U.S. DEPARTMENT OF ENERGY

Office of ENERGY EFFICIENCY & RENEWABLE ENERGY

Next Generation Lighting Systems (NGLS)

Living laboratory approach to researching connected lighting installation, configuration complexity, and performance.

Next Generation LIGHTING SYSTEMS

Pacific Northwest National Laboratory

Ruth Taylor

Ruth.Taylor@pnnl.gov

PNNL-SA-142465

Project Summary

Timeline: New scope/continuing work

Start date: 10/1/2018

Planned end date: 9/30/2021

Key Milestones

1. Outdoor evaluation 1 install 5/31/2019
2. Indoor evaluation 2 install 7/31/2019
3. Outdoor evaluation 1 performance eval 9/30/2019

Key Partners:

Illuminating Engineering Society
International Association of Lighting Designers
The New School, Parsons School of Design
VA Tech Transportation Institute

Budget:

Total Project $ to Date:

- DOE: $1725k
- Cost Share: $0

Total Project $:

- DOE: $4025k
- Cost Share: $0

Project Goals and Outcomes:

Through structured observation and evaluation, NGLS seeks to reduce configuration complexity to increase the likelihood that connected lighting systems will be broadly deployed and deliver exceptional energy savings in the built environment. The project will contribute to the Building Technologies Office goal to reduce lighting energy use intensity 30% by 2030.

Team

Ruth Taylor

Principal Investigator, Founder
NGL/NGLS, PNNL 25+yrs
BA Architecture & Env Design

Michael Poplawski

Technical Support, Connected Lighting
Solid state physics
PNNL 9 years
BSEE, MSEE

Terry Shoemaker

Program and Logistical Support
PNNL Project Specialist 25+yrs

Naomi Miller

Technical Support, Lighting Design
PNNL 10 yrs
MS, Lighting

Tracy Beeson

Technical/CAD Support
PNNL 10 yrs
MS Arch Sciences & Lighting

Jessica Collier

Technical/CAD Support
PNNL research associate 2019
MFA, Lighting Design

Additional Technical Contractor Support

Mary Matteson Bryan
Professional Engineer
Energy Engineering 20+yrs
BSME, MSME

Dan Blitzer
Principal, The Practical Lighting Workshop
Lighting industry 30+yrs
BA Economics

Team – Steering Committee and Advisors

Indoor

Melanie Taylor, IALD, LEED AP
Vice President, Lighting Design
WSP

Craig Bernecker, Ph.D., FIES, LC
Founder and Director
The Lighting Education Institute

Charles Thompson, AIA
IALD LC LEED AP IESNA
Archillume Lighting Design

Avi Mor, LEED AP, IESNA,
Lighting Designer
Lightswitch Architectural

Aram Ebben, IALD, LEED AP BD+C
Principal | Director of Lighting Design
exp, U.S. Services Inc.

Mary Matteson Bryan, P.E.
Energy Engineering

Dan Blitzer, FIES
Practical Lighting Workshop

Chris Wolgamott
Northwest Energy Efficiency Alliance (NEEA)

Outdoor

Nancy Clanton, PE, FIES, IALD, LC, LEED AP
President
Clanton & Associates, Inc.

Ron Gibbons, Ph.D, FIES
Virginia Tech Transportation Institute (VTTI)

Chip Israel, FIALD, MIES, LEED® AP, LC
CEO & FOUNDER
Lighting Design Alliance

Mike Lambert, IES, LC
Senior Lighting Designer
KCL Engineering

Nathan Mitten, Ph.D.
Senior Manager of Property Standards & Improvements
Kimco Realty Corporation

Advisors

- **Gabe Arnold** - DLC, NLC
- **Dave Bisbee** - SMUD
- **Peter Jacobson** - Con Edison
- **Levin Nock** - DLC, NLC

Next Generation Luminaires (NGL) History

- First NGL luminaire design competition in 2008
- 14 Steering Committee members, majority involved since inception
- Weekly Steering Committee calls (indoor and outdoor)
- 15 separate judging/evaluation events
- 64 different lighting professionals involved as judges
- Over 1300 products submitted by over 300 manufacturers

