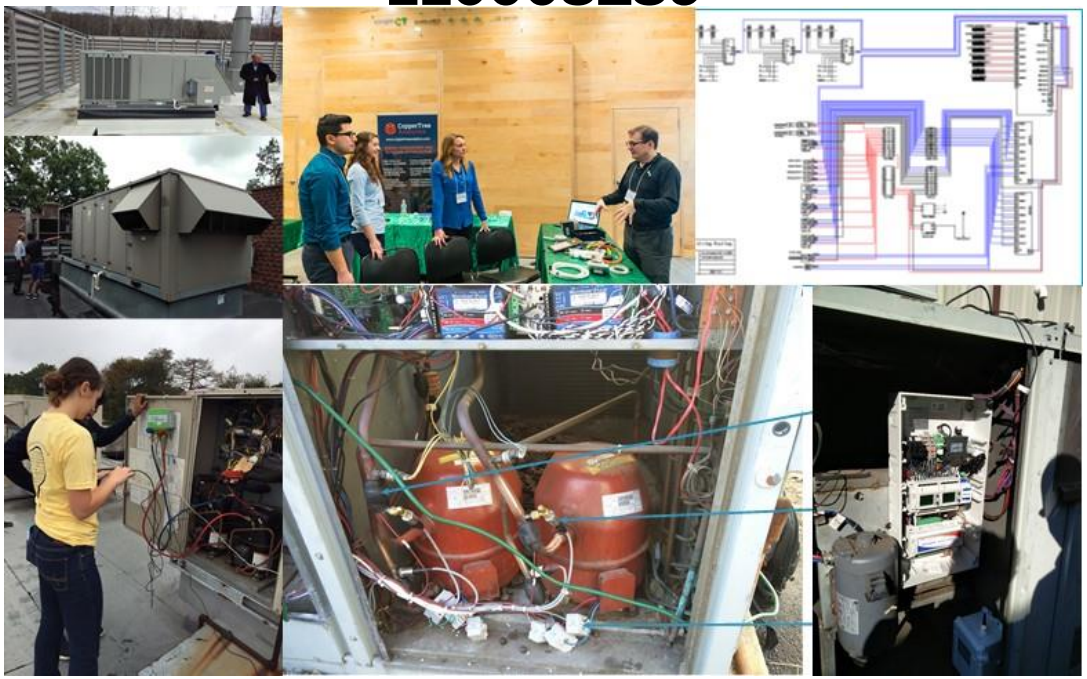
U.S. DEPARTMENT OF ENERGY

Office of ENERGY EFFICIENCY & RENEWABLE ENERGY

Bringing Fault Detection and Diagnosis (FDD) Tools into the Mainstream: Retro Commissioning & Continuous Commissioning of HVAC and Refrigeration Systems

EE0008189



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Project (EE0008189) Summary

Timeline:

Start date: ***September 1, 2017***

Planned end date: ***August 31, 2020***

Key Milestones

1. Stakeholder outreach event; 2/21/2018
2. Final selection of equipment, instruments, resources, partners and place orders; 9/2/2018

Key Partners:

University of Connecticut	United Technologies Research Center
United Illuminating	Eversource
EnergizeCT	Lawrence Berkeley National Lab

Budget:

Total Project $ to Date:

