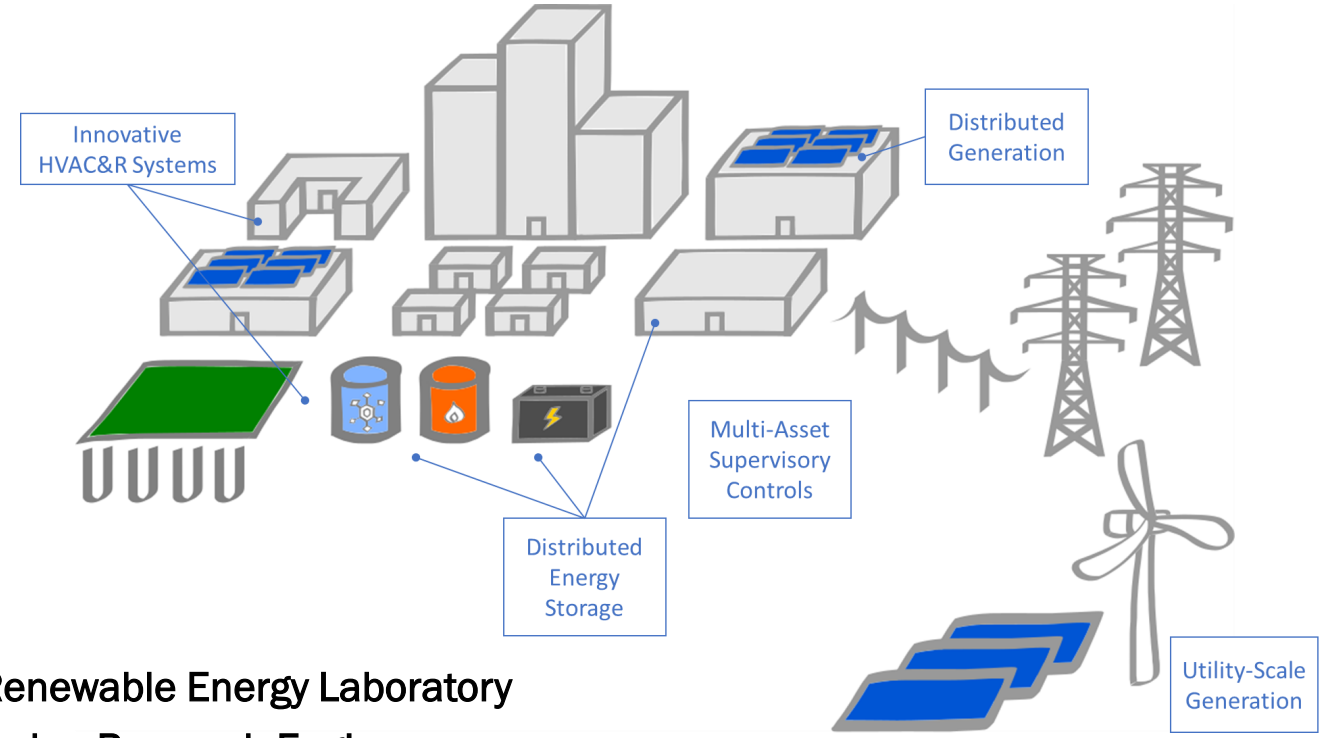
U.S. DEPARTMENT OF ENERGY

Office of ENERGY EFFICIENCY & RENEWABLE ENERGY

Commercial Buildings Integration Laboratory



National Renewable Energy Laboratory
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Building Energy Sciences Group
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Project Summary

Timeline:

Start date: 7/2/18

Planned end date: 06/28/19

Key Milestones:

1. Electrical Design Complete: 11/30/18
2. Electrical Infrastructure Installed: 04/29/19
3. Data Acq. System Installed: 05/31/19
4. Projects begin in CBI Lab: 06/28/19

Key Partners:

ComEd An Exelon Company

Xcel Energy

EMERSON

WELLS FARGO

PURDUE UNIVERSITY

CLEAResult®

Budget:

Total Project $ to Date:

- DOE: $430k
- ESIF Cost Share: $200k

Total Project $:

- DOE: $685k
- ESIF Cost Share: $350k

Project Outcome:

A flexible laboratory designed to evaluate commercial buildings in the context of:

