

# *A Vermonter's Guide to Residential Clean Heating and Cooling*



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FOR THE

Vermont Public Service Department

**January 2021**

## About this Report

This consumers' guide was developed by the Clean Energy States Alliance (CESA), a national nonprofit organization, to inform consumers about the benefits of clean heating and cooling (CH&C) technologies. The guide, prepared for the Vermont Public Service Department's Clean Energy Development Fund (CEDF), provides information to help Vermonters decide whether it makes sense to invest in CH&C technologies and, if so, how. This guide was informed by CESA's Building Decarbonization project, which works with member states to evaluate and develop policies and programs that support the market development of renewable thermal technologies.

## Acknowledgements

The authors would like to thank the following individuals for their contributions to this guide: Andrew Perchlik (CEDF), Susan Mlodozeniec (Massachusetts Clean Energy Center), and Anne Margolis, Kelly Launder, Ed Delhagen and Barry Murphy of the Vermont Public Service Department. The authors would also like to thank Maria Blais Costello, Samantha Donalds, Meghan Monahan, and Warren Leon of CESA, and David Gerratt of DG Communications for their assistance on this report. The authors thank the Massachusetts Clean Energy Center (MassCEC) for its permission to use many of the infographics contained in this report.



### About the Vermont Public Service Department Clean Energy Development Fund (CEDF)

The CEDF, at the Vermont Public Service Department (PSD), has offered a portfolio of incentives and financing opportunities to accelerate the development and production of renewable energy in Vermont over the last 14 years. Since its inception, the CEDF has awarded over \$66 million in federal and state resources for renewable energy and energy efficiency in Vermont, leveraging total investments of more than \$259 million in the state's clean energy infrastructure. Learn more at [http://publicservice.vermont.gov/renewable\\_energy/cedf](http://publicservice.vermont.gov/renewable_energy/cedf).



### About Clean Energy States Alliance

Clean Energy States Alliance (CESA) is a national, nonprofit coalition of public agencies and organizations working together to advance clean energy. CESA members—mostly state agencies—include many of the most innovative, successful, and influential public funders of clean energy initiatives in the country. CESA works with state leaders, federal agencies, industry representatives, and other stakeholders to develop and promote clean energy technologies and markets. It supports effective state and local policies, programs, and innovation in the clean energy sector, with an emphasis on renewable energy, power generation, financing strategies, and economic development. CESA facilitates information sharing, provides technical assistance, coordinates multi-state collaborative projects, and communicates the achievements of its members. Learn more at [www.cesa.org](http://www.cesa.org).

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# HOW TO USE THIS GUIDE

There are many technology choices when it comes to choosing a home clean heating and cooling (CH&C) system. This guide can help you decide which CH&C technology and thermal solution is right for your home. If you are just learning about CH&C technologies, you may want to read this guide from start to finish. However, **the guide was written with stand-alone sections; if you have some background knowledge of CH&C technologies, you can head directly to the sections that have the information for which you are looking.** For example, you may want to jump right to the section on financing options or on choosing a qualified installer.

Because this guide covers whole-home heating, space heating, and water heating, you can use the CH&C Decision Tree Matrices (Table 1 on p. 33 and Table 2 on p. 39) and the information in Section 4: *Are CH&C Systems Right for My Home?* to guide you to the right heating solutions for your particular needs. Section 4 provides a detailed description about how the technologies work, how much they cost, and the kind of maintenance needed.

Another recommendation is to read Section 1: *Efficiency First*, which provides information on the myriad benefits of weatherizing your home before installing a CH&C technology. In Section 1, you can also learn about Efficiency Excellence Network contractors—qualified technicians who can perform home energy audits and home energy retrofits, and, in some cases, also install CH&C equipment.

The guide also includes two appendices. Appendix A is a CH&C project checklist that covers recommended action items to complete before installing a new CH&C heating system. Appendix B provides links to various state and federal resources for more information.



An outdoor condenser for a heat pump unit.

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# 11 KEY THINGS TO CONSIDER

## If You're Thinking about About Installing a CH&C System

1. **Complete a home energy audit.** The first step to reducing household energy consumption and costs is to increase your home's efficiency. Homeowners should consider making energy-savings home improvements before adding a CH&C system.
2. **Implement the home weatherization measures** identified by the home energy audit.
3. **Determine whether you want whole-home heat,** supplemental heat, or single room/single zone heat.
4. **Consider the age of your current heating system.** If your current system is near the end of its life, consider replacing the system with a CH&C technology.
5. **Choose a qualified contractor.** Efficiency Vermont maintains a list of contractors who have completed required training and are qualified to guide homeowners on energy usage, recommended weatherization and efficiency upgrades, energy saving opportunities, and on financing and incentives.
6. **Analyze your current home fuel and electricity use** and steps you can take to reduce that energy use (like attic insulation) that may allow you to buy a smaller and less expensive system, or steps you might take that increase your energy use (building an addition or adding an additional occupant).
7. **Familiarize yourself with the maintenance needs** of the proposed CH&C system.
8. **Ensure that you have enough space** to install a properly ventilated CH&C unit.
9. **For ground source heat pumps,** consider the amount of land you own and its layout. Determine whether you have the space for a horizontal or vertical loop system.
10. **For advanced wood heating,** consider where you will store at least two tons of pellets.
11. **Consider the potential benefits:** energy savings, improved indoor air quality, improved humidity control (with heat pumps), air conditioning (with heat pumps), little maintenance, increased home safety, and increased home value.<sup>1</sup>

<sup>1</sup> Energy efficiency measures including HVAC upgrades increase home value, improve home comfort and have positive impacts on respiratory, circulatory, and nervous systems. See Rachel Gold, "Increasing Home Value Through Home Energy Upgrades, Rocky Mountain Institute, <https://rmi.org/increasing-home-value-home-energy-upgrades> (accessed October 22, 2020).

# Introduction

Are you thinking about making your home more energy efficient and considering the installation of clean heating and cooling (CH&C) equipment? This homeowner's guide provides an introduction to the efficiency measures and CH&C technologies available for your home and describes the best uses for each technology, the steps you can take to make your home more efficient, the incentives available to complete efficiency measures or CH&C installations, and walks you through the contractor selection and installation process. Making your home more energy efficient and installing clean heating and cooling technologies will reduce your home's greenhouse gas (GHG) emissions and may help you reduce the amount of energy your home uses, plus they can improve your indoor air quality and home comfort.

Vermonters spend a large portion of their income on home heating, spending an average of 25 percent of their household energy budget on heating costs. In 2017, this amounted to an average of \$2,600, up 12 percent from 2016.<sup>2</sup> These systems are primarily fueled by fossil fuels such as oil and propane, and in other cases by natural gas, electricity, wood, or kerosene. When a house is not energy efficient, it can impose a higher energy burden on the homeowners or renters—meaning a large percentage of household income is used for heating and electricity expenses.<sup>3</sup> Heating is also the second largest greenhouse gas emissions contributor (after the transportation sector)—the thermal sector accounts for nearly 24 percent of Vermont's GHG emissions.<sup>4</sup>

This energy burden is exacerbated for low-income Vermonters who are likely to live in older, less efficient homes with inefficient heating systems.<sup>5</sup> These inefficient systems can pose serious health risks, either by not supplying sufficient heat or by emitting harmful air pollutants inside the home.

Luckily, homeowners can reduce their fossil fuel use, improve their home comfort, and reduce indoor and outdoor air pollutants with CH&C technologies. These technologies, alongside weatherization upgrades, can provide cost savings compared to higher cost heating fuels like oil and propane, and inefficient electric baseboard heating (as compared to electric heat pumps); and various entities across the state provide incentives and financing to help cover the capital costs of installing CH&C technologies.

Choosing among the different CH&C technologies can be complicated. Each home, each heating system, and each heating distribution system is different, and there are many variables

2 Vermont Public Interest Research and Education Fund, "Clean Heat: Comfortable Homes, Affordable Future. A Vision for Vermont's Heating Future," VPIRG, Spring 2011, <https://www.vpirg.org/wp-content/uploads/2017/03/VPIRG-Clean-Heat-FINAL.pdf> (accessed October 8, 2020).

3 Justine Sears, "Energy Burden in Vermont," *Efficiency Vermont*, July 2016, <https://www.efficiencyvermont.com/Media/Default/docs/white-papers/efficiency-vermont-mapping-energy-burden-vermont-white-paper.pdf> (accessed October 8, 2020). An energy inefficient home may be poorly insulated, lack new windows and doors, and/or have an older, inefficient heating system. The Vermont Mapping Energy Burden white paper reports that energy inefficient homes are the "real cause" of energy poverty.

4 Vermont Air Quality and Climate Division, Department of Environmental Conservation, Vermont "Greenhouse Gas Emissions Inventory and Forecast: Brief 1990–2016," *Vermont.gov*, <https://dec.vermont.gov/air-quality/climate-change> (accessed October 8, 2020).

5 Justine Sears, "Energy Burden in Vermont," *Efficiency Vermont*, July 2016, <https://www.efficiencyvermont.com/Media/Default/docs/white-papers/efficiency-vermont-mapping-energy-burden-vermont-white-paper.pdf> (accessed October 8, 2020). Low- to middle-income Vermonters bear the highest electric and thermal energy burdens, especially if they are living in energy inefficient homes.



Alenkasn/Bigstock.com

that play into the decision-making process: Which technology is most cost-effective? Which is best for the environment? Which fits best for my home's heating and cooling needs?

With this guide in hand, a homeowner can better understand the following:

- **The benefits of an energy audit and home efficiency improvements**
- **The benefits of CH&C technologies**
- **The differences between the various technologies**
- **Which technologies work best under different scenarios**
- **How to choose a contractor, and**
- **State incentives and financing options**

In particular, this guide discusses some of the benefits and unique aspects of CH&C systems. Choosing the right technology for a particular home can be complex; and with a variety of products, financial packages, and vendors to choose from, the process can be confusing. If you are unsure of how CH&C technology can be integrated into your home, this guide is a great place to start getting your questions answered.

CH&C systems can provide homes with space heating and cooling, supply hot water, and heat swimming pools, much the same as conventional, fossil fuel-fired (and electric) systems. CH&C technologies include advanced wood heating systems (e.g., pellet boilers and pellet furnaces), air source heat pumps, ground source heat pumps, solar hot water, and heat pump water heaters. Advanced wood pellet boilers and solar hot water technologies provide thermal energy from



renewable sources, whereas air source and ground source heat pumps are high efficiency technologies with zero on-site carbon emissions.<sup>6</sup> In this guide, we refer to them all as clean heating and cooling (CH&C) technologies.

A CH&C system can work in any home, whether it's for new construction, existing home renovations, or additional space heat. CH&C technologies can deliver equivalent or superior levels of comfort at a fraction of the environmental impact of fossil fuel and electric resistance heating systems. And they may also reduce a household's heating bill.<sup>7</sup> In some cases, however, investing in CH&C technologies may not save the homeowner money. But all CH&C technologies will reduce a household's carbon emissions, improve indoor air quality, and reduce or eliminate fossil fuel use, and may even improve home comfort when replacing an existing heating load.

Some CH&C technologies provide whole-home heating, whereas others are best suited to provide supplemental heating. Different homes and different heating and cooling distribution systems may be better suited for one kind of CH&C technology over another. Some whole-home heating systems deliver heat through hydronic systems (e.g., hot water radiators or radiant floors), whereas others deliver forced hot air through ducts. Ground source heat pumps and advanced wood heating systems, for example, deliver low-temperature heat and work more efficiently with radiant floor systems and low-temperature radiators. For homes without heat distribution systems, ductless air source heat pumps (mini-splits) and wood or pellet stoves are good options. Furthermore, both ducted and ductless CH&C systems can be combined and configured to meet a home's heating needs.

This guide will help you compare one technology to another in the context of your existing heating system. In addition to a consultation with a home heating professional, this guide can help you understand how the various CH&C technologies provide heat, cooling, and hot water for your home. Armed with the information in this guide, you will be better able to assess the heating needs of your home, learn where to find a qualified contractor, and choose a CH&C technology that will work best for your situation.



**Air source heat pumps are easy to use and provide both heating and cooling.**

6 Vermont's electricity supply is 63 percent renewable and thus air source and ground source heat pumps are considered 63 percent renewable. These values will continue to rise as Vermont develops more renewable energy. See "A summary of progress made toward the goals of Vermont's Comprehensive Energy Plan," *Vermont Department of Public Service*, January 2020, <https://legislature.vermont.gov/assets/Legislative-Reports/2020-Annual-202be-report-Final.pdf> (accessed October 8, 2020).

7 A recent study by the Rocky Mountain Institute found that switching to electric renewable heating and cooling technologies (such as air source heat pumps) was a cost-effective solution for customers currently heating with oil or propane. See Sherri Billimoria, Lea Guccione, et al., "The Economics of Electrifying Buildings," *Rocky Mountain Institute*, 2018, <https://rmi.org/insight/the-economics-of-electrifying-buildings> (accessed October 8, 2020).

## Efficiency First

Energy efficiency improvements and energy conservation reduce the amount of heat and electric energy a household uses. The first step to reducing household energy consumption and costs is to increase its efficiency. Homeowners are encouraged to make energy-saving home improvements before adding any new heating system. Increasing a home's energy efficiency not only reduces a home's energy use but it also can result in smaller heating systems needed to heat the home.

Homeowners can learn about their home's energy performance by obtaining an energy audit (also known as a home energy assessment). Energy audits test the efficiency of a home, identifying air leaks, finding inefficiencies in the home's "envelope," and performing safety checks on heating and hot water equipment. This information can help a homeowner understand how much energy a home uses and which appliances or systems use the most. The audit provides homeowners with a list of recommended next steps for home energy savings improvements; many of these also result in cleaner indoor air, better ventilation, and increased home comfort. Efficiency Vermont provides information on home energy assessments on their website.<sup>8</sup>

An energy audit may result in recommendations for weatherization measures and/or equipment upgrades. Weatherization measures "button up" a home through insulation and air sealing.



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**Energy-saving home improvements such as insulation reduce a home's energy use.**

<sup>8</sup> Learn more about home energy assessments at <https://www.efficiencyvermont.com/services/energy-assessments/home-energy-assessments> (accessed October 22, 2020).



**Efficiency measures, such as air sealing around windows, eliminate drafts and reduce a home's energy use.**

Air sealing includes caulking cracks, replacing weather stripping around windows and doors, and eliminating drafts. Insulation is available in different types (cellulose, fiberglass, spray foam, etc.) and can be used in attics, walls, foundations, and roofs. Incentives are available to home-

owners for weatherization and other efficiency measures are offered by Efficiency Vermont as well as by some of Vermont's gas and electric utilities.

Efficiency Vermont maintains a directory of trained, local professional energy auditors—this contractor network is known as the Efficiency Excellence Network (EEN). The EEN contractors are trained Home Performance with ENERGY STAR® contractors. Home-

***Contractors charge for their services, but many of Vermont's utilities (its electric and gas utilities and its fuel providers) offer free energy audit evaluations.***

owners should get quotes from several contractors and should ask for and follow up on references. Contractors charge for their services, but many of Vermont's utilities (electric and gas utilities as well as fuel providers) offer free energy audit evaluations. Rather than a full-fledged home energy audit, these evaluations ask a series of simple questions about your home to determine if your home would benefit from an energy audit. Similarly, many Vermont utilities offer discounted energy audits for their customers. Homeowners should check with their fuel providers and utilities to see what incentive programs and discounts they offer. For example, the Energy Coop of Vermont offers discounted, \$200 energy audits, and Vermont Gas offers them for free.



## Why Should I Install a CH&C System in my Home?

Clean heating and cooling systems offer many homeowner and environmental benefits. In this section, we cover the various sustainability, economic, health, and environmental benefits associated with CH&C technologies. We begin by introducing you to Vermont's interest in CH&C and then we discuss the homeowner benefits.

### The Role of CH&C in Vermont's Energy Landscape

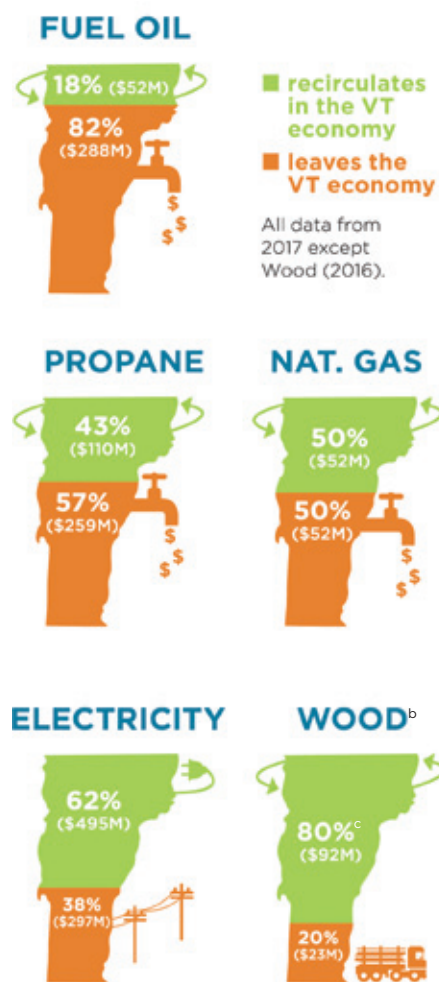
Vermont's Comprehensive Energy Plan (CEP)—the state's framework for advancing Vermont's clean energy transformation—calls for Vermont to increase the portion of renewable energy used to heat Vermont's building sector to 30 percent by 2025. This goal dovetails with a state statutory goal to weatherize 80,000 homes and reduce fuel use and utility bills by 25 percent by 2020. To meet the state's renewable thermal objectives, Vermont homeowners are encouraged to install clean heating and cooling technologies.