Next Generation LIGHTING SYSTEMS

2018 Parsons Installations

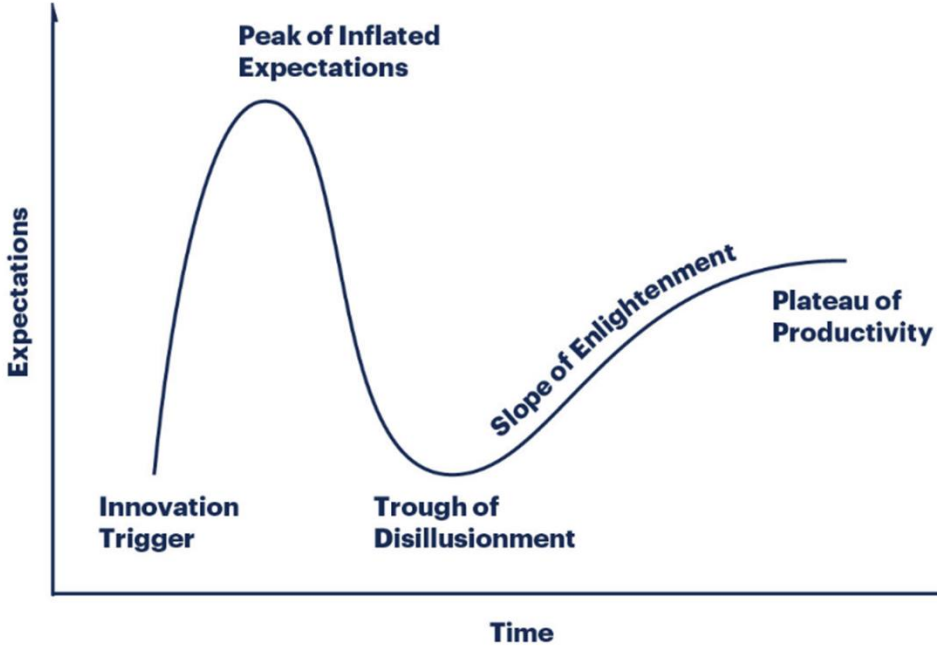
Company	Control System	Luminaire
Lumenwerx	Magnum	Reven SIB
Selux	Easy Sense	M36 D-1
Crestron	Zum	Starfire Versalux D-I
Philips Lighting	SpaceWise DT	Sona
RAB Lighting	RAB LightCloud	Swish 2x2
Cree	SmartCast	CR22
Nextek Power Systems	Sky Control	Independence iLED R Series

Company	Control System	Retrofit Kit
Philips Lighting	SpaceWise DT	EvoKit Troffer Retrofit Kit
Lutron Electronics	Vive	Orion Ison Retrofit Modular
Acuity Brands	nLIGHT AIR	BLT Relight Series Kit
Eaton	WaveLinx	Metalux Cruze LED Retrofit Kit
LG Electronics	Sensor Connect	Simple Choice Retrofit Kit

	# of Systems Each Rating		
Installation and Configuration Evaluation	**Good**	**Fair**	**Poor**
Ease of Luminaire/Kit Installation	6	3	3
Ease of Control Component Installation	4	4	4
Ease of Initial Configuration	2	5	5
Ease of Adjustment of Control Settings	5	4	3
Ability to Install without Manuf Assistance	6	3	3
Usability of Installation Instructions	0	6	6
Operation Evaluation	**Good**	**Fair**	**Poor**
Operation to Specification	5	2	5
Ability to Operate without Manuf Assistance	5	3	4
Limited Punch List Items	5	1	6

Challenge – Connected Lighting

Configuration complexity is contributing significantly to the Trough of Disillusionment.



Challenge – Configuration Complexity

- Connected systems that are overly complicated and time-consuming to install/configure often never perform to expectations and eventually get disabled.
- Reducing configuration complexity will increase the likelihood of energy savings. Systems that don't get used don't save energy.
- For connected systems to be broadly deployed, installation and configuration must be simplified to match owner/occupant needs.

Project Goal: Reduce configuration complexity in connected lighting systems.

Approach – Observational Research

To find the real ‘pressure points’ in configuration complexity, *people* need to observe and evaluate the *people* installing and configuring the system in real time, without assistance - it just can’t be done in a demonstration, mock-up, or testing lab.

