Vermont Heat Pump Market Assessment

Residential Market

March 2025

Efficiency Vermont
20 Winooski Falls Way
Winooski, VT 05404

Contents

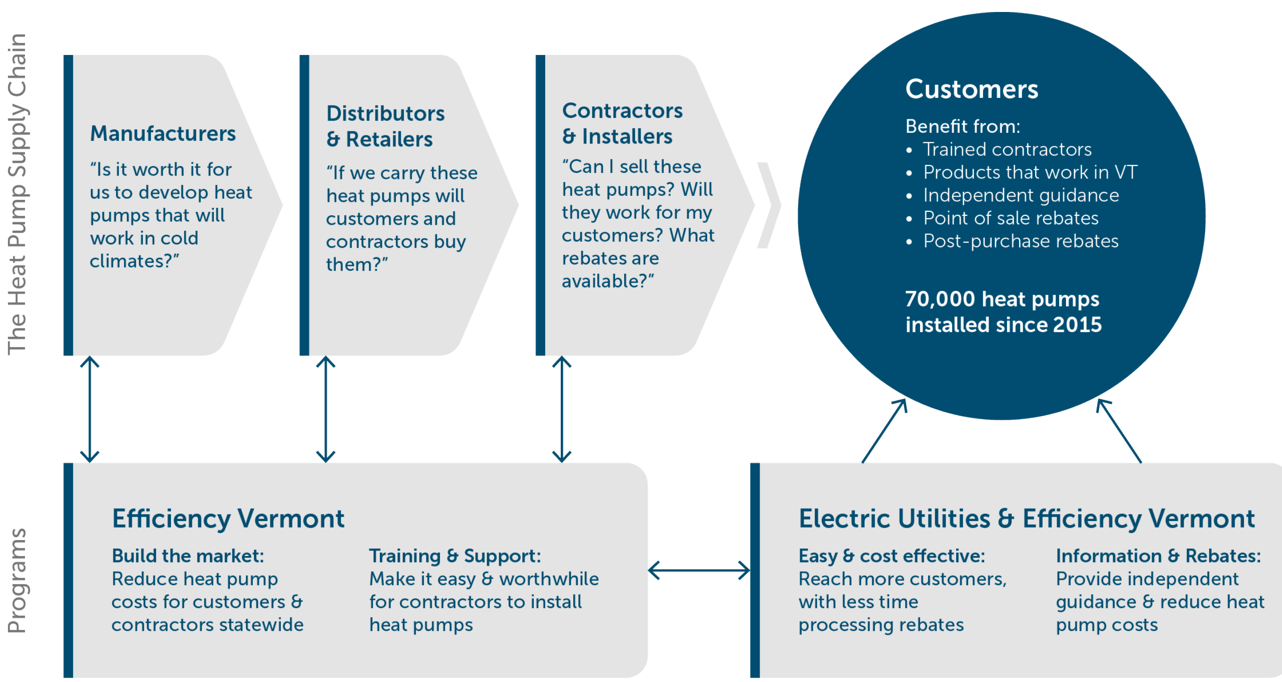
Executive Summary

Purpose, Objectives, and Scope

Aggressive electrification of the heating sector is a key strategy for achieving Vermont's ambitious carbon emissions goals, as well as reducing costs and promoting climate resilience for homes and businesses. Since 2015, Efficiency Vermont and the state's electric distribution utilities (DUs) have partnered on a multifaceted effort to help increase the adoption of heat pumps. Key program strategies include:

- Working with manufacturers, retailers, and distributors to ensure availability of heat pump models that can effectively and efficiently provide heating in Vermont's cold climate
- Training contractors to install heat pumps and provide guidance to customers on using this technology in their homes and businesses
- Providing point-of-sale and post-purchase rebates to help reduce upfront costs for customers

Figure 1 A graphical representation of how Vermont's cold-climate heat pump program relies on collaboration and integration at every level of the supply chain.



This Market Assessment investigates the status of heat pump technology, availability, accessibility, and adoption in Vermont as of fall 2024. The goal of this document is to help program administrators:

1. Assess the impact of programs on heat pump adoption in the residential sector over the last decade
2. Understand the remaining market barriers and potential for continued widescale adoption of heat pumps in the residential sector
3. Estimate the remaining market potential for heat pumps as a primary and supplementary heating source in Vermont homes

The assessment includes cold-climate heat pumps used for space heating and cooling, and heat pump water heaters, with a focus on the residential market. To the extent that small businesses use equipment designed for residential applications, those systems are included. Other heat pumps, like heat pump clothes dryers, are not part of the study. No primary research was performed, although this project benefited from preliminary results from two concurrent Efficiency Vermont surveys that were launched independently. Although this assessment did not consider commercial and industrial applications, future updates will broaden the scope to include these sectors.

Findings

Vermont has seen significant uptake of ductless mini split heat pump technology over the last decade, with 70,960 units installed since midstream heat pump programs launched in 2015. Ten percent of housing units in Vermont have a heat pump,[i] indicating that Vermont is in the "early adopter" phase of market adoption.[ii]

However, customer research indicates that some of the potential emissions reductions associated with heat pump installation are not being realized due to customers' use of their heat pumps. Many use their heat pump to air condition in the summer (with a small percentage reporting they use their heat pump only for air conditioning and never for heating), and many rely heavily on secondary heating systems during the winter. Given Vermont's location on the market adoption curve for this technology, and indications that customers may not be using these units to their full heating potential, we believe that there is an important opportunity to continue supporting customers and contractors in installing ductless mini splits, while increasing our focus on education and training, to ensure customers can maximize the value and usage of their systems.

Somewhat newer to the market are heat pump configurations that can be retrofitted to existing heating distribution systems to provide "whole-home" ducted heating. These systems currently have a much higher upfront cost than ductless mini splits, are more technically complicated to install, and have so far reached a relatively smaller proportion of potential customers. We estimate that both ducted and ductless technologies are in the "innovators" stage of adoption, indicating a significant need for support and market intervention to ensure Vermonters can access and adopt them at greater scale.

There are a wide range of trade allies serving this market, having responded to strong demand from Vermonters for ductless mini split systems over the last decade. As more complicated heat pump technologies continue to advance and become more widely available in Vermont, it will be important to ensure that these contractors have access to training, support, and resources that give them confidence to recommend and install heat pumps that perform as whole-home solutions to customers.

As of 2024, Vermonters have adopted heat pumps at the highest per capita rate of any state in the Northeast.[iii] In order to continue this progress – and to maximize benefits for customers while mitigating impacts on the electric grid –heat pump programs should focus on four core strategies going forward:

Strong Customer Uptake

Vermonters have adopted heats pumps at the highest per capita rate of any state in the Northeast.

1. **Leverage our success:**
    a. Continue to support the market by bolstering businesses throughout the supply chain that are critical to customer decision-making and to the broader uptake of whole-home and emerging heat pump technologies
    b. Ensure customers understand the full potential of their heat pump systems and how to leverage them to manage their costs and further offset their heating load
2. **Invest in innovation:** Engage directly with manufacturers to track technological developments that will enable heat pump technology to be a retrofit solution for more of Vermont's homes
3. **Focus on accessibility:** Ensure there are program and technology solutions that meet the needs of Vermont customers, whether they are low-income, rent their homes, or face other major barriers to adoption
4. **Promote complementary actions:** Create opportunities for customers to weatherize their homes and employ controls that will help mitigate the impact of widespread heating electrification on the grid

There are still a significant number of Vermont residents who could benefit from heat pumps. A coordinated, market-wide approach will support them in exploring and understanding the technology, and in taking their next steps.

Background

Programs

Vermont's Energy Efficiency Utilities (EEUs)[iv] and electric distribution utilities (DUs) offer a range of incentives to help make heat pumps more affordable and accessible for Vermont residents. Unless otherwise specified in the table below, these incentives are supported using ratepayer funds, through programs overseen by the Vermont Public Utility Commission (PUC).

Table 1: Overview of Vermont utility heat pump incentives[v]

Type of heat pump	Point-of-sale rebate* (administered by Efficiency Vermont)	Post-purchase rebate (administered by Efficiency Vermont and/or Distribution Utilities)
Air-to-water (AWHP)	Not applicable	Up to $6,500* statewide Additional rebates available for customers of Burlington Electric Department (BED) and Washington Electric Cooperative (WEC)
Ducted	$1,000 - $2,000*	BED and WEC offer additional post-purchase rebates to all customers Green Mountain Power (GMP), Stowe Electric Department (SED), and VT Public Power Supply (VPPSA) member utilities offer post-purchase rebates to low-income customers VPPSA member utilities and VT Electric Cooperative (VEC) offer post-purchase rebates to customers who have weatherized their homes
Ductless mini split	$350 - $450*	BED and WEC offer additional post-purchase rebates to all customers GMP, SED, and VPPSA member utilities offer post-purchase rebates to low-income customers VPPSA member utilities and VEC offer post-purchase rebates to customers who have weatherized their homes
Integrated controls (IC) for ductless mini split	Not applicable	Up to $600 statewide GMP and WEC provide additional post-purchase rebates to customers with qualifying projects
Heat pump water heater (HPWH)	$600	100% of costs for low-income customers statewide (except BED customers), funded through the federal American Rescue Plan Act (ARPA) 90% of costs, up to $6,000, for moderate-income customers statewide (except BED customers), funded through ARPA BED, VPPSA member utilities, and WEC offer additional post-purchase rebates
Ground-source (GSHP)	Not applicable	Up to $2,100* per ton statewide WEC provides an additional post-purchase rebate

* Rebate varies based on system size

In addition to the incentives listed above, there is money available from Efficiency Vermont, leveraging federal American Rescue Plan Act (ARPA) funding, to customers who have been impacted by flooding and need to replace their heating systems. As of this writing, the Vermont Department of Public Service (PSD) has also submitted an application to the U.S. Department of Energy (DOE) that, if approved, will leverage federal Inflation Reduction Act (IRA) funding to provide additional support for low and moderate-income households to install heat pumps,[vi] with programs slated to launch in 2025 and continue through 2028 or until funds are expended.

Eligible customers can use Vermont's low-income Weatherization Assistance Program (WAP), which currently covers 100% of costs for purchasing and installing heat pump water heaters (HPWHs) and ductless mini splits. This program is funded through a mix of state, federal, and Efficiency Vermont incentives.

