Very High-Efficiency Heat Pumps For Multifamily

Resource Guide

ICAST

This material is based upon work supported by the U.S. Department of Energy's (DOE) Office of Energy Efficiency and Renewable Energy (EERE) under the Building Technologies Office, Award Number DE-EE0009080.

7400 14th Ave., Denver, CO 80214 | info@icastusa.org | 866.590.4377 | icastusa.org

Preface

Thank you for your interest in reducing energy waste in multifamily (MF) properties, specifically MF affordable housing (MFAH). Even though this Resource Guide is focused on MF and MFAH properties, its applicability can be across the spectrum of buildings, from single-family homes to commercial buildings. This is because MF buildings are essentially commercial buildings for residential purposes. Unitary energy systems in a MF building are similar to single-family systems, while central systems or those for common areas in the MF building are similar to those deployed in commercial buildings.

This publication is part of a multi-year project designed to catalyze the adoption of very high-efficiency (VHE) technologies in MFAH. This Resource Guide is meant to help MF owners and managers, policymakers, regulators, utilities, energy efficiency program implementers, and affordable housing stakeholders overcome the barriers to deploying VHE technologies such as heat pump HVAC and water heaters in MF properties.

This Resource Guide includes fact sheets on the VHE technologies; white papers on industry best practices on deploying VHE solutions for the MF sector and policy guidelines to promoting VHE deployment; research on market, policy, and regulatory barriers to VHE deployment in MF and recommendations for overcoming those barriers; case studies that showcase VHE system deployments; and other information on programs to train individuals on the design and installation of these VHE technologies.

This Guide is meant to help increase the energy efficiency of MFAH, reduce utility bills for the income-qualified residents, and make their homes healthier, safer, and more comfortable. Mass deployment of VHE solutions can benefit the power grid, create local jobs and stimulate local economic development.

ICAST (International Center for Appropriate and Sustainable Technology) is a 501(c)(3) nonprofit with a mission to provide economic, environmental, and social benefits to underserved communities in a manner that builds local capacity. ICAST has a 20-year history of designing and managing utility-led, state, inter-state, and federal programs that leverage innovative green technologies to benefit low- and moderate-income (LMI) communities.

This Resource Guide has been made possible through support by the U.S. Department of Energy and their Building Technology Office, and other supporters. ICAST is grateful to all its supporters for their commitment to increasing access to green solutions for underserved and LMI communities.

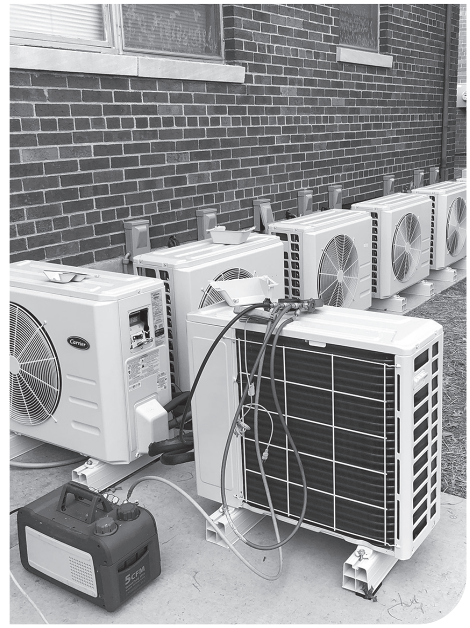
Table of Contents

Section 1

Fact Sheets for Property Owners and Managers

High-Efficiency Heat Pumps

What are Heat Pumps?



- Heat pumps are systems that transfer heat from one source to another. In summer, a heat pump moves hot air from inside the apartment to the outside, while in winter, it pulls heat from the outside into the apartment.
- There are three main types of heat pumps: air, water, and ground source. The most common type of heat pump is the air-source heat pump that transfers heat between the apartment and the air outside.
- Heat pumps can be used for space heating and cooling (HVAC) and also for domestic hot water (DHW).
- For apartment buildings, heat pump systems can be whole-building central solutions or for individual apartments.

How are Heat Pumps Similar/Different to Air Conditioners?

Heat pumps and air conditioners effectively function the same: they use compressed refrigerant to gather heat from inside the apartment, transfer that heat through the coils in the air handler, and release it into the outside air. The main differences are:

1. Heat pumps can reverse the process to also heat an apartment in the winter, thus not requiring another heating source.
2. Heat pumps are a lot more energy-efficient and thus cost less to operate. Very high efficiency heat pumps can be three times more efficient than resistance electric heat.

This material is based upon work supported by the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy (EERE) under the Building Technologies Office, Award Number DE-EE0009080.

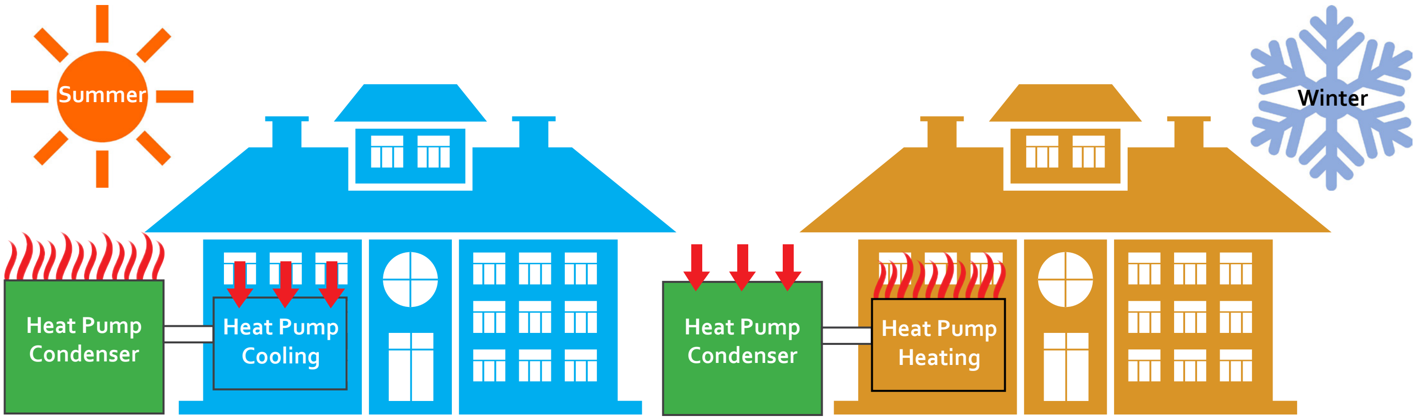
www.icastusa.org | 866-590-4377 | info@icastusa.org

ICAST is a nonprofit that provides economic, environmental, and social benefits to local communities. ICAST delivers green upgrades to multifamily homes to preserve affordable housing, address climate change, and create local jobs.

How Do Heat Pumps Work?

Heat pumps use coils inside and outside the apartment that act as either an evaporator or a condenser. In winter, the outdoor coils act as an evaporator while the indoor coils act as the condenser, so that heat gets transferred from the exterior coils and is released into the apartment. In summer, the process is reversed, transferring heat to the exterior and keeping the apartment cool.

With technological advancements of inverter-driven compressors, heat pumps can now operate in sub-zero climates.



Pros & Cons

Pros:

- Heat pumps use far less energy than traditional HVAC and DHW systems, resulting in lower utility bills and less environmental impact.
- Heat pump HVACs have lower up-front costs since the one system acts as both a heater and an air conditioner.
- High-efficiency heat pumps dehumidify air better than standard central air conditioners.
- Heat pumps have an extended warranty of 10 to 12-years.

Cons:

- Older generation heat pumps can lose effectiveness in temperatures below 30 degrees. But newer cold-climate heat pump mini-split systems can operate effectively well below 0°F, depending on the equipment and manufacturer.
- DHW heat pumps cost more than traditional hot water heaters. But new technology solutions, currently available outside the USA, that combine the HVAC and DHW into one heat pump system can reduce costs below traditional systems and reduce space needed for HVAC and DHW inside the apartment.

Did you know?

Today's heat pumps can reduce electricity use by as much as 70% when compared to electric resistance heating (for both space heating and cooling, and domestic hot water).

This material is based upon work supported by the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy (EERE) under the Building Technologies Office, Award Number DE-EE0009080.

High-Efficiency Heat Pumps

ICAST

Why Install High-Efficiency Heat Pumps in Multifamily Buildings?

1. Lower Capital Costs

- Combining the heating and cooling systems into one piece of equipment can lower upfront equipment costs.
- Install only one piece of equipment vs. a furnace (or electric resistance heating) and an air conditioner lowering the install cost. Also, the price of ducting the apartment can be lower with ductless systems.
- A combined HVAC and hot water heat pump system will reduce capital costs and reduce the space needed to place the equipment inside the apartment.

2. Lower Operating Costs

- High-efficiency units reduce the energy needed to heat, cool, or produce hot water, saving utility costs.*
- Lowering utility bills means tenants stay longer, which equals lower turnover and less turn costs for the multifamily property owner.

3. Greater Tenant Satisfaction

- Heat pump HVAC systems operate with much less noise resulting in higher occupancy rates** and higher NOI for the multifamily property owner.

4. Reduced Maintenance Costs

- Heat pump technology has come far in the last few years. It is more dependable and reliable, which reduces constant maintenance.
- Heat pump units generally come with 10-12 year warranties.

5. Reduced Financing Costs

- Most green loans from Fannie, Freddie, or FHA require high-efficiency equipment that provides a certain percentage of savings over 'baseline,' heat pump solutions meet that criteria.

6. Meet Local Code

- High-efficiency heat pumps can help achieve the efficiency measures required by new state and municipal building codes, including California's Title 24 Standard for Code Compliance and NYC's Local Law 97.
- After 2020, only recovered, recycled, or reclaimed supplies of R-22 will be available for existing systems that depend on R-22 refrigerant for air conditioning systems.

**According to the Department of Energy, converting from electric resistance heating to high-efficiency heat pumps could save up to 50% of annualized energy-related costs depending on the climate.*

*** According to the EPA, there is, "Empirical evidence suggests that many buildings exhibit lower vacancy rates when the building has higher energy and environmental performance."*

This material is based upon work supported by the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy (EERE) under the Building Technologies Office, Award Number DE-EE0009080.

www.icastusa.org | 866-590-4377 | info@icastusa.org

IICAST is a nonprofit that provides economic, environmental, and social benefits to local communities. ICAST delivers green upgrades to multifamily homes to preserve affordable housing, address climate change, and create local jobs.

Section 2

WHITE PAPER

Industry Best Practices for Adoption of Very High-Efficiency Heat Pump Technology in Multifamily Properties

Industry Best Practices for Adoption of
Very High-Efficiency Heat Pump Technology in Multifamily Properties

A White Paper by:
International Center for Appropriate and Sustainable Technology (ICAST)

March 2022

Sponsored by:
U.S. Department of Energy

This white paper is a result of the work supported by the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy (EERE) under the Building Technologies Office (BTO) Award Number DE-EE0009080.

Table of Contents

Acronyms and Abbreviations

ACEEE: American Council for an Energy-Efficient Economy

ASHP: Air-Source Heat Pump

AWHI: Advanced Water Heating Initiative

AWHS: Advanced Water Heating Specification

ccASHP: Cold-Climate Air-Source Heat Pump

DOE: United States Department of Energy

EE: Energy Efficiency

EEM: Energy Efficiency Measure

EEN: Efficiency Excellence Network

EMT: Efficiency Maine Trust

GHG: Greenhouse Gas

HP HVAC: Heat Pump-Based Heating, Ventilation, and Air Conditioning

HPWH: Heat Pump Water Heater

HSPF: Heating Seasonal Performance Factor

HVAC: Heating, Ventilation, and Air Conditioning

ICAST: International Center for Appropriate and Sustainable Technology

ISO-NE: Independent System Operator—New England

LI: Low-Income

LMI: Low- and Moderate-Income

Multifamily: MF

MFAH: MF Affordable Housing

NEEA: Northwest Energy Efficiency Alliance

NYSERDA: New York State Energy Research and Development Authority

OSS: One-Stop-Shop

PV Solar: Photovoltaic solar

RMI: Rocky Mountain Institute

RMP: Rocky Mountain Power

SEER: Seasonal Energy Efficiency Ratio

SMUD: Sacramento Municipal Utility District

VHE: Very High-Efficiency

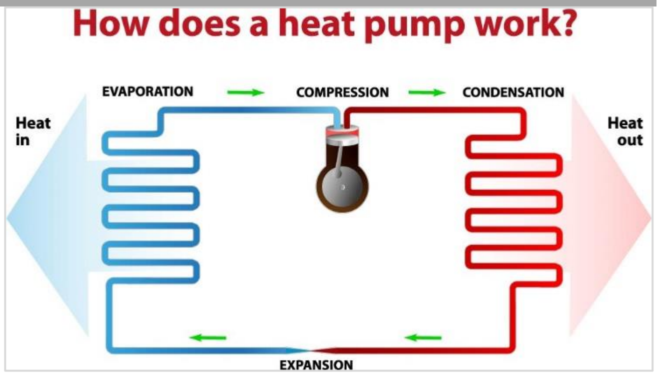
WSHP: Water-Source Heat Pump

Introduction

Very high-efficiency (VHE) heat pump based heating, ventilation, and air conditioning (HP HVAC) and heat pump based water heaters (HPWHs) can assist the United States in achieving critical greenhouse gas (GHG) reduction goals and help to preserve housing affordability for low- and moderate-income (LMI) communities. ICAST (International Center for Appropriate and Sustainable Technology) is a national nonprofit that provides green upgrades to the multifamily (MF) housing market, with a focus on the affordable housing sector. With funding from the U.S. Dept. of Energy (DOE), ICAST has been working to catalyze the mass adoption of VHE systems, having already facilitated the installation of over 10,000 HP HVACs in the MF market.

This White Paper provides an overview of the prevalent VHE technologies and outlines the best practices for deploying those VHE technologies in the MF housing market. The paper is organized by the types of HP HVAC technologies, i.e., air-source heat pumps (ASHPs), ground-source heat pumps (GSHPs), and water-source heat pumps (WSHPs); and HPWHs. ICAST reviewed programs across the nation that were successful in deploying VHE systems at scale. Not every successful program served the MF market, but some of their approaches are applicable to the MF housing market. This White Paper leverages applicable approaches from our research and ICAST's own experience delivering VHE technologies at scale to the MF market, to summarize the current industry best practices for deploying VHE heat pump technology in MF housing.

Overview of Technology



Heat pumps are an energy-efficient alternative to conventional systems for space heating and cooling, such as furnaces, boilers, central air conditioners, and chillers, as well as hot water systems. Heat pumps can heat a space or water by moving available heat from one space to another, rather than generating heat (DOE n.d.b). Heat pumps for space and water heating can be several times more efficient than their conventional counterparts (Pantano, Malinowski, Gard-Murray, and Adams 2021; DOE n.d.c). However, despite their potential to reduce utility bills and GHG emissions, VHE heat pump systems have struggled to gain traction in the U.S. All conditioned air systems, including refrigerators, are a form of heat pump. The basic refrigeration cycle has been utilized on a worldwide scale for more than 140 years.

Heat pumps as a heating appliance have also been available in the U.S. market since the 1970s and have performed well in warmer climates such as Florida because winter temperatures there do not dip below 40°F. These first-generation heat pumps, even though limited in their cold weather performance, performed well without any supplemental heating when the outside temperature stayed above 40°F. Newer heat pumps utilize advanced approaches, like inverter-driven compressors, to improve performance and efficiency, especially in colder climates, allow for installation in all U.S. climate zones, including Alaska, largely without the need for backup heat (McKenna, Shah, and Silberg 2020).

The widespread adoption of VHE technologies would greatly assist the United States in becoming more energy efficient and achieving critical carbon reduction goals. Minimum standard-efficiency heat pumps perform well in climate zones 1, 2, and 3 (provided in **Figure 1: IECC Climate Regions**). However, VHE equipment would yield significant energy savings in the cooling season (which is 7-9 months of the year). In climate zones 4-8, where energy consumption is driven by the heating season, widespread adoption of VHE technology would greatly reduce energy usage during the heating season and would yield more moderate savings during the cooling season, especially in the more northern climate zones.

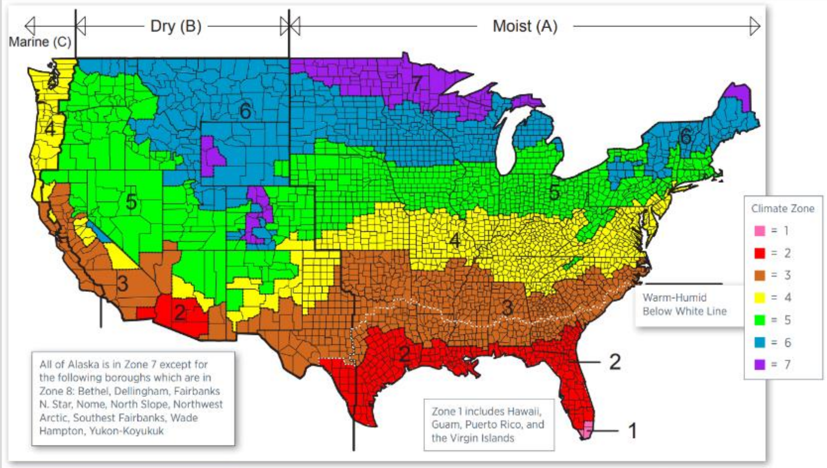


Figure 1: International Energy Conservation Code (IECC) Climate Regions Image provided by the U.S. DOE: Building America Best Practices Series, Volume 7.3: Guide to Determining Climate Regions by County, August 2015

Although this new generation of heat pumps have been successfully installed by the tens of thousands, the technology has encountered many barriers to mainstream adoption and remains a small percentage of installed the heating, cooling and hot water equipment, as evidenced by **Figure 2: Global Heat Pump Adoption Rates.** In 2019, heat pumps met approximately 5% of residential heat demand, while fossil fuel-based and conventional electric technologies made up three-quarters of sales globally (Abergel 2021).