Approach – Using NGL History

- Decade long experience in subjective evaluations
- ‘Competitions’ motivate manufacturers to differentiate themselves and innovate
- Long history of trust and respect from manufacturers and specifiers
- Highly engaged and committed expert Steering Committee and evaluators
- Extensive experience developing technical requirements and evaluation protocols/processes

Approach – Documenting the Evaluations

Test 1: Occupancy Function

Room: 623, Acuity
Date: 10-Feb
Name: Ruth and Craig

1 Complete measurements when room is unoccupied.
2 Turn all lights on with wall switches.
3 Exit room and close door. Wait outside for 20 minutes.

Test Results

X **PASS** — Lights Turn Off within 20 minutes. Record Elapsed Time: 10 min (Time Out Period)

FAIL — Lights do not turn off after 20 minutes. Move to next room.

Comments: Initially the system was not working, wall switches did not work, lots of time required to update the firmware. Once the firmware was updated, the system worked flawlessly. Daylighting response

Continue with Test 2, Sensitivity

Test 2: Occupancy Sensitivity

1 Complete measurements when room is unoccupied
2 Calculate Test Duration as TD (min) = Time Out Period measured in Test 1 + 2
Test Duration (TD): 12 min
3 Turn all lights on with wall switches.
4 Sit at a location close to the center of the room as shown on the room layout

Test A, Minor Movement:

6 Conduct test for Test Duration from step 2.
7 Place LD+A magazine on desktop. Read magazine, being sure to turn a page a

Test Results

X **PASS** — Lights do NOT switch off. Continue with Test B.

Rm 1106 Cree

Assuming 10' mounting height for sensor.
Coverage = 6' radius (100 sf)

Entire room is covered.

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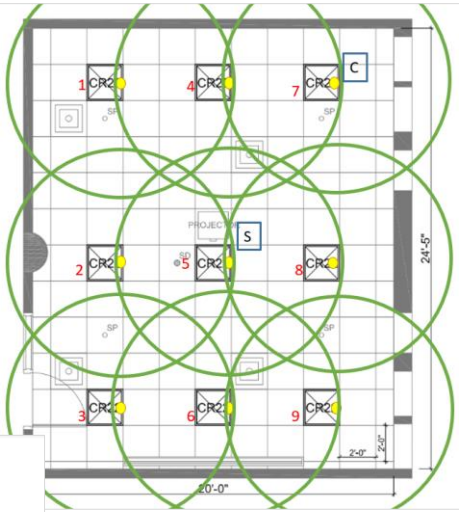
rage Chair Location



DAYLIGHTING PERFORMANCE MEASUREMENTS FORM

General Information			
Entrant #		Room Number	
System Name			

Measurement Point	Blinds Closed — Illuminance (lux)	Blinds at 25% — Illuminance (lux)	Blinds at 50% — Illuminance (lux)	Blinds Open (lights on) — Illuminance (lux)	Blinds Open (lights off) — Illuminance (lux)
1					
2					

CONTROL SETTING VERIFICATION STEPS FORM
Sheet 1 of 3

General Information			
Entrant #		System Name	
Installer Name			
Room Number		Date of Installation	
Evaluator Name			

PHASE 2 - CONTROL SYSTEM INSTALLATION AND STARTUP
Start with blinds closed. Allow lighting levels to stabilize (5 minutes).

Function	Verification Steps	Comments
Grouped into zones	Visually verify **two** zones using manual dimming controller	☐ Complete
Manual dimming	Test each zone independently 1. Adjust manual dimming control to maximum setting. 2. Measure light level at specified locations. 3. Adjust manual dimming control to lowest setting. (NGLS Spec = min dim setting of **10%** lumen output)	☐ Complete

Metric	Value
adjust control settings *from the NGLS specified settings to the Alternate settings*	
Number of steps required to adjust control settings *from the NGLS specified settings to the Alternate settings*	
Number of attempts required to successfully adjust control settings *from the NGLS specified settings to the Alternate settings*	

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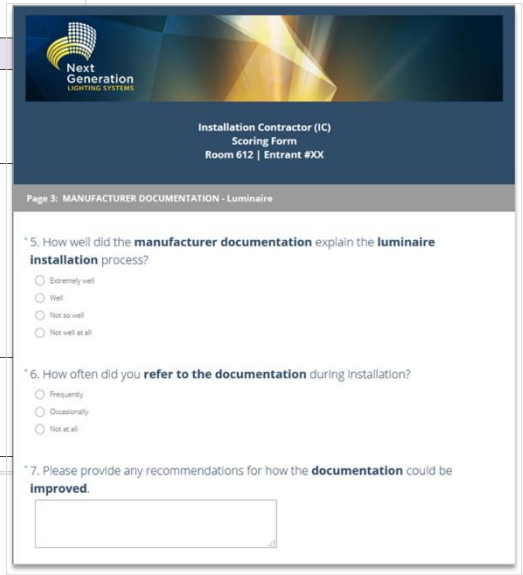


