# REALIZE-CA Design & Installation Guide

Produced by Association for Energy Affordability, RMI, Integral Group, David Baker Architects, and UC Davis

March 2024

# Contents

# Acknowledgements

First and foremost, RMI would like to thank the California Energy Commission (CEC) for its unwavering support and guidance throughout the REALIZE-CA program. Together, we retrofitted over 300,000 square feet of multifamily affordable housing throughout California, developing a standardized approach to scaling building decarbonization and improving the lives of low-income ratepayers statewide.

In addition, RMI would like to thank the tenants and building owners at each pilot demonstration for their trust and patience during the program. Pilot demonstrations present unique challenges, and without committment from each community our work would not have been possible.

And last but certainly not least, RMI would like to thank our wonderful project partners for their invaluable contributions and perseverance over the years:

- Association for Energy Affordability
- David Baker Architects
- RDH Building Science
- UC Davis — Western Cooling Efficiency Center

# Overview

# Introduction

This guide summarizes a recommended set of technologies to be combined and applied to a common existing multifamily building type across California. Technologies in this retrofit package were selected based on learnings from pilot demonstrations funded by California Energy Commission awards *EPIC 17-040: Mass Deployment of Energy Efficiency Retrofits in Multifamily homes in California* (also referred to as REALIZE-CA) and *EPIC 19-036: Varieties of Prefabricated Envelope Solutions for CA Low-Rise Buildings*. For each technology, the guide includes a detailed description of design recommendations and installation guidelines based on lessons learned across demonstrations:

- Corona del Rey Apartments – 1148 D St, Corona, CA 92882
- Vera Cruz Village Apartments – 631 Rd 210, Richgrove, CA 93261
- King's View Manor – 949 E. Annadale Ave, Fresno, CA 93706
- Light Tree Apartments – 1804 E. Bayshore Rd #100, East Palo Alto, CA 94303

The guide also includes financing recommendations driven by incentive opportunities for affordable multifamily housing through the federal Inflation Reduction Act, including gap financing options where incentives are not adequate to cover total project costs.

The REALIZE-CA retrofit package encompasses innovative building systems that reduce demand and can be paired with on-site renewable generation (e.g., solar panels).

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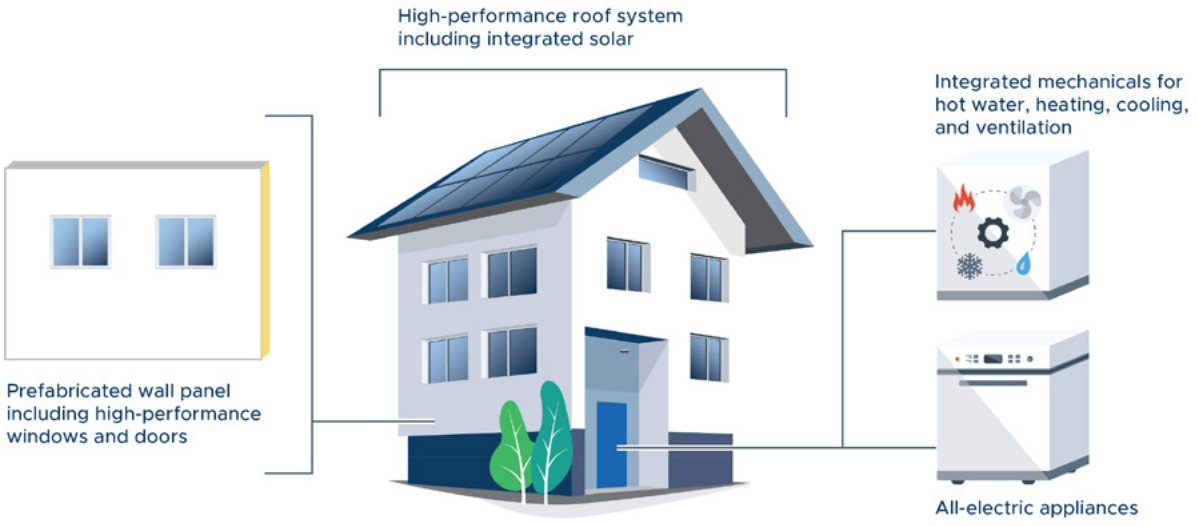
Exhibit 1 **REALIZE-CA Retrofit Package Measures**



As shown in Exhibit 1, package measures can include some combination of envelope, HVAC, domestic hot water, lighting, and appliance replacement with (optional) renewable energy technologies. REALIZE also focuses on value-chain and process innovation and seeks to support delivery models that create supply chain efficiencies and more seamless installation.

REALIZE-CA retrofit package guidelines are thus intended to pair buildings with specific characteristics with technologies that are commercially available and scalable today. Promising emerging technologies deployed in REALIZE-CA demonstrations that were not selected for the package should be considered in future pilot demonstrations and will be outlined in the REALIZE-CA final report.

To date, multifamily retrofit projects have proven costly and difficult to deploy efficiently. REALIZE, an RMI initiative and the parent initiative of REALIZE-CA, has been working to change this since 2016. Specifically, REALIZE-CA has focused on mass deployment of zero-carbon-aligned retrofits for affordable multifamily housing in California. Taking a programmatic approach, REALIZE-CA leverages retrofit package standardization and streamlined financing solutions to aggregate demand. Since its inception, REALIZE-CA has:

1. Conducted 300,000 square feet of retrofit demonstration projects, and,
2. Designed a scalable multifamily retrofit program, informed by our demonstration data.

The REALIZE-CA retrofit package is comprised of commercially available components and is ready to be deployed in decarbonization programs statewide. An overview of desirable building characteristics for the

Exhibit 2 **REALIZE-CA Building Selection Criteria**

| Location | Priority project areas/regions with greatest number of multifamily affordable units (Central Valley, Southern California, Bay Area) |
|---|---|
| Owner Portfolio Size | 3-5+ sites |
| Affordability | Serving 30%–80% AMI |
| Vintage | Any |
| Historic status | Listed historic buildings are not eligible. |
| Stories | 1 or 2 stories only |
| Structure | Conventional wood framing |
| Exterior wall | Insulated or uninsulated |
| Cladding | Any |
| Attic | Attic only. Flat-roof solutions are not eligible. |
| Roof | Any |
| Windows | Any |
| Electrical Capacity | Buildings without adequate electrical capacity are not eligible. |
| Heating System | Any (ducted or packaged, gas or electric) |
| Cooling System | Buildings without existing air conditioning are not eligible. |
| Hot Water System | Unitized only. Central water heating is not eligible. |
| Appliances & Fixtures | Any |

## Existing Conditions

Deterioration including plumbing failures, structural deficiencies, and hazardous materials that would preclude the work or constitute active life safety hazards for occupants must be addressed by the owner to be eligible. Unless funded as part of the owner's scope in a planned capital improvement/rehabilitation, the following criteria would render a prospective building ineligible:

Exhibit 2 **REALIZE-CA Existing Building Conditions**

| | |
|---|---|
| Plumbing failures | Major capital repairs (e.g., significant active leaks) must be resolved prior to package installation. |
| Structural failures | Major capital repairs must be resolved prior to package installation. |
| Mold, organic growth | If mold/organic growth is present at the site, the building owner proposed scope of work must be sufficient to resolve the issue (e.g., insufficient bathroom ventilation vs. a significant waterproofing issue). |
| Asbestos, lead | The standard retrofit is designed not to significantly disturb surfaces that may be contaminated with lead or asbestos, so the presence of these materials must be disclosed, as it will impact eligibility. |
| Stucco condition | Existing stucco must not show signs of significant bubbling or cracking, or other evidence of wall waterproofing failure. |
| Firewalls | Fire separation between units must be intact. |
| Electrical | Knob and tube wiring or other recalled electrical products must be replaced by the building owner. |
| Duct condition | Ductwork must be accessible and sealable, or in good condition. Asbestos on ductwork must be accessible for remediation or removal. |

# Eligibility Screening Process

The REALIZE-CA program intends to support delivery of the specified package through REALIZE-CA partner, Association for Energy Affordability. Other solution providers are also highly encouraged to deploy the recommended package as well. The following encompasses our project intake recommendations and plan.