Vermont Energy & Climate Goals

The Vermont legislature passed the Global Warming Solutions Act (GWSA) in 2020, which committed the state to achieving binding greenhouse gas emissions (GHG) reduction targets with key milestones in 2025, 2030, and 2050. As of 2023, the Energy Action Network estimated that the state had achieved 14% and 34% of those targets, respectively, with heat pumps playing a role in advancing GHG reduction.[vii]

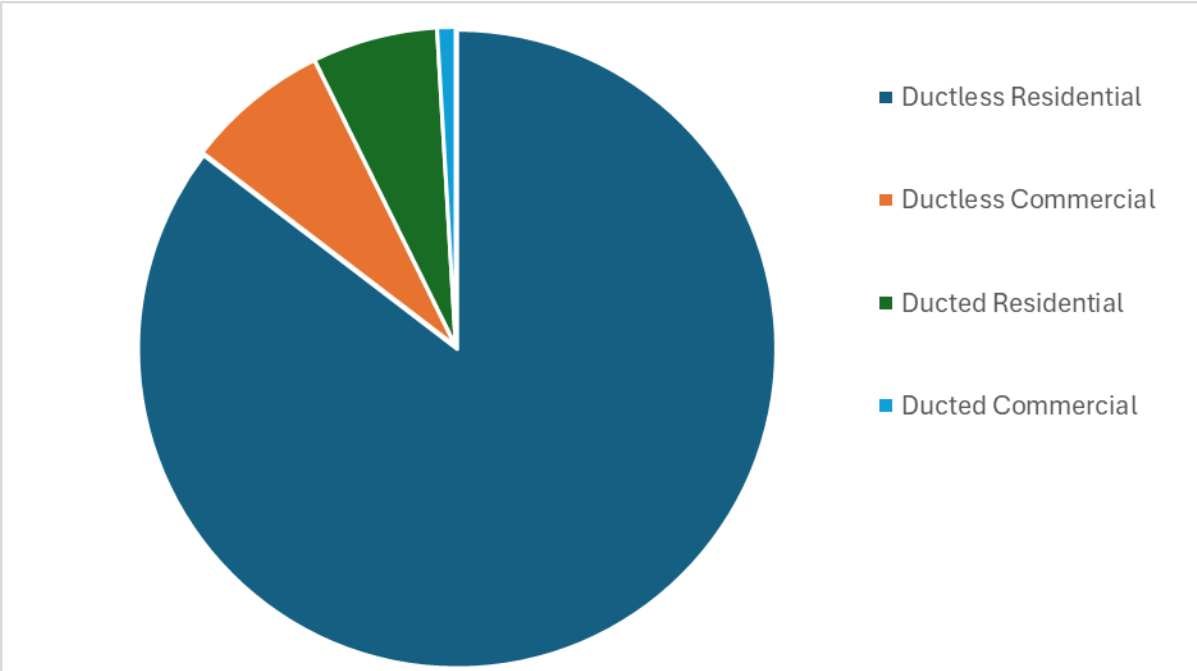
Customers

Data about customer perceptions in this section come from two Efficiency Vermont studies unless otherwise indicated: Midstream Incentive Participants Survey October 2024 (n=1,765) and Homeowners Without Heat Pumps Survey December 2024 (n=222). Details about these surveys are in Appendix A.

Adoption

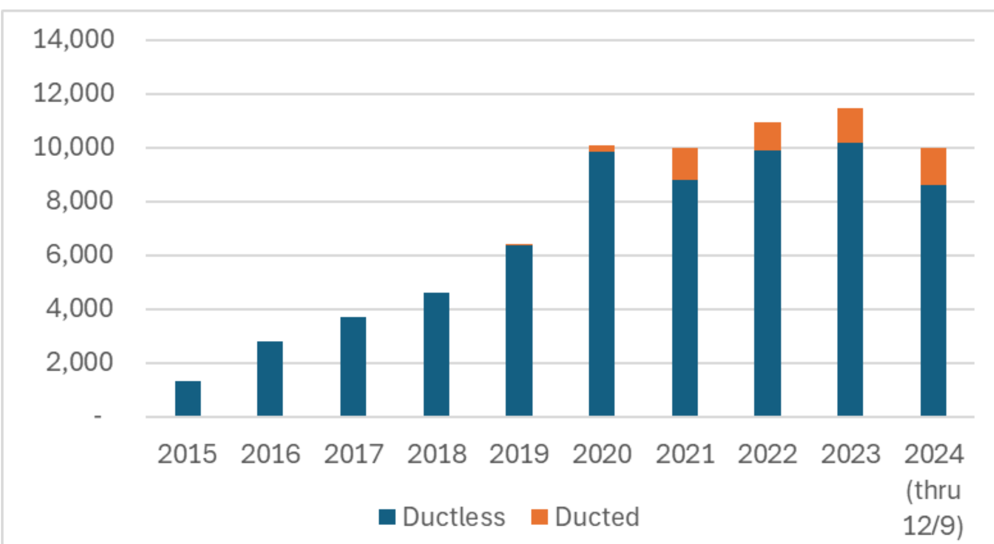
Nearly 71,000 heat humps that received Efficiency Vermont incentives (ductless and ducted) were installed in commercial and residential buildings between 2015 and 2024. Nearly 10,000 of these were installed in 2024.

Figure 2 HVAC heat pumps by type and market



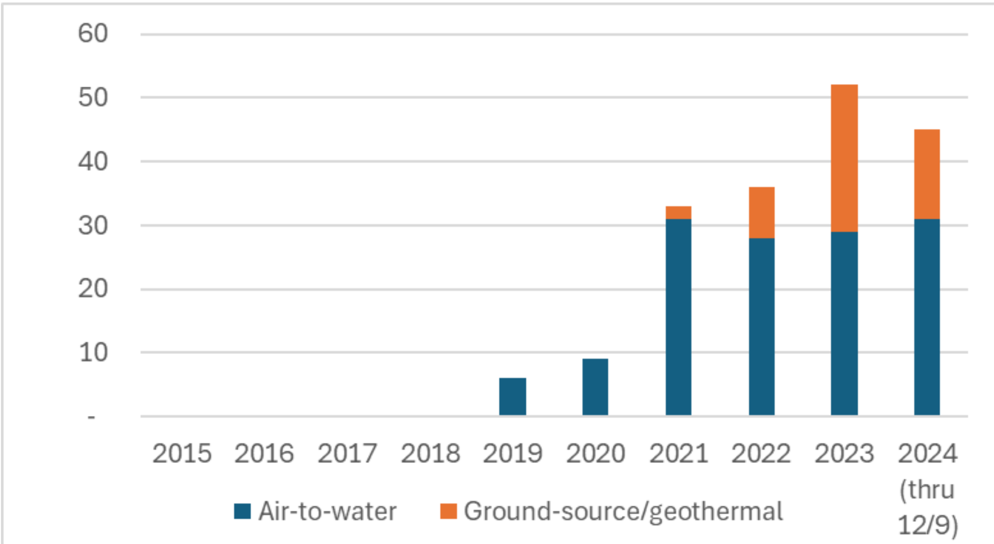
The annual quantity of heat pump installations increased quickly from 2015 through 2020 and has been consistent since then.

Figure 3 Ductless and ducted air source heat pump installations by year



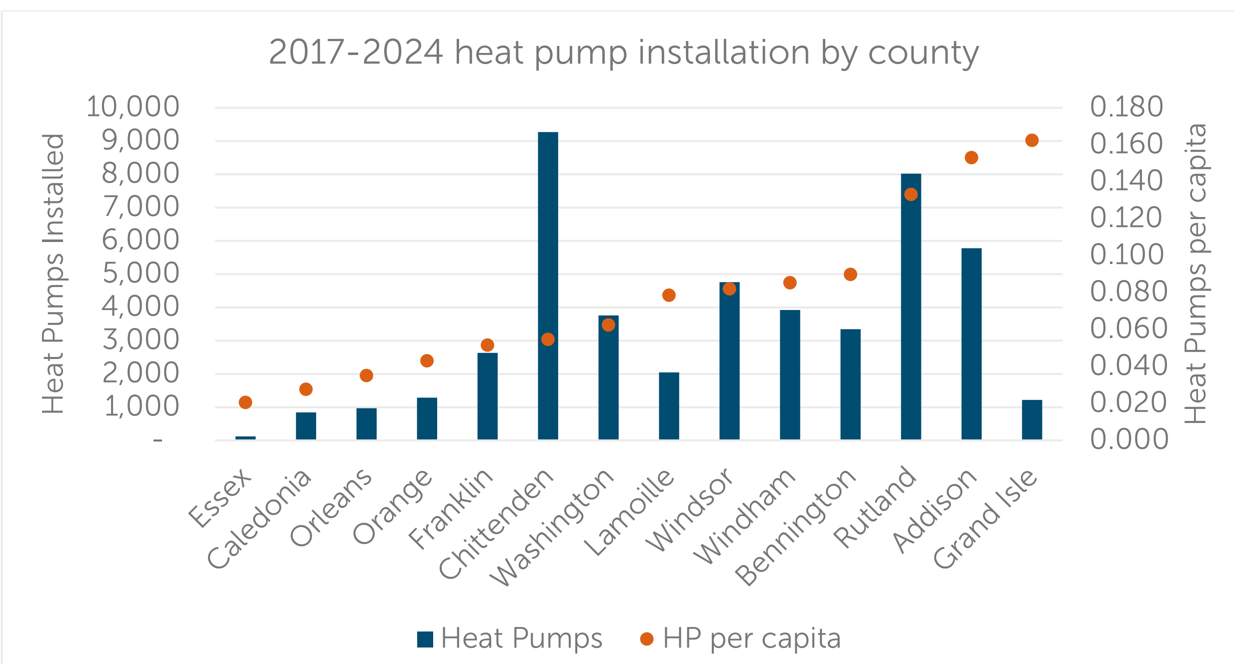
The annual quantity of air-to-water and ground-source heat pump installations increased around the same time as ductless and ducted ones, but the total number of installations remains much lower, for reasons discussed in the section below.

Figure 4 Air-to-water, and ground-source heat pump installations by year



While Vermont on the whole has seen a strong uptake of heat pumps, this trend has not been evenly distributed across the state. For example, Addison and Grand Isle counties have seen the highest adoption to date, with over 0.15 HVAC heat pump installations per capita relative to fewer than 0.03 HVAC heat pumps installed per capita in Essex and Caledonia Counties.

