



DE-EE0009064

Integrated Mechanical System Pods (IMSPs)

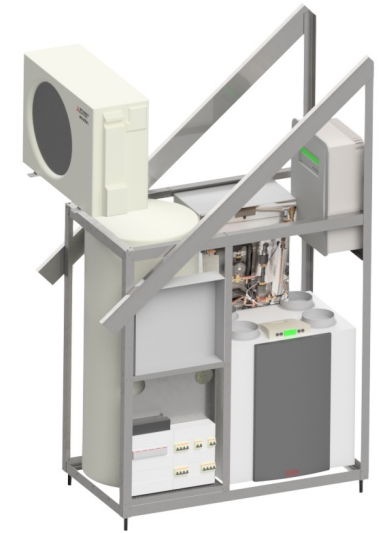
Phius Presentation October 2022

Brett Webster, Galen Staengl

Project Background

The business-as-usual approach to deep energy retrofits of multifamily buildings is **time-consuming, disruptive, bespoke, and costly**, resulting in low retrofit rates ($\sim 1\%/yr$), unrealized energy savings, and poor indoor living environments.

Prefabricated building envelope and packaged, multifunction mechanical system solutions represent an integrated retrofit package that could help unlock \$4.3 billion of annual energy savings in the multifamily sector just in ASHRAE climate zones 3, 4, and 5.



Research Questions

- What are the integrated mechanical system prototypes that can best serve the market needs for targeted multifamily building typologies?
- What design and manufacturing approaches will allow these prototypes to commercialize and scale up quickly, adapt to a variety of existing conditions, easily integrate evolving technologies, and achieve cost compression necessary for widespread adoption?

Project Goals

Value Proposition

- Easy to install – supports occupied retrofits
- Better occupant comfort
- Improved indoor air quality
- Opportunity for integration with panelized envelope systems
- Opportunity for cost compression at scale

IMSP-C

- Designed for applications in buildings with central HVAC and DHW systems
- Targeting NE Midrise MF Building Typology

IMSP-U

- Designed for applications where HVAC and DHW equipment is located in individual apartments
- Targeting CA Lowrise MF Building Typology

Both prototypes will be

- all electric
- assembled with off-the-shelf components
- designed to be deployed in low-load applications driven by corresponding envelope improvements or mild climates

Project Team Roles



RMI: Prime, management of grant and overall project strategy and vision



Staengl Engineering: Prototype design



TKF: Prototype fabrication, commercialization plan



SCOE: Prototype testing



LBNL: Ventilation design advisor, test plan peer review



AEA: CA typology & field advising

Phase 1 Accomplishments

- **Product Requirements**
- **Prototype Detailed Designs**
- **Building Conceptual Designs**
- **Controls Package**
- **Prototype Fabrication**
- **Testing**
- **Market Analysis and Commercialization Plan**

Completed Prototypes!



RMI – Energy. Transformed.

IMSP-C



IMSP-U

IMSP-C

BUILDING TYPOLOGIES - NE MIDRISE

Typical mechanical systems for identified prototypical buildings

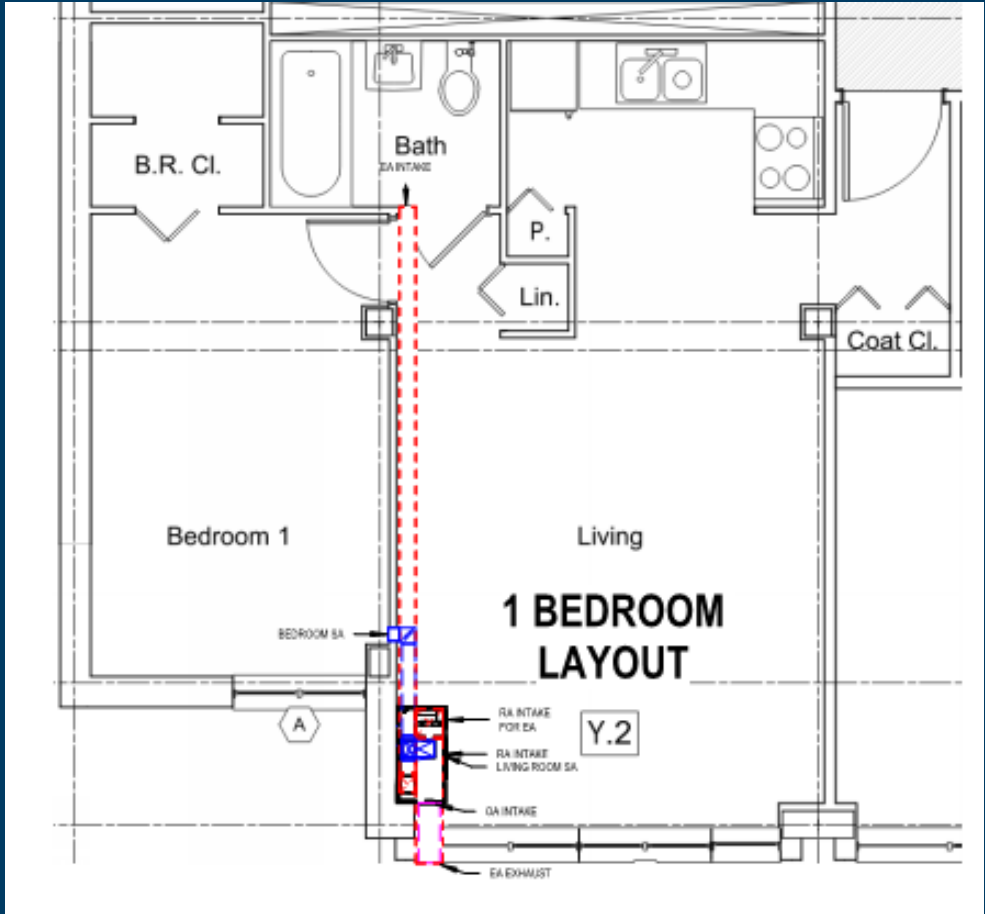
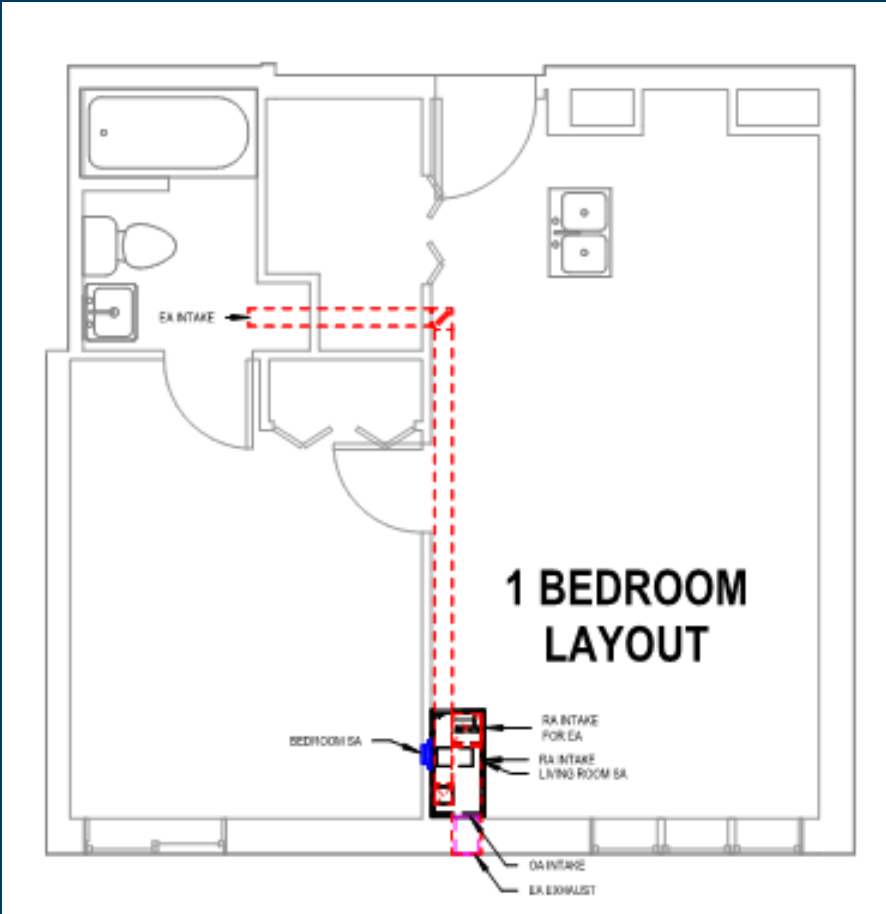
System	#1	#2
# Units Represented	1,429,380	569,540
% Units Represented	20.7%	8.3%
Heating System	Steam or hot water system with radiators or pipes	Central furnace
Heating Fuel	Piped NG	Piped NG
Cooling System	Room AC	Central AC
Water Heater in Apt?	No	Yes