- Intelligent efficiency
- Interoperability
- Advanced controls
- Flexibility of demand-side management

Team

Principle Investigators:

Grant Wheeler

- 7 years HVAC Laboratory experimentation
- 5 years of project management

Bethany Sparn

- 5 years of ESIF experimentation
- Designed the SPL in ESIF
- Led HIL projects in ESIF

NREL Team:

Buildings and Thermal Sciences Center
Expertise provided: commercial building infrastructure, building energy simulation, energy storage, communication networks, data acquisition

ESIF Engineering Team
Robust experience in grid integration, emulation, and power systems experimentation

ESIF Research Operations
Experts at installing and maintaining research equipment

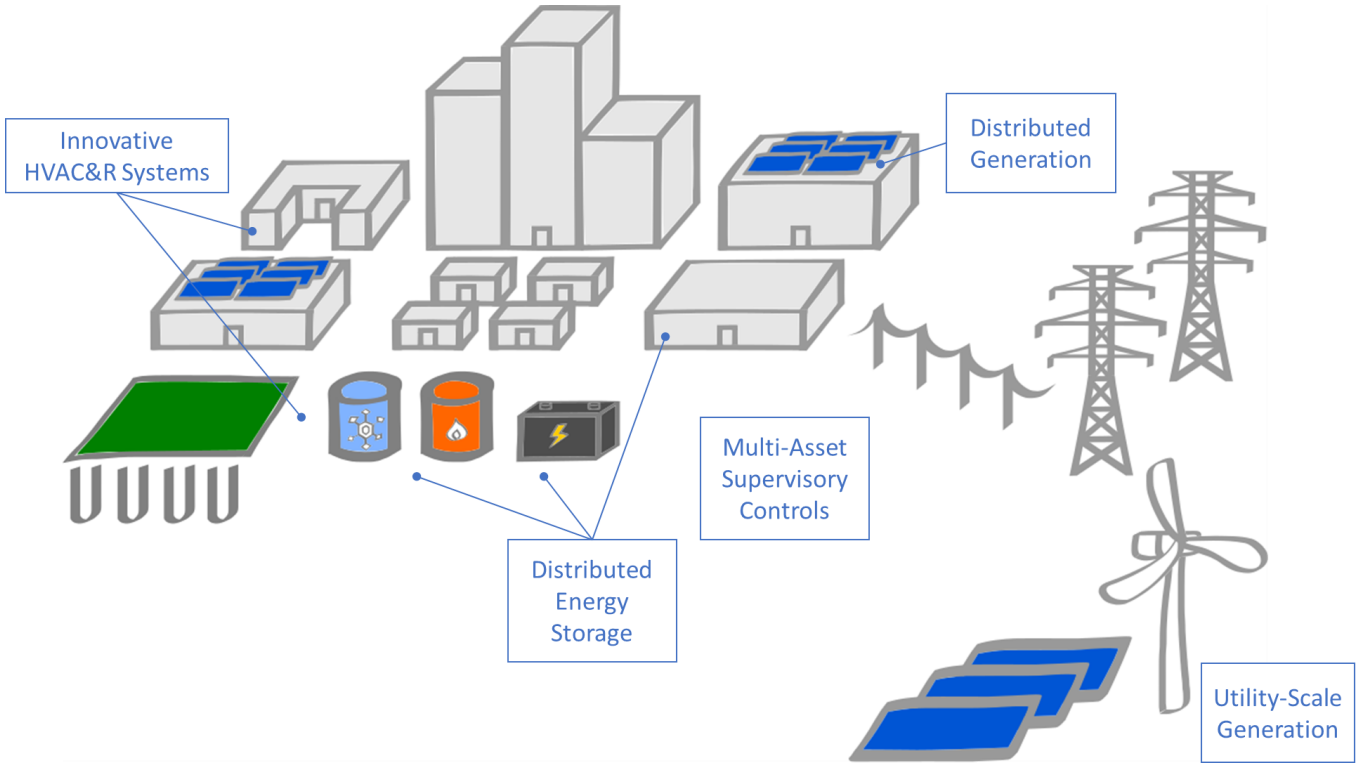
DOE:

DOE Technical Managers
Stephanie Johnson
Cindy Zhu

Challenge

How do we quickly and cost-effectively evaluate building technologies that provide efficiency and grid services while still maintaining occupant comfort?

