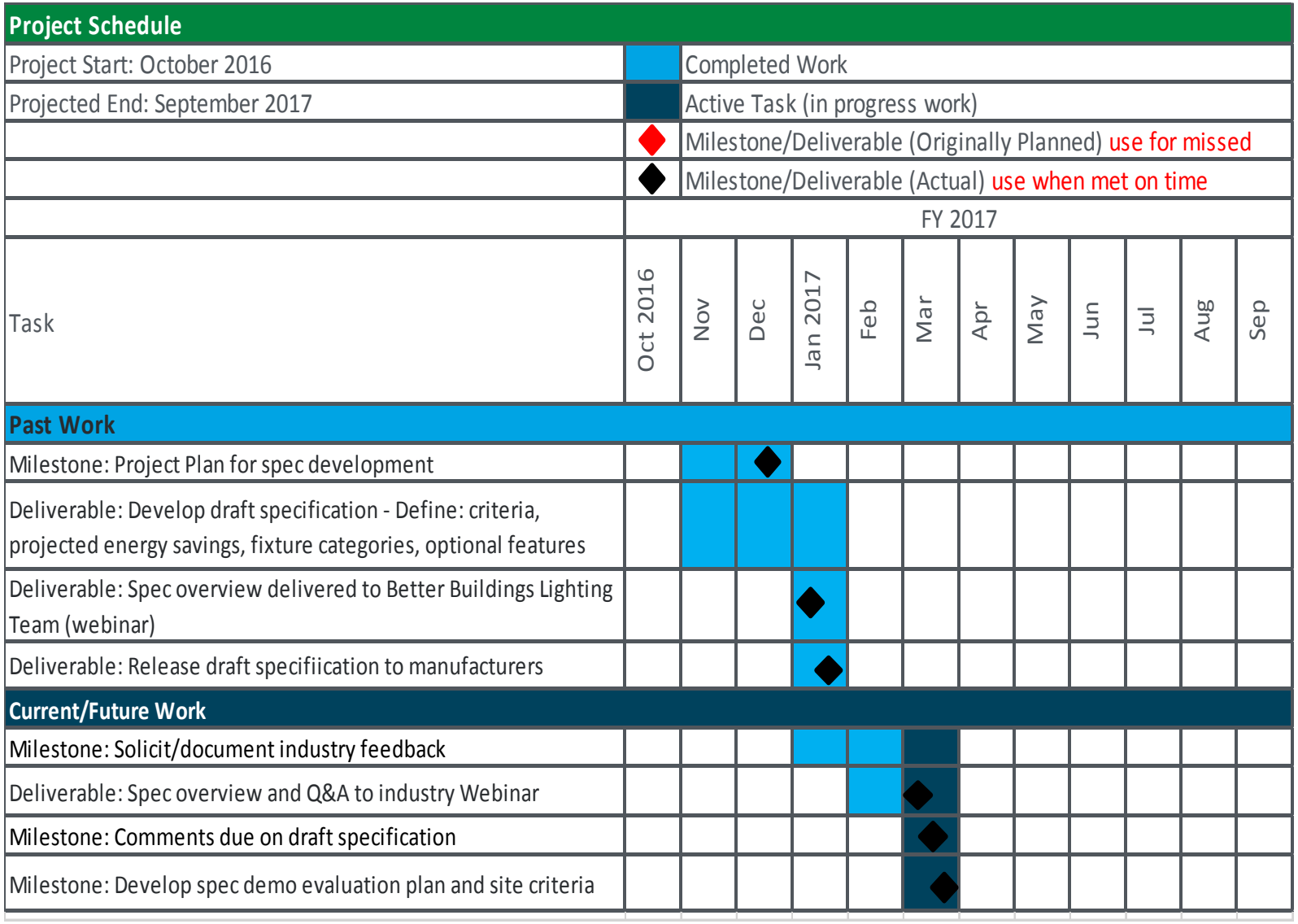
REFERENCE SLIDES

Project Budget

Project Budget: **Variances**: No variances
Cost to Date: $40K (as of 2/23/2017). Demonstration project budgets are separate from this specification development task
Additional Funding: No cost share, however there is significant industry in kind support. Our work enables significant industry investment in energy efficiency.

