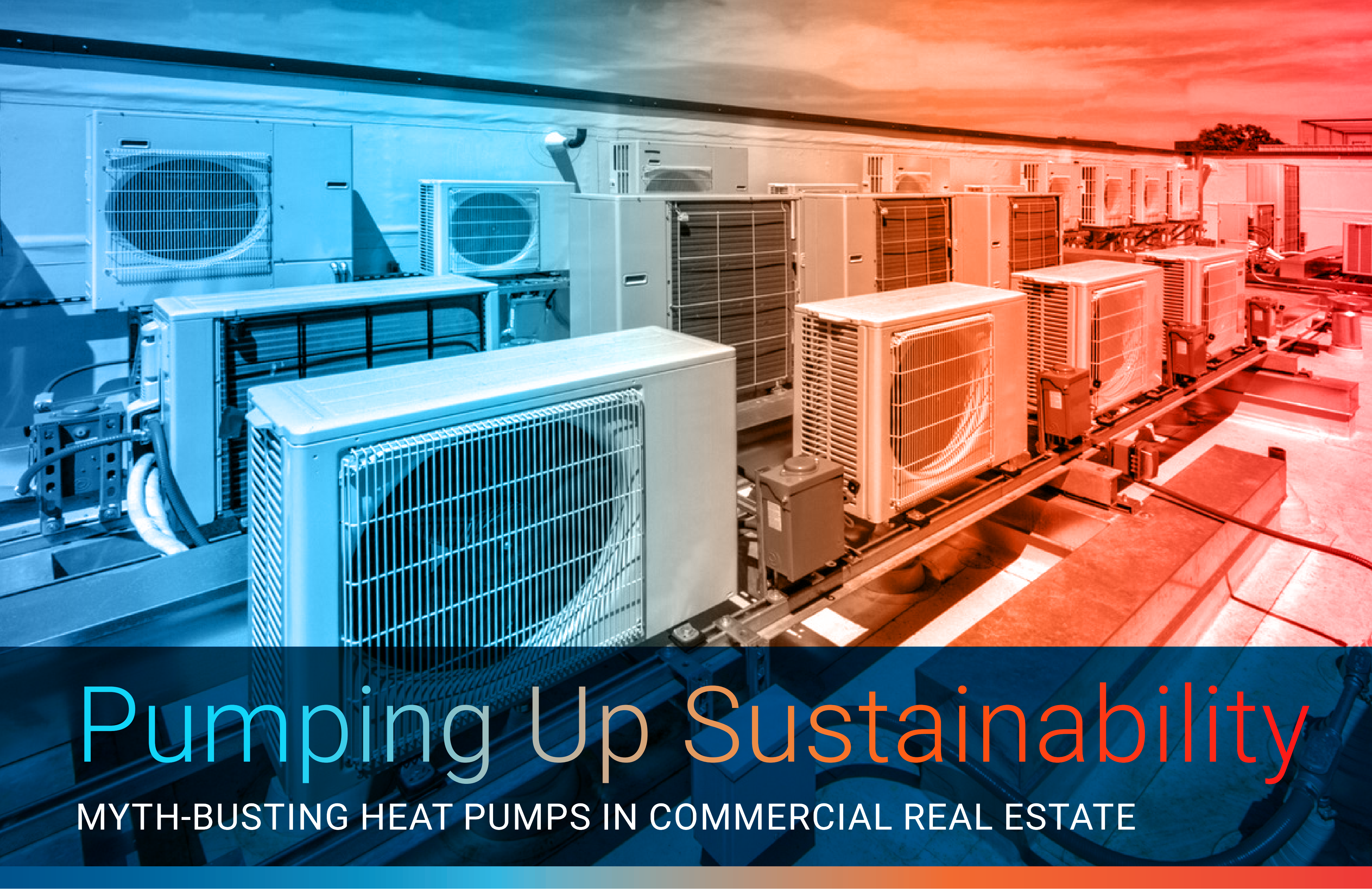

Pumping Up Sustainability

MYTH-BUSTING HEAT PUMPS IN COMMERCIAL REAL ESTATE

ASHRAE®

ULI Urban Land Institute

About the Urban Land Institute

The Urban Land Institute is a global, member-driven organization comprising more than 48,000 real estate and urban development professionals dedicated to advancing the Institute's mission of shaping the future of the built environment for transformative impact in communities worldwide. ULI's interdisciplinary membership represents all aspects of the industry, including developers, property owners, investors, architects, urban planners, public officials, real estate brokers, appraisers, attorneys, engineers, financiers, and academics. Established in 1936, the Institute has a presence in the Americas, Europe, and Asia Pacific regions, with members in 84 countries. More information is available at uli.org. Follow ULI on X (formerly known as Twitter), Facebook, LinkedIn, and Instagram.

About ULI's Randall Lewis Center for Sustainability in Real Estate

The ULI Randall Lewis Center for Sustainability in Real Estate leads the real estate industry in creating places and buildings where people and the environment thrive. In collaboration with ULI members and partners, the Lewis Center drives industry transformation, cultivates leaders and champions, and helps foster solutions for sustainable, resilient, healthy, and equitable cities and communities. The center pursues these goals via cutting-edge research, global convenings, community technical assistance, and other strategies. The center's main programs are Decarbonization, Urban Resilience, and Healthy Places. Discover transformative practices for real estate and land use at uli.org/sustainability. Connect with the Lewis Center at sustainability@uli.org.

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About the ULI Net Zero Imperative

The ULI Net Zero Imperative is a multiyear initiative to accelerate decarbonization in the built environment and is a significant aspect of ULI's work to advance its net zero mission priority. The program sponsors technical assistance panels in a select number of global cities per year and is designed to help building owners, cities, and other relevant constituents reduce carbon emissions associated with buildings, communities, and cities. The generosity of Owen Thomas and additional gifts from Lynn Thurber, Joe Azrack, Franz Colloredo-Mansfeld, and Dan Cashdan have made it possible to further support and bolster the Net Zero Imperative program's scale and impact in global cities to help accelerate efforts toward net zero.

