



# 2024 PROJECT PEER REVIEW

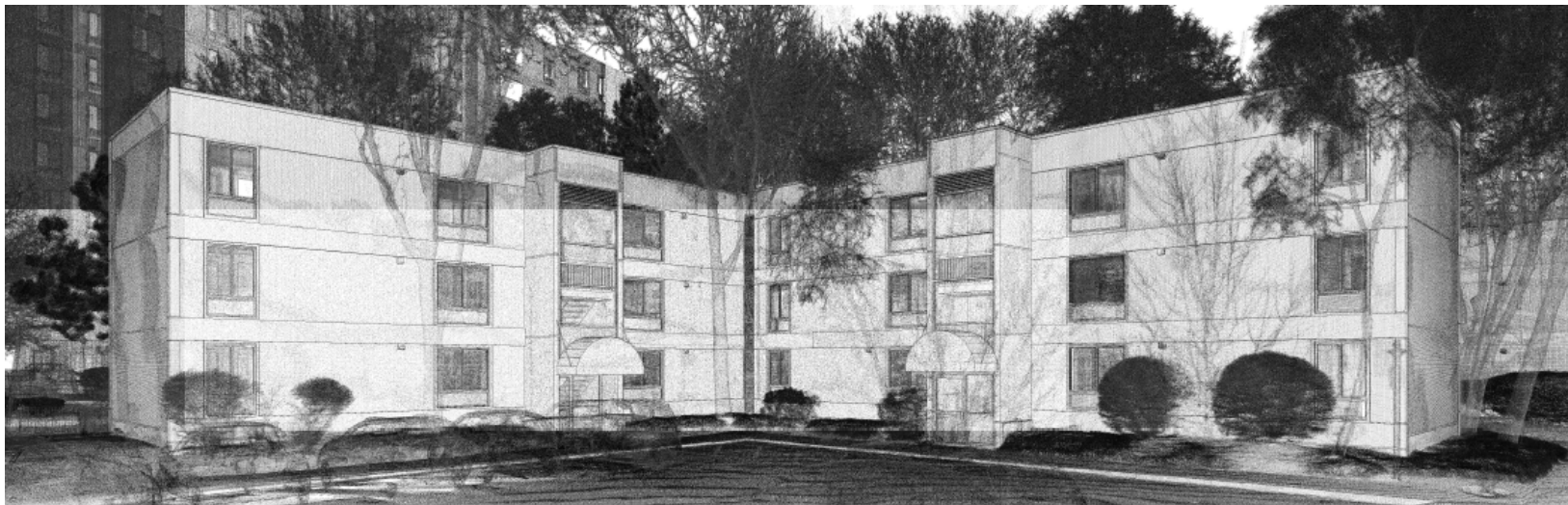
U.S. DEPARTMENT OF ENERGY  
BUILDING TECHNOLOGIES OFFICE

## BTO Peer Review:

A Recipe for ABC Multifamily  
Retrofits: Technologies,  
Financing, and Project Delivery



# A Recipe for ABC Multifamily Retrofits: Technologies, Financing, and Project Delivery



RMI

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DE-EE0009064

# Project Summary

## OBJECTIVE, OUTCOME, & IMPACT

Demonstrate whole building retrofit solutions that improve efficiency through ABC technologies and streamlined design and project delivery process. The outcome includes the retrofitting of two demonstration sites and the development of IMSP-C, including integration with prefabricated panels, to launch commercially by the end of the award period. By validating the retrofit package through a scalable model, the team will bring to market a solution to enable the rapid acceleration of deep energy retrofits of multifamily buildings.