Seventy-six percent of Vermonters heat their homes by burning fossil fuels—fuel oil, propane, kerosene.<sup>9</sup> These fuels contribute significantly to climate change and to poor air quality. The remaining households are heated by burning wood or through electric heating. Although locally sourced wood is used for home heating, most of Vermont's home-heating dollars leave the state. In 2017, Vermonters spent over \$650 million on imported fossil fuels for residential heating.<sup>10</sup> An average of nearly 70 percent of each dollar spent on fossil fuel heating left the state. See Figure 1.

Investments in residential CH&C technologies can reduce the annual amount a homeowner spends on heating. Investments in weatherization and home

FIGURE 1

*Wood heat keeps 80% of every dollar circulating in the Vermont economy<sup>a</sup>*



Source: Energy Action Network

a. Vermont Agency of Commerce and Community Development, 2020.

b. Assumes use or purchase of cord wood, wood chips, or wood pellets from Vermont.

9 "2019 Annual Energy Report," Vermont Department of Public Service, January 2019, <https://publicservice.vermont.gov/sites/dps/files/documents/2019%20Annual%20Energy%20Report%20Final.pdf> (accessed November 30, 2020).

10 Jared Duval, Pamela Hathaway, et al., "2019 Annual Progress Report for Vermont," Energy Action Network, <https://www.eanvt.org/wp-content/uploads/2020/03/EAN-report-2020-final.pdf> (accessed October 8, 2020).



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**Cordwood and wood pellet stoves that meet certain efficiency and air quality standards are also eligible for financing and incentives in Vermont.**

efficiency improvements can further reduce home heating costs. Beyond the economic benefits an individual homeowner can accrue from investing in CH&C, local supply chains can reap economic benefits and employment opportunities. An increase in homes using advanced wood heat can be met sustainably with wood from Vermont's forests, which could be processed in state.<sup>11</sup> Electricity used for powering CH&C technologies can be produced locally with renewable energy systems.

CH&C technologies can have significant benefits for Vermont's most vulnerable populations. Low- and moderate-income households pay a far greater percentage of their annual income towards home heating. Weatherization, energy efficiency improvements and CH&C technologies not only have the potential for significant savings, but also can improve indoor air quality and comfort.

Vermont must accelerate adoption of CH&C technologies and weatherization efforts to meet the CEP goals and capture the economic benefits of moving away from imported fossil fuels to local fuel. Both state and federal incentives are available to help with that (these are covered in Section 10). These incentives have supported the conversion to CH&C technologies, and technology innovations have helped make these more affordable and viable heating options in Vermont's cold climate. Outreach and information, in addition to new funding and finance options, are key strategies for increasing CH&C adoption and accelerating weatherization efforts.

<sup>11</sup> Vermont only has one wood pellet mill, currently—in Clarendon (Vermont Wood Pellet). Wood pellets are also produced in Quebec, and neighboring states.

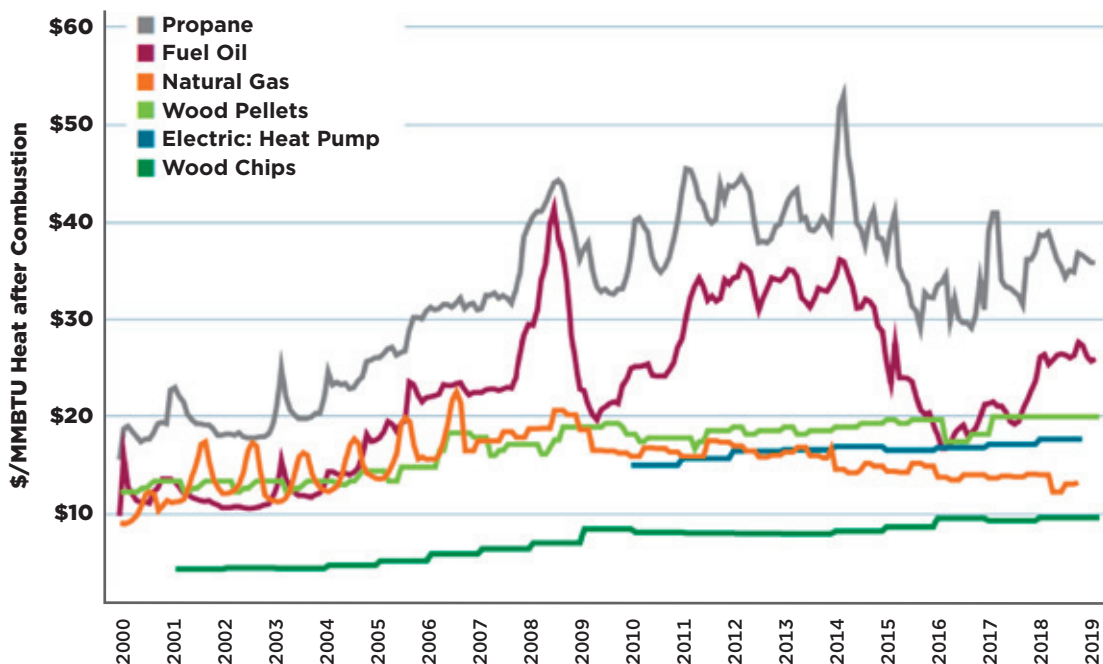


## The Benefits of CH&C Technologies

In Vermont, nearly 60 percent of the energy used in homes is for space heating and hot water. Vermont households spend an average of \$2,600 per year on heating.<sup>12</sup> Clean heating and cooling technologies present an opportunity for homeowners to reduce their fossil fuel use, reduce their carbon footprint, improve their indoor air quality, support the local clean energy economy, and reduce costs.

CH&C technologies are commercially available, efficient, and safe. They work most efficiently and most economically in homes that have a tight envelope (i.e., good insulation and weatherization upgrades). While, at the time of this writing, fossil fuel prices are relatively low, they have more volatile pricing than electricity and renewable alternatives. Figure 2 shows that fuel oil and propane pricing has been more volatile and significantly more costly than renewable fuels and electricity over the last 19 years. For homeowners who currently use a fuel source other than natural gas, switching to or adding supplemental heat from a CH&C technology will likely make economic sense. Those who heat with natural gas or have higher than average electric rates will likely not experience cost savings, but may be motivated by the significant greenhouse gas emission reductions associated with switching to a CH&C technology, and/or by the local economic benefit of using a local heating fuel.

FIGURE 2 *VT heating fuel costs variability by year*



**Fuel oil and propane pricing experienced price volatility, whereas electricity and wood biomass pricing remained relatively stable between 2000-2019. Switching to a CH&C technology is likely to save a homeowner money.**

Source: Energy Action Network (EAN)/Biomass Energy Research Center, 2019

<sup>12</sup> A household's energy budget includes electricity, transportation, and heat and hot water.

Homeowners who choose to install a CH&C system usually do so for one or more of the following reasons:

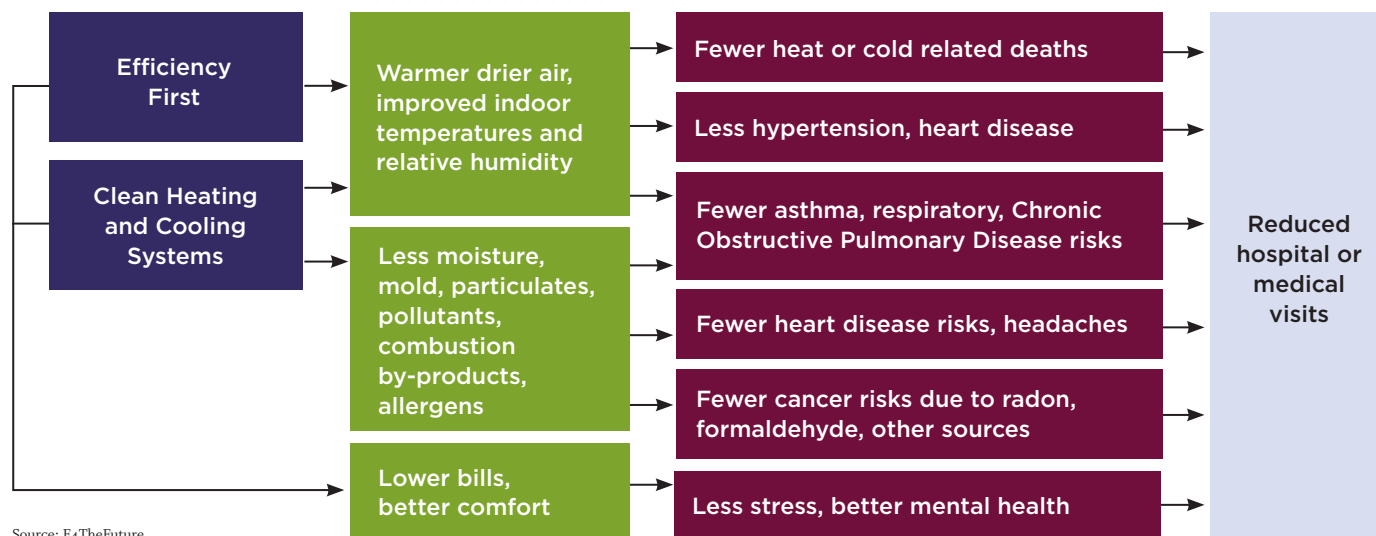
### Health & Home Benefits *(See Figure 3.)*

- Improves indoor air quality
- Increases home comfort
- Improves indoor humidity
- Provides additional space heat
- Provides hot water
- Provides air conditioning
- Replaces an aging or failing boiler or furnace

### Environmental Benefits

- Reduces fossil fuel consumption
- Reduces carbon emissions
- Boosts investment in renewable energy or energy efficient technologies

**FIGURE 3** *Health Benefits of CH&C Technologies*



**CH&C systems and efficiency measures provide health benefits by lowering humidity, reducing air leaks, and improving indoor air quality.**



## Economic

- Lowers potential heating costs, with the added benefit of air conditioning and hot water (only for some technologies).
- Supports the local economy. Between 50 and 82 percent of each dollar spent on fossil fuels leaves the state, whereas energy efficiency and CH&C alternatives keep energy dollars in state.
- Creates new jobs in Vermont. The advanced wood heating sector, for example, currently creates 54 full-time equivalent jobs in Vermont, according to the Vermont Working Lands Enterprise Board's report, *Expanded Use of Advanced Wood Heating in Vermont*.

## Energy Resilience and Sustainability

- Improves energy independence and resilience.
- Supports new, innovative green technologies.
- Improves new home performance. When constructing a new home or a net-zero home, air source and ground source heat pumps are ideal solutions for highly efficient homes.

## Health and Home Benefits

One obvious reason for replacing a boiler or furnace is that it is no longer working. This presents a natural opportunity to install a new clean heating system. The old system can be removed and replaced with a CH&C technology or a combination of technologies (e.g., air source heat pump plus a pellet stove). Whole-home clean heating technologies can tie into a building's current heat delivery system, including forced hot air, hydronic heating, central heating, and space heating. Advanced temperature and zone control systems can be integrated into a CH&C heating system to ensure that particular zones in a home are heated to the required temperature at the right time and to ensure that a system is operating most efficiently.

Another reason for considering replacing a boiler or furnace is because the heating system is not keeping occupants comfortable and the building needs more heat. Before replacing the heating system, a homeowner should first determine whether the problem is that the current boiler or furnace is underperforming or that the heat emitters (e.g., baseboards) are insufficient for the heating space. If the former, it may make sense to replace the inefficient furnace or boiler. If it is malfunctioning or poorly vented, it could be releasing pollutants and dangerously affecting indoor air quality.

If the heating system is working properly, replacing the heat emitters with newer, larger, or more efficient equipment may improve the heat distribution. However, if replacing room heat emitters is not an option, a homeowner can choose to install additional space heat with CH&C technologies. Air source heat pumps, pellet woodstoves, and efficient cordwood stoves are good options for providing additional space heat.

Many homeowners simply want additional heat in a particular room (versus whole-house heat). If you have an addition on your home, have an unheated space, or simply need more warmth, several CH&C technologies work well in space heating applications. These technologies can provide stand-alone heat (e.g., a wood pellet stove) and do not need to be tied into the existing home heating system. An air source heat pump is a good space heating option, especially in

smaller rooms (where there may not be enough room for a woodstove) or in urban areas where space constraints limit the storage of wood pellets and cordwood. Air source heat pumps are also good options for well-insulated homes where there may not be enough air circulation to sustain a fire in a wood or pellet-burning stove.

### Economic Benefits

If you are looking to reduce the amount of money and fossil-fuel energy from your domestic hot water use, solar hot water heating and heat pump water heaters are good, efficient technology options. Approximately 18 percent of total energy use in US homes is for domestic hot water heating.<sup>13</sup> If you choose to install a solar hot water heater, you will still need to rely on your existing (or add a supplemental) hot water system because solar water heating systems usually cannot meet your home's entire hot water needs all year. A heat pump water heater can provide whole-home hot water. Advanced wood heat boilers and ground source heat pumps also can provide domestic hot water, though each technology has different working temperature ranges and may need supplemental heat.



Source: CESA

### Other Benefits

Homeowners building net-zero homes will need relatively little heat due to high levels of insulation, passive solar gain, and air exchange/ventilation systems. CH&C technologies can meet the low-heat needs of net-zero energy buildings. Air source heat pumps, heat pump water heaters, and solar hot water technologies are especially well suited for meeting low-heat demands.

Lastly, if you are looking to add air conditioning to your home or to replace older AC units, ground source heat pumps and air source heat pumps provide both cooling and efficient space heating. You should consider the additional benefit of cooling when you compare technologies.

The best first step toward deciding whether—and which—CH&C is right for you is to have a home energy audit or home performance test. This will help you understand the heating demands of your house before you install a new heating system or purchase supplemental room heaters. In addition, the home energy audit will include suggestions for energy-efficiency improvements to your home. Homeowners should make any cost-effective energy improvements recommended by the audit prior to installing a new heating system or adding supplemental heat—an energy-efficient home will need less heat, thereby making possible a smaller, less expensive heating system. This means more money remains in your pocket. Good insulation is especially significant for efficient operation of CH&C technologies. (Home energy audits and weatherization are covered in Section 1: *Efficiency First*.)

<sup>13</sup> U.S. Energy Information Association, “Residential Energy Consumption Survey (RECS), EIA,” <https://www.eia.gov/consumption/residential/data/2009> (accessed October 8, 2020).

## What are Clean Heating and Cooling Technologies?

In this section, we review several CH&C technologies that are available to Vermonters under two categories: Advanced Wood Heating, and Heating and Cooling with Electricity.

### Advanced Wood Heating

Vermont considers woody biomass a source of renewable energy and a promising resource to reduce fossil fuel use, support the local economy, help maintain forest health, and strengthen Vermont's forest products industry.

It is a Vermont tradition to heat with wood, and wood heating is a great way to support the local economy while reducing greenhouse gas emissions from fossil fuels. In 2016, approximately \$70 million heating dollars remained in Vermont due to Vermonters heating with wood rather than with fossil fuels.<sup>14</sup> Wood is relatively low cost in comparison to propane and fuel oil, and its prices are mostly stable. Pellets are more expensive than cordwood, but this type of dried fuel burns more efficiently and cleanly than cordwood.

Advanced wood heating includes wood pellet boilers and furnaces that meet defined efficiency and air quality metrics. To qualify for incentives and financing, Vermont requires advanced wood heating systems to include at least one ton of pellet storage, automated operation and fuel feed,

and to be installed by an Efficiency Excellence Network contractor. Vermont's Clean Energy Development Fund maintains a list of eligible equipment.<sup>15</sup> Wood pellet stoves, cordwood stoves, and cordwood and chip boilers that meet certain efficiency and air quality standards are also eligible for financing and incentives. Efficiency measures the percentage of available heat from wood combustion that is delivered to the area being heated. We cover each technology below, with a focus on wood pellet boilers, furnaces, and stoves.

***Wood pellet stoves, cordwood stoves, and cordwood and chip boilers that meet certain efficiency and air quality standards are also eligible for financing and incentives if they meet established efficiency and air quality standards.***

### Wood pellet boilers

Wood pellet boilers tie directly into a home's central hydronic heat distribution system and deliver both heat and hot water through radiators, baseboards, and/or underfloor radiant heating.