Source: RECS - New England, Mid-Atlantic, East North Central

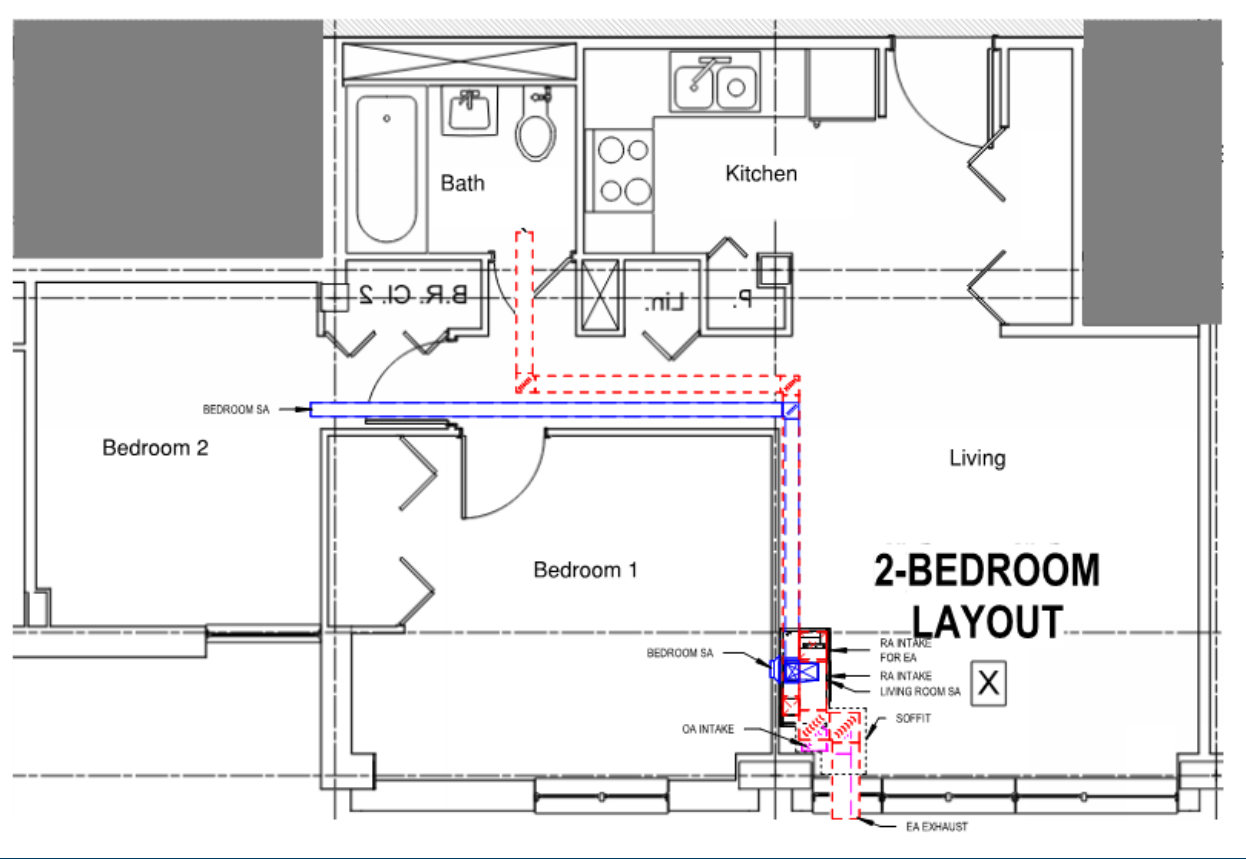
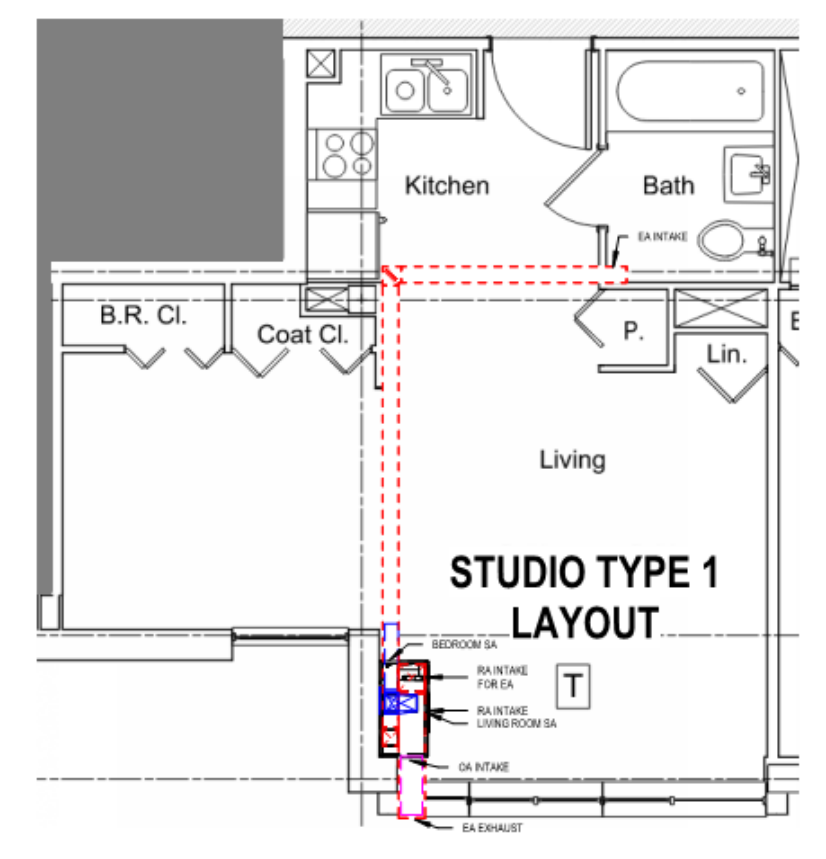
System	NYC		Boston	
	20-49 units	50+ units	20-49 units	50+ units
Heating System	<ul style="list-style-type: none"> 30% Furnace 60% Steam/hot water 	<ul style="list-style-type: none"> 35% Furnace 49% Steam/hot water 	<ul style="list-style-type: none"> 46% Furnace 30% Steam/hot water 	<ul style="list-style-type: none"> 59% Furnace 17% Steam/hot water
Cooling System	<ul style="list-style-type: none"> 16% Central AC 84% Room AC 	<ul style="list-style-type: none"> 31% Central AC 69% Room AC 	<ul style="list-style-type: none"> 43% Central AC 57% Room AC 	<ul style="list-style-type: none"> 69% Central AC 31% Room AC