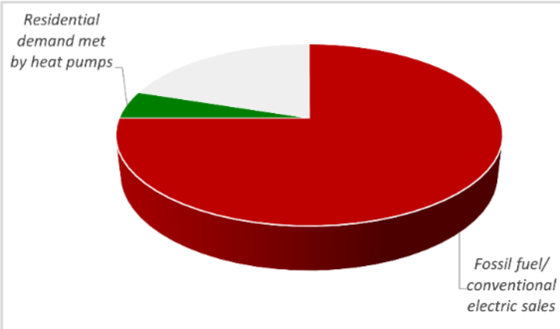


Figure 2: Global Heat Pump Adoption Rates

Very High-Efficiency Systems in Multifamily Housing

More than half of the household energy consumption and 40% of household energy bills in the U.S. are for residential heating and cooling (Pantano, Malinowski, Gard-Murray, and Adams 2021). Approximately 80% of all heating and cooling systems currently in use are inefficient and this applies to residential, commercial, and industrial buildings (Ibid.). Even though this White Paper is focused on MF and MFAH properties, its applicability can be across the spectrum of buildings, from single-family homes to commercial buildings. This is because MF buildings are essentially a commercial building for residential purposes. Unitary energy systems in a MF building are similar to single-family systems, while central systems or those for common areas in the MF building are similar to those deployed in commercial buildings.

High-efficiency heat pumps can be critical to GHG reduction and housing affordability, as they can be used for both heating and cooling and are approximately four times more efficient than their conventional counterparts

(Ibid.; McKenna, Shah, and Silberg 2020). MF housing is a historically underserved segment, comprising low-rise residential, mid-rise, and high-rise properties, and often serving LMI families, fixed-income seniors, and disabled individuals (Samarripas and York 2019). Deployment of VHE technologies in MFAH can:

1) curb property owners' operational costs, such as maintenance or repairs for old, faulty, or simply more expensive and inefficient conventional systems;
2) Offer VHE equipment at the same or lower cost to replace aging HVAC and hot water systems (assuming available incentives bridge the budget gap between VHE and baseline equipment installs)
3) reduce tenants' utility bills; and
4) create healthier, safer, and more comfortable environments for LMI tenants (NEEP 2020; NRDC 2014).

However, ICAST's experience in serving the MF market shows that very few MF owners have the resources (knowledge, staff, or funding) to implement VHE upgrades. Further, there are myriad barriers to VHE adoption in the MFAH space, such as insufficient incentives to offset upfront costs for most VHE heat pump systems; limited education for contractors, consumers, and distributors; and limited training in VHE installations for installers. VHE upgrades in MFAH can also be accompanied by technical challenges. For example, HPWHs have different physical space requirements than gas water heaters and must be able to exhaust cold air as a by-product of producing hot water. In extremely cold climates, dual-fuel heat pumps (i.e., an electric heat pump with a gas furnace) may be necessary for sufficient heating, though modern VHE HP HVAC systems can largely operate without backup heating (McKenna, Shah, and Silberg 2020). Further, while electric-to-electric equipment conversions typically do not require additional upgrades to the electrical infrastructure (i.e., electrical panels and transformers), such upgrades may be required for gas-to-electric conversions, or fuel-switch replacements. Fuel-switch upgrades have significant decarbonization benefits but they can be very costly, and while some utilities such as Sacramento Municipal Utility District (SMUD) have begun incentivizing electrical infrastructure upgrades, those utilities are the exception (Nadel 2020).

Surmounting such barriers is key to reducing utility bills and improving quality of life for underserved residents in multifamily housing. Low-income (LI) MF residents typically experience disproportionately high energy burdens (Drehobl, Ross, and Ayala 2020). Many MF buildings were built before or during the 1970s, making them 50 years old and energy inefficient with health and safety hazards for tenants (JCHS 2021). ICAST manages energy efficiency (EE) programs sponsored by utilities and states and accesses others for its MF clients. Based on its experience, most of these EE programs focus on incentivizing 'low-hanging fruit' energy efficiency measures (EEMs), such as LED lighting, low-flow devices, weatherization, and thermostats, while many others offer a prescriptive incentive for a very limited list of EEMs. ICAST has found that sufficient incentives for the installation of VHE HVAC and HPWH are currently the exception, but some programs are leading the way with innovative ideas on promoting the installation of VHE equipment. We will cover these exceptional programs below, and showcase them as case studies that others need to emulate.

Industry Best Practices

New heat pump technology has been shown to be effective, even at extremely low temperatures. Successful installations in locations such as Park City, UT, upstate New York, and Alaska, where temperatures can get down to -20°F, will help to spur the adoption of this VHE technology. This paper investigates best practices that have shown promise in facilitating the adoption of VHE heat pump solutions, and are referenced and presented below as case studies, as examples to scaling this technology in the MF housing industry.

Programs to deploy high-efficiency heat pumps to replace fossil fuel and electric resistance space heating in residential and commercial buildings have been growing, primarily in the West Coast and Northeast (Nadel 2020). Programs are funded by Federal, State or Local Government programs or utilities. While some of these programs have achieved market penetration (e.g., Efficiency Vermont), others are still relatively nascent (VEIC 2018; Nadel 2020). To increase participation, some programs offer upstream incentives to manufacturers and distributors while others offer incentives downstream to end-use consumers as well as education and training to contractors and consumers (Nadel 2020; DCASR 2021).

Most of these programs promote multiple VHE technologies, including ASHPs, GSHPs, and HPWHs, but ASHPs experience greater program focus and customer uptake due to factors including lower costs and greater availability (DOE n.d.b; Nadel 2020; VEIC 2018). One such program for MF housing is managed by ICAST for Rocky Mountain Power (RMP). The program covers retrofits and new construction projects for market-rate and income-qualified properties. The program covers the entire MF property, including in-unit residential and common-area commercial meters. The program offers customer rebates based on the deemed energy savings achieved by the retrofit project at each MF property. ICAST offers its award-winning one-stop-shop (OSS) approach to serving the MF client by providing site assessments, design reviews, energy modeling, access to financing, project planning, local contractor and construction oversight, education and training for property maintenance staff, and measurement and verification services. The program allows ICAST to be the sole point of contact for mixed-use MF properties, or projects with MF and single-family (SF) homes on the same property, making it easy for the RMP customer, to access their incentives and available services from one source, rather than engage with multiple service providers. This program has facilitated the installation of over 10,000 cold-climate ASHPs (ccASHPs) and continues to increase the number of installations each year at a growth rate exceeding 50%. Most of the ccASHPs installed are 1.5- to 2-ton systems. A micro apartment may install a 0.5- or 1-ton system and a large 3- or 4-bedroom apartment might utilize a 3-ton system, as do some of the common areas. Central VRFs are rare in MF properties.

To gain information on other MF installs, ICAST attempted to obtain implementation data from manufacturers, such as a list of their MF installation sites. The attempts were unsuccessful because manufacturers are two steps removed from the actual installs. So, ICAST talked to multiple HVAC contractors regarding their heat pump installations at MF properties, and the data gleaned through those discussions is incorporated into this paper. One such data point was the predominance of ASHP technology with most contractors, primarily due to cost considerations for the MF retrofit market. Discussions with manufacturers indicated that they react to market needs and are not influencers to create market demand. Manufacturers will supply whatever equipment their customer demands.

A summary table of ICAST's findings from existing literature, interviews, and its own experience serving the MF housing market, is provided below:

Tech. Type	Features	Best Applications	Implementation Challenges	Successful Programs[1]	Recommended Incentives
ASHP	- Outdoor compressor - Condenser (heat exchanger) - Air distribution system	Unitary HVAC replacements	1) Lack of education for contractors, consumers, and distributors leading to insufficient market demand to motivate manufacturers to produce them at volume and lower costs. 2) Upfront costs are higher than for conventional systems and available incentives rarely make up the cost difference. 3) Lack of knowledge regarding benefits including cost savings or even available incentives.	1) Minnesota ASHP Collaborative; 2) Efficiency Vermont heat pump rebate program; 3) Efficiency Maine heat pump program; 4) Zero Energy Now	Downstream incentives for consumers that can be paid directly to contractors. Incentives should be custom rebates tied to energy savings achieved rather than prescriptive rebates tied to the expected cost of the equipment. Incentives should be offered for fuel-switch upgrades.
GSHP	- Ground loop/water source heat exchanger - Indoor compressor - Distribution system	MF properties with sufficient space for horizontal drilling or budgets for vertical drilling, or located near ponds/lakes	1) Too expensive for the MF market; upfront costs cannot be justifiably offset by incentives. 2) Need access to sufficient ground acreage. 3) Few large-scale successful deployments, fewer incentive programs and a lack of education and outreach	New York State Energy Research and Development Authority (NYSERDA) GSHP Initiative	1) Midstream incentives for contractors and distributors 2) Downstream incentives for consumers
WSHP	- Central heating system - Central cooling system - Heat exchanger - Distribution system	Large MFAH properties with central mechanical rooms for chiller/boiler	1) Too expensive for the MF market; upfront costs cannot be justifiably offset by incentives. 2) Requires access to large amounts of water that is not always readily available. 3) No large-scale deployments and thus, a dearth of incentives, education, and outreach efforts	None to date.	No large-scale retrofit programs to date; thus, no specific recommended incentives for achieving widespread adoption.
HPWH	- Compressor - Storage tank	Central or in-unit if sufficient vertical space in mechanical closet	1) Too expensive for the MF market; upfront costs cannot be justifiably offset by incentives. 2) Very small (2%) market share of water heating technologies, thus a lack of education at all levels for consumers, contractors, distributors	1) Efficiency Vermont; 2) SMUD Go Electric; 3) Advanced Water Heating Initiative	Midstream and Downstream incentives based on deemed savings and should be offered for gas-to-electric and electric-to-electric conversions

[1] Non-comprehensive; describes successful programs featured in this White Paper to illustrate applicable best practices in deploying VHE technologies.

Air-Source Heat Pumps

ASHPs use the refrigeration cycle to transfer heat from outdoor air for indoor space conditioning; as the external temperature varies throughout the heating and cooling season, the performance of an ASHP will vary considerably over the annual cycle and therefore 'seasonal' efficiencies should be considered (MCS 2020). ASHPs can either be ductless or ducted. A relatively new class of ASHPs which have been improved to perform efficiently in cold climates, sometimes referred to as cold-climate ASHPs (ccASHPs), can provide comfortable heating for a home when outdoor temperatures are well below 0°F, depending on the equipment and manufacturer. Many of the ccASHP models work with little or no need for supplemental or backup heating (which was commonly required in first-generation heat pumps). For example, using historical hourly weather conditions and performance data for modern ASHPs, Rocky Mountain Institute (RMI) calculated operational year-round heat pump efficiency (adjusted for backup heat where needed) for each state's most populous city and found that backup electric resistance heat was rarely required. In Fargo, North Dakota, which falls under DOE's designation of a Cold/Very Cold state (see **Figure 3: Building America Climate Zones**) and has an average minimum daily temperature of -23°F, backup capability was needed for approximately 5% of the year (McKenna, Shah, and Silberg 2020). ASHPs and ccASHPs do not generate heat directly, rather they transfer heat to run a refrigeration cycle whose product is heat. Therefore, they can heat a home approximately four times more efficiently than a heating system which relies on a thermal efficiency through burning fossil fuels for heat. (Pantano, Malinowski, Gard-Murray, and Adams 2021; McKenna, Shah, and Silberg 2020).

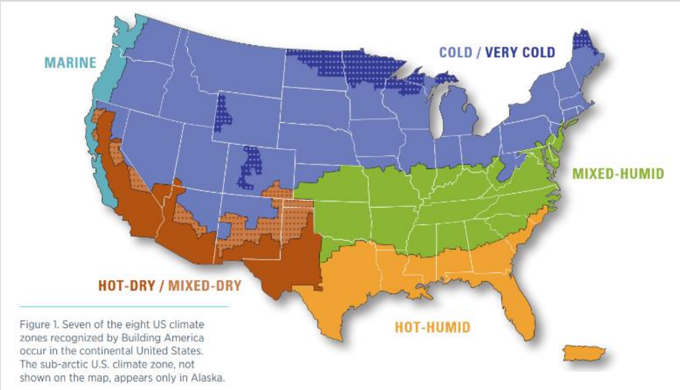


Figure 3: Building America Climate Zones

Image provided by the U.S. Department of Energy: Building America Best Practices Series, Volume 7.3: Guide to Determining Climate Regions by County, August 2015

Older existing HVAC equipment in MF properties that ICAST retrofits, built in the 1970s, have efficiencies as low as 6.0 Seasonal Energy Efficiency Ratio (SEER), which is a measure of a system's cooling efficiency, and 5.0 Heating Seasonal Performance Factor (HSPF), which is a measure of its heating efficiency. In contrast, present-day minimum efficiency heat pumps are 14 SEER/8.2 HSPF (DOE 2012). ccASHPs can have efficiencies of 33 SEER/14.2 HSPF (NEEP n.d.). According to certain manufacturers, the ASHP units available today have balance points (the temperature at which they would shift from heat pump to back-up resistance heat) of 35°F; while ccASHPs are usually designed to run at 100% capacity at 5°F, continue to operate at 76% to 93% capacity at -13°F, and can operate all the way down to -18°F (Mitsubishi… 2020; LeMons 2020).

According to the American Council for an Energy-Efficient Economy (ACEEE), Maine has possibly the largest heat pump deployment program in the U.S. In addition to passing legislation committing to reduce GHG emissions 80% by 2050 below 1990 levels, the legislature has defined "beneficial electrification" and directed the Public Service Commission and the Efficiency Maine Trust (EMT, the state's third-party energy efficiency program administrator) to conduct studies, pilots, and full-scale programs to advance beneficial electrification in buildings and transportation (Nadel 2020). Among other electrification initiatives, EMT is leading a ductless heat pump program for both residential and commercial customers, with the following rebate offerings:

- Residential customers can receive up to a $1,000 rebate for the first indoor unit and $500 for a second one, with incentives tied to efficiency ratings.
- Enhanced rebates are available for eligible LI customers.
- Commercial customers can receive up to $1,250 in rebates for multizone units; the first zone qualifies for a $500 rebate and subsequent zones qualify for additional increments of $250.

The residential and commercial programs are funded by a combination of revenues from the Independent System Operator—New England (ISO-NE) Forward Capacity Market, funds from allowance sales in the Regional Greenhouse Gas Initiative, and a 'systems benefit charge' on each kWh of electricity sold in the state (Ibid.). Since 2011, more than 50,000 units have been installed through the program. Per the ACEEE, EMT attributes the high adoption rate to Mainers' sensitivity to volatile prices for delivered fuels and familiarity with hybrid heating systems; the high rebates have also contributed. EMT is also aggressively promoting HPWHs through its residential and LI programs.

ICAST research shows that the Rocky Mountain Power Custom DSM program for MF properties is possibly the largest VHE deployment program in the nation, specifically for MF properties and installing ccASHPs. Since 2018, this program has deployed over 10,000 ccASHPs in MF properties, with most of the installs in the last two years, for both retrofits and new construction. The custom incentive program is designed to minimize the cost differential between a business-as-usual install and a ccASHP install. The rebate is based on the energy savings achieved by each project. Retrofit project savings and thus rebates are based on efficiency of current equipment installed and the SEER and HSPF rating of the ccASHP replacing the current equipment. For new construction, the savings and rebate are based on the rating of the ccASHP and local code.

In 2016, the ACEEE conducted a study on multiple ccASHPs installed in Minnesota. Three sites were monitored during the 2015-2016 heating season. Data analysis was performed to determine energy savings, heating capacity, installed efficiency, and the ability to reduce reliance on the backup heating system. The project concluded the following (Schoenbauer, Kessler, Bohac, and Kushler 2016):

- The measured performance of ccASHP installed in real homes confirms the potential to provide significant energy savings (39% to 65% of space heating energy use) and cost savings (14% to 29% of space heating costs).
- ccASHPs reduce reliance on delivered fuels in 52% to 89% of homes.
- The reduced usage of propane could lead to even greater savings at times when limited availability makes propane unavailable or cost prohibitive.
- Further improvement of the controls and integration with the backup systems can result in increased utilization of the ccASHP – and would thus provide even greater savings and further reductions of delivered fuel consumption.
- Utility EE programs are able to successfully receive credit for energy savings achieved from ccASHPs through the reduction in delivered fuels.

Efficiency Vermont launched its first heat pump rebate program in 2014 and has since incentivized more than 19,600 heat pump installs (Nadel 2020). Efficiency Vermont developed the program through engagement with manufacturers to understand and promote heat pumps that could perform in cold climates and partnerships with distributors to ensure those models were in stock, and by training local contractors to properly install the technology (Efficiency Vermont 2021). Efficiency Vermont attributes their program success to the combination of midstream program delivery and an aggressive supply chain strategy. Efficiency Vermont provides midstream incentives to wholesale distributors who are, in turn, required to pass the cost savings on to contractors in the form of an instant discount at the point of purchase. Efficiency Vermont sends a letter to consumers, explaining that their contractor has received a discount on the equipment, which in turn motivated contractors to pass the cost savings on to the customer. In addition, customers could receive financial incentives from their electric retail provider; moderate-income customers (with incomes of 80% to 120% of area median income (AMI)) were eligible for an additional $200 rebate (Nadel 2020).

Going forward, Efficiency Vermont plans to continue providing midstream rebates in collaboration with retail electric providers, while developing the supply chain through training, education, and promotion. Efficiency Vermont also provides electrification support services, such as facilitating the processing of ccASHP rebates for Green Mountain Power (Vermont's largest utility) and other interested parties. This enables participating distributors to engage in one seamless transaction rather than working with two separate programs (Nadel 2020).

Zero Energy Now is another program in Vermont that is encouraging the adoption of ccASHPs. The program was launched in 2016 by the Building Performance Professionals Association of Vermont, Green Mountain Power, and Efficiency Vermont, with the goal of moving Vermont homes closer to net zero energy (Nadel 2020). Zero Energy Now provides a comprehensive package of retrofit services, including weatherization, heat pumps, and photovoltaic (PV) solar. Installing ccASHPs has been a key component of minimizing each home's energy consumption. In 2016–2017, 35 projects were completed through the program; actual savings for 24 of these projects resulted in 64% average electric grid and fossil fuel savings, for an average of $1,861 savings per year (Ibid.). To encourage deeper fuel savings, Zero Energy Now also encourages the installation of HPWHs. ICAST has found that this approach, i.e., leveraging heat pumps with weatherization and renewable energy generation, is the most effective for the MF market for several reasons: 1) better windows, insulation, air and duct sealing, and other weatherization measures reduce the loss of hot or cold air, consequently reducing the size of the VHE system and the work it needs to do to effectively condition the space; 2) it drives the deepest energy savings and therefore the greatest utility bill reductions for tenants; and 3) it maximizes efficient delivery of the retrofit by providing all of these services at one time under one contract.

