

Integrated Zero Energy Ready Retrofit Solution for Multifamily Renovations



Performing Organizations: Rocky Mountain Institute, Passive House Institute US, Net Zero Energy Coalition, Re:Vision Architecture, Staengle Engineering, The Levy Partnership

Principal Investigator: Jamie Mandel, Managing Director jmandel@rmi.org

Presented by: Martha Campbell, Manager, mcampbell@rmi.org

Project Summary

Timeline:

Start date: January 1, 2018

Original Planned end date: December 30, 2020

New Planned end date: June 30, 2022

Key Milestones

1. Building Owner Commits to Install Retrofit Package; June 2020
2. Retrofit Package Installed; June 2021

Budget:

Total Project \$ to Date:

- DOE: \$258,263
- Cost Share: \$158,351

Total Project \$:

- DOE: \$499,999
- Cost Share: \$167,480

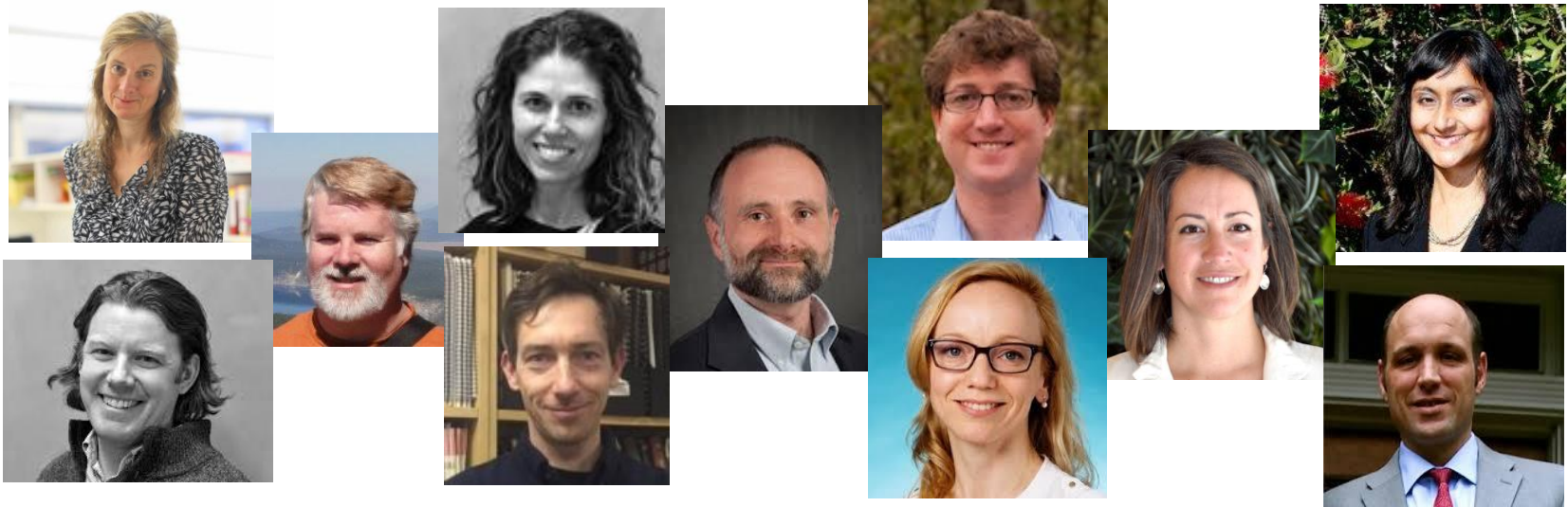
Key Partners:

Rocky Mountain Institute (RMI)	The Levy Partnership (TLP)
Passive House Institute US (PHIUS)	Centria
Net Zero Energy Coalition (NZEC)	Bunting Architectural Metals (BAM)
Re:Vision Architecture	Mitsubishi Electric
Staengl Engineering	

Project Outcome:

Design and apply a standardized, transferable, highly scalable, holistic zero energy ready retrofit assembly in one US climate zone. The team will explore and address the technical risks associated with an integrated retrofit assembly, and will develop a set of guidelines that inform others in the market on how to develop such integrated retrofit solutions.