About ASHRAE

Founded in 1894, ASHRAE is a global professional society committed to serving humanity by advancing the arts and sciences of heating, ventilation, air conditioning, refrigeration (HVAC&R), and their allied fields. The organization is an industry leader in research, standards writing, publishing, certification, and continuing education. ASHRAE and its members are dedicated to promoting a healthy and sustainable built environment for all, through strategic partnerships with organizations in the HVAC&R community and across related industries.

About This Report

Heat pumps have a critical role to play as the real estate industry undertakes holistic energy-efficiency improvements on its journey to net zero. Practitioners in America are not yet comfortable with heat pumps, and there is a lack of resources available to guide commercial developers toward the incorporation of heat pumps into new construction and retrofits. There are also misconceptions about the availability or feasibility of incorporating heat pumps into different climates and use cases. The need for this publication came from Net Zero Imperative participants across the United States who are struggling to electrify and convince individuals to use heat pumps, and thus the topic was elevated nationwide. Many myths surround heat pumps, given how they challenge the traditional gas heating model. This report seeks to convey up-to-date information about electric heat pump technology, to equip real estate practitioners with the knowledge they need to inquire about heat pumps in new and existing projects.

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Introduction

As the real estate industry rises to meet net zero energy goals, there is global interest in building electrification. According to research by the World Green Building Council, 28 percent of global carbon emissions currently comes from building operations; and the World Economic Forum reports that 15 percent comes exclusively from heating and cooling buildings. To achieve net zero targets, buildings will eventually need to be powered by 100 percent renewable electricity. Thus, the heating and cooling of buildings presents a clear opportunity for investors, owners, and developers of new construction and retrofits to leverage energy-efficient innovations. Heat pumps are a key technology that will facilitate the transition to all-electric buildings.

Learn more about the electrification movement at uli.org/electrify.

The real estate industry continues to drive decarbonization to meet investment demand as the policy regulation landscape evolves. Heat pump technology is becoming an increasingly scalable solution toward fully electrifying commercial real estate and—as part of the holistic effort to tighten building envelopes and reduce overall building energy loads—could lessen building-related heating and cooling emissions by up to 20 percent. In addition to their environmental benefits, heat pumps offer the potential for enhanced occupant comfort and energy bill savings for tenants.

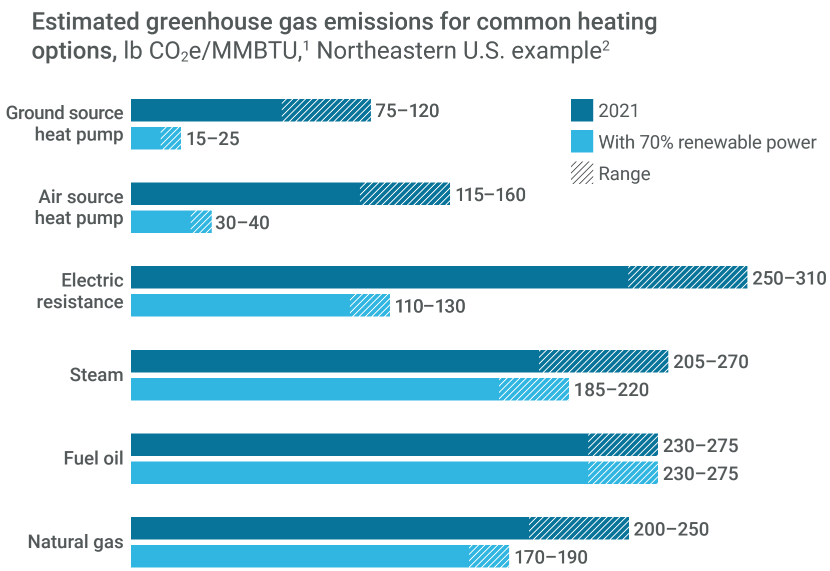
BUILDING CODES

An expanding number of U.S. cities have introduced building code amendments that create more stringent requirements for energy efficiency for both new and existing buildings. Some cities prohibit buildings from hooking up to natural gas systems altogether (e.g., New York City; Berkeley, California; and Denver, Colorado), while legislation in Seattle, Washington, requires heat pumps in future multifamily construction.

The transition to electric heat pumps is already underway. In 2022, global sales of heat pumps grew by 11 percent, marking the second year of double-digit growth for the technology. If this growth trend continues, heat pumps could double their share of heating buildings across the globe by 2030.

The United States has historically trailed significantly behind Europe and Asia in heat pump adoption. In 2022, for the first time, electric heat pumps outsold gas furnaces in America.

FIGURE 1. EMISSIONS FROM HEAT PUMPS POWERED BY RENEWABLE ENERGY VERSUS OTHER HEATING METHODS



[1]Pounds of carbon-dioxide equivalent per million British thermal units.
[2]Averages across different building types.

Source: U.S. Environmental Protection Agency; McKinsey & Company analysis.