Figure 5 Heat pump installations 2017-2024 by county



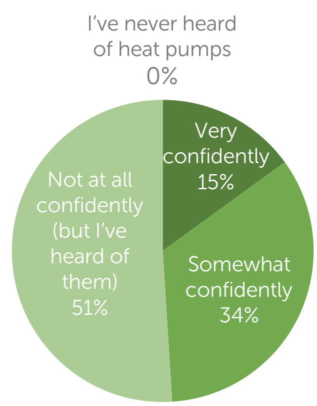
Efficiency Vermont surveyed customers who received a midstream heat pump incentive between January 1, 2019 and December 31, 2022. Based on the 1,765 respondents, heat pumps owners are, relative to the Vermont population[viii], more likely to be:

- high-income (43% of incentive recipients vs. 24% of the state)
- white (97% of incentive recipients vs. 90% of the state)
- male (60% of incentive recipients vs. 49% of the state) – although this skew may more closely represent which member of a household served as the contact for the heat pump installation than a skew in overall ownership
- be over the age of the 65 (56% of incentive recipients vs. 36% of the state)
- have a college degree (81% of incentive recipients vs. 42%[ix] of the state).

Perceptions

Almost all Vermonters have heard of heat pumps, although familiarity with heat pumps among people who don't own one is low: 51% of respondents in a survey of Vermont homeowners who don't own heat pumps said they could "not at all confidently" describe what a heat pump is.

Figure 6 Non-owners confidence describing "what a heat pump is"



Vermonters mostly **feel positively** about heat pumps, although many who don't own heat pumps **feel neutral** about them due to their limited familiarity. Almost all (94%) Vermonters who own a heat pump are satisfied with it. Of Vermont homeowners who don't have a heat pump, 48% have a positive overall impression and 46% have a neutral impression. Across heat pump owners and non-owners, **positive impressions** relate primarily to heat pumps' efficiency and operating cost. **Neutral impressions** relate primarily to not having enough knowledge about heat pumps to form an impression. **Negative impressions** relate primarily to poor heating performance, particularly in cold weather.

"Installing a heat pump was the best purchase I made in my twenty years as a homeowner. Couldn't be happier!" – feedback provided to the Efficiency Vermont call center by a Rutland County customer (2022)

Air conditioning is a substantial motivator for heat pump installation. 73% of Vermonters who own a heat pump indicated that adding air conditioning was one of their reasons for installing a heat pump. (This was the most cited reason.) In response to an open-ended question "What's the best thing about your heat pump?" slightly more than half of heat pump owners discussed air conditioning. Some Vermonters (33%) who don't own a heat pump identified air conditioning as "a good reason" to install a heat pump, but among non-owners saving money on heating/cooling costs (51%) and replacing a broken heating system (42%) were more salient drivers.

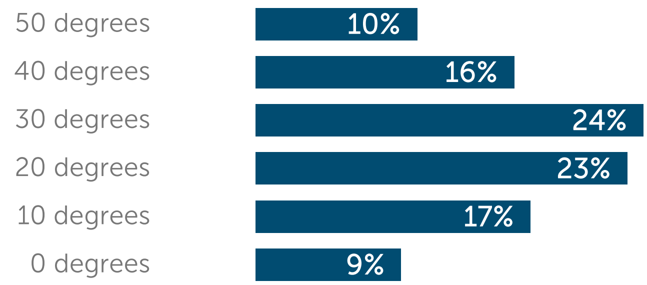


Figure 7 Temperature below which heat pump owners use a secondary heating system

Many heat pump owners think their heat pump's **performance declines in cold weather**. Almost all (90%) heat pump owners use a secondary heating system instead of or in addition to their heat pump on "very cold" days. The outdoor temperature below which they use a secondary heating system varies widely by customer.

Although the perception that heat pumps alone aren't adequate for heating during Vermont winters is shared by many Vermonters who don't own heat pumps (only 7% predicted they'd have "no need to ever use a secondary heat source"), uncertainty about whether a secondary heating system would be necessary was the more common perception (44%), especially among low-income respondents.

Many Vermonters who don't own heat pumps **don't prioritize installing a new heating or cooling system**. In response to a question asking what home improvement projects Vermonters are "interested in pursuing," only 27% of Vermonters who don't own a heat pump selected "replace or add heating system" and only 23% selected "replace or add air conditioning system."

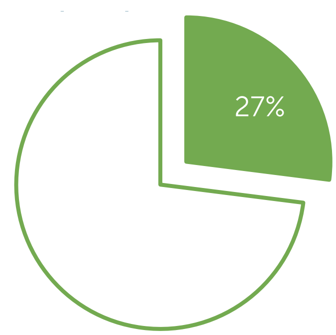


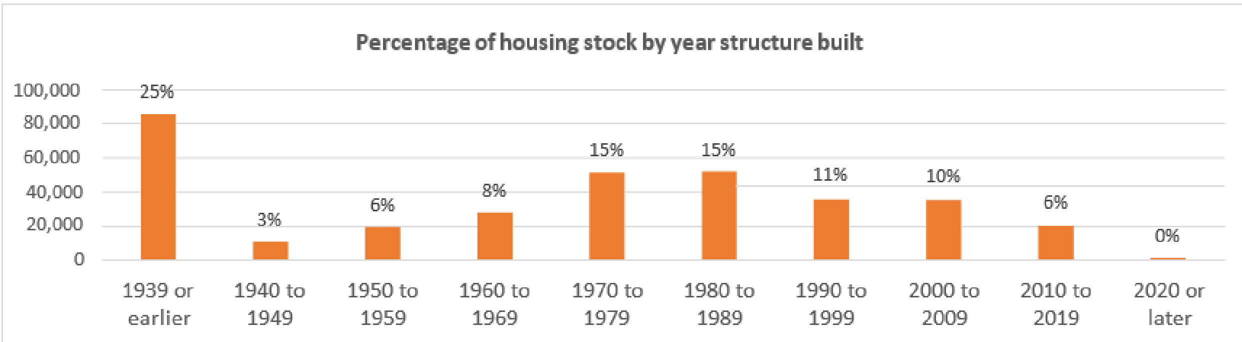
Figure 8 Vermont homeowners without a heat pump who "are interested in pursuing"

Barriers

When asked to consider installing a heat pump, survey respondents' most-cited barrier was upfront cost (52%). This is also the most discussed reason for not pursuing a heat pump project among customers who contact Efficiency Vermont for information about heat pumps but decided not to move forward with a heat pump project. Contractor availability was also commonly referenced as a barrier among customers who contacted Efficiency Vermont and survey respondents (20%).

Limited familiarity with heat pumps is also a substantial barrier among Vermonters at large – this was the second most common barrier identified in a survey of Vermonters who don't own heat pumps (32%). Vermont's housing stock can also create a significant barrier for customers who are considering installing a heat pump. The majority (57%) of homes in Vermont were constructed before 1980, with a quarter of homes built before 1939, leaving the state with some of the oldest housing stock in the country.[x]

Figure 9 Vermont housing stock



It is challenging, expensive – and in many cases not recommended – to install heat pump systems in homes that have outdated wiring or are poorly insulated, since this can create safety issues or lead to high electricity usage and costs. If a home is segmented into many living spaces (a common scenario in old farmhouses, for example), it can be particularly challenging to use ductless mini splits which operate more like space heaters than central heating systems. Ducted or air to water "whole home" heat pumps systems require a functional existing distribution network into which they can be retrofit, which is also less likely in older homes. It is estimated that at least 50% of Vermont single-family homes are heated with a boiler and 28% with a furnace, both of which require a distribution network. [xi]

Heat pumps produce lower temperature output compared to conventional fossil fuel furnaces and boilers. Traditional boilers typically send 170–180°F water through radiators, but most air-to-water or ground source heat pumps supply water temperatures with a maximum of 140°F, sufficient for buildings with low temperature emitters such as radiant floors, or panel radiators. Upgrading or replacing existing baseboard heaters to work effectively with a heat pump can be costly, potentially involving the installation of low temp panel radiators or radiant floor heating.

It is worth noting that there are high temperature air to water units available in common use in Europe, though this equipment is not yet in use here in the U.S. due to flammability of the refrigerant contained in the equipment.

Another significant barrier to heat pump adoption is the need for electric system upgrades. This is something Vermonters are aware of – 30% of surveyed Vermonters who don't own a heat pump indicated "electrical panel or other upgrades" as a barrier. Many older homes in Vermont have outdated electrical systems that may not be able to handle the increased load from a heat pump and other high-power electrification upgrades like electric vehicle charging, which generally require 200-amp service. Upgrading the electrical panel and wiring can be costly and cause project delays due to electrician availability and utility timeline for service upgrades. These added costs and delays, especially when replacing a failed system, can deter homeowners from installing heat pumps.

To address this, Efficiency Vermont in partnership with Burlington Electric Department, Vermont Gas Systems and Green Mountain Power, launched a Home Electric System Upgrade (HESU) incentive. Low and moderate-income Vermont homeowners and rental property owners can receive up to $10,000 for upgrading their home electric system for reasons such as installing equipment that triggers a panel upgrade, future-proofing for additional loads like EV chargers, or addressing safety and reliability concerns. Eligible costs include service line fixes, customer-owned poles or conduits, trenching, meter sockets, service entrances, wiring, disposal of old equipment, and other critical safety corrections. This program anticipates serving approximately 1,080 households. Funding is dependent on Federal ARPA funds currently projected to fund the program through the end of 2026.

Technology

Current

There are three common types of space heating heat pumps on the market.

1. Air-source heat pumps (ASHPs), which include ductless and ducted options, are the most common. Ductless heat pumps, sometimes referred to as mini splits, are modular and have straightforward installation, making them a great option for buildings without an existing heat pump compatible heating distribution system. For spaces with good existing ductwork, ducted heat pumps can integrate with an existing furnace for a whole-home heating and cooling solution.

Image 1: A window-mounted heat pump unit.

2. Ground-source heat pumps (GSHPs) provide extremely efficient heating and cooling for homes with ductwork or other low-temperature heat distribution. Ground loops must be well designed to ensure adequate heat transfer to ground (or water) source over the expected life of the system.
3. Air-to-water heat pumps (AWHPs) also connect to low-temperature radiators, fan coils or radiant floors and are easier to install and lower cost than ground-source.

These options cover most common heating and cooling needs but are not a great match for all situations.

Air-Source Heat Pumps

Over the last few years, the performance of ASHPs has improved significantly. There are now models that are well-suited for colder climates. Hybrid systems that combine a furnace with a ducted ASHP that can be operated as a furnace or as a heat pump interchangeably are also more widely available.