- DOE: $434,571
- Cost Share: $461,046

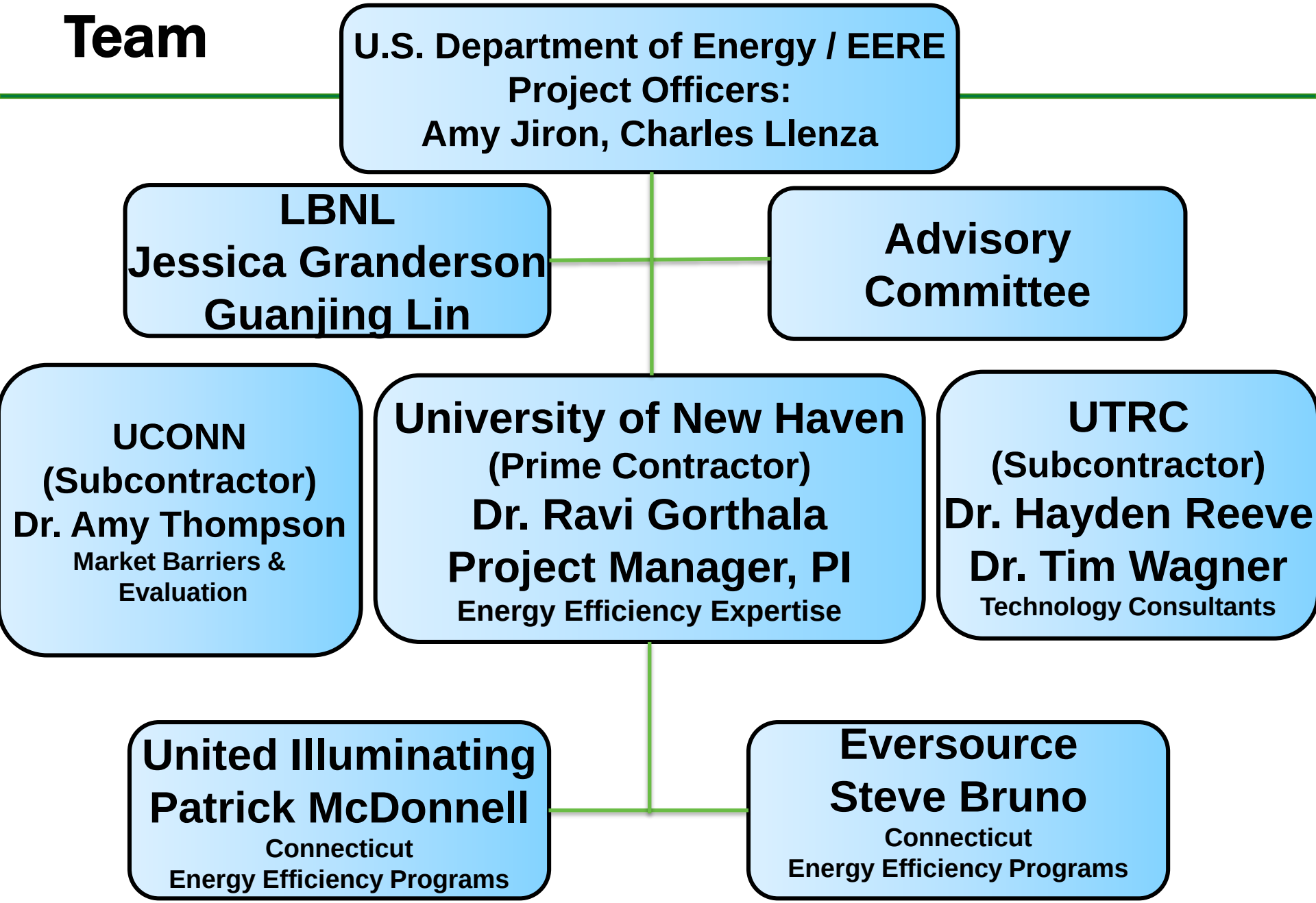
Total Project $:

- DOE: $594,493
- Cost Share: $639,859

Project Outcome:

Establishing the technical and economic feasibility of automated fault detection and diagnosis (AFDD) tools for HVAC&R through field demonstrations, and supporting the utilities in the development of incentive programs to accelerate the adoption of AFDD.

Team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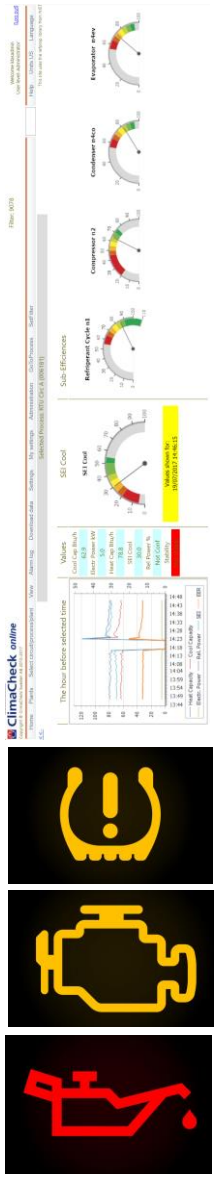
Challenge/Significance