- Supply and demand from buildings varies by generation source, climate, location, and building type
- Solutions can come from sophisticated control, connectivity and interoperability
- Need a way to assess building-level impact and aggregated impact of grid interactions

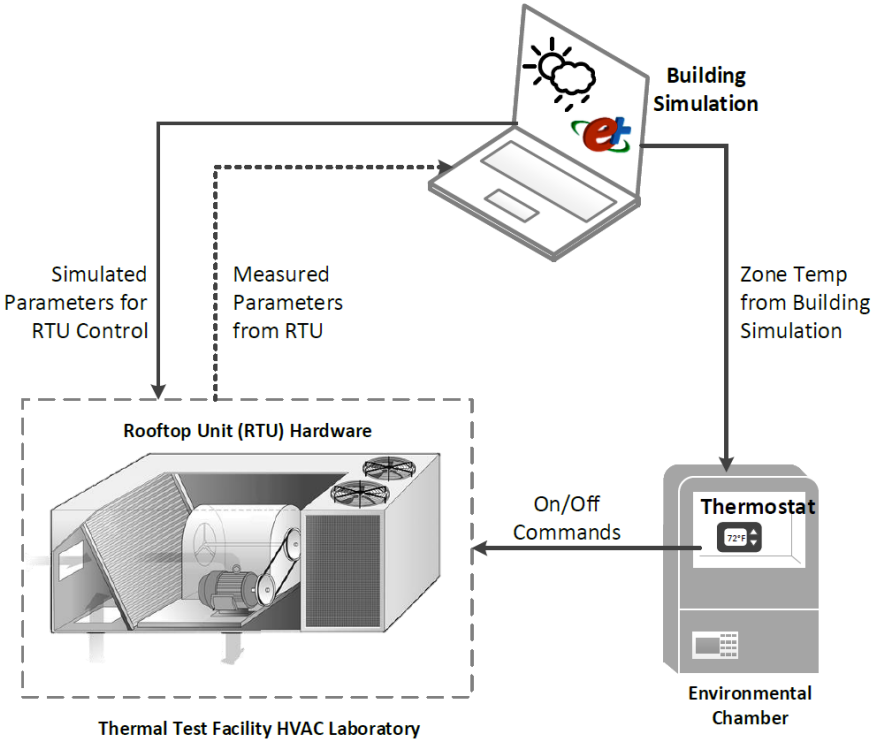


Hardware-in-the-Loop

Hardware-in-the-Loop (HIL): A technique that combines hardware and simulation in continuous feedback loop to explore complex scenarios in a controlled environment.