WORKFORCE TRAINING

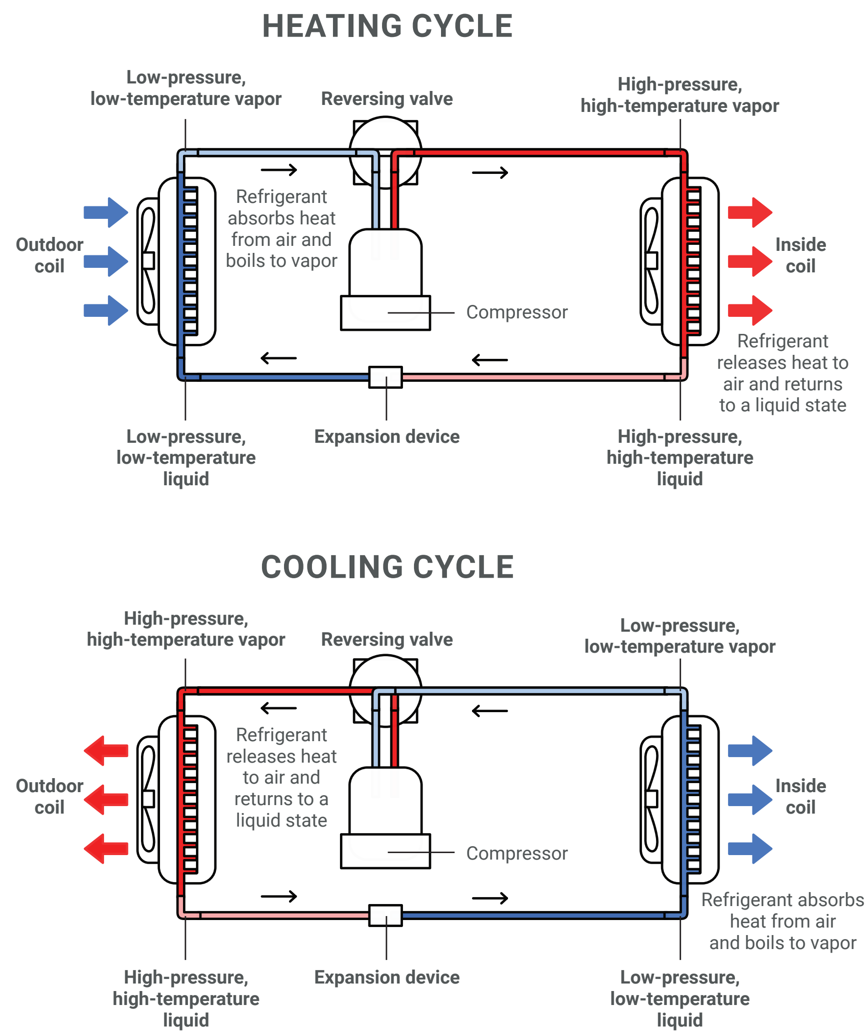
One of the major barriers to heat pump adoption in the United States is resistance from the workforce who are neither knowledgeable about nor skilled in installation of heat pumps. Training programs are sprouting up across the country to educate a new workforce for this energy transition, especially at mechanical, electrical, and plumbing firms. Increased extreme heat events have also created a business opportunity to increase heat pump manufacturing and equipment installation training hubs in markets that were previously unaccustomed to this heating and cooling technology.

Despite the benefits of and demand for heat pumps, many myths about their effectiveness, cost, and performance still plague the industry. Heat pumps have been around since the 1850s, but technological breakthroughs have made them even more effective and efficient. Modern heat pumps can heat spaces and water in mid- or high-rise buildings efficiently in cold weather down to −10 degrees Fahrenheit and, equally, cool spaces in mid- or high-rise buildings in the warm summer months. Heat pumps powered by renewable electricity are a crucial part of real estate's journey toward net zero. See figure 1 for estimates of carbon emissions savings achieved by different types of heat pumps and other heating and cooling mechanisms.

What Is a Heat Pump?

Heat pumps are able to both heat and cool spaces. They offer an electric, low-carbon alternative to gas furnaces, boilers, and air-conditioning (AC) units, acting as all-in-one heating and cooling mechanisms that run in both modes of operation. When the weather is warm, air-source heat pumps function as traditional AC units, pumping heat out of the building to circulate cooled air inside a building. When the weather is cold, they change the direction of refrigerant flow, drawing heat from outside into the building. (Yes, there is heat outside, even when the temperature is colder outside than inside.) Ground-source and water-source heat pumps operate the same way, but they transfer heat from the ground and water, respectively. Regardless of the energy source, the process uses refrigerant and a compressor to move heat from one location to another.

HOW HEAT PUMPS WORK



Heat pumps provide hot or cold air or water for distribution. However, rather than using electricity or gas to adjust temperature, they use a compressor to move heat in the direction needed for thermal comfort. And they have advanced heat recovery, whereby heat energy is transferred back into the system for use in heating air, water, or other applications.

As already mentioned, heat pumps can use a variety of energy sources. And they may be ducted or ductless. Most commonly, they are air-source or ground-source (water-source is only occasionally utilized). Air-source heat pumps transfer heat between indoor air and outdoor air and are often seen in both single-family and multifamily residential heating and cooling.

Ground-source (or geothermal) heat pumps transfer heat between the air inside a space and the ground. Ground-source heat pumps may have a higher upfront cost but can be more efficient, especially at low ambient outdoor temperatures, and have a lower operating cost due to the consistency of ground temperature throughout the year. The ground-source option may be particularly viable for master-planned projects on ample land, allowing for efficiency at scale.

Figure 2 outlines a variety of heat pumps for commercial real estate and the benefits of each, which apply based on the specifics of a given project or building. The main difference is the source of the heat they extract.

DIFFERENT HEAT PUMPS FOR DIFFERENT RETROFIT USE CASES

While heat pumps offer a strong decarbonization solution, particularly in new construction, operational viability and installation costs vary widely across different asset classes for existing buildings. The age and size of the building, along with the current heat distribution system, all have an effect. For this reason, it is imperative that building owners and developers meet with an experienced engineering consultant early and often when considering the switch from gas to electric. For more information, refer to the Questions to Ask Design Professionals for Heat Pump Retrofits section of this primer.

