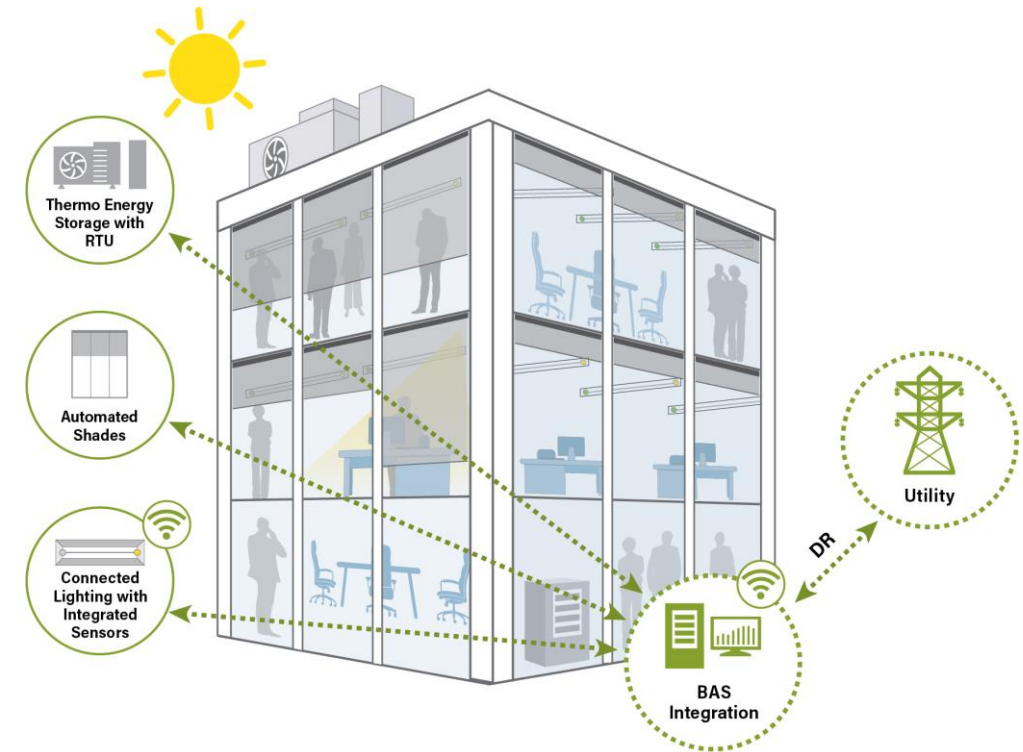
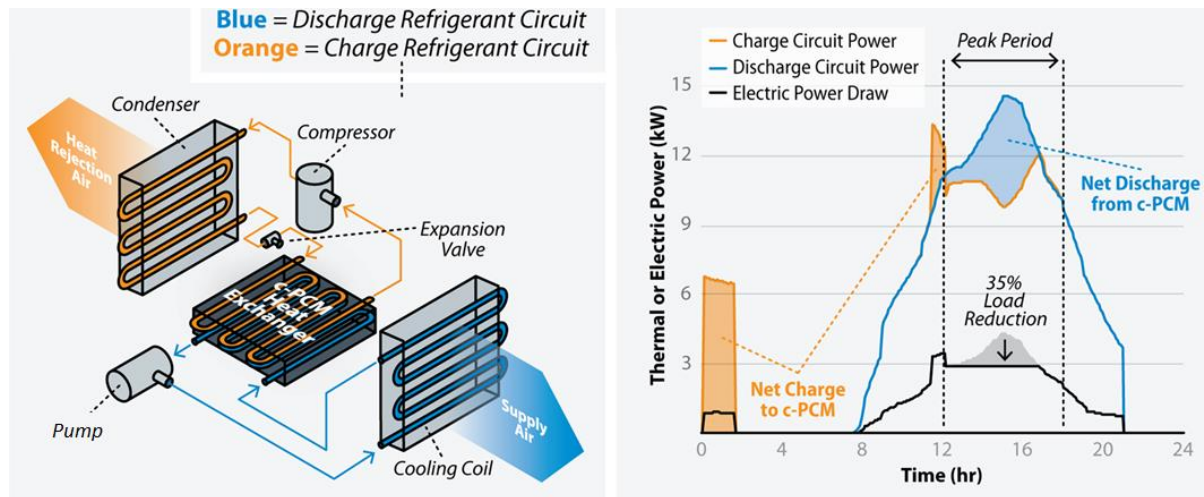


Technology analysis and validation of integrating connected lighting, automated shades, and intelligent energy storage for load flexibility



Slipstream Group, Inc.
Xiaohui Zhou, Ph.D., PE, CEM, Director of Research and Innovation
608 -210 -7155; jzhou@slipstreaminc.org
FOA #: DE-FOA-0002099, Award #: DE-EE0009083

