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Beyond Policy: The Economic Forces Powering the Global Shift to Electric Heating and Cooling

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Beyond Policy: **The Economic Forces Powering the Global Shift to Electric Heating and Cooling**

The electrification of global heating and cooling is an unstoppable trend, propelled by superior system economics in comparison to natural gas. Recent legislation has done nothing to slow its momentum. The dual drivers of increasing energy cost—favoring the higher efficiency of heat pumps (HPs)—and continued cost reduction as HP technology improves will keep adoption on this upward trend. HPs now dominate the U.S. residential market, capturing over 50% market share, and are rapidly expanding in all other space conditioning sectors. As global demand for air conditioning (AC) soars, ductless HPs emerge as the essential, and often only, solution for retrofitting existing buildings—especially across the EU where most lack AC.

These favorable economic and efficiency trends are fueling Galvanize's strategic investments—such as Galvanize Innovation and Expansion (I&E) portfolio company Quilt and their ductless HP offering with industry leading efficiency. It has led the Galvanize Global Equities (GGE) team to invest in Carrier, a global leader in efficient HVAC offerings across residential and commercial markets. Finally, it drives Galvanize Real Estate's (GRE) strategy to retrofit many of their buildings with HPs, reducing both emissions and energy bills at their properties.

Innovation & Expansion (I+E)	Galvanize Real Estate (GRE)	Galvanize Global Equities (GGE)
Quilt, an I+E investment and Expansion investment, builds sleek, intelligent ductless heat pump systems for the home. The company displaces incumbent fossil-fuel based heating systems and inefficient cooling systems with highly energy efficient electric alternatives.	GRE intends to replace fossil fuel HVACs in favor of high-efficiency heat pumps. Combined with building envelope improvements, these systems are right-sized to match the building's reduced heating and cooling load. Paired with rooftop solar, the upgrade aims to deliver strong environmental and financial returns.	Carrier, a GGE portfolio company and global leader in HVAC and climate control solutions, is well-positioned to capitalize on rising demand for energy-efficient systems in the built environment. Its recent acquisition of Viessmann Climate Solutions enhances its exposure to the European heat pump market, further strengthening its strategic position in the energy transition.
		

1 Introduction

The primary technology for electrifying heating and cooling in built environments is the HP. It is often said that HPs perform "magic", producing as much as four or more units of heat energy for every unit of electricity they consume (specified as the coefficient of performance or COP[1]) through use of the vapor-compression cycle. While the recent attention HPs have received makes it appear that they are new to the scene, HP technology was invented in the 1850s [1] and sales of HPs into the U.S. residential home market began in the 1950s [2]. Since that time, their use has expanded geographically and across applications. HPs now service residential and commercial heat and cooling, residential and commercial hot water needs, and low temperature industrial heat needs. This paper explores the adoption trends of HPs in the residential and commercial heating and cooling market, the economics that drove this adoption, and the widening advantages that are expected to sustain it.

The key metric for space heating economics is the spark spread tuned for heating[2]. The spark spread is the difference in cost of delivering a kilowatt hour (kWh) of heat from a HP versus a comparable natural gas fired source. For any individual situation, a fulsome version of this comparison requires inputs that include building type, outside temperature, specific performance of the equipment to be installed, and energy costs. To make this analysis more general, a common range of equipment performance for both HPs and natural gas-fired equipment alongside state or country-wide energy costs is used. These regional spark spreads present a set of cases generalizing the comparison of HPs to natural gas solutions across geographies.

2: Heating

1) Note that heat pumps typically have a significantly different COP when heating relative to their COP when cooling – we use an appropriate Seasonal COP (SCOP) depending on which function is being analyzed.

2) For more details on the spark spread calculation used in the power sector, upon which the heating spark spread is based, please see https://www.eia.gov/todayinenergy/detail.php?id=9911.

2 Heating

Residential

For the first time in 2022, air-sourced HPs captured the majority of the residential market share in the U.S. and they continue to maintain that market lead (see Figure 1). While the Inflation Reduction Act included a variety of subsidies for HP adoption, the extended history of increased HP adoption has been driven by the favorable performance and economics of HPs in regions of the U.S. where winter temperatures are more moderate, particularly in the Southeast part of the country.

HP adoption in Europe shows a similar trend, though it lags the U.S. due to a differing legacy of space heating technology (Figure 2). Most homes in Europe are heated with radiators through which hot water is circulated—called hydronic systems. Air-to-water HPs can be used to replace the traditional gas or oil-fired boilers that heat this water, but these systems cannot be retrofitted to provide AC which lessens the attractiveness of HPs.

Figure 1: U.S. Annual Shipments and Market Share of Technologies for Residential Building Heating[3]