A collaboration between the nonprofit Center for Energy and Environment and five Minnesota utilities aims to make heat pumps mainstream by the end of the decade by offering generous rebates to consumers. The Minnesota Air Source Heat Pump Collaborative identified rebates available to customers in nearly every utility territory, ranging from $200 to $2,000 (Jossie 2021). As a result, the number of rebates awarded by its members more than doubled to 3,107 in 2020 compared to 1,356 in 2019. The recent rise of heat pumps in those territories is a result of 1) more generous rebates; 2) supply chain problems with air conditioning equipment (cooling only); and 3) more people doing improvement projects (Ibid.). Utility officials expect those numbers to keep climbing, in part due to the state's recently signed Energy Conservation and Optimization Act. The legislation frees up utilities to make comparisons between propane and other fuels when marketing heat pumps. In addition, it allows utilities to count energy savings from fuel-switching toward their energy conservation targets. Utility EE programs classically stay within their fuel type for defined programmatic savings goals (like for like replacements, i.e., a gas furnace being replaced by a more efficient gas furnace, or electric resistance furnace to heat pump). A reprioritization on electrification that considers gas consumption in relation to electric consumption under the lens of fuel energy intensity and GHGs will empower legislators and utility commissions to compare all fuel types against one another instead of only comparing to the same fuel type.

ICAST is part of the newly created “Clean Energy Construction Career Accelerator” in Denver, Colorado, which is part of a Denver initiative, ‘Workforce Development for Good Green Jobs,’ from Denver’s Office of Climate Action, Sustainability, and Resiliency. With Denver’s push towards decarbonization, upskilling small contractors with the skills needed to perform beneficial electrification activities (including installation of ccASHPs) will become essential. ICAST has partnered with the Energy Efficiency Business Coalition to provide training to local contractors on the installation of ccASHPs – training that includes on-the-job experience in installing ccASHPs at actual project sites. This workforce program not only advances Denver’s decarbonization goals but also helps the local electric utilities push their incentive programs to promote VHE technologies. And perhaps most importantly, these trainings build a workforce that can help drive down the cost of installs through simply increasing the supply of available talent for such installs.

Workforce training is crucial for installers to deliver appropriate, high-quality installs tailored to MFAH households or properties. For example, “right-sizing” HP HVAC installs helps reduce residents’ utility costs and maximize the longevity and efficiency of the equipment. Without sufficient education, contractors may recommend equipment sizes based on apartment square footage, capacity of the old equipment, or their personal experience, rather than conducting comprehensive energy audits or using recommended HVAC sizing resources. Leading sizing procedures in the U.S. are produced by the by the Air Conditioning Contractors of America and found in Manuals J (used to calculate heating and cooling needs) and S (used to determining the appropriate equipment based on Manual J calculations) (ACCA 2015; FSEC 2002). Manual J calculations account for sources of heat gain or heat loss, e.g., insulation, leaky ducts, building envelope inefficiencies, etc. (ACCA 2015; FSEC 2002). In deeper retrofits where multiple EEMs are used, it is essential for contractors to account for measures that trap hot or cold air indoors and thus, reduce the necessary capacity of the new HP HVAC system. Another area where education is key is fuel-switch upgrades—contractors must be able to understand, and clearly explain to the MFAH customer, the necessary upgrades to the electrical infrastructure as well as the associated costs. They also must be able to articulate the long-term benefits of those upgrades that offset higher upfront costs, such as reduced operational costs over the long term.

Ground-Source Heat Pumps

GSHPs, or geothermal heat pumps (GHPs), have been in use since the late 1940s and have been endorsed by both DOE and EPA for their high efficiencies and environmental benefits (IGSHPA n.d.; DOE n.d.a). They use the relatively constant temperature of the earth (a few feet below the earth's surface the ground remains at a relatively constant temperature), as the exchange medium, instead of the outside air temperature. Depending on latitude, ground temperatures range from 45°F to 75°F (DOE n.d.a). This ground temperature is warmer than the air above it during the winter and cooler than the air above it in the summer. The GSHP takes advantage of these more favorable temperatures to achieve high efficiencies by exchanging heat with the earth through a ground heat exchanger (Ibid.). Relative to ASHPs, they are quieter, last longer, need little maintenance, and can heat and cool in any location and condition because their efficiencies and capacities are not as affected by the temperature of the outside air (IGSHPA n.d.).

A dual-source heat pump is a combination of an ASHP with a GSHP. Dual-source heat pumps have higher efficiency ratings than air-source units, but are not as efficient as geothermal units (DOE n.d.a). The main advantage of dual-source systems is that they cost much less to install than a geothermal-only unit and work almost as well (Ibid.).

The downside of GSHPs is that they are expensive. The cost of an installed GSHP can be a lot more than the cost of an ASHP, for the same heating and cooling capacity. For a MF property, where the need to access sufficient ground acreage can add significant costs for the vertical collectors, the total cost of a GSHP installation can be prohibitively high. Due to the split-incentive i.e., owners paying for the install while tenants benefit from lower utility bills, a MF property is unlikely to invest in this expensive solution, even though the additional costs may be returned in energy savings and a longer system life (estimated at up to 24 years for the inside components and 50+ years for the ground loop). According to the U.S. Department of Energy, approximately 50,000 GSHPs are installed in the U.S. annually (DOE n.d.a).

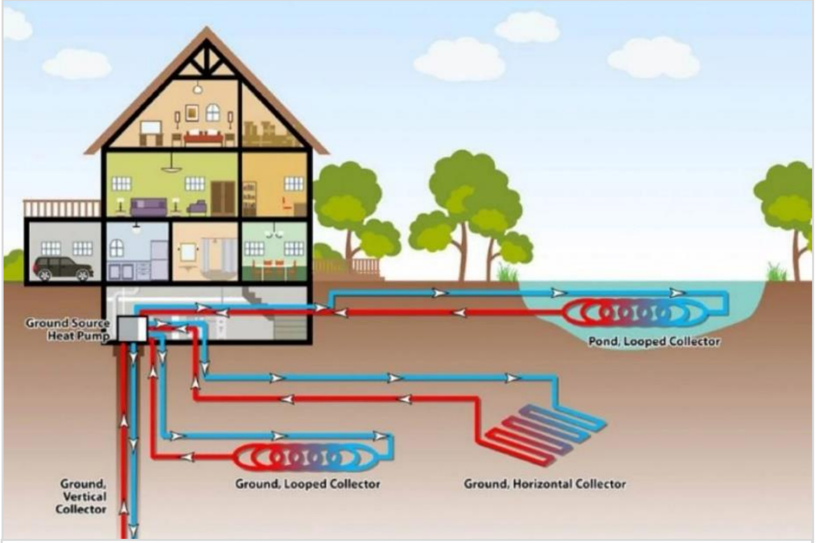


Image provided by Climatebiz: "What Temperature Does a Ground Source Heat Pump Produce?" August 24, 2021

While heat pump initiatives sometimes include GSHPs, there are some initiatives that specifically target GSHPs, that could be referenced as best practices to promote GSHPs. One such program was launched by NYSERDA, which included distinct ASHP and GSHP initiatives, in partnership with manufacturers, distributors, and contractors (VEIC 2018; Dyson 2020). The program leveraged midstream incentives for the contractors from NYSERDA and downstream incentives provided to consumers by the utilities (VEIC 2018). The initiative comprised several components including: 1) direct incentives to GSHP and ASHP contractors and distributors to encourage wider adoption of these technologies; 2) marketing to GSHP and ASHP contractors to build awareness of the incentives which includes webinars, email notifications, web banner ads, ads in HVAC industry magazines, and phone calls to key Initiative trade allies when there are key changes in Initiative offerings or requirements; 3) an advisory group of GSHP professionals which included manufacturers, representatives from trade association groups, architects, designers, and engineers; 4) a co-op marketing effort where NYSERDA paid up to 50% of the installer's marketing costs as well as the costs of any marketing or technical training they may offer; and 5) a competition called the Geothermal Clean Energy Challenge jointly administered by NYSERDA and the New York Power Authority (Dyson 2020).

NYSERDA commissioned an evaluation report for the program which found that the initiative appeared to be having a positive impact on the GSHP market in NY: two thirds of the 15 GSHP installers interviewed for the evaluation reported seeing an increase in their sales since joining the Initiative. In addition, one of the two trade association representatives that were interviewed reported market growth in GSHP adoption and installations in areas where the GSHP rebate programs were operating heavily. In addition to the effects of the incentives, one trade association said that NYSERDA's sponsorship of the Initiative validated the GSHP technology for wary or unfamiliar customers (Dyson 2020). NYSERDA's evaluation report did not contain measured or verified energy savings achieved through GSHP installations.

Water-Source Heat Pumps

WSHPs work by extracting heat from a body of water and converting it into useful energy to heat your home (Energy Saving Trust 2019). They use a series of submerged pipes containing a working fluid to absorb the heat from a river, lake, large pond or borehole. This is then turned into useful heat for space heating and hot water by compressing the working fluid so it can give the heat off at a higher temperature (Ibid.). WSHPs are often more efficient than air-source devices because heat transfers better in water, and water temperatures are generally more stable throughout the year, while the average air temperature fluctuates a lot more over the year (Ibid.). WSHPs are typically more expensive than ASHPs. However, for a MF property, they have an additional disadvantage: they need access to large amounts of water.

There are a few case studies of WSHPs used in new construction projects, but market penetration of WSHPs in the retrofit market is minimal (Steven Winter Associates 2019). In the MF market, typically luxury buildings, a WSHP installed with a condenser loop in tandem with a central boiler plant and cooling tower can lower the typical high capital costs of individual WSHP systems in each apartment (Ibid.). ICAST was unable to find successful examples of MF retrofits with WSHPs that could be replicated and scaled.

Heat Pump Water Heaters

Similar to HP HVAC systems, HPWHs use electricity to move heat from one place to another instead of generating heat directly (DOE n.d.c). To move the heat, heat pumps work like a refrigerator in reverse. While a refrigerator pulls heat from inside a box and sends it into the surrounding room, a stand-alone ASHP water heater pulls heat from the surrounding air and transfers it—at a higher temperature—to heat water in a storage tank (ibid.). A HPWH system is typically an integrated unit with a built-in water storage tank and with a back-up resistance heating element. HPWHs are installed inside apartments because they remain in the 40°–90°F range and provide at least 1,000 cubic ft. of air space around the HPWH (Ibid.). Air passing over the evaporator is exhausted into the room or outdoors. This space requirement has been a hurdle for retrofit installs, especially in the MF housing, where utility closet space is limited; however, some newer HPWH models have designs that do not require this air space. Also, installing them in a space with excess heat, such as a utility closet in an apartment, increases their efficiency.

The U.S. Environmental Protection Agency found that HPWHs currently have 2% market share of water heating technologies; however, a growing number of stakeholder groups are leading market transformation efforts to increase HPWH adoption across the United States (EPA 2021; Perry, Khanolkar, and Bastian 2021). For instance, the Advanced Water Heating Initiative (AWHI) is a collaborative, market transformation effort by the New Buildings Institute with key partners Bonneville Power Administration, the Northwest Energy Efficiency

Alliance (NEEA), and SMUD, and more than 145 other organizations, all working to overcome market and technology barriers to catalyze and transform the market toward higher HPWH adoption. AWHI is laying the groundwork to increase the adoption rate steeply and rapidly and has working groups focused on residential and commercial technology and market advancement (Perry, Khanolkar, and Bastian 2021). The MF sector is one area of focus for AWHI; as an example, it began research and development of cross-cutting training modules for central HPWH field testing in large MF buildings. In addition to AWHI, several other national and regional efforts are underway to help accelerate HPWH technology adoption. The ENERGY STAR water heater program meets with manufacturers regularly as part of the Manufacturers Action Council. Additionally, both NEEA and Building Decarbonization Coalition recently announced consumer HPWH campaigns (Ibid.). ICAST's own market research shows that the cost difference between baseline hot water systems and HPHW is too large for available incentives to bridge the gap, at least in any cost-effective manner i.e., in meeting program cost-effectiveness metrics such as utility cost test (UCT) or total resource cost test (TRC).

Efficiency Vermont's Heat Pump Water Heaters program provides rebates at retail, online, wholesale, and distributor levels, achieving market penetration of more than 29 times the national average on electric-to-electric conversions (Nowak, Kushler, and Witte 2019). This is one of the programs showcased in ACEEE's profiles of successful program models in the category: *Leading upstream- and midstream-focused programs leverage rebates in product distribution channels for greater market impact.* Efficiency Vermont and Burlington Electric Department, the state's two EE utilities, implement the program. Efficiency Vermont has longstanding relationships with retailers and wholesalers/distributors. A sponsored HPWH contractor trade group (new in 2018) helps contractor-members of the Efficiency Excellence Network (EEN) of trade allies. The program uses the EEN and distributes point-of-sale collateral at retailers, and it also uses digital content marketing via social media, e-newsletters, and blogs that offer education, benefits, and customer stories. It offers digital advertising that targets "moments that matter" (e.g., water heater failure) and workshops, events, and campaigns that engage the community. The program accomplishments include:

1. 7,800 installed HPWHs since 2013; Vermont now has one of the highest uptake rates of HPWH technology, as a percentage of total water heater volume, in North America.
2. Nearly 60% market penetration on electric-to-electric conversions, which is upward of 2,900% above national average.
3. Energy Trust of Oregon, NEEA's Hot Water Solutions, AEP-Ohio, Puget Sound Energy, and NYSERDA have adopted the model.

ACEEE has identified five MF programs that incentivize HPWHs in existing buildings: SMUD, Bay Area Regional Energy Network, Rocky Mountain Power (RMP), Baltimore Gas and Electric, and Orlando Utilities Commission (Perry, Khanolkar, and Bastian 2021). ACEEE found that the SMUD Go Electric program offers some of the most robust HPWH incentives for MF. Go Electric leverages a deemed savings approach wherein SMUD provides incentives for individual technologies that shift end uses to electricity. The RMP program similarly offers incentives based on deemed savings for both electric resistance to HPWH and gas water heaters switching to HPWHs.

SMUD's Go Electric program is centered around building electrification, giving it more flexibility to incentivize HPWHs (Perry, Khanolkar, and Bastian 2021). In the past, the MF program was modeled on a comprehensive EE approach that gave owners incentives for kWh savings. However, the new electrification program uses a deemed savings approach in which SMUD provides incentives for individual technologies that shift end uses to electricity. SMUD funds the program using electrification funds and supplements it with EE funds. Eligible LI customers receive additional incentives. The Go Electric program provides significant up-front support to building owners interested in participating and program advisors help customers all through the process. In addition to financial incentives, SMUD offers expedited and streamlined permitting, which can greatly reduce project time. The program allows building owners to make upgrades in a staged approach so if an owner does not have the up-front capital necessary to retrofit their entire property at once, they can phase their project. The program also requires participants to deliver a Tenant Engagement Plan that provides education to tenants about the project and about ways to save energy (Ibid.).

The Northwest Energy Efficiency Alliance (NEEA) has worked closely with manufacturers, utilities, and other market partners to develop the Advanced Water Heating Specification (AWHS) (NEEA n.d.). This tool provides guidance in the development, manufacture, and marketing of HPWH products across the northwest region. By fostering communication and collaboration between product manufacturers, utilities, and HPWH installers, the AWHS has allowed for the development of a more optimized suite of available products for the region as well as a straightforward means of meeting consumers' needs. The AWHS designates a series of tiers for HPWH performance based on factors such as efficiency and customer comfort, with each tier having both an increased minimum Seasonal Coefficient of Performance baseline and requirements for additional features to provide further efficiency gains, consumer comfort, or cold climate resistance (NEEA 2019). While most tiers denote varying levels of existing HPWH products, the AWHS also establishes tiers beyond what is currently available as a guide for future product development, with the goal of further increasing HPWH adoption in the future (NEEA n.d.). These tiers and their requirements are updated annually to reflect the industry developments from the previous year. From 2015-2019, the market share of HPWH in the region served by the AWHS increased from 3% to 9%, with over 50,000 units sold; further, the current average HPWH is 30% more efficient than the best-in-class products in 2015 (Ibid.).

While there has been extensive metering of baseline energy consumption of conventional domestic hot water products, market penetration of HPWHs is low and field study data for HPWH performance in large-scale retrofit programs is limited. The DOE-funded grant that ICAST is currently implementing is attempting to study the impact of HPWHs but results are not yet available for publication.

Conclusions

The conclusions and recommendations below are meant for MF and MFAH buildings, but due to the fact that MF buildings are essentially a commercial building for residential use, they apply equally to single-family homes and commercial buildings. The unitary systems deployed in a MF apartment are the same for a single-family home and the central systems deployed in a MF building are similar to a commercial building as are larger systems for common areas in a MF building.

The one common theme for any successful VHE technology implementation program is that appropriate incentives (rebates) are crucial to achieving scale. Also, the size of the rebates will vary by region, due to various factors, including supportive policies (e.g., state-level GHG reduction plans), volume of VHE installs in the region, the availability of qualified installers and the price they charge for a VHE system install, etc. Interestingly, the cost of energy does not seem to impact the successful scaling of VHE solutions. We see successful programs in the Northeast with high cost of energy, both fuel oil and electricity, and in the Southwest with some of the lowest costs of energy, both gas and electricity. However, the successful programs cited above demonstrate that midstream (for the contractors) and downstream (for the consumers) incentives are vital to expanding VHE technology adoption. Contractors must be brought on board so that they can market VHE technologies to MF property owners/managers and assuage any concerns they have about the function or value of the technology. For consumers, the size of the incentives is even more important. ICAST's own experience and its discussions with MF owners/managers and also HVAC contractors across the nation, confirms that the MF market is extremely price sensitive. MF owners are loathe to spend extra money for a host of reasons, including the split-incentive (tenant pays the utility bills so any utility cost savings accrue to the tenants, while the owner makes the capital investment). To influence the MF market and hasten their adoption of VHE systems, the incentive must at a minimum cover the cost differential between the contractor-grade (baseline) equipment and the VHE equipment, so that the MF owner's budget for their planned HVAC or hot water system upgrade remains the same, or if possible, the rebate should offer the owner some cost savings on their capital costs to tip the balance in favor of VHE technologies.