- Packaged RTUs provide cooling (and some heating) for over 60 percent of the commercial building space (87 billion ft^2) in the U.S.
- Refrigeration accounts for 10-16% of energy consumption in restaurants and 44-62% in supermarkets.
- Most HVAC&R systems have one or more faults that result in increased energy use.
- Automated Fault Detection and Diagnosis (AFDD) Tools have been developed to address this problem.
- Reports by Navigant indicate that annual energy savings as much as 111 TBtu can be achieved for RTUs alone and 325 TBtu for non-Packaged HVAC by AFDD
- Savings potential of about 900 Tbu for HVAC&R AFDD
- However, FDD implementation is lagging behind due to market/technical barriers – lack of awareness of the problem/FDD technologies; cost-benefit justification; building owners looking for short-term ROI; not independently verified (FDD an unknown quantity), integration/security issues….



Approach

Key Objectives

- Demonstrate technical and economic feasibility of HVAC&R AFDD technologies for retro-commissioning and continuous commissioning through field demonstrations.

- Identify technical and market barriers, and develop strategies to promote widespread adoption of AFDD by bringing together all stakeholders.

- Support the development and roll out of utility rebate programs for the use of AFDD to promote energy efficiency in commercial buildings.

- Contribute to stakeholder education, outreach and dissemination; undertake workforce development and training.

Approach

Project Plan

- Uniqueness is the comprehensive nature – outreach to stakeholders, identification of diverse AFDD products, selection of different commercial building types for the field demonstration, process evaluation, performance verification, determination of technical and economic viability, development of utility incentives, and education and workforce development.

Outreach/Identification of Barriers

- The purpose of this is to educate all stakeholders including utility companies, building owners, contractors, consultants and other guests on the importance of HVAC&R Fault Detection and Diagnostics along with the scope of the DOE-UNH FDD project.
- Seek input from stakeholders, advisory group
- Conduct surveys to identify technical, operational and market barriers



Approach

Project Plan

AFDD Product and Site Selection

- Identify all commercial AFDD products – factory installed, retrofit tools; hardware-based; BMS-based; combination (VFD/FDD) products
- Select 10 FDD tools through RFI process for the field demonstration.
- Conduct site visits and select 10 diversified sites with input from stakeholders

Field Testing and Evaluation Plan/M&V Plan

- Develop a field demonstration plan to study and verify the technical and economic feasibility, ease of installation, operation and energy impacts of AFDD through the field installation of AFDD tools, and independent monitoring.

Approach

Independent Monitoring System for M&V

- Develop a comprehensive field monitoring system for field verification

Field Installation and Testing

- Install AFDD tools and the independent monitoring system at 10 sites
- Monitor the base-line (as is) performance
- Undertake retro commissioning based on base-line performance
- Continuous Commissioning

Data Analysis and Utility Support

- Analyze technical performance of AFDD Tools
- Estimate regional and national savings potential
- Work with CT utilities for the roll-out of incentives

Education and Training Materials

- *Develop education and training materials*

Impact

- The importance of FDD technology has been duly recognized since the 1990's.
- The DOE, LBNL, NIST, Purdue, CEC, Southern California Edison, Western HVAC Performance Alliance, ASHRAE, many manufacturers and numerous researchers have been involved in the FDD development, standards development, economics, roadmap development, identification of technical and market barriers.
- Small-scale pilot demonstration projects involving prototypes have been done in the past.
- FDD and continuous commissioning are on the US DOE's HIT list for high impact technologies as part of the Energy Management and Information Systems category (EMIS). According to US DOE, the national savings potential for EMIS is over 1,000 TBtu/year.
- Now, there are several FDD technologies on the market with a variety of capabilities at varying costs.
- However, there hasn't been a comprehensive project in the Northeast or elsewhere in the US to bring stakeholders together to undertake extensive FDD field demonstrations, to identify local market barriers, or to provide education and outreach for HVAC technicians and building owners.
- This project aims to change that.

