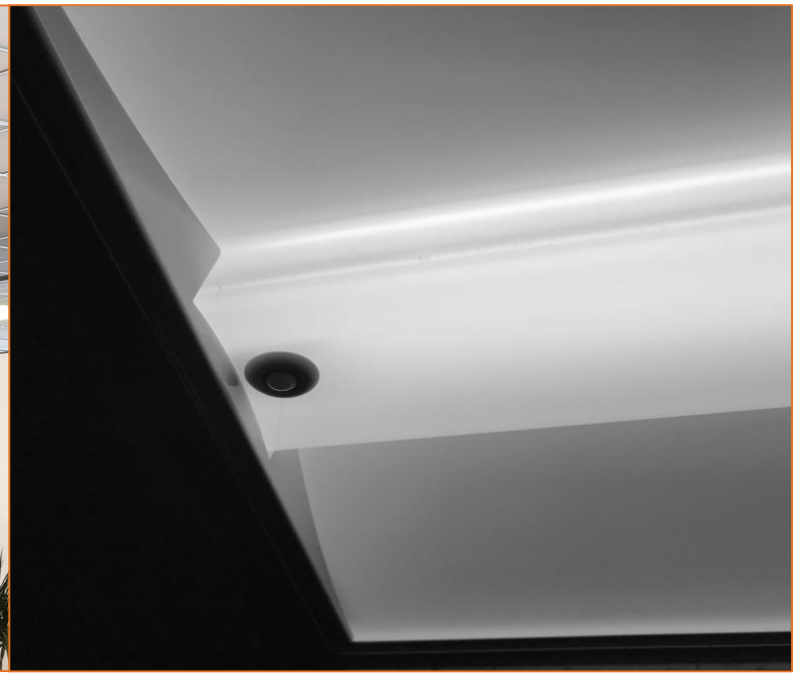
U.S. DEPARTMENT OF ENERGY

Office of ENERGY EFFICIENCY & RENEWABLE ENERGY

IoT-Enabled Troffer Lighting Challenge



Pacific Northwest National Laboratory

Felipe Leon, Engineer

509.372.6516

felipe.leon@pnnl.gov

Project Summary

New Project

Timeline:

Start date: September 2018

Planned end date: Late 2020

Key Milestones

1. Establish Challenge working group; target members representing building owners, energy efficiency organizations, and utilities; 5/15/2019
2. Initial determination on feasibility; 9/30/2019

Budget:

Total Project $ to Date:

- DOE: $61,000
- Cost Share: N/A

Total Project $:

- DOE: $370,000
- Cost Share: N/A

Key Partners:

• Working group of building owner/managers (e.g., Better Buildings), energy efficiency groups, utilities, others
• Technology developers and product manufacturers
• Industry groups focused on connectivity issues

Project Outcome:

The R&D Challenge project encourages the development of competitively priced and easily commissioned IoT-enabled troffer lighting fixtures that are “plug-and-play” ready for luminaire-level lighting sensor/control, IoT sensors/devices, and internet connectivity.

Outcomes include new to market products meeting performance requirements deemed essential by buyers, and increasing awareness regarding products that have completed laboratory testing and field validation to evaluate performance in real buildings.

Team

Linda Sandahl, Program Manager
29 Years PNNL experience. Successful track record in managing technology introduction projects and stakeholder engagement activities.

Felipe Leon, Task Lead
5 years PNNL experience. Lighting Engineer with private sector product management and lighting product development experience.

Michael Myer, Technical Guidance
12 years PNNL experience. Research expertise in SSL, lighting controls, lighting market transformation, and codes & standards.

Ruth Taylor, Technical Guidance
17 years PNNL experience. Decade-long track record of managing technology innovation focused on design competitions.

Anne Wagner, Technical Guidance
10 years PNNL experience. Managed the Wireless Metering Challenge and was involved with the High Performance RTU Challenge.