Source: AHS

IMSP-C 1-bd Apartment Layouts



IMSP-C Studio, 2-bd Apartment Layouts



IMSP-U

BUILDING TYPOLOGIES – CA LOWRISE



Townhouse

762,018 Units

- 5-9 Units, 2 Stories: 70%
- Pre-1980: 60%
- 80s-90s: 30%
- Modern: 10%



Garden Style

647,511 Units

- 10-19 Units, 2 Stories: 70%
- Pre-1980: 60%
- 80s-90s: 30%
- Modern: 10%



Loaded Corridor

629,470 Units

- 20-49 Units, 2-3 Stories: 79%
- Pre-1980: 62%
- 80s-90s: 27%
- Modern: 11%

Heating System	<ul style="list-style-type: none"> • Natural gas gravity wall furnace • Central gas forced air furnace 	<ul style="list-style-type: none"> • Natural gas gravity wall furnace • Central gas forced air furnace 	<ul style="list-style-type: none"> • Natural gas gravity wall furnace (rarer) • Electric Resistance Wall Heater/Baseboard • Central Steam/Hydronic Boiler w/ radiator
Cooling System	<ul style="list-style-type: none"> • No cooling • In-unit system 	<ul style="list-style-type: none"> • No cooling • In-unit system 	<ul style="list-style-type: none"> • No cooling • In-unit system
DHW System	<ul style="list-style-type: none"> • In-unit non-condensing tank 	<ul style="list-style-type: none"> • In-unit/central non-condensing tank • Central boiler 	<ul style="list-style-type: none"> • Central non-condensing tank • Central boiler

* Data availability statewide was limited and this data is skewed towards Central Valley and Bay Area building types