Team



Team members listed from left to right:

Katrin Klingenberg – PHIUS: Standards and guidelines, quality control, M&V

Justin Weiser – Re:Vision: Pre-designed package project integration

Graham Wright – PHIUS: Standards and guidelines, quality control, M&V

Jenn Rezeli – Re:Vision: Pre-designed package project integration

Jordan Dentz – TLP: Manufacturer engagement, energy modeling

Galen Staengl – Staengl Engineering: MEP guidance and design

Kimberly Llewelyn – Mitsubishi: MEP guidance and design specifications

Jamie Mandel – RMI: Strategic guidance, project management

Martha Campbell – RMI: Strategic guidance, project management

Shilpa Sankara – NZEC: Manufacturer engagement, market research

Joshua Bunting – BAM: Unitized panel fabrication

Dario Giandomenico – Centria (not shown): Panel system design and engineering

Challenge

Problem Definition

- **Emissions:**
 - Buildings account for 70% of electricity use and 39% of emissions in the US
 - Seventy million American homes and businesses burn natural gas, oil, or propane on site generating one-tenth of total US carbon emissions
 - Even with a 100% renewable power grid, 25% of buildings emissions will remain, unless buildings' thermal loads are significantly reduced and electrified
- **Costs:**
 - Low-income families spend up to 20% of their income on energy—compared to just 4% for the average household
 - Roughly one third of the nation's families are considered low-income, the impact from deep retrofits on improved living conditions and utility savings would be considerable
 - ***Many of these families live in multifamily buildings; multifamily retrofits are costly, invasive, and to date have not been easily scalable***

Approach

Integrated Zero Energy Ready Retrofit Solution for Multifamily Renovations is developing a pre-designed and prefabricated net zero energy ready retrofit system to be installed on a prototypical multifamily building in a cold climate, in order to:

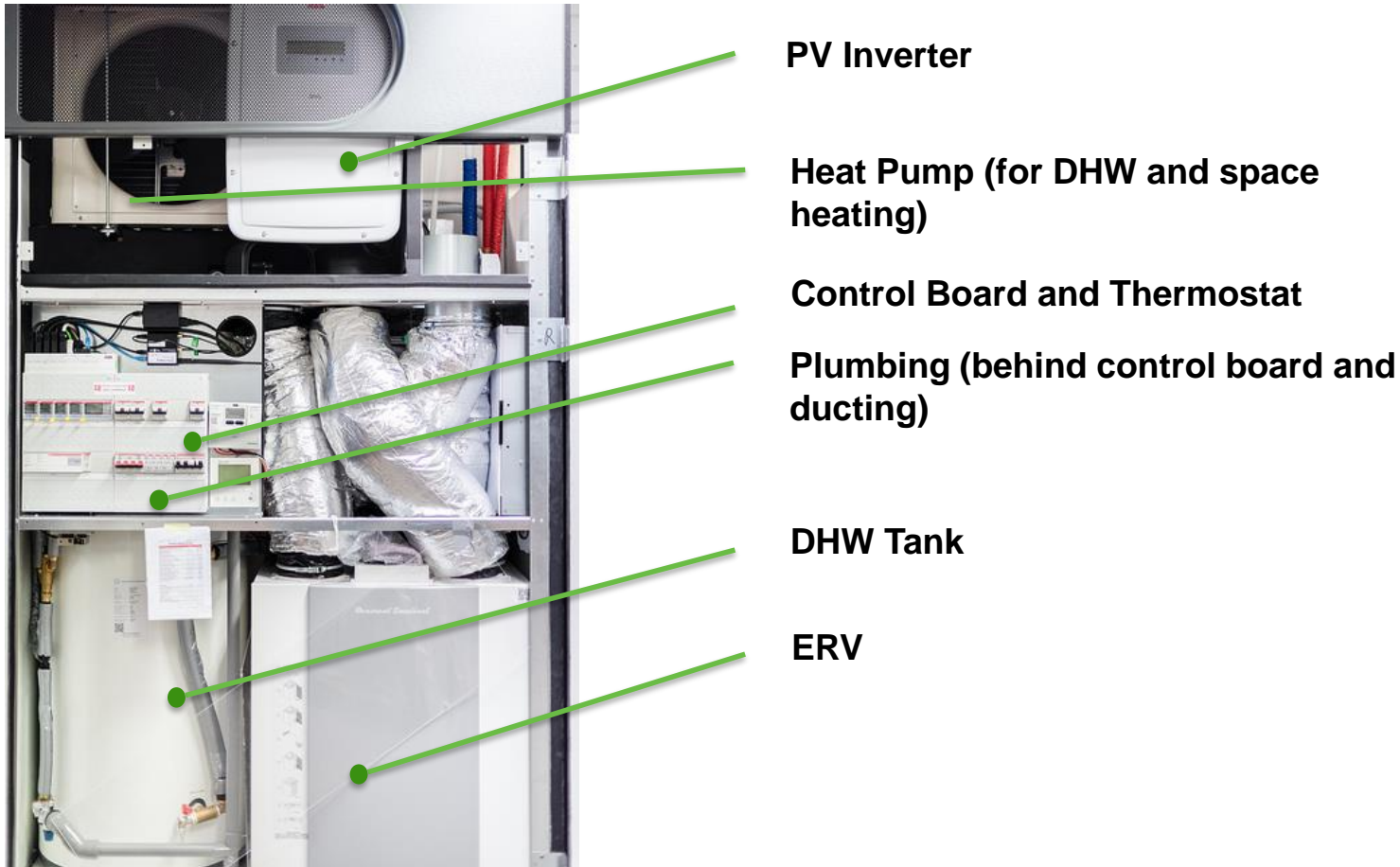
- Validate a pre-integrated envelope and mechanical system package
- Demonstrate a “kit of parts” style retrofit that can serve as a model for similar products that will streamline the retrofit process across thousands of similar buildings, reducing retrofit complexity, time, risk and costs