Resources/Synergies

DOE Solid-State Lighting (SSL) research and development team

- Connected Lighting Test Bed

Better Buildings

- Interior Lighting Campaign supporters and participants
- Lighting and Electrical Research Team

U.S. GSA Proving Ground

American-Made Challenges

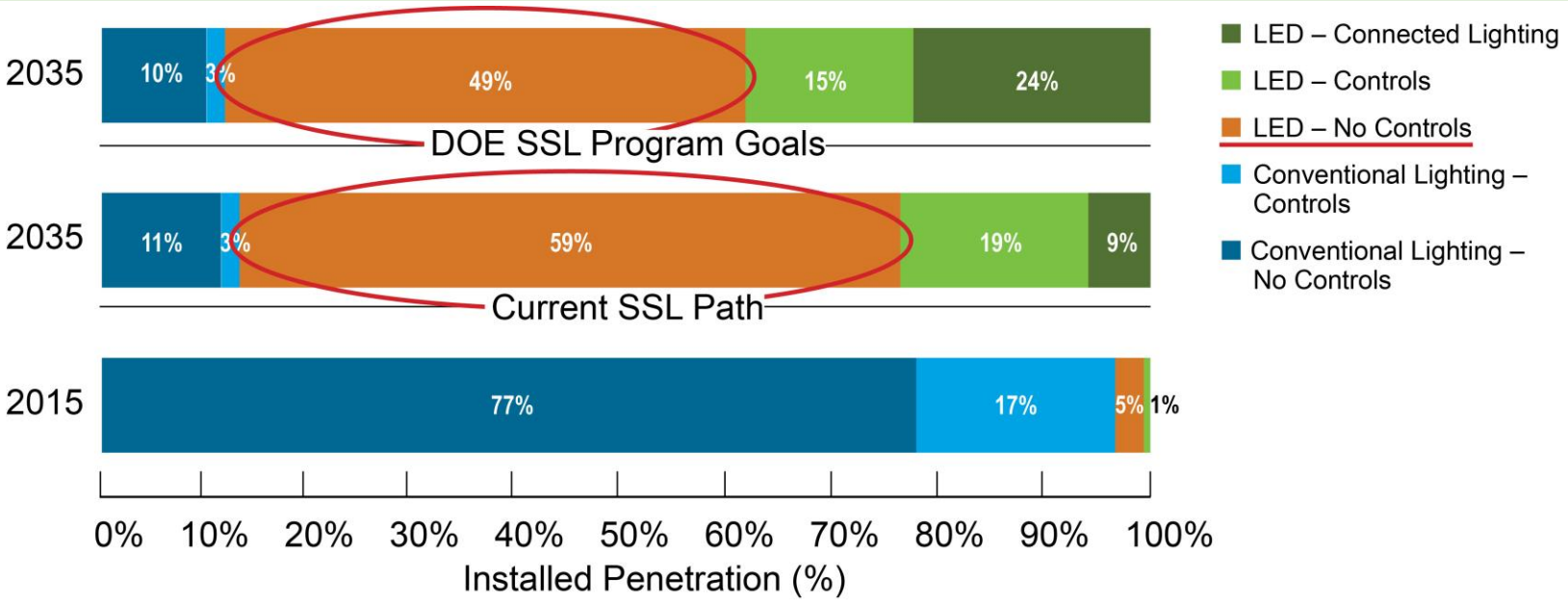
Consortium for Energy Efficiency

DesignLights® Consortium

Zhaga/IoT-Ready Alliance™

Illuminating Engineering Society

Challenge – General Illumination Controls*



Problem Definition: Over half of LED lighting will not have controls or be connected† in 2035. The **cost to upgrade a luminaire with controls after installation is generally cost-prohibitive** and, as a result, energy saving opportunities from controls for lighting—and possibly from interactions with other building systems—might never occur in these luminaires. CBI program goals are supported by providing a **low-cost approach to easily upgrading luminaires and capturing energy savings**.

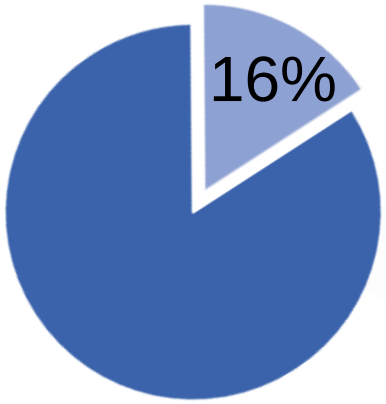
Solution: *Catalyze the market to deliver a low-cost, easily upgradeable troffer for future luminaire-level lighting control and Internet of Things functionality.*

* Based on *Energy Savings Forecast of Solid-State Lighting in General Illumination Applications*, U.S. DOE, September 2016.