Wood pellet boilers have improved significantly in terms of heating performance, operating ease, emissions, and efficiency over the years. Now, wood pellet boilers operate automatically

<sup>14</sup> Juliette Juillerat, "Wood Heating in Vermont. A Baseline Assessment for 2016," Vermont Dept. of Public Service, July 2017, [https://publicservice.vermont.gov/sites/dps/files/documents/Renewable\\_Energy/CEDF/Reports/AWH%20Baseline%20Report%20FINAL.pdf](https://publicservice.vermont.gov/sites/dps/files/documents/Renewable_Energy/CEDF/Reports/AWH%20Baseline%20Report%20FINAL.pdf) (accessed October 8, 2020).

<sup>15</sup> "Eligible Equipment Inventory (EEI)," Renewable Energy Resource Center, July 2017, <http://www.rerc-vt.org/advanced-wood-heating-system/eligible-equipment-inventory-eei> (accessed October 8, 2020). The pellet boilers and furnaces listed in the Eligible Equipment Inventory are eligible for the state's advanced wood heating system incentive.





**Automated wood pellet boilers are compact and fit easily into spaces previously occupied by a fossil fuel boiler.**

and efficiently using a two-stage combustion process. By controlling combustion, metering air intake, and modulating heat output, wood pellet boilers operate reliably and cleanly, resulting in low emissions. With their high degree of automation, pellet boilers can respond quickly to a user's demand for heat, although not as quickly as fossil fuel boilers. The pellet boilers approved for Vermont incentives have efficiencies in the 85–90 percent high heat value (HHV) range.<sup>16</sup>

Wood pellet boilers operate most efficiently when they burn steadily. Varying demands for heat cause the boiler to cycle on and off, which produces the most smoke and particulate emissions. For this reason, it is important not only to select a boiler that modulates to 30 percent or less of its heating capacity, but also to work with a contractor trained in calculating a home's heat load so that the boiler is properly sized. Installers in Vermont's Efficiency Excellence Network program know how to do this.

Wood pellet boilers also operate most efficiently when paired with low-temperature hydronic distribution systems (<120° F), which distribute heat evenly. They are, therefore, best suited for homes with a large thermal mass such as a low-temperature, radiant floor system or low-temperature radiators.

Advanced wood heat systems have a 20– to 25-year lifespan. They require minimal hands-on operator involvement. Most systems include an integrated pellet storage unit, which can hold

<sup>16</sup> "What is HHV and LHV Heating Efficiency for Wood Burning," Rocky Mountain Stove and Fireplace, June 2019, <https://www.rockymountainstove.com/blog/what-is-hhv-and-lhv-heating-efficiency-for-wood-burning-stoves> (accessed October 8, 2020). HHV is a term used with combustion units that have secondary or tertiary combustion chambers that condense water vapor and recovers most the latent heat. The water's condensation heat is included in the HHV value.

## The Main CH&C Technologies At-a-Glance

### Advanced Wood Heating

Residential advanced wood heating (AWH) systems are boilers or furnaces that burn wood fuel (cord, chips, and pellets) much more efficiently and with drastically less particulate pollution emissions than in the past. These systems are often fully automated and tie directly into central heating and hot water systems. They can operate much like fossil-fuel-based central heating systems and meet all the heating needs of a building. Vermont offers incentives for residential systems that are listed on Efficiency Vermont's Eligible Equipment list and have been installed by an Efficiency Excellence Network contractor. These systems comply with Vermont's standards for particulate matter emissions. The contractors meet service quality criteria. Other types of wood heating systems—wood pellet stoves, cordwood stoves, and the cordwood boilers—are not covered in depth in this guide, but they are good options to consider.

### Ground Source Heat Pumps

Ground source heat pumps (GSHP) are highly efficient systems that take advantage of the ground's constant temperatures to heat or cool a building by circulating a liquid through tubes that are placed horizontally or vertically in the ground. The heat pump amplifies the temperature to provide high-efficiency heating or cooling into the building. These systems can also supply hot water.

### Cold Climate Air Source Heat Pumps

Cold climate air source heat pumps (CCHP) use electricity to extract heat from the outside air and deliver it indoors. They operate in reverse when operating in cooling mode. Heat pumps can provide high-efficiency heating or cooling. They are available as ducted and ductless units. The former are generally whole-home heating solutions, whereas the latter can provide either whole-home heat or single-zone/single-room heating.

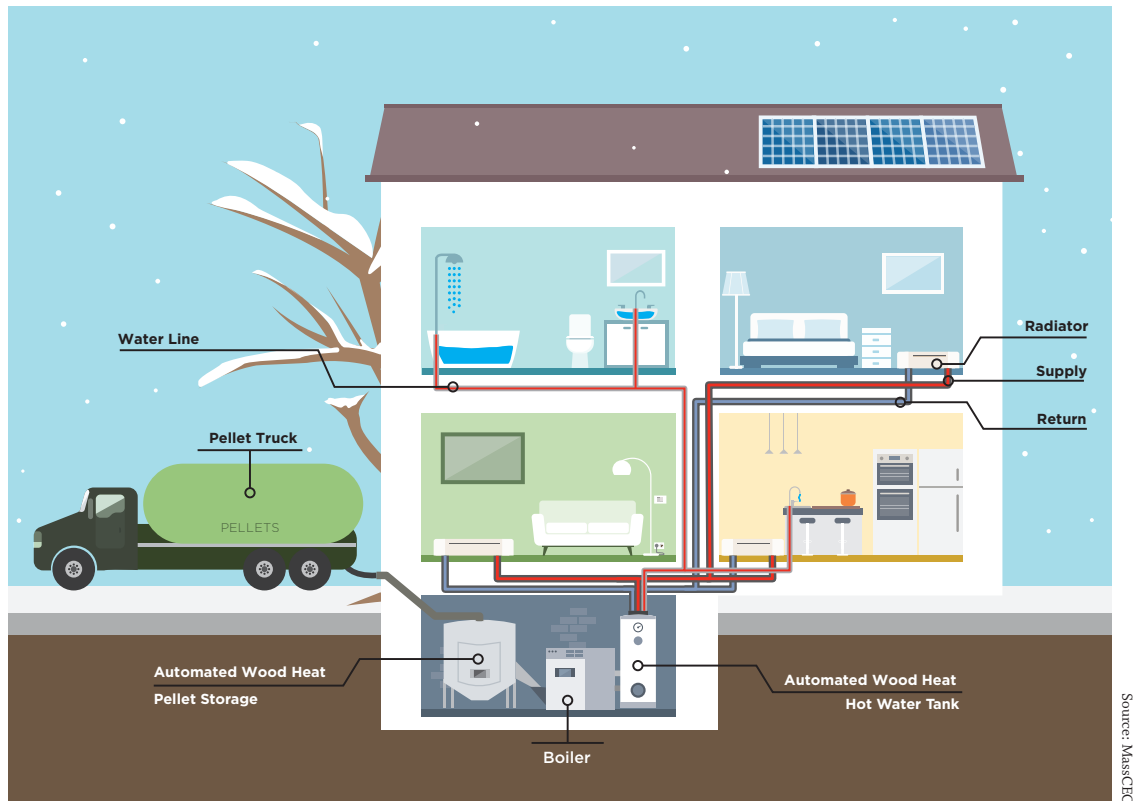
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3–5 tons of pellets—enough to keep a single-family home heated for one year. The pellets are automatically fed into the boiler where, after the burning process, the remaining ash is moved to an external ash container and compressed. Some boiler models can burn up to three tons of pellets before the ash container needs to be emptied, although most ash containers are smaller. A homeowner will most likely need to empty the ash container two to three times a year. Other general operation and maintenance tasks (e.g., checking sensors and greasing gears) should be performed annually by the system installer. Be sure to compare various models because boiler design can affect the amount of maintenance the system will need.

Thermal storage tanks, also referred to as heat storage systems, store hot water heated by the boiler. This hot water is available to meet the call for heat and eliminates the constant cycling of the boiler. In addition, thermal storage tanks increase boiler response time and are recommended to improve the efficiency and emissions profile of wood pellet boilers.

Boilers can also be used to produce domestic hot water. In this case, the same hydronic distribution system used for house heating circulates water through a coil in an indirect water heater, which transfers heat to water stored in the tank. (See Figure 4.)

**FIGURE 4** *Pellet Boiler with Hydronic Heat Distribution*



Pellet boilers distribute hydronic heat throughout the home via radiators or radiant floors (not shown).

## What are wood pellets?

Wood pellets are produced from compacted sawdust and other wood waste from sawmills, wood products factories, and timber harvests. Premium-grade pellets can maximize the longevity of an advanced wood heat boiler (and improve emissions), because they leave the least amount of ash—less than 1 percent ash by weight. Most advanced pellet boilers cannot handle pellets with higher ash content. Some manufacturers require the use of Pellet Fuel Institute-certified pellets to maintain good standing with the manufacturer's warranty.



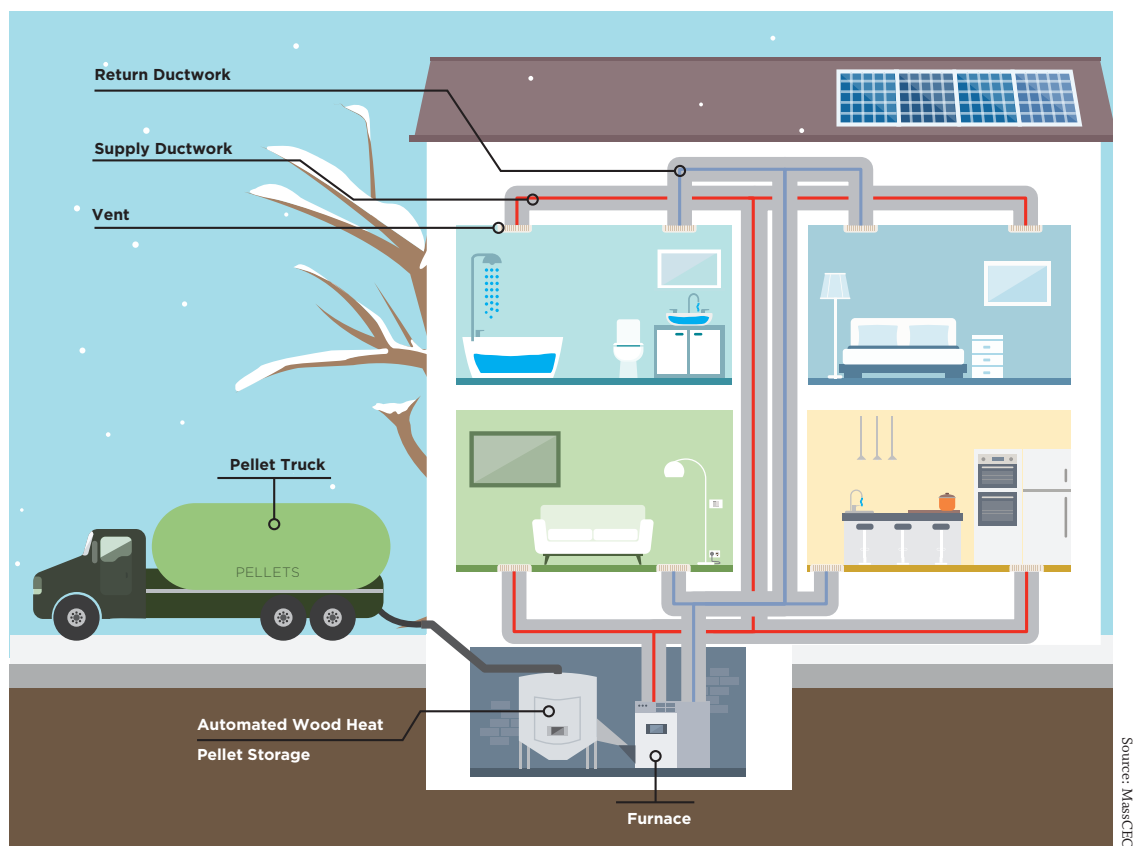
## Wood Pellet Furnaces

Wood pellet furnaces are different from wood pellet boilers. Whereas boilers provide space heating through hydronic distribution systems, furnaces distribute heat through air ducts. See Figure 5. In other respects such as fuel storage and delivery, and maintenance, they are similar to boilers. However, most wood pellet furnaces have lower efficiencies than boilers; their average efficiency ratings are about 85 percent.

Wood pellet furnaces do not provide hot water like a boiler, but like a boiler system, pellets are kept in a storage bin and are automatically conveyed to the burner as needed. A thermostat communicates with the furnace's controller that regulates the most efficient rate of pellet burning to maintain the desired level of warmth. Ashes are automatically compressed and stored in an ashbin.

Like pellet boilers, pellet furnaces must be installed by an Efficiency Expert Network contractor to unlock the state of Vermont's incentives and financing. Similarly, the furnace must be accompanied by at least one ton of pellet storage and meet efficiency and emissions criteria. Currently, the Eligible Equipment Inventory list only includes one pellet furnace; the listed furnace's HHV efficiency rating is 89 percent.

**FIGURE 5** *Pellet Furnace and Ductwork*



**Pellet furnaces distribute heat throughout the home via ductwork.**

## Wood Pellet Stoves

Pellet stoves are similar to wood stoves in that they burn wood to provide space heating. However, pellet stoves burn wood pellets rather than cordwood and have thermostats and automatic combustion controls that maximize efficiency. They operate more efficiently than their cordwood counterparts.

Pellet stoves operate automatically. They can run for long periods without attention. They need electricity to power an auger and a fan. The auger feeds wood pellets from a small hopper into the combustion area of the stove. A thermostat determines the burn rate by adjusting the pellet feed rate. The fan helps control the pellet burn rate. Pellet stoves also have another fan to help disperse their heat into the room.

The size of the hopper and the stove's efficiency determine how long the stove can run before the hopper needs to be refilled. Generally, a standard size 40-pound bag of pellets can power a pellet stove between 15–24 hours, depending on the stove's temperature settings. Hoppers can hold between 45 to 120 pounds of pellets.

EPA-certified pellet stoves generally operate in the 70–83 percent efficiency range and produce approximately one-third of the emissions produced by an EPA-certified cordwood stove for the same amount of heat output.

Pellet stoves have heating capacities of 8,000–90,000 BTU/hour.<sup>17</sup> BTU/hour is a way of determining how much heat must be generated to warm an area. It takes about 16,000 BTUs to heat an average size room in a Vermont home to 68° F.<sup>18</sup> They range in cost from \$1,500–\$3,500.<sup>19</sup>

## Heating with cordwood and chips

Cordwood boilers, furnaces, and wood stoves operate similarly to their pellet counterparts, but burn cordwood rather than pellets. Cordwood generally contains more moisture than wood pellets and thus burns less efficiently and with higher emissions. The higher moisture content in cordwood generates more ash, and cordwood-fueled appliances require more frequent maintenance; ash containers may have to be emptied daily.

Wood chip boilers are generally not used in homes; this technology is geared toward small commercial and institutional applications like schools, and in district heating. Chips have more moisture than pellets, but less moisture than cordwood. However, dried chips are available for commercial customers. These chips, also referred to as semi-dry chips, are dried either passively



A pellet stove hopper filled with wood pellets.

Hilda Weges/Bigstock.com

17 “Wood and Pellet Heating,” EnergyGov, <https://www.energy.gov/energysaver/heat-and-cool/home-heating-systems/wood-and-pellet-heating> (accessed October 8, 2020).

18 “BTU Calculator,” calculator.net, <https://www.calculator.net/btu-calculator.html> (accessed October 8, 2020). An average size of 1,300 square feet was used for this calculation.

19 “Costs and benefits of pellet stoves,” EnergySage, January 2020, <https://www.energysage.com/clean-heating-cooling/pellet-stoves/costs-benefits-pellet-stoves> (accessed October 8, 2020).



or actively to a moisture content of less than 30 percent. The chips are often screened to a uniform small size so that they can then be fed easily into storage bins. Due to their higher moisture content, wood chips are not as energy dense as pellets, and more storage space is needed.

## HEATING AND COOLING WITH ELECTRICITY

### Cold Climate Air Source Heat Pumps (CCHPs)

Vermont defines renewable energy as “energy produced using a technology that relies on a resource that is being consumed at a harvest rate at or below its natural regeneration rate.”<sup>20</sup> Both ground source and air source heat pumps are considered energy efficiency technologies, and they fall under the “clean heating and cooling” technologies rubric. Since emissions from the generation of electricity in Vermont are very low (varies by electric utility), ground source and air source heat pumps can be considered to be sufficiently emissions-free for inclusion in this guide.<sup>21</sup>



**A wall-mounted ductless air source heat pump indoor unit.**

<sup>20</sup> “Chapter 089: Renewable Energy Programs, 30 V.S.A. § 8002,” Vermont General Assembly, <https://legislature.vermont.gov/statutes/section/30/089/08002> (accessed October 12, 2020).

<sup>21</sup> “Northeast/Mid-Atlantic Air-Source Heat Pump Market Strategies Report—2016 Update,” Northeast Energy Efficiency Partnerships, [https://neep.org/sites/default/files/NEEP\\_ASHP\\_2016MTStrategy\\_Report\\_FINAL.pdf](https://neep.org/sites/default/files/NEEP_ASHP_2016MTStrategy_Report_FINAL.pdf) (accessed October 9, 2020).



Cold climate air source heat pumps (CCHPs) use electricity to extract heat from outside air and deliver it indoors during the heating season. They operate in reverse when operating in cooling mode.<sup>22</sup> A heat pump can provide high-efficiency heating or cooling.