FIGURE 2. TYPES OF SPACE HEAT PUMPS FOR COMMERCIAL REAL ESTATE

Heat Pump	Key Characteristics
Air-source heat pump (ducted)	• The most common type of heat pump in the United States • Transfers air from inside to outside to heat and cool a building with a split system (one indoor and one outdoor coil) • Versatile: can be used in almost any climate, on rooftops in mid- or high-rise buildings, and is viable for new constructions and retrofits • Dual-source capabilities: if necessary, can be combined with a gas furnace as a backup heat source • Cold climate heat pumps: viable in extreme temperatures—regularly below 0 degrees Fahrenheit (Traditional air-source heat pumps run less efficiently in temperatures regularly below 0 degrees Fahrenheit.)
Centralized variable refrigerant flow (VRF) systems	• High-powered, high-efficiency commercial devices with zone-by-zone comfort control for occupants • Uses refrigerant to capture and repurpose existing heat from the environment • Ideal for high-rise and larger commercial and multifamily projects (Instead of each unit having its own HVAC system, the VRF system uses a central, rooftop condensing unit that allows a building to heat and cool simultaneously.) • Risk of refrigerant leakage and resulting fugitive emissions: may outweigh emissions savings in the full life cycle depending on leakage rate
Mini-split heat pump (ductless or ducted)	• Single-zone heat pump with one indoor unit and one outdoor unit • Ductless: a wall-mounted unit (most common) • Ducted: delivers heating or cooling to multiple rooms • Strong option for smaller multifamily projects (only one needed for studios/one-bedrooms) with limited thermal zones, or for larger spaces with precise temperature control in different rooms • Risk of refrigerant leakage and resulting fugitive emissions
Water- or ground-source heat pump (geothermal)	• Uses water or ground as the heat source (otherwise similar to air-source heat pump) • Available in a variety of configurations and sizes and can be placed in several areas of a building (e.g., a small closet in multifamily units) • Functions efficiently in nearly any climate, regardless of outside air temperature since that is not the heat source • Ground-source: much higher upfront cost because a ground loop must be installed; once installed, can serve multiple buildings; strong option for multi-building, greenfield development projects • More challenging in denser areas with existing underground infrastructure (e.g., metro lines) • Lower impacts on electrical infrastructure in cold climates as the connected load is greatly reduced

Source: From "The 9 Types of Heat Pumps," the *Air Conditioning, Heating, Refrigeration News*.

The Business Case for Heat Pumps

The business case for moving commercial real estate toward heat pumps as a high-impact way to reduce carbon emissions is clear. The benefits to implementing heat pumps into real estate projects range from financial to regulatory, environmental, and social (see figure 3). Given the increasing stakeholder pressures to electrify and the significance of the business opportunity, real estate practitioners who lead in the decarbonization effort are seeing the return on investment play out.

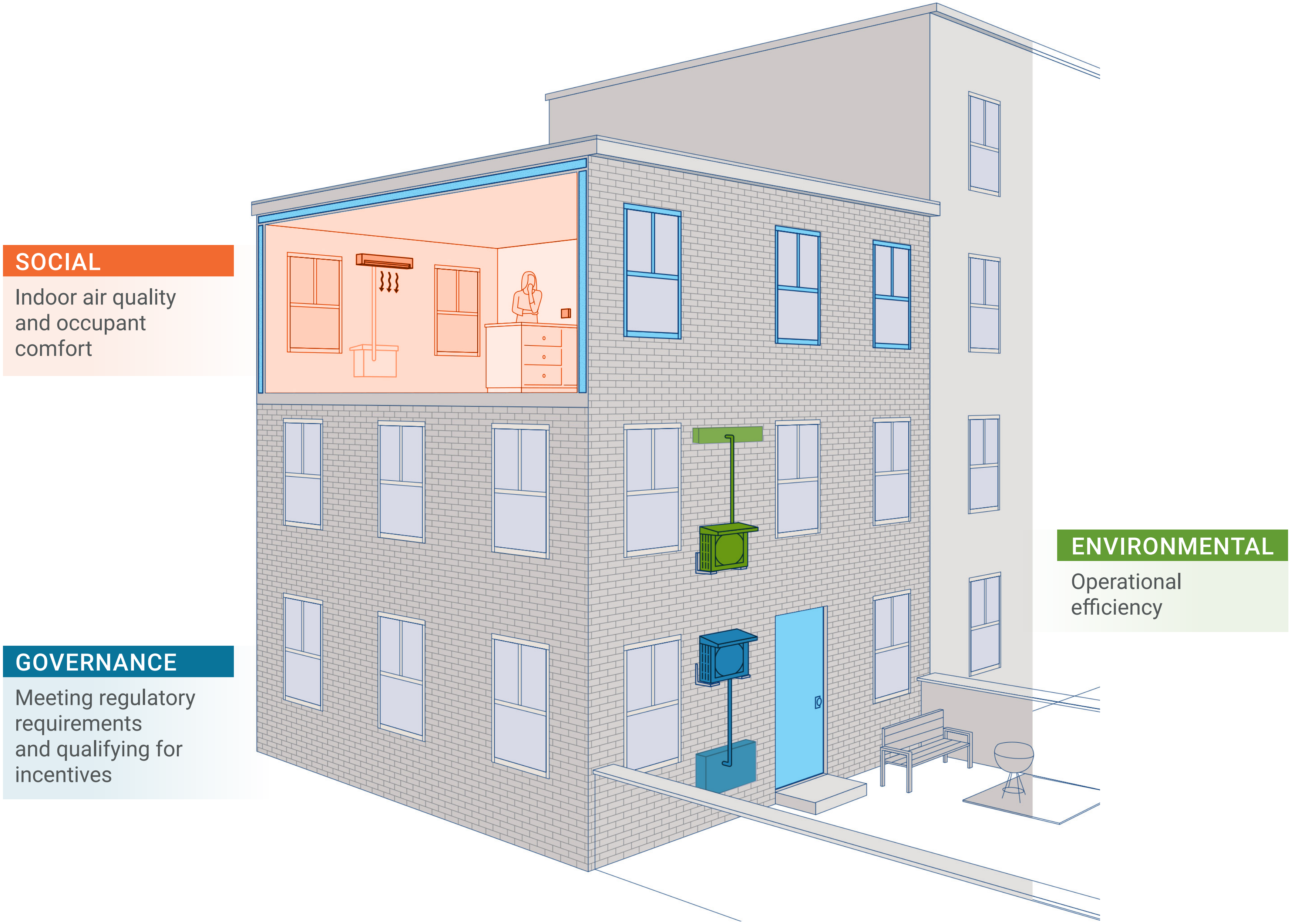
In particular, heat pumps are an obvious choice for new construction with tight building envelopes of any asset class. They offer significant long-term cost savings despite occasionally requiring a higher upfront cost. The decision to retrofit buildings that have existing gas furnaces or boilers is more nuanced, but heat pumps are still often a viable option and worth discussing with an engineer.