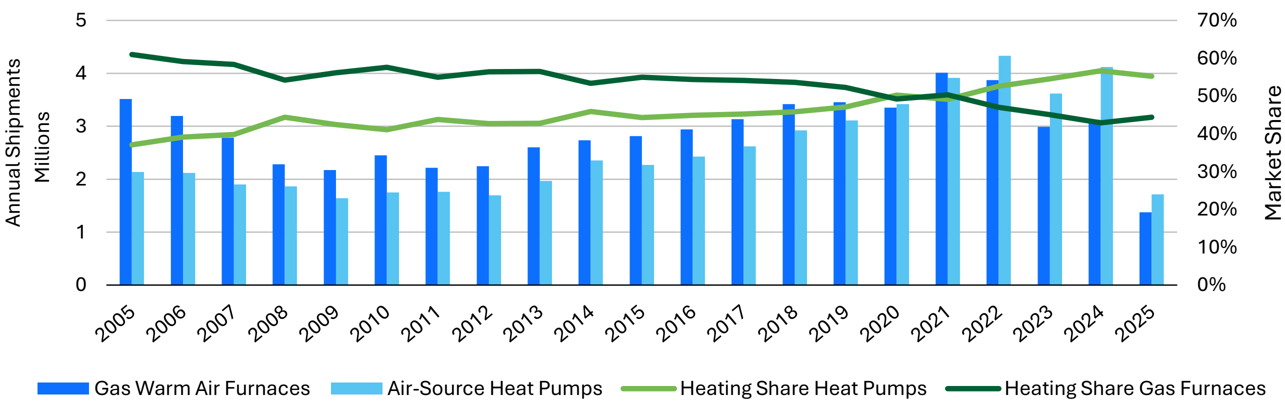
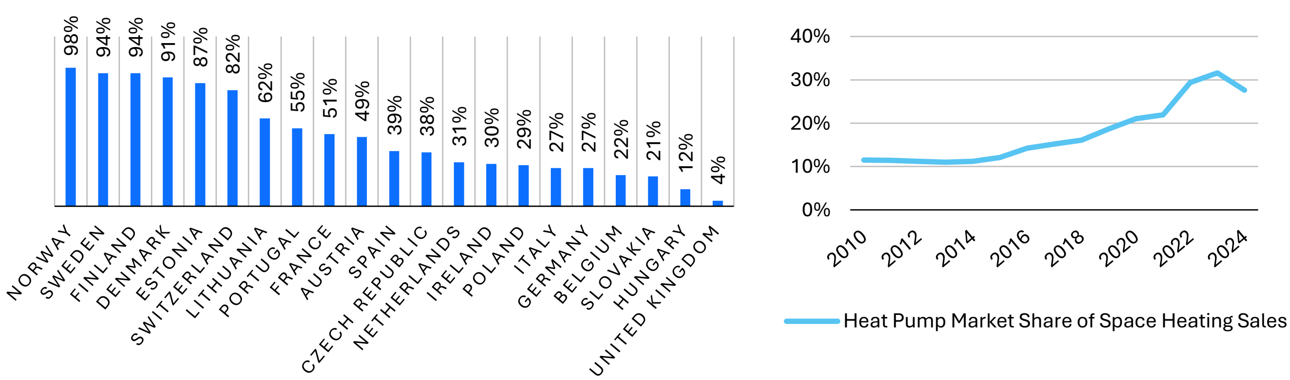


Figure 2: HP Share of Hydronic Heater Market in Select European Nations in 2023 (left) and Total Share Across Nations 2010-2024[4]



3) Data sourced from [3].

4) Data sourced from [4].

To explain adoption trends of HPs for heating it is useful to compare operating costs via a spark spread analysis. Beginning with the U.S., the most common competition for a HP is an air-source natural-gas fired furnace. Both equipment types have a range of efficiencies – driven mostly by the appliance's age—and differing standards, which can vary by geography[5].

There are two common type of HPs—central units with ducts to deliver heat through a home and ductless models that are typically wall-mounted. Ductless HPs —like those produced by Galvanize I&E portfolio company Quilt—usually have significantly higher COPs (~4, relative to ~3.5 for the best central HPs) due to their lower auxiliary power needs and the lack of losses in the duct system. Table 1 lays out efficiency metrics of note for common heating equipment in the U.S.

Table 1: Efficiency Metrics for Residential Heating Equipment in the U.S.

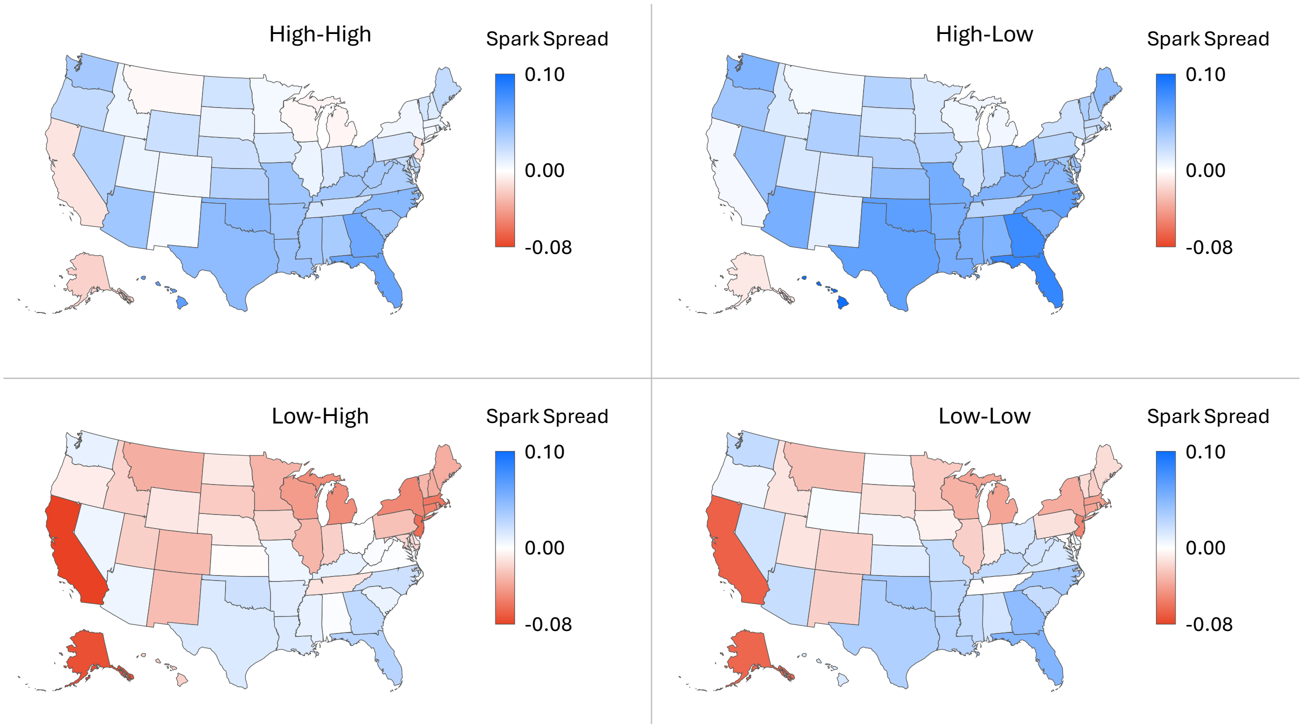
	Gas Furnace – South (%)	Gas Furnace – North (%)	HPs[6] (SCOP)
Current Efficiency Standard	80% [5]	81% [5]	2.2 [6]
Current EnergyStar Requirement	90% [7]	95% [7]	2.37 warm climates, 2.49 cold climates [8]
Best Available Today	~97%	~97%	~4.1
Future Efficiency Standard[7]	95% [5]	95% [5]	~2.6