## TEAM & PARTNERS

Pod Development Team: RMI, TK Fabricate, Staengl

Engineering, Morben Technologies, OTS R&D

MA Demonstration Team: RMI, Open Market ESCO, Reisen Design Architects, Staengl Engineering, Signetron

CA Demonstration Team: RMI, Open Market ESCO, David Baker Architects, Staengl Engineering

M&V: Lawrence Berkeley National Lab, RMI



## STATS

Performance Period: 07/07/2020-12/31/2027

DOE Budget: \$5.282M, Cost Share: \$1.406M

Task 1: IMSP Advancement

Task 2: Panel Integration Development

Task 3: Demonstration Project Pre-Development Design and Engineering

Task 4: Demonstration Project Implementation

Task 5: Field M&V

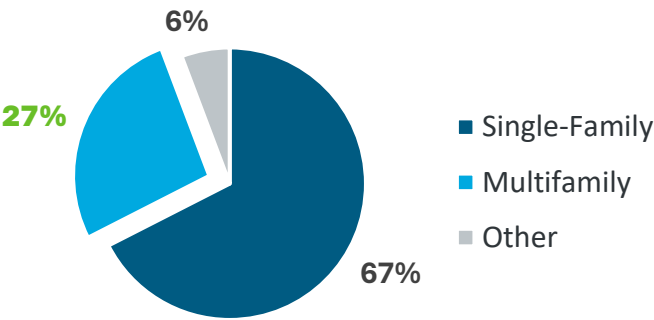
Task 6: Market Transformation

Task 7: Final Technical Report and Updated T2M



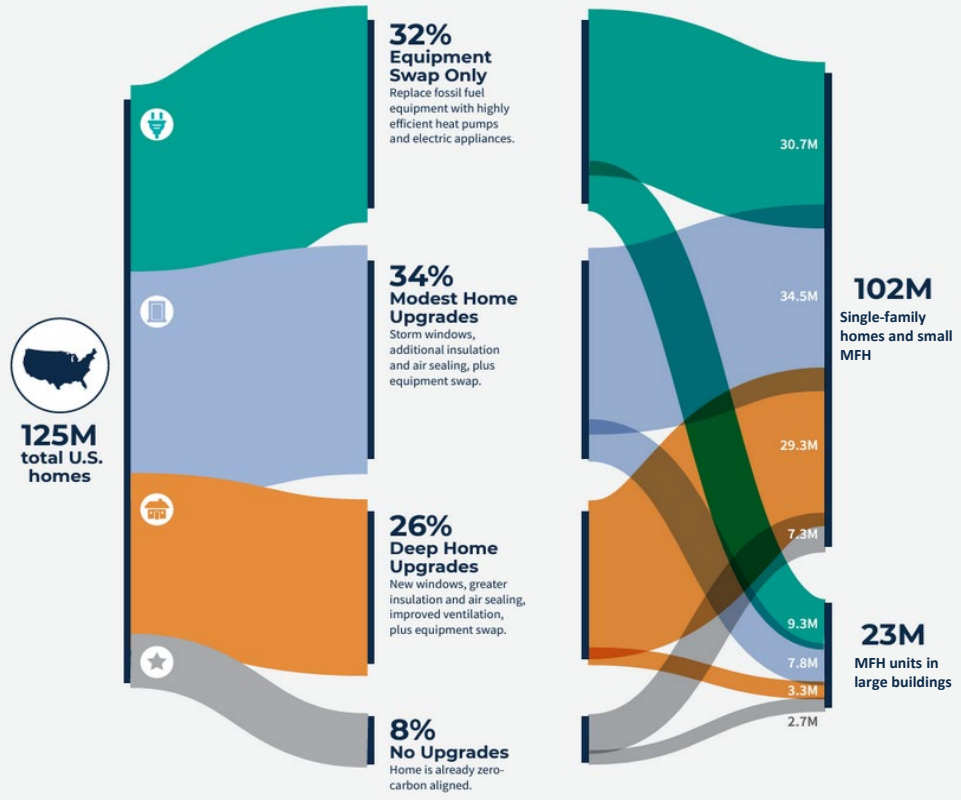
# Problem

US Housing Units by Type



Multifamily housing (MFH) is an important minority of the US building stock that represents many households disproportionately affected by climate change and energy burdens. The rate of MFH decarbonization retrofits must drastically accelerate while maximizing benefits and minimizing disruption for vulnerable residents.