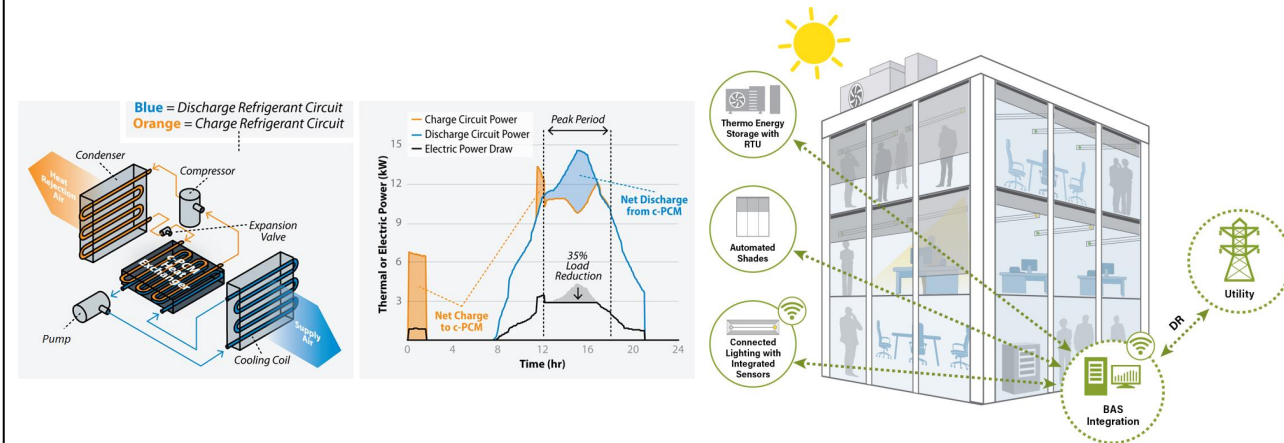
Project Summary

Objective and outcome

Field test the integration of automated shades, connected lighting, and NETenergy's new hybrid RTU + PCM thermal storage for building load shifting and peak load reduction at TWO commercial buildings. Conduct technical analysis using building energy modeling.

Team and Partners

Slipstream Group, Inc. (Prime)
Michigan State University (subrecipient)
NREL (subrecipient)
Mecho (partner)
NETenergy (partner)
Emerson (partner)



Stats

Performance Period: 6/1/2020 – 11/30/2024
DOE budget: \$499k, Cost Share: \$415k
Milestone 1: Conceptual design of integrated controls
Milestone 2: Identify and recruit two test sites
Milestone 3: Preliminary technical analysis

Problem

- Commercial buildings have great potential in providing deep energy savings as well as grid-interactive flexible building loads*.
- However, most existing commercial buildings do not control energy systems for building load reduction, or only control them independently, or manually.
- To maximize building load flexibility, one pathway is through integrating multiple building energy system controls (HVAC, lighting, building envelope / windows) to optimize system operations based on real-time weather conditions, and respond to utility automated demand response signals

* DOE EERE. 2019. *Grid-interactive Efficient Buildings – Overview*, https://www.energy.gov/sites/prod/files/2019/04/f61/bto-geb_overview-4.15.19.pdf.