5) In the U.S. there is a designation of Northern and Southern, defined by the number of Heating Degree Days (HDDs).
6) For heating, the standards are given in measurement of HSPF2. Here HSPF2 is converted to COP by dividing the HSPF2 value by 3.412.
7) For furnaces, the future efficiency regulations have been set and will take effect December 18, 2028. For heat pumps, regulations have been proposed but not yet adopted.

To examine current economics, a spark spread scenario using the current efficiency standards as a low case and best available efficiency as a high case for each appliance type is presented below. Electricity prices [9] as of and 12-month average natural gas prices [10] ending in June 2025[8] were used[9].

As seen in Figure 3, heating costs are lower for HPs in in at least 44 states when HP efficiency is high, states are divided evenly when efficiency is low for both equipment types, and HP economics are favorable favored in 17 states even when HP efficiency is low and furnace efficiency is high.

Figure 3: State-by-State Spark Spread Scenarios in the U.S. (all values $/kWh) *Positive value (blue coloring) is favorable to heat pumps



* We model four combinations of equipment efficiency: the first designation in each case is HP efficiency, the second is natural gas equipment efficiency.

In Europe, hydronic heating is fired by a variety of fuels—oil, gas, biomass, and even coal. Efficiencies vary by type and age, but with non-condensing boilers generally banned since 2015 and oil becoming increasingly expensive, gas condensing boilers hold a plurality of new-install market share [11].

On the HP side, sales in Europe are split evenly between air-to-water and air-to-air systems, with air-to-air being prevalent in areas where summer cooling is needed [12]. Also, unlike the U.S., most air-to-air HPs in Europe are ductless systems, leading to the significantly higher SCOP required under regulation (Table 2).

8) June data was the most recent pricing available for most states. The latest data available for Florida, Nevada, and West Virginia was May 2025 and for Maine was December 2024.

9) 12-month averages were used for gas given the greater volatility in price relative to electricity.

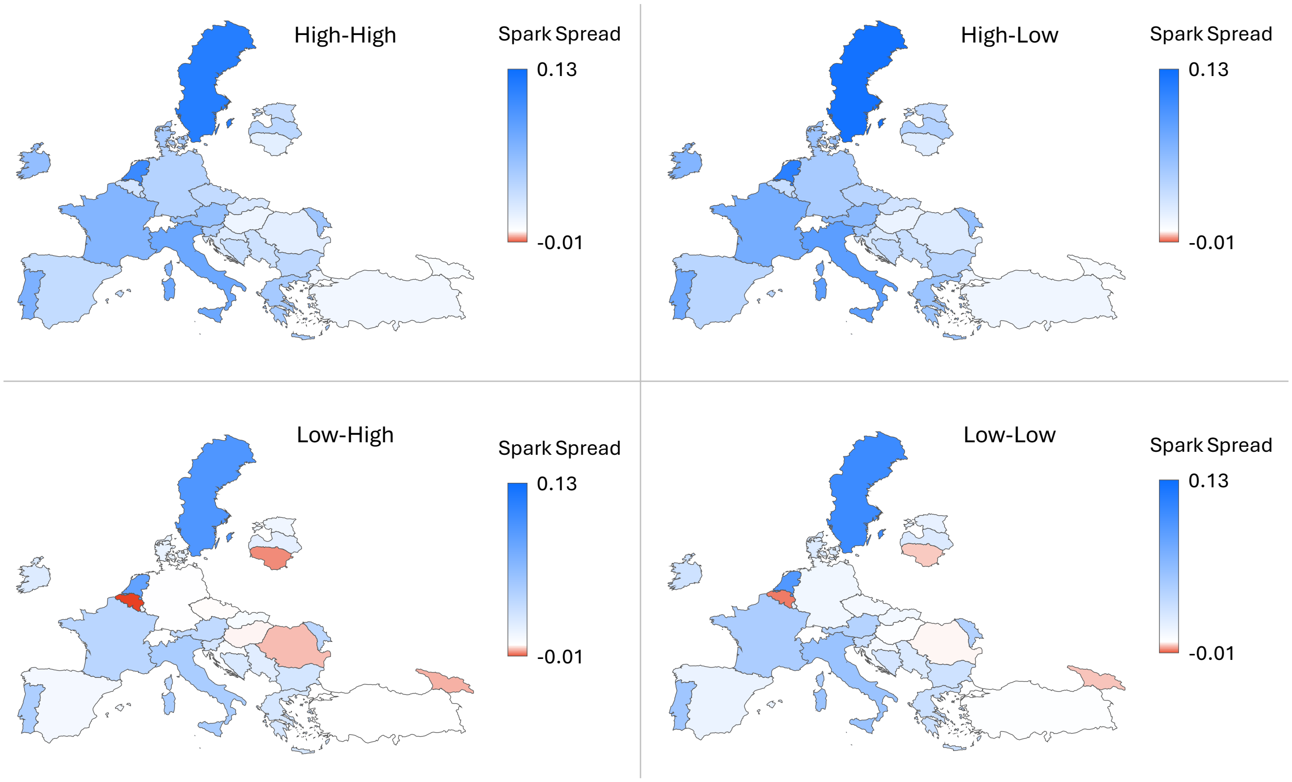
Table 2: Efficiency Metrics for Residential Heating Equipment in Europe