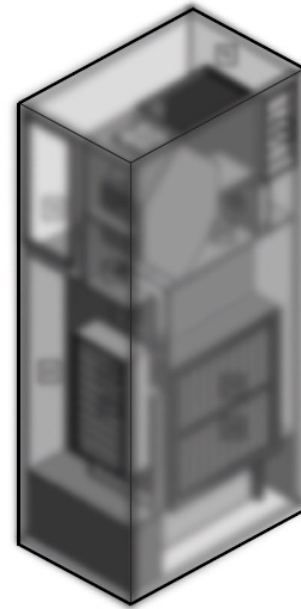
IMSP-U Prototype

EPC 19-032 LG-MM Concept

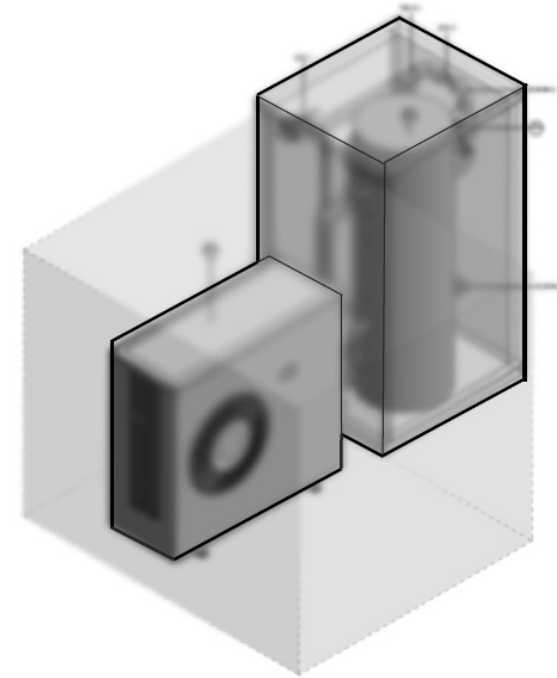


All-in-one Unit

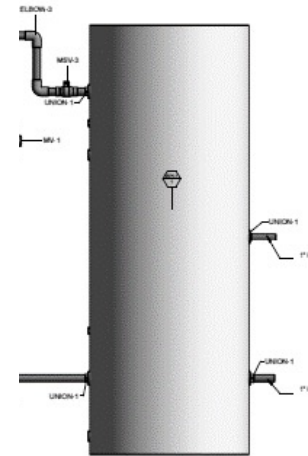
IMSP-U "Split Pod" Concept



Indoor Unit



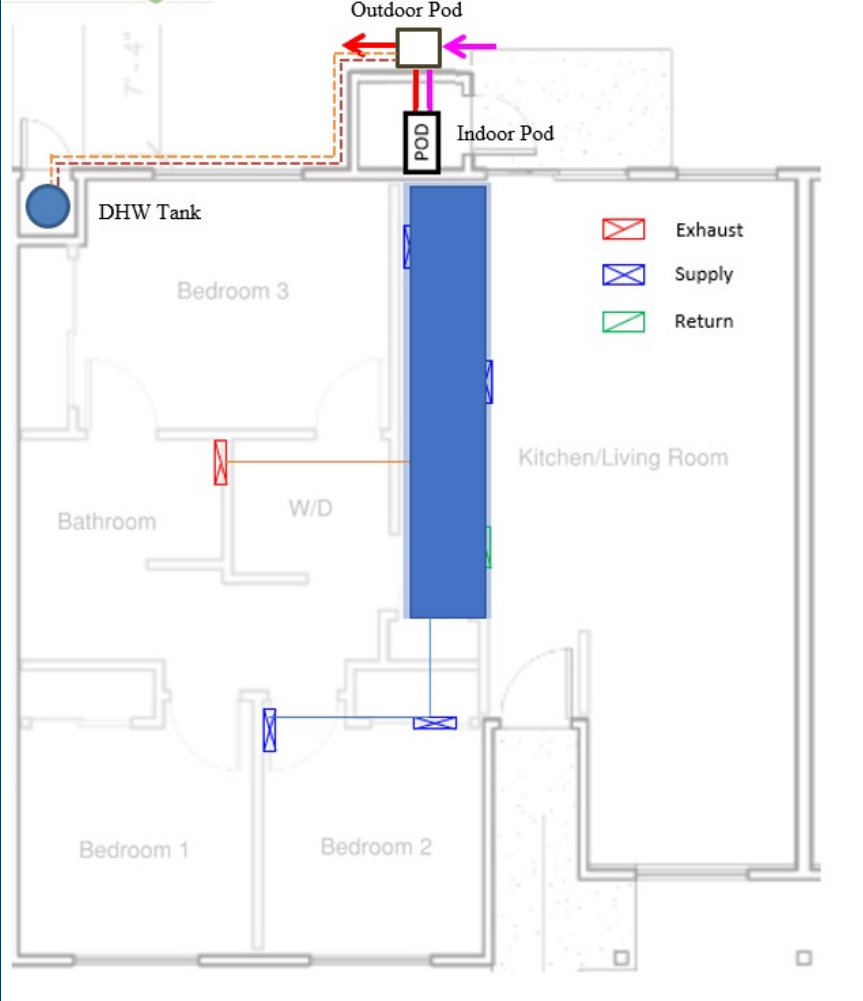
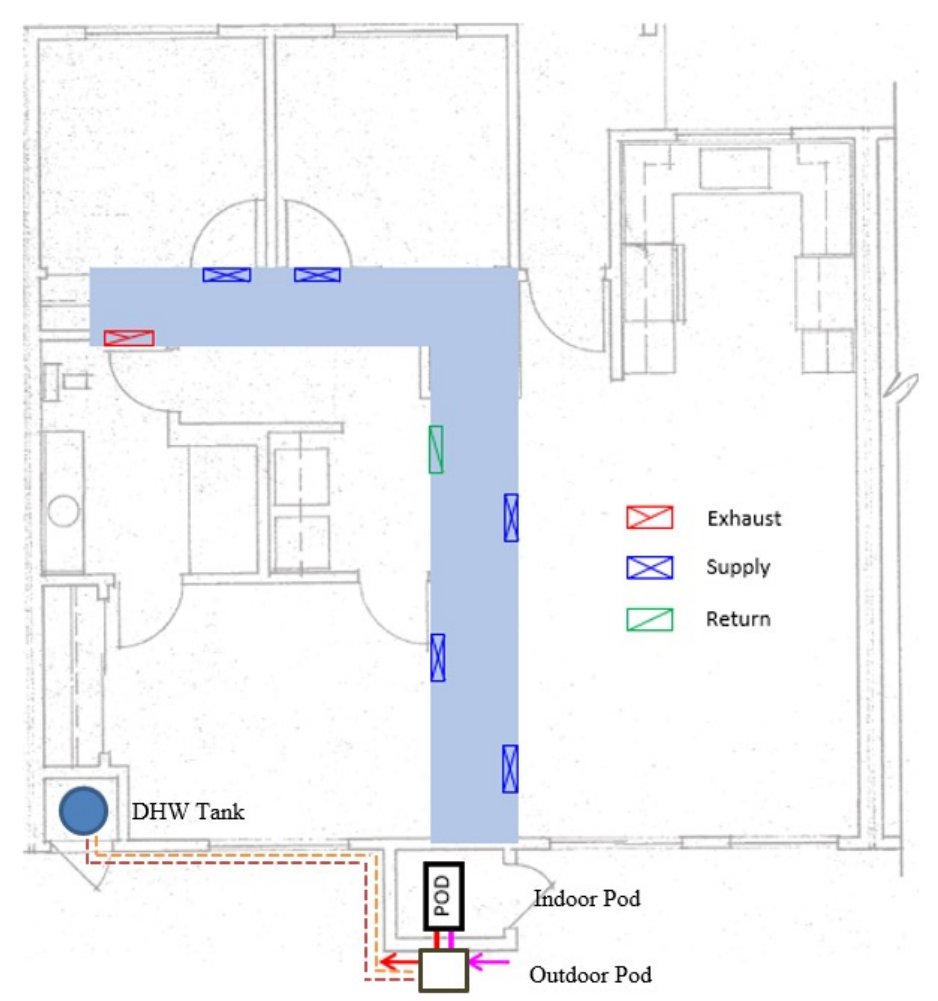
Outdoor Unit



DHW

ERV | Heating/Cooling | Economizer | Fire smoke mode | DHW | Demand flex | Requires 1-2, 240V and 1 120V electrical connections

IMSP-U Apartment Layouts



Distribution Duct Concept – both products



- Phenolic ductwork with finish face (paintable) could eliminate the need for site-built soffits.
- Lightweight and insulated
- Easy to assemble on-site
- Multiple air pathways within one duct