## Initial screening

To enroll, a building owner will complete an initial screening through our anticipated web-based application confirming their building(s) meets core eligibility criteria. The project team will request any recent property needs assessments and building drawings (if available). The project team will also ask for utility bills to analyze historic consumption, as well as review AB802 whole building, aggregated energy information to identify property-wide trends. The project team will review this information with the building owner and discuss project feasibility and requirements, and any other required commitments before advancing to project scoping.

## Field audit

Once the building passes an initial screening, the building owner will be enrolled and scheduled for a field audit, the results of which will confirm the final retrofit package components, including appropriate HVAC and envelope upgrades. The field audit will identify existing conditions, including but not limited to space conditioning equipment and distribution systems, water heating equipment and hot water distribution systems, envelope, lighting, and appliances. Specifically, the field audit will confirm:

- Window type and condition
- Stucco and attic insulation condition
- Space constraints and available locations for new equipment
- HVAC and hot water equipment types and condition
- Duct condition (whether they are accessible for replacement, sealable, or in good condition)
- Electrical distribution panel and sub-panel capacity

## Technical Assistance

Contractor and building owner technical assistance is recommended for REALIZE-CA retrofits as a critical component of package deployment. By standardizing the retrofit package, bulk pricing and economies of scale can help control contractor markups, as well as develop book pricing for common ancillary installation items (e.g., pipes, valves, fittings, wiring, conduit, junction boxes, etc.).

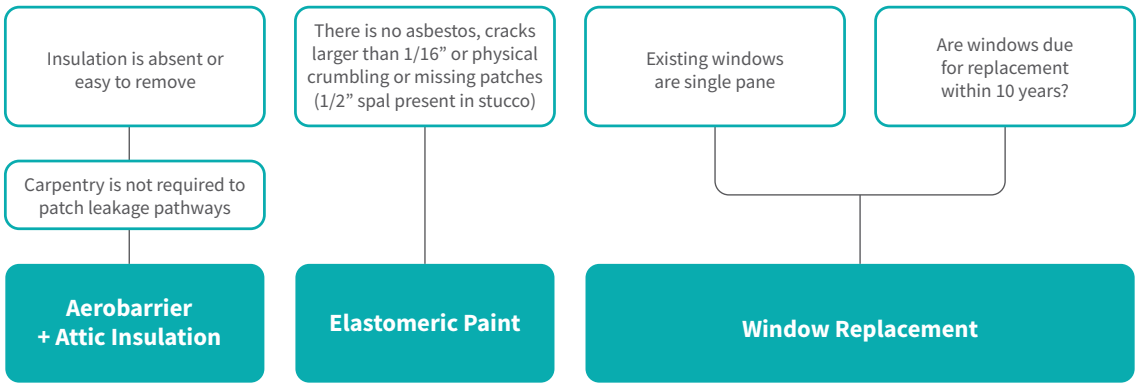
In addition, the project team recommends the inclusion of contractor and building owner support services. For contractors, these services include, but are not limited to, assistance accessing incentives, developing comprehensive scopes of work, and meeting compliance and reporting requirements. For multifamily building/portfolio owners, these services include but are not limited to, analysis of contractor bids in accordance with preferred vendor costs and services, as well as contract negotiation and execution.

# Retrofit Package

## Envelope

In most cases, the retrofit package will include new windows and attic sealing and insulation, depending on existing conditions, as described in the envelope measure decision tree in Exhibit 4. For stucco walls in good condition, an elastomeric sealant may be added to the package for added durability. Overcladding solutions including insulated roof and wall panels are not included in the REALIZE-CA retrofit package but represent promising technologies for future research and development.

Exhibit 4 **Envelope Measure Decision Tree**




## Windows

### *Product Description and Performance Specifications*

Like the current standard weatherization upgrade, the typical retrofit candidate will have existing single-paned windows, often sliding windows, that are to be replaced with double-paned windows meeting Title 24 performance specifications. An upgrade to a higher-performing triple or thin-triple-paned window was determined to have diminishing returns relative to the incremental cost above the current code minimum requirements. However, the REALIZE-CA retrofit package includes a higher-performing installation detail than current practice, along with expanded performance criteria to increase quality and resilience, as outlined in Exhibit 5.

Exhibit 5 **Window Performance Specifications**

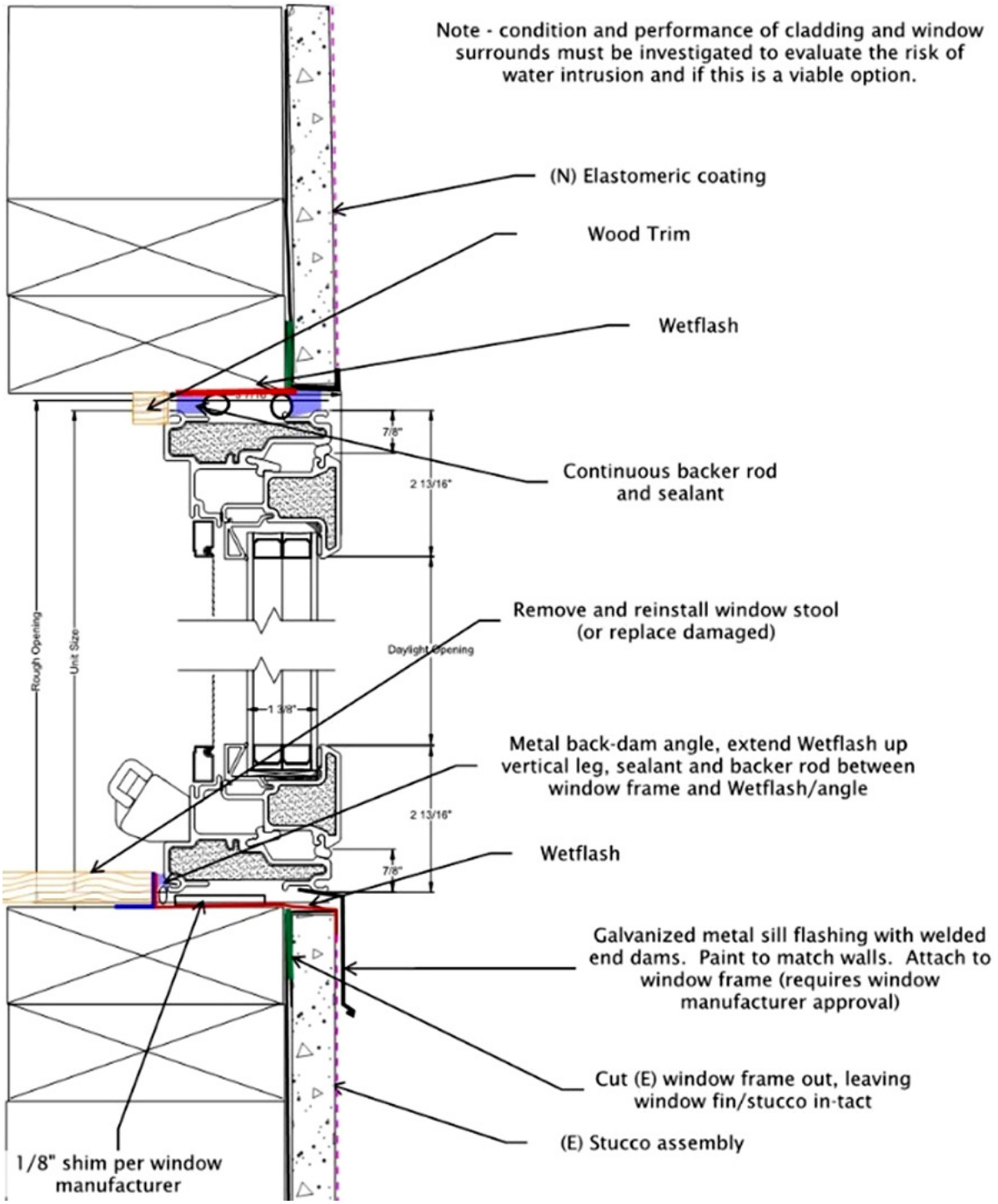
| Metric | |
|---|---|
| U-value | 0.29 maximum |
| Solar Heat gain Coefficient | 0.25 maximum |
| Visual Light Transmittance (VLT) | 50% minimum |
| Sound Transmission Coefficient (STC) | 31 minimum |
| Frame construction (AMMA rating) | AMMA 101 LC25 |
| ENERGY STAR rated | Yes |
| ADA-compliant hardware | Yes |
| Warranty | 10-year minimum |