	Gas Condensing Boiler (%)	Air-to-Water HP (SCOP)[10]	Air-to-Air HP, <12kW (SCOP)
EU Minimum Requirement	92% [13]	3.57 low temperature, 3.14 medium temperature [13]	~3.4 [13]
Best Available	98%	4.8	5.0

A similar spark spread calculation with efficiency standards as a low case and best available as a high case was performed for the 29 EU countries with sufficient data. Gas [14] and electricity [15] prices from the second half of 2024 were used. Figure 4 shows high efficiency HPs provide energy savings in all countries.

When comparing low efficiency equipment, HPs are still favored in all but 4 countries. In the scenario comparing high gas equipment efficiency to low efficiency HPs, HPs are favored in all but 6 countries and even in those locations the difference in operating costs is marginal.

Figure 4: Spark Spread Scenarios in Select EU Countries (all values €/kWh) *Positive value (blue coloring) is favorable to heat pumps



* We model four combinations of equipment efficiency: the first designation in each case is HP efficiency, the second is natural gas equipment efficiency.

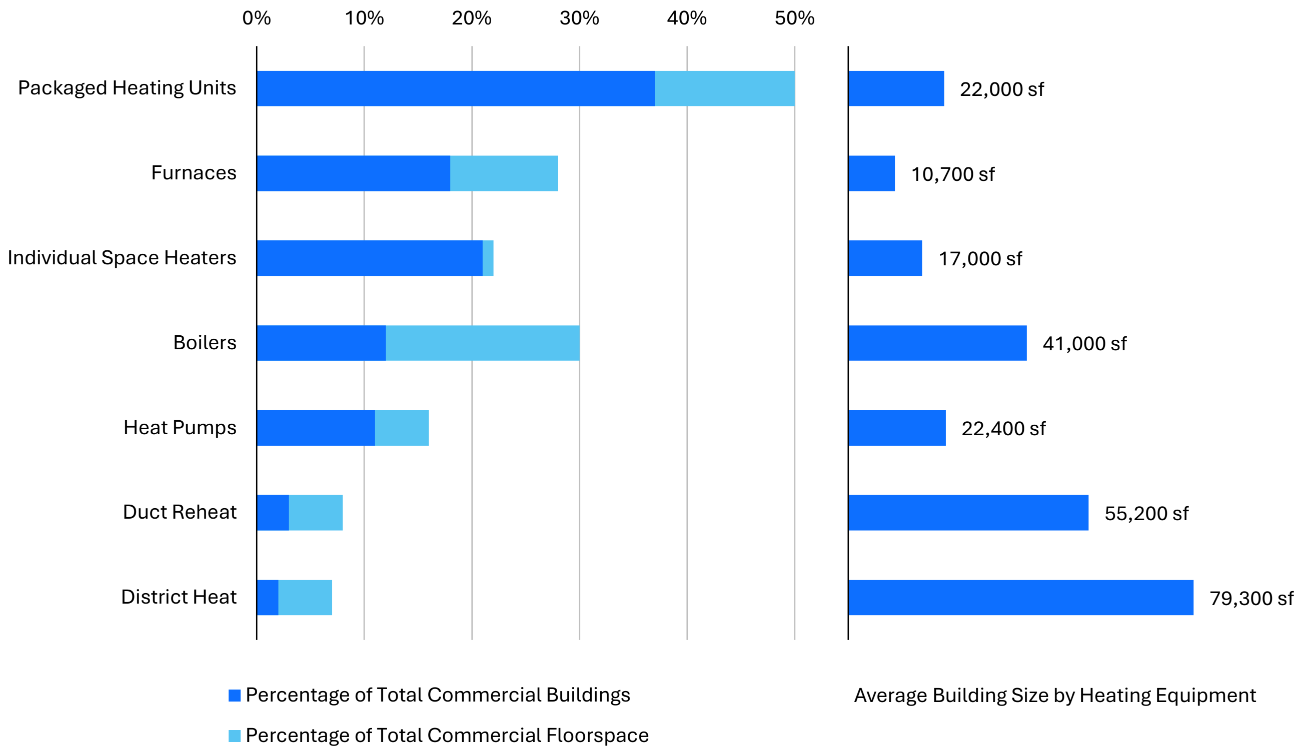
10) Note that EU regulations specify Seasonal Space Heating Energy Efficiency which is then converted to COP by dividing that value by 35.

