Bear Creek Case Study

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Electrifying homes with efficient heat pumps is essential for reducing greenhouse gas (GHG) emissions. However, space constraints, installation complexity, up-front costs, and the potential impact on energy bills hinder retrofit electrification progress. Many of these barriers are especially acute in multifamily housing.

Multi-function heat pumps (MFHPs) offer a promising solution by utilizing a single compressor to provide heating, cooling, and domestic hot water (DHW) — the most intensive residential thermal loads. MFHPs simplify retrofits by consolidating systems and reducing system redundancy. They also streamline installation, reduce electrical circuit requirements, and enable opportunities for enhanced performance through energy recovery, ultimately helping to accelerate multifamily housing electrification. This case study highlights the Villara AquaThermAire (AQTA), an MFHP that uses a low global warming potential (GWP) R454b refrigerant, in two low-income, single-floor apartments in Planada, California.

System Description

The Villara AQTA is a split, centrally ducted air-source heat pump with two refrigerant linesets — one between the outdoor unit and the air handler, and another between the outdoor unit and the hot water tank. The outdoor unit is a Carrier heat pump that is modified by Villara with a four-way refrigerant valve connected to a single-speed compressor and includes a finned tube refrigerant-to-air heat exchanger. The air handler is a centrally ducted vertical air handler with a single-speed fan and an "A-coil" finned-tube refrigerant-to-air heat exchanger. The 60-gallon hot water tank was designed and manufactured by Villara and integrates a wrap-around refrigerant coil that heats the water in the tank and then transfers that heat to potable hot water lines suspended in the tank.

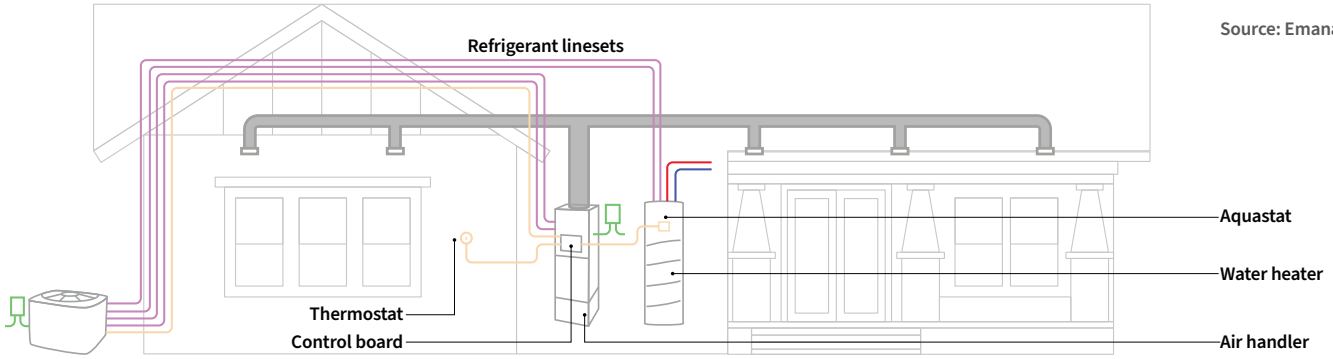
The Villara AQTA also has a unique approach to managing the heat pump's defrost cycle, using the heat stored in the hot tank as opposed to the standard method of using the heat from the conditioned air. This facilitates much shorter defrost cycles that typically last only two to three minutes. This innovative feature also prevents the most common complaint associated with the defrost cycle: blowing cold air into a heated space.