Cold climate air source heat pumps work best in well-insulated buildings with a low air exchange rate. The electricity that Vermonters consume is considered approximately 63 percent renewable (based on data from the Vermont Public Service Department's 2019 Annual Energy Report) and can be up to 100 percent, depending on the electric utility. As Vermont's electricity

supply becomes more renewable, so will the heat pumps it powers.

Cold climate air source heat pumps are the lowest-cost heating option for newly-constructed homes. For home retrofits, homes that are currently heated with electric baseboards, propane, or oil have the most energy and cost savings to gain from switching to, or supplementing with, a CCHP.<sup>23</sup> CCHPs are especially efficient when compared to electric resistance heating. Depending on the local cost of electricity that can mean an average annual savings of 50 percent or more compared with electric resistance

***Cold climate air source heat pumps use electricity to extract heat from outside air and deliver it indoors during the heating season. They operate in reverse when operating in cooling mode. A heat pump can provide high-efficiency heating or cooling.***

heating.<sup>24</sup> Homeowners who heat with heating oil and propane are well aware of their price volatility; generally, the cost of heating a home with CCHPs is lower than with some home heating fuels—if CCHP is sized, installed, and operated properly in an efficient home. As fossil fuel prices rise and heat pump technologies improve, homeowners will realize greater savings.<sup>25</sup>

Until recently, CCHPs were most effective in milder climates and unable to operate efficiently below freezing. Now, CCHPs can operate at temperatures well below freezing. “Cold climate” is an industry designation; there are no standard criteria for determining which units are appropriate for cold climates. However, the Northeast Energy Efficiency Partnerships (NEEP) has facilitated the development of a CCHP specification and a list of products that includes performance level and reporting requirements.<sup>26</sup> NEEP's list identifies the CCHPs that are most efficient at heating in cold climates. Efficiency Vermont refers to this high-performing equipment list for incentive eligibility.

22 Ground source heat pumps operate in the same manner, but extract heat from either water or the ground. This technology is described in the next section.

23 In utility territories with high electric rates, the homeowner may not realize any savings from switching to a CCHP.

24 “Electric Resistance Heating,” Energy.Gov, <https://www.energy.gov/energysaver/home-heating-systems/electric-resistance-heating> (accessed October 9, 2020).

25 “2019 Annual Progress Report for Vermont,” Energy Action Network, <https://www.eanvt.org/wp-content/uploads/2020/03/EAN-report-2020-final.pdf> (accessed October 8, 2020). Currently, fossil fuel prices are so low that it may cost more to heat with a CCHP. However, CH&C technologies are significantly lower cost over time than fossil fuel systems. The VT PSD finds that fossil fuel dependence for heating and transportation is more costly to Vermonters than the currently available efficient and renewable alternatives.

26 “NEEP's Cold Climate Air Source Heat Pump List,” Northeast Energy Efficiency Partnerships, <https://ashp.neep.org/#/> (accessed October 9, 2020).

## Ductless and Ducted CCHP Units

Cold climate air source heat pumps are available in both ductless and ducted units. Typically, the existing duct work in a building can be used for a CCHP, provided that the duct work is in good shape. The ability to tie into existing ductwork reduces the cost of a CCHP for whole-home heating. However, it is important to note that not all ductwork is appropriately sized for CCHPs. In new home construction, ductwork can be tailored specifically to integrate with a whole-home CCHP.

In a ductless system, no internal ducts are needed; rather, refrigerant is circulated from outdoor coils to indoor units through a small flexible pipe. Ductless units are commonly referred to as “split” or “mini-split” systems—one or more indoor units are used with a single outdoor condensing unit. Having multiple indoor units allows the homeowner to heat and cool multiple zones. Smaller ductless systems can be used for space heating and work best when they are used to heat or cool a single room or large open space (e.g., an open kitchen/family room). A home with separate rooms would be better suited for a multi-zone ductless system.

The placement of a ductless CCHP greatly affects its ability to deliver heat throughout a building. A qualified installer can help you design the best system for your home and plan the placement of the indoor unit. In cold climates like Vermont, indoor units are most effectively placed low on the wall using a floor-mounted or wall-mounted system. This is especially true for ground floor rooms. However, they may also be mounted on the wall at ceiling height. Floor- and ceiling-mounted units may add significantly to the cost of the system.

The average installed cost of a ductless CCHP system falls approximately in the \$3,500–\$5,000 range for a single-head unit and up to \$20,000 for whole-home systems.<sup>27</sup> CCHPs are ideally suited for situations where the customer:

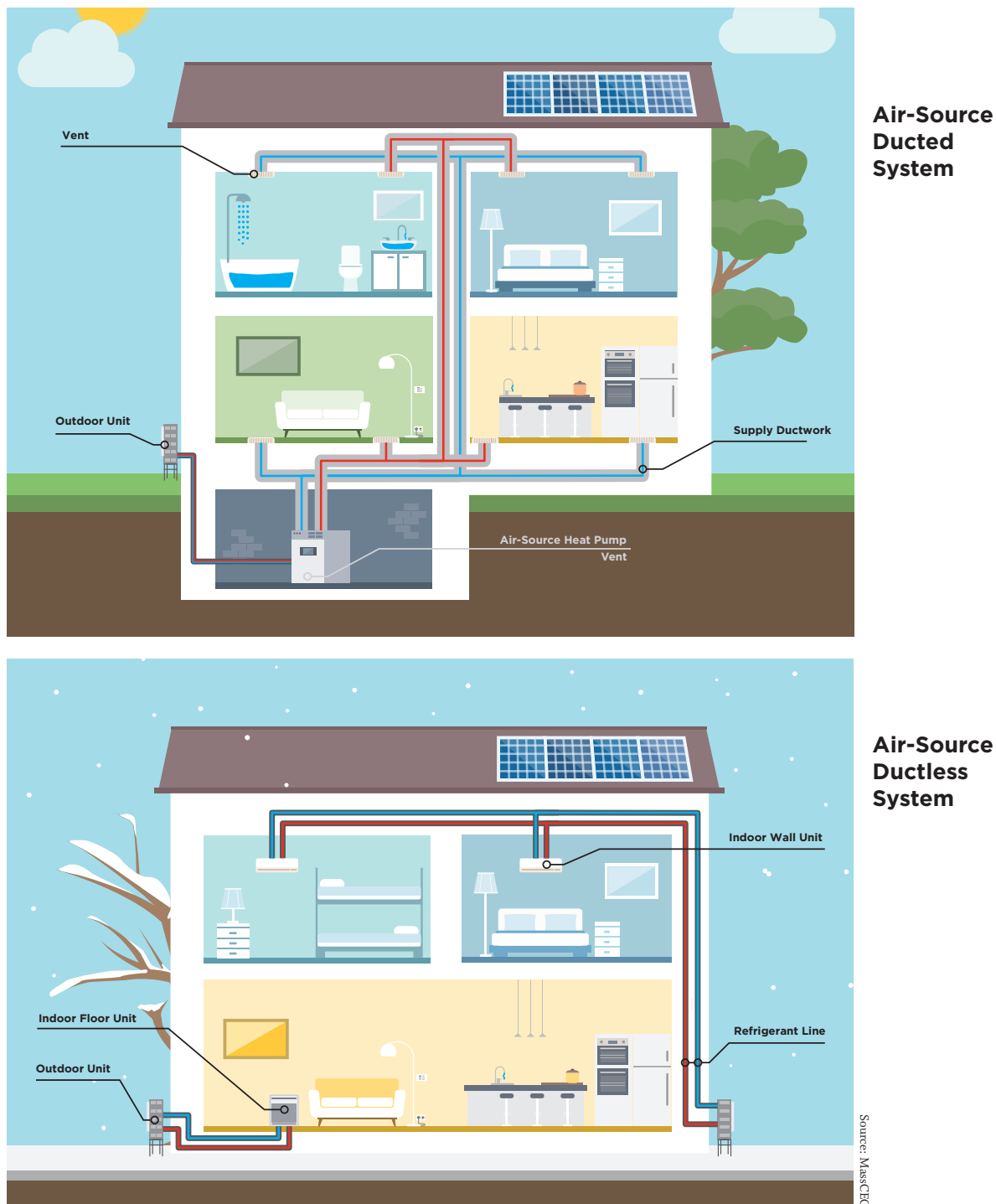
- Is interested in additional room heating (for supplemental heat or to reduce fossil fuel consumption from primary heating source)
- Has an older central heating unit and would like to replace it with a whole home clean heating solution
- Would like to take advantage of the cooling capability of CCHPs, eliminating the need for air conditioners
- Has a low-load, well-insulated home
- Is building a new home, including net-zero/Passive House homes.



**Floor-mounted indoor air source heat pump unit.**

<sup>27</sup> “Costs and benefits of air source heat pumps,” EnergySage, <https://www.energysage.com/clean-heating-cooling/air-source-heat-pumps/costs-and-benefits-air-source-heat-pumps> (accessed October 12, 2020). These costs do not account for the various incentives.

**FIGURE 6** *Ducted and Ductless Air Source Heat Pump Systems*

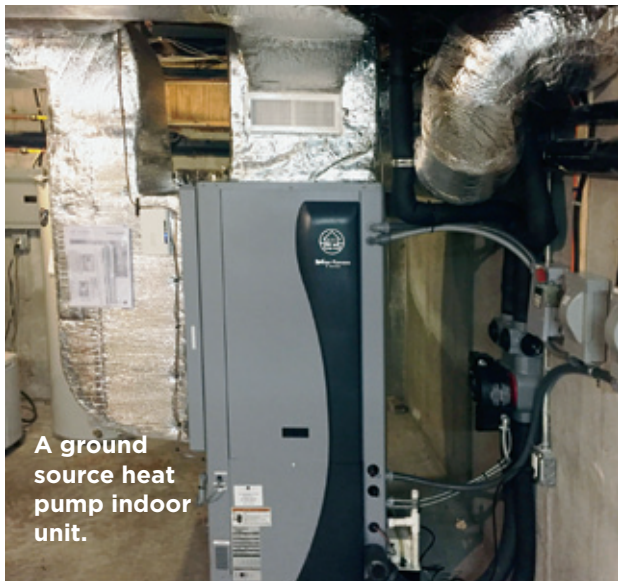


Air source heat pumps can work with a home's existing ducts (top image). Ductless (mini-split) air source heat pumps can be installed in homes without ducts. The indoor unit delivers hot (or cold) air (bottom image).

## Air-to-Water Heat Pumps

Air-to-water (ATW) heat pumps extract heat from outdoor air and transfer that heat to a hydronic system, usually water or a water with antifreeze solution. Key to this technology's efficiency is the conveyance of that heated water to low-temperature hydronic radiant panels. The heat pump works in summer to provide cooling by producing chilled water that can be transported to air handlers to cool and dehumidify a room. ATW heat pumps can also provide hot water if a water storage tank is added to the system.

Air-to-water heat pumps are extremely efficient; they are 47 percent more efficient than a typical condensing boiler and use 70 percent less electricity than baseboard heat.<sup>28</sup>



Source: MassCEC

A ground source heat pump indoor unit.

## Ground Source Heat Pumps (GSHPs)

Several feet below the earth's surface in Vermont, the ground maintains an annual average temperature of 55°F—warmer than the outside air during the winter and cooler during the summer. Like CCHPs, ground source heat pumps (GSHPs) use electricity to take advantage of the ground's temperature to heat or cool a building by circulating a liquid through loops of underground pipes. Heat is transferred from the ground into the home during winter. In summer, heat from the home is transferred back to the ground. They are sometimes called geothermal heat pumps.

Ground source heat pumps are the most efficient heating and cooling technology for buildings, but they have a high upfront cost. Due to the high

initial costs, the technology lends itself best to new construction and multi-family residences. They can also be a good option for a whole-home heating replacement, particularly if the homeowner wants both heating and air conditioning. GSHPs that are replacing existing whole-home heating systems may be able to take advantage of the home's existing heat distribution system, including forced hot air ducts, hot water baseboards, and radiant floors. However, it is important to note that because GSHPs deliver hot water in the 110°–120° Fahrenheit range, existing radiators or baseboards may need to be upgraded for compatibility.

Even though ground source heat pumps use electricity to operate, they are much more efficient than conventional heating and cooling systems. The U.S. Department of Energy estimates that GSHPs use between 25 to 50 percent less electricity than conventional heating and cooling systems. Additionally, the EPA reports that GSHP systems are 44 percent more efficient than air source heat pumps and up to 72 percent more efficient than electric resistance heating with standard air-conditioning equipment.<sup>29</sup>

28 "2019–2020 Air-to-Water Heat Pumps," Energy Star, [https://www.energystar.gov/about/awards/2019\\_Air-to-Water\\_Heat\\_Pumps](https://www.energystar.gov/about/awards/2019_Air-to-Water_Heat_Pumps) (accessed October 12, 2020).

29 "Choosing and Installing Geothermal Heat Pumps," Energy.Gov, <https://www.energy.gov/energysaver/choosing-and-installing-geothermal-heat-pumps> (accessed October 12, 2020).



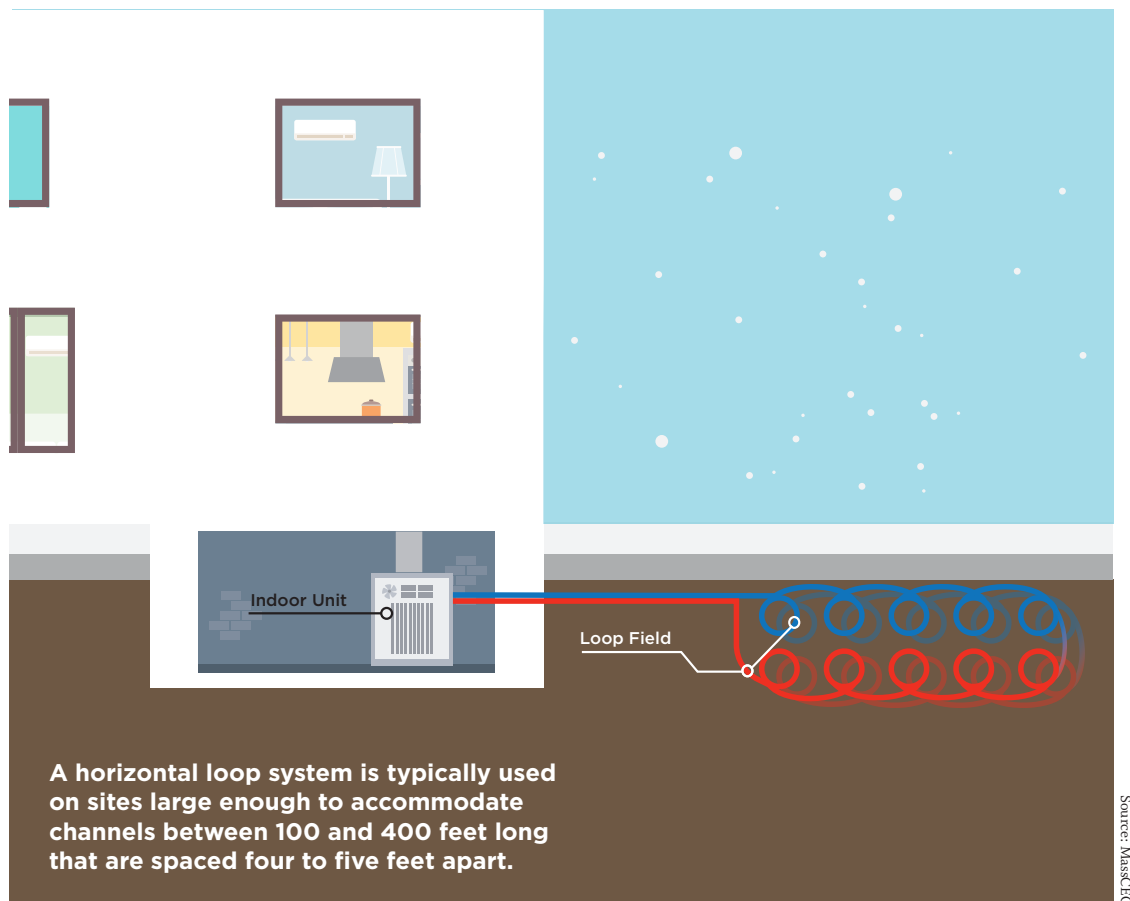
### ***Closed-Loop or Open-Loop Systems***

GSHPs can perform on either a closed-loop or an open-loop system. Closed-loop systems are the most common installation type in Vermont. They circulate a refrigerant through an enclosed pipe loop. Open loop systems circulate water from the ground through a heat exchanger, and the water is discharged back into the ground.

For closed-loop systems, there are three types of installation methods: horizontal, vertical, and pond/lake. Horizontal systems use trenches that are typically used on sites large enough to accommodate channels between 100 and 400 feet long that are spaced four to five feet apart. Soil is the most suitable substrate for horizontal trenches. (See Figure 7.)