Progress

Outreach Event

- Outreach Event was held on February 21, 2018 at the Energize CT Center in North Haven, CT
- AFDD technologies were introduced. The scope of the DOE-UNH FDD project was presented and participation in the project was encouraged.
- Brief surveys were implemented to gauge market barriers
- In attendance - U.S.DOE, United Illuminating, Eversource, Emcor, New England Mechanical (NEMSI), UCONN, UTRC, CT Department of Energy and Environmental Protection, Energy Resource Inc., University of Nebraska-Lincoln, LBNL, Coppertree Analytics, Enerfit, Cimetrics, Virtjoule.
- Outcome: The event provided a good environment to create connections with those that attended. Energy efficiency engineers from utilities were engaged and energized for the FDD project. Market barriers surveys provided preliminary insight into market issues.

Progress

Project Plan

AFDD Product and Site Selection

- Through an RFI process, 10 FDD Tools were selected for the demonstration. These included hardware-based, software-as-a-service based and combinations tools
- Conducted more than 15 site visits. Selected 10 sites in CT – UCONN, UTRC, Alinabal, Fairfield Town Hall (two different locations), Chili's, TYL Middle School, Wesleyan University, Staples, East Brook Mall

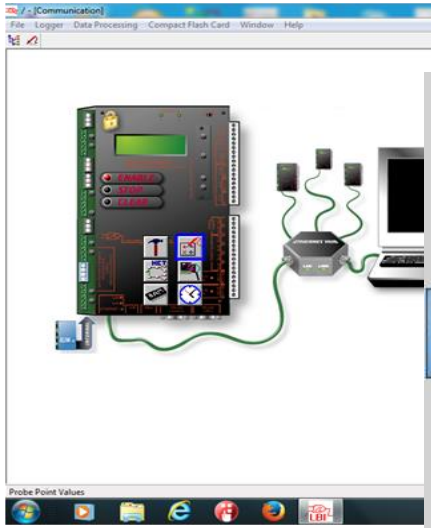
Field Testing and Evaluation Plan/M&V Plan

