

Geothermal Heat Pumps: Demand is Heating Up

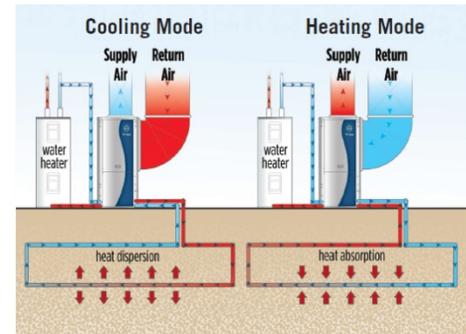
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U.S. interest in geothermal heat pumps (GHPs) is steadily increasing, as companies and governments make investments to meet growing demand in low carbon and efficient heat sources. This increase in demand has contributed to an increase in the investment in GHPs in the United States. The significant size of the U.S. HVAC industry makes the United States a competitive market for GHPs, yet many problems still plague the GHP industry from greater consumption and deployment.

What are geothermal heat pumps (GHPs)?¹

GHPs – often referred to as earth-coupled, ground-source, water-source, or GeoExchange heat pumps – have been around since the late 1940s. As with other types of heat pumps, GHPs are used to heat and cool buildings, and if equipped, to supply them with hot water. Unlike air-source heat pumps, which depend on the temperature of the outside air, GHPs use the constant temperature of the earth as the exchange medium to heat and cool homes (figure 1), with GHPs often receiving higher energy efficiency ratings than air-source units.

Figure 1: GHP system schematic



Source: Geothermal Exchange Organization

U.S. competitiveness in a global market

As of 2016, the United States accounts for 29 percent of the world’s GHP systems with an installed capacity of 4.8 million cooling tons (16,800 MW_{th}) in all 50 states.² The United States is a leading global manufacturer of GHPs for residential and commercial use, with over 50,000 GHPs installed each year and approximately 75 percent of residential GHP applications in new construction and 25 percent in retrofits of existing homes. Due to the historical significance of U.S.-based HVAC suppliers, such as Trane, Carrier, York, and Copeland, nearly one-third of companies producing GHPs and components are based in the United States.³ Some U.S. manufacturers focus exclusively on GHPs for residential and commercial uses, such as GeoCool (Georgia), ClimateMaster (Oklahoma), WaterFurnace (Indiana), and Dandelion (New York), which is at the early stages of the development and deployment of GHPs for the residential market. Other major markets with significant GHP systems production and installation include Europe (led by Sweden, Germany, and Finland), Canada, and China (table 1). As of 2016, due to the increased requirement for installations of GHPs in its infrastructure, China leads the global market in both production and installation of GHPs with a growth rate of nearly 30 percent per year.⁴

Table 1: Selected global GHP system manufacturers, by country

| Country | Company |
|---------|---|
| USA | • Dandelion, GeoCool, ClimateMaster, Waterfurnace |
| China | • Shandong Fuerda, Guangdong Foshan |
| Europe | • Thermia, Bosch Thermotechno-logy, CTC Heatpumps, Master Therm, Kensa Heat Pumps |
| Canada | • GeoSmart Energy, Maritime Geothermal Ltd. |

¹ GHPs constitute many components that are provided in a range of headings of the U.S. Harmonized Tariff Schedule (HTS). Fully assembled GHPs are included in the statistical 10-digit subheading 8415.10.6000, while many of its components, such as heat exchangers and condensers, are included in 8415.90.8065. Most of the statistical reporting numbers are broad categories that contain other products besides GHPs and its components, including non-geothermal heat pumps and components that are used in the assembly of non-geothermal heat pumps. Scroll compressors, the most prevalent type compressor used in GHPs and one of its costliest components, is included in several subheadings, including 8414.30.8050, 8414.30.8060, and 8414.30.8070, dependent on output.

² Installed capacity represents 1 percent of the U.S. heating, ventilation, and air conditioning (“HVAC”) market.

³ Based on media reports, company information, and trade data.