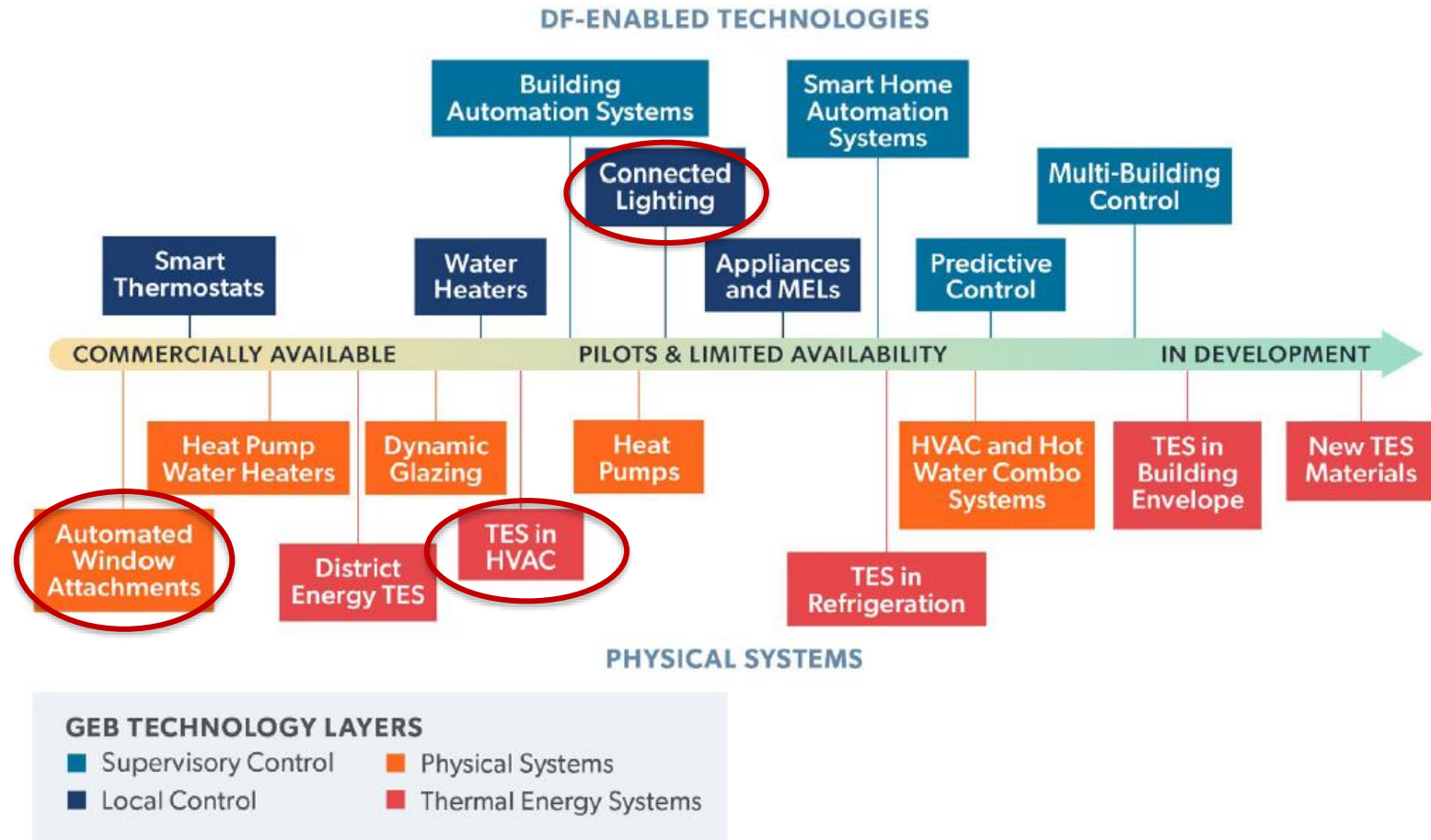
Alignment and Impact

- Project outcomes contribute to EERE/BTO goals
 - Transform the grid edge at buildings - advance the state-of-the-art in building load flexibility control
 - Increase building energy resilience

- Success criteria
 - Shed 50% lighting load (for automated shades and connected lighting system)
 - Shift 40 percent of HVAC (RTU) load during peak period
 - < 10% occupant complaints

Approach

- How is the problem being addressed today?
 - There are a few automated shades solutions for commercial buildings, but they are focused on saving energy, not demand response.
 - TES (ice storage) integrated with HVAC is rare in small commercial buildings*
 - Using connected lighting for load flexibility are mostly in pilot stage
 - There is no integrated solution to maximize the overall load flexibility

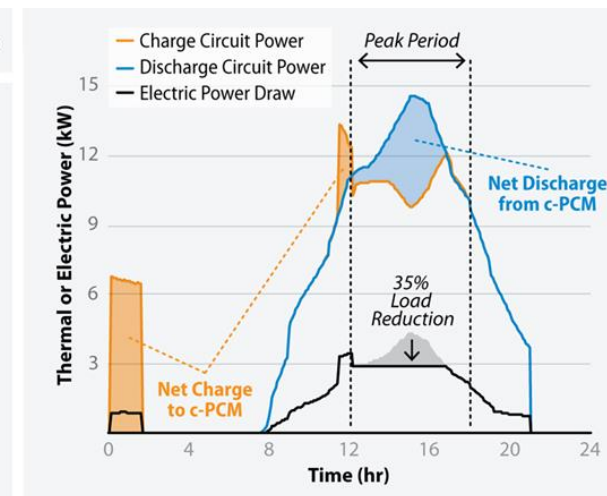
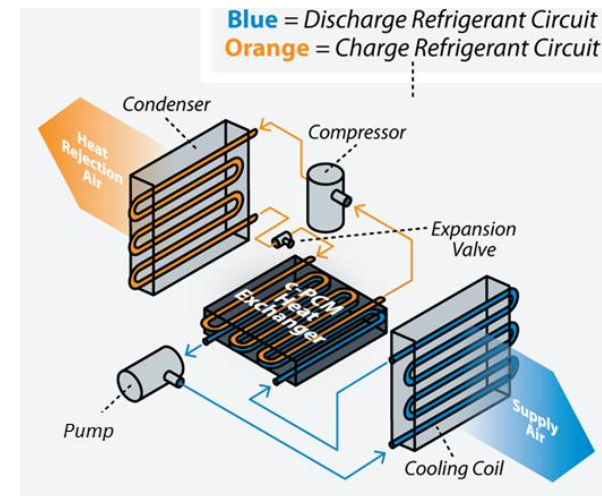
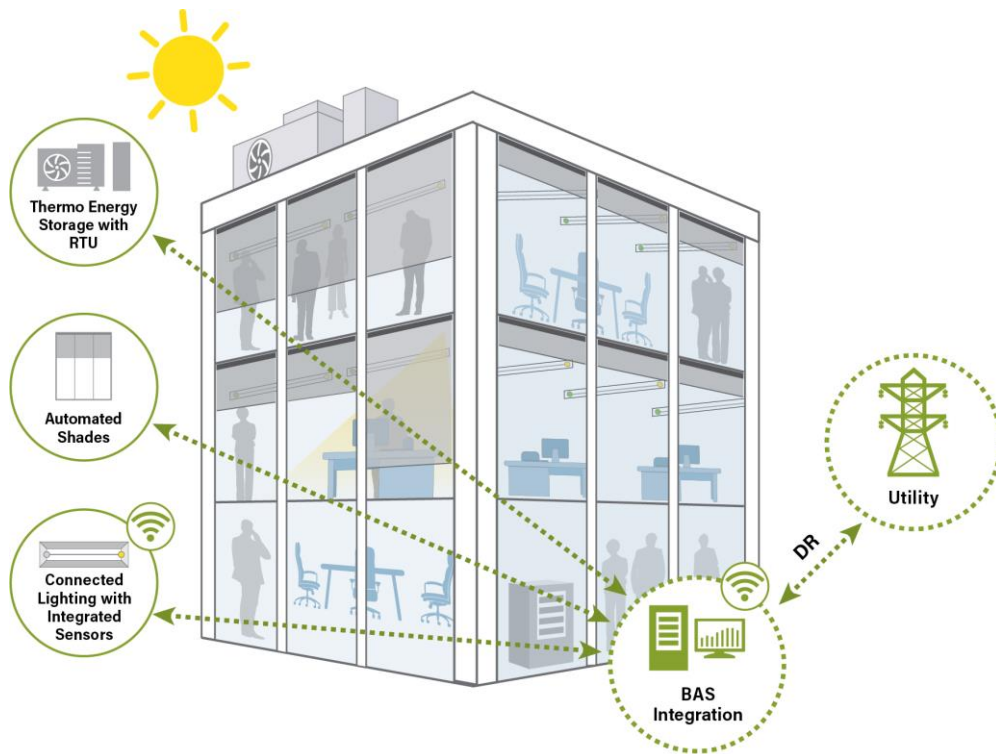