Credit: https://www.altus.af.mil/News/Art/igphoto/2000940295/

Flight Simulator: The original HIL



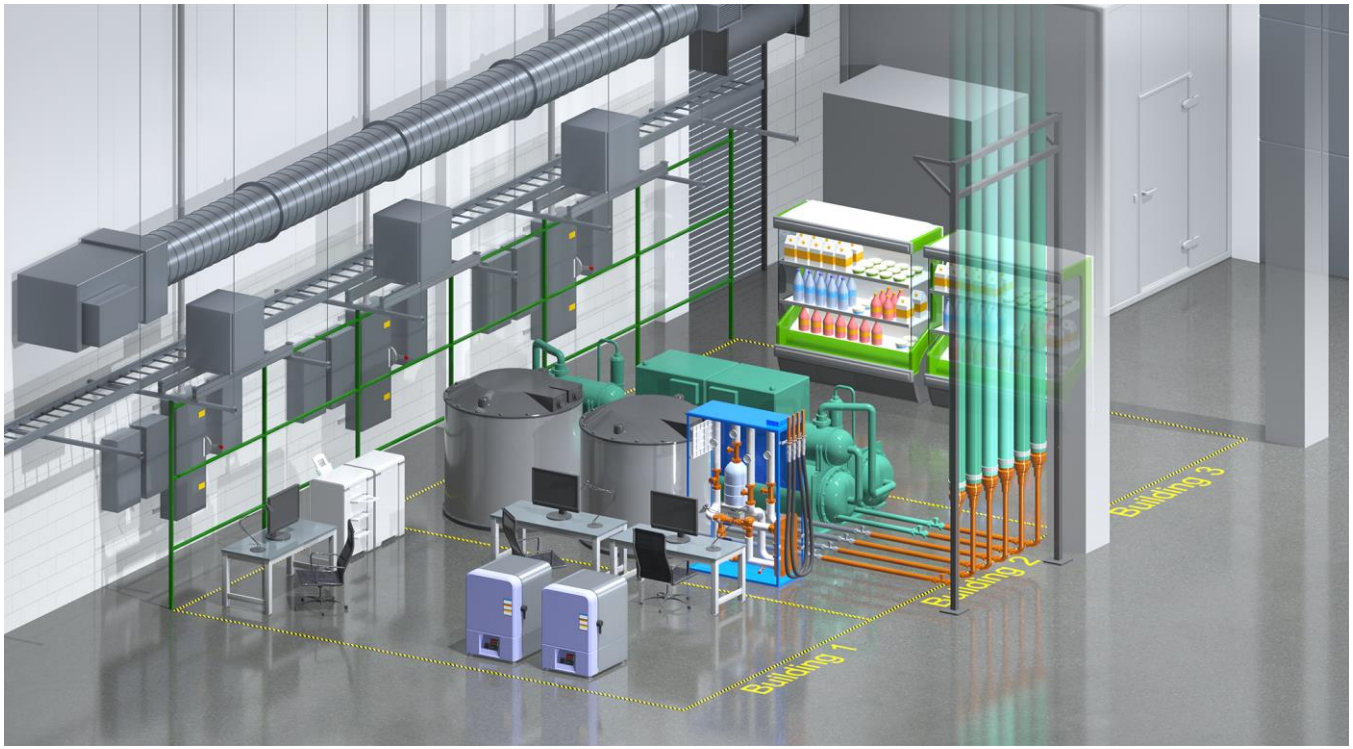
HVAC HIL: An application of HIL for buildings research.

RTU hardware operated in a realistic fashion without need for physical building and real climate.

Approach

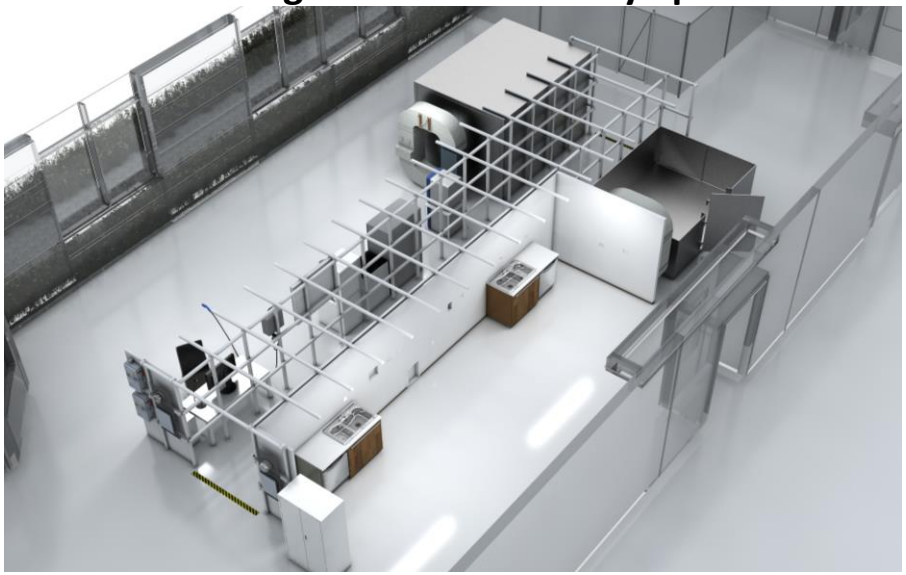
The ESIF **Commercial Buildings Integration Laboratory** will provide a flexible research platform that takes advantage of hardware-in-the-loop functionality for grid-interactive efficient buildings, specifically in these key focus areas:

- Intelligent efficiency
- Interoperability
- Advanced controls
- Flexibility of demand-side management