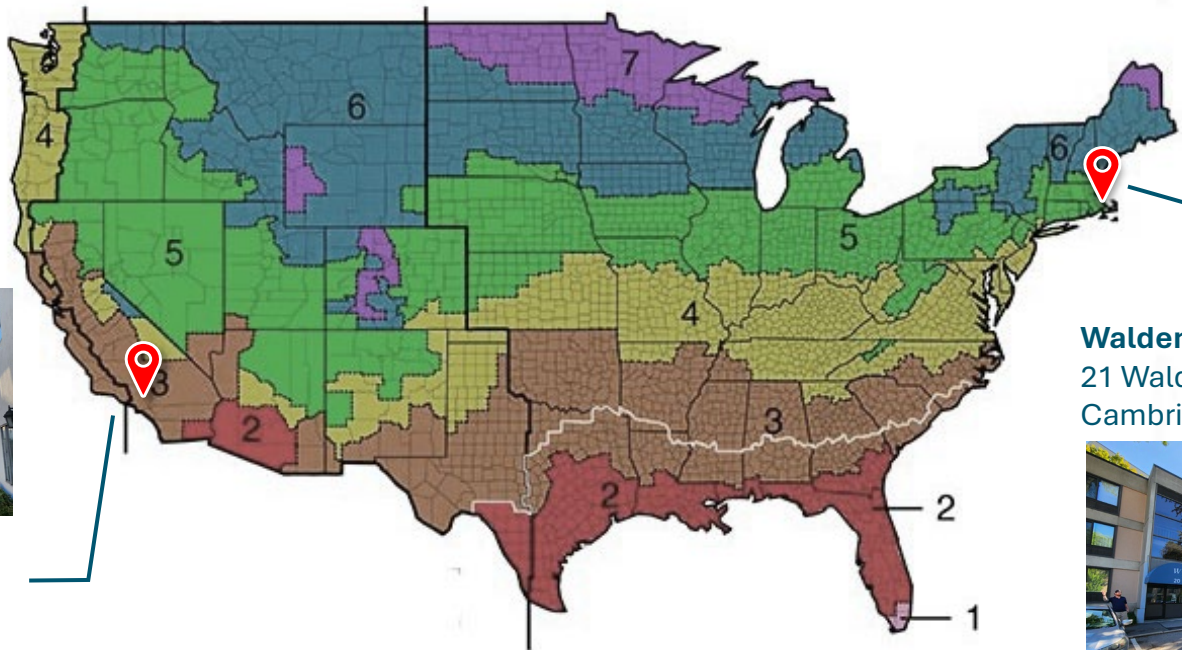
Retrofit packages needed to make homes zero-carbon aligned fall into three categories, each applying to roughly a third of US housing units.





# Targeting Low-Income Multifamily Housing

Develop standardized retrofit solutions for the most common building typologies, and demonstrate on two distinct building types in two different climate zones, with the goal to scale low-income multifamily housing retrofits across large portfolios.



**Elizabeth Court**  
5227 Elizabeth Street  
Cudahy, California

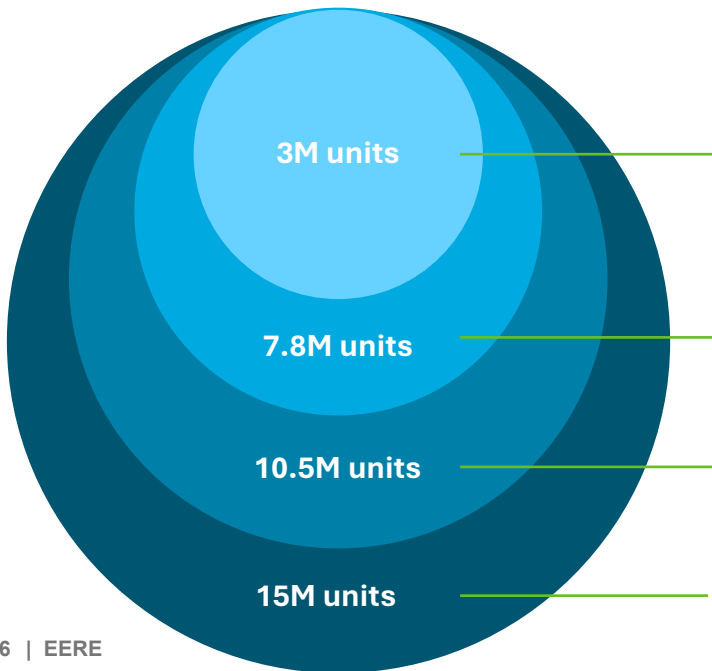
**Walden Square Apartments**  
21 Walden Square Road  
Cambridge, Massachusetts