Besides the size of the incentive, the design of the incentive program is also crucial to success. Utilities should provide custom rebate programs that offer incentives tied to energy savings achieved for each specific installation, rather than prescriptive rebate programs that offer the same rebate for a VHE system, irrespective of its size or efficiency. Custom rebates can keep the program up to date with evolving technologies and allow for newer, more efficient VHE solutions to be appropriately incentivized and promoted.

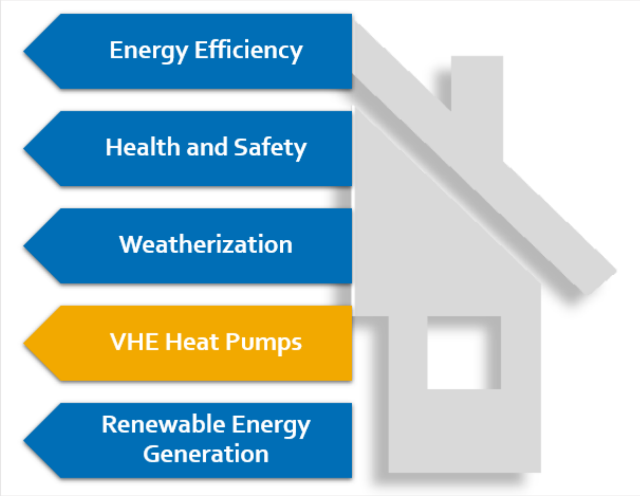
It is also essential to train contractors in best practices for delivering high-quality VHE installs. At the program level, education and training for contractors can grow local networks of qualified installers who can design, install, and maintain VHE systems, and deliver optimized VHE solutions to MFAH customers at a reasonable price. These networks can in turn support the programs' continued growth and advance widespread awareness and adoption of VHE systems.

Keeping it simple is another common theme with the successful programs. Even if the incentives are offered by multiple sources, the programs that make it easy for the consumer to access the multiple incentives, by making them all available through one common application or source, are more likely to be successful. Similarly, programs that combine the various services being offered into a one-stop-shop (OSS) service model are more likely to succeed because they make it easy for the consumer to access those services from one source, rather than engage with multiple service providers (auditors, contractors, utility DSM program implementer, utility, financier, etc.). This is especially true for the MF market where the owner, who benefits from these programs, is not engaged with the program, but it's the property manager, who sees more work for themselves, with no upside, when engaging with programs that are complex. The OSS approach helps overcome the multiple hurdles for the MF market by making it easy and simple for the MF customer to engage with the program.

While certain heat pump deployment practices are applicable in both the SF and MF markets, residential programs focusing on the SF market do not succeed in the MF market because the hurdles to achieving success are different for the two markets. Programs should offer solutions tailored to the unique challenges of the MF market, such as the split-incentive hurdle to achieve a higher success rate.

Policy changes that institute legislative mandates for VHE installations are an obvious winner when it comes to promoting VHE. A perfect example of a policy win for VHE is when some states (and their Public Utility Commissions) allowed rebates for a fuel-switch from gas heating to electric heating. Local governments banning the use of gas, i.e., not providing new gas connections, when coupled with local energy codes that require high performance buildings, can literally force the market towards VHE installations.

Finally, there is a caveat to this push towards VHE installs. With the low cost of natural gas, one downside for LI households is that replacement of gas equipment with heat pump technology (even VHE equipment) can result in an increase in utility costs (depending on climate and utility rates). The ideal approach to making VHE upgrades, in MF affordable housing especially, is to take a holistic view, where HVAC and HPWH upgrades are made in conjunction with other efficiency measures (such as LED lighting, low-flow devices, insulation upgrades, air and duct sealing, etc.) and perhaps even paired with PV solar, to effectively reduce utility bills for the LI tenants.



References

ACCA (Air Conditioning Contractors of America). 2015. *Instructors' Lesson Plans for Manual J – Residential Load Calculations, Manual S – Residential Equipment Selection, Manual D – Residential Duct Systems.* Arlington, VA: ACCA. https://www.acca.org/HigherLogic/System/DownloadDocumentFile.ashx?DocumentFileKey=f70b9778-19be-4577-8c72-5adae8c6d0ed&msclkid=69a97e16aa3a11ecb51599bfef9d3384

Browning, Kyle. 2021. "What Temperature Does a Ground Source Heat Pump Produce?"[2] *Climatebiz*, August 24, 2021. *https://climatebiz.com/ground-source-heat-pump-temperature/*

Dyson, Christopher. 2020. *Clean Heating and Cooling: Heat Pumps and Solar Thermal Market Evaluation: Final Report*. Prepared by Det Norske Veritas (DNV)[3] for NYSERDA. Madison, WI: DNV. https://www.nyserda.ny.gov/-/media/Files/Publications/PPSER/Program-Evaluation/2020-Heat-Pump-Market-Evaluation-Report.ashx

Baechler, Michael C., T. Gilbride, P. Cole, M. Hefty, and K. Ruiz. 2015. *Building America Best Practices Series, Volume 73: Guide to Determining Climate Regions by County*.[4] PNNL-17211 Rev. 3. Prepared by Pacific Northwest National Laboratory (PNNL) for the U.S. Department of Energy. Richland, WA: PNNL. https://www.energy.gov/sites/default/files/2015/10/f27/ba_climate_region_guide_7.3.pdf

DOE (U.S. Department of Energy). n.d.a "Geothermal Heat Pumps." Accessed January 22, 2022. https://www.energy.gov/energysaver/geothermal-heat-pumps

DOE. n.d.b "Heat Pump Systems." Accessed January 22, 2022. https://www.energy.gov/energysaver/heat-pump-systems

DOE. n.d.c "Heat Pump Water Heaters" Accessed January 22, 2022 https://www.energy.gov/energysaver/heat-pump-water-heaters

DOE. 2012. "Energy and Water Conservation Standards." *Federal Register* Vol. 3, Sec. 430-32 (January 1, 2012): Page 473. https://www.govinfo.gov/content/pkg/CFR-2012-title10-vol3/pdf/CFR-2012-title10-vol3-sec430-32.pdf.

DCASR (Denver Office of Climate Action, Sustainability, and Resiliency). 2021. *The Energize Denver Renewable Heating and Cooling Plan.* Denver, CO: DCASR. denver-renewable-heating-and-cooling-plan_june-2021.pdf (denvergov.org)

Drehobl, Ariel, L. Ross, and R. Ayala. 2020. *How High are Household Energy Burdens?* Washington, D.C.: ACEEE. https://www.aceee.org/research-report/u2006

[2] Image for GSHP, pg. 8

[3] Formerly Det Norske Veritas Germanischer Lloyd (DNV GL)

[4] Images for Climate Maps, pg. 3 and pg. 6.

Efficiency Vermont. 2021. "Little State, Big Impact." Accessed January 22, 2022. https://www.efficiencyvermont.com/20-year-impact-report

EPA (Environmental Protection Agency). 2021 ENERGY STAR® *Unit Shipment and Market Penetration Report Calendar Year 2019 Summary*. Washington, DC: EPA. www.energystar.gov/sites/default/files/asset/document/2019%20Unit%20Shipment%20 Data%20Summary%20Report.pdf

Energy Saving Trust. 2019 "Could a water source heat pump work for you?" London, England: Energy Saving Trust. https://energysavingtrust.org.uk/advice/water-source-heat-pumps/

FSEC (Florida Solar Energy Center). 2002. *Technology Fact Sheet: Right-Size Heating and Cooling Equipment*. Prepared for the U.S. DOE. https://www.nrel.gov/docs/fy02osti/31318.pdf?msclkid=d5c7a732a97f11ecaa62d54256edc4d1

Thibaut Abergel. 2021. *Heat Pumps.* Paris, France: International Energy Agency https://www.iea.org/reports/heat-pumps

IGSHPA (International Ground Source Heat Pump Association). n.d. "Geothermal: An Overview of Geothermal Ground Source Heat Pumps." Accessed January 22, 2022. https://igshpa.org/geothermal/

JCHS (Joint Center for Housing Studies of Harvard University). 2021. *The State of the Nation's Housing*. https://www.jchs.harvard.edu/sites/default/files/reports/files/Harvard_JCHS_State_Nations_Housing_2021.pdf

Jossie, Frank. 2021. "Heat Pumps on the Rise After Minnesota Passes New Energy Law." *U.S. News,* July 10, 2021. https://www.usnews.com/news/best-states/minnesota/articles/2021-07-10/heat-pumps-on-the-rise-after-minnesota-passes-new-energy-law

LeMons, Shawn. 2020. "Cold Climate Air Source Heat Pump Strategies." https://www.fcgov.com/greenbuilding/files/ft-collins-heat-pumps-shawn-lemons-8-24-21.pdf

McKenna, Claire, A. Shah, M. Silberg. 2020. "It's Time to Incentivize Residential Heat Pumps." *Rocky Mountain Institute*, June 8, 2020. https://rmi.org/its-time-to-incentivize-residential-heat-pumps/

MCS (MCS Certified). 2020. *Domestic Heat Pumps: A Best Practice Guide*. Cheshire, England: MCS. https://mcscertified.com/wp-content/uploads/2020/07/Heat-Pump-Guide.pdf

Mitsubishi Electric Trane HVAC Performance Construction Team. 2020. "Achieve Comfort and Reliable Performance with Cold-Climate Heat Pumps." Bend, OR: Zero Energy Project. https://zeroenergyproject.org/2020/01/22/achieve-comfort-and-reliable-performance-with-cold-climate-heat-pumps/

Nadel, Steven. 2020. *Programs to Electrify Space Heating in Homes and Buildings*. Washington, D.C.: ACEEE. https://www.aceee.org/sites/default/files/pdfs/programs_to_electrify_space_heating_brief_final_6-23-20.pdf

NEEA (Northwest Energy Efficiency Alliance). 2019. *Advanced Water Heating Specification Version 7.0: Specification for Residential Water Heaters*. Portland, OR: NEEA. https://neea.org/img/documents/Advanced-Water-Heating-Specification.pdf

NEEA. n.d. "2019 Success Stories." Accessed January 22, 2022. https://neea.org/annual-report/2019/2019-hpwh

NEEP (Northeast Energy Efficiency Partnerships). 2020. "Air Source Heat Pump Buying Guide." https://neep.org/sites/default/files/resources/ASHP_buyingguide_5.pdf

NEEP. n.d "NEEP's Cold Climate Air Source Heat Pump List." Accessed December 10, 2021. https://ashp.neep.org/#!/product_list/

Nowak, Seth, M. Kushler, and P. Witte. 2019. *The New Leaders of the Pack: ACEEE's Fourth National Review of Exemplary Energy Efficiency Programs*. Washington, D.C.: ACEEE. https://www.aceee.org/sites/default/files/publications/researchreports/u1901.pdf

NRDC (Natural Resources Defense Council). 2014. "Fact Sheet: Energy Efficiency for All." https://www.nrdc.org/sites/default/files/energy-efficiency-for-all-FS.pdf

Pantano, Stephen, M. Malinowski, A. Gard-Murray, N. Adams. 2021. *3H 'Hybrid Heat Homes': An Incentive Program to Electrify Space Heating and Reduce Energy Bills in American Homes*. CLASP. https://www.clasp.ngo/wp-content/uploads/2021/05/3H-Hybrid-Heat-Pumps_CLASP_May26.pdf

Perry, Chris, A. Khanolkar, and H. Bastian. 2021. *Increasing Sustainability of MF Buildings with Heat Pump Water Heaters*. Washington, D.C.: ACEEE. aceee.org/research-report/b2101

Schoenbauer, Ben, N. Kessler, D. Bohac, and M. Kushler. 2016. *Field Assessment of Cold Climate Air Source Heat Pumps*. Washington, D.C.: ACEEE. https://www.aceee.org/files/proceedings/2016/data/papers/1_700.pdf#:~:text=This%20paper%20reports%20on%20Center%20for%20Energy%20and,a%20traditional%20air%20conditioning%20system.%20ASHPs%20transfer%20heat

Samarripas, Stefen, and Dan York. 2019. *Closing the Gap in Energy Efficiency Programs for Affordable Multifamily Housing*. Washington, DC: American Council for an Energy-Efficient Economy. https://www.aceee.org/sites/default/files/publications/researchreports/u1903.pdf

Steven Winter Associates. 2019. *Heat Pump Retrofits Strategies for Multifamily Buildings*.

New York: Natural Resources Defense Council. www.nrdc.org/sites/default/files/heatpump-retrofit-strategies-report-05082019.pdf

VEIC (Vermont Energy Investment Corporation). 2018. *Driving the Heat Pump Market: Lessons Learned from the Northeast*. Prepared by VEIC for NRDC. Winooski, VT: VEIC.veic-heat-pumps-in-the-northeast.pdf

Section 3

Fact Sheet for Policymakers and Regulators

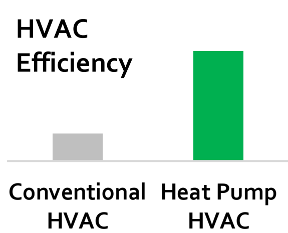
Benefits of Very High-Efficiency Heat Pump Adoption in the Multifamily Market

ICAST (International Center for Appropriate and Sustainable Technology) is implementing a U.S. Department of Energy-funded program to catalyze the mass adoption of very high-efficiency (VHE) heat pump technologies in the multifamily (MF) housing market.

VHE installs in MF properties can:

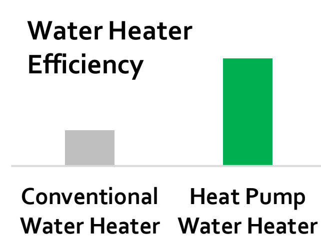
- **Reduce energy costs for low- and moderate-income (LMI) residents**
- **Address climate change**
- **Preserve affordable housing**

Multifamily affordable housing (MFAH) is typically older, in poor condition, and energy inefficient, yet this segment remains underserved by energy efficiency (EE) programs. MFAH property owners often lack the resources to pursue green upgrades, and few EE program implementers have experience dealing with this market segment and its nuances. Bridging this gap through education is crucial to increasing VHE heat pump adoption.



Heat pump-based heating, ventilation, air conditioning (HVAC), and water heater technologies are clean, efficient alternatives to conventional systems. There are different kinds of heat pump HVAC systems, including air-source, ground-source, and water-source, but air-source heat pumps (ASHPs) are the most widely used and financially viable for the MF market. Heat pumps represent a significant technological advancement in HVAC and water-heating equipment.

Heat pump HVAC systems can be approximately four times more efficient than conventional HVAC. Heat pump water heaters can be three times more efficient than some conventional water heaters.



Impacts of Widespread Adoption of VHE Heat Pumps in the Multifamily Market

Economic

- Reduces residents' utility bills, thus increasing their housing affordability
- Reduces property's operations & maintenance costs
- Offers a cost-effective, consumer-friendly option for utilities to manage energy demand
- Creates local economic development and jobs

Environmental

- Reduces carbon and other emissions

Social

- Preserves and improves affordable housing
- Offers a healthier, more comfortable, and safer home to the tenants
- Provides equitable access to advanced green technologies

For the Record: Correcting Misperceptions about Heat Pumps

Misperception	Fact
"Heat pumps don't work in cold climates. If I buy a heat pump, I will also have to get back-up heating."	Modern VHE heat pumps can comfortably heat spaces when outside temperatures outdoor temperatures are well below 0°F, depending on the equipment and the manufacturer.
"Heat pumps are too expensive."	Upfront costs for heat pump installs can be higher, but they can be offset by utility rebates and long-term operational cost savings.

Maximizing the Benefits of Very High-Efficiency Heat Pumps in Multifamily Properties

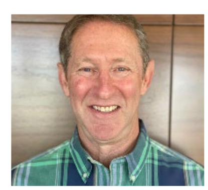
ICAST delivers multiple energy efficiency upgrades that reduce energy and water waste in concert with heat pumps upgrades. These include LED lighting, better windows, insulation, and low-flow devices. Where possible, ICAST also delivers solar installs so that MF customers can generate their own energy. This approach is especially important when electric heat pumps are replacing gas-fired systems, because the low cost of natural gas (as compared to electricity), could potentially increase the residents' utility bills. Holistic green upgrades that include other EE and solar installs will reduce residents' energy costs.

Catalyzing the Mass Adoption of Very High-Efficiency Heat Pumps: ICAST Pilots

ICAST has facilitated the installation of over 10,000 VHE solutions. In five such properties, ICAST is conducting a VHE pilot by monitoring all sorts of data, to demonstrate the benefits of heat pumps for MF properties. At each site, ICAST is measuring the performance of VHE heat pumps to the conventional systems, to quantify their relative efficiencies. ICAST has installed air-source heat pump HVACs of various types and sizes at the sites, and also heat pump water heaters. The data is still preliminary, but there are early indications of large savings, especially for the winter months, since the pilot sites are in cold climates.

About ICAST

ICAST is a 501c3 nonprofit with a mission to provide economic, environmental, and social benefits to underserved communities in a manner that builds local capacity. ICAST has been utilizing its award-winning one-stop-shop approach to deliver green solutions to the multifamily market for 20 years. To date, ICAST has installed EE upgrades in over 100,000 apartments; it has facilitated **over 10,000 VHE heat pump installs in the last four years.** ICAST is also implementing workforce development programs on the design, installation, and maintenance of VHE systems. ICAST is a national leader in designing and managing utility, state, and federal programs that deliver innovative green solutions to LMI communities.