Budget History					
FY 2016 (past)		FY 2017 (current)		FY 2018 (planned)	
DOE	Cost-share	DOE	Cost-share	DOE	Cost-share
0	0	$65K	0	0	0

Project Plan and Schedule



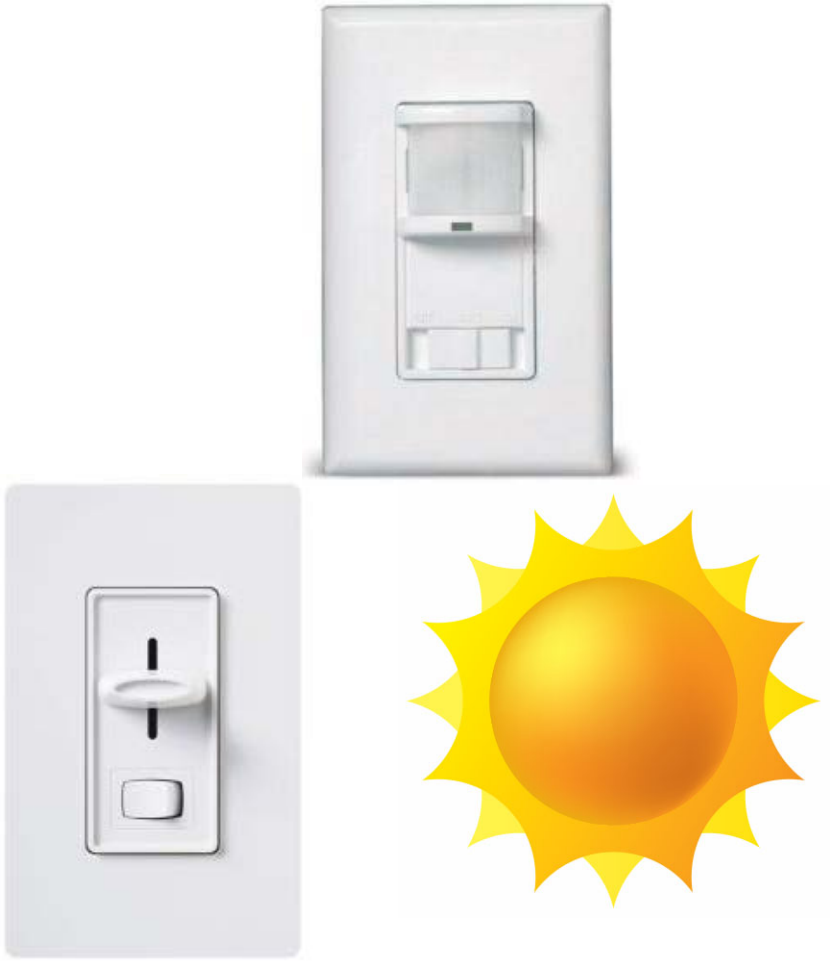
Project Plan and Schedule

Project Schedule		
Project Start: October 2016		Completed Work
Projected End: September 2017		Active Task (in progress work)
	◆	Milestone/Deliverable (Originally Planned) use for missed milestones
	◆	Milestone/Deliverable (Actual) use when met on time
	FY 2017	

Task	Oct 2016	Nov	Dec	Jan 2017	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Current/Future Work												
Deliverable: Release final Challenge specification							◆					
Milestone: Intent to Submit a product due from manufactureres								◆				
Deliverable: Manufacturers notified of product eligibility based on Intent to Submit								◆				
Milestone: Prototype products submitted to PNNL (date subject to change based on manufacturere timelines for product development)										◆		
CBI demonstrations - Select products for demo - Candidate demonstration site(s) selected - Select product(s) for demo									◆	◆	◆	
Next Generation Lighting Systems Demos: - Sets performance criteria for demo - Select products for demo											◆ ◆	
Milestone: Demonstration results complete, documenting in-the-field performance												
Deliverable: Track specification uptake (e.g. through ILC and partner utilities)												

Retrofit Kits and Controls

- Take advantage of controls
  - Occupancy
  - Dimming
  - Daylight sensing
- Integrated sensors
- Advanced controls possible
  - New driver/electronics



Draft Specification Performance Levels (for comment)

Energy Performance

Photometric Performance for Fixed CCT Retrofit Kits				
Category	Minimum Initial Delivered Lumens*	Minimum Luminaire Efficacy (LE)†	Zonal Lumen Density (ZLD)	Spacing Criteria (SC)‡
Troffer	375 × A_{lum}	140 lm/W	ZLD: ≥ 75% total lumens Within 0˚ – 60˚ Zone	SC: 1.0 – 2.0 0˚ – 180˚ Plane or 90˚ – 270˚ Plane
Linear Ambient	375 × L_{lum}	140 lm/W	ZLD: ≥ 40% total lumens Within 0˚ – 60˚ Zone	-
Low Bay	5,000	140 lm/W	ZLD: ≥ 30% total lumens Within 20˚ – 50˚ Zone	-
High Bay	10,000	140 lm/W	ZLD: ≥ 30% total lumens Within 20˚ – 50˚ Zone	-

