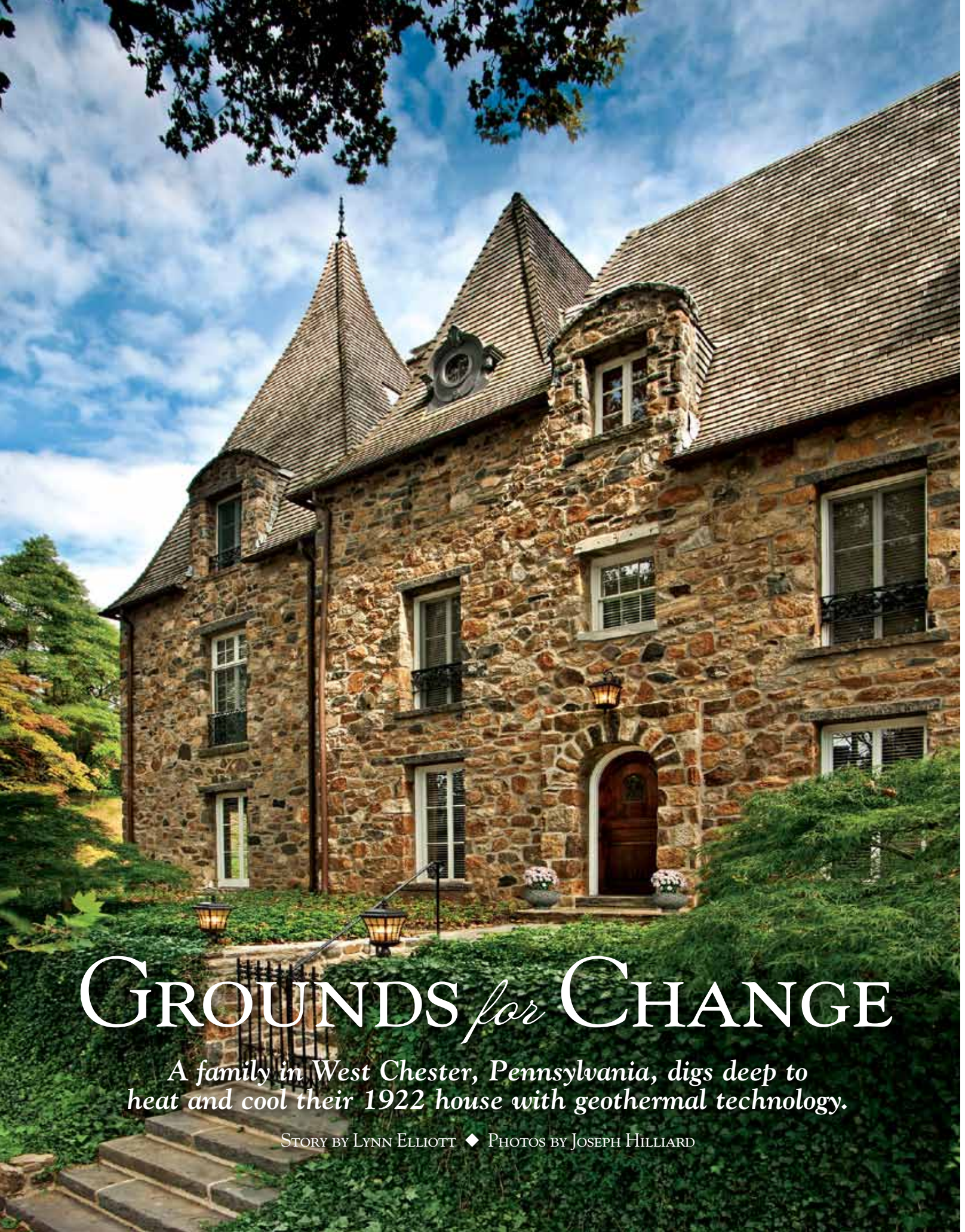


Grounds *for* Change

A family in West Chester, Pennsylvania, digs deep to heat and cool their 1922 house with geothermal technology.

Story by Lynn Elliott ◆ Photos by Joseph Hilliard

In August 2011, David and Susanne Neiblum opened their electricity bill to find a pleasant surprise: It was for $7—the total cost for one month of the electric company's service charges for their 6,700-square-foot home in West Chester, Pennsylvania. The energy payday was the result of the three and a half months the Neiblums spent sensitively converting their 1922 house from oil heat to a geothermal heating and cooling system that runs on electricity from a solar array.

OPPOSITE & BELOW: Homeowners David and Susanne Neiblum were able to maintain the historic character of their 1922 French Norman house by locating the system's solar technology on an otherwise unusable hill in their back yard.