* <https://www.energy.gov/sites/default/files/2021-10/bto-peer-2021-hybrid-hvac-thermal-energy-storage.pdf>

Note: DOE EERE. 2019. A National Roadmap for Grid-Interactive Efficient Buildings. <https://gebroadmap.lbl.gov/A%20National%20Roadmap%20for%20GEBs%20-%20Final.pdf>

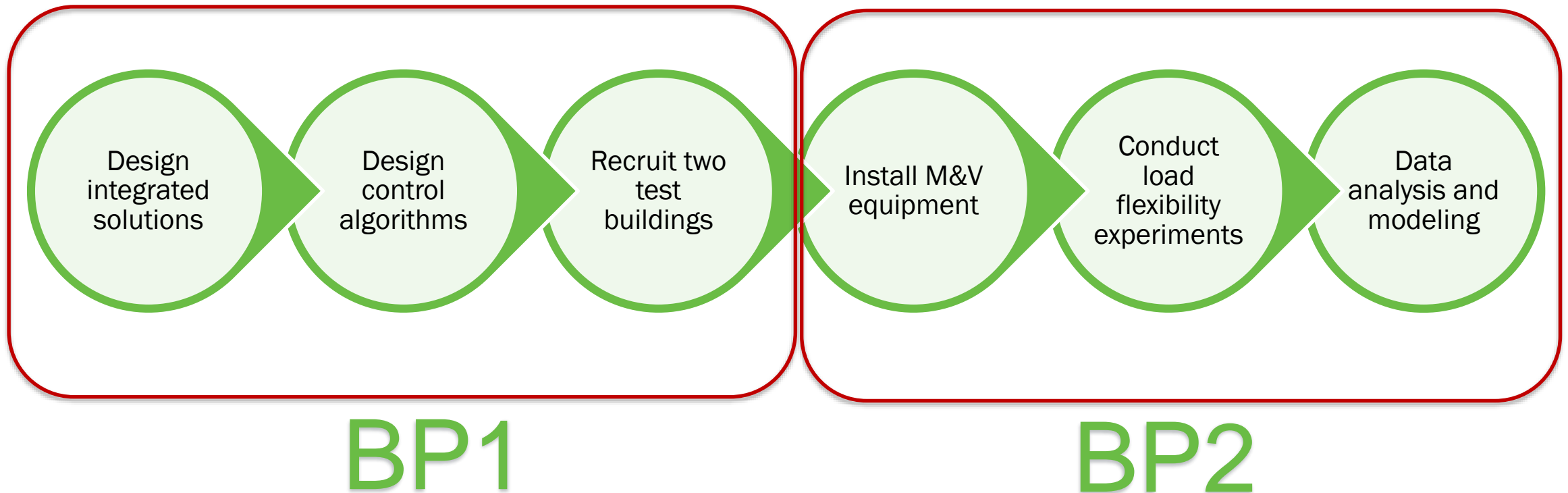
Approach

- What is novel and promising about the approach taken in this project?
 - Integrate automated shades, connected lighting, and the new hybrid PCM thermal storage + RTU
 - Design and implement a practical solution to maximize overall building flexible load
 - Test automated demand response



Approach

- What is the plan to deliver intended outcomes? How will the expected benefit be demonstrated/validated?



