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## Upgrading a Carlisle home with geothermal heating and cooling

*by Jennifer Roberts*

Invisible improvements to your home can make a big impact on both your personal quality of life, and sometimes, the wellbeing of the planet. When my husband and I bought our home in Carlisle in 2021, the oil burner for our forced-hot-air heating system was close to 25 years old and at the end of its expected lifespan. Faced with replacing it or converting our home to rely less on fossil fuels, we decided to install a geothermal ground source heat pump to heat and cool our whole home. Taking advantage of the incentives and rebates offered by the federal government and the state of Massachusetts cut our up-front costs by roughly 50%. In 2023, geothermal federal tax credits increased to 30%.

A whole-home ground source heat pump, often referred to as simply “geothermal,” takes advantage of the constant temperature of the earth below the frost line to heat and cool your home. In the summer, the earth is cooler than the air, and in the winter, the earth is warmer than the air, so using that stable temperature (roughly 50-55°F in Carlisle year round) as the baseline, the system only has to work hard enough to raise or lower the temperature slightly.

The system operates by circulating a mixture of water and antifreeze through a closed loop of pipes underground. The fluid-filled pipes are in contact with the temperature of the surrounding earth and either absorb or release heat. The fluid then returns back to the house to be passed through an air exchanger. Electricity is used to raise or lower the air temperature to the final level desired. The air is then distributed throughout the home via ductwork. The heat pump uses variable speed technology which makes it highly efficient, quiet, and great at reducing humidity in the home.

Some general observations of life with geothermal include unrivaled comfort and serenity. We no longer have to steer clear of the hot or cold regions created by the strong gusts of heat and a/c blowing at full force out of the air ducts. The soothing consistency of having the entire home always at a refreshing 70°F makes it perpetually t-shirt temperature. The irritating rattling or heavy blowing noises disappear and are replaced with nearly inaudible, tranquil whispers of air. The reason for the lack of drama in the system is that it’s working smarter, not harder, and always subtly running rather than switching on and off with extreme temperatures. We adjust the thermostat roughly once per quarter in severe weather. Overall, we’ve saved money on our utilities by reducing our oil use substantially.

As the lead “engineer” behind our project, I must give my husband most of the credit for educating me on the subject.

In order to understand the full spectrum of options for converting to heat pumps, I spoke with Bob Zogg, cofounder of the Heatsmart Alliance. The nonprofit organization consults on sustainable heating and cooling conversions from start to finish. Volunteer coaches work on an “as available” free basis, and will help walk you through every aspect of your project, from recommending vendors to helping prepare paperwork for rebates. Zogg is also a member of the town’s Environmental Sustainability Committee (ESC). If you’re interested in learning more about converting your home, visit him at the ESC’s Earth Day event, Route To Sustainability Day, on April 22. Zogg and other members of the committee will be presenting ways to lower your carbon footprint at various locations around the center of town.

### **Retrofitting an existing home**

The first step in deciding whether geothermal is right for your home is to take a look at your current heat distribution systems. Ground source heat pumps are best suited for homes that have existing forced air ductwork with supply and return vents. Our home was ideal for geothermal as we already had existing, insulated, central air ductwork and air handler units in our basement and attic servicing three zones. If you have hydronic heat without ductwork (baseboard heating, steam radiators, or a furnace) then you may have to consider either retrofitting your home with ducts at a greater expense or exploring air source heat pump options. The one exception may be homes with radiant heating.

### **Air source heat pumps are popular**

For those looking for sustainable systems, the most popular option is to install air source heat pumps—either the ductless mini-split systems installed into the walls or ceilings that generally service a small area of the home or a central air system in a home with existing ductwork. According to Zogg, air source heat pumps are more common than ground source heat pumps at a ratio of ten to one. First, they are less expensive up front, most heating/cooling system (HVAC) vendors can install them, and they don’t require anything beyond a wall hook up and a drain for condensation.

While a more sustainable choice than conventional fossil fuel systems, the major disadvantage of air source heat pumps arises in extreme cold weather, when the system may be unable to generate adequate heat. This means you will be using significantly more electricity to heat very cold air and may need a backup system in the winter. With electric costs as volatile as they have been this year, the long term operational costs are something to consider. Ground source heat pumps are roughly 50%-70% more efficient in power use than air source heat pumps.

### **Geothermal more efficient**

While geothermal does seem to be gaining in popularity in town over the past decade, it’s still less common. Board of Health Agent Linda Fantasia said the board receives about three permit applications per year. I spoke with Tom Bilotta, Chair of the Transfer Station Action Committee, who has been helping local residents reduce their carbon footprint through recycling. He has first-hand experience with heat pumps. He says, “It’s an education process” and notes that a reason most homeowners are unaware of geothermal in town may also be due to a lack of contractors. Billotta says, “There are tens of local HVAC contractors, most of whom install air source heat pumps. Geothermal contractors, you have to reach out and find these folks and typically you’re dealing with individuals or small companies.” He continued, “Suppose your furnace is dying and needs replacement, who are you going to call? You’re going to call whoever services your HVAC system and they’re going to tell you to put in an air source heat pump because they don’t do geothermal.”

### **First step—a Mass Save energy check up**

Once you've made the decision to explore converting to a heat pump system, you'll need to start by getting a free Mass Save energy assessment. An energy specialist will come to your home and assess opportunities for energy efficiency. This is required for the Mass Save rebates, which are up to \$15,000 for ground source heat pumps (up to \$10,000 for air source). Mass Save also offers the HEAT loan at 0% interest for up to \$50,000 for qualified applicants. Local installers are featured on their website so you can collect quotes from HVAC vendors.