Approach – NGLS Perspective

- Evaluation process compares multiple approaches in a single environment
- Observations reveal areas for improvement and help identify approaches that work
- General principles and practices that minimize configuration complexity can be shared with the entire industry

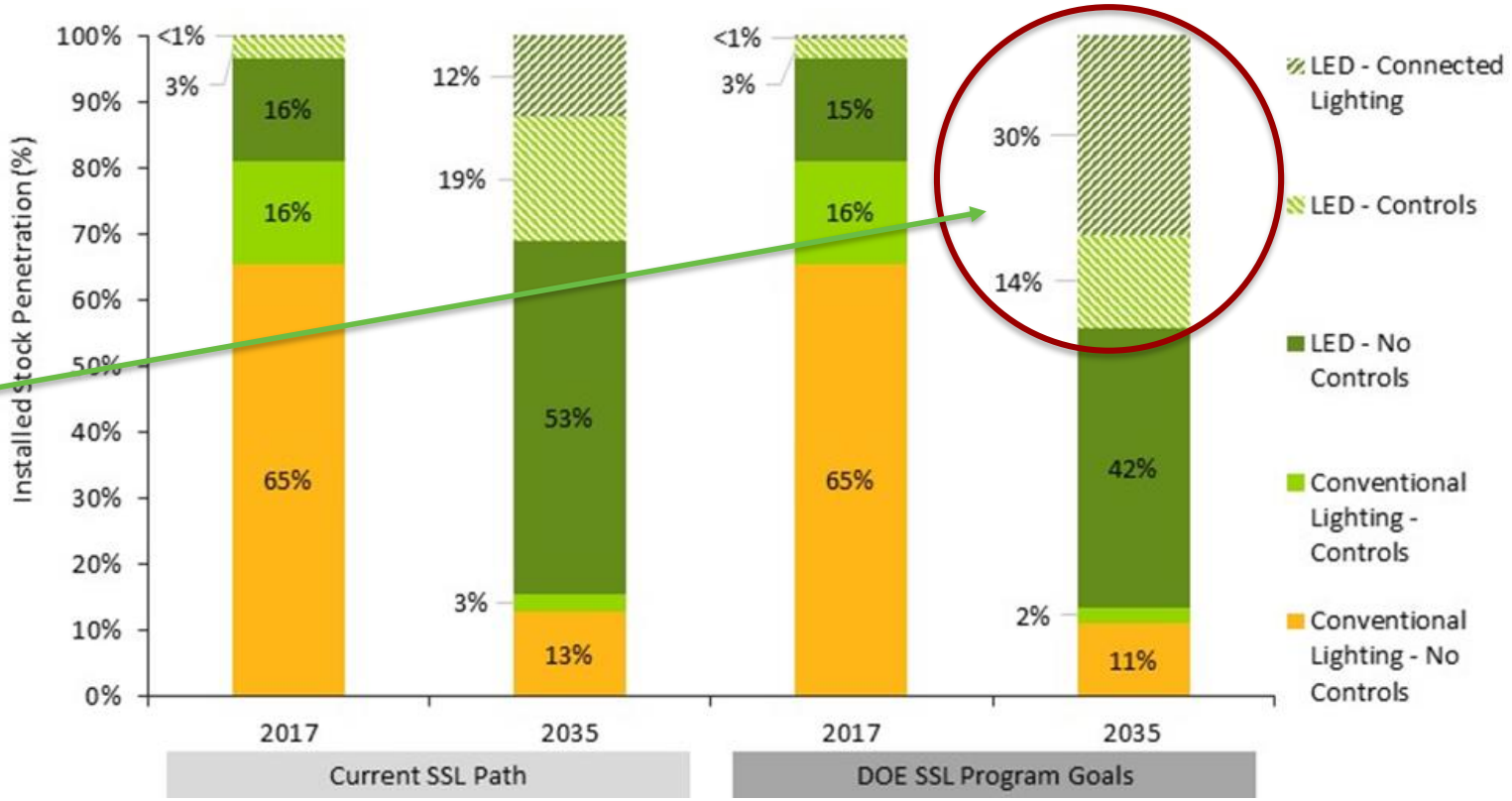
Industry research, which is not shared, typically has a narrow focus with preconceptions that can limit broad solutions to configuration complexity.