Approach

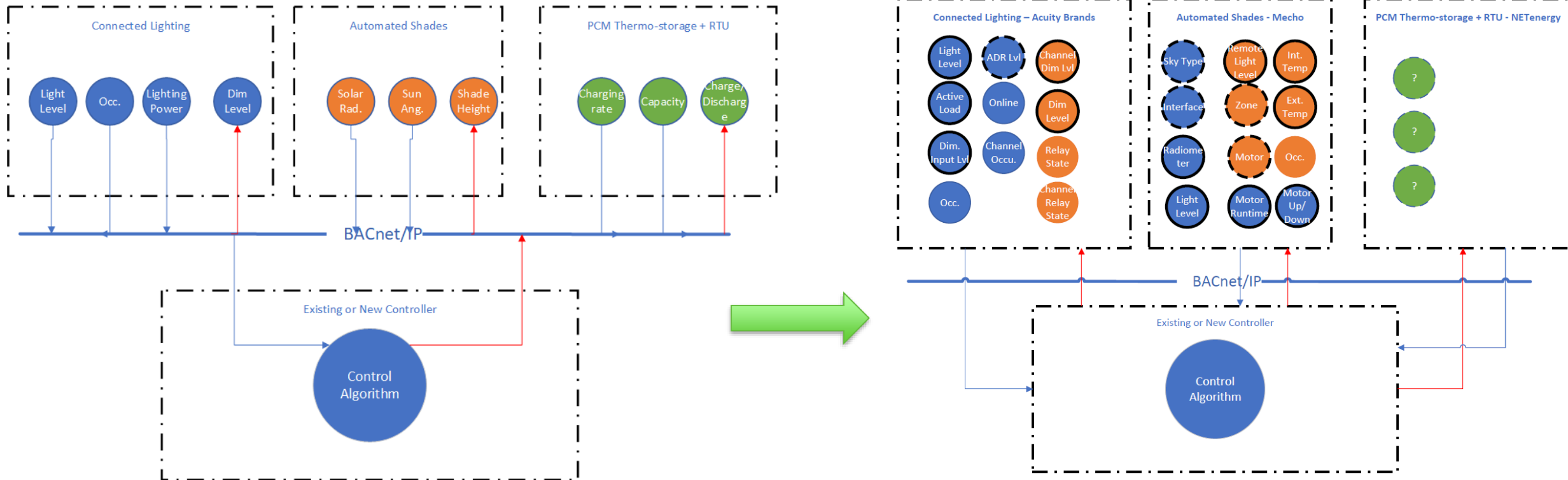
- What are the barriers, technical challenges, and project risks? What mitigation strategies are in place?
 - NETenergy's PCM thermal storage + RTU is still in pre-commercialization stage – additional design, research, and lab testing is needed. There is a risk of a delayed timeline to build the prototype for field testing.
 - **Closer collaboration with NREL and Emerson. Got additional funding for R&D.**
 - Difficult to find building owners who would like to apply (and have budget for) THREE new technologies in one building/space.
 - **Provide some incentives to building owners**
 - **One site focuses on automated shades + connected lighting, the other site tests NETenergy's PCM thermal storage + RTU**

Approach

- How will you commercialize, transform the market, address a barrier, and/or engage stakeholders, if any?
 - **NETenergy and Emerson** will assess system economics and ROI which will be used to develop a commercialization plan and go-to market strategy
 - Engage stakeholders: DoD ESTCP demonstrations at three U.S. Army installations (2024 and 2025) for improving facility resilience.
 - Rethink the applications of the three energy systems and identify the best use cases.
 - Disseminate project outcomes and lessons learned