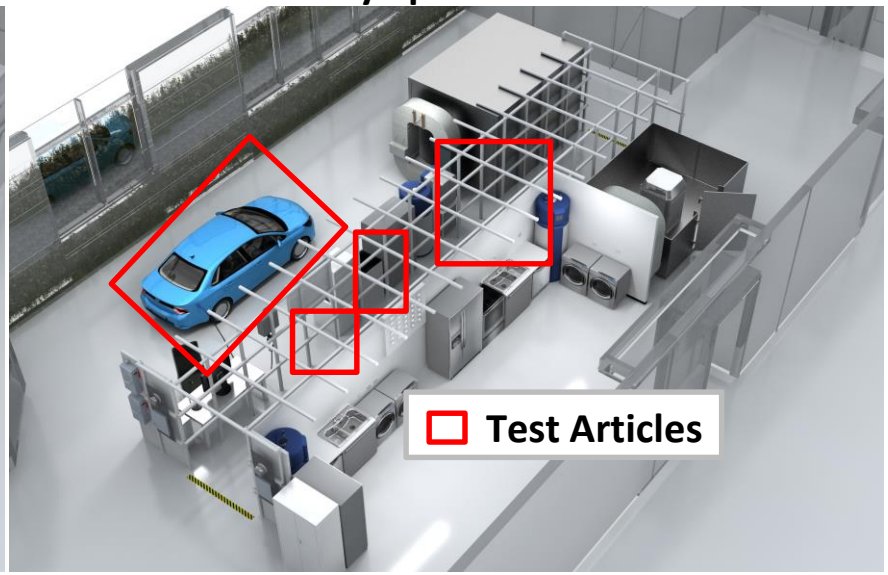


Building From Experience

Original SPL Laboratory Space



SPL Laboratory Space with Test Articles



The Systems Performance Lab (SPL) provides a research platform for residential buildings research, which includes:

- Electrical and water infrastructure, including connection points and sensors
- Data acquisition and control equipment
- HVAC HIL platform

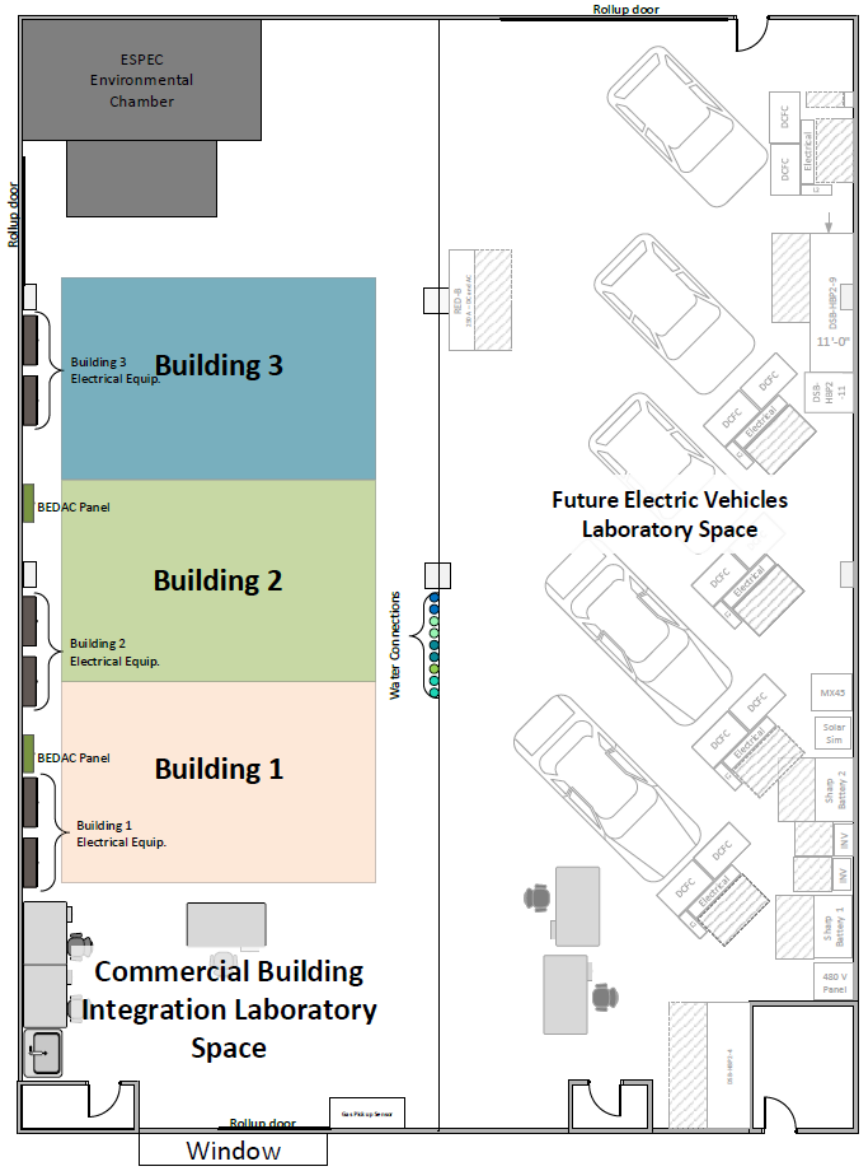
→ Test articles (appliances and other residential equipment) were installed as projects dictated.