Window-mounted heat pumps are relatively new to the market and represent an opportunity to help make this technology accessible to renters, since they can be self-installed and travel with residents when they move. Efficiency Vermont recently launched a pilot program with 60 renters to test the effectiveness of this technology and its impact on heating costs. Results are expected in the fall of 2025.

Internet connectivity and smartphone integration have also been introduced into the ASHP marketplace, creating specialized options for homeowners as well as access to real-time diagnostics and tracking. In addition, some heat pumps can be connected to other heating sources in the home, to work in tandem to achieve a desired indoor temperature. These systems are referred to as "integrated controls" (IC) and are especially useful in hybrid ASHPs where the automation programming decides when to engage either fuel source for different purposes. However, IC technology is still quite nascent in the ductless mini split heat pump market. Available solutions are often expensive and time-consuming to set –up, while providing limited functionality.

"All-in-One" Air Source Heat Pumps are a type of ventilation unit that integrates air source heat pump technology and heat recovery ventilation into a single unit that provides all aspects of HVAC; heating, ventilation and air conditioning. Only a handful of products are available currently. One major advantage of these units besides the inclusion of fresh ventilation air, is they do not have a separate outside unit. Eliminating all refrigerant piping and an outdoor unit reduces risk of refrigerant leakage and saves space. This is an especially attractive option for apartments where having multiple outdoor units presents a challenge. These units have lower heating capacity than other air source heat pumps, so their use is limited to more efficient and/or small spaces.

Ground-Source (Geothermal) Heat Pumps

GSHPs are designed to provide whole-house heating and cooling. They can also provide domestic hot water. Because they pull energy from underground instead of the air, their performance does not vary much with the outdoor temperature. This means they do not contribute nearly as much to winter peak demand as air-source heat pumps. GSHPs are often more efficient than air-source heat pumps. However, the installed costs are much higher, and few contractors have the experience to install them. The ground loop requires drilling or trenching, and can add tens of thousands of dollars to the project cost. Careful design is important to avoid excess pumping energy, which erodes the efficiency of the system. As of this writing, Efficiency Vermont has processed incentives for 47 residential GSHP systems since the program launched in late 2021.

Air-To-Water Heat Pumps

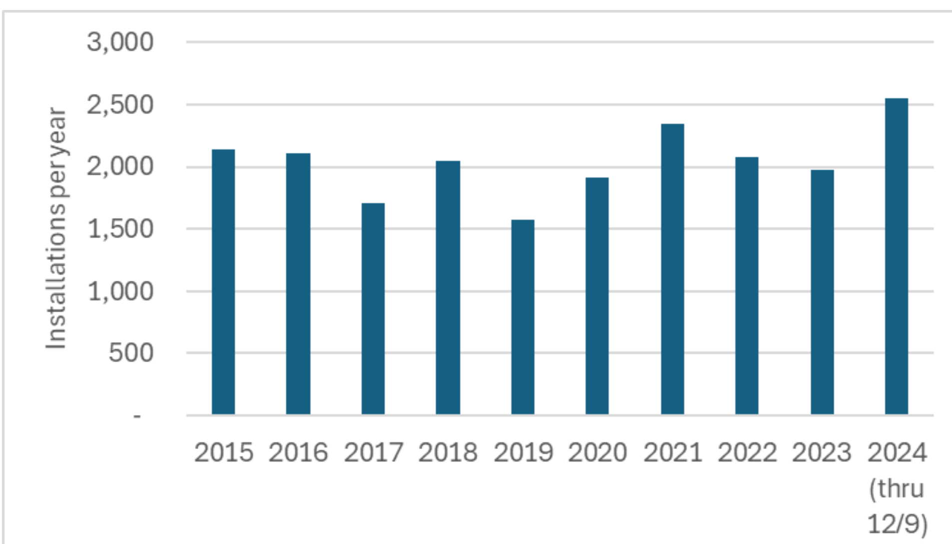
Another type of heat pump in the market are Air-to-Water Heat Pumps (AWHP). The 2020 Single Family Existing Homes Baseline Study[xii] estimates 53% of homes Statewide are heated with a forced hot water boiler and those customers often call to ask about heat pumps that might be able to heat hot water. While ductless heat pumps may be used to provide heating in these homes, they are point source heaters that can lead to some areas of the home being cooler than others. If warm water could be delivered around the perimeter of homes or through radiant floors the home would be more evenly heated and be fully heated with an AWHP system. The main barrier to these systems besides costs is the low delivered water temperature they provide and the fact that most boiler heated homes rely on high temperature baseboard radiators that may not provide adequate heat with lower water temperatures from the heat pump.

Heat Pump Water Heaters

HPWHs are widely available and are familiar to contractors. In new construction, there is no technical obstacle to using them as standard practice, though the upfront costs of HPWHs are higher than fossil-fuel-powered and standard electric water heaters. They require a 240V outlet, which can increase installation costs when the water heater is installed as a retrofit. It is important to ensure that the space where they are being installed is large enough to extract sufficient heat and will not be adversely affected by a reduced temperature. Many customers appreciate that HPWHs dehumidify the spaces in which they are installed. Water heater replacements are often completed on an emergency basis, so contractor recommendations and product availability are important factors that can impact whether customers install HPWHs.

Over 20,000 HPWHs have been installed since 2015. Their annual installation rate has held steady over the past 10 years. Flood response and "switch & save" incentives for households with low income boosted 2024 installations to the highest number yet.

Figure 10 Heat pump water heater installations by year



Appendix B provides a more detailed overview of heat pump technologies.

Integrated Controls

System Optimization

Integrated controls (IC) represent a possible solution to overcome the comfort impacts of flexing cold-climate heat pump (CCHP) heating load. The legacy system can be used to provide supplemental heat, which balances cost, GHG emissions, and comfort considerations.

By using a cost-optimized swap-over temperature, homeowners can ensure the lowest total heating cost. The heat pump runs only when it is less expensive to operate than the legacy heating system.

To optimize GHG reduction, the heat pump is used as much as possible. IC can automatically switch to the legacy system when the heat pump is unable to meet the load of the building. However, this can also be achieved without the IC. By simply setting the legacy system thermostat a few degrees below the heat pump's setpoint, the legacy system will only come on if the heat pump can no longer meet the load of the building. This does not require any special controls, though this approach does have limitations when compared to full IC.

System integration comes with some challenges. The complexity of integrating these systems can lead to higher installation and maintenance costs, as sophisticated controls are needed to communicate with two different heating systems to ensure seamless operation. Installers often mention a fear of callbacks which are costly in terms of time and reputation if the systems get disconnected from Wi-Fi, leading to their apprehension to promote or install such technologies. Many installers are not familiar with the technology and are hesitant to adopt and promote it with their customers. Maintaining operational efficiency during the transition between the heat pump and the fossil-fuel-based system is another challenge, as poorly configured systems may not achieve the desired energy savings or carbon reductions.

While IC present a significant operational benefit to heat pumps, customers don't have enough awareness of these technologies to ask their contractors about it because the markets are so underdeveloped. For ducted heat pump systems that share ductwork with legacy fossil fuel systems, contractors use smart thermostats to ensure the heat pump and legacy fuel systems are coordinated according to customer preferences. Air to Water heat pumps can be designed with thermal storage that may be utilized in demand management strategy. In this instance the thermal storage is used to heat (or cool) the home during the peak event.

If a customer were to pursue installation of IC for ductless heat pumps with their contractor, they would encounter potential compatibility concerns with their existing system, and high costs to purchase and install. They would also be hard-pressed to know what to expect for a return on investment (ROI), as adoption of these technologies has not been widespread enough for thorough research to be conducted.

Flexible Load Management (FLM)

Flexible Load Management (FLM) uses a combination of data analytics, communication platforms, and load control measures to shift loads from less optimal (more expensive, grid-constrained, and dirtier) times of day to more optimal (less expensive, excess grid capacity, cleaner) time periods. Advancing FLM allows Vermonters to share the benefits created by intentionally shifting energy usage patterns in homes or businesses. FLM provides utilities with the ability to anticipate and plan for peak usage periods. This helps utilities proactively manage usage patterns, reduce greenhouse gas emissions, and drive down costs for everyone.

Solutions are beginning to emerge that can integrate heat pumps with auxiliary heating systems while incorporating FLM functionality, but FLM functionality can vary greatly. FLM functionality is more advanced for ducted heat pump systems, but the vast majority of heat pumps installed in Vermont are ductless. The varying levels of FLM functionality are summarized below:

- **Passive demand flexibility**: ability to set an advanced schedule to respond to a TOU (time-of-use) rate
- **Active demand flexibility**: ability to shift/shed load in response to utility-called events

FLM utilizes integrated controls (IC). Almost all IC technologies can provide passive demand management through weekly scheduling to optimize heat pump usage by pre-loading before a peak period and floating downward (or upward for cooling) within a few degrees of the set point. More advanced IC solutions coordinate with the legacy system during load shifting events to better maintain comfort. Coordination between systems within a home can either happen through local protocols (most often using the local Wi-Fi network) or through cloud-based solutions.

The IC market is still emerging, and it will take more time to be able to fully leverage load shifting opportunities and respond to price signals. Currently, there are limited control options for cold climate heat pumps (CCHPs), and the variety of features can sometimes lead to confusion. Additionally, many customers tend to override automated controls, opting for manual operation of their HVAC systems.

Some technologies offer the possibility of active demand flexibility that allow load shifting (or shedding if a legacy fossil fuel system is integrated) to respond to events called by utilities. Customers that opt-in to active demand management programs allow direct control of their heat pump operation and settings through a Wi-Fi-enabled connection that coordinates with utility events. Other forms of communication such as radio or cellular can be used where internet connectivity is not available to enable utilities to control customer heat pumps.

To date, active demand management of ductless heat pumps integrated with legacy heating systems remain restricted to pilot-scale implementation. Distribution utilities have expressed interest in piloting these FLM/IC solutions, but are encountering similar barriers of cost, compatibility, and lack of existing field research.

Additionally, the cost of advanced control systems, including emerging artificial intelligence (AI)-based solutions, can be high, and these costs need to be justified by the savings and benefits they provide. Homeowners must also understand how to properly operate and maintain these systems to avoid inefficiencies and higher operational costs. While dual-fuel systems can reduce peak electric loads, they still rely on fossil fuels during peak times, which can impact carbon savings at the individual home level and the grid level. Savings from peak reduction probably need to be shared with homeowners to make installing controls worth it to them.