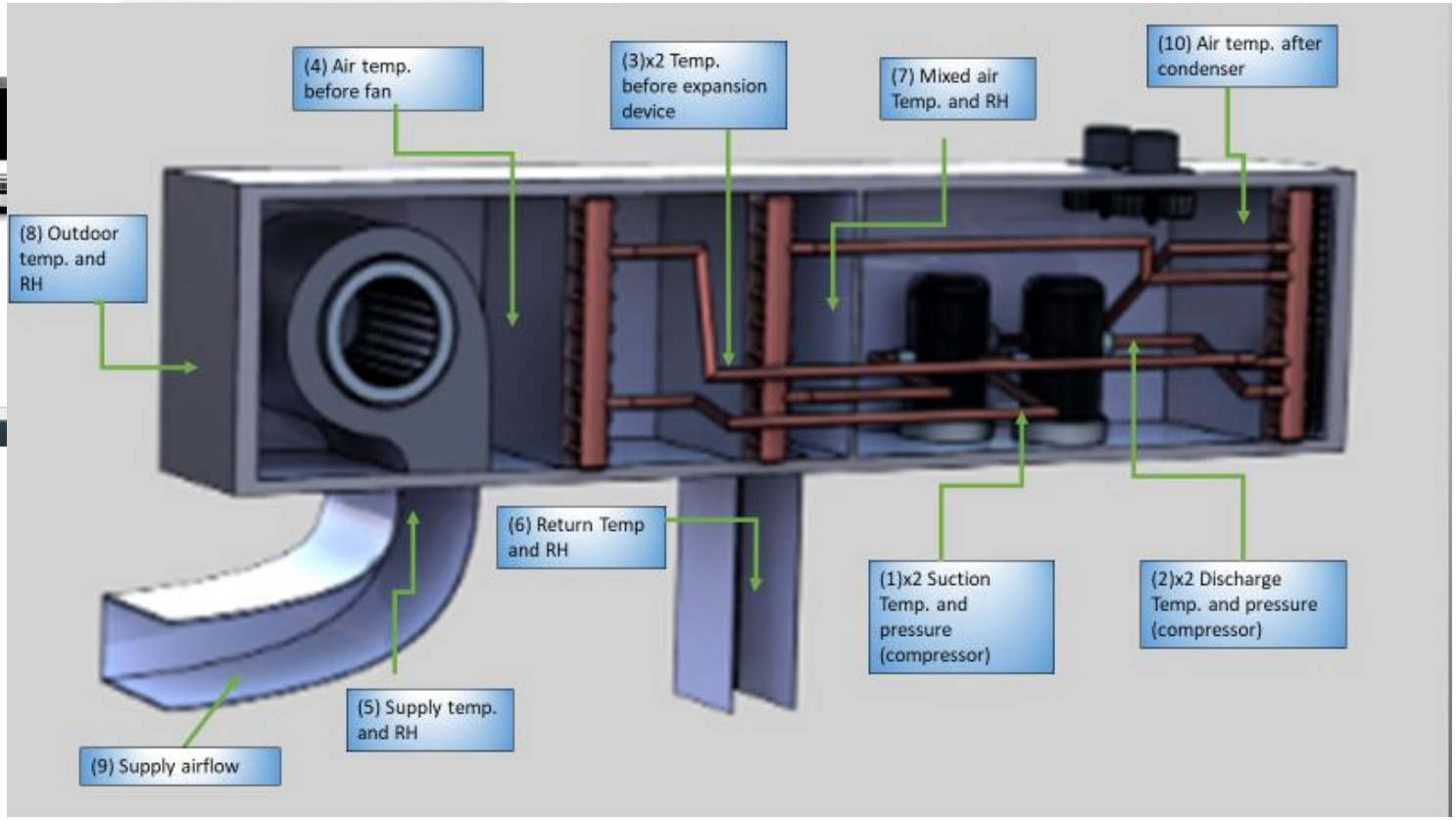
- The field demonstration plan to study and verify the technical and economic feasibility, ease of installation, operation and energy impacts of AFDD through the field installation of AFDD tools, and independent monitoring has been developed.
- Sought input from NIST, UN-Lincoln, LBNL

Progress

Independent Monitoring System for M&V

- A comprehensive field monitoring system with a remote access has been developed. Equipment has been ordered and received.



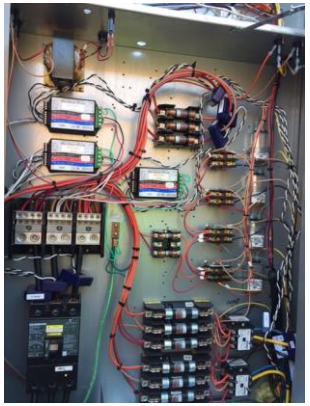


Progress

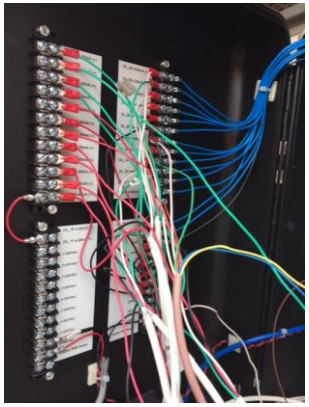
Field Installation and Testing

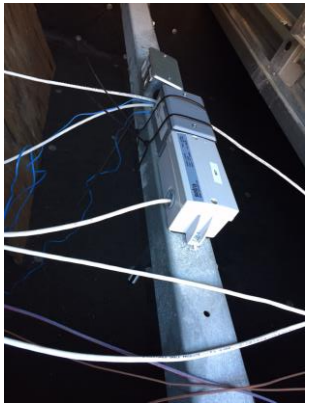
- Installation of AFDD tools and the independent monitoring system at 6 sites is complete despite snow and cold weather. Currently, in the initial stages of checking the installations.