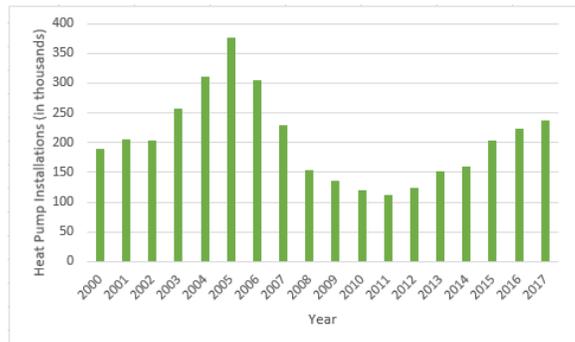
⁴ In 1997, the U.S. Department of Energy and China’s Ministry of Science and Technology signed Annex IV under the U.S.-China Protocol for Cooperation in the Fields of Energy Efficiency and Renewable Energy Technology Development and Utilization – an agreement focused on the advancement of the GHP market in China.

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Growing use and investment in GHPs

The market for GHPs in the U.S. is not necessarily new, but in recent years there has been growing interest and demand for GHPs due to improvements in the technology, policy goals around renewables and climate change, and the expansion of renewable energy tax credits to include geothermal alongside other renewables. Installations of heating systems for single-family homes saw a steep decline leading up to and during the 2008 financial crisis due to the mortgage crisis and the reduction in construction of new single-family homes. Since then, demand for GHPs have seen a steady recovery (figure 2). Due to advances in heat pump efficiency, GHPs have seen significant reductions in their up-front costs. One area where interest is visible is in technology investment by new companies, such as Dandelion, which has raised over \$20 million dollars since 2017 for R&D and to kickstart its sales and operations in the State of New York and other New England and Mid-Atlantic states. Born out of Alphabet, Dandelion has made significant investments in installation technology, reducing the installation cost from approximately \$45,000-\$60,000 to \$20,000 for homes in the range of 1,500-2500 square feet, after state rebates and federal tax credits. To reduce upfront and installation costs – the primary obstacle to increasing uptake in GHPs– Dandelion designed its own custom GHP technology and installation process and offers a loan scheme that allows more flexible financing by spreading cost into monthly payments. According to a 2019 U.S. Department of Energy (DOE) report, 7 to 15 percent of the residential sector and 4 to 5 percent of commercial buildings are projected to be conditioned by GHPs by 2050. European private and public entities have also made similar investments, such as through projects like GEOTECH, which has a stated goal of promoting greater utilization of GHP systems in the EU through advancement in innovative drilling and ground heat exchanger technologies.

Figure 2: GHP Systems Used in New Single-Family Houses (U.S.)



Source: U.S. Census Bureau

Factors affecting adoption of GHPs and U.S. competitiveness

While the growth in GHP installations and interest in recent years has benefited the industry, obstacles still exist for greater penetration in the HVAC field. In a survey conducted of U.S. GHP manufacturers and installers, the major concern remains the high initial cost of GHP systems to consumers. U.S. manufacturers and suppliers of GHPs compete globally and regionally with companies like Bosch and Daikin and in a highly fragmented HVAC services market, which is dominated by local providers with limited payment schemes for consumers. Recent innovations in design and installation, coupled with a growing political interest in renewables, may help relieve some of the challenges that have historically plagued the industry. U.S. companies have also made significant advances in drilling efficiency, system performance, and business models that can help offset the upfront technical costs for consumers. Analysis from DOE projects that by 2050 GHP systems could be deployed in 28 million homes (compared to roughly 2 million residential GHP systems nationwide as of 2016). Similarly, GEOTECH in Europe has made progress in improving overall GHP systems through several technological and project management innovations. Factors that will impact the adoption of GHPs include the competitiveness of substitute incumbent heating technologies, advances in technology, fossil fuel prices, the region's climate, policy, and utility partners.

Sources: DOE, [Geothermal Heat Pumps](#); [GEOTECH](#); Liu, Xiaobang, et. al. [GeoVision Analysis Supporting Task Force Report: Thermal Applications—Geothermal Heat Pumps](#); Bertoli, Andrea, [Dandelion Energy Closes \\$16 Million Series A Round To Expand Geothermal Energy](#); DOE, [Department of Energy Announces New American-Made Challenge Prize](#); OpenEI, [GeoVision Report](#); Brown, Mike, [Elon Musk Tesla Product Idea Could Help Fight Climate Change](#); BloombergNEF, Case Study: Financing Model for Geothermal Heat Pumps; DOE, [GeoVision: Harnessing the Heat Beneath our Feet](#)

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