Heat Pumps for Cold Climates?? Yes, Indeed!

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This is not your parent's heat pump!

The conventional wisdom is that it's a bad idea to heat a home with an electric heat pump in New England. Everyone knows that heat pumps are noisy, inefficient, unreliable, and just don't put out enough heat for New England winters. So, why did my wife and I install an electric heat pump two years ago? We did it to cut our heating bills in half[1], to reduce our environmental footprint, and to make our home more comfortable year-round.

Heat pumps have evolved dramatically over the years to address the performance issues mentioned above. In fact, heat pumps designed specifically for cold climates are now available. Read on to see if a cold-climate heat pump might be right for you.

How does a heat pump work?

Heat wants to flow from warm places to cool places, and will do so on its own. If, however, we want heat to flow from a cool place to a warm place, we need to pump it, which is exactly what a heat pump does. We all have heat-pumping devices in our homes, although we may not call them heat pumps. One example is a household refrigerator, which pumps heat from the relatively cool interior of the refrigerator to the relatively warm kitchen. Another example is an air conditioner, which pumps heat from the relatively cool interior of the home to the relatively warm outdoors. A home-heating heat pump is essentially an air conditioner that can pump heat both ways—from inside to outside (for summer air conditioning) and from outside to inside (for winter home heating). While this article focuses primarily on the home heating function of heat pumps, air conditioning is a nice side benefit!

The colder it gets outside, the more heat a home needs. Unfortunately, a heat pump provides less heat at colder outdoor temperatures than at milder temperatures. As a consequence, a heat pump used in a cold climate generally needs a supplemental heating system to provide some (or all) of the required heat at very low outdoor temperatures. Heat pumps often use electric-resistance heat (i.e., conventional electric heating technology) for supplemental heating, but it's more energy-efficient to use oil, propane, or natural-gas furnaces or boilers for supplemental heating.

Most heat pumps are air-source, which means that they exchange heat with the outdoor air. Heat pumps can also be ground-source or water-source (also called GeoExchange® or geothermal), which

[1] The author's rough estimate of savings compared to an oil furnace.

means that they exchange heat with the ground, a well, or a pond/lake. Ground-source and water-source heat pumps are generally more energy efficient than air-source heat pumps, but they are also more expensive. This article focuses on air-source heat pumps.

Central heat pumps circulate heated air through ducts to the various rooms in a home. Central heat pumps have an outdoor unit (usually mounted on a pad next to the home) and an indoor unit, or air-handling unit (usually in the basement, utility closet, or attic). In recent years, however, ductless heat pumps have grown in popularity in the U.S. market (see photos). Ductless heat pumps do not require ductwork, so they can be installed in homes designed to be heated with boilers or electric baseboard. The outdoor units are generally mounted to the side of the home. The indoor units (often called "heads") for ductless heat pumps are generally mounted on the interior walls in the rooms to be heated. While a central (ducted) heat pump generally heats the entire house, a ductless heat pump heats only the rooms in which indoor heads are installed. In some existing homes, it is not practical to use ductless heat pumps to heat every room, so the existing heating system must heat the remaining rooms.

Typical Ductless Heat Pump

(Photos courtesy of the Northeast Energy Efficiency Partnerships—used with permission)

What's different about a cold-climate heat pump?

Cold-climate heat pumps are specifically designed for use in cold climates. To work well in cold climates, a heat pump needs to maintain good heating capacity (heat output) and efficiency at low outdoor temperatures. Many of the design features that manufacturers use to improve capacity and efficiency

at low outdoor temperatures also improve performance at milder temperatures, and in the cooling (air-conditioning) mode. One of these features is variable-speed operation, which allows the heat pump to vary its heating (or cooling) capacity to match the amount of heating (or cooling) that the home needs. At low outdoor temperatures, a cold-climate heat pump runs extra fast, allowing it to pump more heat. Variable-speed operation not only helps heat pumps work better on cold winter days, but also provides several other benefits. Because the heat pump can generate just the amount of heating (or cooling) needed, it doesn't have to cycle on and off as frequently as conventional fixed-speed heat pumps. Reduced cycling improves efficiency, improves dehumidification during the summer, and provides a more uniform home temperature. A more uniform temperature, along with less air movement in the home and quieter operation associated with variable-speed operation, provide a significant comfort benefit that one has to experience to really appreciate. People *buy* cold-climate heat pumps to save energy and lower their environmental footprints, but they *love* them because they improve comfort.

Is a cold-climate heat pump right for my home?

Simple estimates, based on NSTAR residential (A4) electric rates and Massachusetts-average residential prices for other fuels, suggest that a cold-climate heat pump that replaces your current heating system could reduce your home heating costs by:

- Nothing if you currently heat with natural gas
- 40 to 50% if you currently heat with fuel oil
- 50 to 60% if you currently heat with propane
- 60 to 70% if you currently heat with electric resistance (such as electric baseboard).[2]

Your savings will be higher if you keep your existing furnace or boiler for supplemental heating, rather than using electric resistance. As a bonus, you'll have a high-efficiency air-conditioning system for additional savings when you replace room air conditioners or an older central air conditioner. Even if you heat with natural gas, if you're considering adding air conditioning or replacing an existing air-conditioning system, a cold-climate heat pump may still be economically attractive.