Test Setup

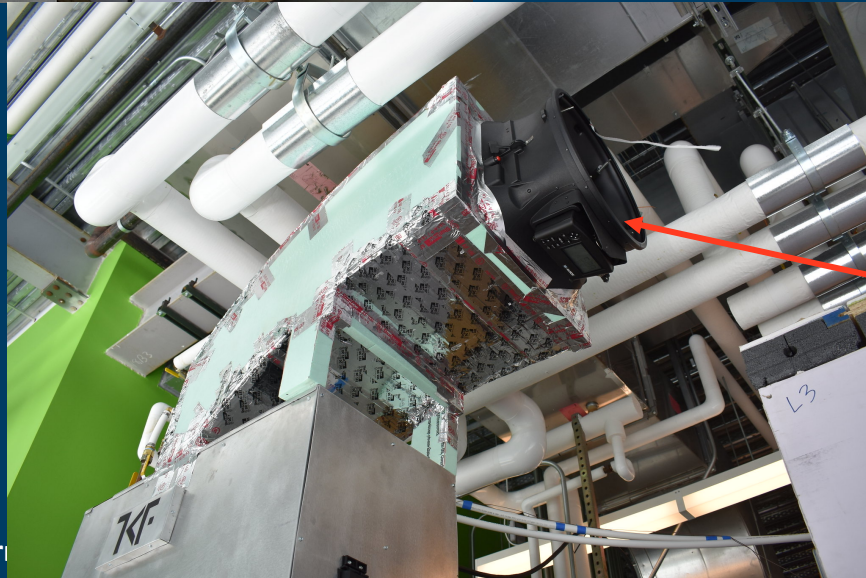


"Outdoor"
Chamber



Power Monitoring and
Test Controls

Pod Water
Supply



Airflow and
Capacity
Measurements



Strategic Pivot

Team decision to prioritize **IMSP-C** for demonstration and commercialization efforts moving forward. Primary factors driving this decision:

- **First costs**
- **Energy efficiency advantage**
- **Path to market**
- **Applicability of IMSP-C in both target geographies**

BUILDING TYPOLOGIES – CA LOWRISE



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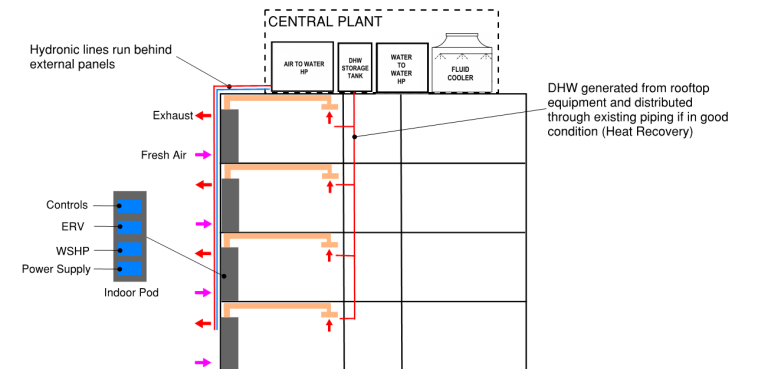
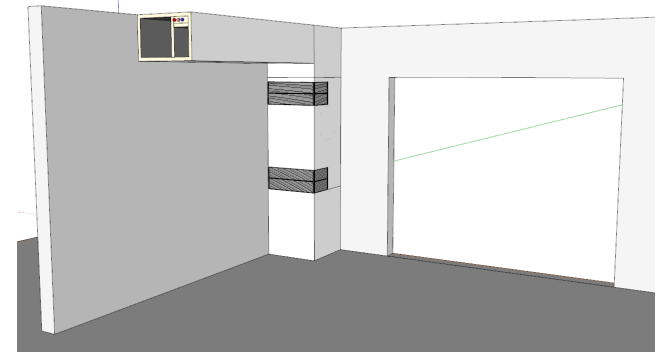
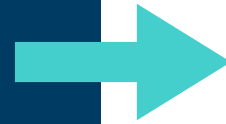
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IMSP-C Retrofit Package





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

ABC Phase 2

Phase 1 Integration

9064

Integrated Mechanical System Pods



IMSP-C, Central Plant Concepts,
Prefabricated Ductwork

9062

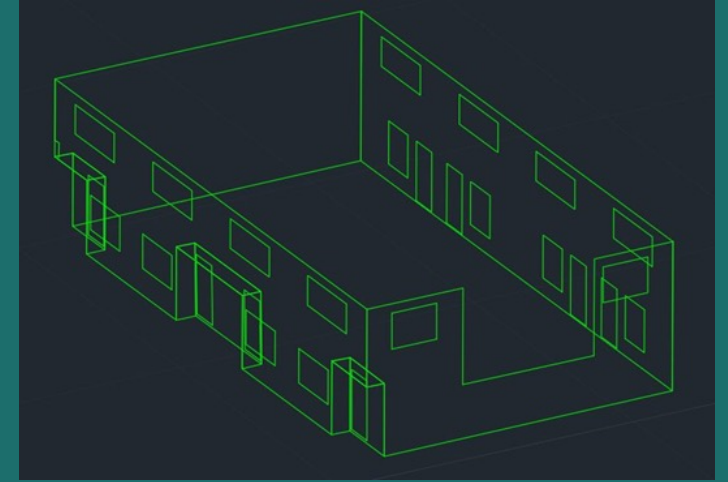
Transforming Public Housing with
Deep Energy Retrofits



Integrated design and engineering,
standardized solution, prefabricated
panel, financing mechanism

9067

Streamlining BIM/CAD/CAM
Conversions for Panel Manufacturing



Improve scan to panel manufacturing
workflow, 3D scanning to wireframe
model creation



RMI
Prime, Project Manager

Integrated Mechanical System Pod (IMSP)

TKFabricate

TKF Manufacturing, Commercialization

Staengl Engineering

STAENGL ENGINEERING  Design & Engineering

Morben


M Controls, User Interface

Optimized Thermal Systems

 Lab Testing, Field Validation

Envelope Panel

Open Market ESCO

 **OpenMarket ESCO** Panel coordination with design team, contracting, digital workflow demonstration

Signetron


 Scanning to BIM/CAD/CAM

Panel Manufacturer

IMSP & Panel Integration

Finance and Project Delivery

Open Market ESCO

 **OpenMarket ESCO** Demonstration lead. Whole building retrofit design, financing and construction activities. Market scaling.