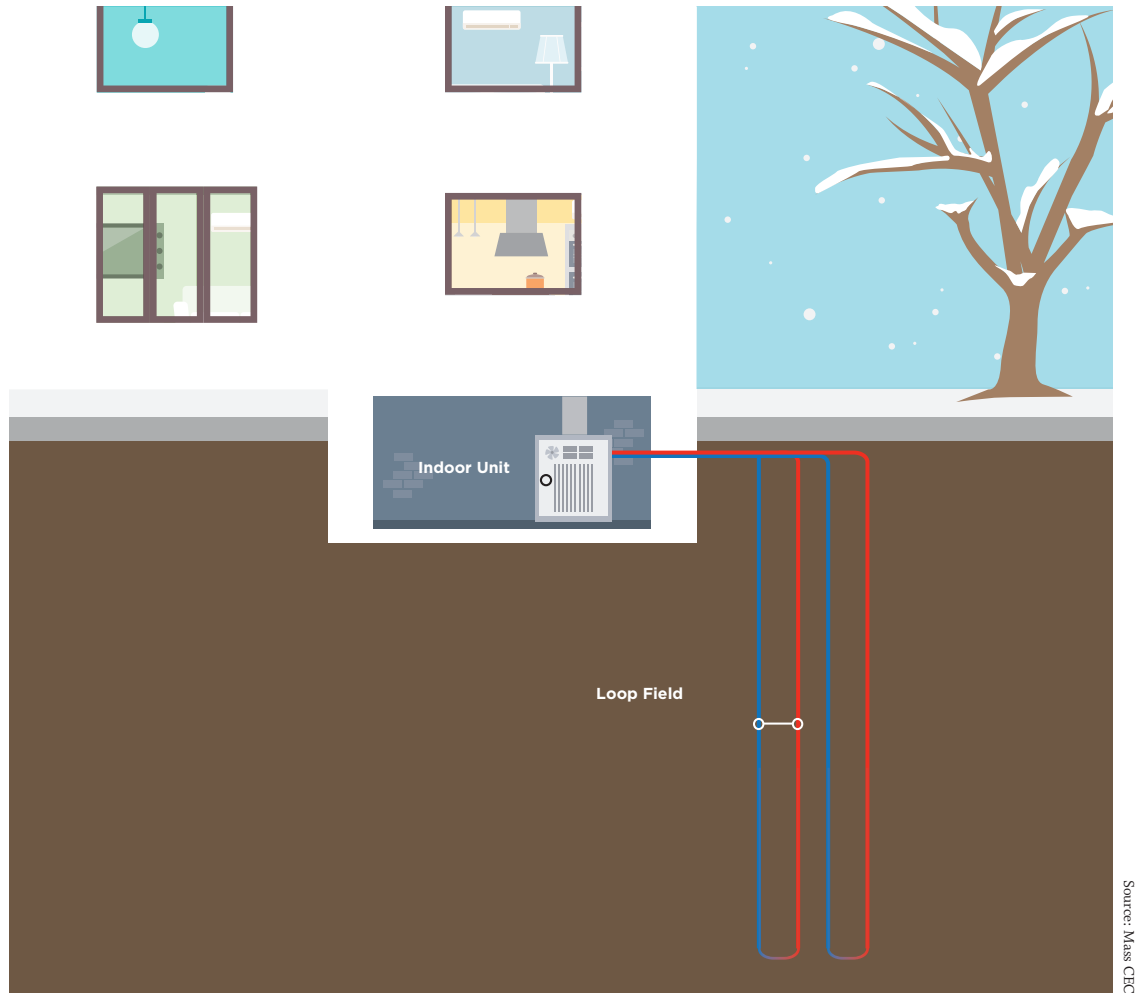
Vertical loops are a better choice for small or rocky sites. They are more common in urban and residential neighborhoods where space is limited. They extend 100 to 700 feet vertically into the ground and are placed ten to fifteen feet apart. It is not the area's size that determines the heating and cooling capacity of a system, but rather the total length of the loops. For example, an area the size of a parking space is sufficient for a vertical loop system serving a 2,500 square foot building.<sup>30</sup> (See Figure 8.)

**FIGURE 7** *Horizontal Closed-Loop Ground Source Heat Pump System*



<sup>30</sup> “Geothermal FAQs,” Achieve Renewable Energy, <http://achieverenewable.com/f-a-q-s/geothermal-questions> (accessed October 12, 2020).

**FIGURE 8** *Vertical Closed-Loop Ground Source Heat Pump System*



**Closed-loop systems are most common in Vermont. They circulate a refrigerant through an enclosed pipe loop. A vertical loop is used in rocky areas or where space is limited.**

Instead of the ground, ponds or water sources may also be used as a source of constant temperature heat, though this is relatively rare.

The loop field for a GSHP system can account for as much as 50 percent of the cost of the installation.<sup>31</sup> Vertical loops are typically more expensive than horizontal loops because drilling is more costly than trenching. However, vertical loops are more efficient since they are buried deeper than horizontal loops.

<sup>31</sup> “How a Geothermal System is Priced,” Geothermal Genius, <http://www.geothermalgenius.org/thinking-of-buying/average-cost-of-geothermal-heat-pump-installation.html> (accessed October 12, 2020).



David Dodge, Green Energy Futures, via Flickr (CC 2.0)

**This net-zero home mechanical room includes a solar thermal water tank, a rainwater collection system, solar PV inverters, water filter, and more.**

While GSHPs provide a range of benefits to the consumer, including reduced energy consumption, low maintenance costs, and system longevity,<sup>32</sup> they come with a high, up-front installation cost due to the complexities of the system and the need to professionally design and install it. For most residences, a three-ton GSHP is sufficient.<sup>33</sup> Plan on spending approximately \$2,500–\$5,000 per ton for an average geothermal heat pump system.<sup>34</sup> Installation and drilling costs will add \$10,000–\$30,000 to the project cost.<sup>35</sup>

32 “Geothermal Heat Pumps,” National Renewable Energy Laboratory, <http://www.nrel.gov/docs/legosti/fy98/24782.pdf> (accessed October 12, 2020).

33 “Ton” refers to the amount of heat that can be extracted from the ground. Typically, a single ton is the equivalent of 12,000 BTU/hr.

34 “Guide to Geothermal Heat Pumps,” U.S. Department of Energy, [https://www.energy.gov/sites/prod/files/guide\\_to\\_geothermal\\_heat\\_pumps.pdf](https://www.energy.gov/sites/prod/files/guide_to_geothermal_heat_pumps.pdf) (accessed October 12, 2020).

35 “Ground Source Heat Pumps,” E3A, <https://www.e3a4u.info/energy-technologies/ground-source-heat-pumps/economics> (accessed October 12, 2020).

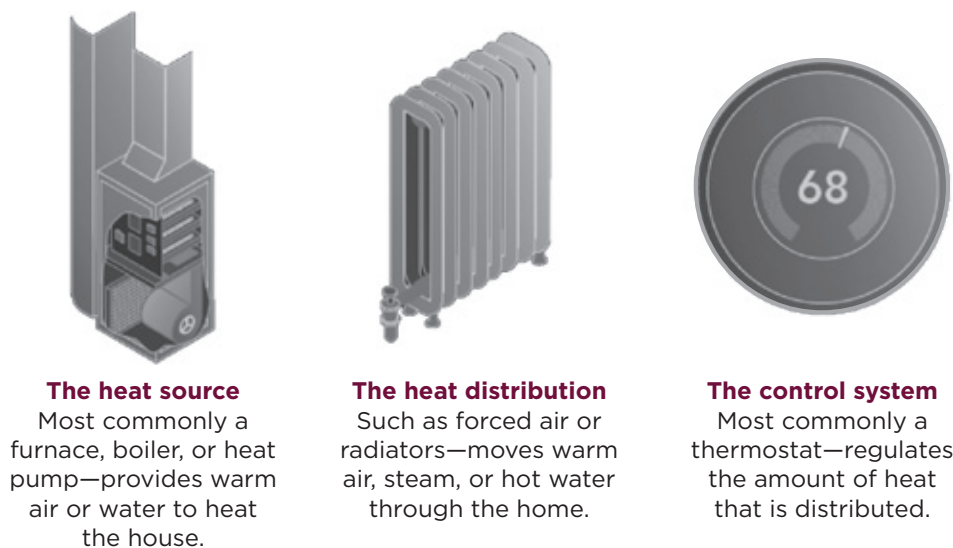
## Are CH&C Systems Right for My Home?

CH&C technologies present an opportunity to reduce your home heating fossil fuel use, reduce your carbon footprint, and support the local clean energy economy. CH&C technologies are commercially available, efficient, and safe, and there are many equipment manufacturers from which to choose. Homeowners are strongly encouraged to perform efficiency upgrades and undertake weatherization measures prior to installing any new heating system. These measures can reduce the amount of energy needed to heat a home and, as a result, smaller, less expensive heating equipment could be installed to meet the reduced heating/cooling loads.

Choosing among the different CH&C technologies can be complicated (see Figure 9). Each home, each heating system, and each heating distribution system is different, and there are many variables that play into the decision-making process: Which alternative is most cost-effective? Which is best for the environment? Which fits best in my home?

We have developed a decision tree matrix to help you determine which CH&C options can easily integrate with your home. (See Table 1 on p. 33.)

**FIGURE 9** *How Heating Systems Work*



**All heating systems have three basic components. If your heating system isn't working properly, one of these basic components could be the problem.**

Source: Energy.Gov

**TABLE 1** *Decision Tree Matrix for CH&C—Which technology meets your home’s needs?*

What would you like your heating and cooling system to do?	Ductless mini-split air source heat pump	Ducted air source heat pump	Ground source heat pump (geothermal)	Pellet Boiler
You want to <b>meet most of your current heating needs</b> with a new, high-efficiency or renewable heating system.	Can cover whole home depending on number and location of indoor units, and house characteristics.	✓	✓	✓
You want to use your new system <b>for cooling</b> , in addition to heating.	✓	✓	✓	✗
You have a central heating system and your central heating system uses <b>radiators or radiant floors (hot water)</b> .	Can be used as supplemental heat to existing central system.	✗	✓ Best suited for radiant floors or low temperature radiators.	✓
You have a central heating system and your central heating system uses <b>ducts and registers (forced air)</b> .	Can be used as supplemental heat to existing central system.	✓	✓	Pellet furnace is an option.
You do not have a central heating system, <b>only space heaters</b> (e.g. through-the-wall furnace, wood, or pellet stoves).	✓	✗	✗	✗
You want your new system to <b>provide domestic hot water</b> in addition to space heat.	✗	✗	✓	✓
You are looking for a system with <b>lower capital costs</b> , to supplement your heating system (and/or provide cooling).	✓	✗	✗	✗

**The table presents the technology options suitable to connect to your existing heat distribution system, assuming that no changes will be made to the heat distribution system (e.g., radiators and ducts).**

Source: CESA

## Home Efficiency

The first step towards deciding whether—and which—CH&C system is right for you is to have a home energy audit or home performance test. An audit will help you understand the tradeoffs between the cost of making your home more energy efficient and the potential energy and cost savings with each energy efficiency upgrade.

An energy audit is the best way to evaluate your home’s potential for energy savings. No matter what fuel you use to heat your home and hot water, you’ll use more if your home is drafty or poorly insulated. If weatherization upgrades are recommended by the energy audit, they should always be made prior to installing a new system or adding a supplemental system—after all, a well-insulated home will be more comfortable and less expensive to heat and cool. Moreover, once you make efficiency upgrades, you may be able to install a smaller, less expensive CH&C system.



.....

Vermont's Energy Efficiency Utilities offer programs and incentives to increase residential energy efficiency.<sup>36</sup>

To learn more about energy audits and home efficiency improvement options, see Section 1: *Efficiency First*.

## **Reasons to Consider CH&C Systems for Your Home**

Homeowners who choose to install a CH&C system usually do so for one or more of the following reasons.

### **To replace an older boiler or furnace to meet whole-home heating needs**

One obvious reason for replacing a boiler or furnace is that it is no longer working and a new system is needed immediately. Retiring an older fossil fuel-fired heating system presents a natural opportunity to install a new renewable system. The old system can be removed and replaced with a renewable technology or a combination of technologies (e.g., a ductless cold climate air source heat pump plus a wood pellet boiler).

Another reason for considering replacing a boiler or furnace is that the heating system is not keeping occupants comfortable, and the building needs more heat. Before replacing the heating system, a building owner should first determine whether the problem is that the current boiler or furnace is underperforming or that the heat emitters (e.g., baseboards) are not large enough for the heating space. If the former, it may make sense to replace the inefficient furnace or boiler. If it is malfunctioning or poorly vented, it could be releasing dangerous pollutants, thereby reducing indoor air quality.

### **For additional space heat and increased home comfort**

Many homeowners don't need a whole-house solution, but simply want additional heat in a particular room. If you have built an addition on your home, have an unheated space, or just need more warmth, several CH&C technologies work well in space heating applications. A ductless air source heat pump (also known as a mini-split) is a good space heating option, especially in smaller rooms where there may not be enough room for a wood stove. A cold climate air source heat pump is also a good option for a well-insulated home where there may not be enough air circulation to sustain a wood or pellet-burning stove.<sup>37</sup>

### **For hot water**

If you are looking to reduce the amount of fossil-fuel energy used to meet your hot water needs, consider replacing your current system with a heat pump water heater or supplementing with a solar hot water system. Advanced wood heat boilers and ground source heat pumps can also provide domestic hot water.

<sup>36</sup> "Rebates and Financial Incentives," Vermont Department of Public Service, <https://energysaver.vermont.gov/programs-incentives/rebates-financial-incentives> (accessed October 12, 2020).

<sup>37</sup> Vermont energy code requires most new installations of this type of equipment (pellet stoves) to use outside air for combustion. See "Vermont Residential Building Standards, Energy Code Handbook," Vermont Department of Public Service, [https://publicservice.vermont.gov/sites/dps/files/documents/2020\\_VT\\_Energy\\_Code\\_Handbook\\_v6-DIGITAL\\_for\\_website.pdf](https://publicservice.vermont.gov/sites/dps/files/documents/2020_VT_Energy_Code_Handbook_v6-DIGITAL_for_website.pdf) (accessed October 12, 2020).

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### **When constructing a new home or a net-zero home**

A true net-zero home is able to produce enough renewable energy to meet its energy requirements. New homes can be constructed to require relatively little heat due to high levels of insulation, passive solar gain, and air exchange/ventilation systems. CH&C technologies can meet the low heat needs of both buildings. Air source heat pumps are especially well suited for meeting low heat demands.

***Older fuel-burning appliances release harmful toxic pollutants and particulate matter into the home and to the outdoors. Ground source heat pumps and cold climate air source heat pumps can improve your indoor air quality, since they do not combust fuel.***

### **To improve indoor and/or outdoor air quality**

Older fuel-burning appliances release harmful toxic pollutants and particulate matter into the home and to the outdoors. Ground source heat pumps and cold climate air source heat pumps can improve your indoor air quality, since they do not combust fuel.

### **To reduce fossil fuel consumption and carbon emissions**

Most Vermonters heat their homes with fossil fuels, primarily propane and home heating oil. Of all the fossil fuels used in Vermont, fuel oil emits the most greenhouse gases and natural

gas the least.<sup>38</sup> CH&C technologies release less greenhouse gas emissions than fossil fuels. These technologies are also more efficient at producing heat and consume less electricity or wood pellets to deliver the same level of heat.

### **To invest in renewable energy**

Solar hot water equipment and advanced wood heating units use renewable energy resources. Ground and air source heat pumps are considered energy efficient technologies, but since Vermont's state-wide average electricity supply is considered 63 percent renewable, according to the Vermont Public Service Department's 2019 *Annual Energy Report*, efficient cold climate air source heat pumps are 63 percent renewable as well.

### **To support the local economy**

The 2016 Vermont Comprehensive Energy Plan estimates that if 25 percent of residential heating can be accomplished with Vermont wood products, it will increase the industry's employment and profits.<sup>39</sup> Most of the fossil fuel heating dollars leave Vermont's economy, but heating with wood not only creates local jobs, it also supports sustainable harvesting.<sup>40</sup>

38 "2019 Greenhouse Gas Taskforce," Efficiency Vermont, [https://www.efficiencyvermont.com/Media/Default/docs/white-papers/2019\\_RD\\_GHG\\_taskforce.pdf](https://www.efficiencyvermont.com/Media/Default/docs/white-papers/2019_RD_GHG_taskforce.pdf) (accessed October 12, 2020).

39 "Vermont Comprehensive Energy Plan 2016," Vermont.gov, [https://outside.vermont.gov/sov/WebServices/Shared%20Documents/2016CEP\\_Final.pdf#search=Vermont%20Comprehensive%20Energy%20Plan%202016](https://outside.vermont.gov/sov/WebServices/Shared%20Documents/2016CEP_Final.pdf#search=Vermont%20Comprehensive%20Energy%20Plan%202016) (accessed December 8, 2020).

40 WoodEnergy," Vermont.gov, <https://pr.vermont.gov/forest/wood-energy> (accessed December 8, 2020).

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## The Differences Between Space Heating and Whole-Home Heating

Whole-home heating refers to heating the entire home with a central heating system through a central heat distribution system. Central heating systems such as boilers or furnaces distribute heat through hot air ducts or hot water heating systems. In contrast, space heating refers to heating equipment that heats only one room or space. Space heating systems directly warm the air and do not use heat distribution systems. (In some Vermont homes, woodstoves provide whole home heat; these homes do not have central heat distribution systems.)