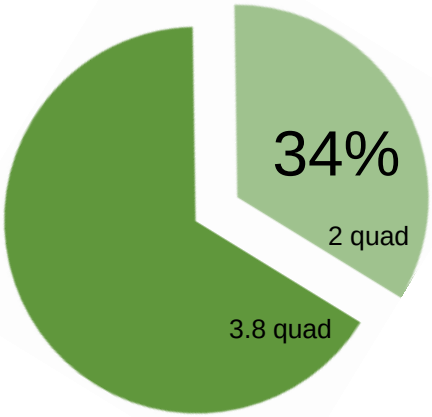
† *Connected*: All four traditional control strategies (dimming, daylighting, occupancy sensor, and timer) are implemented. Additional energy savings based on communication between connected lamps and luminaires, as well as use optimization through machine learning algorithms.

Challenge – Why Troffers?

Linear luminaires by the numbers* as of 2015

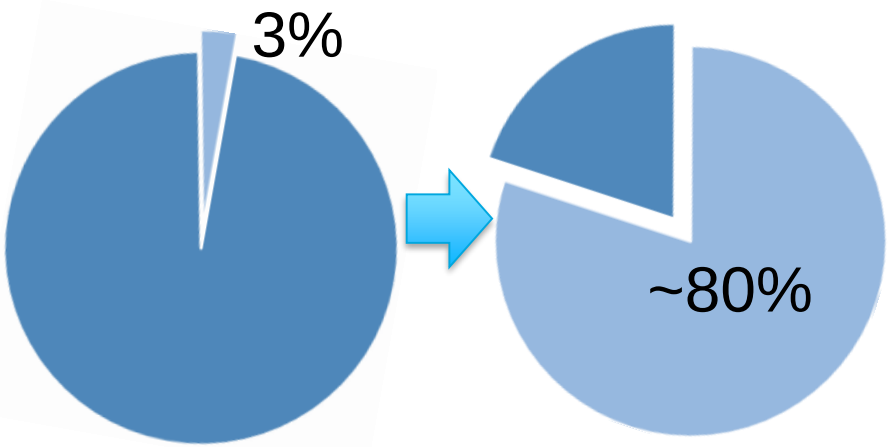


Installations



Lighting total: 5.8 quad

Energy Use



LED Penetration

Troffers represent nearly half of the linear fixture market

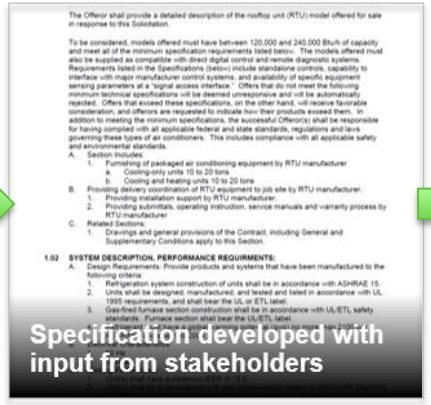
Legacy - Fluorescent

LED Troffers

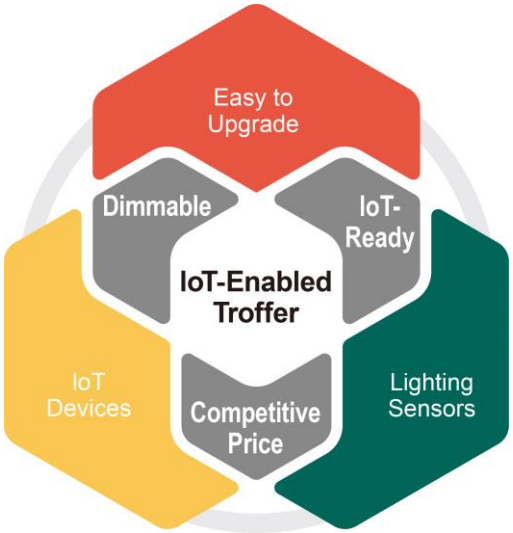
* Based on *Energy Savings Forecast of Solid-State Lighting in General Illumination Applications*, U.S. DOE, September 2016.