M&V

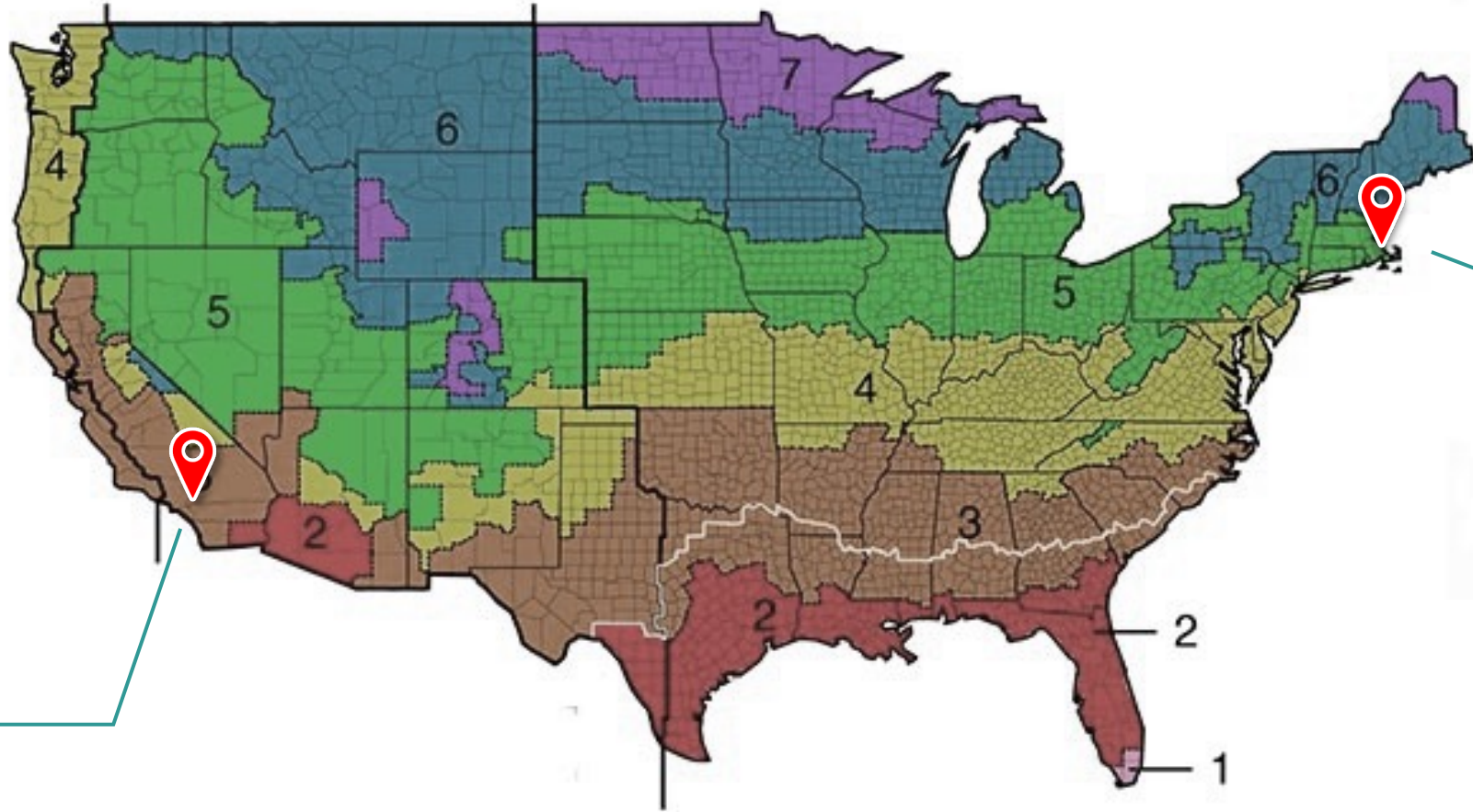
Lawrence Berkeley National Lab



Whole building retrofit M&V

Demonstrations

Demonstration Sites: 100% Low-Income Housing



Elizabeth Court
5227 Elizabeth Street
Cudahy, California



Walden Square Apartments
21 Walden Square Road
Cambridge, Massachusetts

MA Demonstration: Walden Square Apartments



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

Envelope

Min. Wall Insulation
30+ y/o windows

DHW

Central Condensing
Gas Boilers

Heating

Condensing Gas
Boiler Plant with
Hydronic Baseboard

Cooling

Window ACs

MA Demonstration Retrofit Package

Envelope

Scanning to BIM/CAD/CAM workflow

Prefabricated unitized retrofit panel

Mechanical

IMSP-C & Whalen Whispertherm

(Partial) Central plant upgrade

Prefabricated ductwork

REALIZE-MA & Building America 8185 Industrialized Retrofit Envelope Specs

Passive Measures	ASHRAE CZ 5A	ASHRAE CZ 4A
Wall R-value	R-32	R-27
Roof R-value	R-41	R-39
Basement/Ceiling R-value	R-22	R-13
Infiltration (cfm50 per sqft wall area)	0.08	0.08
Window	Whole window U-0.26, SHGC 0.41	Whole window U-0.26, SHGC 0.38

CA Demonstration: Elizabeth Court



- 13 units, 2 stories
- 100% low-income rental housing
- Owned by Corporation for Better Housing (CBH)
- Managed by WinnCompanies