Stakeholder Engagement

- Outreach to and engagement of stakeholders are the integral part of the project
- CT DEEP, United Illuminating (Avangrid), Eversource are heavily involved in the project. A significant cost-sharing is provided by these entities
- Advisors from NIST, LBNL, NREL, PNNL, UN-L, and the industry are involved.
- Engineers from CT utilities are engaged and have been reaching out to building owners, facility managers and energy consultants. They are helping recruit sites for the project
- This project outreach event has been critical to the project success so far.
- The project team presented at CT AEE conference on the project and received a significant interest in the project.
- Established contacts with numerous FDD vendors and participated in webinars to understand the tools and processes.
- Visited numerous sites and had meetings with building owners, facility managers
- Have been working with HVAC contractors, technicians
- The team will be presenting at ASME and ASHRAE conferences in 2019 and 2020

Remaining Project Work

- The project is on-track and is midway to a successful conclusion.
- It is targeted to complete all 10 installations by mid May, 2019 (ideally April 30, 2019)
- Monitor the base-line (as is) performance until June, 2019
- Undertake retro commissioning based on baseline performance through September 2019
- **Proceed with Continuous Commissioning**
- Analyze technical performance of AFDD Tools
- Estimate regional and national savings potential
- Work with CT/NY/MA utilities for the roll-out of incentives
- Develop education and training materials

Thank You

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REFERENCE SLIDES

Project Budget

Project Budget: Total project budget is $1,234,352 which includes 48% funding from DOE and 52% from Cost Share.
Variances: Cost to date is about 10% behind schedule, but will fulfill FY19&20
Cost to Date: $514,104 (42% of total budget)
Additional Funding: N/A

Budget History					
9/1/2017 – FY 2018 (past)		FY 2019 (current)		FY 2020 – 8/31/2020 (planned)	
DOE	Cost-share	DOE	Cost-share	DOE	Cost-share
$242,291	$245,728	$192,280	$215,318	$159,922	$178,813

Project Plan and Schedule

- No major deadlines missed
- Project is on track
- Working to install all sites before May 2019 and collect data for cooling period 1

Project Schedule														
Project Start: September 1, 2017		Past Work												
Project End: August 31, 2020		Future/Current Work												
Task = T Milestone = M Deliverable = D	Task Title or Milestone/Deliverable Description	Year 1				Year 2				Year 3				
		Q1(Oct-Dec)	Q2(Jan-Mar)	Q3(Apr-Jun)	Q4(Jul-Sep)	Q1(Oct-Dec)	Q2(Jan-Mar)	Q3(Apr-Jun)	Q4(Jul-Sep)	Q1(Oct-Dec)	Q2(Jan-Mar)	Q3(Apr-Jun)	Q4(Jul-Sep)	
Past Work														
M	Hold outreach event and receive preliminary feedback through survey													
M	Obtain Preliminary feedback from market and create link plan													
T	Send out RFI and building owner one pager													
D	Site selection criteria, product selection criteria													
T	Draft M&V plan, market link plan, and quality and risk plan													
M	Make final selection of equipment, instruments, resources, partners, and place orders													

Project Plan and Schedule

Project Schedule													
Project Start: September 1, 2017		**Past Work**											
Project End: August 31, 2020		**Future/Current Work**											
Task = T Milestone = M Deliverable = D	Task Title or Milestone/Deliverable Description	Year 1				Year 2				Year 3			
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In progress/Future Work													
T	Inspect equipment												
M	Pre installation testing of FDD tools												
M	Install and verify FDD technology and instrumentation in field												
D	Update measurement and verification plan												
T	Recommend/schedule repairs etc.												
M	Finalize Market Link Plan												
M	Establish FDD Technology Baseline Performance												
M	Conduct Market Link Plan, plan baseline activities												
D	FDD baseline report												
M	Continuous Commissioning, collect performance data												
T	establish problem solving team and make fixes where needed												
M	Conduct Stakeholder engagement meetings and evaluate progress and performance of market link plan												
M	Develop Training Protocals and Materials												
M	Training sessions and outreach												
T	Create training material, publish material, and hold outreach event to train												
M	Create Draft and Final Reports												
D	Final report submission to DOE and publishing of results												
M	Project wrap up												