"The renovated apartment is very comfortable, more comfortable than before the renovation. The temperature is easy to control, and the air is very good — fresh, clean, and healthy."
- Nicolás Rodríguez, Bear Creek Apartments Resident

Exhibit 2 The Villara AQTA MFHP system at Bear Creek Apartments: outdoor unit (left) outside mechanical closet, hot water tank (left) and air handling unit (right) inside mechanical closet

Exhibit 3 Bear Creek Apartments — two adjacent, single-story residences in Planada, CA

Exhibit 1 Villara AQTA: Ducted split air-source multi-function heat pump (MFHP) system at Bear Creek Apartments



Source: Emanant Systems

System Benefits

MFHPs show potential to reduce life-cycle costs compared to typical split HVAC heat pumps and heat pump water heaters (HPWHs):

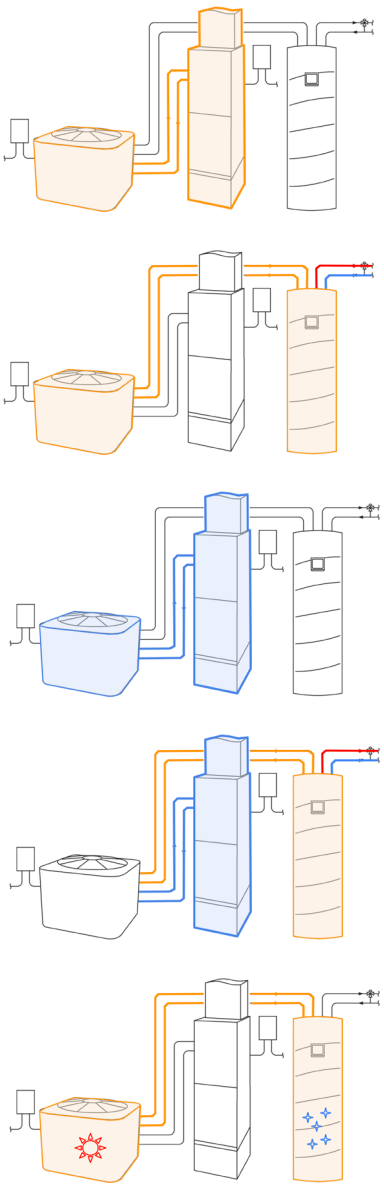
- A drop-in replacement for a common multifamily HVAC typology: Centrally ducted unitary A/C and furnace systems are ubiquitous in the California multifamily building stock. This MFHP can utilize existing electrical connections at both the outdoor unit and the air handler, reuse the concrete pad for the outdoor unit, and likely reuse the ductwork if it's in acceptable condition. Additionally, the DHW tank (which is now served by the outdoor heat pump unit) does not need an electrical connection.
- Using the single compressor with sufficient capacity for space heating satisfies DHW heating rapidly without the need for supplemental electric resistance, reducing the need for electrical upgrades and improving DHW system efficiency.
- Recovering heat when operating in simultaneous space cooling and domestic water heating mode improves efficiency.
- The unique "defrost mode" pulls heat from the DHW tank, preventing cold drafts on occupants, improving thermal comfort.

Overall comparison of MFHP and conventional heat pump retrofits

	Conventional	Villara AQTA	Ventilation add-on
Installation Cost ($)	$21,396	$21,141	$8,966
Installation Time (hrs)	59	44	20
Seasonal COP - Heating / Cooling	n/a	2.68 / 2.63	n/a
COP- Water Heating	n/a	2.11	n/a
Type of Refrigerant	R410A / R134A	R454b	n/a
Refrigerant GWP	2,088 / 1,430	466	n/a

Note: The coefficients of performance (COPs) of Villara AQTA are the highest we measured between the two apartments. Conventional equipment is from an actual project and includes the cost of a split-ducted HVAC heat pump, ductwork, unitary tank-type heat pump water heater, and exhaust-only ventilation.

Exhibit 4: Five core operation modes demonstrating the refrigerant flow and heat exchange between the outdoor unit, the air handling unit, and the hot water tank system at Bear Creek Apartments



Source: Emanant Systems

Lessons learned

- Leveraging heat recovery benefits, optimizing space flexibility, and utilizing existing mechanical installation locations make combined systems most viable for the market.
- Improving heat recovery capabilities by extending operation beyond periods of coincident space cooling and hot water demand will further enhance MFHP performance.
- Streamlining installation of the MFHP system with more contractor experience and repetition will likely reduce the installation time and cost. The Villara AQTA's installation cost is currently similar to a conventional split system plus HPWH.

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