The project is:

- Engaging manufacturers to develop predesigned and integrated panel and mechanical systems through a competitive RFP process
- Supporting manufacturers by developing design specifications and guidelines
- Testing the efficacy of prefabricated retrofit panel systems, with an eye to hygrothermal risk and performance
- Walking through the implementation process with a building owner to better understand how such pre-designed solutions must be integrated into major capital improvement projects

Approach

Factory Zero Integrated Climate Energy Module (iCEM)



When integrated properly with retrofit panel systems mechanical modules are intended to minimize invasive interior mechanical improvements

Approach

RC Panels Prefab Retrofit Systems



Prefabricated integrated panels reduce system performance risk, installation times, and ultimately cost

Impact

REALIZE uses offsite design and construction to scale the delivery of integrated envelope and HVAC systems to existing buildings. REALIZE facilitates collaboration of manufacturers, contractors and housing providers to do so and serves the 2015 Building America Technology to Market Roadmap A and B objectives.

Roadmap A: High Performance, Moisture-Managed Envelope Solutions

- At present, no US panel manufacturer produces panels specifically designed for retrofits

Roadmap B: Optimal Comfort Systems for Low-Load Homes

- At present, mechanical combination systems that provide HVAC, DHW, ventilation, and dehumidification all while being properly instrumented for smart grid integration are not available in the US

The combination of these systems will deliver a minimum of a 50% site energy use reduction, in line with RBI's 2025 Multi-Year Program Plan goal of a 35% reduction in EUI for thermal loads.

Progress – Mid Stage

Task	Major Milestone	Status
Project Management	Project Management Plan	Completed
Test Planning and Pilot Selection	Test Plan (living document)	Completed
Test Planning and Pilot Selection	Pilot building RFP	Completed
Test Planning and Pilot Selection	Pilot Selected	Completed
Pilot Design and Engineering	Market Research Report	Completed
Pilot Design and Engineering	Potential Materials Cost/Priority List	Completed
Pilot Design and Engineering	Pilot Retrofit Package Design	Commencing

Progress – Mid Stage

Pilot Selection

Eva White - 450 Tremont Street, Boston

- Single pane windows
- Uninsulated concrete walls with brick veneer
- 3” roof insulation (varies for drainage slope)
- Uninsulated ground floor walkway
- 7’6” floor to ceiling height
- Through-window units
- 2 boilers last replaced in 90’s
- Radiators in hallways and apartments
- Make-up air handling unit supplies air to hallways, leaks into apts., then is exhausted by kitchen and bathroom exhaust