*A_{lum} and L_{lum} refer to the area or length, respectively, of the luminaire being retrofitted (e.g. a 2' x 4' troffer's Area is 8)
†Retrofit kits are to be tested in Approved or Pre-approved Equivalent Housings as described in the DesignLights Consortium® specification (https://www.designlights.org/solid-state-lighting/testing-reporting-requirements/retrofit-kits/)
‡The ratio of center-to-center fixture spacing to mounting height (ceiling-to-workplane)

Typical commercial light fixtures: 50 – 60 lm/W

Typical industrial light fixtures: 70 – 80 lm/W

Draft Specification Performance Levels (for comment)

Performance – Tunable White

Allow adjusting correlated color temperature of light output

Benefits observed in some applications (e.g., healthcare)

Photometric Performance for Tunable White Retrofit Kits*						
Category	Minimum Initial Delivered Lumens			Minimum Luminaire Efficacy (LE)		
CCT:**	**Min CCT**	**3500 K**	**Max CCT**	**Min CCT**	**3500 K**	**Max CCT**
Troffer	335 × A_{lum}	375 × A_{lum}	375 × A_{lum}	125 lm/W	140 lm/W	150 lm/W
Linear Ambient	335 × L_{lum}	375 × L_{lum}	375 × L_{lum}	125 lm/W	140 lm/W	150 lm/W
Low Bay	4,450	5,000	5,000	125 lm/W	140 lm/W	150 lm/W
High Bay	8,900	10,000	10,000	125 lm/W	140 lm/W	150 lm/W

*The spacing criteria and zonal lumen density requirements for tunable white retrofit kits are the same as those for fixed CCT retrofit kits

** Provide LM-79 reports at the minimum CCT in the range, 3500 K, and maximum CCT in the range in Approved or Pre-approved Equivalent Housings as described in the DesignLights Consortium® specification (https://www.designlights.org/solid-state-lighting/testing-reporting-requirements/retrofit-kits/)

Draft Specification Performance Levels (for comment)

Performance: Sensors/Controls

- Required (integral)
  - Dual-tech occupancy
  - Daylight
- Dimming capable
  - Various methods allowed
  - No phase-cut or step dimming
- Optional
  - VLC
  - Sniffer
  - Sensor network

Draft Specification Performance Levels (for comment)

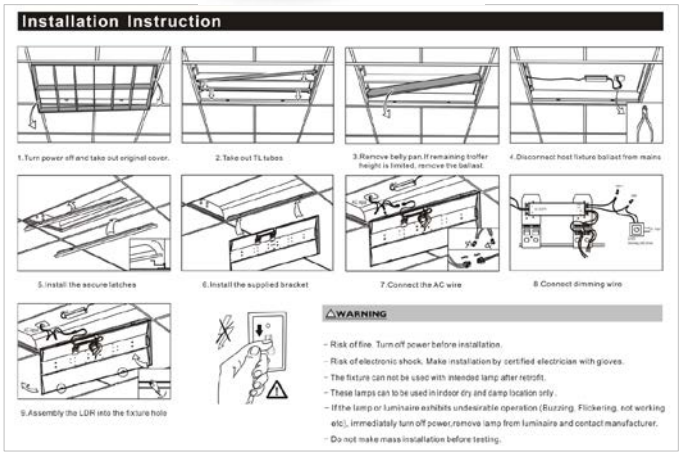
Performance: Installation

- Retrofit kits require:
  - Removal of various existing components (lamps, ballast, diffuser, etc.)
  - Installation of new components (light modules, drivers, etc.)
  - Rewiring to new electronics
- Will likely require a qualified electrician for at least some portion of the installation

Draft Specification Performance Levels (for comment)

Performance: Installation

- Compatibility list
  - Luminaire models known to fit
  - Luminaire types generally known to fit
- Tools required
- Step-by-step instructions
- Installation time
  - Experienced installer
  - First touch to last



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Draft Specification Performance Levels (for comment)

Performance: Installation – Optional Guidance Support

- Video
- Tips/frequently asked questions
- On-demand support
  - Installer hotline
  - Training staff/classes

Videos

GORK Install

Source: Columbia Lighting, Inc.