# Combined Impact

Targeted typologies and geographies make solution set broadly applicable. For multifamily buildings in target climate zones:



Climate	Total Square Feet (Millions)	Total Number of Buildings	Total Site Energy Savings (Tbtu)
Cold/Very Cold	9,323	1,760,789	472
Hot-Dry/Mixed-Dry	2,767	538,401	98
Mixed-Humid	8,071	1,240,669	372
Total	20,161	3,539,859	941*

\*10.5% of all residential energy use

- Pre-1980 existing central DHW AND hydronic heat in target regions (Pacific, New England, Middle Atlantic, South Atlantic)
- Pre-1980 existing central DHW OR hydronic heat in target regions
- All existing central DHW OR hydronic heat in target regions
- All existing central DHW OR hydronic heat in all regions



# Today's Business as Usual Approach

Bespoke retrofit  
solutions



Building by  
building delivery  
model



Non-integrated  
design and  
construction  
approach



Tenant  
relocation

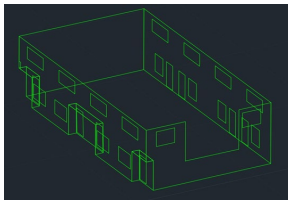
= **Slow, costly, and disruptive retrofits resulting in < 1% retrofit rate**





# Integrated Retrofit Solution for Multifamily Housing

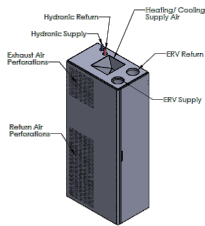
## Typology Specific Standardized Retrofit Package



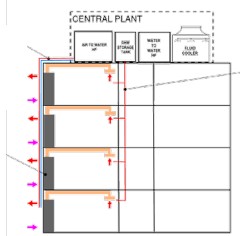
Scanning to  
BIM/CAD/CAM



Envelope Improvement  
(Prefab Unitized Panel)



Integrated Mechanical  
System Pod



Central Plant



Prefabricated  
Ductwork

## Project Finance & Delivery

Streamlined Design  
/ Engineering



Financing Package



Replicable  
Business Model

## ABC Multifamily Retrofit Solution

=

**Fast, Replicable, Deep Savings, Cost Compression at Scale**





# Integrated Mechanical System Pod

## Central System Pod

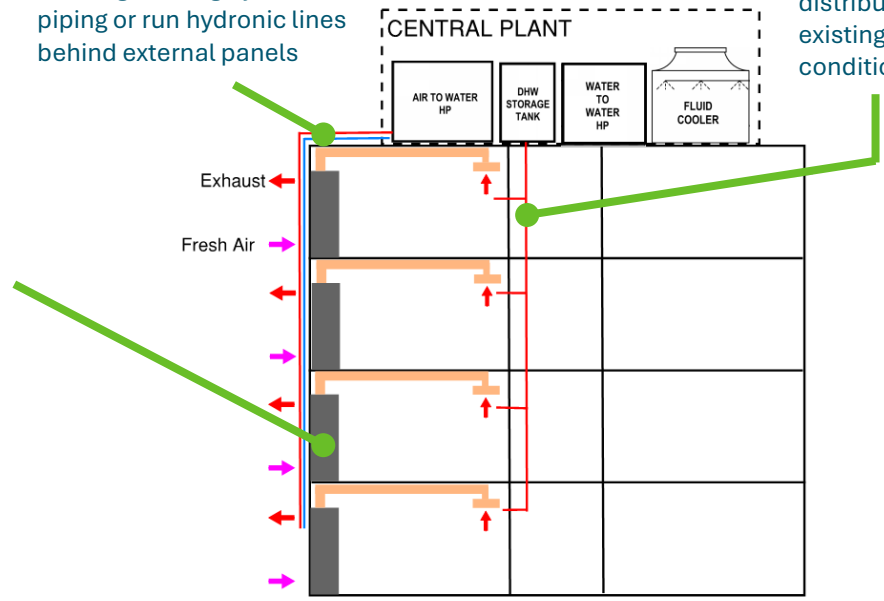
ERV with Boost | Heating/Cooling | Economizer | Dehumidification | Central DHW