Envelope

Min. Wall Insulation
Single Pane Windows

DHW

Central Gas Boiler
Plant

Heating

Individual Furnaces

Cooling

Window ACs

CA Demonstration Retrofit Package

Envelope

New Roof + insulation

High performance windows

Air sealing

Mechanical

IMSP-C

Prefabricated ductwork

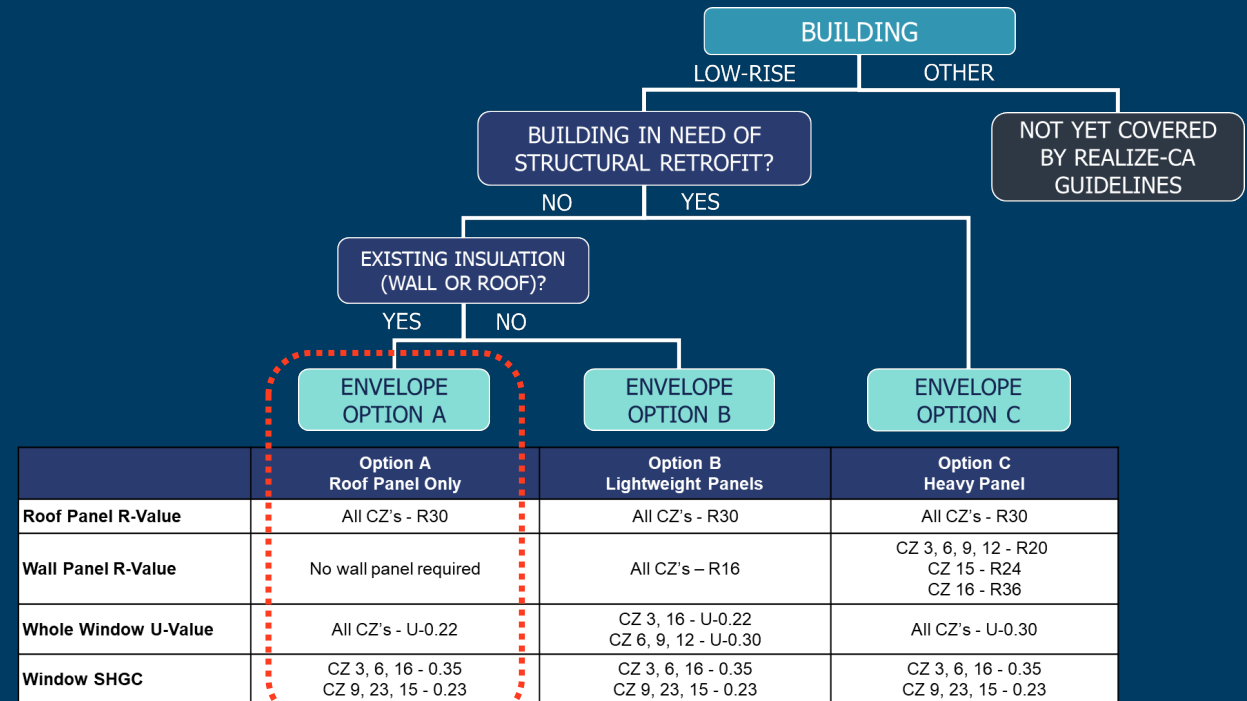
New central plant + new piping distribution