### *Installation*

A REALIZE-CA retrofit package window replacement improves upon the standard window replacement detail which comes with increased risk of air and water intrusion and ultimate wall damage. Instead of adhering the window flange to the outside face of stucco, the replacement window will be installed as a box frame (without a flange) and sealed around the inside and outside to the rough opening, with head flashing.

This installation detail requires some degree of training, including a “first in place” mock-up and review by a waterproofing consultant for first-time installers.

Exhibit 6 **Box Frame Window Detail (No Flange)**



### *Availability and Commercialization*

The performance criteria listed in *Exhibit 5: Window Performance Specifications* are standard in commercially available sliding, single-hung, or casement configuration (assuming typical residential window sizes) from manufacturers currently offering retrofit windows.

### *Environmental Impact*

Vinyl is chosen as the presumed frame material due to cost and ubiquity. However, fiberglass windows that meet the performance criteria are also available. Moving forward, relative costs will continue to be vetted to phase toxic materials out of the REALIZE-CA retrofit package.

## Attic Aerobarrier

### *Product Description and Performance Specifications*

Aerobarrier is an aerosolized elastomeric sealant that is released into an interior space while it is pressurized or depressurized so that the sealant is automatically drawn into leakage pathways until they are sealed. Compared to manual sealing in an attic application, Aerobarrier uses less material, whereby the sealant is released into the attic space while a blower door depressurizes the conditioned area of the home. Because the method is driven by creating a pressure differential, the sealant targets and seals cracks that may not be easily discovered or accessed by manual methods. REALIZE-CA pilot demonstrations successfully demonstrated that Aerobarrier could achieve whole unit leakage reduction by 55% compared to a 14% reduction from manual sealing with foam. This application does not require extensive preparation and protection of the living area and is thus relatively quick and non-invasive.

This measure will be applied to all eligible projects if the existing attic is not insulated with R30 blown-in insulation or R38 batt insulation.

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Exhibit 7 **Attic Application of AeroBarrier**

Exhibit 8

## AeroBarrier Manual Sealing

Exhibit 9

## AeroBarrier Manual Sealing Air Leakage Results

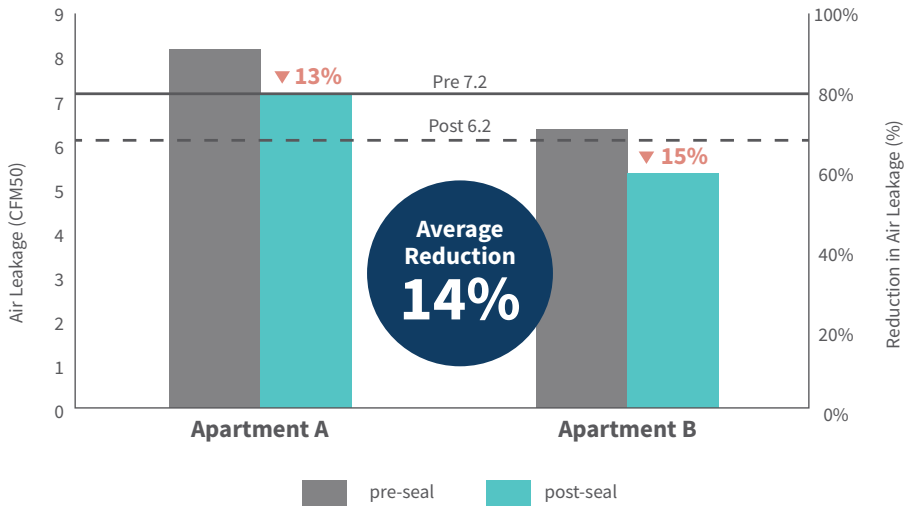
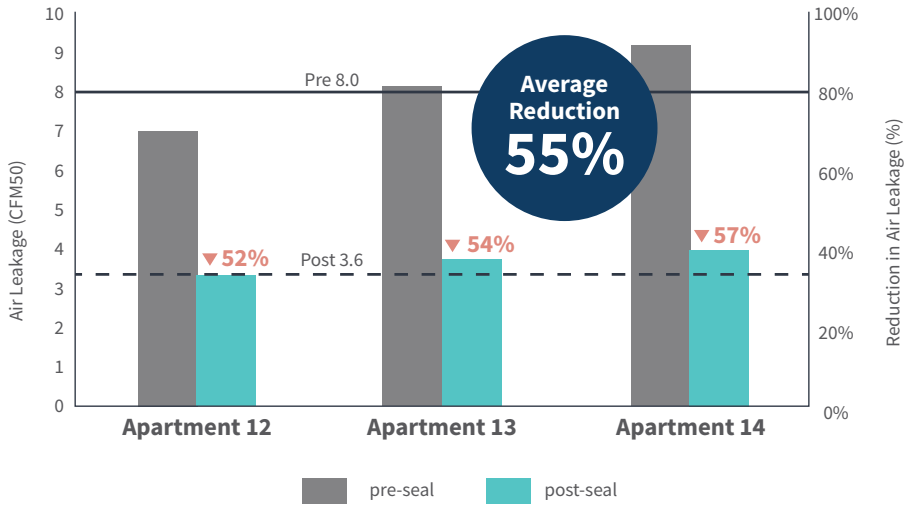


Exhibit 10 **AeroBarrier Attic Sealing Air Leakage Results**




### *Installation*

Attic Aerobarrier installation is typically phased toward the end of a retrofit project, after other work in the attic space has been completed. Preparation for attic Aerobarrier includes removal of existing attic insulation (using commercial insulation vacuum for existing blown insulation, or manual removal if batt insulation). The attic is inspected for any durability issues that need to be addressed prior to installation of new insulation (e.g., large air leakage pathways, open electrical boxes, debris, or pest infestation). Any excessively large holes between the attic and conditioned space must be sealed with traditional methods prior to installing Aerobarrier.