When David Neiblum first spotted the French Norman style house for sale, he thought, "It's too big, too much, but how can I walk away from this house?" Clad in local fieldstone, with a central staircase and fireplaces imported from France, the impressive house was perfect for this family of five, but it was expensive to heat and had no air conditioning.

The family looked into installing central air ductwork and a standard compressor, which, for such a large house, would've cost approximately $100,000—but for a bit more money, they realized they could opt for geothermal energy instead. "We had looked into geothermal for a house we planned to build," says David, so they were familiar with the costs. "But we weren't sure it was possible for this house."

Geothermal systems can reduce heating and cooling bills by 70 percent in comparison to oil, but the upfront costs are expensive. For this house, the entire geothermal installation, including the ductwork but excluding the solar array, was approximately $160,000. (The cost varies with the size of the house.) A federal tax credit for green technology—30 percent of the entire project, including ductwork—helped to offset the expense.

With the energy savings of geothermal, David estimates they'll earn back the upfront expenses in five to seven years. "The price for ductwork and regular A/C with oil-heat radiators was the same as geothermal with the tax credit," David points out. "It made sense in the long run."

The Neiblums hired Bill Sinton of Sinton Air Conditioning and Heating to do the work. "The geothermal installer you choose is crucial because it's a major job for the house," says David. Geothermal installation was only 7 to 10 percent of Bill's business as recently as 2003, but it now encompasses 95 percent of his company's work. The increase in oil prices has spurred homeowners' interest in geothermal energy, which is a renewable resource.

Geothermal systems tap into the constant temperature under the earth, which is found as shallow as 11' to 12' below the surface. Ground temperatures vary from region to region. "Florida, for example, may be 61 degrees," Bill explains. "The ground is slightly colder at a higher latitude; slightly warmer at a lower latitude." In Pennsylvania, where the Neiblums are located, it is 53 degrees.

ABOVE: Air-return grilles are incorporated into the home's décor. TOP: The kitchen and dining room were in such poor shape that they had to be gutted, allowing the Neiblums to run ductwork under the floors.

This heat is then transferred from the ground to the home through a series of underground pipes that are filled with and antifreeze solution and then sealed. Unless a house has no accessibility to the grounds around it, neither the size of the house or the plot are limitations to tapping into that heat source.

What Lies Beneath

The Neiblums' house sits on an acre of land that includes a hill, which became the site of the bore field for the geothermal system, as well as for the solar array that would provide electricity to run the system and power the entire house (see "Solar Spotlight," page 48).

For this project, six 6"-diameter vertical boreholes, called geothermal exchangers, were drilled at a depth of approximately 350' to 400'. (Although constant ground temperatures can be found at the shallower depth as noted above, to find the most stable and consistent temperature, it's best to go deeper.) The number of boreholes and depth varies, depending on the size of the house. Because bedrock runs below the earth in Pennsylvania, Bill created the boreholes with a rock hammer drill, whose bit hammers as it spins. Not only is rock a much better conductor of heat—a benefit to the geothermal exchangers—but boreholes drilled in rock also won't shift or fill in, which can happen coastal areas with soil composed of sand, shale, and loose rubble. For these sandy areas, a mud rotary drill is used, which is labor-intensive and costly.

A loop, made of 1¼" high-density polyethylene (HDPE) pipe, a long-lasting thermoplastic that won't corrode, is inserted into the boreholes. Each loop bends in a U shape at the bottom of the borehole, so each hole contains two pipes but one circuit.

The pipes are filled with an antifreeze fluid that conducts heat. There are three antifreeze options for residential installations: propylene glycol, methanol, and ethylene glycol. The Neiblums chose methanol, the densest of the three, because of its enhanced energy-carrying properties. (The denser the fluid, the better its heat-carrying ability.)

After the loops are installed, the area around them is filled with bentonite grout,

FROM LEFT: Installing the geothermal system first involved drilling six boreholes into the earth to access consistently warm temperatures. A trench between the bore field and the house holds both the refrigerant lines for the geothermal system and the electric wires for the solar array. Refrigerant lines in the attic run to the two separate units used to heat and cool the second and third floors.

which remains pliable so it can expand and contract seasonally. The function of the grout is threefold: First, it maintains uninterrupted heat conductivity between the pipes and the earth. Second, it serves as a seal to bring the ground back into balance. Third, it prevents any aquifers from getting contaminated.

Once the grout is in place, a pipe ties the loops from each borehole together. The pipe is connected to a 3" manifold, which attaches the ground loops to the heat pumps in the house. A trench running down the hillside from the bore field to the foundation of the house holds the manifold.