RETROFIT TIP: EXPLORE ELECTRIFICATION OPPORTUNITIES DURING BUILDING TURNOVER

For retrofits, converting to heat pumps for cost savings is generally contingent on the scope of the building upgrades. For large multifamily and commercial buildings, holistic building retrofits can be unobtrusively explored while buildings are temporarily vacant or undergoing other renovations. For hotels looking to upgrade from traditional packaged terminal air conditioner systems, heat pump retrofits are easily feasible during slow season when sizable percentages of rooms are unoccupied. Retrofitting individual pieces of equipment can also be explored at the end of the useful life of existing equipment—a less invasive way to slowly retrofit components of a building without displacing occupants.

An architecture, engineering, and construction consultant can assess the building envelope and any supplemental installation (e.g., ductwork or wiring), if needed. And other electrification improvements can be explored at the same time—induction cooking, electric vehicle charging, water heating, or general increased electrical capacity.

FIGURE 3. BUSINESS CASE FOR HEAT PUMPS



Source: ULI.

Operational Efficiency

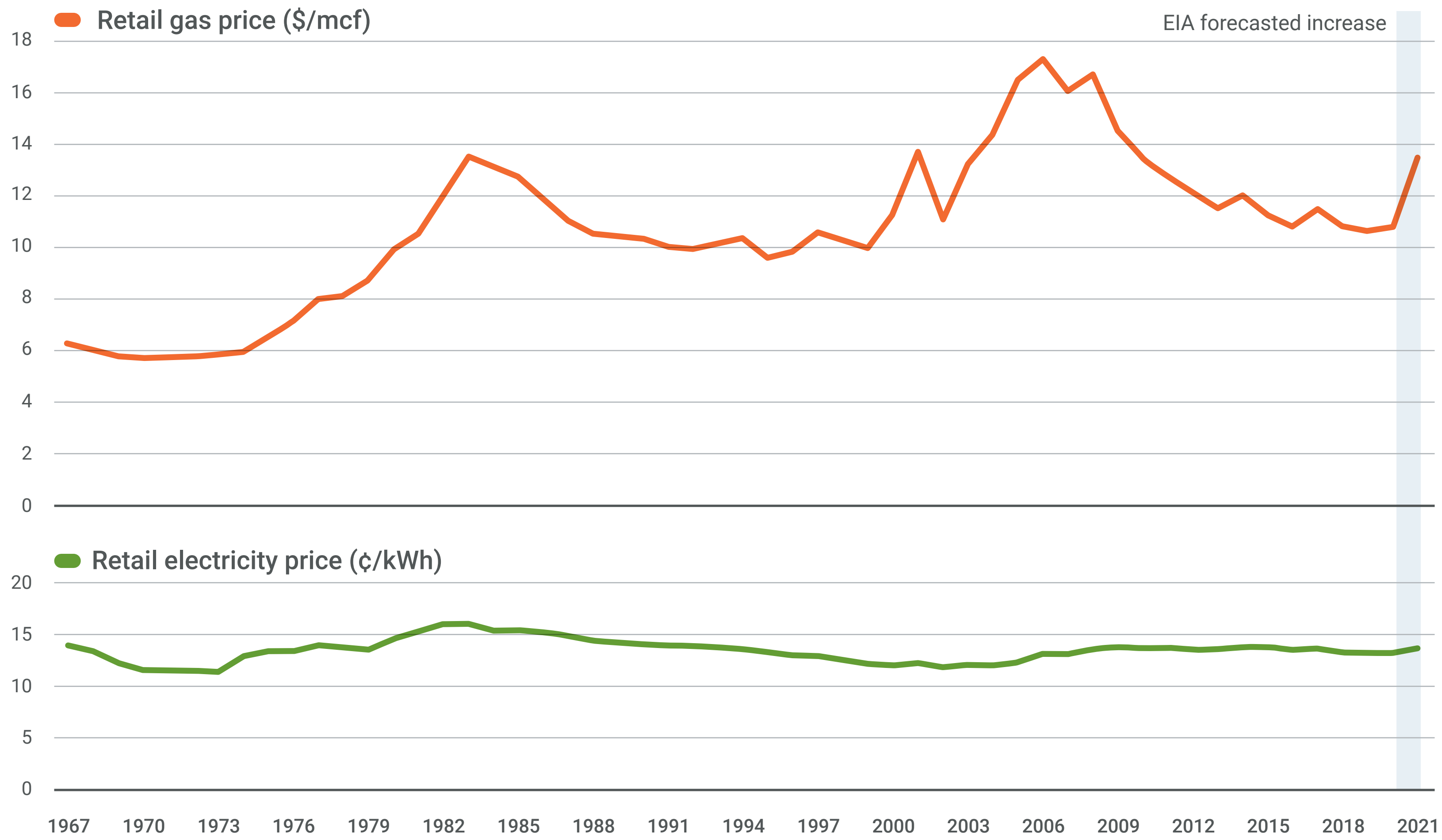
Heat pumps are extremely efficient—at least three times more efficient than traditional gas or electric heating systems. Over time, they have become increasingly competitive—beating fuel oil, propane, and electric baseboards in operating cost—and can lead to life-cycle cost savings during development and operations. These energy savings are contingent on the overall energy efficiency of the building's structure, specifically a tight envelope, to avoid leakage of conditioned air.

Natural gas is the main cost competitor as the utility of choice to heat the building, but the price gap has been closing in recent years. Historically, the market has experienced significant volatility in gas prices, while electricity has remained more constant and therefore more predictable (figure 4).

Commercial heat pump systems, such as VRF, can simultaneously handle both heating and cooling thermal loads. Although they may require a higher upfront and investment cost, the long-term energy savings will return the higher initial investment several times over the heat pump's life cycle.

Research suggests that over the course of an average year, heat pumps can save multifamily residents 20 to 40 percent on their annual heating and cooling bills compared to non–heat pump conditioned units. And if well-maintained, heat pumps can last between 15 and 20 years. As housing prices continue to increase, lower energy costs are becoming increasingly important to renters searching for affordable living spaces. With competition for occupants, building owners and developers face more pressure to deliver the most efficient and low-cost spaces to gain a market advantage of tenant attainment and retention—and ultimately to realize high asset value upon sale.