Table 2: Heat pump control methods

Category	Method	Description
Disjointed	Manual	Manually operate the auxiliary heat (for example, turning on an older oil system, or fueling a woodstove)
	Parallel	Allowing the systems to operate in parallel without any communication. The auxiliary system is often set 5-10 degrees lower than the heat pump, effectively droop operation. Both the auxiliary and the heat pump can run simultaneously.
Integrated	Balance point changeover	The heating switches to an auxiliary system at a specified balance point (BP) outdoor temperature. This can be measured directly through on-site equipment, or from cloud-based data from local weather sources.
	Droop operation	The heating switches to the auxiliary system when the indoor temperature falls below a set point. Control is often exclusive (heat pump is switched off when the auxiliary heat is called) but can be set up to allow systems to operate simultaneously (in parallel). Can also have a changeover point where operation is either heat pump only (above a certain temperature) or auxiliary only (below a certain temperature).
	Lead/Lag	Both systems are always on, but the heat pump leads (set 2-3 degrees higher) above a specific BP temperature and the auxiliary leads below the BP temperature.
Integrated with FLM	Direct load control (Binary)	Temporarily turning off the heat pump and calling the auxiliary heat to run. This can result in efficiency losses if the cycling is too frequent (by treating the heat pump as a single stage device) and higher costs (if the auxiliary fuel is more expensive at the given temperature of the utility-called fuel switch).
	Direct load control (Throttle)	Throttle to a reduced capacity, for example 50%. Requires specific knowledge of internal heat pump controls that likely only the original equipment manufacturers (OEMs) have, and is not scalable from one device to retrofit multiple heat pumps. Best combined with droop controls.
	Dynamic load control (Lead/Lag)	FLM events can switch or change the lead/lag controls for integrated systems (for example, during a peak event, the set point of the heat pump is 3 degrees lower than the auxiliary system).

Future

Heat pump performance at lower outdoor temperatures is improving, which removes or reduces the need to retain a secondary heating system for the coldest days. Heat pump manufacturers are also moving toward lower-impact refrigerants and providing solutions for more situations, including higher output temperatures.

Air-to-Water Combi Heat Pumps

A "combi" heat pump combines space heating and water heating in a single piece of equipment, making it a versatile solution for both new construction and retrofits. Combi heat pumps have a much higher capacity than most water heaters which allows some heating to be provided by the water heater. This eliminates the need for backup resistance heat that a typical heat pump water heater would require. Additionally, backup indoor heating may not be necessary, as the hydronic loop provides the necessary thermal capacity in some homes. Since these are split systems there is no need to draw heat from the house for defrosting. The reduced footprint allows for the electrification of heating and water heating loads without requiring more breaker panel space than a traditional air conditioner and furnace. However, retrofitting with combi units is not as straightforward as with ductless heat pumps or window heat pumps. These units are particularly well-suited for buildings with lower-than-average heating and cooling loads. They are increasingly being installed in highly efficient new homes because more efficient envelopes improve comfort and resiliency, and may allow a smaller capacity heat pump.

These systems are single packaged units that are hermetically sealed and factory charged, meaning the installer does not need to interact with the refrigerant. This design eliminates common issues associated with heat pump installation and refrigerant circuits, and it also enables the safe use of near-zero Global Warming Potential (GWP) natural refrigerants.

Non-vapor compression

Heat pumps, like air conditioners, refrigerators, and dehumidifiers, use a vapor compression cycle to create hot and cold sides and move heat between them. Non-vapor compression (NVC) heat pumps are an area of research. Solid state, electro-mechanical, and thermally-activated options are being investigated. These options may offer higher efficiency, simpler design, and eliminate the need for refrigerants. These technologies have not been brought to market, but are gaining attention in research and development investments through DOE and at universities.[xiii]

Plug-in 120V

Plug-in 120V HPWHs effectively address some of the barriers that limit 240V HPWH installation, like higher installation costs for new wiring and the need for additional space in the electrical panel for a new double pole breaker. While there are concerns about the performance of 120V units in cold climates, many models include backup electric elements and recommend sizing up from the unit being replaced, which can add to the cost. However, manufacturers are developing solutions to common issues like slow hot water production. These include larger tanks for increased capacity, mixing valves that allow the tank to overheat and store water at higher temperatures than the delivery temperature, providing additional storage capacity with minimal efficiency impact, and larger compressors. Typical HPWH compressors consume 300-500W, but larger compressors consuming 900-1,400W can recharge the tank faster, depending on air and water conditions.

Contractors play a crucial role in guiding customers through the 120V versus 240V decision, especially when replacing high output fuel-fired water heaters. Whenever possible, 240V HPWHs should be the primary choice for electric water heating. However, 120V HPWHs are an excellent option for replacing fuel-fired water heaters due to easier electrical installation, which can help expand efficient water heating into more applications. Excitingly, low-GWP versions of retrofit-ready 120V HPWHs are on the horizon, set to be released after their conventional-refrigerant counterparts, which are currently the manufacturers' priority.[xiv]

240V Low-GWP HPWHs

These HPWH units use CO2 or other low- or zero-GWP refrigerants. They have the same applications and barriers as other 240V HPWHs, but offer higher greenhouse gas savings potential. There are a limited number of products available today. The high cost compared to other water heating options, including non-CO2 HPWHs, is a challenge in the current market where the value of GHG reductions is little to nothing. Increasing market and contractor awareness of low -GWP refrigerants and their benefits will be key. Additional manufacturers and product offerings are needed to increase installation options and pricing range, especially for cold-climate applications. Producing low-GWP systems requires significant changes in product design and development to ensure the new refrigerant type and cycle meet performance specifications. Proven market demand or new regulatory requirements could drive manufacturers to make a rapid shift from current products.[xv]

Thermal Storage

Thermal storage options offer significant benefits to the grid by reducing peak power demand and improving heat pump efficiency. By utilizing heat pumps when outdoor conditions are most conducive to efficiency and storing the output energy for later use, customers can maximize the performance of their heat pumps. This approach also allows the use of heat pumps when the grid is cleanest and stores energy for times when the grid is most taxed and potentially relying on the most polluting power plants. Thermal storage is gaining traction in the marketplace, particularly with systems that support active charging and discharging. There are three main types of thermal storage systems:

Water/glycol/mix systems: Typically used in air-to-water systems, energy is stored in a water tank as heat and can be deployed for both hot water and home heating. These systems can connect with low-temperature radiators or air handlers with hydronic coils for space heating.

Solid material systems (bricks/ceramics): This system converts off-peak electricity to heat, storing it in heating elements within high-density ceramic bricks. This stored heat can be transferred to water through a heat exchanger and delivered to areas where it is needed. Heat can be distributed via radiant floor systems, baseboard radiation, free-standing radiators, forced air systems, or a combination of zoned delivery systems.

Phase change material (PCM) systems: These systems incorporate energy storage radiators. The indoor "head" of the heat pump contains energy-storing material (PCM), the heat exchanger, and a quiet variable-speed fan. This setup allows for efficient energy storage and distribution, enhancing the overall performance of the heat pump.

Panel Constraint Solutions

There are some emerging solutions to integrate heat pumps into existing electric panels, removing or reducing a significant barrier to installation. Smart home devices and optimized charging controls can manage the timing of various household electric loads and prevent electric panel overloads and reduce impacts to the electric grid. In addition, smart devices may be retrofitted to existing electric panels, at a lower cost than full panel replacement. These devices provide automatic load management either between two shared loads or based on a set power threshold and the homeowner's priorities. As new lower-power electric heat pumps, water heaters, appliances, and smart controls become available owners can look to reduce the total power a home needs. These energy-efficient options will help homeowners use their existing electric infrastructure and reduce both installation and operating costs. Furthermore, using 15 minute interval data to demonstrate low power needs is an option within the electrical code and could be used to avoid panel upgrades.

Contractors

Efficiency Excellence Network

Contractors play a pivotal role in the adoption of heat pumps, since they are often the primary resource for customers who are considering installing or retrofitting a heating system. Contractors serve as technical experts to identify the right equipment to meet their customers' goals.

Efficiency Vermont maintains an Efficiency Excellence Network (EEN)for support accessing rebates and completing their heat pump projects. To be eligible to join the EEN, contractors must operate a business that helps customers meet their energy goals. Members are expected to complete at least one project with Efficiency Vermont and earn at least eight credits in energy efficiency education, every year.[xvi] Additionally, Contractors are expected to meet all applicable federal, state and local laws and regulations.

Table 3 provides a view of the heat pump contractor market in Vermont as of December 2024. Midstream heat pump incentives are available to customers working with EEN and non-EEN contractors. Column 3 below, "Total installations to date," is inclusive of all contractors. Contractors that install multiple types of heat pumps appear in multiple categories in Table 3. There are a relatively small number of contractors who specialize in the maintenance and service of existing systems, but these services will become increasingly important, given the increasing number of installed units.

Table 3: Efficiency Excellence Network (EEN) heat pump contractors

Heat Pump Type	Number of EEN Contractors [xvii]
Air-to-water (mono)	49
Air-to-water (split)	55
Centrally ducted heat pump	172
Ductless heat pump	209
Ground-source heat pump (GSHP)	24
Water-to-water GSHP	15
GSHP driller	6
Heat pump water heater	98

The pool of non-EEN installers may provide other efficiency services such as installing solar or other services Efficiency Vermont does not incentivize and therefore does not have data on.

To displace all or most of a home's heating needs, it is valuable to understand building science, and how to size and design HVAC systems. "HVAC contractors" have those skills and are in high demand. This results in longer lead times for projects and often much higher prices than other options such as "heat pump installers" who focus on completing a high number of projects quickly.