### Indoor Pod

- ERV
- WSHP
- Controls & HMI
- Power Supply

Reusing existing hydronic piping or run hydronic lines behind external panels



DHW generated from rooftop equipment and distributed through existing piping if in good condition (Heat Recovery)



# Fast, Affordable, and Efficient Retrofit Solutions

## IMSP-C

- Repurpose existing hydronic piping
- Prefabricated, easy to install package with no site-built closets or soffits
- High-efficiency, all electric unit with air and water side heat recovery
- Economizer reduces need for mechanical cooling
- Flexibility for phased implementation with boilers and ground source loops
- \$19-21k/unit installed cost including central plant

## Deep Energy Retrofit Panel and Digital Workflow

- 30+% project time saving with digital workflow
- Faster install using prefab panels with pre-installed and flashed windows
- Reduced on-site labor with manufacturing at scale aimed to drive down costs
- Continuous insulation leading to reduced thermal bridging and passive house air tightness

## Project Design and Delivery

- Reduced uncertainty and streamlined project development through standardized scope packages
- Fast track contractor engagement and shop drawings
- Reduced or eliminated typical architectural fees
- Less field work with packaged systems
- More streamlined project development

## Replicable Business Model

- Standardized details and design package reduces risk, unknowns, and cost uncertainty
- Aggregating similar projects drives cost compression for ABC technologies
- Market transformation drives more buildings and greater savings

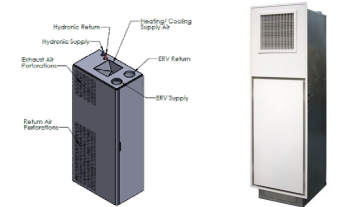
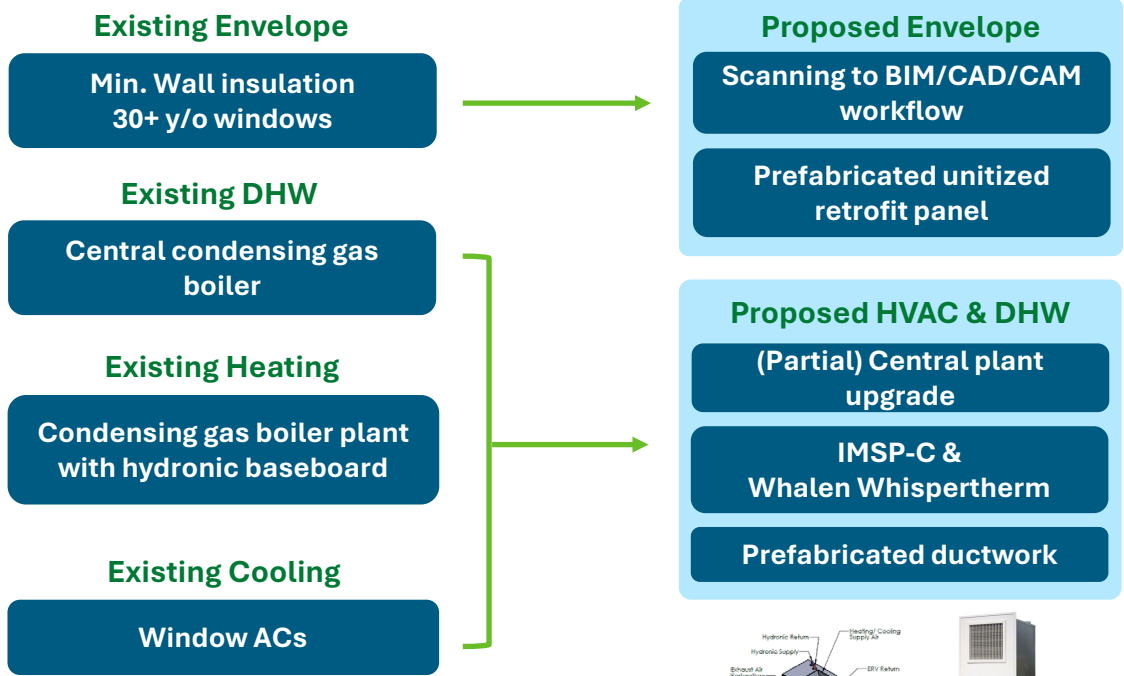