FIGURE 4. VOLATILITY OF GAS PRICES VERSUS ELECTRICITY PRICES



Source: Rocky Mountain Institute analysis of EIA retail gas and electricity prices and forecasts and Federal Reserve Economic Data inflation adjustment factors.

Improved Occupant Comfort and Air Quality

According to the Environmental Protection Agency, the average American spends about 90 percent of his or her time indoors (in homes, schools, offices, hotels, retail spaces, places of worship, and so on). The most vulnerable groups (infants, children, the elderly, and immunocompromised individuals) tend to spend even more time indoors. These significant statistics underscore the importance of indoor air quality and its effects on human health outcomes.

Indoor combustion sources are a leading pollutant contributing to poor air quality. Several studies have shown the adverse effects of gas heaters and stovetops on respiratory health, including the significant negative outcomes in development of asthma during childhood.

Across all asset classes, tenants are increasingly prioritizing their health when making decisions about where they will live, work, and play, particularly following the COVID pandemic. The Global Wellness Institute found that between 2019 and 2021, the number of WELL Building Standard and Fitwel buildings increased by nine times. Heat pumps, along with other electric technology such as induction cooking stovetops, offer the opportunity for healthier buildings and spaces.

In addition to removing a contributor to chronic health conditions, heat pumps offer improved occupant comfort over gas heating and cooling technology. Mini-split systems, known for being cost-effective and energy efficient, have the same precise control that all heat pumps do. In addition, given their distributed nature, they allow tenants to control the temperature in their own apartment or condominium units—and in each room for larger multi-zone units—presenting a significant market advantage. “Potential tenants get excited when they are touring larger [multifamily] units and see a [mini] split system,” says Sara Lebastchi, vice president of operations at D&S Development, based in Sacramento. “The control of different temperatures in different rooms is a big selling point.”

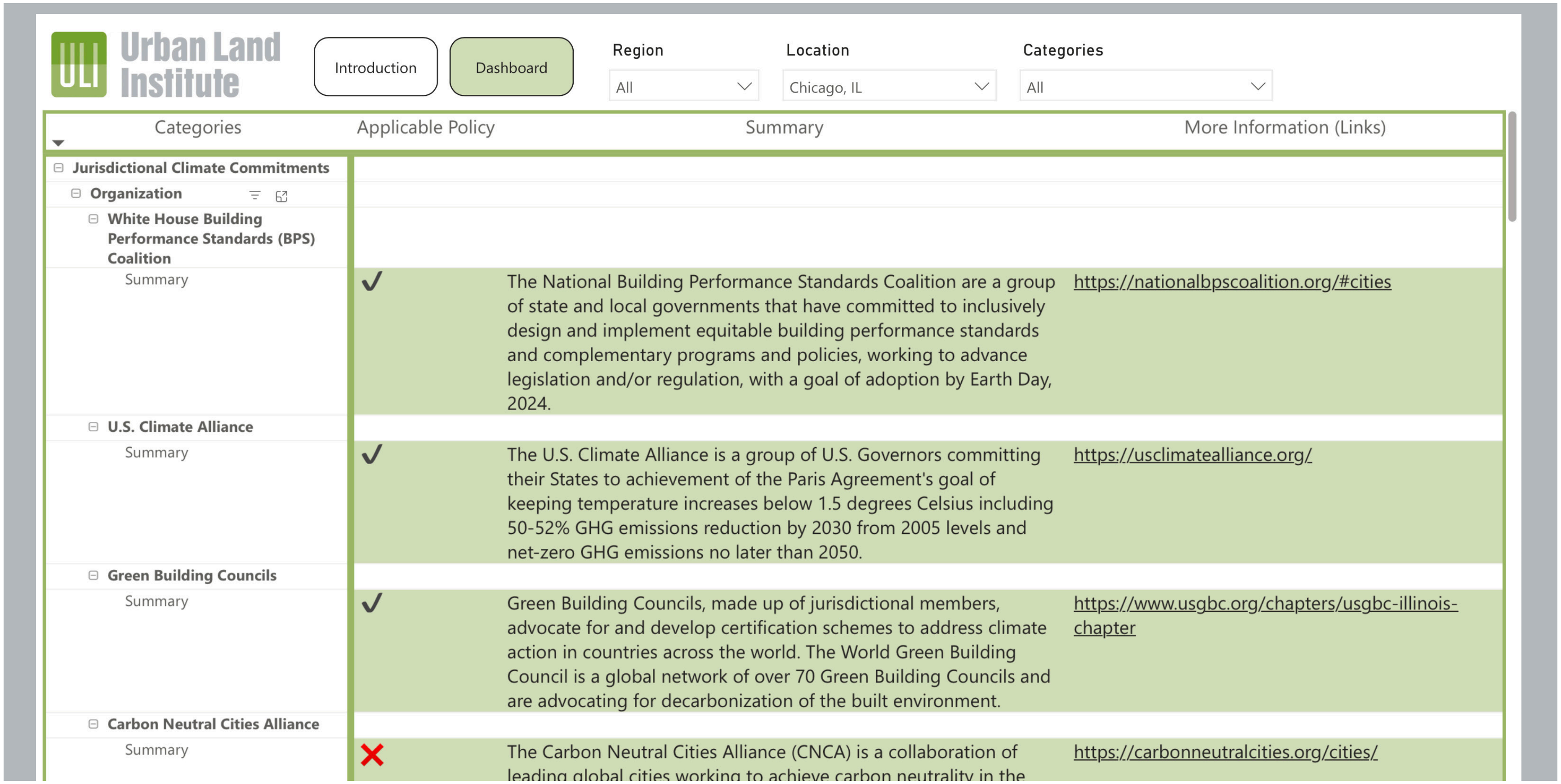
In the warmer months, when heat pumps function as AC units, they can cool spaces while also removing humidity from the interior air. They also filter the air whether they are cooling or heating. This means that beyond acting as an all-in-one heating and cooling mechanism, they also function as a dehumidifier for a building—another market advantage.