As you begin to assess which CH&C technology is compatible with your home, consider whether you are looking for a whole-home heating system replacement or for supplemental room/space heat. If your current central heating system is nearing the end of its life, now may be the time to consider a whole-home replacement. If you are building a new home, this is the perfect opportunity to install a whole-home clean heating and cooling system.

If your current whole-home heating system is in good working condition, but you feel like you need more heat in certain areas of the home, then space heating CH&C technologies might be the best options to explore. Work with an installer to explore which options are most suitable.



## Assessing Your Home's Current Distribution System for Heating

It is important to know whether your home distributes heat through ducts or through a hot water system because some CH&C technologies distribute heat through ducts, whereas others distribute heat through hot water systems. See the Decision Tree Matrix (Table 1 on p. 33) to learn more.

In general, a home uses one of three methods to distribute heat (or a combination thereof):

- Ducted forced hot air system
- Hydronic (water-based) system
- Space heating units



**Contented cat with a modern, low temperature radiator.**

If your home's current heating distribution system is in good shape and can accommodate a clean heating technology, it makes financial sense to choose a CH&C technology that will work with your home's existing distribution system. You can, however, install a new distribution system to accompany a CH&C technology (see Figure 10).

If your home delivers hot and/or cool air through ducts, it can be used by wood pellet furnaces, ground source heat pumps (GSHPs), and centrally-




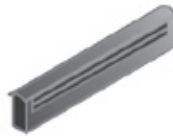

ducted cold climate air source heat pumps (CCHPs). However, it is important to note that not all ductwork is appropriately sized for CCHPs. In new home construction, ductwork can be tailored specifically to integrate with whole-home CCHPs.

If your home distributes heat and hot water via a hydronic distribution system, then GSHPs and wood pellet boilers are good options that will work with the existing distribution system. It is important to note, however, that GSHPs are not compatible with high-temperature radiators and baseboards. GSHP systems require low temperature heat emitters to deliver heat efficiently. And don't forget that GSHPs provide not only heat, but also cooling and potentially, hot water.

If your home does not have a heating distribution system, you can still benefit from CH&C space heating systems such as ductless CCHPs (both single- and multi-head systems), wood pellet

stoves, and cordwood stoves. In a ductless system, internal ducts are unnecessary; instead, refrigerant is circulated from the outdoor unit coils to the indoor units through small flexible pipes. Ductless units are commonly referred to as “split” or “mini-split” systems, with one or more indoor units used with a single outdoor condensing unit. Multiple indoor units allow for the heating and cooling of several zones. Ductless CCHP systems use wall-mounted, ceiling-mounted, or floor-mounted units to deliver this hot or cold air.

**FIGURE 10** *Types of Distribution Systems for Heating Systems*

				
<b>FORCED AIR SYSTEM</b>	<b>STEAM RADIANT</b>	<b>RADIANT HEATING</b>	<b>HOT WATER BASEBOARDS</b>	<b>ELECTRIC BASEBOARDS</b>
The most common type of home heating system, a forced air system distributes heat from a furnace throughout the home using air ducts and vents.	One of the oldest types of heating systems, steam radiant heating uses radiators to distribute heat.	Radiant heating—which can be installed as floor, ceiling or wall panels—transfers heat directly from a hot surface to people and objects in the room.	Similar to radiant heating, hot water baseboards (also called hydronic heat) use hot water to heat a space via wall mounted baseboard units.	A type of zone heater, electric baseboards release heated air out of the top while pulling cooler air to the bottom of the unit.
<b>PRO</b> Can be used for cooling	<b>PRO</b> Relatively trouble free	<b>PRO</b> Doesn't distribute allergens	<b>PRO</b> Provide close temperature control	<b>PRO</b> Quiet operation and low maintenance
<b>CON</b> Distributes allergens throughout the house	<b>CON</b> Requires separate distribution system for cooling systems	<b>CON</b> Can be expensive to install and repair if problems arise	<b>CON</b> Limits furniture placement and slow to increase temperature	<b>CON</b> Limits furniture placement
<b>ENERGY SAVING TIP</b> Clean your air filters monthly and replace them regularly.	<b>ENERGY SAVING TIP</b> Bleed trapped air from hot water radiators, which can impede flow of hot water throughout the system.	<b>ENERGY SAVING TIP</b> When installing in a wood-framed floor, consider converting it with ceramic tiles, which add thermal mass.	<b>ENERGY SAVING TIP</b> Install a programmable thermostat to take advantage of zone heating.	<b>ENERGY SAVING TIP</b> Clean the heating coils regularly to prolong the heater's life and maintain its efficiency.
<b>COMPATIBLE HEAT SOURCE SYSTEMS</b> Furnace, heat pump, active solar heating	<b>COMPATIBLE HEAT SOURCE SYSTEMS</b> No compatible CH&C technologies. Consider a ductless heat pump for supplemental heat	<b>COMPATIBLE HEAT SOURCE SYSTEMS</b> Boiler, heat pump, active solar heat, electric heating	<b>COMPATIBLE HEAT SOURCE SYSTEMS</b> Boiler, active solar heating air to water heat pumps	<b>COMPATIBLE HEAT SOURCE SYSTEMS</b> Electric heating

Source: EnergyGov

This table describes how heat moves through your home via a distribution system.



## Assessing Your Home's Current Home Heating and Hot Water Systems

In Section 4, we introduced you to technologies that can provide renewable and clean heating and cooling for your home. In Section 5, we explained how this heat gets through your house. In this section, we discuss the CH&C technologies that can supply hot water in addition to space heating and cooling and the CH&C technologies that provide hot water only. (See Table 2.)

Your current home heating system may be supplying both heat and hot water to your home (e.g., a fossil-fuel-based boiler). In the subsections below, we differentiate between the CH&C technologies that provide both heat and hot water (for instance, pellet boilers), those that provide only heat (e.g., pellet stove), and those that supply only hot water (e.g., solar hot water).

**TABLE 2** *Decision Tree Matrix for CH&C—Comparing Heat Pump Water Heater and Solar Hot Water Systems*

Heat Pump Water Heater	Solar Hot Water
Similar in size to a conventional tank water heater, but taller; provides all your hot water, with built-in backup.	Requires a conventional water heater for backup during long sunless periods. This backup could be a simple electric tank water heater.
Requires an open space around the heater, at least 1,000 cubic feet (approximately a 12 foot by 12 foot room); does not work well installed in an enclosed closet.	Requires a sunny place on your roof or on the ground to locate 2 to 3 collectors; a south facing, pitched roof is ideal.
Provides some dehumidification to the space around it, and also cools that space, as it uses the energy in the surrounding air to heat the water.	Does not affect the space surrounding the water tank.
Makes noise that might be bothersome if it is installed within the living space.	Quiet operation.
Requires electricity from the electric grid; the degree to which the system is renewable depends on the mix of renewable electricity powering the system.	Directly uses renewable energy and can be designed to work during a power outage.

Source: CESA

### Hot Water for Your Home

Some CH&C technologies can provide your home with heat and hot water. Ground source heat pumps and advanced wood pellet boilers are whole-home heating solutions that provide not only heat, but also hot water. Both can meet a home's entire hot water needs. Air-to-water heat pumps also can provide both heat and hot water.

Other CH&C technologies only provide hot water, not heat. Heat pump water heaters and solar water heaters fall into this category. Heat pump water heaters can provide whole-home hot water, whereas solar hot water heaters should always be installed alongside another source of hot water heating. Solar hot water heaters are best for providing supplemental hot water. They can help lower hot water heating costs and reduce fossil fuel use.

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The amount of a household's hot water use generally depends on the number of household occupants, but the average Vermont family of four spends more than \$600 annually powering an electric hot water heater.<sup>41</sup> If you are looking for a clean heating system that provides both space heating and hot water, advanced wood pellet boilers and ground source heat pumps are good solutions.<sup>42</sup> But if you are simply looking for a renewable or highly efficient hot water heater, solar hot water heaters and heat pump water heaters are two options to consider.

Table 2 on p. 39 provides a brief overview of the differences between the two clean heat technologies that provide hot water only.

### Solar Hot Water Systems

In Vermont and other cold climates, solar hot water systems can provide supplemental hot water heating. Solar hot water systems use the energy of the sun to warm fluid in “collectors” and pumps circulate this warmed fluid to heat water in the tank. On cloudy or snowy winter days, solar hot water systems generally cannot provide sufficiently hot water for a home, and a backup system is needed. You can learn more about solar hot water in Section 6. As with other clean heating and cooling system, make sure you look at the Solar Energy Factor (SEF) rating on the ENERGY STAR® label. For electric backup solar water heaters, the SEF must be equal to or greater than 1.8 to be ENERGY STAR®-rated. For gas backup systems, the SEF must be equal to or greater than 1.2.

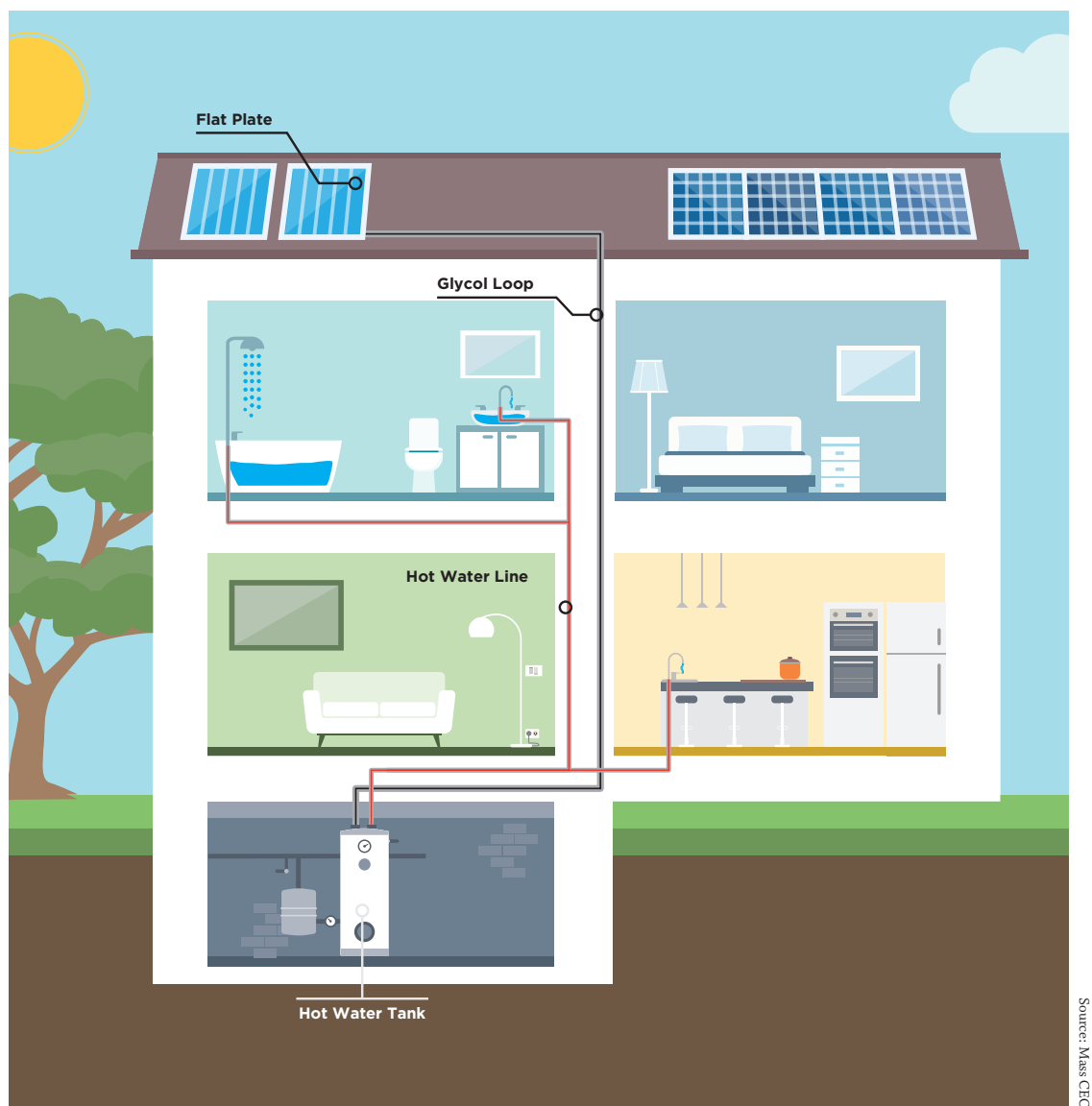


Source: Mass CEC

41 “Clean Heat: Comfortable Homes, Affordable Future,” VPIRG, <https://www.vpirg.org/wp-content/uploads/2017/03/VPIRG-Clean-Heat-FINAL.pdf> (accessed December 8, 2020).

42 Some types of air source heat pumps can also provide hot water, but these are niche technologies and are not widely available in the U.S.

FIGURE 11 *Solar Hot Water System*



Rooftop solar flat-plate collectors delivering heated glycol to a hot water tank.



### Heat pump water heaters (HPWH)

Heat pump water heaters are highly efficient systems that use electricity to move heat from the air through a heat exchanger, which is then transferred into a water storage tank. These should be installed in a room with at least 750 cubic feet of clearance with an ambient year round temperature above 50 degrees. An unconditioned room with residual heat from a furnace, boiler,

***Heat pump water heaters are highly efficient systems that use electricity to move heat from the air through a heat exchanger, which is then transferred into a water storage tank.***

or washer/dryer is ideal. The room must have either a drain (floor drain, sink, washing machine drain, etc.) or the condensate must be pumped outdoors.<sup>43</sup> HPWH are often configured as hybrid models—this means that the HPWH is equipped with electric resistance back-up water heating. The back-up mode is rarely used if the unit is installed properly.

HPWHs are available as ENERGY STAR®-rated systems. Look for the energy factor on the ENERGY STAR® label; this number indicates the appliance's efficiency and the higher the number, the more efficient the water heater. An ENERGY STAR® HPWH

that can heat 55 or fewer gallons has an EF greater than or equal to 2, while a larger HPWH needs to have an EF greater than or equal to 2.2.<sup>44</sup> High efficiency HPWHs can save a Vermont household an average of \$258 annually; as fossil fuel prices rise, the savings will also increase. These units are the most cost effective solutions for heating water, using up to 63 percent less energy than a traditional water heater.<sup>45</sup>

As with space heating technologies, energy-efficiency measures should be considered prior to installing a new high-efficiency hot water system. The home energy audit can help you identify measures to reduce hot water use and optimize hot water distribution systems. These measures may include fixing leaks, insulating water pipes, and installing low-flow faucet fixtures. It's best to consult with a qualified contractor for the installation of a HPWH.

HPWH have higher up-front and installation costs than electric water heaters (average equipment cost of \$1,100 for a 50-gallon HPWH versus \$300 for an electric water heater), but due to their high efficiency, they can pay for themselves in a few years. Rebates are available through Efficiency Vermont to help mitigate the upfront costs; some utilities also offer rebates. See Section 10 for details on available incentives. In addition, federal and state tax credits are available, and manufacturers may offer additional rebates.

43 Some types of air source heat pumps can also provide hot water, but these are niche technologies and are not widely available in the U.S.

44 "Heat Pump Water Heaters," Efficiency Vermont, <https://www.efficiencyvermont.com/rebates/list/heat-pump-water-heaters> (accessed October 12, 2020).

45 "Water Heater Key Product Criteria," Energy Star, [https://www.energystar.gov/products/water\\_heaters/residential\\_water\\_heaters\\_key\\_product\\_criteria](https://www.energystar.gov/products/water_heaters/residential_water_heaters_key_product_criteria) (accessed October 12, 2020).