Approach

- **Learn from and emulate prior challenges**
  - High Performance Rooftop Unit (RTU) Challenge
    - Outcome: Daikin McQuay's Rebel RTUs are expected to reduce energy use by as much as 50% over current standards
  - Low-Cost Wireless Metering Challenge
    - Outcome: Meazon wireless submeter solution met the target equipment cost of under $100
- **This Challenge uses a similar approach**
  - Desired outcome: Manufacturer meets the price target and demonstrates upgradeability, connectivity, and IoT functionality



Approach – General



Challenge the industry to develop an easily upgradeable troffer that is competitively priced and provides for connectivity … then verify that it works

Product

- Luminaire
- Retrofit Kit

Add-Ons

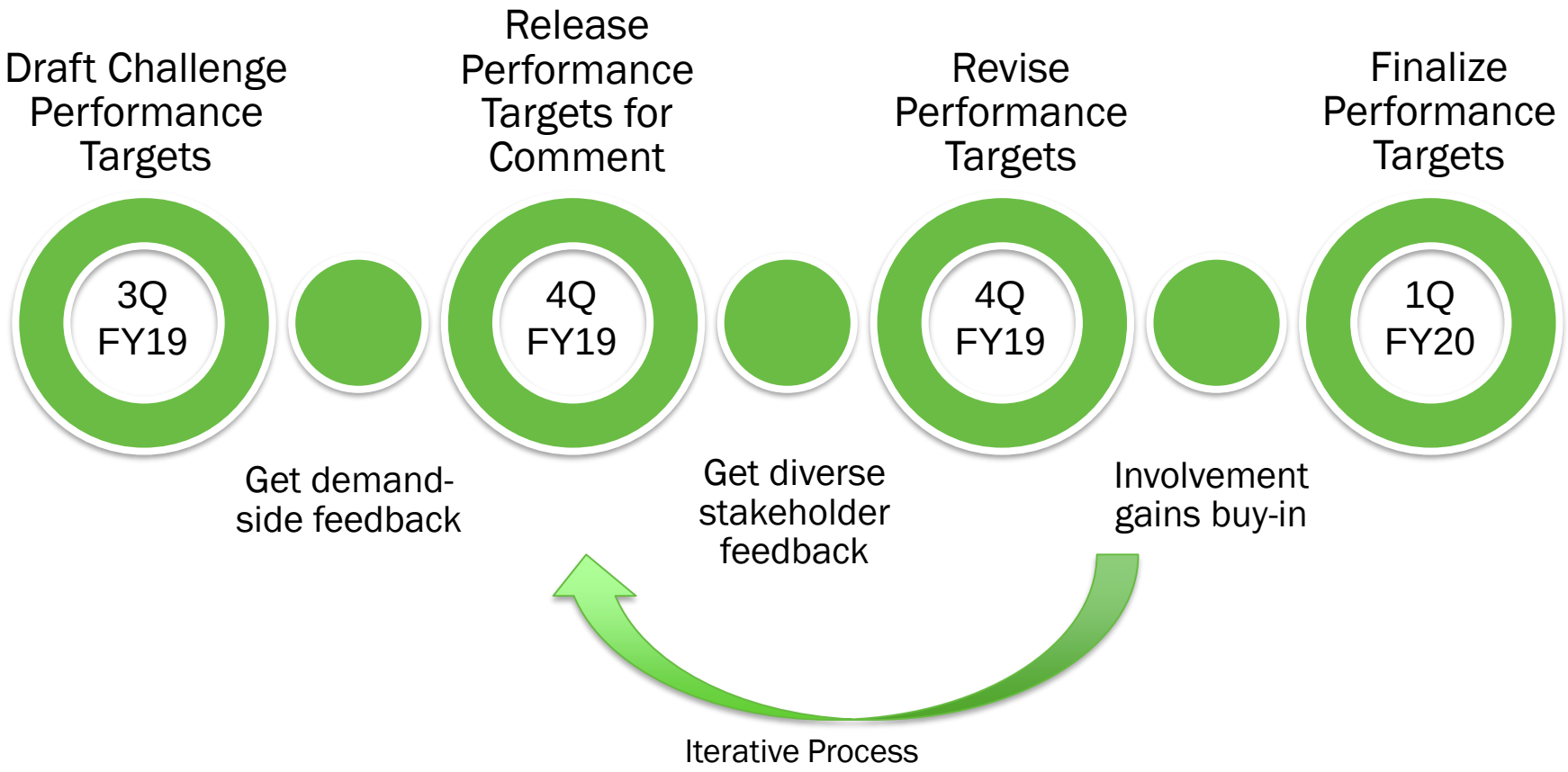
- Lighting sensors
- IoT devices

Field Validation

- Office
- Education
- Healthcare

Approach – Preparing to Challenge the Industry

- The early stages establish performance targets with feedback from end-users
- All stakeholders (including manufacturers) are provided a chance to review and comment on the established performance targets
- End-users provide letters of support (incentive); utilities and other partners may provide financial incentives