The choice between a central (ducted) or ductless heat pump is often determined by your home. If your home has ductwork that is sized appropriately, you'll probably want a central (ducted) heat pump. If not, you'll probably want one or more ductless heat pumps unless ductwork would be easy to install.

Costs for cold-climate heat pumps start at about $5,000 and can go up to $35,000 or more per home, depending on the size and layout of your home, the number of heat pumps installed, the equipment

[2] Based on $1.279/therm for natural gas, $3.83/gallon for fuel oil, $3.206/gallon for propane, and $0.17/kWh for electricity. Assumes current furnace or boiler seasonal efficiency is 82% and consumes 150 kWh electricity per heating season (for air or water circulation). Assumes seasonal efficiency of the cold-climate heat pump is 2.5 (low end of savings range) to 3.0 (high end of savings range) using electric-resistance supplemental heating. Savings estimates are rounded. Many factors impact savings—these estimates are for general guidance only.

being removed (if any), and other installation details specific to your home.[3] While the cost is generally higher than the cost of a new furnace or boiler, you're getting air conditioning, too.

Other considerations may influence your decision to install a cold-climate heat pump:

- *Savings Estimates:* Estimating energy savings for heat pumps is inherently challenging, and it can be difficult to get accurate estimates of energy savings and economics. Reliable, objective analysis tools are hard to find. The results of manufacturer-supplied analysis tools sometimes exaggerate benefits.[4]
- *Life Expectancy:* The average lifetime of a heat pump is 12 years, while the average furnace lasts 15 – 17 years and boiler 20 years.[5]
- *Noise:* While cold-climate heat pumps are generally very quiet compared to conventional heat pumps and air conditioners (especially the ductless models), one can still hear them indoors when they are working hard on particularly cold winter days.[6] Consider installing the outdoor unit away from bedrooms.
- *Nighttime Thermostat Setback:* Heat-pump manufacturers generally recommend limiting nighttime thermostat setback to a few degrees. If you currently save significant energy by setting back your thermostat every night by 8 or 10°F, a cold-climate heat pump may save you a little less than the estimates above suggest
- *Excessive Snow:* Blowing, drifting snow can temporarily lower heat-pump performance if the outdoor unit is mounted at ground level. If possible, install the outdoor unit in a protected location. Shoveling around the outdoor unit after a particularly heavy snow storm will help.[7] The supplemental heating system ensures that the home stays warm during these periods.
- *Frost:* The outdoor unit is designed to periodically heat the outdoor heat exchanger to melt frost that naturally forms on the heat exchanger. Under some, infrequent conditions, the frost may not be completely removed during the defrost operation, leading to some temporary performance degradation.[8] The supplemental heating system ensures that the home stays warm during these periods.
- *Aesthetics:* While manufacturers try to make them aesthetically pleasing, some find the indoor heads for ductless heat pumps unattractive or obtrusive. Also, both central and ductless heat

[3] Range is based the author's experience, anecdotal information from other Carlisle residents, and Table 7 (using costs for Massachusetts), *Northeast/Mid-Atlantic Air-Source Heat Pump Market Strategies Report*, Northeast Energy Efficiency Partnerships, January 2014, http://www.neep.org/Assets/uploads/files/market-strategies/emerging-tech/ASHP/ASHP%20Report_FINAL%20(2).pdf

[4] One of the contractors who submitted a bid to the author estimated that the author's old furnace consumed 1300 gallons of fuel oil during a typical winter. Actual consumption was more like 500 gallons.

[5] Average lifetimes from the U.S. Department of Energy, Buildings Data Book, Table 5.3.8, http://buildingsdatabook.eren.doe.gov/TableView.aspx?table=5.3.8. These lifetimes are not specific to cold-climate heat pumps. The average lifetime of a gas-fired furnace is 15 years and an oil-fired furnace is 17 years.

[6] Based on the author's experience with a central (ducted) heat pump.

[7] The author shoveled his outdoor unit once in two years.

[8] The author observed this once in two years, and has heard anecdotal reports from others of frost accumulation significant enough to impact performance.

pumps require installation of one or more outdoor units, mounted on the ground near, or on the side of, the house, which some find unattractive.

Perhaps the best approach is to get a free home energy audit before you make a decision. Your auditor will look at your whole home and help you decide if a cold-climate heat pump might be right for you. Often, it makes sense to invest in insulation and air sealing of your home and/or your existing ductwork, in addition to replacing the heating system. Your auditor will also inform you of all the incentives for which you are eligible. The Town of Carlisle has partnered with Next Step Living, Inc. to encourage residents to take advantage of the free home energy audit program. Sign up at: http://www.nextstepliving.com/partners/carlisle

For more information on sustainable living in Carlisle, see the Green Carlisle website: http://greencarlisle.org

The Outdoor Unit of the Author's Heat Pump, with his Wife, Kimberley