Commercial

Across the U.S., 32% of total energy use in commercial buildings is used for space heating [16], highlighting the potential for efficiency to lower operating costs in this sector. There is little recent, publicly available market share data on sales of commercial heating and cooling equipment, and what little exists is often mixed in with broader residential numbers.

In the U.S., the EIA performs a Commercial Building Energy Consumption Survey (CBECS) periodically—the latest conducted in 2018—that provides insight into equipment use in existing building stock. Like the residential sector, there is geographic discrepancy in heating sources—but overall ~12% of commercial buildings representing ~17% of total commercial floor space use HPs (Figure 5) with the majority of other space heating equipment using natural gas as a fuel [17].[11]

Figure 5: Share of Commercial Building Heating by Equipment [17]. Note more than one type of heating equipment can apply.



Because of their prevalence, boilers and packaged heating units are used as fossil benchmarks for a spark spread analysis. For the boundary assumptions of efficiency, regulatory and EnergyStar standards—which vary based upon the size of the equipment—were used.

Table 3 provides the lowest acceptable value for a given standard for commercial equipment of any size. For HPs, size plays an outsized role in efficiency with smaller commercial units often operating with a COP of up to 3.6 while larger commercial units tend to operate around the regulatory minimums.

11) Note that the EU has the Building Stock Observatory [18] but does not present heating data by equipment type so a similar analysis cannot be performed for all of Europe.

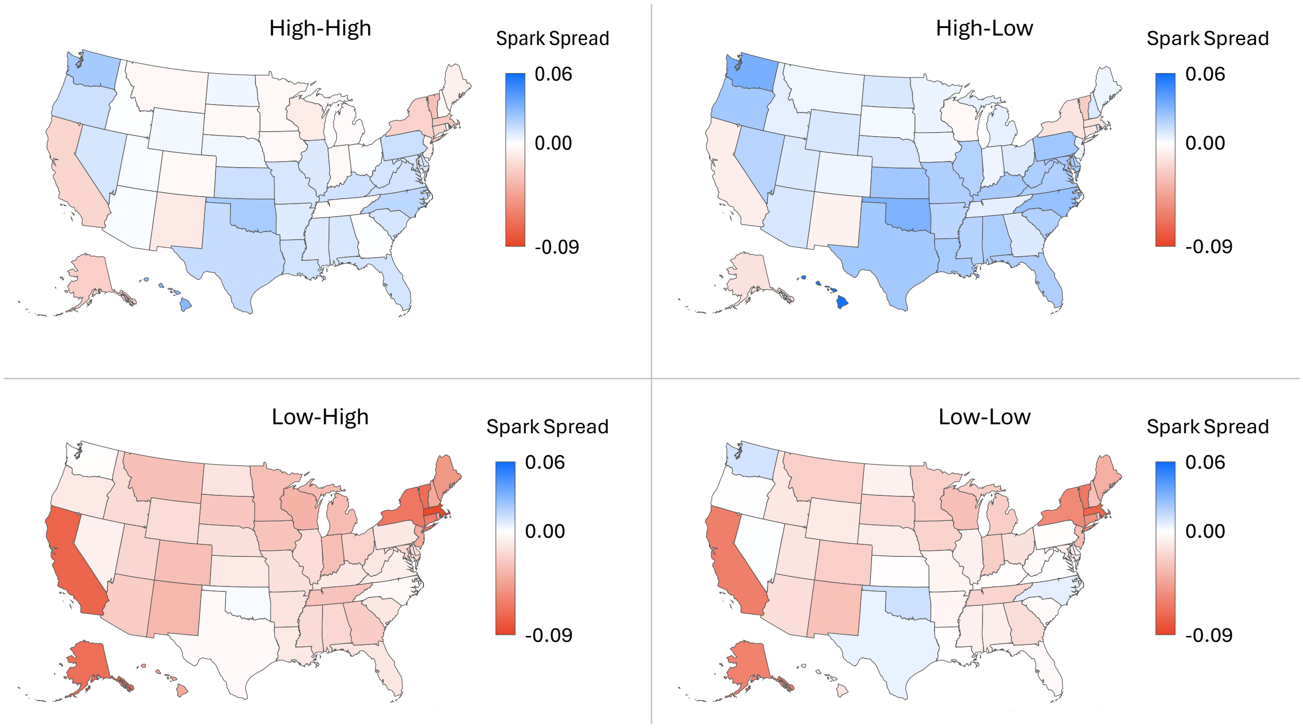
Table 3: Efficiency Metrics for Commercial Heating Equipment in the U.S.

	Boilers (%)	Gas Furnaces (%)	HPs[12] (SCOP)
Current Efficiency Standard	77-79% [19]	81% [20]	2.9[13] [21]
Current EnergyStar Requirement	94% [22]	N/A[14]	3.2 @ 47F, 2.1 @ 17F [23]
Best Available Today	~94%	~94%	~3.6

The spark spread analysis presented in Figure 6 is conducted using commercial electricity prices [24] from and 12-month average gas prices [25] ending in June 2025.

Unlike the residential sector, the commercial sector shows a key dependency on HP efficiency—high efficiency HPs reduce operating costs in nearly every state, while gas solutions are favored in most states when HP efficiencies are low.