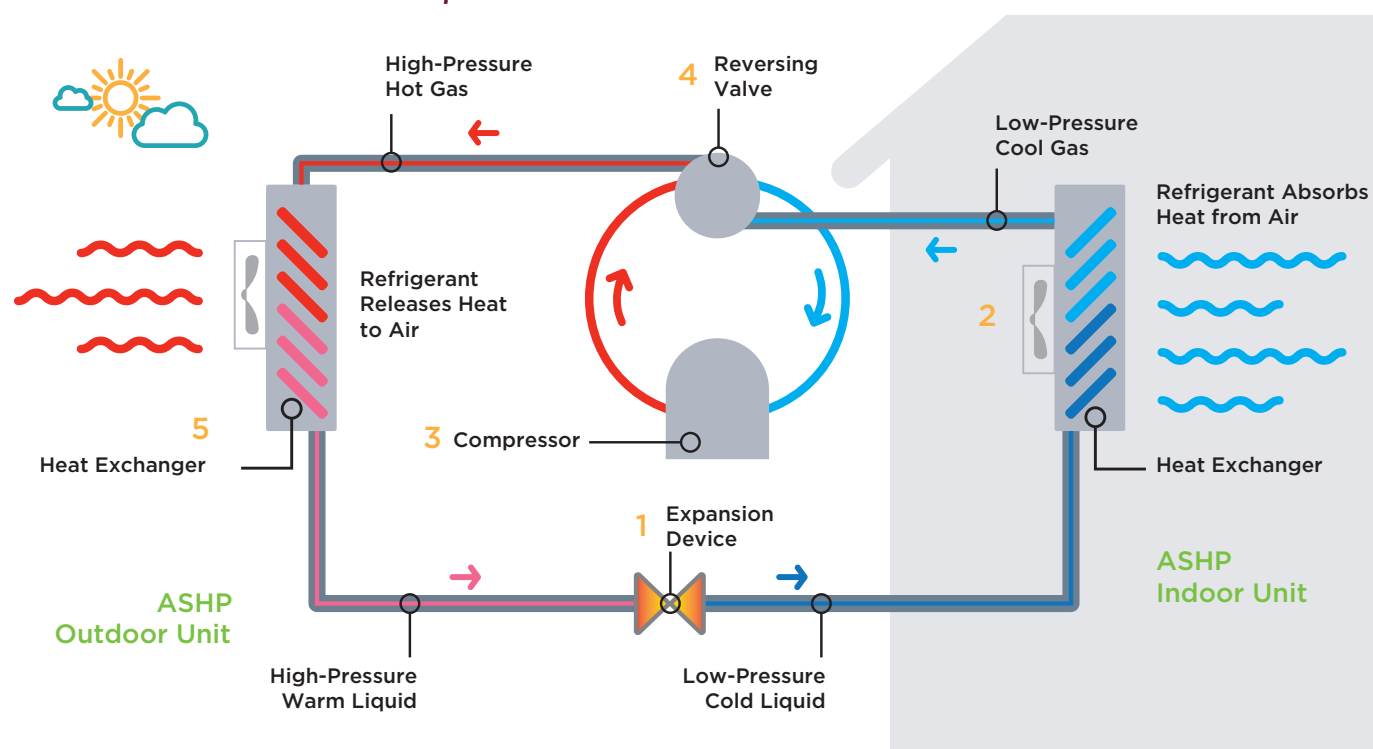
## Cooling Your Home

Clean heating and cooling technologies present an opportunity to reduce your home heating fossil fuel use, reduce your carbon footprint, and support the local clean energy economy. CH&C technologies are commercially available, efficient, and safe, and there are many equipment manufacturers from which to choose. Homeowners are strongly encouraged to perform efficiency upgrades and undertake weatherization measures prior to installing any new heating system. These measures can reduce the amount of energy needed to heat a home and, as a result, smaller, less expensive heating equipment could be installed to meet the reduced heating/cooling loads.

Choosing among the different CH&C technologies can be complicated. Each home, each heating system, and each heating distribution system is different, and there are many variables that play into the decision-making process: Which alternative is most cost-effective? Which is best for the environment? Which fits best in my home?

We have developed a decision tree matrix to help you determine which CH&C options can easily integrate with your home. (See Table 1, p. 33.)

**FIGURE 12** *Air Source Heat Pump, Summer Mode*



Source: MassCEC

CCHPs provide cooling too! To do so, they operate in reverse of heating mode. 1) First, the refrigerant passes through an expansion device and cools. 2) The cooled refrigerant absorbs heat from the indoor air in the heat exchanger in the indoor unit. This cools the home's interior. The warmed refrigerant heads outdoors, 3) passes through the compressor and heats up further. 4) A reversing valve pushes the hot refrigerant to the outdoor unit 5), where its heat is transferred to the air.





Did you know that an added benefit of some CH&C technologies is that they can provide air conditioning? If you install a ground source or air source heat pump, you can do away with your heavy window units and enjoy the cool comfort of your home with a simple click of a remote or turn of a thermostat dial.

As temperatures increase across the Northeast due to climate change, Vermont will experience warmer summers and increased demand for cooling. An increasing number of Vermonters are installing air conditioning units. As more Vermonters install cooling technologies, the amount of energy used in Vermont homes will rise. However, efficient cooling technologies (and appropriate home weatherization and landscape design) can reduce cooling costs.

***If you install a ground source or air source heat pump, you can do away with your heavy window units and enjoy the cool comfort of your home with a simple click of a remote or turn of a thermostat dial.***

If you have an existing cooling system in need of replacement or are considering adding a cooling system, consider a clean cooling option. Homeowners looking to install a clean cooling system have two options: air source and ground source heat pumps. Like whole-home heating and space heating systems, these cooling systems can distribute cool air to your whole house or to specific areas in the home.

Ground source heat pumps provide whole-home cooling via the home's central heat distribution system, whereas air source heat pumps can provide whole-home, multi-room, or single-room cooling based on whether the

system is ducted, ductless, or a ductless multi-head (see Figure 12, p. 43). Please see Section 3 for more information on these technologies.

Both air source and ground source heat pumps use less electricity for space cooling than typical window air conditioners, according to Efficiency Vermont. In addition, they both provide better humidity control than standard air conditioners, which improves indoor comfort and can reduce humidity issues like mold. Homeowners replacing window AC units with heat pumps will realize energy savings and cost.<sup>46</sup>

If home cooling is your main motive for installing an air source heat pump, be sure to look at the heat pump's seasonal energy efficiency ratio (SEER). The SEER rating can be found on the heat pump's ENERGY STAR® label. ENERGY STAR® ductless ASHPs must have a SEER of 15 or greater.

<sup>46</sup> John Walczyk, "Evaluation of Cold Climate Heat Pumps in Vermont," Cadmus, 2017, <https://publicservice.vermont.gov/content/2017-evaluation-cold-climate-heat-pumps-vermont> (assessed October 20, 2020).

## Integrated Smart Thermostats and Controls

There are some relatively new gadgets that you can install to remotely control the heating equipment in your home. Some of the more sophisticated technologies even communicate between different heating systems, optimizing the temperature setting of each system to maximize efficiency. You do not have to install these with your CH&C technology, but there are rebates available through utility programs and Efficiency Vermont if you choose to do so.

Popular smart thermostats allow homeowners to remotely control their homes' heating and cooling through a smartphone or computer.<sup>47</sup> Remote control and programmable thermostats help a homeowner not only stay comfortable, but also save money. Homeowners can purchase ENERGY STAR®-certified smart programmable thermostats that feature remote control, automatic adjustments, and temperature preference learning.

Remote control operation enables homeowners to adjust their home heating and cooling system to save energy while away from home and then to adjust the temperature prior to returning home. With a programmable smart thermostat, homeowners can easily set the temperature to maximize savings while they are away or at night. Certain smart thermostats can detect when a homeowner has left for the day and can adjust the temperature to save money. Similarly, the thermostat can automatically adjust the temperature prior to a homeowner's arrival.

When shopping for a smart thermostat, look for the ENERGY STAR® label and make sure it is Wi-Fi compatible. Research if your heating and cooling equipment company makes a smart



**Smart thermostats allow homeowners to remotely control their homes' heating and cooling through a smartphone or computer.**

Oasisimage/Bigstock.com

<sup>47</sup> For example, Nest, Ecobee, and Honeywell make smart thermostats.



thermostat; if it does not, make sure the smart thermostat will be compatible with your heating and cooling system. Zone controllers, which control the temperature in individual rooms or zones, can save more energy compared to whole-house controls.

Thermostats and smart thermostats should be located away from direct sunlight, windows, or drafts for best performance and efficiency. Make sure there is plenty of natural airflow around the thermostat.

***Thermostats and smart thermostats should be located away from direct sunlight, windows, or drafts for best performance and efficiency. Make sure there is plenty of natural airflow around the thermostat.***

Another feature of the smart thermostat is its ability to learn a homeowner's temperature preferences over the course of a day and to automatically adjust to these energy-saving temperatures to fit your schedule. Often, these smart thermostats come with software that enables the homeowner to track and manage temperature data.

Integrated smart controls are also valuable as system integration tools; these controls recognize the interaction among different heating systems within the house and control the temperature settings of each system to maximize efficiency. For example, the Burlington Electric Department (BED) offers the "Packetized Energy Program" through which BED controls a customer's electric water heater use. BED places a small smart control device on the

electric water heater and optimizes when the heater draws electricity from the grid to heat water. This program and other similar utility-controlled device programs help utilities balance supply and demand on the grid, which in turn, helps reduce carbon emissions and keeps system and electric costs low.

## Selecting a Contractor/Installer and System Maintenance

Understanding your home's heating needs, its current distribution system, its insulation and R-values—R-values measure the insulation performance of a building's insulation, the higher the number, the greater the insulation performance—and compatible CH&C technologies is complicated. For this reason, it is imperative that you consider working with qualified contractors and installers who can guide you through the process of choosing and installing a CH&C system for your home. Luckily, Efficiency Vermont maintains a contractor network of qualified installers, making energy saving and CH&C installation an easier process.

### Selecting a Contractor or Installer

Efficiency Vermont has a program that qualifies and identifies electrical installers and contractors for heating, ventilation, and air conditioning (HVAC), new construction, commercial refrigeration, insulation and air sealing who have met Efficiency Vermont's training criteria and who are qualified to guide homeowners on energy usage, weatherization and efficiency upgrades, energy saving opportunities, and on financing and incentives. This contractor network is known as the Efficiency Excellence Network (EEN). EEN contractors are experts in their field and are certified to perform home energy audits, weatherization measures, and equipment installations. All projects completed by an EEN contractor are eligible for exclusive incentives, from Efficiency Vermont as well as low-or no-interest financing through the Home Energy Loan Program, administered by Efficiency Vermont with Vermont State Employees Credit Union and NeighborWorks of Western Vermont overseeing the loans.



Romaviv/Bigstock.com

Participating HVAC EEN contractors have experience installing CH&C systems, participate in manufacturer trainings, provide incentive program-eligible equipment, train homeowners in system operation, provide system warranties, and are familiar with incentive and financing application processes.

All CH&C equipment installers will first conduct a site visit to assess the building's heating (space or water) needs and design a system to meet those needs. If the CH&C system is designed to cover 100 percent of the building's heat load, the installer is required to conduct a heat load calculation. The installer's proposal should include the system design, a description of work, a project schedule, liability insurance, equipment and workmanship warranties, and project costs.

Seeking multiple bids from several contractors will help ensure that the estimate you are receiving is cost competitive. Try to compare the proposals and estimates of at least three installers. In addition to reviewing the bids and the installers' qualifications, be sure to review the equipment warranties and workmanship warranties.

## **Maintaining CH&C Equipment**

Below are some general tips for maintaining a variety of CH&C equipment. Most technologies require very little maintenance—even advanced wood boilers require minimal maintenance. Annual (or biannual) maintenance will keep your system operating at its maximum efficiency.

### **Heat Pumps**

- Have your CH&C equipment inspected by a qualified technician at least annually. This should entail an annual cleaning. (GSHP should be inspected biannually in the spring and fall.)
- Check heat pump outdoor units for signs of excessive dust, pollen, ice, or snow. Remove debris carefully and as instructed by homeowner's manual.
- Prune and trim back any shrubs, bushes, or tall plants that may be obstructing the heat pump outdoor unit.
- Check heat pump air filters monthly and clean or replace as needed.

### **Advanced Wood Heating**

- Empty advanced wood pellet boiler's external ash box two to four times a year.
- Have the AWH equipment serviced annually.

### **Hot Water**

- Check your solar hot water collectors annually to ensure they remain in full sun. Trim back any vegetation as needed. Clean off any dust, pollen, or dirt to maximize the collector's efficiency.
- Hot water tanks should be flushed annually to remove any sediment build-up or mineral deposits. Mineral deposits can accumulate in tankless heaters as well, and these units should likewise be flushed out regularly. Many hot water heaters come with instructions for flushing the unit, but you can call a qualified technician to perform this service as part of the system's annual maintenance.



# Incentives and Financing

Purchasing a heating and cooling system of any kind can be expensive. But switching to a CH&C system can be a cost-effective solution in the right situation. The various rebates, loans, and incentives available for CH&C technologies help customers reduce the upfront costs of installing a CH&C system. The Vermont's Clean Energy Development Fund (CEDF), Efficiency Vermont, the federal government, and utilities provide a variety of incentives to encourage the installation of CH&C technologies. There are also different low-interest public and private financing options available to homeowners.

## VERMONT INCENTIVES

Discounts and rebates are two types of direct support provided by CEDF, Efficiency Vermont, the federal government, and local electric utilities. Discounts lower the price of a product to make it more affordable. Rebates are refunds paid directly to the buyer.

Incentives are available until funding runs out, so it is best to check program websites for up-to-date information.

Below are a few examples and links to incentives by technology as of July 2020; each program has its unique set of eligibility criteria, including eligible equipment lists, specific warranty terms, and participating installer/contractors.

## Advanced Wood Heating

### Pellet-Only Furnaces and Boilers

CEDF provides a \$3,000 discount for advanced wood heating systems that are installed by contractor from the Efficiency Vermont's Efficiency Excellence Network (EEN). Efficiency Vermont offers an additional \$3,000 rebate, for a total of \$6,000. See [www.efficiencyvermont.com/rebates/list/central-wood-pellet-furnaces-boilers-business](http://www.efficiencyvermont.com/rebates/list/central-wood-pellet-furnaces-boilers-business).

### Pellet Stoves

Efficiency Vermont offers up to a \$750 rebate on EPA-certified pellet stoves that meet a greater than 2.0 GPH<sup>48</sup> emissions rating and that are more than 70 percent efficient as measured by the Higher Heating Value.<sup>49</sup> Consumers are also eligible for a \$100 adder for turning in the old stove. To qualify for the instant discounts, the stove should be installed by a National Fireplace Institute Pellet Specialist.<sup>50</sup>

<sup>48</sup> Grams per hour.

<sup>49</sup> For current rebates and incentives, check these two resources: "Current Wood Heat Incentives and Rebates," Vermont Agency of Natural Resources, <https://fpr.vermont.gov/woodenergy/rebates> and <https://www.efficiencyvermont.com/rebates/list/wood-stoves> and "Wood and Pellet Stoves," Efficiency Vermont, <https://www.efficiencyvermont.com/rebates/list/wood-stoves> (accessed October 12, 2020).

<sup>50</sup> "Wood and Pellet Stoves," Efficiency Vermont, <https://www.efficiencyvermont.com/rebates/list/wood-stoves> (accessed October 12, 2020).

## Pellet Storage

CEDF offers a voucher up to \$3,000 to purchase a bulk pellet storage bin from a participating vendor. This allows homeowners and businesses to receive deliveries of bulk pellets to use in their stoves instead of having to use 40-pound bags of pellets. Rebates are also available from some Vermont utilities and the Windham & Windsor Housing Trust.

**TABLE 3** *Advanced Wood Heating Rebates*

Entity	Amount	Website
Efficiency Vermont/ Vermont Clean Energy Development Fund	\$6,000 for wood pellet boilers or furnaces (\$3,000 purchase rebate and \$3,000 installer incentive).	<a href="https://www.efficiencyvermont.com/rebates/list/central-wood-pellet-furnaces-boilers-business">https://www.efficiencyvermont.com/ rebates/list/central-wood-pellet-furnaces- boilers-business</a> <a href="http://www.rerc-vt.org/advanced-wood-heating-systems">http://www.rerc-vt.org/advanced-wood- heating-systems</a>
Efficiency Vermont	Up to \$500 rebate on pellet or cord wood stove; plus \$100 for proper disposal of old stove.	<a href="https://www.efficiencyvermont.com/rebates/list/wood-stoves">https://www.efficiencyvermont.com/ rebates/list/wood-stoves</a>
Vermont Electric Co-Op	\$150 bill credit for purchased pellet stoves.	<a href="https://vermontelectric.coop/energy-transformation-programs">https://vermontelectric.coop/energy- transformation-programs</a>
Washington Electric Co-Op	\$250 for pellet stove; \$500 for pellet furnace; \$1000 for pellet boiler.	<a href="https://35coti2fdydv27b6wjrhdxq9-wpengine.netdna-ssl.com/wp-content/uploads/2020/02/1-2020-WEC-Button-Up-sheet.pdf">https://35coti2fdydv27b6wjrhdxq9- wpengine.netdna-ssl.com/wp-content/ uploads/2020/02/1-2020-WEC-Button- Up-sheet.pdf</a>
Stowe Electric Co-Op	\$150 rebate for purchased pellet stove.	<a href="https://www.stoweelectric.com/programs/rebate-programs">https://www.stoweelectric.com/ programs/rebate-programs</a>
Vermont Clean Energy Development Fund	Up to \$3,000 voucher to purchase a pellet storage bin from a participating vendor.	<a href="http://www.rerc-vt.org/pellet-storage">http://www.rerc-vt.org/pellet-storage</a>
Clean Energy Development Fund	Coal Change-out adder. Up to \$7,000 additional for a pellet heat- ing system, if replacing a coal heating system or stove. Business- es can get up to an additional \$27,000 incentive.	<a href="http://www.rerc-vt.org/coal-change-out">http://www.rerc-vt.org/coal-change-out</a>

In addition, NeighborWorks of Western Vermont has incentives for low- and moderate-income Vermonters in select counties.

## Heating with Electricity

### Heat Pump Systems

#### *Centrally Ducted (whole-home) Air Source Heat Pumps*

Efficiency Vermont offers rebates up to \$4,900 for whole-home ducted CCHPs. Income-eligible households can take advantage of an additional \$500 moderate-income bonus.