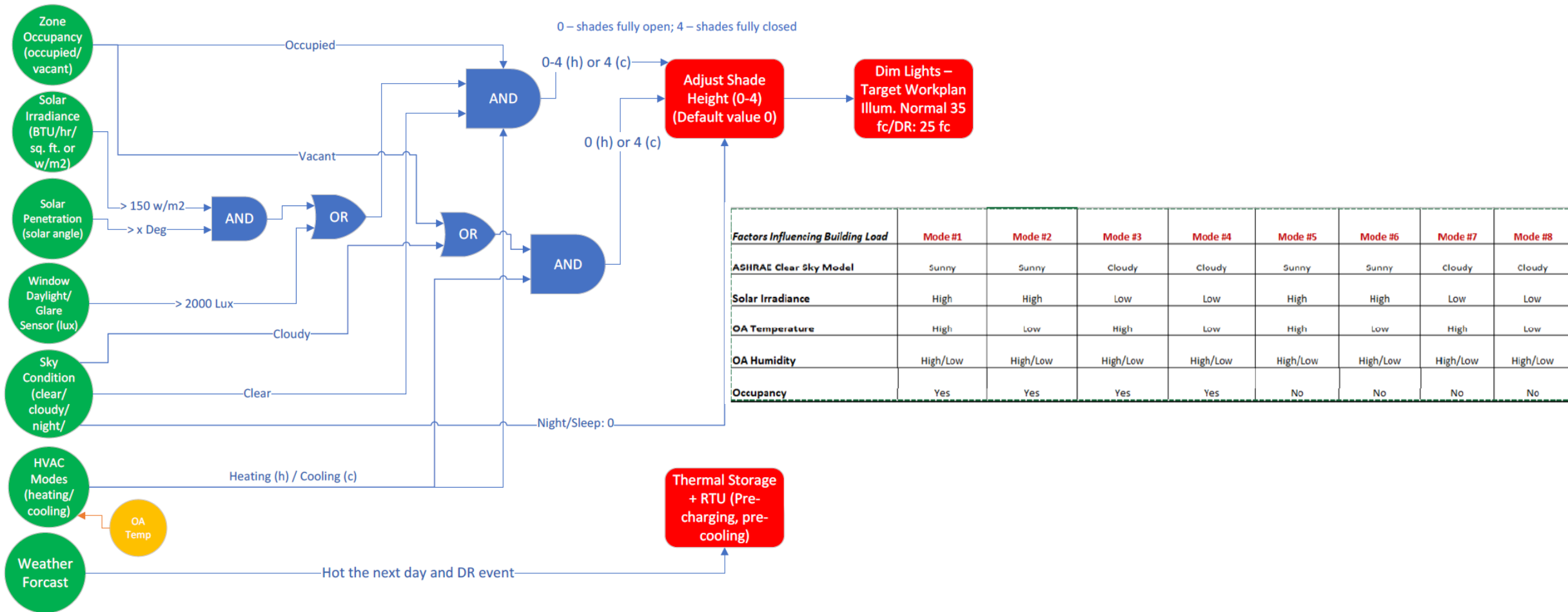
Progress and Future Work

- What are your major accomplishments and findings to date? What major milestones have been achieved?
 - Integrated controls concept



Progress and Future Work

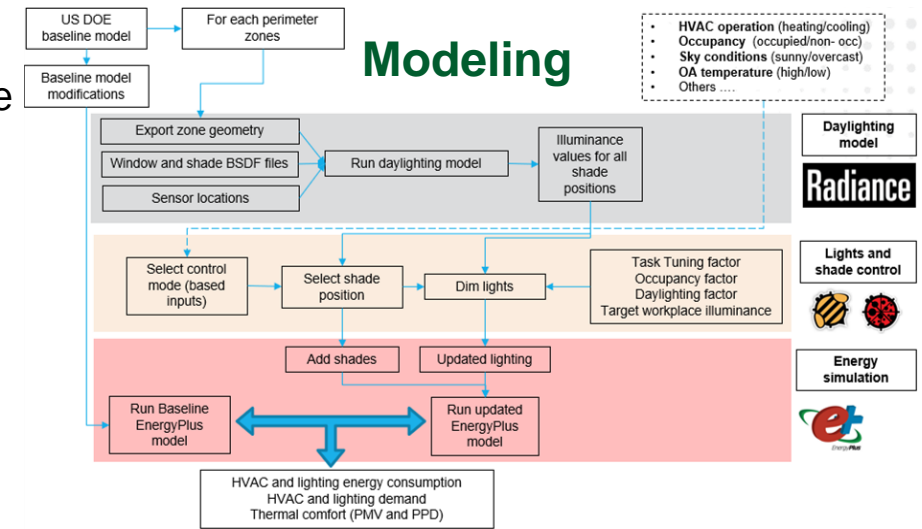
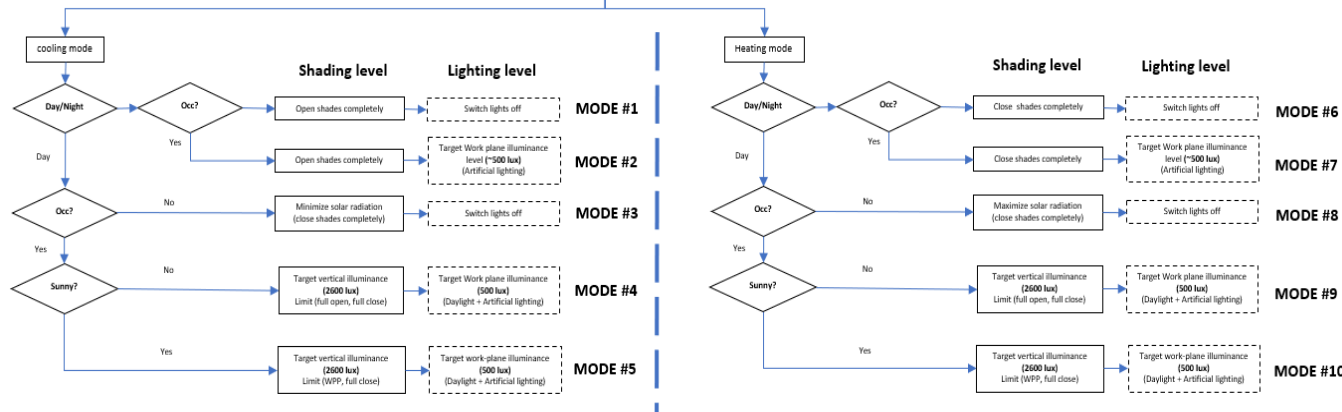
- What are your major accomplishments and findings to date? What major milestones have been achieved?
 - Integrated control algorithm development