Figure 6: U.S. Commercial Building Spark Spread Analysis (all values $/kWh) *Positive value (blue coloring) is favorable to heat pumps



* We model four combinations of equipment efficiency: the first designation in each case is HP efficiency, the second is natural gas equipment efficiency.

12) For heating, the standards are given in measurement of HSPF2. Here HSPF2 is converted to COP by dividing the HSPF2 value by 3.412.

13) Note that testing conditions specify this is the COP at 47F.

14) There is a specification for cooling efficiency, the packaged unit only must meet that metric and the DOE regulatory minimum for heating efficiency to receive the EnergyStar certification.

A commercial spark spread calculation was also performed for the 29 EU countries with data. Gas [26] and electricity [27] prices from the second half of 2024 were used.

Table 4 shows regulatory minimum and best available efficiencies for common commercial space heating equipment in the EU.

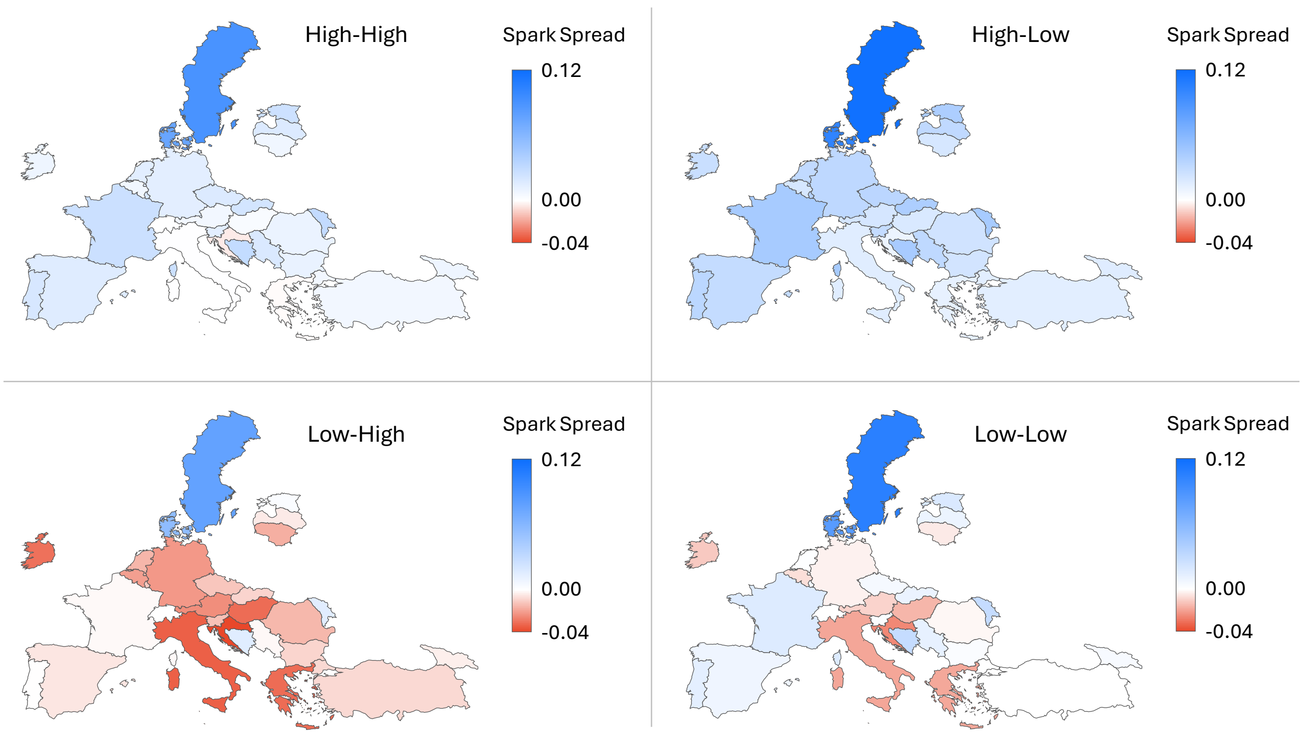
Table 2: Efficiency Metrics for Residential Heating Equipment in Europe

	Gas Boilers <400kW (%)	Commercial Gas Warm Air Heaters <1MW (%)	Electric HPs (SCOP)
EU Minimum Requirement	86% [28]	78% [29]	~2.5 for medium temp, ~2.9 for low temp [29]
Best Available	~98%	~96%	~4.0

Figure 7 shows that HP efficiency is the determining factor in heating economics for commercial EU buildings. High efficiency HPs offer savings in all countries regardless of gas equipment efficiency.

Meanwhile, highly efficient gas equipment is cheaper to operate in most countries when HP efficiency is low. When both types of equipment have low efficiency, the situation is more nuanced—HPs are favored across most of Northern Europe while gas wins in Southern Europe.

Figure 7: EU Commercial Building Spark Spread Analysis (all values €/kWh) *Positive value (blue coloring) is favorable to heat pumps



* We model four combinations of equipment efficiency: the first designation in each case is HP efficiency, the second is natural gas equipment efficiency.

Future Economic Competitiveness

Looking to the future, there is great concern over rising electricity prices, which would increase the operating costs of HPs. While true, one of the key drivers of electricity price increase in the U.S. is natural gas price increases. U.S. natural gas prices are expected to more than double to $4.90/mmBtu from $2.20/mmBtu in 2024, driven by increasing liquid natural gas (LNG) export volumes. While these bulk price increases are not always directly passed on to consumers, it is likely that natural gas prices will increase as fast or faster than electricity prices [30]. This would maintain or improve the economics of HPs for heating in the U.S. moving forward.