Contact:
Dan Golden
dang@icastusa.org

Section 4

WHITE PAPER

Hurdles and Recommendations for Adoption of Very High-Efficiency Heat Pump Technology in Multifamily Properties

Hurdles and Recommendations for Adoption of
Very High-Efficiency Heat Pump Technology in Multifamily Properties

A White Paper by:
International Center for Appropriate and Sustainable Technology (ICAST)

July 2021

Authors:

Rob Foley
ICAST Project Manager

Ola Czastkiewicz
ICAST Demand-Side Management Technical Manager

Introduction

ICAST (International Center for Appropriate and Sustainable Technology) is implementing a program to catalyze the adoption of very high-efficiency (VHE) heat pump-based heating, ventilation, and air conditioning (HVAC) and hot water technology in the multifamily (MF) market. Heat pumps can be several times more efficient than conventional systems for space and water heating (DOE n.d.; Pantano, Malinowski, Gard-Murray, and Adams 2021; McKenna, Shah, and Silberg 2021). When deployed in MF apartments, they can help curb greenhouse gas emissions, reduce utility bills for low- and moderate-income residents, and preserve affordable housing. However, MF housing is historically underserved by clean energy programs and there are significant market and regulatory barriers to heat pump deployment in this segment. In this White Paper, ICAST subject matter experts leverage existing literature and their expertise delivering green solutions to MF properties to discuss key hurdles and provide recommendations for overcoming them. While there are several types of heat pump, including air-source, ground-source, water-source, and air-to-water source, we will focus on the air-source heat pumps (ASHPs) since they are the most viable solution for the MF market.

About the Authors

Rob Foley is a veteran of the clean energy space, having worked with ICAST to help drive its green programs for over a decade, and in the construction industry for over 30 years. He provides clean energy workforce training as part of ICAST's programs and has trained hundreds of individuals. His credentials include an HVAC contractor's license in Denver, general contractor licenses in several states, and NATE and BPI Building Analyst certifications.

Ola Czastkiewicz has a decade of experience providing measurement and verification, energy modeling, and technical assistance in the clean energy space. She is a Certified Energy Manager (CEM) and has an EPA 608 Universal Technician certification. She also serves as the Energy Engineer for ICAST's VHE program.

Barriers to Heat Pump Adoption

Market Barriers

First-generation heat pumps when introduced in cold climates left the market with an unfavorable impression of their performance (Gartman and Shah 2020). Often, they did not adequately heat homes, which disappointed multifamily (MF) owners and their maintenance staff. Additionally, they blew cooler air than residents were accustomed to from their existing gas-fired, forced-air systems or electric resistance heating. Heat pumps typically blow air at 85°-95°F compared to 140°F+ air common to the existing heating systems. This led to the impression that the heat pumps were not working, even when they were operating as intended. As the outside temperature fell, their supply temperature dropped, leaving residents with the perception that their heat pumps were not providing hot enough supply air to heat their apartments to the desired set point, which was exacerbated when the equipment switched to back-up heat and suddenly provided 140°F air. Over time, contractors who installed this equipment decided that it was problematic since their customers were disappointed in the performance. Contractors are also very risk-averse when it comes to their businesses, and any follow-up service needs impact their profits. Many contractors started adding risk premiums to installation of this type of equipment, further impeding the growth of this technology. Not only were first-generation heat pumps prone to under-delivering during colder seasons, but even when they were properly conditioning the space, the air was supplied in a way that discouraged consumers, as it did not compare to their conventional heating system. The consumers' thermal discomfort and lack of confidence has unfortunately made the contractors as, if not more resistant to this technology, than the consumer.

A similar pattern unfolded over 30 years ago when compact fluorescent light bulbs (CFLs) came to the market. It was a newer technology with much promise, but consumers were accustomed to a different lighting experience. For many years, they had experienced a specific colorization of bulbs that created a certain environment. CFLs' unfamiliar features, such as slow start-up, clashed with human conditioning and made it challenging for the technology to gain traction in the market. CFLs persevered in the industry with the assistance of the U.S. Department of Energy (DOE), utilities, and other stakeholders. Eventually, newer more efficient lighting options (both CFLs and LEDs) were developed that proved more palatable than those initial CFL products.

Heat pump technology has come a long way and modern technologies can provide effective heating well below 0°F, depending on the equipment and the manufacturer. However, the problems encountered in the past continue to erode confidence in the advancements to the equipment performance that have been made in recent years (Gartman and Shah 2020; NEEP 2020). Unfortunately, some poor marketing by manufacturers of this new type of equipment has added confusion in the marketplace. The industry does not want to settle on a consistent label to describe this equipment. Some of the many terms used include:

- Mini-Split
- Ductless heat pump
- Mini-Split Ductless (which are often ducted, creating further confusion)
- Cold Climate Mini-Split
- Inverter-Driven Mini-Split
- Hyper Heat (or other manufacturer-specific labels)

As a result, consumers and contractors are overwhelmed with confusing terms and are not sure what technology they are buying, whether it is all the same thing, or if the different labels refer to different levels of performance.

More recently, the refrigerants used in all air conditioners and heat pumps themself have become a barrier. In the 1980s, the last generation of refrigerants were deemed obsolete due to their ozone depletion potential (Dewan 2021). We are now facing a very similar challenge with the current generation of refrigerants regarding their global warming potential. As nations adopt the Montreal protocols or other similar climate agreements, almost all current high-global warming potential (high-GWP) mainstream refrigerants will need to be replaced with low-GWP refrigerants (EPA 2021). Manufacturers are only now starting to develop those products, and so some contractors are likely to hold back until those new generation products are available.

Regulatory Barriers

Federal Government

Messaging from the federal government speaks to the value of beneficial electrification (sometimes referred to as decarbonization), which is the process of reducing overall carbon emissions by replacing fossil fuel-fired appliances with electric appliances. They have also launched initiatives (e.g., the Initiative for Better Energy, Emissions, and Equity) to accelerate development and adoption of advanced heat pump technologies. However, they have yet to establish viable policies and incentives to not only move consumers towards electrification but, more importantly, towards more efficient and climate-friendly technologies such as heat pumps, versus simply moving to resistance electric solutions. Some areas where the federal government could have real impact in encouraging adoption of these technologies include:

1. **Incentivize (or require) manufacturers to require all central air conditioners (CACs) and window air conditioners be configured to also serve as heat pumps.** This is a simple, inexpensive modification that would require any CAC unit to also provide heat in the winter. While this recommendation would only be feasible for standard heat pumps, it is a relatively painless policy that would greatly expand heat pump adoption. Approximately 80-85% of currently installed equipment is replaced on failure with a 'like-for-like' approach, i.e., the failed equipment is replaced with similar equipment, quickly and cheaply, with little to no thought given to adopting better technology (Pantano, Malinowski, Gard-Murray, and Adams 2021).
2. **Continue updating federal minimum standards for heating and cooling equipment.** The DOE should work with the Air Conditioning, Heating, and Refrigeration Institute (AHRI) and other similar agencies to push for increased efficiency standards for HVAC and domestic hot water (DHW) equipment, even though we expect pushback from the trade associations. Such a strategy might include a potential phase-in over time for heat pumps, to allow manufacturers, contractors, MF owners, and consumers the opportunities to adjust to the new technology as standards continuously improve.
3. **Use current federal assistance programs to facilitate adoption of high-efficiency heat pump HVAC and DHW.** Programs like the DOE's Weatherization Assistance Program (WAP) regularly replace heating equipment (rarely cooling due to poor savings-to-investment (SIR) scores) and heat pumps are currently not approved by WAP. In fact, quite often such programs impede adoption since cost-effectiveness tests are driven by cost savings, not energy savings, and thus end up prioritizing fossil fuel equipment over electric equipment.
4. **Require the Environmental Protection Agency (EPA) ENERGY STAR program to prioritize beneficial electrification over fossil fuels.** Currently, the program rewards fossil fuels over electricity by prioritizing the source energy use intensity (EUI) metric (as opposed to site EUI). Therefore, properties with old, inefficient gas-based space conditioning and water heating can receive a higher ENERGY STAR score than their more efficient electric counterparts because properties are being penalized for electric grid generation inefficiencies and transmission losses. Additionally, the ENERGY STAR equipment ratings do not recognize the superior technology in cold climate air-source heat pumps (ccASHPs) and continue to treat all heat pumps as roughly equivalent. In other words, the ratings are based on equipment heating and cooling efficiencies, and heating efficiencies are not tested in

sufficiently cold outdoor temperatures; thus, the ratings do not accurately capture the heat pumps' cold climate performance.

State Public Utility Commissions and Utility Programs

State Public Utility Commissions (PUCs) regulate investor-owned utilities' (IOUs) Energy Efficiency (EE) and Demand Side Management (DSM) programs. Currently, few of these regulators are providing encouragement or guidance to accelerate heat pump adoption; California, New York, and Massachusetts are notable exceptions. Oftentimes, regulators are actively preventing beneficial electrification by prohibiting fuel switching. Fuel switching is when a customer using gas space and water heating switches to an electric space and/or water heating solution. Classically, fuel switching has been discouraged given the loss in revenue that a gas supplier would experience due to the switch. This revenue loss has not been addressed through conventional cost recovery mechanisms that are in place for utility companies which implement energy efficiency for their fuel type exclusively.

Until the last few years, almost all utilities and technical resource manuals (TRMs) discouraged fuel switching (particularly from gas to electric). Some new TRMs have made a small move in the direction of encouraging fuel switching by recognizing and allowing the energy savings to be calculated using the existing gas-fired equipment as the baseline, usually in relation to a dual fuel HVAC system where the gas heating acts as a back-up source to the heat pump.

In addition, utility rebate programs are almost always tied to some version of cost-effectiveness testing using metrics like total resource cost. Generally, these cost-effectiveness tests are calculated using a formula outlined in a TRM approved by the PUCs. Most of the TRMs do not treat high-performance heat pumps differently from first-generation heat pumps, again, the exceptions being states like New York and Massachusetts. State PUCs need to recognize this shortcoming and better incentivize high performance heat pumps by treating them distinctly from conventional heat pumps in terms of savings and applicability.

Another tool available to regulators would be to quantify the cost of carbon inherent in conventional HVAC vs. high-efficiency heat pumps. Factoring the cost of carbon into cost-effectiveness calculations would better reflect the value that heat pumps bring to the market.

Industry Product Performance Certification Programs

HVAC equipment in the U.S. is certified for its efficiency by a voluntary program managed by AHRI. Currently, these efficiency ratings do not recognize the superior performance of ccASHPs, inverter technology, and highly efficient reduction in electric supply. The AHRI standard equipment testing does not test below 17°F (Gartman and Shah 2020).

Another example of the limitations of the AHRI testing is that inverter systems are still tested with a locked hertz cycle, which seriously minimizes their true efficiency. Essentially, this locked condition creates a rating at 100% load conditions, when 90% of the time, the units are not operating at 100% load conditions. This means that ratings of these variable type systems are always inaccurate, specifically due to the AHRI testing procedure.

The Canadian organization CSA Group and the American nonprofit Northeast Energy Efficiency Partnerships (NEEP) have already done much of the work to improve testing and rating procedures, and all AHRI would need to do is adopt their process if not develop their own (Bresler 2015; Gartman and Shah 2020; CSA Group n.d.).

Recommendations

Although the performance of first-generation heat pumps left something to be desired, new heat pump technology has been shown to be effective even at extremely low temperatures. Successful installations in locations such as Park City, UT, and Upstate New York and Alaska, which can regularly get down to -20°F, will help to spur the adoption of this VHE technology. However, the push for the adoption of heat pumps will require coordinated efforts by state and federal regulators, industry leaders, and PUCs, and utilities to educate consumers and contractors. There are many hurdles to overcome in heat pump adoption, but a concerted effort lead by policy and backed by investments from the government, utilities, and manufacturers can transform the way we think about the simple act of heating and cooling our MF apartment communities.

With the continued low cost of natural gas and the ongoing increase in the cost of electricity, one downside for low-income housing is that replacement of gas equipment with electric heat pump technology (even VHE equipment) will sometimes result in an increase in utility costs, depending on climate. The very best approach to making these upgrades is a holistic one, where HVAC is upgraded in conjunction with other efficiency measures (such as LED lighting, low-flow devices, insulation upgrades, air and duct sealing, etc.) and paired with photovoltaic solar where possible to effectively reduce utility bills for the low-income tenants.

One of the keys to achieving widespread adoption of heat pumps is effective messaging from manufacturers as to the benefits and capabilities of this new technology, while also agreeing to standardize the label used to reference these solutions. That will involve effective education and training of the designer and contractor base (Robb, Lis, et al. 2017). Architects and engineers already have much of the knowledge needed and should be easier to bring along, especially as municipalities consider and adopt more climate-friendly building codes such as decarbonization and a ban on new gas connections for new construction (Gough 2021).

In the replacement market, there is big effort that needs to happen to facilitate adoption. Again, approximately 80-85% of all residential replacement HVAC decisions coincide with equipment failures. That means that replacement contractors need education in why heat pumps are the preferred solution while ensuring they are available in stock locally. Many replacement contractors have limited training in marketing, recommending, or installing this new generation of equipment. Currently, many HVAC distributors do not stock heat pumps, which eliminates the possibility of capturing those "replace on fail" decisions which by necessity require immediate availability of equipment.

There are some other opportunities to deploy heat pumps for the replacement market. At the local and state level, policies can be put in place that require repairs, replacements, renovations over specific financial values (e.g., $25,000) to be only heat pump systems. Another approach could be to disallow installation of new or replacement resistance electric systems or CACs – and that only heat pump systems can be deployed in their stead. Another opportunity is well known in the utility industry: Utilities often offer mid-stream incentives to distributors who have incentive to educate and move the technology into the market space. There are numerous examples of successful mid-stream programs across the US (ENERGY STAR n.d.; SWEEP 2016).

Manufacturers and industry experts need to greatly increase their education efforts with distributors and replacement contractors on the benefits and importance of heat pump adoption as a key component of beneficial electrification. Partnering with local utility incentive programs to educate contractors can also facilitate adoption by leveraging the utility rebate programs. Distributors need to be brought into the conversation so that they can effectively market to replacement and new construction contractors and be convinced of the value of keeping a ready stock of heat pumps. Training in best practices for installers will help remove concern and uncertainty surrounding this new technology. Simplifying pricing and equipment configurations will also facilitate more ready acceptance. When fewer stock keeping units (SKUs) are available, it makes choosing an appropriate heat pump easier as excessive choices can lead to "analysis paralysis," especially if the contractor is already struggling to understand the technology. Faster adoption of new refrigerants within the heat pump equipment will also facilitate heat pump adoption and remove contractor and consumer hesitance.

For the Federal Government

Adopting regulation to require that all CAC units also be standard heat pumps is likely the fastest, simplest, and least expensive method to advance widespread adoption of heat pumps. It removes the barriers without adding any significant costs to installations. Typical manufacturing costs for this simple modification would be an additional $250-$400 per unit, which the federal government could subsidize in order to quickly further climate goals.

In assistance programs like the WAP, incenting and promoting heat pumps over fossil fuel solutions would require these programs to view these improvements through a different lens than “the least expensive thing we can do to boost SIR,” thus adding an energy savings perspective to the decision-making. It would require rule changes in their programs that value these improvements.

Adoption of the proposed new federal building performance standards would demonstrate by example how these new technologies should be used whenever possible. It would also allow manufacturers to embrace these technologies knowing there is a steady appetite for this equipment in the market. This could also lead to lower production costs due to the economy of scale, which would further increase adoption rates.

The ENERGY STAR program is a world-recognized advocate for energy efficiency, and yet has processes in place that incentivize fossil fuels through its source EUI rating system, thus negating the efficiency of ccASHPs. Further, its ratings for heating and cooling equipment do not accurately capture heat pumps’ performance in cold climates. Both these hurdles can be corrected through administrative decisions at the U.S. DOE and EPA.

For State Regulators

PUCs and IOUs need to take dramatic leaps in their EE and DSM programs to appropriately incentivize and reward adoption of heat pump technologies. TRMs should be updated to treat high-efficiency and high-performance heat pumps appropriately. Incentive programs should be revised to stop incentivizing fossil fuels and appropriately incentivize technologies like ccASHPs for their very high energy efficiencies and carbon reduction benefits. Taking a fuel-agnostic approach to energy efficiency will greatly facilitate adoption of these technologies.

For Industry Groups

AHRI should update their testing and ratings systems to appropriately rate ccASHPs, similar to the work already done in Canada. Much work has been completed in the Northeast with NEEP and U.S. DOE on this technology. Over the past 12 years, the EPA ENERGY STAR New Homes Program has shown how federal resources and market players were able to provide replicable educational materials for consumers, manufacturers, builders, designers, and MF owners. Heat pumps should be tested below 17°F (preferably at subzero temperatures) and their efficiency and capacity in low temperatures should be rated so that contractors can properly size systems and consumers can utilize these ratings to determine which equipment performs the best for their buildings and climate zone.

Technology Cross-Pollination

In other fields, technology is becoming much more interactive. The advent of the internet of things (IOT) and 5G rollouts are allowing millions of devices, including many energy-consuming devices, to be connected and controlled by large and small organizations. Utilities and building owners can use energy management systems (EMS) to control energy consumption and demand. Buildings are becoming more grid-enabled and therefore able to respond to directions from either a utility or energy manager to control HVAC and hot water systems through smart controls.

Consumers are very interested in IOT and connectivity between phones, tablets, and their living environment. Manufactures should recognize these trends and build intelligence into their equipment so that each device (furnace, AC, thermostat, even ductwork) can be separately addressed, monitored, and controlled through the internet. Unfortunately, much of the VHE heat pump equipment now being sold in the U.S. does not come with smart controllers, and since most of the equipment being sold in the U.S. was developed for the larger Europe and Asia markets, it was designed with proprietary controls which are not typical of U.S. manufactured equipment. Adding nonproprietary control features that allow standard low voltage thermostats, common in the U.S., to control these units will also facilitate adoption of these units.