Types of Projects and Contractor Capacity

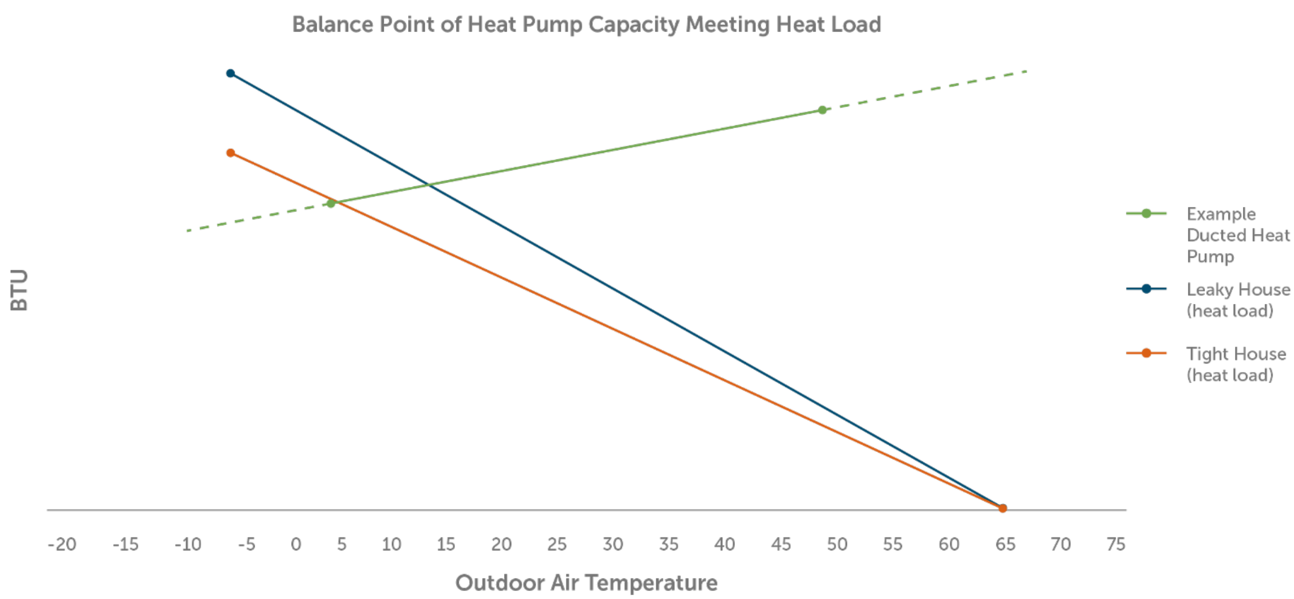
Depending on the type of heat pump, the existing conditions of the home, and the customer's goals, heat pump projects range from simple to complex.

At the simple end of the range, heat pump water heater projects can be straightforward if the space meets the necessary requirements. While installation itself may be considered easy to some, customer familiarity with the technology is limited and would benefit from contractors doing more to help them understand the different settings or mode options: heat pump/efficiency, hybrid/auto, electric. Many contractors tell the customer to run the HPWH in hybrid mode because that virtually guarantees the customer will not run out of hot water and will not need to call the contractor back. But heat pump mode is often sufficient and has a lower operating cost.

On the complicated end of installation projects, retrofitting ducted, air-to-water, or ground-source heat pumps into an existing hot air or hot water distribution system is likely to require modification to the distribution system and potentially IC that manage hybrid systems.

Weatherization of our buildings is a key part of the transition to heat pump heating. Air sealing and insulation can allow heat pumps to more effectively meet the heating needs of a building. This is not only because a weatherized building has a lower heat load (Figure 11). Weatherization solves comfort and building durability problems, like frozen pipes, that are some of the reasons owners with ductless heat pumps don't use them in colder weather. With effective air sealing and insulation comfort improves and the likelihood of a de-centralized ductless heat pump keeping an occupant comfortable increases. However, weatherization efforts are projects in themselves and can be more invasive. It is difficult to sell that to people who are expecting a quick and easy project. An additional challenge is that these skillsets are often held by two different types of contractors. It is uncommon for weatherization contractors to offer HVAC services, or for HVAC contractors to have even limited weatherization services. Because of this it is important to coordinate efforts of weatherization rebate programs and work force development efforts and find ways to encourage HVAC contractors and weatherization contractors to work together.

Figure 11 Heat load



As outdoor temperature decreases a buildings heat load increases. If the building is weatherized (orange line) the rate of heat loss is reduced. This allows a heat pump to provide adequate heating down to a lower temperature than if not weatherized.

Contractors seek to avoid call-backs as much as possible. Failure to provide sufficient heat is more noticeable, and more likely to cause a call-back, than inefficient operation or short cycling, so there may be some tendency to oversize equipment. If a customer wants to remove their existing heating system, the heat pump must be sized for the coldest anticipated conditions, and it will be less efficient at milder temperatures than a lower-capacity heat pump. This is especially the case with "multi-zone" ductless systems. If customers expect to continue to use and maintain their old system, the heat pump should be sized to reflect its off-peak role so that it can operate more efficiently and avoid short cycling. Similarly, a heat pump sized for cooling will not be as effective at heating in Vermont's cold climate.

Contractor capacity in Vermont is fairly low in all areas. According to a 2023 EEN survey of contractors, 54% of respondents are trying to hire more staff. However, 94% of respondents find some amount of difficulty in finding qualified staff, up from 72% the previous year. Contractors often have more interest installing heat pumps than maintaining and repairing them. This is influenced by available incentives, the price of heating fuel, and project cost. As heat pump systems become more advanced and manufacturer-specific, they become more difficult for contractors to maintain. This is especially true in areas where there is limited internet connectivity or no cell signal to reach technical support teams to walk contractors through troubleshooting. This presents a critical issue for Vermont heat pump customers in the winter months: if their machinery fails and they are unable to use the heat pump for warmth, the high cost and low availability of repair services can create a major issue, especially for those with limited means.

Contractor Training

Vermont's contractor base is made up of those with EPA 608 technician certification (for safe handling of refrigerants including equipment leak detection), plumbing licenses, and other assorted specializations. Consequently, contractors with 608 certification are the ones managing refrigerant-related projects. Those with plumbing licenses are mainly installing HPWH, GSHP or air-to-water heat pumps. All other skillsets related to heat pump installation and servicing have little to no certification or licensure needs.

Presently, there are several types of training available to contractors who are looking to expand their skills. Training ranges from 8 hours to 8 weeks, from private for-profit and non-profit training providers. Many of these providers are manufacturers and will issue certifications specific to their products and list them as certified technicians or installers on their website.

There are also training providers that work with the State of Vermont or Vermont-based universities, and present certifications with broader applicability like EPA 608. This certification is a requirement for contractors who work with refrigerants. An EPA 608 license does not require continuing education credits, and the contractor only needs to pass the exam once. Cost and availability for in-person and online courses for the EPA 608 vary. The maximum listed cost for a course that qualifies its graduates in EPA 608 is $3,400. However, many of these courses, such as the Energy Works program from Vermont Adult Learning, are free to the student and are subsidized by grants.[xviii]

Other Market Context

Policy and Regulatory

Vermont EEUs and DUs collaboratively support Vermont's current statewide heat pump programs, with a focus on supporting the deployment of energy-efficient models to reduce fossil fuels used for heating. These programs seek to influence the entire supply chain in order to support customers in making efficient choices. Those choices could include whether to install a heat pump instead of a fossil fuel system, or to install a more efficient cold-climate heat pump rather than a less efficient model with a lower upfront cost (that will ultimately cost more to operate over its lifetime).

Oversight of these utility programs by the Vermont PUC and PSD ensures that they continue to provide benefits to customers and that the energy and cost savings being claimed by EEUs and DUs are accurate. An evaluation of the statewide program is currently underway and will be completed in December 2025. The findings of this evaluation may be used to significantly revise the savings assumptions for these heat pump programs and could lead to substantial changes in the 2027-2029 programs. For example, if it is determined that customers are using their heat pumps for air conditioning in summer more than has been assumed, that could increase the kWh that EEUs claim toward their goals; conversely, if units are being used less for heating than has been assumed, it could reduce the ability of DUs to achieve their goals. Either of these changes would likely impact the incentives offered to customers.

Table 4: Vermont point-of-purchase rebate

Point-of-purchase rebate	Utility payments	Customer and energy benefits	Energy program value
$350 Processed and paid by Efficiency Vermont, with reimbursement from electric utilities and the other EEUs	$100 EEUs	994 kwh* per unit Reduced electric usage $188.87** per unit Reduced operating cost	Heat pumps sold in VT use less electricity and are rated to provide winter heating, supporting attainment of EEU electricity reduction goals[xix]
	$250 DUs	6,952 kwh equivalent per unit Reduced fossil fuel usage	Heat pumps are assumed to significantly offset fossil fuels, supporting compliance with Tier 3 of Vermont's Renewable Energy Standard[xx]

* Weighted average ** Assumes $0.19/kWh

In addition, rebates and upfront customer incentives can be impacted by regulations that require customers to make an energy efficient choice. For example, if the installation of new fossil fuel heating systems is banned, or if less-efficient models are not allowed to be sold. In these cases, energy programs cannot continue to offer incentives to customers, because they cannot pay customers to take steps that the law already requires them to take. As Vermont's policy landscape continues to evolve in favor of energy efficiency and fossil fuel reduction requirements, it may force the end of customer incentive programs that support those same outcomes.

Another policy development that will likely impact the heat pump market relates to the refrigerants that they use. Through the 2020 American Innovation and Manufacturing (AIM) Act and 2022 ratification of the Kigali Amendment to the Montreal Protocol, the United States committed to a staged phasedown of refrigerant emissions, which will begin to affect the heat pump market by forcing manufacturers to redesign their products to comply. They may also be required to include internal leak detection systems to address potential flammability risk for some lower-GWP refrigerants.

Codes and Standards

As Vermont's policy landscape continues to evolve in favor of energy efficiency and fossil fuel reduction requirements, it may force the end of customer incentive programs that support those outcomes

Finally, Vermont's power grid planners are continually working to understand and anticipate the effects of heat pumps and other load-building electrification technologies. The Vermont Electric Power Company (VELCO) is responsible for managing Vermont's electric grid and supporting statewide planning among all of Vermont's regulated utilities. Current worst-case projections indicate that the state could face system constraints within the next decade if existing electrification trends continue and are not mitigated by load-shifting strategies such as FLM.[xxi] Other strategies that do not require the buildout of transmission projects, such as energy efficiency and storage, will become increasingly important opportunities to reduce costs and help Vermont make the most of its existing distribution system.