The most important component in planning your system is conducting an HVAC load test, called a "Manual J," usually performed by your geothermal installer. This measurement is used to calculate the amount of energy required to maintain the temperature of your home. The calculation estimates the size of the compressor(s) needed and the size of the loop needed for a closed loop system (open loop systems are not permitted in Carlisle). Your custom plan will take into account variables like the square footage and volume of the house interior, the quality of insulation of the walls, windows, and doors. Sizing the system correctly and taking into account potential future additions is paramount in the process. It's incredibly difficult to increase the depth of the wells retroactively. Massachusetts alternative energy credits (AEC) vary based on the size of the system.

### **Vendors help navigate local regs and permits**

Typically, HVAC and well-drilling companies will handle the permitting process for you, as they did for us, but it's important to be aware of the regulations in town. Geothermal wells require a Board of Health permit (\$325 for one to five wells) and a Title V for your septic system. Geothermal wells must be drilled at least 100 feet from drinking water wells and septic systems; and cannot be drilled within the 100-foot wetland buffer zone; 25 feet from property lines, petroleum tanks, and roads.

In Carlisle, you must use a state-licensed well drilling company. We chose to use a vertical system that required four, 480-foot wells. The drilling accounted for almost half the total cost of the project and required the longest lead time in scheduling. The pipe loops can be installed horizontally; however, according to Zogg, vertical loops are far more common because New England has ideal subterranean conditions of bedrock, which makes for a predictable, easy-to-bore well. The drilling took about five days and used a great deal of water, which we ran from an irrigation line to avoid running the water through our water softener system. The runoff and debris from drilling should be accounted for. If you don't have a place to deposit the dirt and silt that is dug up from the ground, it will need to be hauled away as an added expense. Unlike a septic field or drinking water wells with caps, the area has no visible markings above ground and our lawn grew back in one season. Unless you have intricate landscaping that can't be replaced or accommodate large drilling rigs, Carlisle is an ideal location to add geothermal wells due to our two-acre zoning regulations.

Once the wells are drilled, the heat pumps and air handlers are installed. We installed two five-ton Waterfurnace units (ten-ton total) which took about a week. We have a 7-series for the first floor (two zones, compressor and air handler in basement, single unit) and a 7-series split for the second floor (one zone, compressor in basement, air handler in attic). Our system is controlled by a wifi-enabled digital thermostat with remote phone app access so we can adjust temperatures when we are away from our home.

### **Keep a backup?**

While geothermal is capable of replacing fossil fuel backup systems and running with an electric resistance backup, it's important to know you will most likely be adding the heat pump and maintaining a secondary system. Zogg explains that, "Most people maintain some type of backup, whether it's electric resistance, a boiler, or a furnace." We kept our existing hydro-boiler system primarily to heat our water. While it functions as our backup, we have never needed to use it, even with February's  $-9^{\circ}$  Fahrenheit low. Zogg brought up another important reason for having a backup, "You want to have a strategy for a power outage. Sometimes in Carlisle we have line voltage drops

and it may not affect a conventional heating system, but a brownout will cause the heat pump to stop running. Only a wood stove requires no energy. You may need to upgrade what you're using as an emergency generator if you don't have fossil fuel alternatives.”

### **Calculating the net cost**

Bilotta said it best, that “At the end of the day everyone is concerned about the economics.” After speaking with Zogg, it was clear that up front costs vary considerably based on site specific variables such as the size and insulation of the home. There are many options for sustainable systems at different price points so having a personalized estimate, sized appropriately to your specific needs is vital. Long-term energy use costs will be higher with air source over ground source heat pumps due to the difference in efficiency.

Because we needed to replace our system, our total costs after rebates yield a 12-year payback period after subtracting incentives and the comparable cost of replacing the existing fossil fuel system to heat and cool our 4,500 square-foot house. Without subtracting the cost of a comparable fossil fuel system, the payback period is about twice that at 24 years. After incentives, the up-front cost was around \$60,000 and we are saving roughly \$2,500 per year by using significantly less oil.

Zogg explained, “When you're comparing the costs of the heat pump, make sure that you're not just looking at the full price of the heat pump. Make sure you're looking at both your heating and cooling equipment and the cost to replace both of those. If you were going to put in conventional equipment and upgrade for the same comfort level, you would need that high end air conditioner, you would need that high end furnace, and you'd really be closing the price gap. Then put in the incentives and tax credits and decide if you want to put a value on the carbon footprint reduction; that's up to the individual.”

Bilotta echoed the sentiment when converting his daughter's home to geothermal in 2015, “When you look at the costs, I don't think the cost benefit lasts very many years when you consider the totality of the credits. There are really good credits for geothermal. In our case, the return on investment was only a few years. We did that analysis and got it quoted. My daughter had a house with two zones, two oil furnaces, one oil tank, and two air conditioners and the cost to replace with fossil fuels was \$30K and the cost to replace all of it with geothermal was \$50K with \$18K in credits making it \$2K more to install geothermal including the well.”

Since we have switched to geothermal, our home is a comfortable, consistent temperature, virtually silent and only using oil for hot water and as emergency backup heat. In order to optimize the system, we plan to insulate our attic to create a tighter envelope and are investigating solar options to power the geothermal system as well as our plug-in hybrid electric car. While the geothermal heat pump operates with electricity, you can participate in the town's municipal aggregation electricity program with Eversource to choose renewable energy sources to further decrease your impact.

### **To learn more**

The number one link to find more information about geothermal systems is Mass Save: [www.masssave.com](http://www.masssave.com) (<http://www.masssave.com>), which has a heating comparison calculator, local vendor contact information, energy assessment scheduling as well as rebate, incentive and loan information. In addition, the Heatsmart Alliance helps educate homeowners on sustainable energy conversions through volunteer coaches when available: [www.heatsmartalliance.org](http://www.heatsmartalliance.org) (<https://heatsmartalliance.org/>). Δ

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