If performed in cold weather, the home is preheated to ensure effective disbursement of the Aerobarrier sealant. Aerobarrier sealant nozzle(s), tubing, and fogging system are set up in the attic, and a blower door is positioned at an exterior door. Existing air leakage is measured prior to sealing, which is performed by depressurizing the conditioned space and releasing sealant into the attic. Real time air sealing progress and indoor conditions are monitored for excessive fogging during the sealing process, which stops when the installer determines diminishing returns for additional sealing (i.e., sealing improvement slows down). Once sealing has been completed, the blower door and HEPA filters may be used to help remove any residual interior fogging (a process for providing constant removal of indoor fogging is being developed by UC Davis). The installation process is still being refined, but in a production environment it's reasonable to believe that this sealing process (excluding attic insulation removal and hand sealing prep) will take 1–2 hours per unit including sealing equipment set-up and removal.

### *Availability and Commercialization*

Aerobarrier is a proprietary product that is only available from one manufacturer. The attic-based sealing approach is being refined prior to full commercialization and associated contractor training. Contractors are encouraged to work with Aerobarrier in future pilot demonstrations to negotiate material pricing directly, and installation pricing through negotiations with select contractors.

### *Environmental Impact*

In contrast to some elastomeric coatings, the coating that is used as the base for Aerobarrier (Tremco ExoAir230) does not contain harmful chemicals such as PFAS and as recently as 2020 was certified Red-List Free by the International Living Future Institute. Although it is possible for some residue to escape through leakage pathways and settle in the living space, it would not pose any harm to people or pets.

## Attic Insulation

### *Product Description and Performance Specifications*

Provided that existing attics are not insulated with R30 blown or R38 batt, all retrofits will include insulation removal and new blow-in attic insulation to meet a final installed R value of R44. Blown in cellulose insulation will be used for typical projects.

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Exhibit 11

## Typical "Before" and "After" Attic

### *Installation*

The procedure for removing existing insulation and prepping for and installing new insulation follows industry standard quality insulation installation (QII) procedures.

### *Availability and Commercialization*

Blown insulation is fully commercialized and readily available, and many installers are trained to deliver QII. Disposal of existing insulation at scale has not yet been thoroughly researched and presents a potential opportunity for waste diversion.

## Elastomeric Paint

### *Product Description and Performance Specifications*

Elastomeric paint is a flexible, vapor-permeable coating that resists expansion and contraction, and that can bridge small cracks, making it effective for reducing air and moisture intrusion into a wall assembly. It is included as an elective, low-cost measure to benefit the durability of primarily stucco-clad eligible buildings, provided the stucco is in good shape. Because it is an effective waterproofing layer, it is important that the existing wall is properly flashed at penetrations and special conditions, or else the coating may exacerbate existing waterproofing issues. New exterior paint also provides an updated look to accompany the retrofit.

*Installation*

Prior to applying the coating, minor cracks (greater than 1/16”) must be routed and sealed. Any removal of stucco must include great care not to disturb the existing waterproofing layer (building paper). All boundary conditions must be examined so that the elastomeric coating terminates in sealant in order to complete a continuous air barrier and to achieve a functioning waterproofing system. For example, the exterior face of wall should be sealed to the framing and sheathing at the attic ceiling-wall interface. If a weep screed and proper distance to grade does not exist at the base of the stucco, this should be added. Mechanical, electrical, and plumbing work must be coordinated such that the planned removal of building-mounted equipment or conduit or the creation of new penetrations or structural supports is complete prior to painting, and any new equipment that touches or blocks access to the walls is done afterward. While difficult, it is important that stucco removal does not cut into existing building paper.

Finally, it is important that elastomeric coating is applied only to buildings that have properly installed windows, since the sealant will impede the release of any trapped water, unlike a typical stucco assembly.

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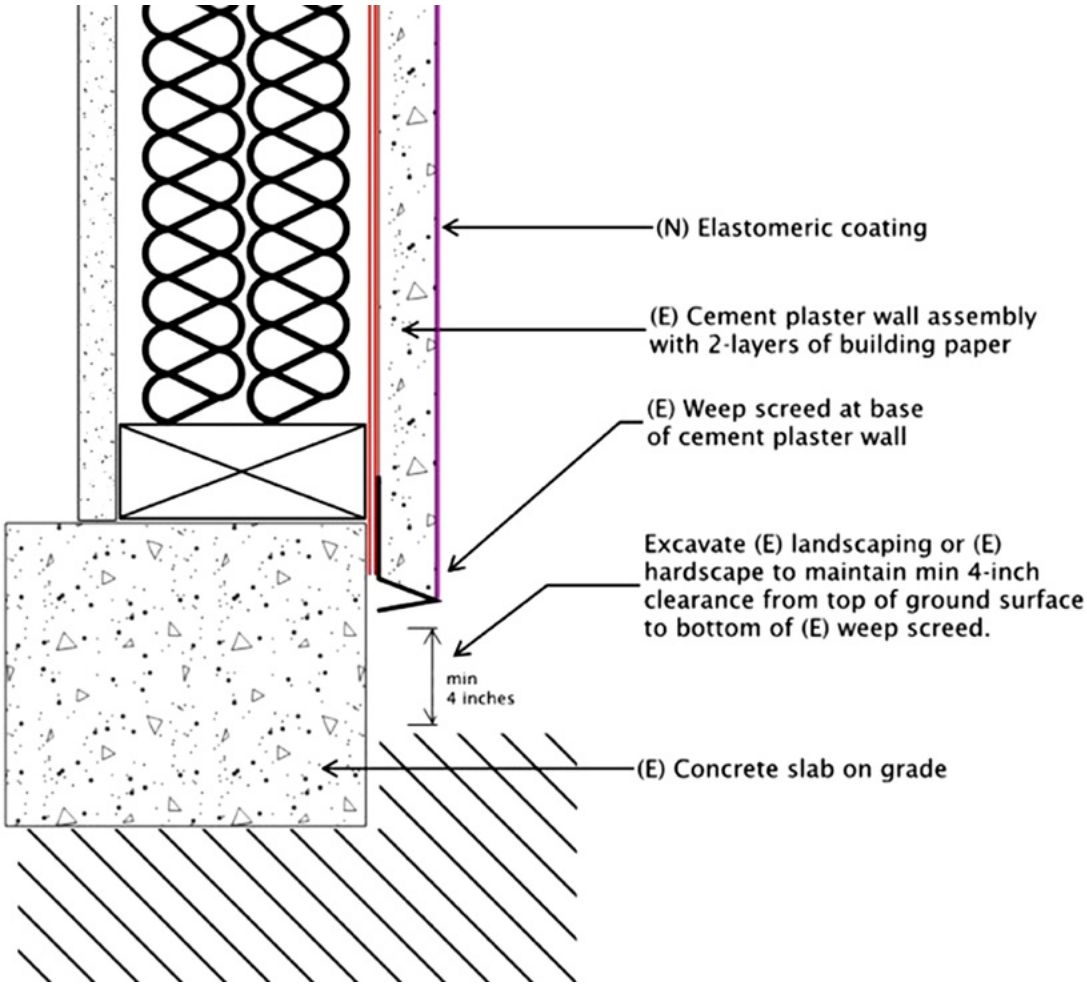
Exhibit 13 **Termination of Stucco at Base of Wall**



### *Availability and Commercialization*

Elastomeric paints are readily available, and some products allow less room for error based on how they change as they are applied in order to achieve a consistent application. If exterior painting is planned, using a more durable coating comes with a modest incremental cost.

### *Owner Education and Maintenance*

Once used, compatible elastomeric paint must only be used for touch-up and repainting projects. This may impact the current approach used by building owner capital improvement staff. Elastomeric paint requires proactive repainting every 10 years, which may increase costs relative to owners' current repainting schedules.