# Massachusetts Demonstration



## Walden Square Apartments

- 9-story midrise (120 units) + 5 lowrise complexes (120 units)
- 100% low-income apartments
- Owned and managed by WinnCompanies



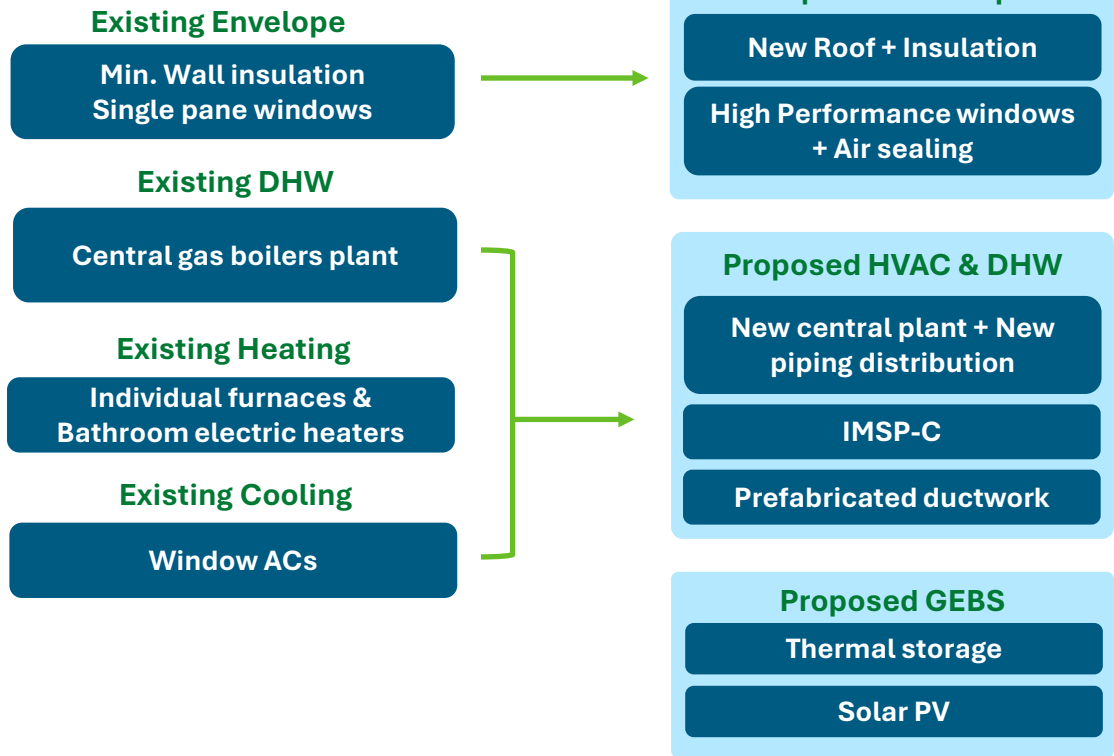


# California Demonstration



## Elizabeth Court

- 14-unit, 2-story + 13-unit & 1 office, 2-story
- 100% low-income apartments
- Owned by Corporation for Better Housing
- Managed by WinnCompanies





# Technical Challenges & Project Risk

- 1 Product development cost and timeline**
  - Identify MVP functionality upfront
- 2 Startup hardware manufacturer**
  - Identify scaling mechanism and auxiliary funding sources
- 3 Demonstration project cost & hidden deferred maintenance issues**
  - Deep dive on existing condition to uncover potential issues early on
  - Identify potential auxiliary funding sources including incentives
- 4 Affordable housing mortgage terms**
  - Engage with building owner, mortgage lender and DOE Legal team