Progress – Mid Stage

Pilot Selection

809 Spring Street, Minneapolis, MN

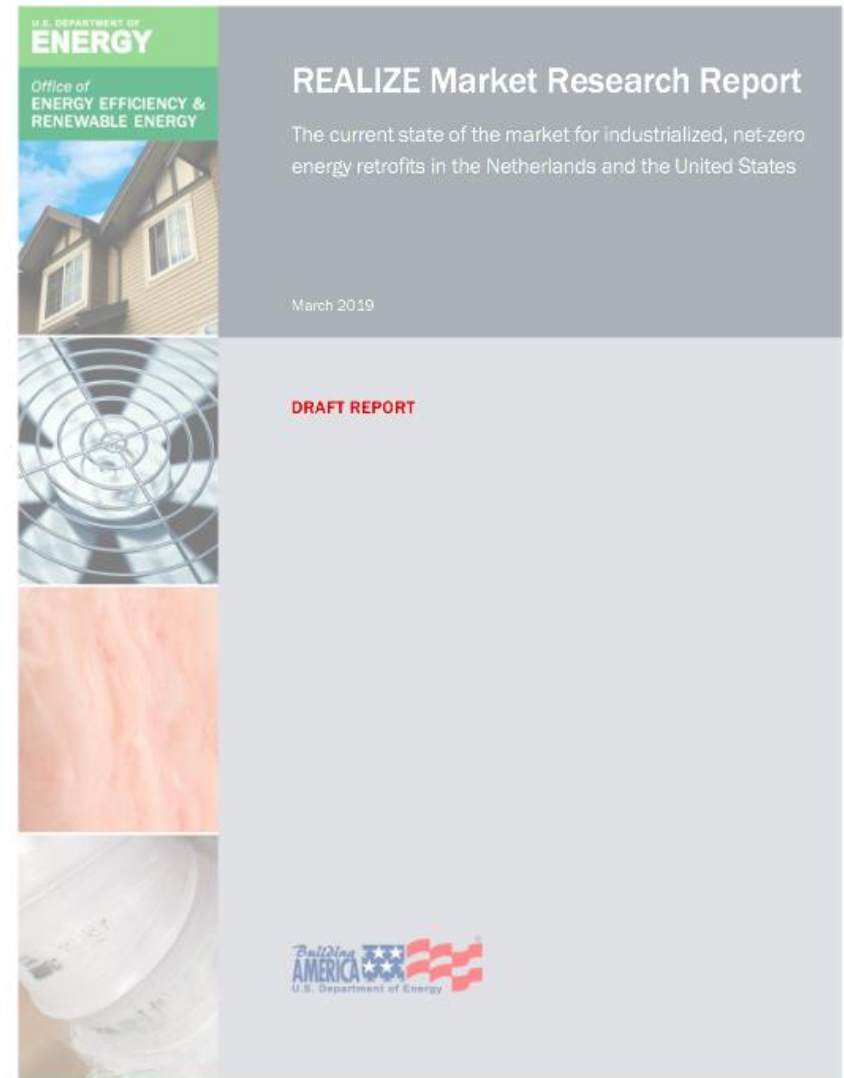
- Single pane windows from early 90's
- Uninsulated walls (some insulation might be present)
- 2"-8" roof insulation
- Through-wall units purchased by tenants
- 28 yr. old condensing HW boilers
- Radiators in hallways and apartments
- Old make-up air handling unit in rooftop penthouse supplies air to hallways, leaks into apts., then is exhausted by bathroom exhaust



Progress – Mid Stage

Market Research Report

- Outlines Dutch retrofit technologies including retrofit panel systems and modularized mechanical systems
- Reviews the landscape of similar technologies in the US market and identifies gaps
- Summarizes a set of recommendations for transferring such technologies (mainly MEP systems) or stimulating the development of similar products in the US market



Progress – Mid Stage

Manufacturer RFPs: Panel and MEP

- Centria was selected as our panel manufacturing partner through a competitive RFP process
- Manufacturer responses to our request for a combined set of mechanical systems were limited
- We are going back and forth on if a MEP modularized approach is the way to go on these two buildings

REALIZE Industrialized Retrofits
Building Envelope Partner Request for Qualifications

Table 1. Envelope Solution Functional Needs

Functional Need	Requirements	Project Goals and/or Preferred Targets
Energy Performance	<ul style="list-style-type: none"> • Wall subsystem thermal resistance is configurable from R-18 to R-28 	

REALIZE Industrialized Retrofits
Mechanical Systems Partner Request for Proposals

Appendix A: Mechanical Basis of Design

Purpose:
The purpose of this document is to outline the design basis for mechanical systems to accompany a deep envelope retrofit as a part of the REALIZE program.