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Exhibit 12

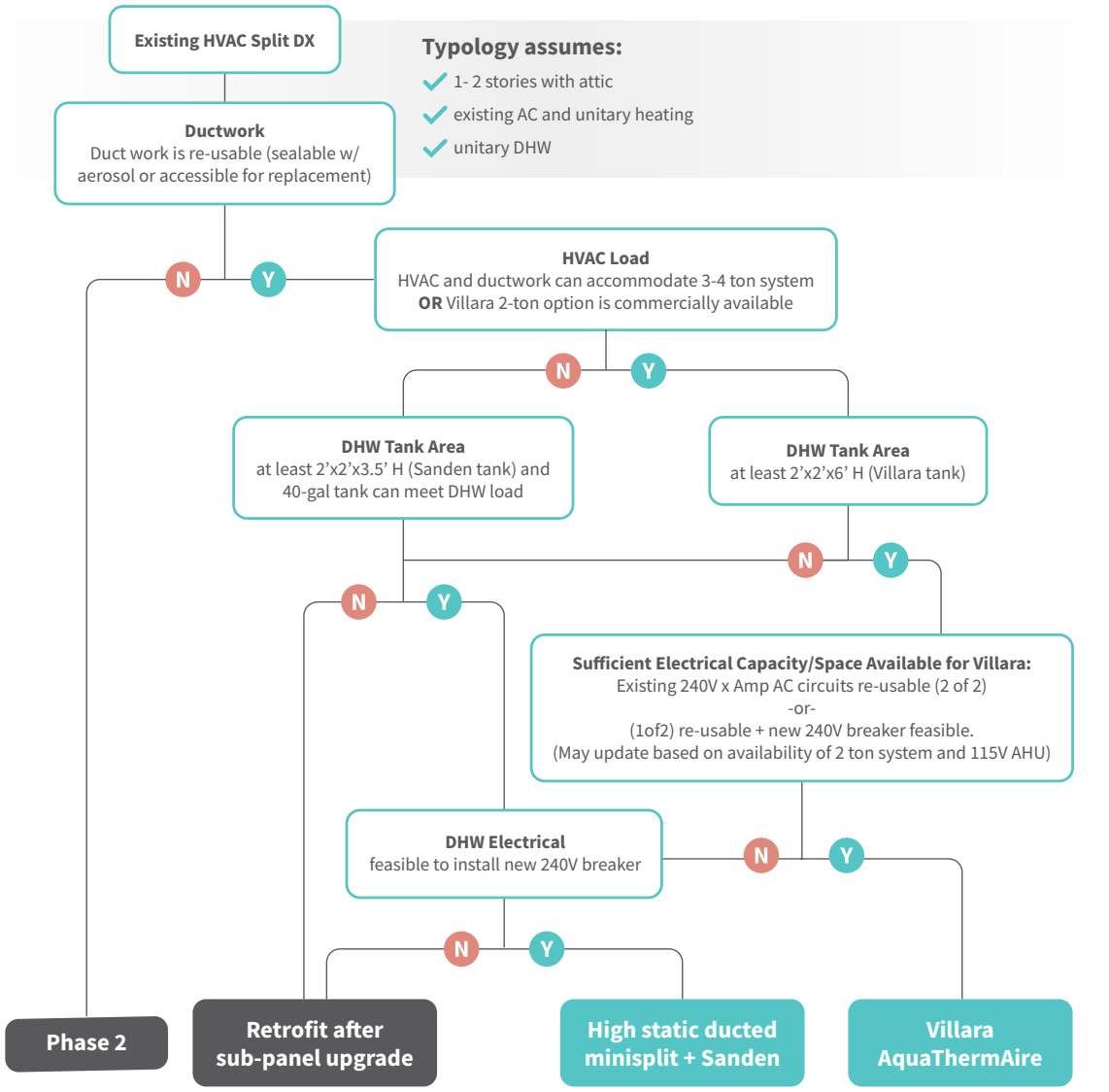
## Vera Cruz Village "Before" and "After" Application of Elastomeric Paint

## Heating, Cooling, Ventilation, and Hot Water

REALIZE-CA retrofit packages will only serve buildings with split direct expansion (DX) HVAC systems paired with unitary tank-style water heating systems. If specific conditions, as described in the decision tree below, are met then these systems will be replaced with the Villara AquaThermAire (AQTA), a 3-in-1 multifunction mechanical system that provides heating, cooling, and domestic hot water with one heat pump compressor. If the Villara 3:1 system is infeasible, then a high-static ducted minisplit HVAC heat pump and split heat pump water heater are paired together to serve as an alternative mechanical package. Buildings requiring ductless HVAC systems or central water heating retrofits are not eligible for REALIZE-CA retrofit packages and should be considered in future pilot demonstrations.