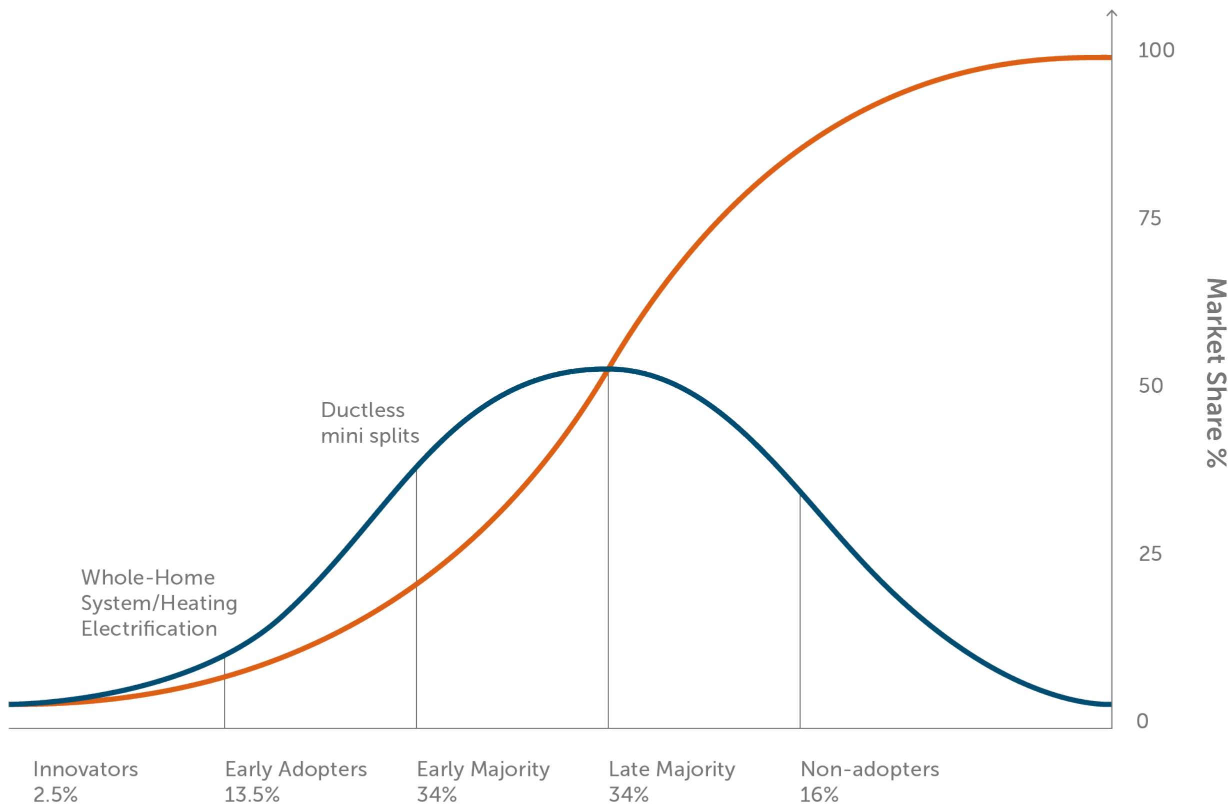
Market Potential

The Diffusion of Innovations Theory provides a helpful framework for understanding how new ideas, products, and services spread through a population. It compares the uptake of a product to its full potential customer market, and outlines five main groups of customers, from those who adopt the new product first to those who are the last to access it. Understanding where a product fits within this framework can help program administrators ensure that they are addressing the most critical market barriers to support continued customer growth and adoption.

There are some challenges with adapting this theory to the Vermont heat pump market, such as how to count heat pumps that are used only for cooling, for shoulder season heating, for primary heating with backup, and for 100% heat pump heating. However, even an imprecise approach allows us to see some clear distinctions between the various heat pump technologies and their relative levels of adoption.

In the context of market transformation, adoption refers to the widespread acceptance and proper utilization of new technology, extending beyond mere installation numbers to include appropriate use and maintenance for optimal performance and energy savings. When considering the overall goal of home heating electrification, the adoption rate is notably lower than the installation rate of heat pumps, underscoring the need for comprehensive strategies to ensure effective use. Electrification of heating is a crucial element of market transformation, essential for reducing greenhouse gas emissions, enhancing energy efficiency, and improving indoor air quality.

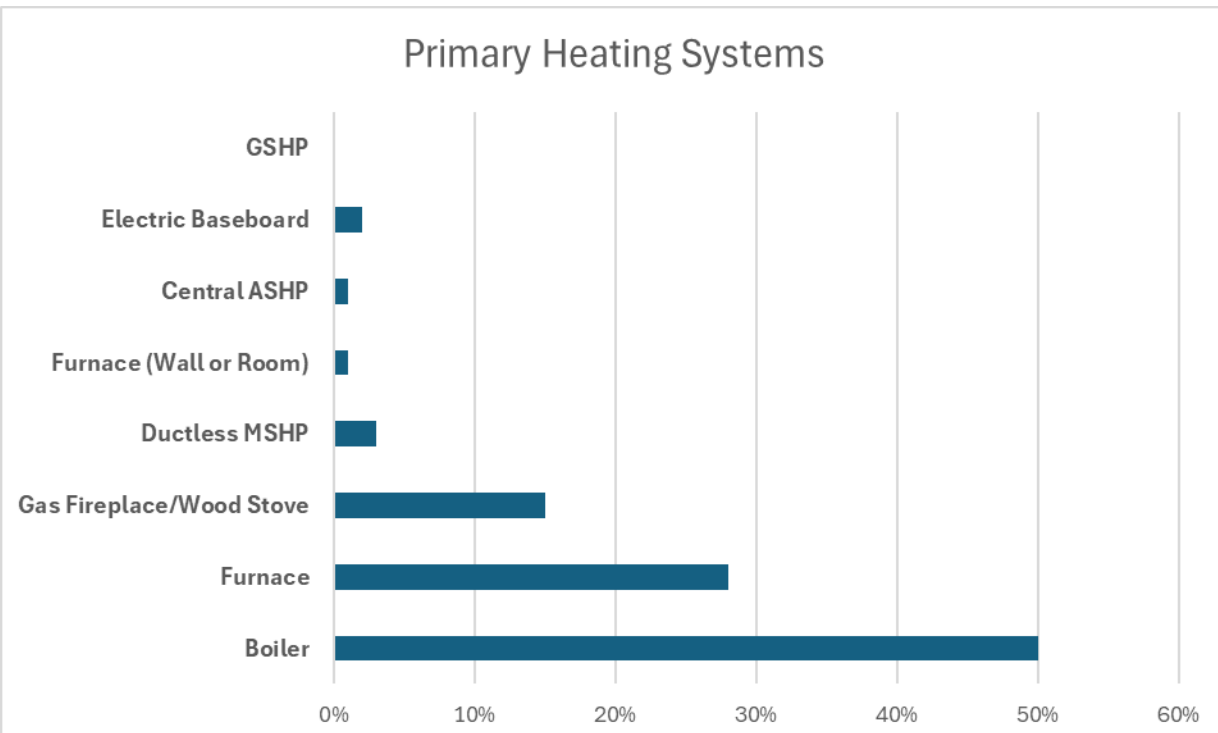
Figure 12 Innovation adoption curve



At a high level, ductless mini split heat pumps will provide the most customer benefits in terms of offsetting fossil fuels in weatherized homes with relatively open floor plans. This means that they are a better solution for more modern homes, likely constructed within the last 50 years, so there is a total potential remaining market of roughly 141,000 homes. Program data indicates that one or more ductless mini splits have been installed in about 45,000 homes, indicating that this technology is in the "early adopters" stage of market development. The market for ductless mini splits has advanced rapidly, and customer interest continues to be strong, but customer survey data indicates that there may be an opportunity to provide more guidance and support to those who would like to use their systems to more effectively offset their heating costs.

As more whole-home heat pump systems become widely available, it will likely become cheaper and simpler to install these systems in more homes. This will be an important development in Vermont, because there are many homes for which a single – or even multiple – ductless mini splits will never be an effective or affordable full-home heating solution. These more comprehensive and complicated systems will need to leverage existing functional distribution systems such as ducts and hydronic baseboards, as homeowners are unlikely to want to build new distribution systems to accommodate a heat pump retrofit. We can therefore leverage data on the frequency of these types of distribution systems to make an estimate of the total market potential for ducted and air-to-water heat pumps, and identify that both technologies are in the "innovators" phase of market adoption.

Figure 13 2020 Vermont Single Family Existing Homes Baseline Study[xxii]



For heat pump water heaters, the potential market is likely larger, given the ability for these systems to more easily replace other heating fuels without needing to change distribution systems. However, it is challenging to estimate the full market potential, as they rely on a specific home configuration, like a basement with sufficient air access from which to draw heat, which is not easily discerned from available data. These systems are most often installed because a prior system has failed, rather than because a homeowner is making an elective choice to opt out of their prior water heating system.

Since sales of GSHP systems are low, and the potential market size dependent on factors such as well capacity, we were not able to make an estimate of that market at this time.

Conclusions

The rapid deployment of ductless mini split heat pumps throughout Vermont over the last decade provides both a foundation and a template for program administrators and policy makers as they consider options to support adoption of more advanced heating electrification. Broader workforce constraints in the trades are hindering deployment of heat pump systems and could impact the willingness of a wider range of contractors to scope and install more complex ducted and air-to-water systems. However, existing contractors and installers will continue to be a critical resource to customers who want to consider these options, and may be a channel for program administrators to encourage customers to use their heat pumps in ways that maximize their decarbonization potential by relying on them more heavily further into the winter. It will be important for program administrators to continue engaging directly with contractors to provide training and incentives that support them in exploring these newer technologies. There is also an opportunity to ensure that customers who have currently installed ductless mini split systems understand their options for leveraging these systems through the year to most effectively manage their energy costs and electric grid impacts.

Many technological improvements and innovations are on the horizon that will enable heat pumps to serve as an effective solution for a wider range of customers, and at lower cost. Leveraging the existing supply chain and program channels will help get these technologies to Vermont customers quickly and efficiently. Other technological developments, such as window units and options to more effectively integrate heat pumps into existing home electric systems, will help make heat pumps more accessible to many of the customers who thus far have not been able to adopt them.

As our understanding grows of the impacts of widespread adoption of heating electrification on the electric grid, it will be increasingly important to support customers in taking complementary actions. These include integrating controls and other steps that can help customers and utilities actively optimize when and how heat pumps are employed. It should also include more comprehensive and durable actions such as weatherizing leaky homes so they can be heated and cooled at lower cost to both customers and the electric system. The VT Heat Pump Action Plan, which is being produced as a companion to this Market Assessment, outlines potential approaches to program design and development in order to help achieve these goals.