Impact – Energy Savings

SSL Program Goals: projected annual energy savings attributable to lighting controls in 2030 increases by 48%, from 741 tBtu under Current SSL Path scenario to 1100 tBtu

- Annual savings in 2035: 1350 tBtu

Reducing configuration complexity is key to reaching these goals



*Energy Savings Forecast of SSL in General Illumination Applications. DOE. 2018. ***Preliminary.***

Impact – Getting the Word Out

Presentations

LEDucation March 2019, Assessing Connected Lighting Systems: What Works and How do we Know?

Strategies in Light February 2019, Bridging the Gap. What it actually takes to get your Connected Lighting System Installed and Configured

LEDucation March 2018, Designers Light Forum | Connected Lighting Systems: How Easy is Easy?

ACEEE Summer Study on Energy Efficiency in Buildings September 2018, Not So Easy: Lessons Learned from Installation and Configuration of 'Easy to Install" Connected Lighting Systems

LightShow West October 2018, Getting What You Want in your Next Connected Lighting Installation

2019 Lightfair International May 2019, Smart Parking Lot Lighting Systems, Do They Really Work? Lessons learned from the NGLS connected lighting parking lot system evaluations

2018 Lightfair International May 2018, So You Think Your System is Easy to Install and Startup? Lessons Learned from the NGLS Connected Lighting Systems Evaluations

CEE: 2018 Residential Lighting and the Integrated Home Workshop June 2018, What Can Lighting for Tomorrow learn from NGL's transition to Evaluating Connected Lighting Systems?

DLC Stakeholder Meeting July 2018, Connected Lighting Installations - Learning From Watching

IES 2018 Annual Conference August 2018, Surprises from Connected Lighting Installations: What to know before you specify your next connected lighting project.

Evergreen Efficiency September 2018, Lessons Learned from the Initial Indoor Evaluations

Street and Area Lighting Conference September 2019, Understanding Connected Parking Lot Systems. Lessons Learned from NGLS Installations in a Living Lab

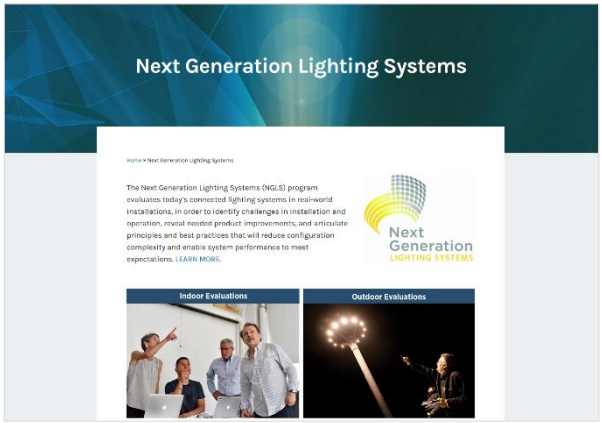
Articles

LD+A May 2018, Connected-Lighting Lessons from a Living Lab

IALD Reflections February 2018, Update on the Next Generation Lighting Systems Competition

PNNL Research Highlights May 2018, Report Cards for Today's Connected Lighting Systems

West Coast Lighting Insider, May 2018, NGL Moves on "Easy-to-Install" Connected Lighting Systems



www.energy.gov/eere/ssl/next-generation-lighting-systems

Impact – Manufacturers are Listening

EATON

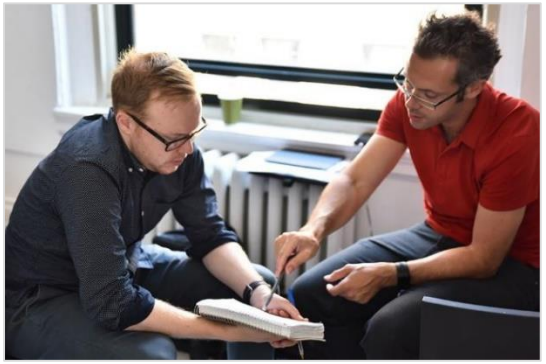
Lighting solutions

The NGLS competition helped us further improve our **Eaton WaveLinx** Connected Lighting Solution by updating how we deliver our documentation as well as how we define instructional items in our manuals to make it easier to understand. It was invaluable to observe how the installers went straight to installing without really reading instructions - and while we know we cannot change an industry practice - we know we can continue making enhancements to solve this complex issue with our Connected Lighting products. We're looking forward to being part of future competitions to keep pushing ourselves as an industry leader.