> With the changing climate, more and more cities will need to add cooling to their buildings. As record-breaking heat waves continue to strike areas of the United States and Canada accustomed to mild temperatures, heat pumps present a climate-friendly and scalable solution for maintaining a comfortable and safe indoor air environment.

Government Sticks and Carrots: Mandates and Incentives

All-electric new construction mandates are cropping up around the country and around the globe. They range from requiring feasibility studies for electric equipment when seeking a permit for a new gas hookup (Denver) to completely banning gas in new buildings (New York City).

Carrots and sticks, or incentives and consequences, are inevitable as municipalities determine how to push industry toward decarbonization. ULI's Global Green Building Policy dashboard summarizes key requirements related to policies on building certifications, greenhouse gas emissions, embodied carbon, energy, electric vehicles, renewable energy, and resilience. Real estate practitioners can use the dashboard to filter by location to see a summary of requirements relevant to their area.



Categories	Applicable Policy	Summary	More Information (Links)
Jurisdictional Climate Commitments			
Organization			
White House Building Performance Standards (BPS) Coalition			
Summary	✓	The National Building Performance Standards Coalition are a group of state and local governments that have committed to inclusively design and implement equitable building performance standards and complementary programs and policies, working to advance legislation and/or regulation, with a goal of adoption by Earth Day, 2024.	https://nationalbpscoalition.org/#cities
U.S. Climate Alliance			
Summary	✓	The U.S. Climate Alliance is a group of U.S. Governors committing their States to achievement of the Paris Agreement's goal of keeping temperature increases below 1.5 degrees Celsius including 50-52% GHG emissions reduction by 2030 from 2005 levels and net-zero GHG emissions no later than 2050.	https://usclimatealliance.org/
Green Building Councils			
Summary	✓	Green Building Councils, made up of jurisdictional members, advocate for and develop certification schemes to address climate action in countries across the world. The World Green Building Council is a global network of over 70 Green Building Councils and are advocating for decarbonization of the built environment.	https://www.usgbc.org/chapters/usgbc-illinois-chapter
Carbon Neutral Cities Alliance			
Summary	✗	The Carbon Neutral Cities Alliance (CNCA) is a collaboration of leading global cities working to achieve carbon neutrality in the	https://carbonneutralcities.org/cities/

ULI's Global Green Building Policy dashboard.

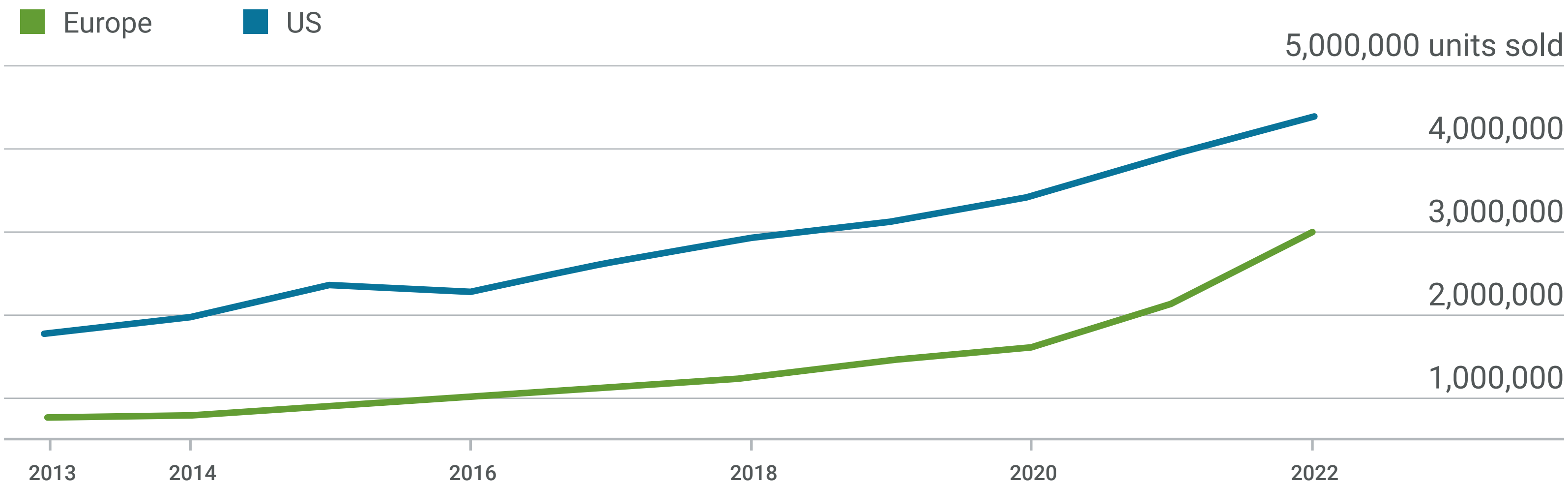
In addition to mandates, many municipalities are offering developers rebates or incentives to work with utility companies on electric hookups. For a 111-unit mid-rise apartment building in midtown Sacramento built with heat pumps, Sara Lebastchi with D&S Development says that the local electric provider, Sacramento Municipal Utility District, offered incentives to go all electric: The utility contributed to research on how to manage the energy load of the building and how to price it out to be more cost-effective. As a result, the developer was able to implement heat pumps at a cost savings.

For retrofits, many state and local governments are offering weatherization and direct installation programs for owners to improve energy efficiency in buildings. This is a crucial first step for many building owners and operators who want to enhance their building envelope efficiency. The savings that accrue from tightening the envelope (and thus reducing the energy load) of an existing building allow owners to invest in other electrification upgrades, eventually enabling the end goal of net zero buildings powered by renewable energy.

The federal government, in the form of legislation such as the Inflation Reduction Act of 2022 (IRA), offers numerous rebates for heat pumps. For instance, if a building achieves 35 percent energy reduction, the rebate per unit is $4,000 maximum; if the building includes more than 50 percent low-to-moderate income housing, the maximum rebate is $8,000. Another example is the New Energy Efficient Home Credit (IRA Sec. 45L), which allows a $2,000 credit per unit to multifamily developers, investors, or general contractors that build energy-efficient properties (including the installation of a heat pump). The credit increases to $2,500 per unit under the Energy Star New Construction program and to $5,000 per unit under the Zero Energy Ready Homes program from January 1, 2023, through December 31, 2032.