Exhibit 14

## HVAC Decision Tree for Phase 1

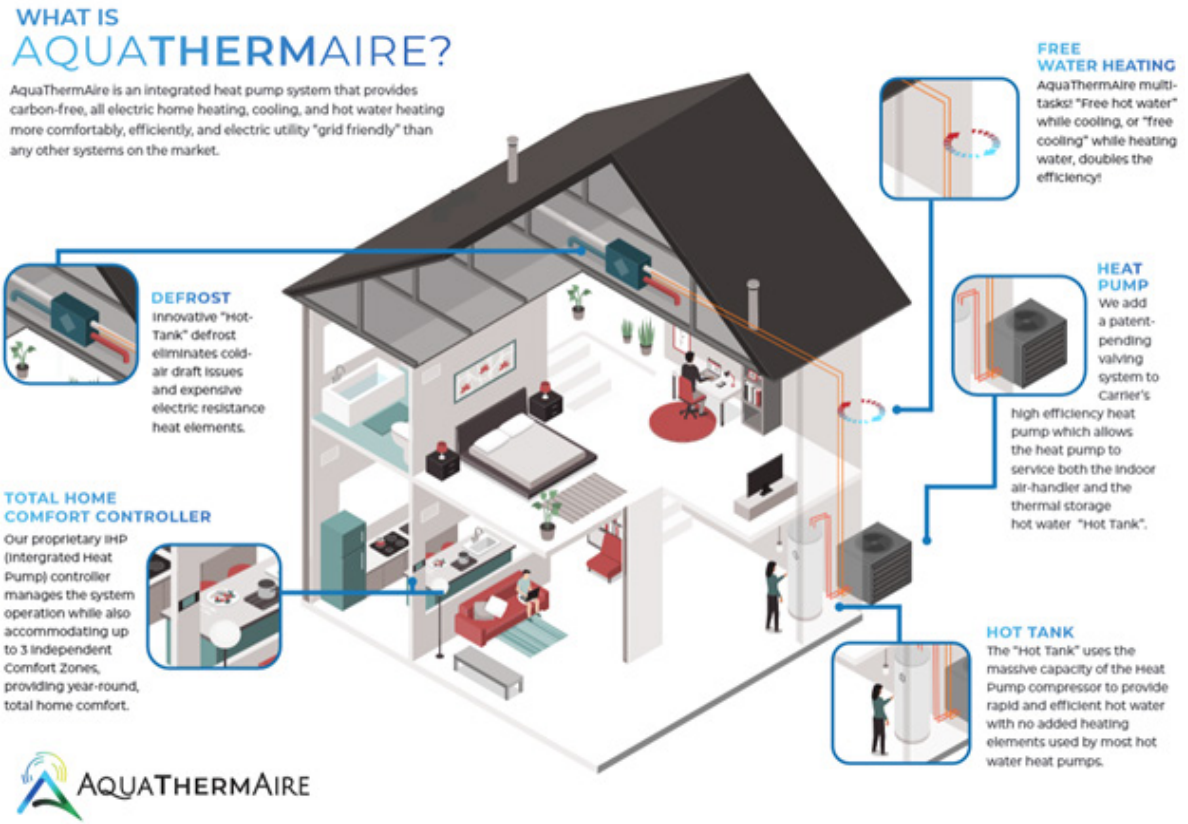



## Option 1. Villara AquaThermAire

### *Product Description and Performance Specifications*

The Villara AquaThermAire (AQTA) is a 3-in-1 multifunction combined mechanical system that provides heating, cooling, and domestic hot water with one heat pump compressor. The AQTA consists of a traditional ducted air handler and a proprietary 62-gallon domestic hot water (DHW) atmospheric storage tank with submersed refrigerant and DHW heat exchanger lines running through it. The tank is connected via refrigerant lines to a single speed outdoor compressor unit, which also serves the air handler with a second refrigerant line set. The compressor has a proprietary 4-way valve that controls to which component the refrigerant is sent: DHW, HVAC, or both and allows for refrigerant heat recovery when the system is in cooling mode. Lastly, the AQTA system should be paired with a smart thermostat to address thermal comfort preferences of the resident and achieve energy savings of HVAC operation. It is also currently being tested for demand response capabilities.

Exhibit 15 **Villara AquaThermAire (AQTA)**



### *Installation and Constructability*

The HVAC portion of the AQTA system is air-based and distributes conditioned air via ductwork. The system relies on cleaning, sealing with Aeroseal, and either re-using the existing duct distribution system or replacing the existing duct system if it cannot be reused. Additional AQTA criteria can be seen below:

- **Equipment sizing.** Currently, the AQTA has been developed for single family homes and is only available in 3-ton and 4-ton models, and the project team is in conversations with the manufacturer to develop 2- and 2.5-ton options. Initial sizing and feasibility will include review of the apartment HVAC and DHW loads and existing ductwork sizing and condition to verify that the combination system is compatible as a retrofit. If limited to 3-ton models, apartments with lower HVAC loads or undersized ductwork may limit installation feasibility.

- **Siting.** The new equipment is designed to be a 1:1 replacement of existing equipment: heat pump air handler replaces furnace with DX cooling, heat pump compressor replaces cooling compressor, and storage tank replaces gas water heater. This is most efficiently performed when existing mechanical equipment is co-located, such as an exterior double-door mechanical closet that houses both the water heater and the furnace. The mechanical systems do not have to be co-located or in an exterior closet; but access to run longer refrigerant line runs is required (e.g., attic space), which will increase project costs. Lastly, the AQTA air handler and DHW tank are similar in footprint to most typical multifamily equipment, but in some situations existing gas water heater or air handler locations may limit installation feasibility (see option 2 for alternatives).

### *Availability and Commercialization*

Currently, the AQTA technology is commercially available, but very new and the installation process is nascent. To date, there have been approximately six installations completed. The air handler and compressor used in the system are Carrier components that are commercially and widely available. The proprietary four-way valve installed on the compressor to connect it with both the air handler and domestic hot water storage tank is still nascent and currently installed "after market." The DHW storage tank is also proprietary and built in small quantities, though the manufacturer entity is currently looking for partnerships with established, industry-leading manufacturers.

The AQTA system is unique in that it was developed by a general contractor and therefore is also currently only installed by that contractor. However, the company has indicated that they will also support third-party contractor installations. Given this system is more directly vertically integrated than most (multifunction) products, there is the potential to allow for quick feedback and product updates between the installation and product development teams, and a significant opportunity to achieve cost compression. Conversely, without sufficient competitive bidding, the potential to further reduce costs may be constrained.

Initial installations experienced challenges that will need to be resolved to allow mass deployment. For example, coordination between plumbers and HVAC technicians must be streamlined or a single trade must be trained to install the system to realize labor efficiencies.

Presumably, installation efficiencies will reduce labor costs in the future. While it is difficult to determine how much, the installation costs above indicate reduced labor cost as orders scale. Again, this does not take into account the impact of competitive bidding, as the system is currently installed solely by Villara.

### *Tenant Education and Maintenance*

Much of the applicable resident education for the AQTA system relates to the topics of resident thermal comfort and expectations. Like any heat pump system, the recovery time is different from that of gas equipment. On the heating and water heating operation, it takes longer to get up to temperature, so residents' expectations should be set accordingly. It is valuable to provide recommendations for residents on best strategies for HVAC thermostat setpoints to optimize for thermal comfort (e.g., avoid on off thermostat use) and system efficiency. The AQTA system also cannot produce hot water and deliver space heat at the same time, so heavy DHW consumption that would deplete the tank may impact space heating recovery depending on the efficiency of the envelope and HVAC thermostat setting. This does not mean hot water cannot be used while the system is heating the house; hot water stored in the tank will still be available, but heavy hot water demand capable of depleting the storage capacity will require a longer wait time before the water heating mode turns back on.

In the multifamily rental scenario, building maintenance or property management will typically conduct a simpler service, like filter maintenance, which requires replacement of the MERV 13 filter at a regular, pre-determined cadence depending on air quality and particulate matter in the air in the area. Technical troubleshooting, annual maintenance (cleaning coils), or repairs to the mechanical equipment, however, are typically performed by outside vendors. Given the proprietary nature of the tank, controls, and 4-way valves, projects that elect to use this system will assume some risk by installing one-of-a-kind technology, which should be paired with strong warranty and service solutions from the manufacturer/installing partner until the system becomes fully mature.

### *Environmental Impact*

The compressor currently uses R410a refrigerant; however, through R&D research, this has been provisioned with R454b. Final low global warming potential (GWP) refrigerant use and performance will likely be determined by the compressor manufacturer's decision to meet refrigerant GWP requirements.


### Option 2. Ducted Split Heat Pump and SanCO2 Water Heater

*Product Description and Performance Specifications*

Where existing conditions do not allow for the installation of the AQTA (Option 1), a ducted inverter-driven heat pump HVAC system (Mitsubishi, Daikin, etc.) and separate split heat pump water heater (SanCO2) are used as the mechanical package. The HVAC system uses a variable speed compressor and variable speed air handling unit (AHU) connected to an air duct distribution system. The SanCO2 split heat pump water heater utilizes a variable speed compressor, which runs on low-GWP R744, and connects to a 43 or 83-gallon storage tank. The SanCO2 system does not have electric resistance backup.

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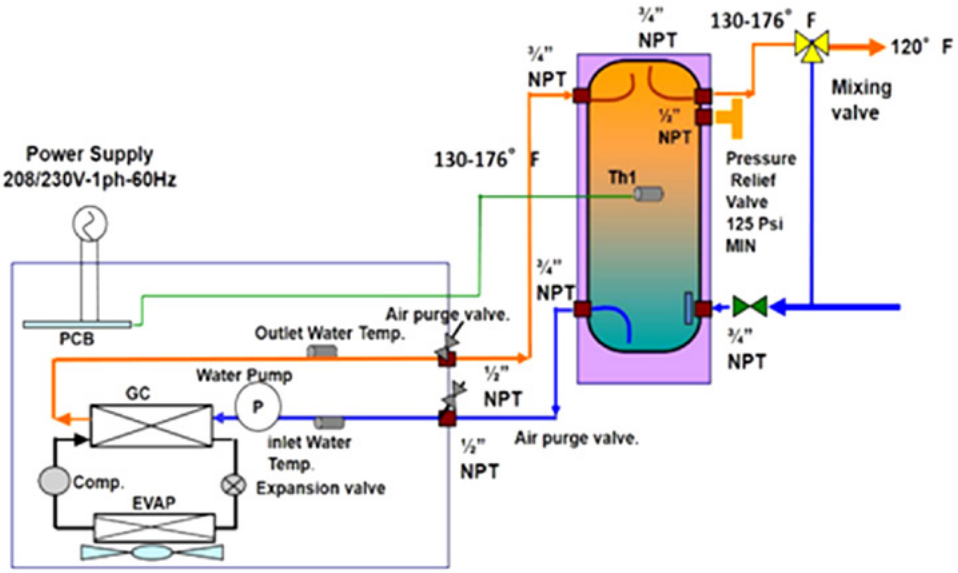
Exhibit 16 **SanCO2 Water Heater**