Resources

- Cold Climate Air-Source Heat Pumps: An Innovative Technology to Stay Warm in Winter and Cool in Summer [Here]
- Accelerating Adoption of Advanced Heat Pump Products and Services [Here]
- Understanding the Market Barriers & Opportunities for Cold Climate Air Source Heat Pumps in Minnesota Residential Households [Here]
- Achieve Comfort and Reliable Performance with Cold-Climate Heat Pumps [Here]
- FACT SHEET: Biden Administration Accelerates Efforts to Create Jobs Making American Buildings More Affordable, Cleaner, and Resilient [Here]
- The Perfect Solution, and Why it is Not Working [Here]
- Heat Pumps: Barriers to Fuel-Switching and Some Success Stories [Here]
- **Deployment of Cold Climate Heat Pumps: Overview of current and planned activities** [Here]. A presentation by Natural Resources Canada highlighted many of these issue in heat pump adoption in 2018. Some of their recommendations were as follows:

  Research and Development Initiatives

  1. Develop high-efficiency lower-cost cold climate heat pumps (CCHPs)
  2. Develop hybrid heat pump solutions, controls, and installation guides
  3. Address ductless heat pump installation issues for existing homes
  4. Reduce ground loop installation costs for ground source heat pumps
  5. Develop lower costs components for gas heat pumps
  6. Conduct lab and field testing for gas heat pumps in cold climates
  7. Lab and field testing for advance technologies

  Deployment Initiatives

  1. Demonstrations of CCHP to support national marketing
  2. Demonstrations of gas heat pumps to educate consumers and industry
  3. Ratings and qualified product lists for CCHPs
  4. Sizing and selection software tools
  5. Market pull for high-efficiency space heating systems
  6. Test procedures and ratings for combination space and water heating heat pump
  7. systems
  8. Test procedures and ratings for gas heat pumps
  9. Training and contractor certification program
  10. Expand access to and uptake of existing and future incentive programs
  11. Harmonization of codes and standards
  12. High performance specifications for CCHPs

References

Alrich, Robb, David Lis, et al. 2017. *Northeast/Mid-Atlantic Air-Source Heat Pump Market Strategies Report 2016 Update.* Northeast Energy Efficiency Partnerships (NEEP). January 2017. https://neep.org/sites/default/files/NEEP_ASHP_2016MTStrategy_Report_FINAL.pdf

Bresler, Samantha. 2015. "Looking for Winter-Proof Heat Pumps?" Lexington, MA: Northeast Energy Efficiency Partnerships. March 24, 2015. https://neep.org/blog/looking-winter-proof-heat-pumps

CSA Group. n.d. "CSA EXP07:19 - Load-based and climate-specific testing and rating procedures for heat pumps and air conditioners." Accessed June 15, 2021. https://www.csagroup.org/store/product/CSA%20EXP07%3A19/

Dewan, Angela. 2021. "A 1980s ban on CFCs to heal the ozone layer is also shaving degrees off global warming, study says." *CNN*. August 19, 2021. https://www.cnn.com/2021/08/19/world/cfcs-ozone-montreal-protocol-climate-study-intl-scn/index.html

DOE (U.S. Department of Energy). n.d. "Energy, Emissions and Equity (E3) Initiative." Accessed June 15, 2021. https://www.energy.gov/eere/buildings/energy-emissions-and-equity-e3-initiative

ENERGY STAR. n.d. "Astonishing Results: Examine Surges in Participation at Distributor-Focused Midstream Programs." Accessed June 15, 2021. https://www.energystar.gov/products/retailers/midstream_programs/astonishing_results

EPA (Environmental Protection Agency). 2021. "EPA Moves Forward with Phase Down of Climate-Damaging Hydrofluorocarbons." May 3, 2021. https://www.epa.gov/newsreleases/epa-moves-forward-phase-down-climate-damaging-hydrofluorocarbons

Gartman, Michael, and Amar Shah. 2020. "Heat Pumps: A Practical Solution for Cold Climates." *Rocky Mountain Institute*. December 10, 2020. https://rmi.org/heat-pumps-a-practical-solution-for-cold-climates/

Gough, Matt. 2021. "California's Cities Lead the Way on Pollution-Free Homes and Buildings." Sierra Club. July 22, 2021. https://www.sierraclub.org/articles/2021/07/californias-cities-lead-way-pollution-free-homes-and-buildings

McKenna, Claire, Amar Shah, Mark Silberg. 2020. "It's Time to Incentivize Residential Heat Pumps." *Rocky Mountain Institute*, June 8, 2020. https://rmi.org/its-time-to-incentivize-residential-heat-pumps/

NEEP (Northeast Energy Efficiency Partnerships). 2020. "Air Source Heat Pump Buying Guide." https://neep.org/sites/default/files/resources/ASHP_buyingguide_5.pdf

Pantano, Stephen, M. Malinowski, A. Gard-Murray, N. Adams. 2021. *3H 'Hybrid Heat Homes': An Incentive Program to Electrify Space Heating and Reduce Energy Bills in American Homes*. CLASP. https://www.clasp.ngo/wp-content/uploads/2021/05/3H-Hybrid-Heat-Pumps_CLASP_May26.pdf

SWEEP (Southwest Energy Efficiency Project). 2016. "Utilities are Heading Upstream to Increase Energy Efficiency." February 9, 2016. https://www.swenergy.org/utilities-are-heading-upstream-to-increase-energy-efficiency#:~:text=Under%20the%20midstream%20approach%2C%20Xcel%20Energy%20works%20with,to%20stock%20and%20upsell%20high%20efficiency%20HVAC%20units.

Section 5

WHITE PAPER

Policy Issues for the Deployment of Very High-Efficiency Technologies in Multifamily Buildings

Policy Issues for the Deployment of Very High-Efficiency Technologies in Multifamily Buildings

A White Paper by:

International Center for Appropriate and Sustainable Technology (ICAST)
and
Southwest Energy Efficiency Project (SWEEP)

September 2021

Sponsored by:

U.S. Department of Energy

This white paper is a result of the work supported by the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy (EERE) under the Building Technologies Office (BTO) Award Number DE-EE0009080.

Introduction

The shift in focus from reducing energy use (kWh) to reducing greenhouse gas (GHG) emissions started gaining momentum during the last decade, but has accelerated in the 2020s. The new Biden administration has made climate change a cornerstone of its policy agenda, promoting a range of clean energy initiatives that include decarbonization and building electrification. The administration is also prioritizing affordable housing and workforce training. While focused on building electrification through deployment of very high-efficiency (VHE) heat pump technologies, this paper also addresses affordable housing by narrowing our focus to VHE deployment in multifamily (MF) properties. Finally, we address workforce development as it pertains to scaling the deployment of VHE solutions in MF properties.

Fossil fuel combustion from residential and commercial buildings contributes nearly 29% of GHG emissions in the U.S., making them a high-impact opportunity for decarbonization (Leung 2018). Additionally, studies show that replacing onsite fossil fuel-based cooking, laundry, space heating, and water heating systems, with efficient electric products can reduce energy use by over 40% and carbon emissions by over 75% (Miller and Higgins 2021). Primarily natural gas, but sometimes propane or heating oil. In the MF sector, the need is particularly acute: two-thirds of MF buildings were built since 1970 (Nedwick 2016). Older buildings are often very inefficient and have health and safety hazards.

Many states and municipalities have adopted decarbonization goals with specific metrics to be achieved by 2025, 2030, 2040, and 2050. For these states and municipalities to meet their ambitious carbon reduction targets, they will need to reduce emissions at existing and new buildings through energy efficiency (EE) upgrades, especially in the MF sector. Cities and states across the country have started updating their building codes to include electrification requirements for new construction, and some are working on building codes that will push existing buildings towards electrification.

International Center for Appropriate and Sustainable Technology (ICAST) and Southwest Energy Efficiency Project (SWEEP) are working to catalyze the mass adoption of VHE technologies, specifically for heating, cooling, and hot water, in the MF market. This paper addresses potential policy barriers to deploying these technologies for the MF sector in the Southwest.

Very High-Efficiency Technologies in Multifamily Buildings

VHE technologies typically comprise heat pump-based heating, ventilation, and air-conditioning (HVAC) and hot water (HW) systems. These heat pump technologies move heat from one space to another, rather than generating heat, and can be several times more efficient than conventional systems for space and water heating (DOE n.d.; Pantano, Malinowski, Gard-Murray, and Adams 2021; McKenna, Shah, and Silberg 2021).

This paper focuses on the need for, and impact of, such VHE HVAC and HW systems in MF buildings. MF is a historically underserved market, comprising low-rise residential, mid-rise, and high-rise commercial MF buildings. Few EE programs serve the MF sector beyond offering mainly ‘low-hanging fruit’ EE measures such as LED lighting, low-flow devices, weatherization, and thermostats. Very few MF property owners have the resources and capacity to implement VHE upgrades. However, replacing inefficient HVAC and HW systems is key to decarbonization and electrification, as well as preserving housing affordability—VHE systems for existing and new MF properties can help curb owners' operational costs, such as maintenance and/or repairs for old, faulty, or simply more expensive and inefficient conventional systems; and increase tenant retention by creating healthier and safer environments and reducing tenants' utility bills. Most MF buildings in the Southwest have unitary HVAC and HW systems, so we will focus our efforts and this paper on air-source heat pump (ASHP) HVAC systems—such as cold climate (ccASHP), ducted, non-ducted, and single- or multi-unit compressors—and heat pump water heaters (HPWHs).

Though MF owners, property managers, maintenance staff, HVAC contractors, architects, engineers, and general contractors, are very comfortable with ASHPs' and ccASHPs' ability to provide the necessary cooling, they doubt their ability to provide space heating—especially in cold climates such as the Rocky Mountains. Therefore, this paper will focus on the hurdles to the deployment of VHE solutions for space and water heating.

Space Heating

ASHPs and ccASHPs have been studied and deployed in MF units across the country. However, in many MF new construction projects that are designed as all-electric, the default space heating choice continues to be electric resistance heat. Although, in western states, gas-fired furnaces are perhaps the most common choice.

For MF new construction projects, there is now ample available data showing that the cost of ccASHPs is lower than, if not on par with, gas furnace and central air conditioning units. MF developers are beginning to realize they can save on the cost of gas infrastructure, including pipes, meters, ducts, etc., and reduce tenant bills by not committing them to a gas utility bill. For new construction, the trend towards all-electric is now real—what is needed is education on VHE options. There are new technologies and products entering the market that will add flexibility and opportunities to incorporate VHE HVAC into MF buildings, including:

- Air-Source Heat Pump, Split System (240V) conventional and low-global warming potential (GWP) refrigerants
- Air-Source Heat Pump, Packaged Terminal (PTAC)
- Air-Source Heat Pump, Rooftop Units (RTU)
- Mini-Split Air-Source Heat Pump (240V)
- Mini-Split Air-Source Heat Pump (120V)
- Hybrid HVAC, Gas Force Air + Efficient Central Heat Pump

- Air-to-Water Heat Pump
- Ground/Water-Source Heat Pump

Water Heating

Similarly, for water heating, HPWHs are far more efficient than either conventional electric tank water heaters or gas-fired tank water heaters, but their deployment in the MF building sector is dismal because of the cost differential. Even for MF new construction projects, the cost of HPWHs is higher than gas or resistance electric units. Innovative MF developers are beginning to plan larger HPWH units that serve 3-6 apartments to reduce costs, but the rest of the new construction with all-electric design uses resistance electric water heaters.

Some industry experts anticipate that HPWHs could see exponential growth as new plug-in 120V HPWHs are released in the next few years (Gibson 2021). ICAST does not see this path to growth with the 120V HPWHs because their cost to deploy, while reduced, will still be much higher than any MF owner will be willing to pay. HPWHs, just like heat pump HVAC, move heat from one place to another, instead of generating heat directly to the water. Some HPWHs may have a separate electric heating element, and these units are referred to as hybrid systems.

The following VHE water heating technologies are currently, or will soon be available for deployment in MF buildings:

- Unitary Heat Pump Water Heater (240V) conventional and low-GWP refrigerant units (15 and 30 amp)
- Unitary Heat Pump Water Heater (120V) conventional and low-GWP refrigerant units
- Central Heat Pump Water Heater (240V) conventional and low-GWP refrigerant units
- Point-of-Use electric distributed
- Tankless electric
- Ground/Water-Source Heat Pump

Technical Issues in the Deployment of Very High-Efficiency Solutions in Multifamily Buildings

Switching to VHE equipment is not always as simple as replacing one system with another. Depending upon the building configuration, ASHP systems may need more than one point of distribution (e.g., in different rooms) for conditioning indoor air. HPWHs have different physical space requirements than gas water heaters and require the ability to exhaust cold air as a by-product of producing hot water. These differences in space and ducting needs can make the deployment of VHE solutions almost impossible in some cases.

If the upgrade is a fuel-switch from a gas-fired to an electric heat pump system, the conversion may also require upgrades to electrical systems and panels, and even the transformer on the property, which can be very costly. However, there should be no significant cost differential in replacing electric resistance heating or standard electric tank water heat with VHE heat pump systems, as they both require the same electric panel capacity.

One manufacturer has recently released a water heater with zero clearance requirements between the HPWH and the walls, which will benefit MF units with limited space in the closet for a water heater (Rheem n.d.). Outside of the U.S., a combined HVAC+HW unit that provides heating, cooling, and hot water, is available, which can potentially reduce not only the space needs but also the electrical infrastructure upgrade needs. Unfortunately, this combi-system is not yet available in the U.S. at scale, although recent conversations by ICAST with Japanese manufacturers indicate they are preparing to bring this product to the US market.

Policy Issues

Policy issues in the deployment of VHE include the design, construction, and installation of heat pump HVAC and HW systems, plumbing configuration, and the workforce and its knowledge of VHE technologies, as well as the practical ability to replace legacy systems in MF buildings. Additional issues include local and state-level building codes that do not require or encourage VHE systems; state or local building department staff that are unfamiliar with the equipment; lack of climate goals and policies to drive awareness of VHE solutions; and obstacles at the state level including current laws and municipal membership organizations fearful of unfunded mandates pushed down to each jurisdiction.

Policy Issues – Building Codes

Local and state building codes typically do not specify equipment requirements for residential MF construction. Commercial MF buildings may have minimum-efficiency requirements based on equipment size, but still do not specify VHE technologies. These requirements reside in the International Energy Conservation Code (IECC).

While existing building codes do not prohibit the use of VHE equipment in new or replacement construction, historically, they haven’t encouraged them either. They require equipment information to be provided in the design documentation, including evidence that the proposed equipment will support the needs of the dwelling occupants based on climate zone. In colder climates, concern around incorporating ASHPs into building codes may be due to some ASHP systems requiring supplementary heating when the temperature drops below freezing—however, this concern speaks to a lack of awareness of the availability of ccASHPs and their ability to function in sub-zero temperatures. Modern heat pumps can provide effective heating well below 0°F, depending on the equipment and the manufacturer.

Another barrier is a lack of understanding or awareness of VHE systems among building department staff. Even though heat pump systems including ccASHPs are being installed across the western U.S., building department staff may never have seen ASHPs installed in their jurisdiction and therefore know very little about them.

Policy Issues – Lack of Published Climate Policies

VHE systems are most likely better known by communities who have adopted climate policies. Given these systems' ability to conserve energy and water and mitigate GHG emissions, some cities and counties are showing interest in these technologies to support the climate and increase community clean energy goals. The city of Denver, Colorado, released the *Energize Denver Renewable Heating and Cooling Plan* in 2021, creating a playbook to electrify buildings with VHE (DCASR 2021). Nevada's 2020 climate strategy will transition buildings from fossil-fuel space and water heating to electric systems, while also moving to net-zero buildings (NV DCNR 2021).

Many local communities have joined national and state climate organizations that provide education to communities about the needs, benefits, and climate impacts of VHE technologies. A few of these regional and national organizations include the Urban Sustainability Directors Network, C40, Climate Mayors, Colorado Communities for Climate Action, Utah Climate Action Network, Coalition of Sustainable Communities NM, and others. A short list of municipalities who participate in these organizations include: **Colorado**–Golden, Denver, Lakewood, Westminster, and Fort Collins; **New Mexico**–Albuquerque and Santa Fe; **Utah**–Salt Lake City and Park City; **Nevada**–Reno and Las Vegas; **Arizona**–Phoenix, Tucson, Flagstaff, and Scottsdale.

Communities that have no climate policy in place will see less interest and knowledge from the building departments, governmental leadership, building developers, design community, and contractors. This may slow or limit opportunities for VHE-specific policies for MF buildings. In these areas, education becomes one of the first policy priorities to support deployment of VHE.

Policy Issues – Workforce Development

Jobs for HVAC workers are expected to grow 13% from 2018 to 2028 (Ferriere n.d.). The Energy Efficiency Business Coalition in Colorado has surveyed its members, which includes HVAC contractors and utilities, and has found continued need for education on VHE equipment (Rothwell and Neuber… 2021). SWEEP has researched ASHP technologies and markets, similarly, finding a need for the HVAC industry to be educated on installation and design practices for heat pumps in residential housing (Kolwey and Geller 2018). There are few training programs in the U.S. specific to VHE technologies. To help address this gap, ICAST will, with the help of a recent grant award by the U.S. Department of Energy's (DOE) Building Technologies Office, offer training to HVAC technicians on the design and installation of ccASHPs across its service territory.

Policy Issues – Technology

When a VHE technology – or any new technology – enters the market, it faces a period where consumption of the product or service has little uptake by the trades because it is unfamiliar to them. Additionally, builders and developers tend to be conservative and risk-averse in their construction practices. New technology creates financial and technical risks for construction workers and their projects until the industry understands the product and its installation. Take, for instance, the deployment of smart thermostats. When the NEST smart thermostat was released in early 2010s, market growth for these products was slow for the first few years (Funk 2014). There were concerns from industry that the thermostats would be mis-wired (illustrating the inadequate education of installers), a need for consumer education, and a need to distinguish the technology from legacy products. Today, a smart thermostat is almost standard equipment and is offered at low-to-no cost to homeowners through many utility incentive programs.

Manufacturers have made great strides to improve ccASHP performance, but there is a lack of awareness of those advances in the marketplace, and they are still in the 'early adopter' phase of buy-in from building owners.

Replacing fossil fuel-based heating systems with VHE, i.e., fuel-switching, comes with its own set of retrofit barriers and risks at each site, including ducting, electrical wire/panel, and the configuration and design of the building. Most existing MF buildings have a 70-amp electrical panel. Upgrading that to allow for an electric HVAC and HPWH system is costly, and MF owners are unlikely to pay for such an upgrade, even if the install cost of the VHE system is equal to that of the gas system. Homebuilders in the city of Fort Collins, Colorado, typically only install 150-amp electrical panels in single-family, two-family and townhouses. Upsizing electrical panels due to new electric appliance requirements is creating backlash from some builders over the increased costs, including labor and materials, associated with larger panels.

Policy Issues – State Obstacles

Each state has different statutes, utilities, utility programs, climate and electrification interest, knowledge, and consumer interest. The following states have policies that either facilitate or stymie VHE technologies in MF buildings.