Premise:
The REALIZE program aims to develop pre-engineered building envelope and mechanical retrofit systems that will reduce residential building energy consumption by at least 50%. A secondary target is that the retrofitted buildings be "Net Zero Ready." Additionally, it is desired that these systems will be part of a "retrofit-in-place." As such, a solution that is mounted and routed from the outside of the building is preferred.

Codes:
The MEP systems in the retrofit package must meet local building code requirements. Adopted codes will depend on project location and governing authority. Ventilation and local exhaust air will be provided based on rates required in ASHRAE 62.2 or local code, whichever is more stringent.

Fuel:
Mechanical systems will be run completely on electricity.

Design Parameters:
The occupied temperature set points shall be maintained during regular occupancy hours, while the unoccupied temperature set points shall be maintained during unoccupied periods. Design outdoor temperatures will be based on building climate and appropriate design criteria.

- Occupied Temperature: Winter: 68°F; Summer: 77°F
- Occupied Humidity Maximum (no minimum): 50% + 5% relative humidity (RH)
- Unoccupied Temperature: Winter: 66°F; Summer: 78°F
- Unoccupied Humidity Maximum (no min): 50% + 5% RH
- Passive House Institute US indoor surface comfort criteria

Heating and Cooling Option #1: Air-to-air heat pump
Heating and cooling will be provided to each apartment by an air-to-air heat pump with a SEER (or

for details

Stakeholder Engagement



Remaining Project Work

Task	Major Milestone
Pilot Design and Engineering	Pilot Retrofit Package Design
Pilot Design and Engineering	Pilot Owner Letter of Commitment
Piloting and Monitoring	Pilot Construction Docs
Piloting and Monitoring	Pilot Constructed
Piloting and Monitoring	Knowledge Transfer Publications: Design Guidelines, Delivery Process Documentation, Cost Curve Projections
Monitoring and Verification	Monitoring results

Major Items to Tack Down:

- Gap funding
- Integrated MEP system

Thank You

Rocky Mountain Institute
Jamie Mandel, Managing Director
jmandel@rmi.org

REFERENCE SLIDES

Project Budget

Project Budget: The project is currently running significantly over on cost share. This has been a function of the degree of complexity involved in recruiting and selecting pilots and engaging manufacturers to develop the products sought for this way of retrofitting buildings.

Variations: Variations exist on the cost share portion of the project. We are running roughly 3x over budget.

Additional Funding: The Noorda Family Foundation has provided cost share support

Budget History

FY 2018 (Actual)		FY 2019 (Budget)		FY 2020 (Budget)	
DOE	Cost-share	DOE	Cost-share	DOE	Cost-share
\$194,011	\$142,426	\$166,668	\$67,073	\$109,939	\$57,073