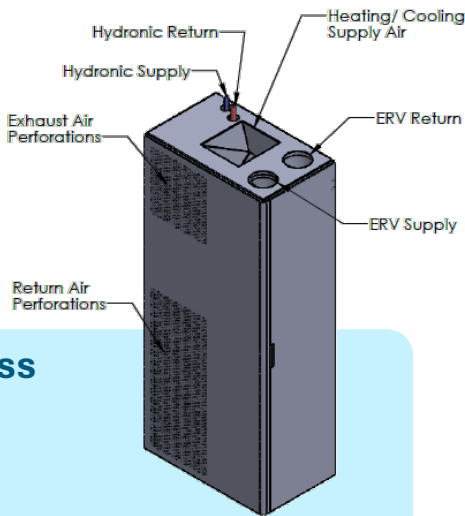


# Pod Development Progress

## Phase 1 Alpha Prototype



## Phase 2 Beta Prototype



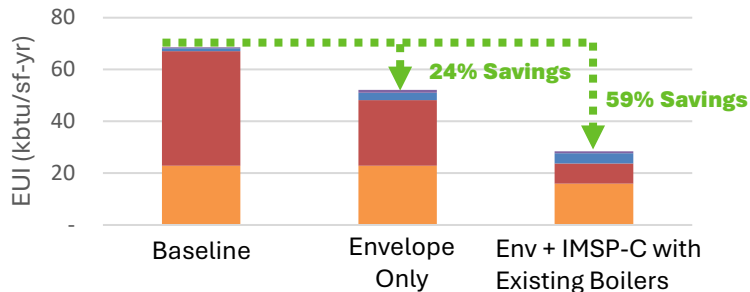
### Design Goals & Progress

- **Update component selection:**
  - ✓ **ERV**
  - ✓ **Damper actuators**
  - **WSHP:** Selected new WSHP, but waiting for R454b version.
- ✓ **Smaller footprint:** Overall footprint stays similar.
- **Backflow issue:** New design pending performance testing verification.
- **Enclosure Design:** Design mostly completed. Currently focusing on designing connection between the pod to the exterior wall louver.
- **Controls & HMI:** PCB controls and HMI design & testing in progress.
- **Certification (s):** Completed preliminary design review. Will pursue UL 60335-2-40 safety certification once testing is completed.
- **Final Tech to Market Plan:** On hold until prototype fabrication completed.

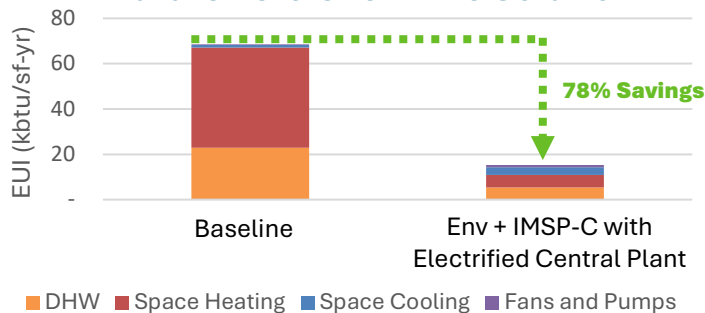


# MA Demonstration Progress

## Demonstration Phased Solution



## Future Zero Over Time Solution



1

## Existing Condition Evaluation

- As-built drawings
- Structural engineering assessment
- Building envelope assessment
- MEP assessment
- Building code analysis

2

## Conceptual Design Narrative

- Energy model optimization for design specification
- Panel manufacturers interview

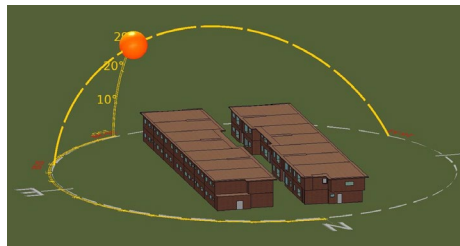
3

## Schematic Design Package





# CA Demonstration Progress



## 1 Existing Condition Evaluation

- As-built drawings
- Building envelope assessment
- MEP assessment

## 2 Schematic Design Package

- Energy model optimization for design specification
- Envelope vs. equipment selection

## 3 Identify Auxiliary Funding Sources

- CA LIWP Assessment



# Unexpected Issues & Lessons Learned

- 1 WSHP selection, refrigerant regulation, and OEM transition plans and timelines
- 2 UL certification
- 3 Component selection & product footprint
- 4 Product capacity sizing vs. demonstration building load