***Arizona*.** Arizona is known for its western independence and conviction that municipalities should govern themselves. In keeping with that conviction, Arizona is a home-rule state with minimal statewide standards for buildings. But ironically, it has two statutes in place limiting local governments' ability to advance VHE technology adoption. In 2016, the legislature issued a law preventing any city or county from adopting policies that would require benchmarking of commercial or MF buildings. This was followed by a bill in 2020 that prevents cities and counties from adopting policies that prohibit or limit the use of natural gas in buildings. It seems that state leadership will overrule local ordinances where it feels that the state has a vested interest.

Most of Arizona's utilities provide either electric or gas service but not both, and utility regulations typically prevent utilities from helping customers switch from one to the other. This limits the incentives, trainings, and marketing that electric utilities can provide for VHE technologies. Changing this would require a policy shift by the Arizona Corporation Commission, or a joint program by an electric and gas utility to offer incentives for a fuel-switch.

Therefore, in Arizona, the best opportunities to increase VHE adoption will be through education of developers and builders who can step up to voluntarily adopt these new and advanced technologies; and for the electric utility providers to offer incentives for VHE systems as part of whole-building electrification and energy efficiency programs.

***Colorado*.** Colorado is another home-rule state which has implemented a mix of state policies throughout its history that touch all building types. Its first statewide energy code policy was adopted in 2008 and then updated in 2019. The latest energy code policy requires a local government to adopt one of the three latest energy code versions when it updates its other building codes. Heftier policy levers, such as moving to a statewide energy code or requiring VHE technologies in new construction projects have not been either legally or politically viable to date.

There are two municipal organizations in the state that could diminish statewide policy opportunities for VHE requirements. The Colorado Municipal League and Colorado Counties, Inc., both represent their local governmental members in legislative and regulatory arenas. These organizations don't participate in policy adoption at the local level (beyond general education about policies) but frown upon state policy that may include mandates for local governments. On the other hand, numerous individual jurisdictions in Colorado have set goals to electrify buildings and are at an appropriate starting point to advance VHE. With the help of SWEEP, cities and towns such as Denver, Fort Collins, Breckenridge, and Dillon have policy or plans in place to electrify both new construction and existing buildings (City and County of Denver n.d.; City of Fort Collins 2015; SCAC 2018). Additionally, the state recently passed Senate Bill 21-246, which creates incentives for households and businesses to upgrade to efficient electric heat pump systems (Colorado General Assembly n.d.).

On the utility front, Colorado's largest utility, Xcel Energy, offers both electricity and gas services and has set goals for an 80% carbon reduction from 2005 levels by 2030, and a 100% reduction by 2050 (Xcel Energy 2019). Reaching these goals will include helping new and existing MF buildings install VHE technologies, and the utility has already begun taking steps to provide rebates for these systems.

Finally, the Colorado Housing Finance Authority (CHFA), which distributes federal and state tax credits for new and renovated MF affordable housing developments, has taken steps in the previous two years to include higher efficiency requirements for developers seeking tax credits. VHE technologies are not explicitly discussed in the requirements or guiding principles in the most recent Qualified Allocation Plan (QAP), but they may be included in future QAPs. Both ICAST and SWEEP are educating staff at CHFA on VHE technologies.

***Nevada*.** Communities in Nevada adopt municipally developed ordinances and codes. The state adopts a statewide energy code with requirements for local municipalities, but there is no enforcement mechanism to mandate these communities update to the latest state policy.

With the release of the 2020 Nevada Climate Strategy addressing emission reductions, resiliency, and ongoing climate action, there has been municipal interest in supporting the state goals. Reno continues to slowly advance their climate strategy for buildings. Clark County is showing interest in updating their model energy code to the latest version while also addressing electrification of transportation in the county.

Electrification of buildings is a new concept in Nevada; uncertainty primarily revolves around the affordability of electric versus gas-fired heating systems, and rightly so. Advocates for supporting efficiency in the low-income housing sector—such as Sierra Club, Nevada Conservation League, NRDC, Western Resource Advocates, etc.—are actively communicating with municipalities on the benefits of decarbonization and improved efficiency in existing buildings and new construction. A concern for local government leaders is the increased costs of construction, such as prices for land and construction materials and ongoing monthly costs for utilities. This concern is at the forefront of many conversations in cities and counties in the state.

***New Mexico*.** New Mexico utilized the 2009 IECC energy code until 2020, when the state adopted the 2018 IECC with amendments. Also in 2020, NM passed a law to become carbon neutral by 2050. But municipalities in NM have produced few climate plans or goals that are similar to equivalent-sized cities in other states in the Southwest. Utility programs have also been strained in offering incentives for VHE, when compared to utilities in other states.

Policy concerns in NM stem from its being an oil-, gas-, and coal-rich state; its revenues and employment are largely tied to these resources. The impact to the workforce from building electrification is not an easy political hurdle to overcome, given the abundance of gas in NM. When advancing VHE policy in NM, workforce training and education should be considered as the primary deployment strategy, and creative deployment schedules or extended schedules may be needed to facilitate VHE adoption. One challenge is the New Mexico Home Builders Association, a powerful organization in NM which opposes cost increases and changes in construction practices, and will likely fight VHE deployment. Appropriate cost analyses will be needed in either local or state EE policies to help demonstrate the value of VHE for the residential sector in NM.

With the slow adoption of new state energy codes and the relative shortage of local climate action plans that incorporate electrification, education and training of architects, builders, trades, and consumers is a top priority. Recently, the NM Energy Mineral Natural Resource Division (EMNRD) was awarded a grant from the U.S. DOE to provide workforce training to the building industry in support of the state's adoption of its energy code (EMNRD 2021). Training and education on VHE equipment positively impacts both the building industry and policymakers.

Sponsored by SWEEP and others, the legislature passed an update to New Mexico's sustainable building tax credit in 2021. There are bonus credits for fully electric buildings and net-zero energy, water, and waste buildings. The updates increase the necessary qualifications for the ongoing tax credit. The state tax credit will now include credits for existing buildings and homes. Homeowners or businesses that install Energy Star heat pump HVAC and HW systems are eligible for tax credits.

***Utah*.** Utah has statewide requirements for all new or renovated buildings. The development of building codes is strongly influenced by the Utah Home Builders Association to limit change in new construction standards. As of 2020, no municipality has exceeded mandatory statewide codes and standards, as state policy requires cities or counties to bring building codes to the legislature for approval.

Utah is progressive, with opportunities for voluntary zero energy homebuilding, electrification of MF buildings, and utility participation to improve the efficiency of new and existing buildings. The dominant natural gas utility and electric utility are working together to allow for fuel-switching and have similar initiatives for efficiency upgrades. The municipalities of Salt Lake City, Salt Lake County, and Park City are working to develop programs that incentivize the inclusion of zero-energy, electrification, and electric vehicles in construction practices. ICAST and SWEEP's local representatives are working closely with Salt Lake City to develop and promote VHE installs in MF properties. ICAST manages the electric utility MF demand-side management program and has been able to influence over 8,000 VHE HVAC installs in Utah over the past three years, and continues to grow those numbers.

***Wyoming*.** Wyoming adopts statewide building codes through the Department of Fire Prevention and Electrical Safety. This department is focused on building safety across Wyoming. The energy code is not viewed as essential for building safety, and is not part of the state code package. Municipalities in Wyoming can adopt and amend building codes including changes to fire and plumbing.

Advancing VHE may be more challenging in this independent Western state where regulation is typically frowned upon by citizens and city officials. Whether regulation is implemented through building codes, planning and zoning, or policies, community leaders are resistant to additional regulation. Opportunities lie in the municipalities that have shown interest in environmental advancement such as Laramie (a college town), Jackson, and Teton County.

Two utility providers—Rocky Mountain Power and Black Hills Energy—provide financial incentives for EE measures including weatherization for low-income households, smart technology, and VHE systems. Local government leaders could leverage their utility incentives to create strategies that promote VHE installations.

Policy Issues – Cost

A 2018 SWEEP report investigating ASHPs and HPWHs for single-family residential units found that while these VHE systems had higher upfront costs, those could be offset by the energy savings achieved over the life of the system. For new construction, heat pump systems are cost-effective because they are cheaper to install than separate gas furnace and AC systems, and are more affordable in terms of supporting infrastructure and, typically, monthly utility bills (Kolwey and Geller 2018). In other words, the new all-electric properties do not need any gas infrastructure (pipes, meters, etc.) and do not incur any monthly gas utility costs, thus saving capital costs for the developer. For MF, ICAST has found that heat pumps can consistently achieve lower costs in new construction projects.

For existing residential buildings, the costs vary based upon climate locations and heating needs of the residential property. Time of replacement is a key consideration in reducing incremental costs; as such, replace-on-fail (when a unit stops working) or during a major rehabilitation (that includes replacement of mechanical systems), are the ideal times for installing VHE equipment because the incremental (or additional) cost is not the total cost of the VHE, but the cost differential between a typical system and a VHE system.

When educating stakeholders on the benefits of VHE in these states and municipalities, it is important to include information on costs and savings. Stakeholders may include state and local policymakers, building designers, builders, building associations, labor, and trades. Typically, upfront cost is the first concern for these parties. However, just as important are the total costs (installation and ongoing operational costs), how they affect the occupants, and how they benefit the community.

Very High-Efficiency Technologies in Multifamily Buildings – Opportunities

Policy challenges abound. However, there are increasing opportunities for the stakeholders listed above to overcome the issues identified in this paper. These include:

1. Educate all stakeholders on VHE technologies, including their market status, benefits, and technological advancements, while developing any policy at the state or local level. Ensure that the information corrects any outdated or inaccurate perceptions of the technologies and their capabilities.
2. Create a VHE campaign that can be tailored for different stakeholders, such as local government or architects.
3. In collaboration with other stakeholders, develop simple and easy-to-read materials showing economic benefits of VHE equipment.
4. Leverage the resources of the VHE product manufacturers and examples of the local deployment of their products to catalyze adoption at the local and state levels.
5. Develop a state tax credit policy for all-electric buildings and for the installation of Energy Star heat pump HVAC and HW systems.
6. Create conceptual or model building codes that encourage or require VHE equipment in MF buildings.
7. Coordinate and support state and local climate organizations and government plans to reach climate goals; ensure VHE technologies and MF buildings are explicitly included.
8. Partner with state and local trade associations, labor organizations, and building trades on workforce development for VHE technologies.
9. Follow statewide policy development and act as technical resources to policymakers when new requirements would intentionally or unintentionally prevent the use of VHE in MF buildings.
10. Continue to encourage utilities, through dockets at the public utility commissions or stakeholder input groups, to offer high incentives and more trainings for VHE technologies in the MF sector.
11. Develop voluntary or stretch goals for municipalities to move toward climate-friendly plans.
12. Advocate for VHE and highly efficient buildings through departments such as state air quality divisions or departments of housing.
13. Encourage housing finance agencies to promote or require VHE technologies in the eligibility criteria for federal tax credits.

Further information about policy opportunities and decarbonization strategies can be found at www.swenergy.org. The authors can be reached at ravim@icastsusa.org, jmeyers@swenergy.org, and cbrinker@swenergy.org.

References

City and County of Denver. n.d. "Net Zero Buildings & Homes." Accessed August 30, 2021. https://www.denvergov.org/Government/Agencies-Departments-Offices/Climate-Action-Sustainability-Resiliency/Initiatives/High-Performance-Buildings-and-Homes/Net-Zero-New-Buildings-Homes

City of Fort Collins. 2015. *Fort Collins 2015 Climate Action Plan Framework*. Fort Collins: CO. https://www.fcgov.com/environmentalservices/pdf/cap-framework-2015.pdf?1465575987

Colorado General Assembly. N.d. "SB21-246: Electric Utility Promote Beneficial Electrification." Accessed August 15, 2021. https://leg.colorado.gov/bills/SB21-246

DCASR (Denver Office of Climate Action, Sustainability, and Resiliency). 2021. *The Energize Denver Renewable Heating and Cooling Plan.* Denver, CO: DCASR. https://www.denvergov.org/files/assets/public/climate-action/documents/hpbh/renewable-hampc/denver-renewable-heating-and-cooling-plan_june-2021.pdf

DOE (U.S. Department of Energy). n.d. "Energy, Emissions and Equity (E3) Initiative." Accessed June 15, 2021.
https://www.energy.gov/eere/buildings/energy-emissions-and-equity-e3-initiative

EMNRD (Energy, Minerals, and Natural Resources Department). 2021. "EMNRD and four higher education institutions awarded $750,000 to expand energy conservation code training and education." August 19, 2021. https://www.emnrd.nm.gov/officeofsecretary/wp-content/uploads/sites/2/EMNRDSEABgrant081921.pdf

Ferriere, Thomas. N.d. "HVAC Job Outlook: Why Technicians Are in Higher Demand Than Ever." InterCoast Colleges. https://intercoast.edu/blog/hvac-job-outlook-why-technicians-are-in-higher-demand-than-ever/

Funk, Jeffrey. 2014. "Biz Model for Nest's Smart Thermostat." April 15, 2014.
https://www.slideshare.net/funk97/biz-model-for-nests-smart-thermostat

Gibson, Scott. 2021. "A New Generation of Heat-Pump Water Heaters is on the Way." *Green Building Advisors*. May 21, 2021. https://www.greenbuildingadvisor.com/article/a-new-generation-of-heat-pump-water-heaters-is-on-the-way

Kolwey, Neil, and Howard Geller. 2018. *Benefits of Heat Pumps in the Southwest*. Boulder, CO: SWEEP. June 2018. benefits-of-heat-pumps-for-homes-in-the-southwest---full-report (swenergy.org)

Leung, Jessica. 2018. *Decarbonizing U.S. Buildings*. Arlington, VA: Center for Climate and Energy Solutions. July 2018. https://www.c2es.org/document/decarbonizing-u-s-buildings/

McKenna, Claire, Amar Shah, and Mark Silberg. 2020. "It's Time to Incentivize Residential Heat Pumps." *Rocky Mountain Institute*. June 8, 2020. https://rmi.org/its-time-to-incentivize-residential-heat-pumps/

Miller, Alex, and Kathy Higgins. 2021. *The Building Electrification Technology Roadmap (BETR)*. Portland, OR: New Buildings Institute. January 12, 2021. https://newbuildings.org/resource/building-electrification-technology-roadmap/

Nedwick, Todd. 2016. "Next Steps for Improving Energy Efficiency in Multi-Family Housing." Presented during an Environmental Protection Agency Webinar. January 19, 2016. https://www.epa.gov/sites/default/files/2017-06/documents/2_introduction_nationalhousingtrust.pdf

NV DCNR (Nevada Department of Conservation & Natural Resources). 2021. *Nevada's 2020 State Climate Strategy*. https://climateaction.nv.gov/wp-content/uploads/2021/01/NVClimateStrategy_011921.pdf

Pantano, Stephen, M. Malinowski, A. Gard-Murray, N. Adams. 2021. *3H 'Hybrid Heat Homes': An Incentive Program to Electrify Space Heating and Reduce Energy Bills in American Homes*. CLASP. https://www.clasp.ngo/research/all/3h-hybrid-heat-homes-an-incentive-program-to-electrify-space-heating-and-reduce-energy-bills-in-american-homes/

Rheem. n.d. "Heat Pump Water Heater." Accessed June 15, 2021. https://www.rheem.com/heatpumpwaterheater/

Rothwell, Patricia and Connie Neuber in conjunction with Southwest Energy Efficiency Project (SWEEP). 2021. *New Colorado Policies to Advance Building Electrification and Energy Efficiency Will Boost Jobs Statewide*. Golden, CO: Energy Efficiency Business Coalition. June 2021. https://eebco.org/resources/Documents/QMM_2021/QMM_JUNE%2024,%202021/EEBC_SWEEP%20REPORT_Electrification%20Boosts%20Jobs%20CO%20Workforce_5.27.21R.pdf

SCAC (Summit Climate Action Collaborative). 2018. *Summit Community Climate Action Plan: Strategies for a Sustainable Future*. https://www.summitcountyco.gov/DocumentCenter/View/31980/Summit-Community-Climate-Action-Plan

Xcel Energy. 2019. *Building a Carbon-Free Future*. February 2019. https://www.xcelenergy.com/staticfiles/xe/PDF/Xcel%20Energy%20Carbon%20Report%20-%20Feb%202019.pdf

Section 6

WHITE PAPER

Policy and Building Code Enhancements Associated with Very High-Efficiency Heat Pump Technology in Multifamily Affordable Housing

Policy and Building Code Enhancements Associated with Very High Efficiency Heat Pump Technology in Multifamily Affordable Housing

A White Paper by:
International Center for Appropriate and Sustainable Technology (ICAST)
and
Southwest Energy Efficiency Project (SWEEP)

Sponsored by:
U.S. Department of Energy

This white paper is a result of the work supported by the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy (EERE) under the Building Technologies Office (BTO) Award Number DE-EE0009080.

Introduction

Policies are required to successfully deploy very high efficiency (VHE) heat pump equipment in affordable housing where state and local jurisdictions can implement equipment replacement when renovations occur in this housing stock. The policy language included in this paper addresses the needs for commercial and residential building stock, as defined by building codes and standards.

This language can be used as a template in states, cities, and counties to promote and implement the deployment of these VHE products in this building sector. The template language can be shared with policymakers in key geographical areas of states and municipalities for feedback and opportunities to incorporate into current governmental policies.

This paper may be used by affordable housing stakeholders to promote and encourage the utilization of VHE technologies by governmental leaders in the multifamily affordable housing market.

Policy Language

The conceptual policy language should be implemented through the practices jurisdictions employ to amend building regulatory requirements. In most cases this will be deployed as an amendment to an adopted, or proposed building code. The language applies to the International Energy Conservation Code (IECC) for existing building and includes amendments for both commercial and residential multifamily buildings. We used the 2021 IECC as the baseline code which is the latest version of published energy codes from the International Code Council (ICC).

We utilize the wording format a building official and building department staff would see by building industry stakeholders to update and amend a building code. Sections of code are documented to be inserted directly into an adopted code. In the case of the definitions, they reside in Chapter 2 section R202 or C202. The R preceding the number indicates the provisions apply to residential buildings and the C preceding the number indicates they are commercial building requirements.

An *italic word or phrase* means it is a word/phrase defined in the definitions chapter of the code. Newly proposed language/words for the code are all underlined in the text format.