Progress and Future Work

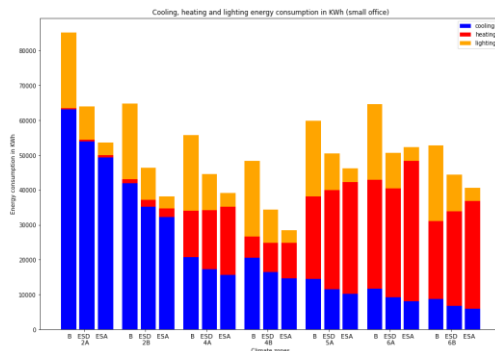
- What are your major accomplishments and findings to date? What major milestones have been achieved?
 - Preliminary data analysis on automated shades + connected lighting
 - Modeling framework in Radiance, EnergyPlus, Ladybug and Honeybee
 - Identify optimal parameters via sensitivity analysis

Shading and Lighting Control Strategy

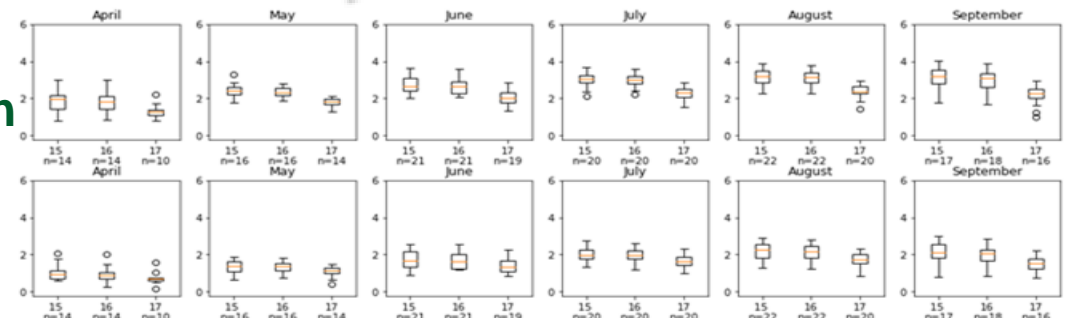


- (1) Energy Efficient (EE) Building
- (2) Demand Response + EE Building

Energy Savings



Demand Reduction



Progress and Future Work

- What are your major accomplishments and findings to date? What major milestones have been achieved?
 - Hybrid RTU with PCM storage: Completed milestones
 - Complete preliminary system design for hybrid RTU with PCM storage
 - Built 1-ton PCM module for characterization at NREL
 - Hybrid RTU with PCM storage: Remaining milestones
 - Characterize 1-ton PCM with refrigerant
 - Complete system construction
 - Started modification of 5-ton RTU
 - Characterize a 5-ton hybrid RTU (part of a DoD ESTCP project)



Task	Subtask	Lead	FY22		FY23				FY24	
			Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2
1	Design/Build 1-tonh PCM module	NETenergy				✓				
2	Characterize 1-tonh PCM module	NREL								
3	Design hybrid RTU w/ 5-tonh PCM module	NREL			✓					
4	Build hybrid RTU w/ 5-tonh PCM module	Emerson								
5	Characterize 5-ton hybrid RTU	NREL								

Progress and Future Work

- What are your major accomplishments and findings to date? What major milestones have been achieved?
 - Recruited TWO test sites for demonstrations
 - Automated shades and connected lighting demo – Adelphi University Nexus Building conference rooms (*summer 2024*)



- NETenergy Hybrid RTU + PCM energy storage demo – a BOX'N Save grocery store (*summer 2025*)