Appendices

Appendix A: Customer Research Overview

Data on Vermonters' perceptions of heat pumps cited in the Customers section comes from two Efficiency Vermont research projects unless otherwise specified.

Midstream Incentive Participants Survey

- Objectives: Understand customers experience with their heat pumps and any support their received from Efficiency Vermont.
- Population: Customers who installed a heat pump (ducted or mini split) with an Efficiency Vermont midstream incentive between Jan. 1 2019 and Dec. 31 2022 and had an email address on file associated with their project.
- Responses: 1,765 completes of 6,540 invitations (27% response rate)
- Method: Online survey. Invitations and reminders sent via email from info@efficiencyvermont.org
- Fielding date: October 2024

Homeowners Without Heat Pumps Survey

- Objectives: Identify awareness and perception of heat pumps and heat pump incentives among Vermont homeowners who do not own a heat pump
- Population: Vermont homeowners who don't have a heat pump.
- Responses: 222 completes
- Method: Online survey. Respondents identified and recruited with support from a panel provider (RepData). Respondents were blind to Efficiency Vermont's sponsorship of the survey.
- Fielding date: December 2024

Appendix B: Heat Pump Technologies Overview

Table 5: Heat Pump technologies on the market today

Terminology	Distribution Type	Delivery Options	Heating Efficiency ($COP5_{max}$ - $COP17_{rated}$)	$/Ton Capacity	Lifetime (yrs) per TRM
Ductless mini split (Single-zone)	Space conditioning	*high wall head, *floor mount, *recessed cassette, *compact ducted	2.1-2.9	3,500-7,000	15
Ductless mini split (Multi-zone)	Space conditioning	*high wall head, *floor mount, *recessed cassette, *compact ducted	1.9-2.6	3,500-7,000	15
Centrally ducted	Ducted (High static)	*large duct system	1.9-2.3	5,000-10,000	18
Air-to-water	Hydronic	*low temperature hot water, *fan coil units *combination heat/domestic water heating/cooling possible	1.9-3	6,000-10,000	18
Water heater	Domestic Hot Water (DHW)	*240V unitary or split, 120V unitary	3-4	2,000 to 3,000 per unit	12
Window units	Space conditioning	*window-mounted point source	TBD	3,800 per unit	TBD
All-in-one units	Space conditioning	*compact ducted *wall or ceiling mounted	1.7 - 2.3	10,000 per unit	TBD
Open-loop geothermal	Hydronic	*low temperature hot water, *fan coil units	3-5	15,000 - 20,000	25
Open-loop geothermal	Ducted	*large duct system	3-5	15,000 - 20,000	25
Closed-loop geothermal	Hydronic	*low temperature hot water, *fan coil units	3-5	15,000 - 20,000	25
Closed- loop geothermal	Ducted	*large duct system	3-5	15,000 - 20,000	25
Closed-loop geothermal	Variable Refrigerant Flow (VRF)	*high wall head, *floor mount, *recessed cassette, *compact ducted	3-5	TBD	25

Appendix C – Acronyms

AIM (American Innovation and Manufacturing): A U.S. act aimed at reducing the production and consumption of hydrofluorocarbons (HFCs) to combat climate change and promote the use of more environmentally friendly alternatives.

ARPA (American Rescue Plan Act): A federal law enacted in 2021 to provide economic relief and recovery from the COVID-19 pandemic, including funding for various public health and economic measures.

ASHP (Air-Source Heat Pump): A heating and cooling system that transfers heat between the inside of a building and the outside air, commonly used for space heating and cooling.

AWHP (Air-to-Water Heat Pump): A type of heat pump that transfers heat from the air to water, which can then be used for space heating, cooling, and domestic hot water.

CCHP (Cold-Climate Heat Pump): A heat pump specifically designed to operate efficiently in colder climates, providing reliable heating even at low outdoor temperatures.

CO2 (Carbon Dioxide): A naturally occurring greenhouse gas that is a byproduct of burning fossil fuels and other industrial processes, contributing to global warming and climate change.

DOE (Department of Energy): A U.S. government department responsible for policies regarding energy and safety in handling nuclear material, as well as research and development in energy technology.

EEN (Efficiency Excellence Network): A network of contractors and service providers who are trained and certified to deliver energy efficiency services and support customers in implementing energy-saving measures.

EPA (Environmental Protection Agency): A U.S. federal agency responsible for protecting human health and the environment by enforcing regulations and promoting environmental stewardship.

EV (Electric Vehicle): A vehicle powered by an electric motor instead of an internal combustion engine, using electricity stored in batteries or generated by fuel cells.

FLM (Flexible Load Management): A strategy that uses data analytics, communication platforms, and load control measures to shift energy usage to more optimal times, reducing costs and strain on the electric grid.

GHG (Greenhouse Gas): Gases that trap heat in the atmosphere, contributing to global warming and climate change. Common GHGs include carbon dioxide (CO2), methane (CH4), and nitrous oxide (N2O).

GSHP (Ground-Source Heat Pump): A heating and cooling system that transfers heat between the ground and a building, using the stable temperature of the earth to provide efficient heating and cooling.

GWP (Global Warming Potential): A measure of how much heat a greenhouse gas traps in the atmosphere over a specific time period, relative to carbon dioxide (CO2).

GWSA (Global Warming Solutions Act): A Vermont state law that sets binding targets for reducing greenhouse gas emissions and outlines strategies to achieve these reductions.

HESU (Home Electric System Upgrade): An incentive program that provides financial assistance to low and moderate-income homeowners for upgrading their home electric systems to support new equipment and improve safety.

HPWH (Heat Pump Water Heater): A water heating system that uses a heat pump to transfer heat from the surrounding air to the water, providing efficient hot water heating.

HVAC (Heating, Ventilation, and Air Conditioning): Systems and technologies used to regulate indoor environmental comfort by controlling temperature, humidity, and air quality.

IC (Integrated Controls): Systems that coordinate the operation of multiple heating and cooling sources, optimizing energy use and maintaining comfort by automatically switching between different systems.

IRA (Inflation Reduction Act): A U.S. federal law aimed at reducing inflation through various economic measures, including investments in energy efficiency and renewable energy.

NVC (Non-Vapor Compression): Emerging heat pump technologies that do not rely on the traditional vapor compression cycle, potentially offering higher efficiency and simpler design.

PCM (Phase Change Material): Materials that absorb and release thermal energy during the process of melting and freezing, used in thermal storage systems to improve energy efficiency.

PSD (Public Service Department): A Vermont state agency responsible for regulating utilities, ensuring reliable and affordable energy services, and promoting energy efficiency and renewable energy.

PUC (Public Utility Commission): A regulatory body that oversees utilities and ensures that they provide safe, reliable, and reasonably priced services to the public.

ROI (Return on Investment): A measure of the profitability of an investment, calculated as the ratio of the net profit to the initial cost of the investment.

TOU (Time-of-Use): A rate structure that charges different prices for electricity based on the time of day, encouraging consumers to use energy during off-peak periods when it is less expensive.

VELCO (Vermont Electric Power Company): A company responsible for managing Vermont's electric transmission system and supporting statewide planning among regulated utilities.

VT (Vermont): A state in the northeastern United States known for its energy efficiency and renewable energy initiatives.

WAP (Weatherization Assistance Program): A program that provides low-income households with energy efficiency improvements to reduce energy costs and improve home comfort.

Endnotes

[i] Efficiency Vermont program data, Distinct Site Count for heat pump incentives 2017-2024.10 / Census Households
[ii] Rogers, Everett M., *Diffusion of Innovations*.
[iii] Efficiency Vermont: https://www.efficiencyvermont.com/news-blog/news/with-more-than-63-000-heat-pumps-installed-vermont-leads-the-northeast-in-zero-emissions-heating-systems
[iv] Efficiency Vermont, Burlington Electric Department and Vermont Gas Systems
[v] Efficiency Vermont: www.efficiencyvermont.com/rebates as of 3/1/2025, rebates are subject to change
[vi] Moderate income customers who earn 150% Area Median Income and below, and will be able to leverage heat pumps to meet 51% or more of their home's annual heating needs.
[vii] Energy Action Network, 2024 Annual Progress Report: https://eanvt.org/2024-annual-report/
[viii] 2023 American Community Survey
[ix] United States Census: https://www.census.gov/quickfacts/fact/table/VT
[x] 2025 Housing Needs Assessment, Vermont Housing Finance Agency: https://outside.vermont.gov/agency/ACCD/ACCD_Web_Docs/Housing/Housing-Needs-Assessment/2025-2029/2025-Factsheet-3-HousingStock.pdf?_gl=1*1uunnpo*_ga*NDAyNTk4ODExLjE2NjI2NTgyMjc.*_ga_V9WQH77KLW*MTczMjczMjk0My4xMi4xLjE3MzI3MzQwMjcuMC4wLjA.

[xi]2020 Vermont Single Family Existing Homes Baseline Study, Vermont Department of Public Service: https://publicservice.vermont.gov/sites/dps/files/documents/VT_2020_SF_EX_Baseline_Final_Report_Jan242023.pdf

[xii] 2020 Vermont Single Family Homes Baseline Study
[xiii] New Buildings Institute: https://filesnewbuilding.s3.amazonaws.com/wp-content/uploads/2021/01/FULL-Building-Electrification-Technology-Roadmap_FINAL_1-22-2021.pdf
[xiv] American Council for an Energy-Efficient Economy: https://www.aceee.org/sites/default/files/proceedings/ssb24/pdfs/How%20to%20Apply%20120V%20HPWHs%20for%20Residential%20and%20Light%20Commercial%20Applications.pdf
[xv] Northeast Energy Efficiency Partnerships: https://neep.org/sites/default/files/media-files/neep_emerging_heat_pump_tech_brief_final_sm.pdf
[xvi] Efficiency Vermont: https://www.efficiencyvermont.com/trade-partners/efficiency-excellence-network
[xvii] Efficiency Vermont EEN enrollment data, January 1, 2024 – December 11, 2024
[xviii] Vermont Adult Learning: https://energyworks.vtadultlearning.org/
[xix] Vermont Public Utility Commission: https://puc.vermont.gov/energy-efficiency-utility-program
[xx] Vermont Public Utility Commission: https://puc.vermont.gov/electric/renewable-energy-standard
[xxi] Vermont Electric Power Company: https://www.velco.com/sites/default/files/2024-04/2024%20VLRTP_publicreview_clean.pdf
[xxii] 2020 Vermont Single Family Homes Baseline Study