Project Plan and Schedule

Task Name	Start	Finish	FY 2019				FY 2020				FY 2021				FY 2022			
			Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
+ TASK 1: Project Management and Building America Support	01/01/18	03/31/21	[Gantt bar spanning FY 2019 Q1-Q4, FY 2020 Q1-Q4, FY 2021 Q1-Q4, FY 2022 Q1-Q4]															
+ TASK 2: Test Planning and Pilot Project Selection	01/01/18	03/29/19	[Gantt bar spanning FY 2019 Q1-Q4]															
- TASK 3: Pilot Design and Engineering	04/02/18	03/30/21	[Gantt bar spanning FY 2019 Q2-Q4, FY 2020 Q1-Q4, FY 2021 Q1-Q4, FY 2022 Q1-Q4]															
Market Research Report	04/02/18	12/31/18	[Gantt bar spanning FY 2019 Q2-Q4]															
Potential Materials Costed and Prioritized	06/01/18	12/31/18	[Gantt bar spanning FY 2019 Q3-Q4]															
+ Panel Manufacturer Recruitment	07/12/18	10/05/18	[Gantt bar spanning FY 2019 Q3-Q4]															
+ MEP Manufacturer Recruitment	08/21/18	03/13/19	[Gantt bar spanning FY 2019 Q4]															
- Energy Modeling	04/01/19	06/28/19	[Gantt bar spanning FY 2019 Q2-Q4]															
Conduct site visit and collect baseline building and energy data	04/01/19	04/30/19	[Gantt bar spanning FY 2019 Q2]															
Generate baseline energy model	05/01/19	05/30/19	[Gantt bar spanning FY 2019 Q3]															
Develop Energiesprong NZC package model	05/31/19	06/28/19	[Gantt bar spanning FY 2019 Q4]															
Develop cost optimized NZC package model	05/31/19	06/28/19	[Gantt bar spanning FY 2019 Q4]															
Develop PHIUS cost optimized NCZ package model	05/31/19	06/28/19	[Gantt bar spanning FY 2019 Q4]															
- Panel and Mech Design Collaboration Concept Phase	11/21/18	03/30/20	[Gantt bar spanning FY 2019 Q4, FY 2020 Q1-Q2]															
- Development of several panel design concepts by Design Team	11/21/18	02/05/19	[Gantt bar spanning FY 2019 Q4]															
ReVision to issue panel concept sketches + window options to Centria/Bunting	11/21/18	11/21/18	[Gantt bar spanning FY 2019 Q4]															
Review Pilot Finalists to inform panel concepts & identify potential issues	01/11/19	01/31/19	[Gantt bar spanning FY 2020 Q1]															
Centria/Bunting develop concept sketches	01/11/19	02/05/19	[Gantt bar spanning FY 2020 Q1]															
Centria/Bunting to share concept sketches with ReVision/CVM	02/05/19	02/05/19	[Gantt bar spanning FY 2020 Q1]															
Design Team workshop	03/20/19	03/26/19	[Gantt bar spanning FY 2020 Q1]															
- Preparation of preferred panel design concept	03/27/19	07/02/19	[Gantt bar spanning FY 2020 Q1-Q2]															
Centria/Bunting refine preferred panel concept design	03/27/19	05/07/19	[Gantt bar spanning FY 2020 Q1-Q2]															
ReVision/CVM review panel concept design	05/08/19	05/21/19	[Gantt bar spanning FY 2020 Q2]															
Development of draft 3-Part specification	05/22/19	07/02/19	[Gantt bar spanning FY 2020 Q2-Q3]															
Centria/Bunting prepare final DRAFT panel design concept documents	05/22/19	07/02/19	[Gantt bar spanning FY 2020 Q2-Q3]															
- Development of panel concept & Mech collaboration	04/03/19	08/05/19	[Gantt bar spanning FY 2020 Q1-Q2]															
Coordination Call	04/03/19	04/03/19	[Gantt bar spanning FY 2020 Q1]															
Staengl prepare mech design concept(s) for review	04/04/19	05/15/19	[Gantt bar spanning FY 2020 Q1-Q2]															
Design team review of mech design concept	05/16/19	05/29/19	[Gantt bar spanning FY 2020 Q2]															
Staengl refine design concept	05/30/19	07/02/19	[Gantt bar spanning FY 2020 Q2-Q3]															
Centria/Bunting refine panel concept for mech integration	07/03/19	08/05/19	[Gantt bar spanning FY 2020 Q3]															
- Full Team Design Review	08/07/19	10/03/19	[Gantt bar spanning FY 2020 Q3-Q4]															
Design review meeting - full team	08/07/19	08/20/19	[Gantt bar spanning FY 2020 Q3]															
Manufacturing Partners refine design per review comments	08/22/19	10/02/19	[Gantt bar spanning FY 2020 Q4]															
Sign off on panel concept design	10/03/19	10/03/19	[Gantt bar spanning FY 2020 Q4]															
Prototype performance testing of panel design concept	08/06/19	02/05/20	[Gantt bar spanning FY 2020 Q3-Q4]															
Task 3.2.1: Retrofit Product Solutions Designed for Use on Selected Pilot	02/07/20	03/30/20	[Gantt bar spanning FY 2021 Q1]															
- Pilot Pre-Design (can happen concurrent to above Concept Phase)			[Gantt bar spanning FY 2021 Q1]															