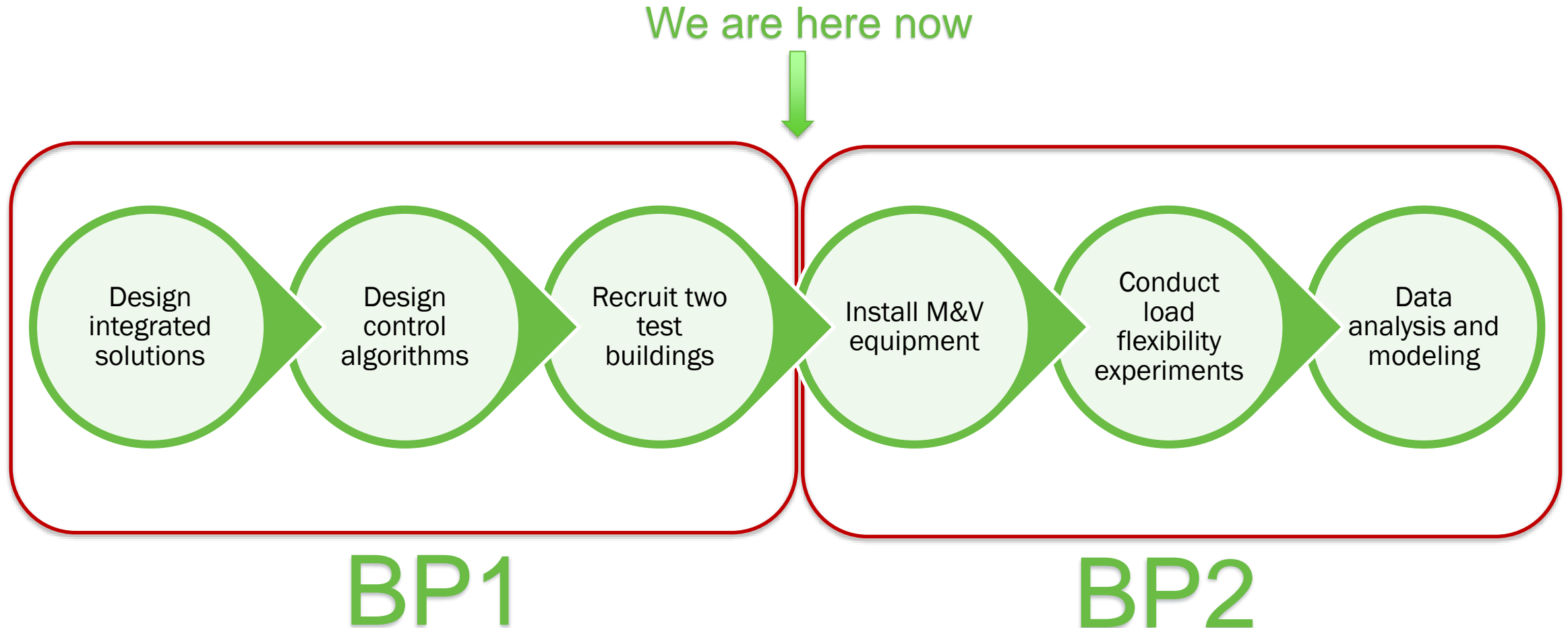


Progress and Future Work

- Have you encountered any unexpected issues or obstacles?
 - Yes. Recruiting two test sites have been very challenging
 - Difficult to find a building owner that is willing to install THREE new systems
 - Not enough budget for retrofits
 - Applications for automated shades and NETenergy hybrid RTU + PCM storage are different

Progress and Future Work

- What are the plans for the rest of the project? Do you anticipate or recommend any changes to the plan?



Progress and Future Work

- What are the plans beyond the end of the project?
 - Information dissemination
 - Commercialization of the NETenergy hybrid RTU + PCM storage
 - More demonstration of NETenergy hybrid RTU + PCM storage at DoD installations

Thank You

Slipstream Group, Inc.

Xiaohui Zhou, Ph.D., PE, CEM, Director of Research and Innovation

608 -210 -7155; jzhou@slipstreaminc.org

FOA #: DE-FOA-0002099, Award #: DE-EE0009083

REFERENCE SLIDES

Project Execution

	FY 2020			FY 2021			FY 2022			FY 2023			FY 2024							
Planned budget (total)	\$307,317									\$606,513										
Spent budget (total)	\$288,743									\$76,303										
	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15	Q16	Q17	Q18	Q19	
Past work																				
Task 1 IPMP and conceptual design																				
Task 2 Recruit test sites							No-cost Extension													
Task 3 Preliminary analysis																				
Current/Future work																				
Task 4 Retrofit, M&V, and testing												Test Site #1			Test Site #2					
Task 5 Modeling												Test Site #1			Test Site #2					
Task 6 Data analysis and reporting																				

▲ BP2 Go/no-go decision point.
 BP1 had a 12-month no-cost extension to recruit two test sites.

↑
 Today (4/27/2023)

Team

Pilot Site #1 (lighting & shades)

- Slipstream (Prime)
- MSU: modeling (subrecipient)
- Lighting contractor: Cole Audio Video
- Automated shades contractor: Mecho
- Building owner: Adelphi Univ. (New York)

Pilot Site #2 (Hybrid thermal storage + RTU)

- Slipstream (Prime)
- MSU: modeling (subrecipient)
- Hybrid thermal storage + RTU:
 - NETenergy (manufacturer partner)
 - NREL (national lab partner)
 - Emerson (NETenergy OEM partner)
- Building owner: Box 'N Save (Maryland)