The CBI Lab will leverage lessons learned from the residential Systems Performance Lab

Commercial Buildings Integration Lab Capabilities

Features of the CBI Lab:

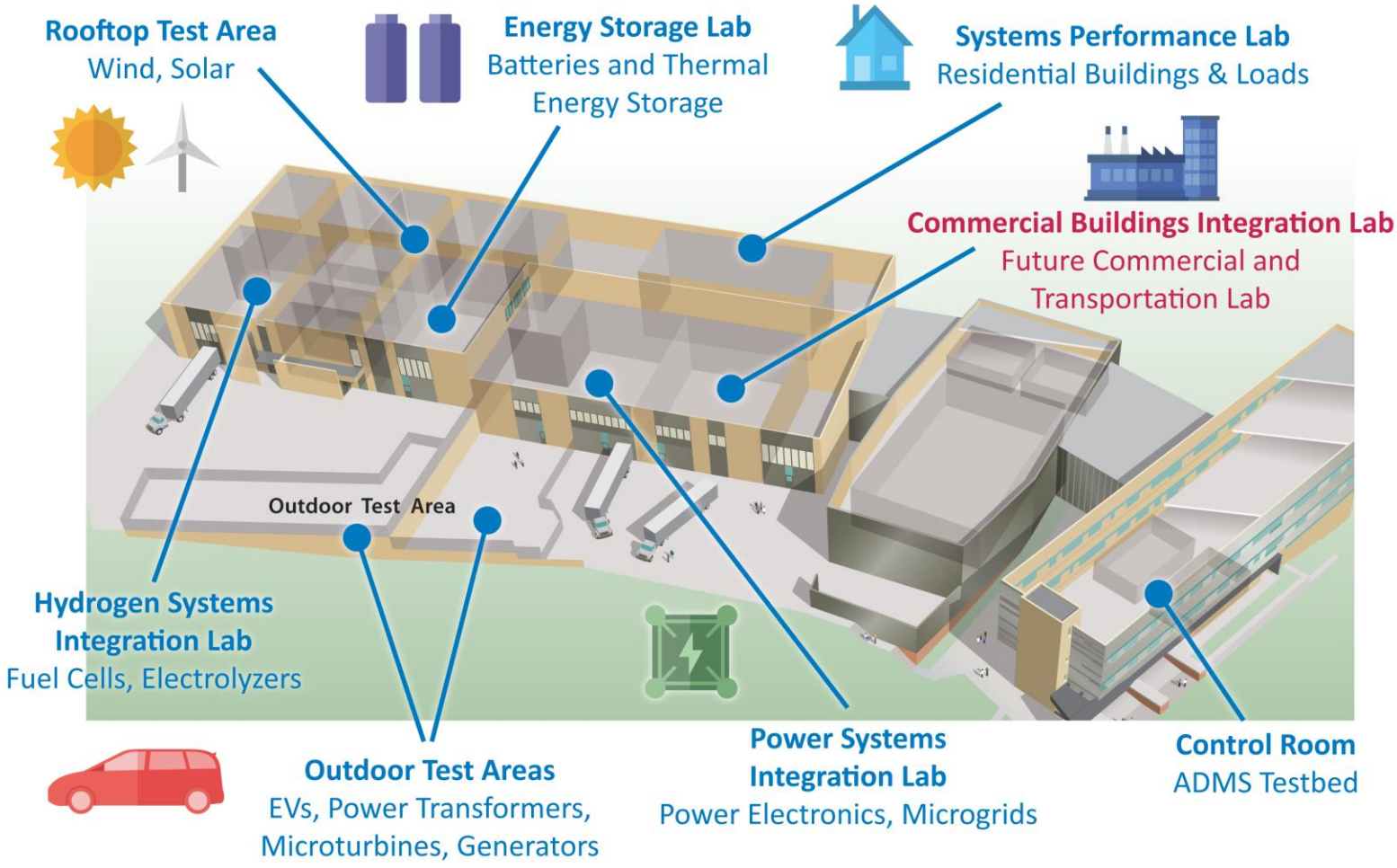
- Electrical infrastructure for 3 buildings
- Integrated data acquisition system – collects data, controls equipment, real-time visualization
- Connections to grid and PV simulators and other distributed energy resources (DER) for grid interactivity research
- Communication/control link to HVAC Lab enables hardware-in-the-loop testing of HVAC equipment
- Connection to building energy simulations platform
- Integration with other ESIF labs and resources