Approach – Validating Products

- **Challenge the industry**
  - Publish finalized performance targets for manufacturers to develop products
- **Evaluate entries**
  - Lab-based testing is used to confirm product performance meets the requirements
  - Third-party testing and limited lab-based functionality testing
- **Pilot/field validations**
  - Small-scale and real-world validations are completed to confirm product performs its more advanced functions (e.g., connectivity, IoT)
- **Case studies**
  - Build knowledge base about lighting implementations of IoT in lighting systems

Impact

Today, lighting systems with advanced functionality are expensive, complex, and seldom installed. Although research and development continue on these fronts, tens of millions of troffers will be installed in the coming years lacking even basic lighting controls, forfeiting energy savings and other functionality.

- **Troffers that are future-proofed can:**
  - Allow customers to integrate lighting controls and IoT devices years after installation
  - Give time for technology to mature and prices to come down
  - Create future lighting energy saving opportunities for building owners
  - Provide other potential revenue streams for manufacturers (products and services)
- **Building systems and operations benefits of upgraded luminaires can include:**
  - Energy savings in other building systems (e.g., HVAC and plug loads)
  - Non-energy benefits (e.g., asset tracking, customer engagement, space utilization, and others)
- **Easily upgradeable interior luminaires have not been encountered in the market**
  - Street lights provide one example of luminaires that are future-proofed via NEMA 7-pin socket

Impact

- **Building with 1000 troffers (≥ 100,000 ft^2):**
  - 36 W per troffer => 138,000 kWh annual energy use for troffer lighting
  - Lighting controls can typically save 30% or more
  - Up to $4,300 may be saved annually by adding sensors to the system
- **Possibility for additional savings via advanced functionality options (i.e., advanced lighting sensors and IoT):**
  - HVAC system (e.g., not heating/cooling unoccupied spaces)
  - Plug loads (e.g., turning off plugs in unoccupied spaces)
  - Building use efficiencies via heat mapping of space utilization
    - Reduce energy use, or
    - Improve use of space, or
    - Lease space
  - 3-30-300 ratio value-added benefits

Impact

- **How will this be realized?**
  - Manufacturers develop products to show what is possible
  - End users validate concept and create a demand
  - Products are preferred as they provide competitive advantage at a reasonable incremental cost
- **The potential benefits will be quantified via:**
  - Field validations using today's prices
  - ROI calculator for future components/systems required for upgrades
  - Tracked in future years via technology adoption campaign(s) such as the ILC

Throughout history, competition has brought out the best in Americans and driven them to break through barriers, opening the door to stunning achievements.

Rick Perry, Secretary of Energy

White House Discussion on Federal Prizes and Challenges

Progress – Outreach and Partnerships

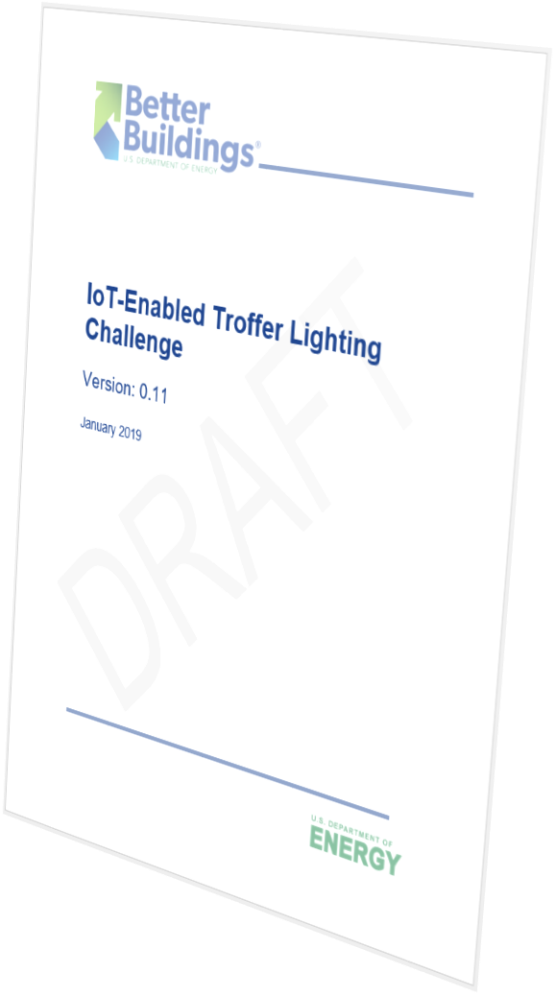
Project is in early stages. Outreach has occurred to gauge end-user interest, identify synergistic activities, and explore collaborative partnerships with other organizations and laboratories.