LUTRON®

Thank you for providing the detailed feedback from the installation of the **Lutron Vive** system during the NGLS competition. We have been evaluating the feedback with our teams internally and have some potential improvements to help streamline the areas where the installers had trouble.

As part of our evaluation process, we would like to test some of these new improvements with the same installers that used the system during the competition to see if they would have helped address those issues.



Impact – Some Initial Findings

- Systems are not as easy to install as claimed, be prepared
- Manufacturers are taking very different approaches to implementing ‘easy to install’ systems
- Occupancy and daylighting sensor performance is difficult to verify
- Maintenance (re-configuration) of a system can be as difficult than initial configuration
- Wall control designs need to be carefully considered, users are often confused
- Vocabulary impacts everything, different industries use very different language
- Be clear on what you really need, more ‘bells and whistles’ bring more configuration complexity

Current Progress – Timeline

Indoor Classrooms/Studios

2018

- Luminaire Installs
- Retrofit Kit Installs
- Initial Performance Evaluation
- Student Measurements

2019

- Occupancy Performance
- Daylighting Performance
- System Updates

2020

- New Studio Spaces
- More Complex Systems
- Multiple Luminaire Types

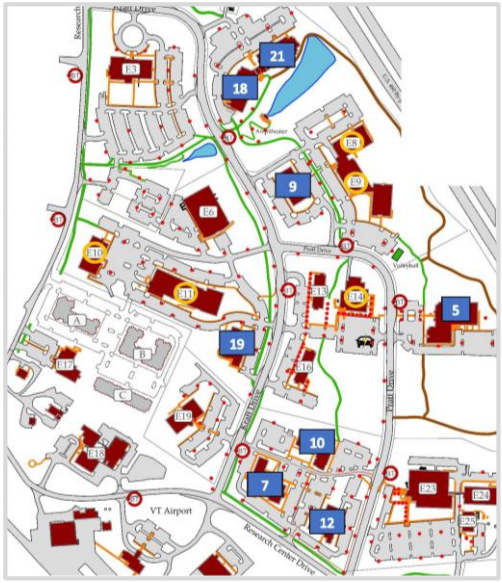
2019/2020 Outdoor Parking Lots

- Installation/Configuration Evaluations
- Performance Evaluations
- Sensor Performance Focus

Current Progress – Living Labs

Parsons School of Design

Virginia Tech Transportation Institute



Assigned Lots

Stakeholder Engagement – Outreach

Stakeholder Engagement – Entrants

INDOOR

OUTDOOR

Remaining Project Work

- **Indoor Evaluations**
  - Current system updates -July 2019
  - New classroom systems - July 2019
  - New installations in large studio spaces - 2020
    - Systems ‘proven’ in evaluation 1
    - Expanding to spaces more like open offices
  - New installations in other university locations - 2021
- **Outdoor Evaluations**
  - Parking lot installations - May 2019
  - Performance evaluation - Sept 2019
  - Focused sensor performance evaluation - 2020
  - More complex outdoor systems - 2021

Thank You

Pacific Northwest National Laboratory
Ruth Taylor, Program Manager
Ruth.Taylor@ pnnl.gov

REFERENCE SLIDES

Project Budget

Project Budget: $1.15m per year for three years.
Variances: No variances; on track to original planned budget.
Cost to Date: as of March 2019 month end: $449k cumulate cost to date
Additional Funding: $0

Budget History					
FY 2018 (past)		FY 2019 (current)		FY 2020 – FY 2021 (planned)	
DOE	Cost-share	DOE	Cost-share	DOE	Cost-share
n/a		$1725k		$2300k	

*Note: Includes FY2018 carry-over funds

Project Plan and Schedule