GEBs

Thermal storage for demand flex

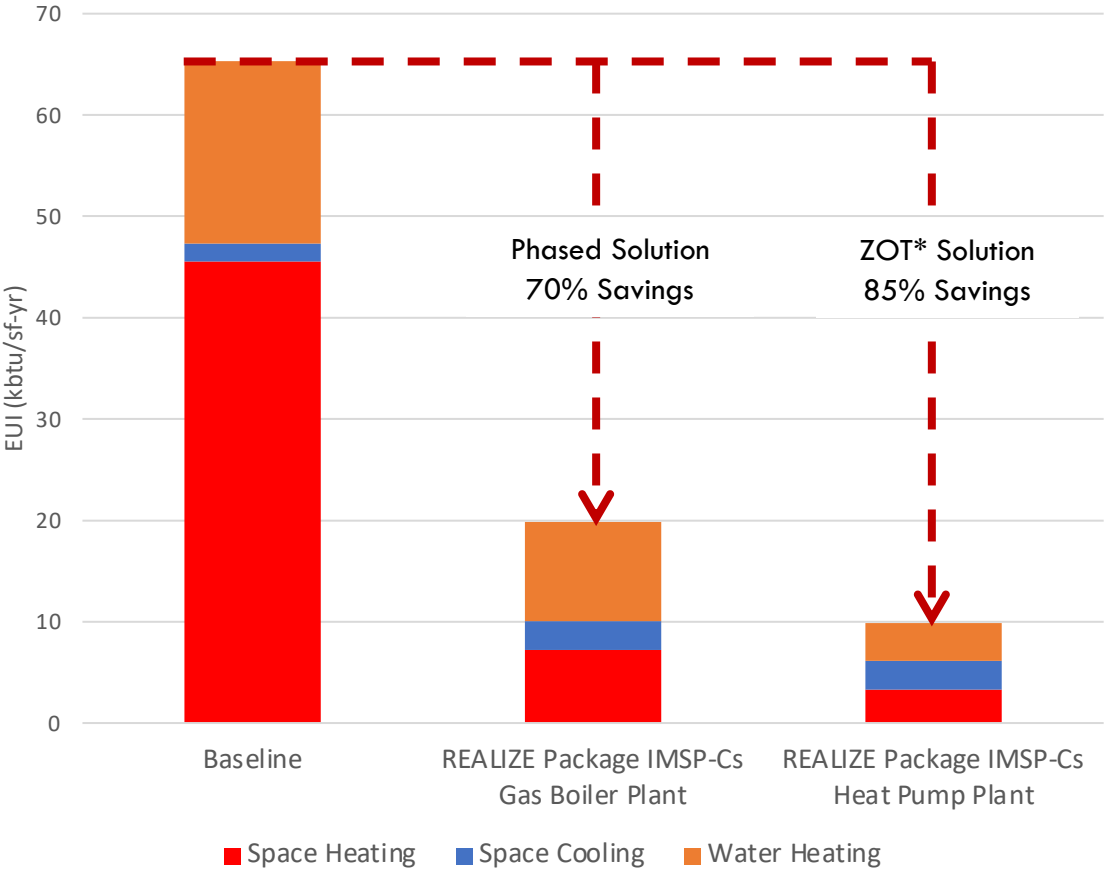
Solar PV

REALIZE-CA Retrofit Guidelines

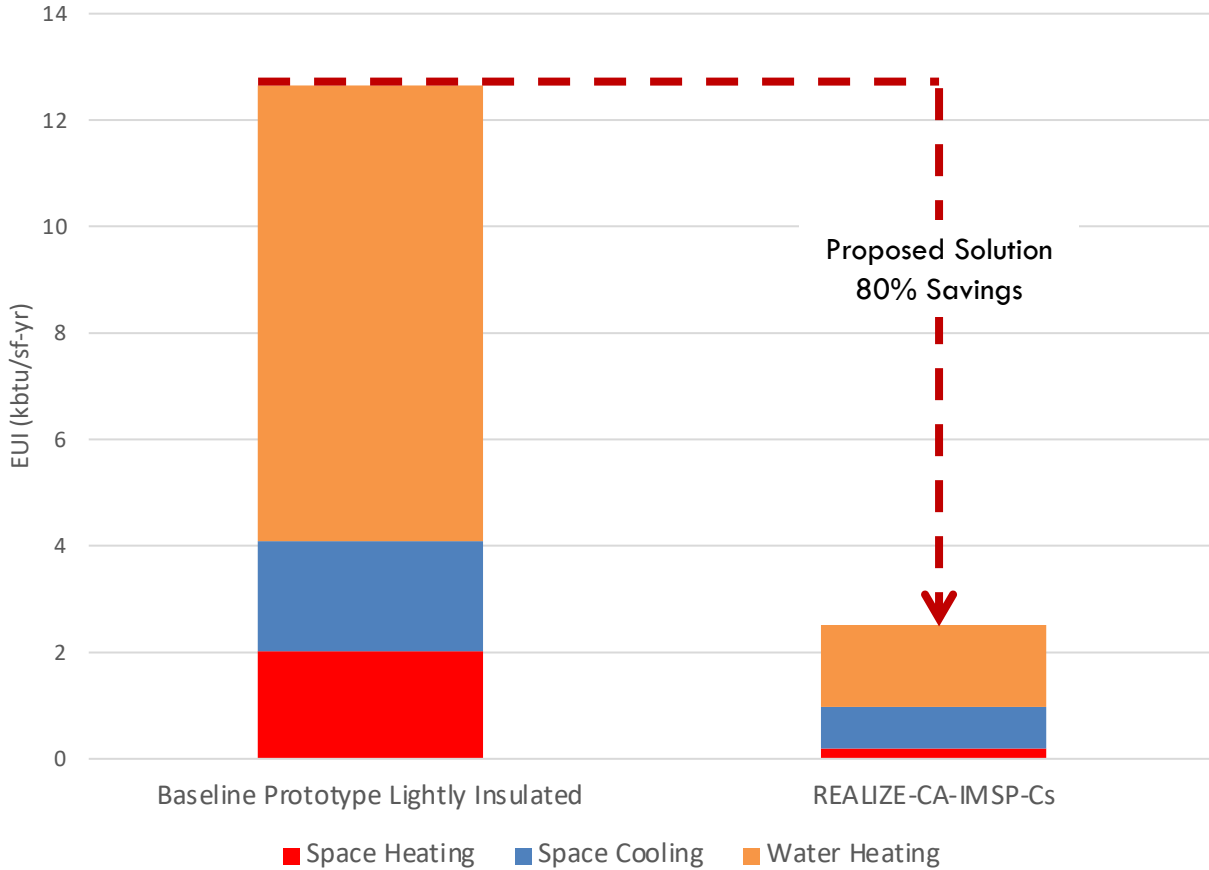


Achieving ABC Energy Saving Target

MA Demonstration Prototype



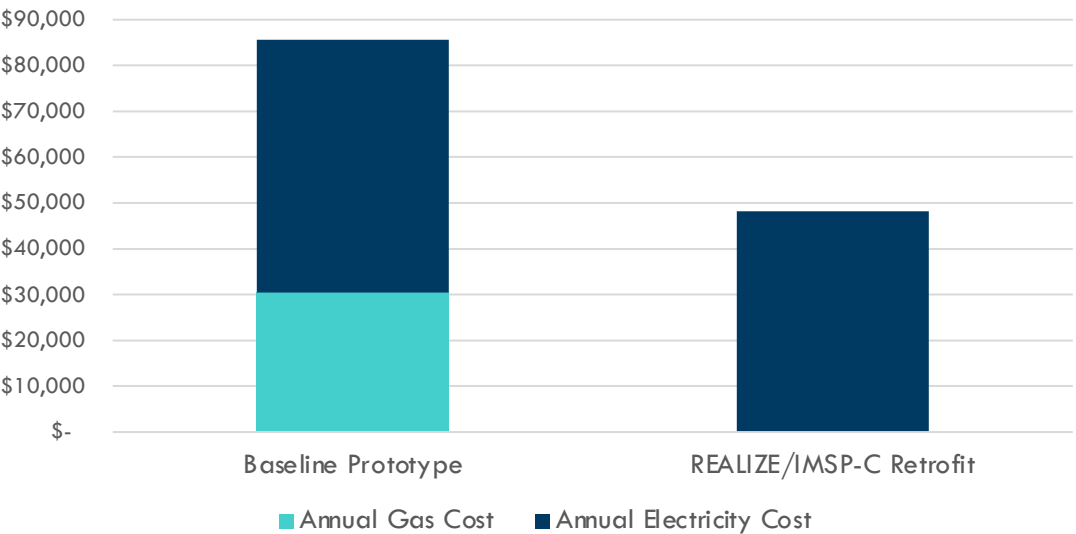
CA Demonstration Prototype



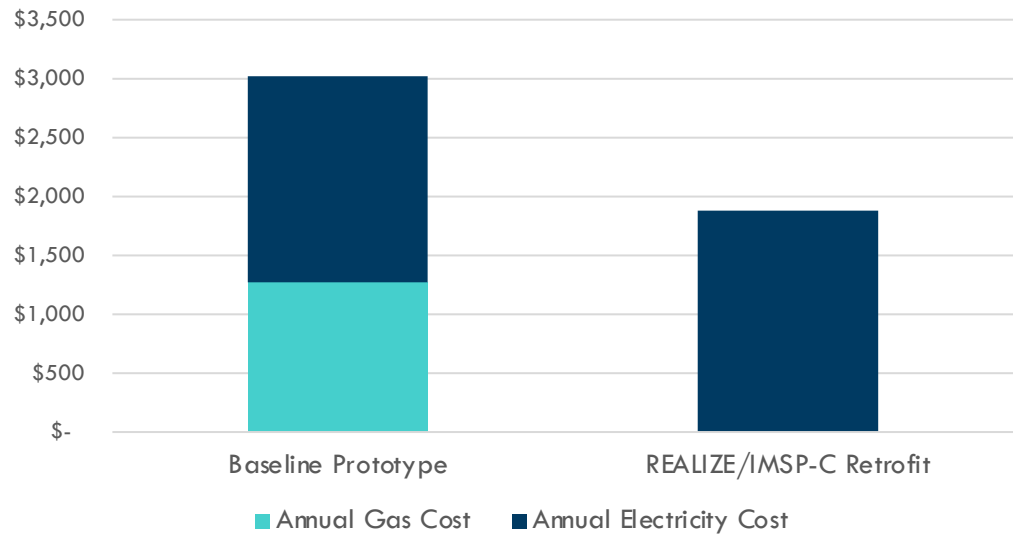
* Zero Over Time (ZOT): A phased decarbonization approach that optimizes retrofit investments at key trigger events in a building’s lifecycle.

Operational Cost Savings

MA – 43% Savings



CA – 37% Savings



Finished Product