The code language in this paper also uses commonly used terminology employed in the building codes and not language a layperson would use. As an example, this language does not use the term “domestic hot water” (DHW) or “hot water heater,” but uses the term “service hot water” or “service water heating” which is a defined term in the definitions of the code. It means the same thing, but this code language minimizes the number of amendments that would be required to introduce a new term through a new definition and a new section for affordable housing. Using code appropriate terminology supports the code enforcement, design, and construction communities.

In the example of affordable housing additions with new HVAC systems, the hierarchy of code language is as follows:

1. Takes the user to the scope section of the code for alterations or additions (example) R501

2. Then takes the user to the new scope section (example) R501.1.2 which mandates new HVAC and hot water systems or heat pump systems
3. Then reminds the builder/trades that Section 403 of the IECC, for new construction, also applies which would include sections as:
    a. R403.1.1 Programmable thermostats
    b. If installing new ducts, they must comply with R403.3 and the subsection of R403.3
    c. And duct sealing in R403.4
    d. And duct testing if new ducts
    e. And piping if using hot water for space conditioning, if using a heat pump water heater.

The practices apply across both residential and commercial building code provisions in this paper.

Commercial Building Energy Code Conceptual Language

The proposed code language is based on the 2021 IECC and uses the **Times New Roman** font while the narrative and descriptions on applying the code use the **Calibri** font as this paragraph is using. The code language is also indented to better distinguish code language from narrative and descriptive information.

Add new definitions to Section C202 Definitions:

> **SUBSIDIZED AFFORDABLE HOUSING**. Residential Group R-2 occupancies where greater than or equal to 51 percent of the households have an income of not more than 80 percent area median income (AMI) and the property was subsidized by a form of governmental financial assistance.

> **NATURALLY OCCURING AFFORDABLE HOUSING (NOAH).** Residential Group R-2 occupancies where greater than or equal to 51 percent of the households have an income of not more than 80 percent area median income (AMI) and the property as a whole is not subsidized by any governmental financial assistance.

Add new sections to Chapter 5 of the commercial energy code. Chapter 5 of the code supports existing buildings and updates/upgrades to these building types. Commercial residential buildings are greater than three stories in height above grade. This language supports commercial multifamily buildings.

> **C501.1.2 Alterations and additions to existing affordable housing.** Additions and alterations to the mechanical systems and domestic hot water systems for *subsidized affordable housing* or *naturally occurring affordable housing* existing buildings, shall provide an energy audit for the existing *building* prior to permit issuance. New heating and cooling systems and service hot water systems for *additions* and *alterations*, replacements shall use very high efficiency electric heat pump equipment.
>
> **Exception:**

Where it is physically unfeasible to alter, add, or replace equipment with very high efficiency heat pump systems the owner/contractor must substantiate feasibility to the building official.

C501.1.3 Resistance electric heating systems. Where some or all of an electric resistance heating system is removed as part of an *alteration* the new heating system shall meet the applicable requirements of C501.1.2.

C501.4 New and replacement materials. <No change to section language>.

Exception:

Like for like HVAC and service hot water equipment is not permitted unless approved by the building official with Section C501.1.2.

C502.1 General. *Additions* to an existing *building*, *building* system or portion thereof shall conform to the provisions of this code as those provisions relate to new construction without requiring the unaltered portion of the existing *building* or *building* system to comply with this code. *Additions* shall not create an unsafe or hazardous condition or overload existing *building* systems. An *addition* shall be deemed to comply with this code if the *addition* alone complies, or if the existing building and addition comply with this code as a single building. *Additions* shall be in accordance with Section C501.

Exceptions:

Like for like HVAC and service hot water equipment is not permitted unless approved by the building official with Section C501.1.2.

C502.2 Change in space conditioning. Any unconditioned or low-energy space that is altered to become *conditioned space* shall be required to be brought into full compliance with this code. *Subsidized affordable housing* or *naturally occurring affordable housing* existing buildings shall comply using very high efficiency electric heat pump equipment.

Add new sections to Chapter 5 of the commercial energy code:

C502 applies to building additions.

C502.3.3.1 Heating and cooling systems affordable housing. Heating and cooling systems newly installed as part of a *subsidized affordable housing* or *naturally occurring affordable housing addition* shall comply with Section C501.1 and C403 and C408.

C502.3.4.1 Service water-heating systems affordable housing. New service hot water systems that are part of a *subsidized affordable housing* or *naturally occurring affordable housing addition* shall comply with Section C501.1 and C404.

C503 applies to building alterations.

C503.3.2 Heating and cooling systems affordable housing. Heating and cooling systems newly installed as part of an *affordable housing alteration* shall comply with Section C501.1 and C403.

C503.4.1 Service water heating systems affordable housing. New service hot water systems that are part of the *affordable housing alteration* shall comply with Section C501.1 and C404.

Residential Building Energy Code Conceptual Language

The proposed code language is based on the 2021 IECC and uses the Times New Roman font while the narrative and descriptions on applying the code use the Century Gothic font as this paragraph is using. The code language is also indented to better distinguish code language from narrative and descriptive information.

Add to R202 Definitions:

SUBSIDIZED AFFORDABLE HOUSING. Residential Group R-2 occupancies where greater than or equal to 51 percent of the households have an income of not more than 80 percent area median income (AMI) and the property was subsidized by a form of governmental financial assistance.

NATURALLY OCCURING AFFORDABLE HOUSING (NOAH). Residential Group R-2 occupancies where greater than or equal to 51 percent of the households have an income of not more than 80 percent area median income (AMI) and the property as a whole is not subsidized by any governmental financial assistance.

Add new sections to Chapter 5 of the residential energy code. Chapter 5 of the code supports existing buildings and updates/upgrades to these building types. Residential buildings are three stories or less in height above grade. This language supports residential and not commercial multifamily buildings.

R501.1.2 Alterations and additions to affordable housing. Additions and alterations to the mechanical systems (HVAC) and domestic hot water systems for *subsidized affordable housing* or *naturally occurring affordable housing* existing buildings, shall provide an energy audit for the existing *building* prior to permit issuance. New heating and cooling systems and service hot water systems for *additions* and *alterations*, replacements shall use very high efficiency electric heat pump equipment.

Exception:

Where it is physically unfeasible to alter, add, or replace equipment with very high efficiency heat pump systems the owner/contractor must substantiate feasibility to the building official.

R501.1.3 Resistance electric heating systems. Where some or all of an electric resistance heating system is removed as part of an *alteration* the new heating system shall meet the applicable requirements of R501.1.2.

R501.5 New and replacement materials. <No change to section language>.

Exception:

Like for like HVAC and service hot water equipment is not permitted unless approved by the building official with Section R501.1.2.

R502.1 General. *Additions* to an existing *building*, *building* system or portion thereof shall conform to the provisions of this code as those provisions relate to new construction without requiring the unaltered portion of the existing *building* or *building* system to comply with this code. *Additions* shall not create an unsafe or hazardous condition or overload existing *building* systems. An *addition* shall be deemed to comply with this code where the *addition* alone complies, where the existing *building* and *addition* comply with this code as a single building, or where the *building* with the *addition* does not use more energy than the existing *building*. *Additions* shall be in accordance with Section R502.2 or R502.3, and R501.

Exception:

Like for like HVAC and service hot water equipment is not permitted unless approved by the building official with Section R501.1.2.

R502.2 Change in space conditioning. Any unconditioned or low-energy space that is altered to become *conditioned space* shall be required to be brought into full compliance with this code. *Affordable housing* existing buildings shall comply using very high efficiency electric heat pump equipment.

Add new sections to Chapter 5 of the residential energy code:

R502.3.2.1 Heating and cooling systems affordable housing. HVAC systems newly installed as part of an *affordable housing addition* shall comply with Section R501.1 and R403.

R502.3.3.1 Service hot water systems affordable housing. New service hot water systems that are part of the *affordable housing addition* shall comply with Section R501.1 and R403.5.

R503.1.2.1 Heating and cooling systems affordable housing. HVAC systems newly installed as part of an *affordable housing alteration* shall comply with Section R501.1 and R403.

R503.1.3.1 Service hot water systems affordable housing. New service hot water systems that are part of the *affordable housing alteration* shall comply with Section R501.1 and R403.5.

Benefits of Policy Language

Building codes are a unique policy tool for states and municipalities to support environmental, community, and affordable housing goals. Building codes are technical in nature, but the requirements within the building codes put in place required practices to construct highly efficient housing stock, while also including provisions to improve energy efficiency in the built environment.

A state or municipality that implements this code language will significantly move the current stock of residential multifamily units to clean and efficient housing for residents of affordable housing across the nation.

Section 7

Case Studies

Success Stories:

Energy Efficiency Project

Stansbury Condos

299,581 | kWh Saved Annually

75-unit market-rate owner occupied property

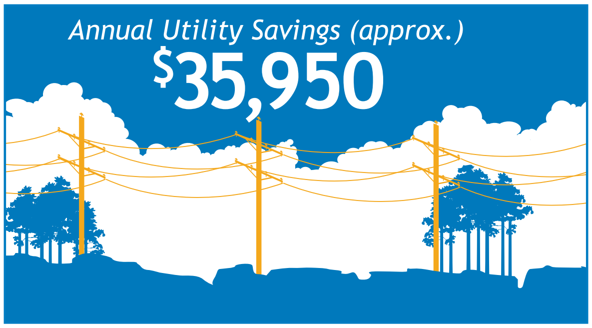
Project Payback - **9 years**

Total Project Cost - **$399,800**

Total savings from utilities - **$74,895**

Carbon Saved Annually - **275 Tons**

The savings was generated by replacing central boilers and chillers with 75 new very high efficiency heat pump HVAC system units.



The Problem:

Stansbury Condos had a very old and inefficient central boiler and chiller system, with high repair and utility costs paid by all tenants through their HOA dues. They decided to convert to an efficient all-electric HVAC system and they needed energy financing to fund the project.

The Solution:

Rather than install standard electric fan coils, we suggested they consider a central electric HVAC solution such as a VRF and also unitary heat pump based HVAC units in each apartment. The unitary solution would move the heating and cooling costs to individual owners and eliminate any waste due to the 'tragedy of commons'. The utility and repair cost savings would result in a small reduction in HOA dues for each tenant, while the HOA dues would pay for the energy financing for the next 8 years. And after the investment was paid off, HOA dues would be reduced accordingly. Stansbury decided to upgrade to high-efficiency unitary heat pumps, and leverage the RMP incentives to reduce their energy financing costs.

This material is based upon work supported by the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy (EERE) under the Building Technologies Office, Award Number DE-EE0009080.

www.icastusa.org | 866-590-4377 | info@icastusa.org

ICAST is a nonprofit that provides economic, environmental, and social benefits to local communities. ICAST delivers green upgrades to multifamily homes to preserve affordable housing, address climate change, and create local jobs.

ICAST Success Stories:

Energy Efficiency Retrofit

The Kirk Apartments

$30,199 Average Annual Utility Savings

48-unit affordable apartment community

Incentives received from utilities - **$78,780**

Total Project Cost - **$230,790**

Annual kWh Savings - **262,602**

Annual reduction in energy costs **-20%**

The savings were generated by replacing the interior and shared public space lighting and fixtures, programmable thermostats, and new very high-efficiency heat pump HVAC systems in every unit.

The Problem:

The electric baseboard heaters were resulting in high utility bills for tenants and causing occupancy issues for the new owner who approached RMP. Additionally, the old property was dealing with health and comfort issues for the tenants due to insulation issues around window air conditioning units: issues such as hot/cold drafts and condensation inside the building.

The Solution:

High-efficiency heat pump-based HVAC units replaced the window A/C and baseboard heaters in each unit. The highly efficient units installed reduce the utility bills drastically for the tenants while closing the window A/C openings took care of the health and comfort issues.

"...They made securing utility rebates hassle-free and easy. They worked with us on every step of our project from planning through construction and worked to ensure the project ran smoothly and on-schedule, minimizing stress and inconvenience for everyone involved."

Tyler Kohler - The Kirk

This material is based upon work supported by the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy (EERE) under the Building Technologies Office, Award Number DE-EE0009080.

www.icastusa.org | 866-590-4377 | info@icastusa.org

ICAST is a nonprofit that provides economic, environmental, and social benefits to local communities. ICAST delivers green upgrades to multifamily homes to preserve affordable housing, address climate change, and create local jobs.

ICAST Success Stories:

Energy Efficiency Retrofit

556 23rd Apartments

$39,278 | In Total Rebates From Utilities

48-unit affordable apartment community

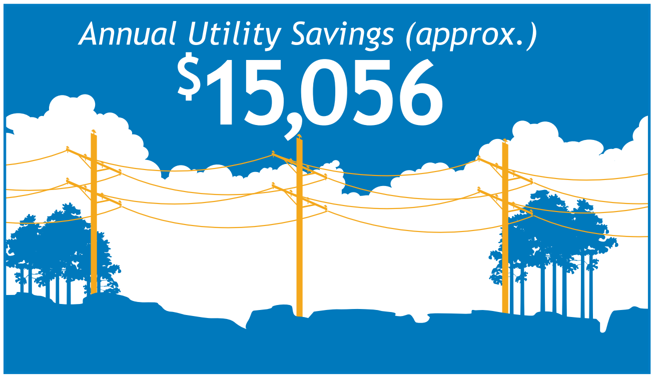
Project Payback - **5 years**

Total Project Cost - **$119,596**

Annual kWh Savings - **130,926**

Carbon Saved Annually - **120.44 Tons**

The savings was generated from new very high-efficiency heat pump HVAC systems, high-efficiency insulation, programmable thermostats and LED lighting.



The Problem:

This micro-unit apartment complex with electric resistance heating system was causing tenant complaints about the high utility costs and their inability to put their furniture in desired locations due to the small size of the units. The property owner wanted to preserve all possible rentable sq. ft. so installing new furnaces that would take away from the rentable space was not an option.

The Solution:

The customer was presented with the idea of a high-efficiency, high wall-head, heat pump HVAC to allow tenants more freedom to rearrange their furniture as well as not taking up any internal sq. footage. Additionally, the owner was shown how RMP incentives would help them get the desired high-efficiency equipment to work within their budget.

This material is based upon work supported by the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy (EERE) under the Building Technologies Office, Award Number DE-EE0009080.

www.icastusa.org | 866-590-4377 | info@icastusa.org

ICAST is a nonprofit that provides economic, environmental, and social benefits to local communities. ICAST delivers green upgrades to multifamily homes to preserve affordable housing, address climate change, and create local jobs.

Section 8

Workforce Development

Workforce Development for Green Jobs

Green Construction Careers (GC^2) Program

ICAST launched its Green Construction Careers (GC^2) Program in 2017 to address the need for skilled workers from its multifamily housing customers and subcontractors installing the green upgrades. GC^2 is available across all ICAST service territories, leveraging the green retrofit work we manage at multifamily properties for on-the-job training opportunities.

GC^2 is an education, training, and apprenticeship program for economically disadvantaged community members such as at-risk youth, formerly incarcerated individuals, veterans, and workers looking to enhance their current skill set. ICAST partners with local organizations that are working with these target groups, to source the trainees for GC^2.

Each GC^2 participant receives online and classroom instruction before they are offered a paid apprenticeship at an ICAST job site. Trainees learn the skills necessary to install and maintain LED lights, low-flow toilets, smart thermostats, PV solar, heat pump HVAC, etc. Trainees can earn a Building Performance Institute (BPI) and/or NABCEP certification to help them advance their careers.

ICAST's GC^2 Program continues to be successful in the territories ICAST currently serves because it has the infrastructure, field supervisors, funding and on-the-job training opportunities for the trainees.

www.icastusa.org | 866-590-4377 | info@icastusa.org

ICAST is a nonprofit that provides economic, environmental, and social benefits to local communities. ICAST delivers green upgrades to multifamily homes to preserve affordable housing, address climate change, and create local jobs.

Workforce Development for Green Jobs

Case Study: New Mexico Service Territory

ICAST has built many partnerships across the State of New Mexico to help manage its GC^2 Program. Some of the key partners include:

Youth Development Inc. (YDI)

YDI helps school drop-outs earn GEDs and provide them basic workforce skills, thus complementing ICAST's GC^2 program. YDI has placed over 200 disadvantaged youth from the Albuquerque Metro area in the GC^2 Program and continues to be a partner to ICAST.

YouthWorks of Santa Fe

YouthWorks is a US Dept. of Labor funded Youth Build organization that helps ICAST identify and recruit disadvantaged youth from the Santa Fe, NM region.

New Mexico Mortgage Finance Authority (MFA)

MFA is the Weatherization Assistance Program (WAP) administrator and has hired ICAST to manage the State's WAP for MF properties. This funding is instrumental to the GC2 program, as it allows for on-the-job training opportunities and helps fund the paid apprenticeships.

New Mexico Gas Company (NMGC)

ICAST manages NMGC's Demand Side Management (DSM) program for the Multifamily market across the NM territory. This funding also supports on-the-job training opportunities and the paid apprenticeships.

US Economic Development Admin. (EDA)

EDA provided funding for ICAST to establish and operate the GC^2 Program in four states.

Albuquerque Community Foundation and Wells Fargo

These funders have provided funding for ICAST to manage and grow the GC^2 Program in New Mexico and attract more trainees.

Workforce Development for Green Jobs

GC² Training at Santa Fe Community College (SFCC)

The EnergySmart Academy at Santa Fe Community College is the primary provider of curriculum and training. They are the US Dept. of Energy's certified training provider for WAP. Some of the training modules include:

- Basics of energy efficiency and bldg. science
- Preparation for the Bldg. Energy Analyst certificate from BPI
- Training videos on the installation of various energy and water saving measures
- Solar PV installation (in-person course) and preparation for NABCEP certification
- Design, install, and maintenance of high-efficiency heat pump HVAC systems

Career Placement

ICAST has a strong network within the green construction and multifamily housing industries to create a direct link from training to job placements. After GC² participants complete their training, ICAST helps them with job placements at the multifamily properties as Maintenance Technicians or with the Contractors as Installation Technicians. These employers get to assess trainees while they are working on the job site. A property maintenance technician receives housing as part of the job perks. ICAST has also created an online job board for participants and employers to post their qualifications and job openings, respectively. ICAST has hired some of its GC² trainees as Site Supervisors.

ICAST is a nonprofit that provides economic, environmental, and social benefits to local communities. ICAST delivers green upgrades to multifamily homes to preserve affordable housing, address climate change, and create local jobs.