ESIF Resources and Laboratories

ESIF Equipment:

- 100 ton chiller loop
- 62.5 ton boiler loop
- 2 MW Grid simulator
- 1.5 MW DC simulator
- 1 MW load bank
- 12 EV charging stations
- Research electric distribution bus (REDB)



Impact

CBI Lab can:

- Evaluate grid services from individual building technologies to multiple building scale
- Develop advanced controls
- Reduce risk of field validations
- Reduce time and cost of field validations

Key Customers: DOE, Building portfolio owners, utilities, building technology developers

Stakeholder Remarks:

- Building technologies have significant and demonstrated potential to be utilized as cost-effective solutions to respond to grid conditions… 75% of all U.S. electricity is consumed within buildings, and building energy use drives 80% of peak demand." – **BTO RFI on Efficient and Flexible Building Loads**
- "We cannot evaluate IoT applications because the risk is too high. We cannot sacrifice occupant comfort to perform field demonstrations, therefore the technologies we evaluate need to be very mature and robust."- **Building Portfolio Owner**
- "Field demonstrations often require 12-18 months of data collection. Finding willing building owners is difficult especially for more advanced energy efficiency measures."- **Emerging Technology Utility Manager**
- "We look at the CBI lab as an opportunity to collaborate with key stakeholders. Connecting with DOE, building portfolio owners, and utilities in the same lab is uncommon but highly desirable especially when looking at the future of grid interactive buildings. "- **Building Technology Developer**

Stakeholder Engagement

Technical Advisory Group	
Company	**Industry**
ComEd	Utility
Xcel Energy	Utility
Purdue University	Academia
Emerson	Product Developer
Wells Fargo	Building Owner

Technical Advisory Group will meet 2 times leading up to the peer review and will advise NREL on the design of the research capabilities.

Description	Date	Status
Electrical Infrastructure Review	December, 2018	Complete
Communication Network Review	April, 2019	Complete