Energy price trends in Europe are a different story—both gas and electricity prices have been falling as they normalize following price spikes driven by the Russian invasion of Ukraine. Prices appear to have recently stabilized and even slightly increased—at least for gas—in 2024 and forward projections call for both electricity and gas prices to generally move in tandem, though with higher volatility in gas [31]. If accurate, this would maintain economic favorability for HPs for heating in the EU as well.

Technical improvements to HPs are another reason to believe that HPs will continue to be the favored choice in heating solutions. HP technology is making meaningful efficiency gains in cold weather and in overall performance [32]. Meanwhile, the maximum efficiency any natural gas fired equipment can achieve is 100% and, given that performance is already near this maximum, there is little opportunity for further improvement.

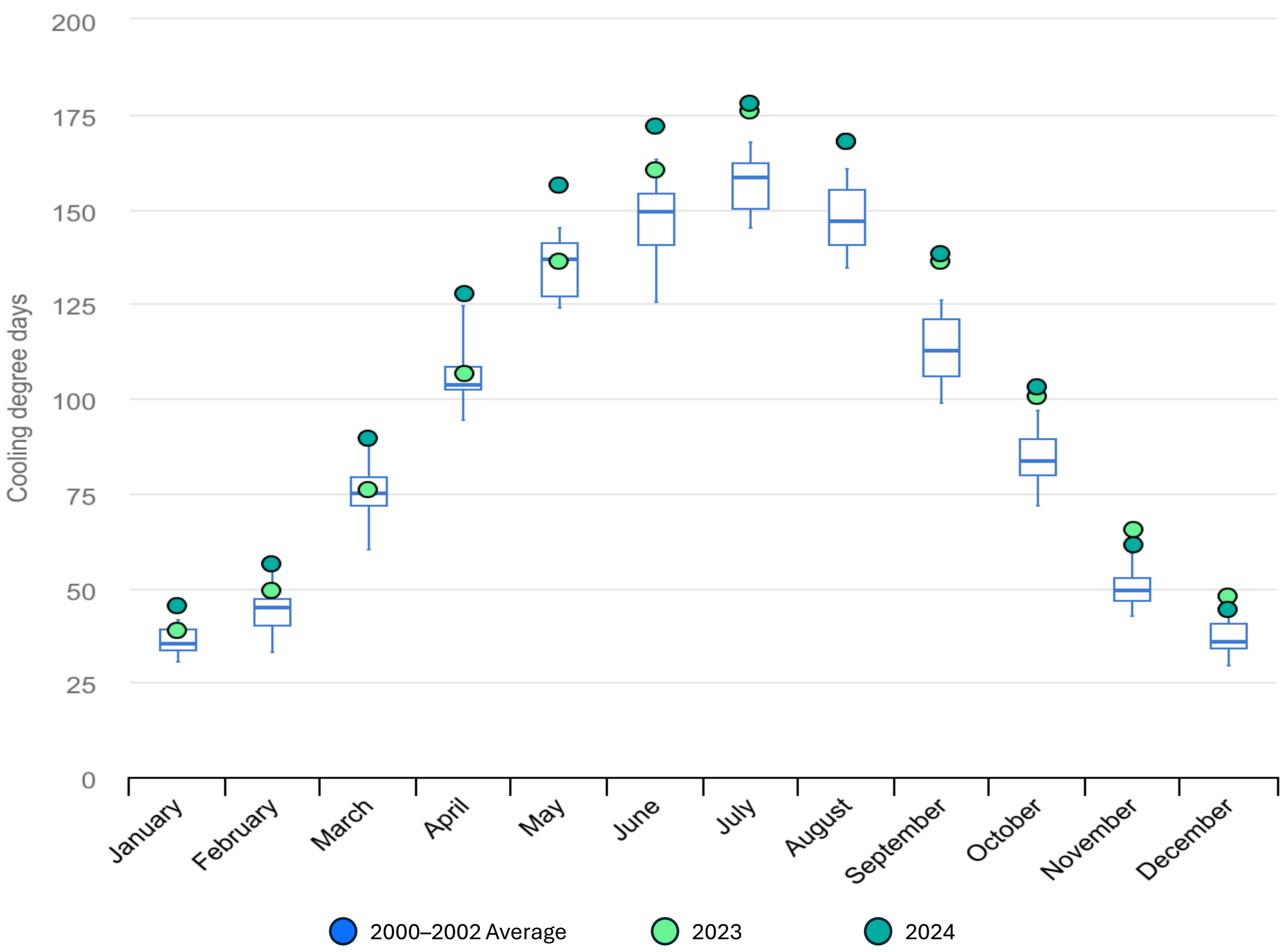
3: Cooling

3 Cooling

As the world warms, the number of global cooling degree days is significantly increasing, creating larger demand for AC (Figure 8) [33]. This is resulting in increased demand for AC in the residential sector as well as regulations specifying workplace temperature thresholds, such as those recently implemented in California [34].

The most recent survey of U.S. residential homes found that 66% of homes had central AC and an additional 22% had AC of some other form (e.g., window, portable unit, ductless HP, etc.) [35]. When it comes to newly constructed homes, nearly 98% of those built in the U.S. in 2024 had a central AC system [36]. Solid data on European use of AC is much harder to come by. The IEA estimates that only 20% of European households have AC today [37] with recent country specific adoption estimates varying widely, from about 5% in the UK [38] to about 10-20% in Germany [39], France [40], and Sweden [40] to ~50% in Italy [41] and Spain [40]. Unlike the U.S., most European AC systems are ductless HP [42].