See <https://www.efficiencyvermont.com/rebates/list/centrally-ducted-heat-pumps>.

### ***Cold Climate Ductless Air Source Heat Pumps***

Efficiency Vermont offers rebates up to \$650, plus a \$200 moderate-income bonus to income-eligible households. See <https://www.efficiencyvermont.com/rebates/list/heat-pump-heating-cooling-system>.

**TABLE 4** *Heat Pump System Rebates*

Entity	Amount	Website
Efficiency Vermont	Applies to whole-home ducted CCHPs. Rebates up to \$4,900, with an additional \$500 moderate-income bonus.	<a href="https://www.efficiencyvermont.com/rebates/list/centrally-ducted-heat-pumps">https://www.efficiencyvermont.com/rebates/list/centrally-ducted-heat-pumps</a>
Efficiency Vermont	Air-to-Water System: Up to \$6,500 rebate  Centrally-Ducted System: Up to \$4,900 rebate  Ductless Heating & Cooling System: Up to \$450 discount at participating distributors  Smart thermostats: up to \$100 rebate for select ENERGY STAR models.	<a href="https://www.efficiencyvermont.com/rebates/list/air-to-water-heat-pumps">https://www.efficiencyvermont.com/rebates/list/air-to-water-heat-pumps</a> <a href="https://www.efficiencyvermont.com/rebates/list/centrally-ducted-heat-pumps">https://www.efficiencyvermont.com/rebates/list/centrally-ducted-heat-pumps</a> <a href="https://www.efficiencyvermont.com/rebates/list/heat-pump-heating-cooling-system">https://www.efficiencyvermont.com/rebates/list/heat-pump-heating-cooling-system</a> <a href="https://www.efficiencyvermont.com/rebates/list/smart-thermostats">https://www.efficiencyvermont.com/rebates/list/smart-thermostats</a>
Vermont Public Power Supply Authority	All VPPSA member customers are eligible for rebates of \$200 on a cold climate heat pump.	<a href="https://vppsa.com/2021-cold-climate-heat-pump-instant-discount">https://vppsa.com/2021-cold-climate-heat-pump-instant-discount</a>
Green Mountain Power	Applies to ductless, cold climate heat pumps. \$400 rebate.	<a href="https://greenmountainpower.com/heat-pump-rebate">https://greenmountainpower.com/heat-pump-rebate</a>
Burlington Electric Department	Receive up to \$3,500 toward the purchase of ductless mini-split, centrally-ducted, and air-to-water heat pumps.	<a href="https://burlingtonelectric.com/cchp">https://burlingtonelectric.com/cchp</a>
Stowe Electric Department	\$675 rebate toward the cost of a cold climate heat pump.	<a href="https://www.stoweelectric.com/programs/rebate-programs">https://www.stoweelectric.com/programs/rebate-programs</a>
Vermont Electric Co-Op	\$600 bill credit	<a href="https://vermontelectric.coop/energy-transformation-programs">https://vermontelectric.coop/energy-transformation-programs</a>



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## Water Heating

### Heat Pump Water Heaters

Efficiency Vermont offers rebates up to \$800, plus a \$200 moderate-income bonus to income-eligible households. See <https://www.efficiencyvermont.com/rebates/list/heat-pump-water-heaters>. Table 5 provides a list of rebates that are available from different organizations.

**TABLE 5** *Heat Pump Water Heater Rebates*

Entity	Amount	Website
Efficiency Vermont	Up to \$800 cash back on qualifying models which replace a fossil-fired fueled water heater.	<a href="https://www.efficiencyvermont.com/rebates/list/heat-pump-water-heaters">https://www.efficiencyvermont.com/rebates/list/heat-pump-water-heaters</a>
Burlington Electric	Up to \$600 toward the purchase of a new heat pump water heater and an additional \$200 for moderate income customers. Applies to customers who are replacing a natural gas water heater.	<a href="https://burlingtonelectric.com/waterheaters">https://burlingtonelectric.com/waterheaters</a>
Burlington Electric	Customers replacing an electric, oil, or propane hot water tanks with a heat pump water heater can receive up to \$600 toward the purchase of a new heat pump water heater and an additional \$400 for moderate income customers.	<a href="https://burlingtonelectric.com/waterheaters">https://burlingtonelectric.com/waterheaters</a>
Vermont Electric Co-Op	\$250 bill credit.	<a href="https://vermontelectric.coop/energy-transformation-programs">https://vermontelectric.coop/energy-transformation-programs</a>

## Financing

### Home Energy Loans

Financing with loans can reduce the high upfront costs of CH&C technologies. There are many loan products available, including home equity loans, special energy loans from banks and credit unions, and loans by system installers. Loans vary greatly in the length of the loan, interest rate, requirements, and security necessary. For example, Efficiency Vermont's Home Energy Loan interest rates vary between 0 percent and 6.99 percent based on the loan term and the household income of the applicant.

Efficiency Vermont offers a low-interest Home Energy Loan for a variety of eligible CH&C projects including central wood pellet boilers and furnaces, cord wood and pellet stoves, heat pump water heaters, and cold-climate ductless and whole-home air source heat pumps, and weatherization improvements. Systems must be installed by an Efficiency Vermont EEN contractor. Projects up to \$40,000 can be financed in full with loan terms up to 15 years.

### Tax and Federal Incentives

#### VT Sales and Use Tax Exemption

Advanced wood heat boilers qualify for a Vermont sales and use tax exemption. They must be installed as the primary central heating system, rated as high efficiency, contain at least one week of fuel storage with automated startup, shutdown, and fuel feed, and they must meet other efficiency and air emissions standards established by the Vermont Department of Environmental Conservation. The tax exemption applies to the values added to your property by the CH&C system. This sales and use tax exemption expires in June 2023. See <https://fpr.vermont.gov/woodenergy/rebates>.

#### Federal Tax Credits

The Federal Residential Renewable Energy Tax Credit allows a customer to claim a 22 to 30 percent tax credit for residential ground source heat pump installations. The credit may be used for on-site preparation, installation, and piping and wiring. If the federal tax credit exceeds the homeowner's tax liability, the excess credit may be carried forward to the succeeding taxable year. This credit expires at the end of 2021. Systems must have been placed in service on or before December 31, 2021. See <https://programs.dsireusa.org/system/program/detail/1235>.

Woodstoves are eligible for a federal tax credit of \$300 until December 31, 2020. The tax credit applies only to wood or pellet stoves with at least a 75 percent energy efficiency rating. The stove must have been purchased between 2018 and the end of 2020. See <http://www.forgreenheat.org/incentives/federal.html>.



# Clean Heating and Cooling Consumer Checklist

This checklist can help you achieve a successful installation of a residential clean heating and cooling project.

## Preliminary Steps

- ☐ Analyze the amount of energy you use to heat your water and home and its associated costs.
- ☐ Conduct a home energy audit.
- ☐ Consider weatherization and/or other energy efficiency improvements.
- ☐ Choose a system and contractor
  - ☐ Ask potential contractors for references, including how many similar systems they have installed, so that you can choose a well-qualified installer with good experience. The Efficiency Excellence Network is a great resource for Vermonters seeking qualified contractors.
  - ☐ Evaluate all of the clean heating and cooling technologies with your contractor to determine which is most appropriate for your budget and energy saving expectations.
- ☐ Calculate (or ask your contractor to calculate and review with you) net savings, return on investment, or payback period to see if your system will be a sound financial investment.
- ☐ Solicit bids from at least three contractors with estimates on the price for the entire installed system.
- ☐ Check the contractor's liability insurance.

## Purchasing and Contracting

- ☐ Talk to your insurance company to inform them about your plans to install an advanced wood heating system to see if it will be covered under your existing policy.
- ☐ Make sure you receive a warranty for the system, parts, and labor.
- ☐ Check your contract to ensure that it clearly lays out what is included and what is not included in the price.
- ☐ Familiarize yourself with the system's maintenance or cleaning requirements. Check to see if annual maintenance services will be part of your contract.
- ☐ Check if the proposed payment schedule offers customer protections such as allowing a portion of the payment to be withheld until the system passes local code inspections and is operating properly.



## Pre-Installation

- ☐ Check to see if state or local building codes or regulations affect your project.
- ☐ If applicable, ensure that the size of your water heater is sufficient.
- ☐ If applicable, check that your existing ductwork in your home will be sufficient to distribute the heat level you need.
- ☐ If applicable, check that your existing radiators will sufficiently distribute heat and that they are optimized for efficiency with your new CH&C system.
- ☐ Ask your contractor if he/she has properly sized the new system to match the heating load. If you will be making any weatherization improvements after installing the CH&C system, be sure to let your installer know. This could affect system sizing.
- ☐ For whole home projects, check to see if you will receive a system design to approve before installation.

## Finances

- ☐ Consider your investment timeframe. Are you looking for a short-term payback or a long-term investment?
- ☐ Consider your up front payment and your payments over time.
- ☐ Work with your contractor to access all federal, state, and utility options including rebates, financing, and tax credits.
- ☐ Make sure you are clear about who receives the incentive or rebate, if any. Some rebates are upstream incentives—this means the rebate goes directly to the contractor who passes the savings on to the consumer.
- ☐ Confirm with a tax advisor that you are eligible to take advantage of any state or federal tax credits.
- ☐ Consider using an Efficiency Excellence Network contractor to take advantage of the Network's exclusive finance packages and incentives and greater assurance of quality work.

## Solar Hot Water

- ☐ Consider your roof's orientation. Is it shaded at certain times of the day or year? If the roof is not ideal, consider whether there are alternate locations on your property to erect solar hot water panels?
- ☐ Verify that your roof can support solar hot water panels.
- ☐ Ensure that your roof is in good condition and that it will not need to be reroofed in the next several years.



### **Air Source Heat Pump**

- ☐ Make sure your contractor reviews the heat pumps operation in both heating and cooling mode with you.
- ☐ If applicable, discuss with your contractor how to optimize efficiency of your heat pump alongside your existing heating source.

### **Ground Source Heat Pump**

- ☐ Make sure your contractor reviews the heat pumps operation in both heating and cooling mode with you.
- ☐ Consider whether you have enough land to install a horizontal or sufficient gallons per minute for a vertical system.
- ☐ Check whether there are any land use restrictions that would impede a GSHP installation.
- ☐ Make sure you have all necessary local permits and approvals.
- ☐ Ask your contractor how long it will take to complete the system.

### **Advanced Wood Heating**

- ☐ Consider whether you have space in your basement for a pellet boiler or furnace and pellet storage unit. If you do not have interior space for pellet storage, be sure to calculate the additional cost of exterior storage.
- ☐ Encourage your contractor to complete a Manual J calculation to properly size the boiler or furnace to the building's heat load. This is often referred to as a "heat load calculation."
- ☐ Ask your contractor about incorporating thermal storage into the system design and discuss its benefits.
- ☐ Be sure you choose a well-qualified installer with sufficient experience and is part of the EEN.

### **Post Installation**

- ☐ Have the installer test and turn on the system.
- ☐ Make sure all necessary inspections have been completed.
- ☐ Acquire reference materials and equipment operating manuals from your installer.
- ☐ Obtain instructions on whom to contact in the case of follow-up questions or system failure.
- ☐ Ask your installer to provide sufficient information to operate and maintain the system throughout the year.

## CH&C Resources

### Advanced Wood Heating

- Advanced Wood Heating, <http://www.rerc-vt.org/advanced-wood-heating-systems>
- Advanced Wood Heating, <https://www.efficiencyvermont.com/products-technologies/renewable-energy/advanced-wood-heating>
- Wood Energy, <https://fpr.vermont.gov/forest/wood-energy>

### Air Source Heat Pumps

- Efficiency Vermont, Heat Pump Systems, <https://www.efficiencyvermont.com/products-technologies/heating-cooling-ventilation/heat-pumps>
- Northeast Energy Efficiency Partnerships, Air Source Heat Pump Installer and Consumer Resources, <https://neep.org/high-performance-air-source-heat-pumps/air-source-heat-pump-installer-and-consumer-resources>
- Northeast Energy Efficiency Partnerships, Cold Climate Air Source Heat Pump Specification & Product List, <https://neep.org/ASHP-Specification>
- Office of Energy Efficiency & Renewable Energy, Air Source Heat Pumps, <http://energy.gov/energysaver/air-source-heat-pumps>
- Office of Energy Efficiency & Renewable Energy, Ductless, Mini-Split Heat Pumps, <http://energy.gov/energysaver/ductless-mini-split-heat-pumps>
- Office of Energy Efficiency & Renewable Energy, Purchasing Energy-Efficient Residential Air Source Heat Pumps, <https://energy.gov/eere/femp/purchasing-energy-efficient-residential-air-source-heat-pumps>
- Energy Star, Air source Heat Pumps, [https://www.energystar.gov/products/heating\\_cooling/heat\\_pumps\\_air\\_source](https://www.energystar.gov/products/heating_cooling/heat_pumps_air_source)

### Ground Source Heat Pumps

- Efficiency Vermont, Heat Pump Systems, <https://www.efficiencyvermont.com/products-technologies/heating-cooling-ventilation/heat-pumps>
- New York State Energy Research and Development Authority, Ground Source Heat Pump, <https://www.nyserda.ny.gov/Researchers-and-Policymakers/Geothermal-Heat-Pumps>
- Renewable Energy Vermont, Ground Source Heating, <https://www.revermont.org/go-renewable/heating-cooling/geothermal>
- Burlington Electric Department, Ground Source Heat Pump Systems, <https://burlingtonelectric.com/gshp>

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## Heat Pump Water Heaters

- Efficiency Vermont, A Guide to Water Heaters, <https://www.efficiencyvermont.com/tips-tools/guides/a-guide-to-water-heaters>
- Efficiency Vermont, Water Heating, <https://www.efficiencyvermont.com/products-technologies/heating-cooling-ventilation/water-heating>
- Green Mountain Power, Heat Pump Water Heater, <https://greenmountainpower.com/product/heat-pump-water-heater/>
- Energy Co-Op of Vermont, Heat Pump Water Heaters, <https://www.ecvt.net/service/heat-pump-water-heaters>

## Solar Hot Water

- A Vermonter's Guide to Residential Solar, [https://publicservice.vermont.gov/sites/dps/files/documents/Renewable\\_Energy/Resources/Solar/consumerguidesolar\\_2018.pdf](https://publicservice.vermont.gov/sites/dps/files/documents/Renewable_Energy/Resources/Solar/consumerguidesolar_2018.pdf)
- Efficiency Vermont, Solar Energy, <https://www.efficiencyvermont.com/products-technologies/renewable-energy/solar-energy>
- Energy Co-Op of Vermont, Solar Hot Water Heaters, <https://www.ecvt.net/service/solar-hot-water-heaters>
- Office of Energy Efficiency & Renewable Energy, Everything You Wanted to Know About Solar Water Heating Systems, <https://energy.gov/energysaver/articles/everything-you-wanted-know-about-solar-water-heating-systems>





## About the Authors

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#### PROJECT DIRECTOR

Val Stori is a project director for the Clean Energy States Alliance (CESA), where she leads projects focused on building electrification and offshore wind policy. She coordinates a multi-state initiative to develop renewable heating and cooling tools that support and accelerate the deployment of renewable heating and cooling technologies. Additionally, she co-directs CESA's offshore wind project, which is focused on regional state cooperation to decrease costs and accelerate market growth. She has also managed projects focused on stakeholder outreach, small wind turbines, bioenergy, and biomass thermal. She currently coordinates working groups on renewable thermal and bioenergy. She has co-authored several reports, including *Case Studies of RPS Best Practices: Solar Carve-outs, SREC Tracking, and Thermal Inclusion*; *Distributed Wind Energy Zoning and Permitting: A Toolkit for Local Governments*; and *Environmental Rules for Hydropower in State Renewable Portfolio Standards*. She currently sits on the board of several nonprofits, including the Friends of Nepal, and sits on the Town of Underhill's Planning Commission. She holds a B.A. from Middlebury College and a Master of Studies in Environmental Law from the Vermont Law School.

### Georgena Terry

#### RESEARCH ASSOCIATE

Georgena Terry is a volunteer research associate for CESA. She is the founder of Terry Precision Bicycles for Women. Her interest in environmental issues arose from many miles on a bicycle, following roads along marshes and grasslands and through forests. This burgeoning passion eventually led her to Vermont Law School, where she earned a Master of Environmental Law and Policy. She also has a Bachelor of Science in Mechanical Engineering from Carnegie-Mellon University and an M.B.A. from the Wharton School. As a volunteer, she hopes to help CESA advance its clean energy mission.

# *A Vermonter's Guide to Residential Clean Heating and Cooling*



This homeowner's guide provides an introduction to the efficiency measures and clean heating and cooling (CH&C) technologies available for your home and describes the best uses for each technology, the steps you can take to make your home more efficient, the incentives available to complete efficiency measures or CH&C installations, and walks you through the contractor selection and installation process. Making your home more energy efficient and installing clean heating and cooling technologies will reduce your home's greenhouse gas (GHG) emissions and may help you reduce the amount of energy your home uses, plus they can improve your indoor air quality and home comfort.