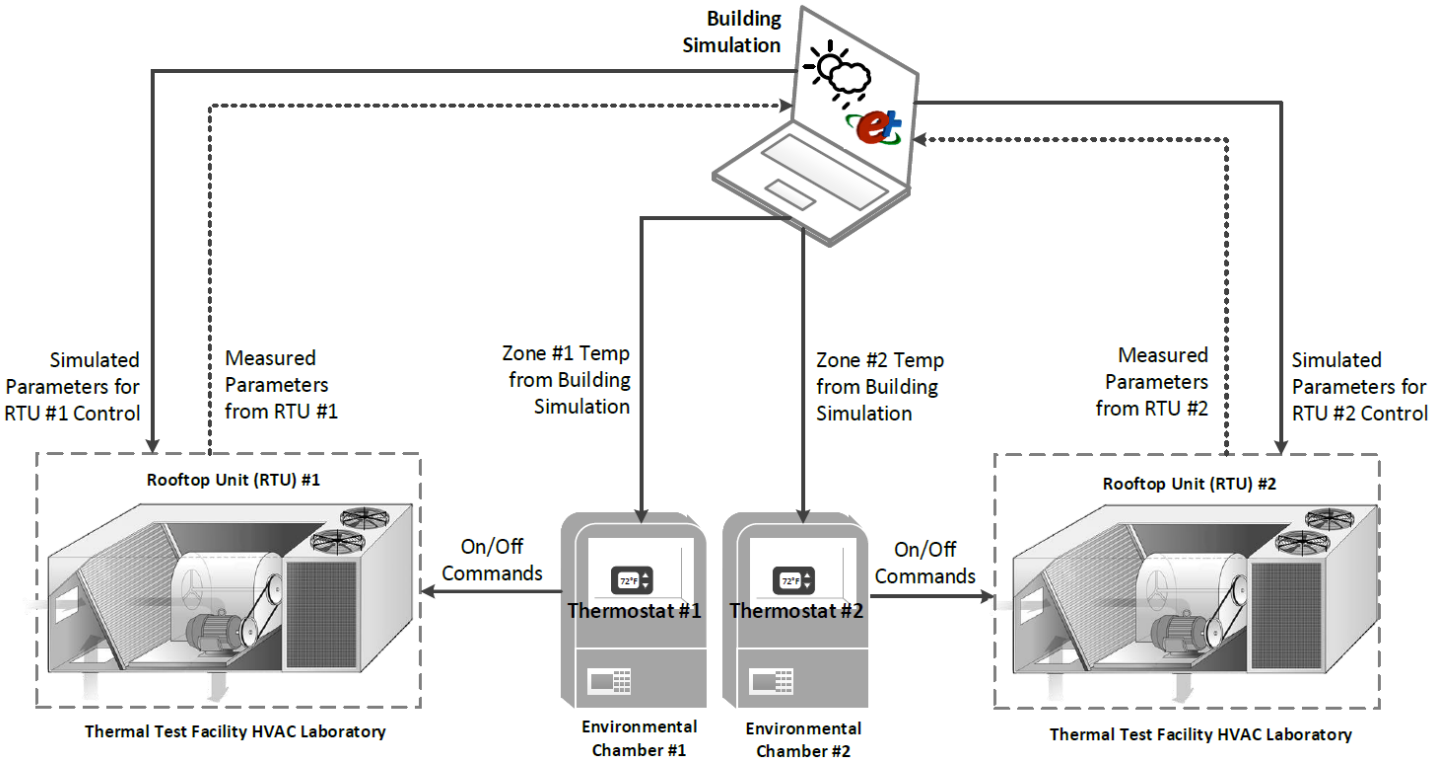
Progress & Next Steps

Description	Finish Date	Status
Project Kick-off	July, 2018	Complete
Initial Electrical Design	September, 2018	Complete
TAG Review: Electrical Infrastructure	December, 2018	Complete
Final Electrical Design	February, 2019	Complete
TAG Review: Communication Network	April, 2019	Complete
Electrical Infrastructure Installed	April, 2019	In Progress
Data Acquisition System Installed	May, 2019	In Progress
Project Setup Begins	June, 2019	Next Step
Multi-facility Integration Validation	July, 2019	Next Step

CBI Lab Status as of 4/3/19

RTU Coordination

- Staged project: laboratory followed by field evaluation
- First project in the CBI Lab
- Laboratory Goals
  - Multi-facility integration validation
  - Evaluate coordinated control of several RTUs
  - Assist with field site selection



External Projects

- **"If you build it, they will come"**
- **$2 million project with ComEd and CLEAResult to evaluate 5-8 technologies for energy efficiency**
- **Collaboration with BTO, additional $750k**
  - Add lab capabilities
  - Evaluate grid interactive capabilities for at least two technologies

Thank You

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REFERENCE SLIDES

Project Budget

Project Budget: $685k
Variances: Requested $185k to construct all three buildings and integrate a building energy simulation platform
Cost to Date: $430k
Additional Funding: $350k of ESIF funding for labor and equipment

Budget History					
07/18– FY 2018 (past)		FY 2019 (current)		FY 2019 – 06/19 (planned)	
DOE	Cost-share	DOE	Cost-share	DOE	Cost-share
$60k	0	$370k	$200k	$685k	$350k

Project Plan and Schedule