### *Installation and Constructability*

The HVAC system is air-based and distributes conditioned air via ductwork. The approach relies on cleaning, sealing with Aeroseal, and re-using or replacing the existing duct distribution system. Additional considerations for the SanCO2 are as follows:

- **Equipment sizing.** Currently, traditional AHU ("high static" model) ducted inverter-driven heat pumps are available in sizes as low as 1-ton, providing the ability to rightsize the HVAC system to the projected loads. Using the 83-gallon tank, the SanCO2 water heating system can meet the first-hour rating required by code for all typical apartment sizes with extra capacity to allow for grid-connectivity and load shifting for DHW production during off-peak grid hours. Where the 83-gallon can't fit, the 43-gallon tank can still meet most apartment first-hour rating code needs.

- **Siting.** New equipment is designed to be a 1:1 replacement of existing equipment: heat pump air handler replaces furnace with DX cooling, heat pump compressor replaces cooling compressor, and dedicated HPWH system replaces gas water heater. The SanCO2 system will require more outdoor space for a new compressor previously used by water heating equipment. The air handler is similar in footprint to most typical existing multifamily gas furnace AHUs. If the existing air handler is a recessed fan coil cassette, the AQTA system (option 1) may be easier to retrofit. Using the 83-gallon DHW tank will require additional footprint relative to existing gas water heaters but has reduced clearance requirements. The 43-gallon model will occupy the same area as most existing gas DHW systems.

### *Availability and Commercialization*

All components of this package are commercially available. The inverter-driven ducted heat pump sizing and form factors are extensive and ubiquitous across manufacturers. The SanCO2 heat pump water heating system is also commercially available.

There are two identified opportunities to improve the SanCO2 product:

- Multifamily buildings in California were sometimes designed around tall, skinny gas water heater models. These legacy models are difficult to replace with gas options and often are too small to accommodate the 43-gallon tank. SanCO2 Australia currently offers a tall, skinny tank that is several inches smaller in diameter and several inches taller than tanks available in the US, which would solve for this issue in most cases, but it is not commercially available.

- Tanks are currently high-performance stainless-steel models built in Australia. While stainless steel tanks offer many benefits (durability and reduced maintenance), they also increase the product cost relative to standard construction (glass-lined steel tanks). Aggregating demand in California for mass deployment of these retrofits could present an opportunity for a domestic tank manufacturer to provide a lower cost product that could further reduce project costs.

### *Tenant Education and Maintenance*

Similar to the AQTA system, the heat pump HVAC system will have a slower recovery time than the baseline gas equipment, is optimized to run for longer periods, and can include defrost cycles that periodically blow cool air into the home. Recommendations for residents on best strategies for HVAC thermostat setpoints to optimize thermal comfort and system efficiency are valuable to provide. The proposed water heating strategy should not impact resident availability of hot water, but opportunities exist to engage residents around opting into load shifting and demand response programs, in addition to learning when it is most expensive to heat water.

### *Environmental Impact*

A few HVAC manufacturers already build systems outside of the United States using low-GWP refrigerants like R32, but the current regulatory and code environments do not yet allow for their sale. This will change in 2025 and those products will be ready to hit the market with mature commercialization from other international markets.

#### Ductwork

Appropriate building typologies and HVAC Options 1 and 2 assume units have ducted HVAC distribution for both the existing and retrofit system. If the existing ductwork is in good condition and appropriately sized, it will be professionally cleaned and sealed. If the ductwork is in poor condition (e.g., excessively dirty, low jacket R-value, disconnections, asbestos) and accessible in the attic, it will be replaced. If ductwork is located behind walls/ceiling and is not in good condition, the project would be recommended for a future demonstration demonstrating ductless distribution.

Sealing the existing ductwork assumes the use of Aeroseal technology. Similar to Aerobarrier, sealing is performed (after cleaning) by pressurizing the duct system and injecting it with aerosolized sealant, which travels to and seals most system leakage points, resulting in duct systems with very low leakage.

### *Availability and Commercialization*

Aeroseal is commercially available, and contractors must be certified/trained by Aeroseal. In addition to their labor and material costs, contractors also have to pay for an Aeroseal licensing fee per sealed system.

### *Tenant Education and Maintenance*

With the use of and regular change out of high efficiency filters, ductwork requires little regular maintenance. However, it is important to perform an annual visual inspection to ensure that the duct system hasn't experienced any damage from maintenance staff/vendors (e.g., walking through an attic) or from rodents.

### *Environmental Impact*

Sealing and reusing existing ductwork where feasible reduces landfill waste and embodied energy associated with the manufacture, delivery, and installation of new materials.

**Ventilation**

The REALIZE-CA retrofit package assumes an exhaust-only ventilation strategy consisting of Energy Star multispeed bathroom exhaust fans that run continuously at low speed with high-speed boost, and a ducted Energy Star kitchen range exhaust. In cases where the existing conditions demonstrate excessive moisture buildup and lack of regular kitchen exhaust hood use, or when needed to meet ASHRAE 62.2, a constant low-speed kitchen exhaust hood will be used. Balanced ventilation with energy recovery is a goal for future packages, but there is not currently a cost-effective, rapid retrofit solution that pairs effectively with the HVAC options included in the REALIZE-CA retrofit package.

### *Availability and Commercialization*

The proposed ventilation strategy is mature and fully adopted.

### *Tenant Education and Maintenance*

Transitioning residents from on/off ventilation to constant ventilation systems requires resident education regarding the benefits and impact of constant ventilation. Building maintenance staff also need to adjust preventative maintenance to test fans annually. Cleaning may be needed more frequently to address accumulated debris on the bathroom cover and fan blades, replacement and/or cleaning of kitchen range grease filters, and degreasing of the kitchen fan.

The price of equipment for this mechanical package option is stable and does not invite cost reduction outside of typical scaling from bulk procurement.

# Appliances and Fixtures

All package options come with the following standard offering of ENERGY STAR energy and water-efficient appliances and fixtures that meet or exceed T-24 and T-20 requirements. Existing appliances with similar energy and water performance to package appliances will not be replaced.