- **Held discussions with several potential partners to gauge interest**
  - Building/energy managers
  - Consultants
  - Contractors
  - Energy efficiency organizations (Consortium for Energy Efficiency, Building Energy Exchange, DesignLights Consortium)
- **Held discussions with others to identify synergistic activities**
  - American-Made Challenges (NREL)
  - WELL Building Institute

Progress – Performance Targets

Developed strawman of product performance targets for this Challenge

- **Overview**
  - Provides motivation for the Challenge and benefits of products meeting performance targets
- **General performance targets**
  - Covers electrical and photometric attributes of product
- **Challenge-specific performance targets**
  - Dimming
  - Sensor connectivity
  - Security
  - Installation
  - Price
- **Process guidance**
  - How to submit an entry
  - Evaluations to be performed



Stakeholder Engagement

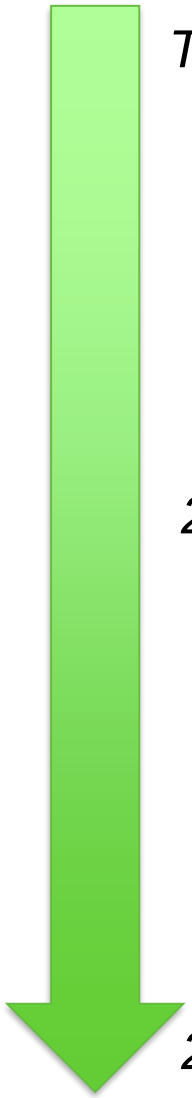
- **Intra- and Inter-Laboratory**
  - PNNL Solid-State Lighting Team
    - Evaluate synergy with L-Prize 21st Century competition
    - Consider Connected Lighting Test Bed for product testing
  - Next Generation Lighting Systems
    - Leverage expertise in planning and executing lighting competitions
    - Evaluate product requirements
    - Explore future NGLS category potential
  - American-Made Challenges (DOE)
    - Understand American-Made Challenges approach – meetings with NREL
    - Consider partnering and leveraging this platform
- **External**
  - IoT research participants
    - Provided insight into use of IoT and its use in lighting
    - Followed up with end-users who participated in an IoT study
    - Included healthcare, office, retail, and education
  - Consultants/Contractors
    - Provided broader perspective on interior lighting projects and IoT being applied in lighting
    - Potential for field validation studies support
  - Manufacturers