Supply and Demand

Three heat pump units, located in the basement, service the entire house. The first one, a package geothermal unit that contains all the heating and cooling components, completely heats and cools the first floor. Ductwork and the ground loops are tied to it directly. The other two units—split systems with geothermal heat pumps in the basement and air-handling units in two separate attics—heat and cool the second and third floors of the house. Each unit handles two floors, but they service different wings of the house.

Supply and return ducts run from the heat pump units to every room in the house so that all areas maintain an even, comfortable temperature. Each room has two termination points: the supply register, which can be adjusted for airflow, and an air-return grille that always remains open.

Running ductwork in an old house is a tricky prospect. The airflow in each room has to be carefully balanced and measured so the temperature remains constant. Any home considering a geothermal system should have a full heat loss and structural analysis. For the Neiblums' home, Bill performed his own proprietary analysis in addition to the standard analysis known as a Manual J, which determines how much energy a home needs to stay cool in the summer and warm in the winter. "If someone only does a Manual J, there's a lot that will be left out," says Bill. "The challenge is finding the proper volume of air to each room on each floor."

Placing the termination points and the ductwork in an old house has to be done "more like a surgeon than a bullfighter," says Bill, so the home's character isn't affected. "You can't just be an engineer; you have to be an artist as well," he says. "You have to be artistically creative but scientifically sound.

"Every place we had the opportunity, we put the ductwork inside the envelope of the house," he continues. Where ducts couldn't be run behind walls, they were tucked into unusual places. "In the great room, there was a hidden wet bar in the wall that was probably from Prohibition, which we took out to hide the ductwork," David says. "You can't tell anything is there."

Ted Trethewey, a contractor who specializes in restoring old houses, custom-built the soffits to hide the ducts. "Ted was essential to not making it look like a new house," David says. Soffits were created in all of the bedrooms on the third floor; painted in bright colors, they blend in with the architecture of the house. "We've taken people through the house, and they don't notice the soffits until we point them out," says David.

LEFT TO RIGHT: In one of the children's rooms, a false wall was built to disguise the ductwork. The far left photo shows the ducts attached to the wall; the center photos show the wall in various stages of completion. At far right, the new wall assembly is highlighted with a cheerful, contrasting paint scheme.

Solar Spotlight

To power the Neiblums' geothermal system, a photovoltaic solar array was placed over the bore field. "We had an unusable hill facing south," David explains. "Geothermal runs by electricity, so we thought it made sense." However, ground installations are a more involved process than solar panels placed on the roof. The Neiblums hired Astrum Solar to build a frame for the panels and dig a trench to run the electrical wires from the ground mount to the home's electrical panel.

Although roof installations may take only a couple of days, the extra steps involved with ground installations means they can take longer. Permits are another factor to consider. "The longest part is all the zoning/permitting, utility interconnection, and incentive paperwork, which can take months," says Michelle Waldgeir, vice president of marketing at Astrum Solar. "[Our company] handles all this for our customers." In this case, the historic status of the Neiblums' house didn't affect the permitting process, since the panels were placed 100' away from the house and screened by landscaping.

Solar panels, which are made up of crystalline silicon, convert light into electricity. The electricity travels from the panels through wires to an inverter. "The inverter converts the type of electricity produced by the panels [direct current, or DC] into the type of power your house uses [alternating current, or AC]," explains Michelle. "Once the electricity goes through the inverter, it travels through wire into your home's electrical panel."

Instead of having all the panels wired in a series to one central inverter, compact inverters (in this case, Enphase Energy micro-inverters) are installed under each solar panel to maximize efficiency. This approach allows each panel to function independently, avoiding the pitfall of having one panel drag down the system. The micro-inverters can be linked to an online performance monitoring system, where the Neiblums can track their energy usage from the panels.

Roof and ground-mount installations that are situated identically can generate similar amounts of solar energy. But because ground mounts can be sited anywhere and aren't constrained in size by a roof, they often produce more power. The region can play a role in the system's power potential, too. "The Northeast is a great place to install solar," says Michelle. "[The Neiblums] get almost 95 percent as much sunlight as Florida."

The Neiblums' 10.36-kW solar energy system is capable of generating 11,740 kW hours per year. In comparison, the average American home uses approximately 9,000 kW hours per year. "It takes care of any electrical needs for the house," says David, not just the geothermal system.

The Neiblums purchased their system for approximately $60,000 and received a 30-percent federal rebate off the installation price. For state rebates, "solar is more complicated," notes David. "Every state is different. In Pennsylvania, there is a rebate, but there is only a certain amount of money, and it keeps reducing."