1. Low-flow plumbing fixtures (WaterSense Approved, 1.0 gpm pressure compensated bathroom sink aerator, 1.5 gpm kitchen sink aerator, 1.5 gpm pressure compensated showerhead, consider handheld to improve resident adoption)
2. ENERGY STAR LED fixtures, with T24 controls for common area lighting
3. ENERGY STAR refrigerator, dishwasher, clothes washer, electric dryer (in-kind replacement only if existing)
4. ENERGY STAR ceiling fan (if central bedroom ceiling lights exist)
5. Induction range

## Dryer

Where apartments have existing in-unit gas dryers, the retrofit will include the installation of a new electric dryer, which will require consideration of the following:

- **Electrical capacity.** If sufficient electrical capacity exists for the overall retrofit without triggering upstream electrical upgrades, a traditional electric dryer will be used. If insufficient capacity exists, a condensing or heat pump dryer will be used.
- **Ownership of equipment.** In-unit laundry is often owned by residents, not the building owner. Fairly compensating residents for the removal of their existing gas dryer is required. If a heat pump dryer that uses a smaller electrical circuit is required, it likely will need to become a building owner-maintained and provided amenity given new residents that move in will not be able to easily secure their owner dryer (without a cost premium).
- **Heat pump dryers.** (When/where applicable) These require careful tenant education, as all heat pump dryers have an additional filter that needs to be cleaned/maintained, and drying cycles are typically longer than electric resistance or gas dryers. Additionally, there are currently very few full size (typically seen in affordable multifamily) commercially available heat pump dryers. Multiple compact models from the European market are available but would impact the size of drying loads.
- **Maintenance.** Heat pump dryers have been available in the market for many years, but widespread adoption has not yet occurred in the United States. Use in affordable multifamily rentals has not been documented, and any increased burden with maintenance and replacement costs requires further investigation.

## Induction Range

Where apartments have existing 30” gas ranges, the retrofit will include the installation of a new induction range. Existing electric resistance ranges will not be replaced, and important installation considerations are as follows:

- Apartments with different gas range sizes (e.g., 20”–24") should be considered in future pilot demonstrations.
- Electrical capacity
  - » If there is sufficient electrical capacity for the overall retrofit without triggering upstream electrical upgrades, a traditional induction range will be used.
  - » If there is insufficient electrical capacity (typical), a battery-integrated plug-in 120v range (Copper Channing) will be used.
- Induction range features must be ADA compliant, and cooktops should be controlled with knobs instead of touch controls for quick resident adoption. Warranty and parts availability must also be considered when comparing options.
- Tenant outreach, education, and engagement
  - » Explain the benefits and changes impacting cooking in tenant move-in resources
  - » Provide replacement pots/pans and/or an opportunity to swap incompatible pots/pans
  - » Schedule cooking demonstrations and provide materials outlining proper use
  - » Provide ceramic cooktop cleaning materials

# Financing Opportunities and Tools

Roughly 2,000 affordable multifamily housing (AMFH) units are retrofit annually across California, leveraging a patchwork of incentives including the State's Low Income Weatherization Program and Solar on Multifamily Affordable Housing. According to the California Housing Partnership, to equitably meet the State's climate action goals, nearly 50,000 AMFH units must be retrofit annually,[i] over 25 times the rate of adoption today. The estimated economic value of this activity is between $1.25 and $2.5 billion annually.[ii] Achieving this level of scale will require effectively braiding incentives and financing together to steadily stimulate the market and drive economies of scale.

At the same time, subsidized affordable multifamily housing owners have unique challenges to financing the necessary decarbonization retrofits. In general, AMFH building owners have relatively few options for financing major capital improvements unless upgrades coincide with a major recapitalization event. We refer to periods outside of such recapitalization events as "mid-cycle." During mid-cycle periods, the up-front costs of deep efficiency and electrification upgrades are difficult to finance for the following key reasons:

- **Mortgage lenders.** Lenders hold exclusive approval rights over — and may prohibit — additional loan indebtedness required to fund efficiency upgrades, whether such debt is in the form of a subordinated, junior mortgage loan or secured equipment loan.
- **Tax equity investors.** Investors in LIHTC buildings have approval rights over any significant additional indebtedness taken on by the buildings.
- **Rent restrictions.** Because of restrictions on rent, AMFH properties usually do not have accumulated cash reserves other than the minimum required for repairs and ordinary capital replacement. They typically do not have meaningful excess annual net income (after operating expenses and mortgage debt service) to cover additional debt service for financing deep retrofits.
- **Split incentives.** For AMFH buildings where tenants pay their utilities, owners are not able to recoup the up-front costs for deep efficiency upgrades over time through energy savings.
- **Utility allowances.** Many subsidized housing programs have a mechanism for ensuring that tenants' living expenses do not exceed a certain percentage of their income. This mechanism consists of a "gross rent" cap, which is the sum of the tenant's rent plus a utility allowance (UA) to pay their utilities. State regulations governing UAs provide protections for tenants, and allow AMFH building owners to increase rents (subject to affordability caps on the total of monthly rent plus the UA) to recoup the cost of upgrades that lower tenant utility costs.

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**i.** Calculated assuming 80% of building stock that exists today will exist in 2050, divided by 26 years to 2050.

**ii.** Calculated assuming a range of between $25,000 and $50,000 per housing unit cost for retrofit packages depending on scope and depth of improvements.

REALIZE-CA has identified two potential solutions to these challenges, energy service agreements (ESAs) and inclusive utility investment (IUI), each of which we document in two ancillary reports to this guide:

- **Tariffed On-Bill to Finance Energy Efficiency and Decarbonization Retrofits for Multifamily Buildings in California**
- **Energy Service Agreements for Deep Efficiency and Electrification Retrofits of Affordable Multifamily Housing in California**

In addition, REALIZE-CA also provided input to the state Treasurer's **GoGreen Financing program**. The program helps provide lower cost capital for energy efficiency improvements and partners with several third-party lenders. A summary of products available through their program can be found in their **GoGreen Multifamily Financing Chart**. Owners interested in leveraging energy service agreements should consider working through the state's GoGreen program.

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Exhibit 17 **GoGreen Multifamily Energy Financing Options for AMFH**

gogreen FINANCING

## GoGreen Multifamily Energy Financing

Energy Efficiency Financing Options for Market-Rate and Affordable Multifamily Property Retrofits

The lenders listed below have indicated willingness to consider both market-rate and affordable multifamily properties.

| | Products* | Financing Available | Term Length | Will finance in-unit improvements | On-Bill Repayment | A Good Fit for Properties Seeking... | Contact |
|---|---|---|---|---|---|---|---|
| ascentium CAPITAL | Equipment Finance Agreements | $20K - $2M | 12 – 60 months (84 months on case-by-case basis) | Yes | No | Quick payback and competitive rates | Kristin McRoberts (714) 309-5301 kristinmcroberts@ascentiumcapital.com |
| dll financial solutions partner | Loans, Leases, Service Agreements | $5K - $5M | 12 – 84 months (120 months on case-by-case basis) | Yes | No | Quick payback or low monthly payments; ongoing service and maintenance | Mike Osselinski (610) 316-5695 mosselinski@leasedirect.com |
| PRIME CAPITAL | Equipment Leases, Loans | $100K - $5M | 36 – 120 months | Yes | Yes | Option to pay down principal | Scott Pinckard (630) 200-7376 scottpinckard@primecapitalfunding.com |
| RenewEnergy | Efficiency Service Agreements | $250K - $5M | 60 – 120 months | Some master-metered | No | Guaranteed savings on the bill and ongoing service and maintenance* | Nathan Montgomery (888) 938-6256 procjects@renewep.com |
| VERDANT COMMERCIAL CAPITAL | Equipment Finance Agreements, Leases | $25K - $5M | 24 – 84 months | Yes | Yes | Flexible approvals | Jonathan Wickersham (248) 860-0013 jwickersham@verdantcc.com |

* All listed finance companies offer financing for distributed generation and storage such as solar panels and batteries. However, finance companies will not receive a credit enhancement for that portion of their financing. As such, these installations may be financed at the discretion of the finance company.
* Please note properties which already have a GoGreen financing cannot be considered.

10/01/2023

With the passage of the Inflation Reduction Act and the California Energy Commission's Equitable Building Decarbonization program, California has a historic opportunity to deploy multifamily retrofits at scale. ESA's and IUI provide elegant structures to leverage subsidies while engaging capital markets to achieve the scale required to meet the state's ambitious climate goals.

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