Stakeholder Engagement

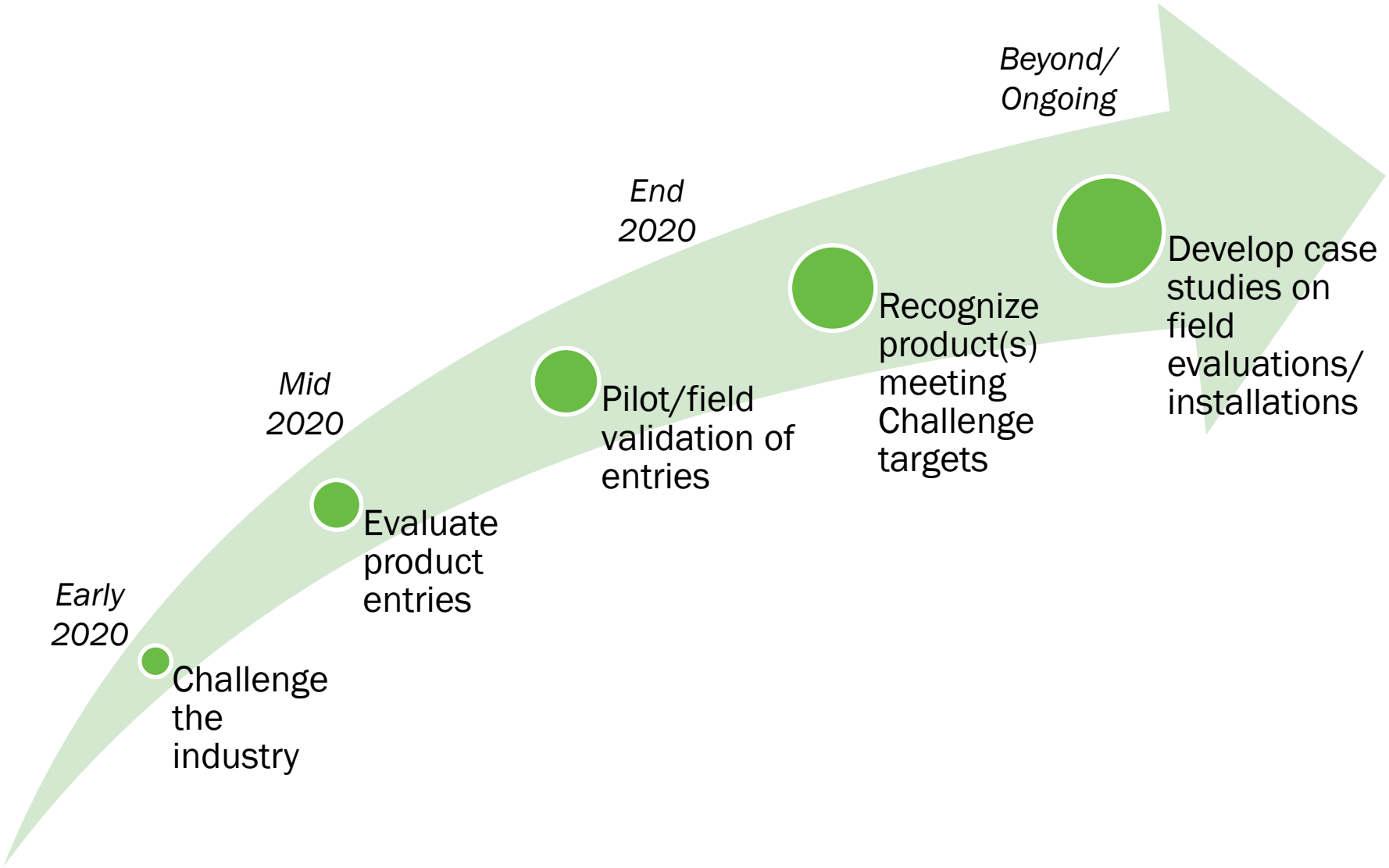
- **Summary of findings**
  - Price sensitivity and lack of understanding about IoT benefits is limiting adoption
    - Very limited advanced applications of sensors in lighting
    - Usually unique, custom-built systems
  - IoT applications of interest mentioned
    - Asset tracking
    - Space utilization
    - Indoor air quality
    - Security
  - Price point
    - Most interviewees noted it cannot significantly impact payback periods of up to five years
    - Acceptable incremental price up to 15% noted; most say 2-10%

Remaining Project Work (Immediate Future)

- **Engage with specific commercial building sectors and socialize Challenge**
  - Understand the specific needs of each sector and the advanced lighting control and IoT functionalities of interest
  - Better Buildings Summit (July 2019)
- **Working group (end-users) to refine first draft of performance targets**
  - Based on the feedback from sectors, the targets for the product (troffer) and sensor needs are initially drafted
  - A working group helps refine these targets and gains buy-in
- **Release draft performance targets for broad review/comment**
  - Draft targets for the Challenge are released to all stakeholders for input
- **Obtain stakeholder feedback (manuf., utilities, etc.)**
  - Feedback from manufacturers help to address the limitations of the technology and consider cost implications
- **Revise performance targets**
  - Targets are revised based on all stakeholder feedback and further analysis
- **Finalize performance targets**
  - Targets are finalized and the Challenge is launched



Remaining Project Work (Distant Future)



Thank You

Pacific Northwest National Laboratory
Felipe A. Leon, Electrical Engineer
509-372-6516 | Felipe.Leon@PNNL.GOV