A solar energy system also can be leased for a monthly rate with no down payment. (Many companies offer rental agreements for solar systems.) "Total costs are based on size," explains Michelle. "If a customer is interested in leasing, the quality of their location (ability to generate energy), their utility rates and the amount they would like to spend (upfront or monthly) will determine their rate."

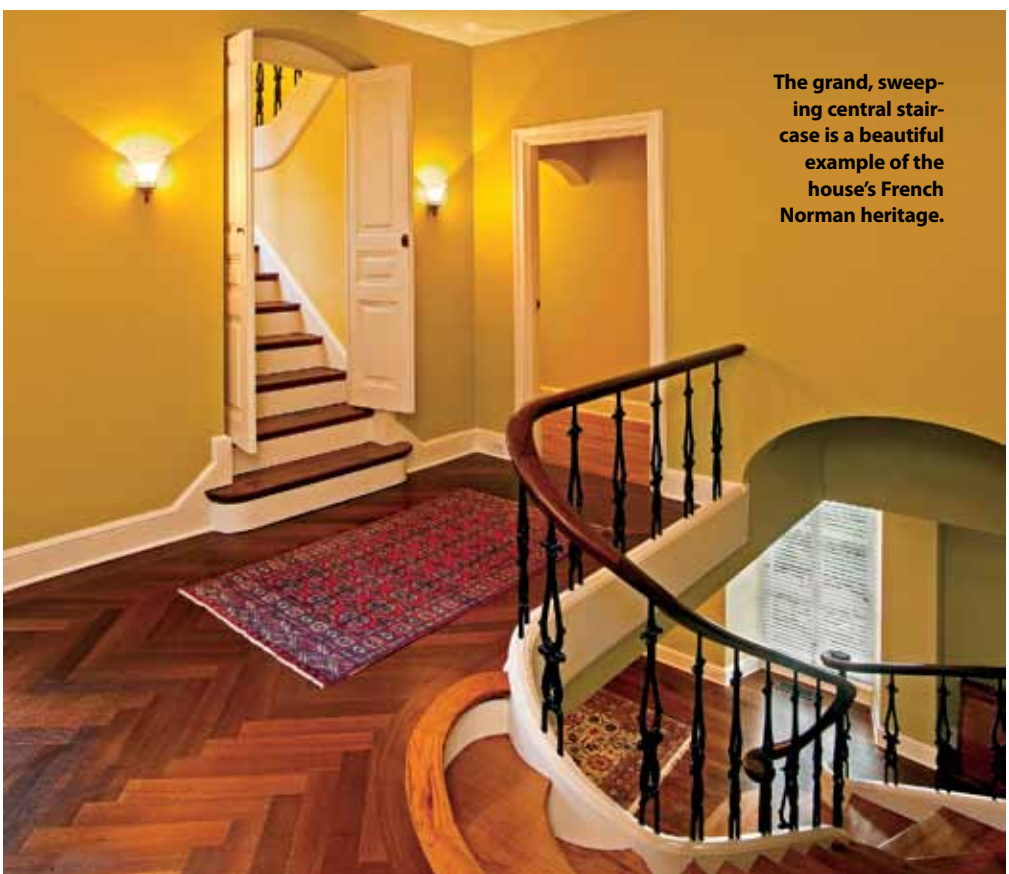
The Neiblums are pleased with the efficiency of the solar array and have noticed a tremendous savings in their electricity bills since setting it up in combination with their geothermal heating and cooling system. "Going solar is one of the best things you can do for yourself, your home, your wallet, and the planet," says Michelle.

Keeping It Going

Geothermal systems are appealing in terms of longevity and maintenance compared to conventional systems because they have very few moving parts. Unlike conventional systems, geothermal heat pumps operate in steady conditions without internal combustion, and boast a 20- to 30-year lifespan. "The amount of heat inside a furnace is a lot for metal surfaces to withstand—that's why furnaces die," says Bill. "Same with outdoor units—they have an 8- to 12-year lifespan," says Bill. "Everything that affects a machine outside destroys it." When a heat pump does need to be replaced, it's easy to swap out the unit. The ground loops will not have to be changed.

The system also needs very little maintenance to keep running smoothly. The air coils should be cleaned twice a year, the filters get changed yearly, and the temperature and pressure get checked annually. There is no outdoor unit to clean.

The Neiblums find the geothermal temperature controls very responsive. "You can change the temperature by one degree, and within fifteen minutes, you can feel the temperature in the room change," says David. They also consider the geothermal system to be in keeping with how the house and outbuildings were originally built. "We think a lot of the stones were salvaged from old buildings," notes David. "That ties in with the green theme."



The grand, sweeping central staircase is a beautiful example of the house's French Norman heritage.

Get a list of links to geothermal resources and suppliers.
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