Project Plan and Schedule

Task Name	Start	Finish	FY 2019				FY 2020				FY 2021				FY 2022			
			Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Site visit by Design Team																		
Observe interior and exterior building conditions																		
Gather information for post site-visit analyses																		
Meet with Client team to outline the full extent of the project																		
Pre-Design Investigation & Narratives																		
Coordinate with REALIZE product manufacturers regarding alignment of the building and pro																		
Collaborate with Client to develop a written Owner's Project Requirements (OPR)																		
Preliminary structural analysis of existing loads on select structural elements & calculations																		
Narrative MEP systems concept for the building																		
Report findings to the Client and plan for next steps																		
3D Building Scanning																		
Building scanner identification and contract negotiation, mobilization																		
Scan pilot building for base drawings																		
Develop base drawings of existing conditions																		
Local code analysis																		
Tenant engagement																		
Illustrative rendering of an exterior building concept based on OPR and emerging product devel																		
Pilot Building Schematic Design	04/01/20	06/30/20																
Any remaining pre-design work not completed with Concept Phase of work	04/01/20	04/01/20																
Develop design of facade improvements																		
Develop design of mechanical systems																		
Develop outline specifications																		
Issue SD Package	06/30/20	06/30/20																
Cost Reconciliation	07/01/20	09/15/20																
Cost estimate based on design package	07/01/20	08/14/20																
Revisions to meet construction budget	08/18/20	09/15/20																
Go/No GO: Building Owner Commits to Implement Retrofit Package	09/16/20	09/30/20																
Retrofit Guidelines	06/01/18	09/30/20																
Review Energy Performance Targets	06/01/18	09/28/18																
Draft Modeling Protocols	04/01/19	06/28/19																
Draft Preliminary Guidelines	07/01/19	09/30/20																
Monitoring and Verification	03/31/20	03/30/21																
Develop Monitoring Plan	09/29/20	01/28/21																
Install Baseline Instrumentation	01/29/21	03/30/21																
Collect Baseline Performance Data	03/31/20	03/30/21																
TASK 4: Piloting and Monitoring	08/18/20	09/28/22																
Construction Documents	08/18/20	03/30/21																
A/E negotiations and contract	08/18/20	09/08/20																
Code official meeting	09/10/20	09/10/20																

Project Plan and Schedule

Task Name	Start	Finish	FY 2019				FY 2020				FY 2021				FY 2022			
			Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Develop DD/CD set	09/14/20	11/12/20																
Issue CDs/permit drawings (Arch and MEP)	11/13/20	11/13/20																
Final materials/products selected	09/30/20	12/30/20																
Issue final specifications	11/13/20	11/13/20																
Panel and Mech system development for specific pilot building	12/30/20	03/30/21																
Finalized construction docs	12/30/20	03/30/21																
Bidding	11/16/20	02/26/21																
Issue contract documents to bidders/GCs	11/16/20	11/16/20																
Pre-bid meeting	12/01/20	12/01/20																
Bids due	01/13/21	01/13/21																
Review bids	01/15/21	02/09/21																
Select GC	02/11/21	02/11/21																
Negotiate	02/26/21	02/26/21																
Construction	03/15/21	12/03/21																
Pre-construction kick off meeting	03/15/21	03/15/21																
Shop drawing preparation by manufacturers	03/17/21	04/06/21																
Shop drawing reviews	04/08/21	04/27/21																
Component fabrication	04/29/21	08/06/21																
Install in-situ monitoring instrumentation	04/29/21	08/06/21																
Contractor mobilization (procurement, scheduling, permitting, etc.)	03/17/21	08/06/21																
Demolition work, general	08/10/21	09/06/21																
Selective demo/prep work for panel & MEP installation	09/08/21	12/03/21																
Interior finish work? Extend unknown...																		
Pilot Constructed	03/31/21	09/28/21																
Monitoring and Verification	08/18/21	09/28/22																
Install any additional monitoring systems	08/18/21	09/28/21																
Collect and process data; publish findings to DOE	09/29/21	09/28/22																
Publishing	04/01/21	12/29/21																
Delivery Process Documentation (including photos and videos)	04/01/21	06/30/21																
Final Design Guidelines	09/29/21	12/29/21																
Cost Curve Projections	09/29/21	12/29/21																