PNNL-SA-142481

REFERENCE SLIDES

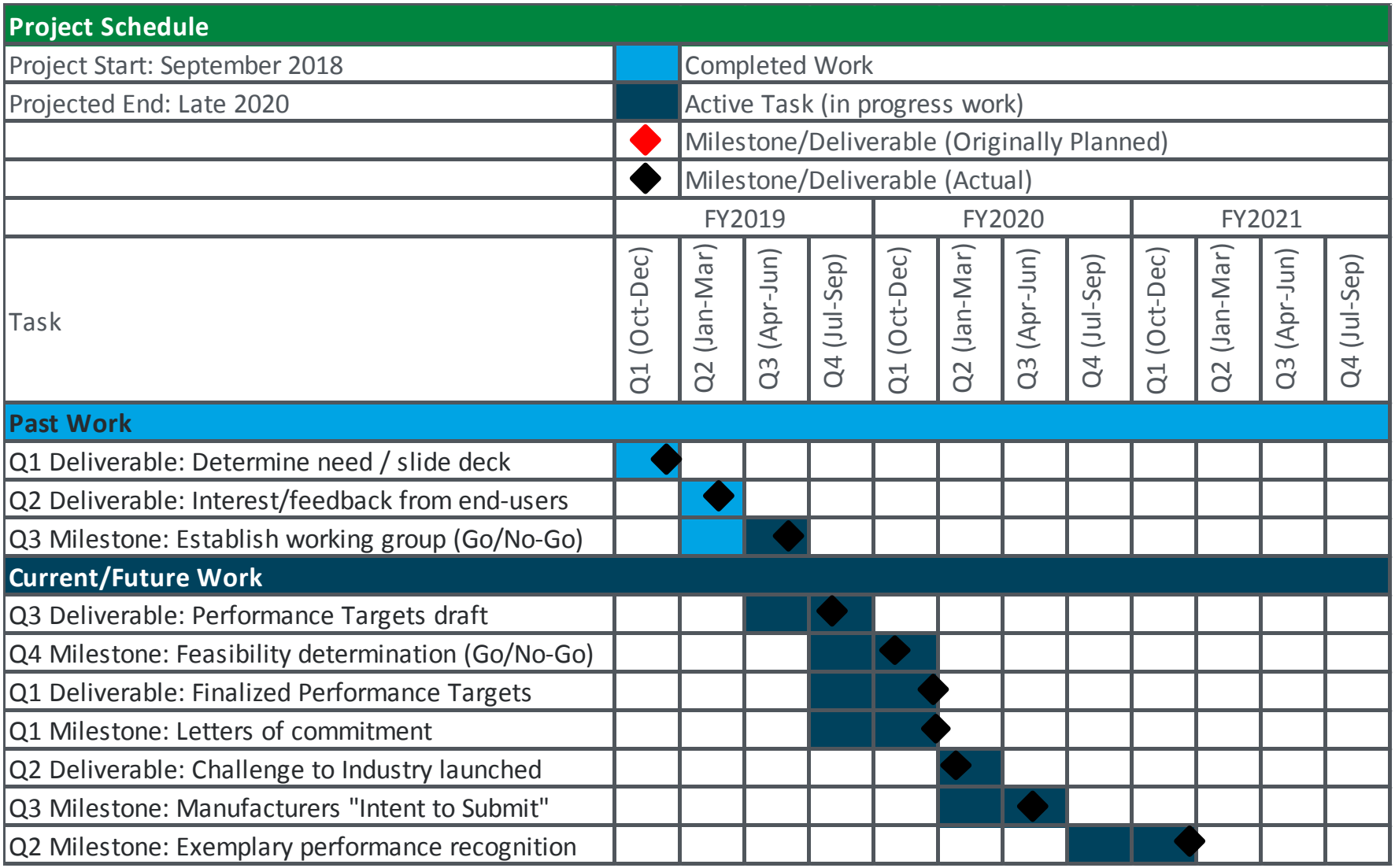
Project Budget

New Project

Project Budget: $370,000
Variances: None
Cost to Date: $61,000
Additional Funding: N/A

Budget History					
FY 2018 (past)		FY 2019 (current)		FY 2020 – Early FY 2021 (planned)	
DOE	Cost-share	DOE	Cost-share	DOE	Cost-share
$1,000	-	$220,000	-	$149,000	-

Project Plan and Schedule



Acronyms and Definitions

3-30-300 Ratio

In business, this ratio is used as a rule of thumb for estimating costs of energy, space, and people in dollars per square foot, respectively

IoT – Internet of Things

The interconnection of machines and devices through the internet, enabling the creation of data that can yield analytical insights and support new operations

IoT-Enabled

Capable of transmitting sensor data to the internet from its own sensor (e.g., troffer energy use) or other connected sensor (e.g., attached IoT sensor)

LLLC – Luminaire-level lighting control

Lighting control strategy where integration of sensors for controlling light output is done at the luminaire

NGLS – Next Generation Lighting Systems

A DOE-sponsored design competition featuring ongoing evaluations of connected lighting systems in real-world installations (https://www.energy.gov/eere/ssl/next-generation-lighting-systems)