Figure 8: Global Cooling Degree Days in 2024 vs. 2023 and 2000-2022 Average [32]



For homes with central systems or for commercial equipment types, use of a HP instead of gas-fired equipment does not offer operational cost savings—when considering a new purchase—as traditional AC systems also use electricity and a vapor compression cycle. And, in fact, in the U.S. all central [8] or commercial [43] systems have the same minimum efficiency requirements and EnergyStar standards [7], [23] regardless of equipment type. This is also true for commercial equipment [44] in the EU—there is not a standard for residential non-HP cooling systems in the EU as they are not used.

There are, however, significant saving opportunities by using ductless HPs. These HPs typically have higher cooling performance than central systems, for the same reasons they perform better in heating (i.e., no air ducts). While regulatory standards are not differentiated for ductless HPs in the U.S., most operate with a COP of ~5.5 – 6 for cooling. When compared to the U.S. regulatory standard for central systems—about a COP of 4.2, where most of these systems operate—this represents a ~31–43% improvement, which would reduce cooling bills by ~24-30%.

HPs also offer cooling costs advantages in existing homes without central systems. Most homes of this type in the U.S., if they have AC, use window or portable AC units. Efficiency regulation depends upon size for these units, but in total the standard only requires that a COP of ~2.7-3.2 be reached for units of these types—though existing regulation will push this to ~3.8–4.7 for units manufactured after May 26, 2026 [45]. Energy Star certification only requires a 10% increase over this standard, meaning a COP of ~3–3.5 [46] for current units and presumably to 4.2–5.1 once the new regulation takes effect, though the new EnergyStar standards are still under development. In either case, ductless HP systems offer cost of cooling advantages—at least 14.5% if considering the 2026 standards and up to 122% when considering today's standards.

As ductless HPs are the leading cooling solution in Europe, their increased adoption is not driven by cost savings. Instead, it is estimated that 33% of the European population already lives in a climate where cooling is needed—against, again, only 20% of households current having it—and the combination of demographic trends and continued warming will require doubling the installed base of AC units to 275M by 2050 [47].

4: Equipment Costs

4 Equipment Costs

The final economic consideration when comparing HPs to more traditional HVAC equipment is the cost for the equipment and installation. This is where generalizations for large regions are difficult. For example, in the U.S. the equipment cost for a full residential HVAC system is similar if heating is done with a furnace or a HP unless the HP[15] is very high efficiency [48]. However, there is wide variation in installation cost. For new construction, the installation costs are similar. Meanwhile, if replacing an existing system—but not the ducts—HP installation can range from $1,000 to >$10,000 in higher costs [49]. Much of the increased cost results from electrical upgrades, if required, and the experience, or lack thereof, of installation teams in the area. Alternatively, if a home needs ductwork or duct replacement, a ductless HP can save tens of thousands of dollars by avoiding this work altogether.

The story for residential equipment in Europe is somewhat different. The cost of equipment is significantly higher for a HP relative to commonly used fossil-fired equipment—recent estimates are up to ~4X and ~2-3X higher in the UK [50] and Germany [51] respectively—driven by the need in some homes to replace the existing radiator piping to accommodate a HP and the lack of associated additional AC equipment for non-HP solutions. However, if a home needs AC—and, as shown, many more will need it—the only viable AC solution for existing building stock is a ductless HP.

Finally, for the commercial sector there is very little comparative data on capital cost between technology types for the U.S. or Europe, driven by the significant amount of customization that is done for each building in this sector. In 2023, the U.S. EIA produced an estimate for the cost of some commercial space heating equipment for their own modeling efforts. Table 5 presents these values for the most comparable space conditioning equipment types available in the survey—representing potentially ~50% of the market—and shows that HPs are expected to offer a slight CAPEX discount across all efficiency ranges.

Table 5: Estimated Commercial Space Heating Equipment and Installation Cost (all values 2022$) [52]

	Commercial Gas Furnace + Rooftop Air Conditioner[16]	Commercial Rooftop HP
Standard	$16,140	$14,810
Energy Star v4.0	$17,550	$15,510
High Efficiency	$20,180	$18,860

5: Conclusion

15) Highly efficient cold weather HPs are still more expensive than even the most efficient furnace equipment, though the relative nascency of the technology means that there is opportunity to materially reduce cost in the future.

16) Costs here are the addition of both equipment types, inclusive of installation. As EIA estimates costs separately, there may be savings of up to ~$1300 if installing both pieces of equipment at the same time.

5 Conclusion

HPs are growing market share across the U.S. and Europe in both the commercial and residential sectors, driven by their favorable operating costs. Based upon estimated future energy costs, this trend is likely to continue moving forward. Further, as the world warms more AC will be increasingly needed globally. In existing building stock without central HVAC systems—effectively all of Europe and a sizeable portion of the U.S—it is cost prohibitive to install the ducting necessary for these systems. Ductless HPs are only real solution available in Europe for this situation at the moment, while in the U.S. they offer considerable operating cost savings over other solutions like window or portable AC units. Finally, there is significant headroom for HPs to improve performance and lower costs—which is not the case for gas-fired alternatives—providing further tailwinds to their growth in market share. Considered in total, this represents a major global trend that Galvanize is actively investing in across strategies and asset classes– from positions in Quilt and Carrier to GRE's emphasis on HP installation in acquired properties.

6: Bibliography

6 Bibliography

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