# Future Work

- 1 Finalize pod development & testing
- 2 Demonstration schematic design, pricing & financing
- 3 Demonstration permit set & installation
- 4 T2M: Scaling mechanism for pod manufacturing
- 5 Portfolio analysis & demand aggregation

# Thank you

RMI

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DE-EE0009064



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# Reference Slides





# Project Execution

	FY2022				FY2023				FY2024				FY2025				FY2026				FY2027			
Planned budget	\$2,133,111																\$3,573,631				\$543,947			
Spent budget																	n/a				n/a			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4												
Past Work																								
M 0.1.1: IPMP and COI																								
M 1.0.1: Draft T2M Plan																								
Current/Future Work																								
M 1.0.2: Final T2M Plan																								
M 1.1.1: System Performance Report																								
M 1.2.1: IOM Manual																								
M 1.3.1: UL/ETL Certification Report																								
M 1.4.1: Printed Circuit Boards Design																								
M 2.1.2 Create Wireframe Model for MA																								
M 2.1.2: Comparative Report																								
M 2.2.1: Wall Panel and IMSP-C Integration																								



# Project Execution

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	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Current/Future Work																								
M 3.1.1: Existing Conditions for MA																								
M 3.1.2: Existing Conditions for CA																								
M 3.1.3: Preliminary BOM for LCA																								
M 3.2.1: Conceptual Design for MA																								
M 3.3.1: Test Plan for MA																								
M 3.3.2: Test Plan for CA																								
M 3.4.1: MA Schematic Design																								
M 3.4.2: CA Schematic Design																								
M 3.5.1: Complete Pricing Exercise																								
M 3.5.2: Funding Strategy																								
Go/No-Go Decision Points																								

- M 3.1.2: Additional site visits had to be scheduled to confirm kitchen exhaust duct routing, which caused some delay in finalizing the Existing Conditions Report for CA site.
- M 3.3.1 & 3.2.2: The original scheduled didn't plan for the fact the test plans depend on a good understanding of the existing conditions of the buildings and there weren't any existing drawings available, so the test plans have been delayed to after a thorough existing conditions evaluation has been completed.





# Project Execution

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Current/Future Work																								
M 4.1.1: Final Design Drawings																		◆						
M 4.1.2: Final BOM																		◆						
M 4.1.3: Pre-retrofit Monitoring Data																		◆						
M 4.2.1: MA Demo Units Fabrication																		◆						
M 4.2.2: MA Demo Units Fabrication																		◆						
M 4.3.1: Complete MA Demonstration																				◆				
M 4.3.2: Complete CA Demonstration																				◆				
Go/No-Go Decision Points																				◆				














# Project Execution

	FY2022				FY2023				FY2024				FY2025				FY2026				FY2027							
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	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4				
Current/Future Work																												
M 5.1.1: MA Evaluation Report																									▶			
M 5.1.2: CA Evaluation Report																									▶			
M 5.1.3: Field Validation for IMSP																									▶			
M 5.1.4: Report data for DCP																									▶			
M 6.1.1: Publish lessons learned																									▶			
M 6.1.2: Hold one workshop																									▶			
M 6.1.3: Apply project screening to OME's portfolio																									▶			
M 7.1.1: Draft Technical Report																									▶			
M 7.1.2: Final Technical Report																									▶			
M 7.2.1: Updated T2M																									▶			

# Team



Prime		RMI	Project management, project oversight
Integrated Mechanical System Pod (IMSP)	   	TKF	Manufacturing, Commercialization
		Staengl	Design & Engineering + MA/CA MEP design engineer
		Morben	Controls, User Interface
		OTS	Lab Testing, Field Validation
Envelope Panel	 	OME	Design team coordination, contracting
		Signetron	Scanning to BIM/CAD/CAM
		TBD	Panel Manufacturer, IMSP & Panel Integration
Finance and Project Delivery	  	OME	Demonstration lead, Market scaling
		RDA	MA demonstration design team
		DBA	CA demonstration design team
M&V		LBNL	Whole building retrofit M&V