The IRA also funds rebates for qualified projects that enable electrification, such as $4,000 for an electric load service center upgrade or $1,600 for insulation, air sealing, and ventilation. These opportunities, which have not historically been available for developers in the United States, offer a strong case for heat pump implementation in buildings and have contributed to a significant increase in sales. (See figure 5 for data on sales in both the United States and Europe.)

FIGURE 5. INCREASES IN HEAT PUMP SALES IN EUROPE AND UNITED STATES, 2013–2022



Source: Bloomberg NEF; European Heat Pump Association; and US Air-Conditioning, Heating and Refrigeration Institute.

These carrots are being supplemented with sticks. According to the Institute for Energy Research, as of 2021, 76 U.S. cities have natural gas restrictions for new construction, end-of-life equipment replacement, and existing-building performance standards. That number will no doubt continue to rise.

One example is Local Law 97 in New York City, a part of the city's broader Climate Mobilization Act aimed at lowering New York's emissions 40 percent by 2030 and 80 percent by 2050. New York's largest buildings have until 2024 to meet the emission targets. If they do not decarbonize in time, they will face a financial penalty of $268 per ton of CO_2 equivalent over the limit, based on 2024 energy usage and emissions. Electrification of building systems, powered by renewable electricity, is one way to achieve the decarbonization targets.

Beyond rebates and incentives, logistical benefits accrue for a developer implementing heat pumps for new construction. Working with one utility (that is, a local electricity provider as opposed to both electricity and gas providers) can streamline permitting efforts and reduce administrative burdens. And ultimately, even if a power plant burns natural gas to supply the electricity, the lower energy use and efficiency of a building using heat pumps make it more carbon efficient than a building using a natural gas furnace, according to the Rocky Mountain Institute.

PROJECT PROFILE

17 Central by D&S Development

SACRAMENTO, CALIFORNIA

KEY FACTS

- Eight-story, mixed-use mid-rise new construction in midtown Sacramento
- 111 units (one-bedrooms and studios)
- Estimated savings of $200,000–$300,000 in labor and materials avoided by not installing individual gas lines to the units
- One air-source mini-split heat pump per apartment
- Delivered in June 2022

In the design phase of 17 Central in 2020, D&S Development was motivated to implement heat pump water and space heaters because of the significant cost and time savings associated with the technology. Heat pumps allowed the company to bypass the regional gas provider and forgo a gas hook-up to the building. Instead, D&S worked with just one utility provider for electric, Sacramento Municipal Utility District. The utility's help in explaining the energy load requirements and researching the best option for electrifying the building with heat pumps saved time during the permitting process.

D&S Development also recognized that figuring out heat pumps on the front end would save time and money later, when Sacramento eventually moves to all-electric requirements for buildings. Making the effort to implement heat pumps ahead of the requirement saves both time and money in the long run.

Significant financial savings came from installing heat pumps rather than gas lines for each unit. "While the heating equipment is comparable, there is a cost savings to not having to bring gas lines into the units, the individual gas meters, and manifold that would be required for gas service," says Sara Lebastchi, vice president of operations at D&S Development. "Just a rough estimate on what that may cost for a 100-unit apartment could be an additional $200,000–300,000 in labor and materials."

Lebastchi also noted that although residents may not notice the heat pumps when they tour the building, they have made fewer maintenance requests in the building's first year of operation than is typical in other properties. In addition, residents have reported satisfaction with lower meter costs, which helps lower turnover—an indirect benefit to the developer.

D&S DEVELOPMENT

17 Central apartments in Sacramento, California, are conditioned by mini-split heat pumps.

Heat Pump Myths: Busted

Many heat pump myths surround their efficiency, reliability, applicability, and more. One of the most common myths is that heat pumps can only be used to heat spaces. In fact, heat pumps are not only used for heating spaces and water, they are also effective for cooling and dehumidifying. Despite the word “heat” in the name, which implies the primary function is heating, heat pumps simply move (or pump) energy from one location to another. A driving advantage of implementing heat pumps into commercial real estate projects is their dual use as air conditioner and heater. This section discusses eight myths about heat pumps, the facts that dispel these myths, and projects exemplifying the benefits of using heat pumps in commercial development.

MYTH 1 Heat pumps are not cost-effective, and my utility bill will go up by switching to heat pumps.

MYTH 2 Heat pumps are not a viable option for properties in cold climates.

MYTH 3 Heat pumps are not commercially proven; they are too new.

MYTH 4 Heat pumps are only for single-family homes or small commercial and don’t work for mid-rise, high-rise, or industrial properties.

MYTH 5 Heat pumps can only be implemented in new construction, not in retrofits.

MYTH 6 Electric heat pumps do not heat as well as gas systems.

MYTH 7 There is only one type of heat pump.

MYTH 8 Heat pumps are too loud and take up too much space.

MYTH 1

Heat pumps are not cost-effective, and my utility bill will go up by switching to heat pumps.

FACT

Heat pumps are at least three times more efficient than traditional heating and cooling, and as gas prices continue to exhibit volatility with unexpected price fluctuations, electric heating is becoming increasingly competitive. Natural gas prices spiked in February 2022, reaching their highest level in two decades. That volatility makes electric heat pumps a cost-effective and reliable option in many locations (figure 6).

Although heat pump equipment may have a higher upfront cost, it yields significant long-term cost savings. In new construction projects with tight building envelopes and energy-efficient finishes (e.g., high-performance windows and insulation that preserve heat in the envelope), heat pumps will lead to lower utility bills for tenants in both offices and multifamily buildings—a major selling point for those leasing spaces.

"The upfront cost of commercial heat pumps is still a little more in terms of its contemporaries, but the spread between the two is coming down every day," says Andy Bush, founder of Morgan Creek Ventures, a design-driven real estate development firm based in Colorado. "In San Francisco, for example, heat pumps are becoming the norm, so the skilled trade groups are making the costs very similar."

For retrofits, implementing heat pumps for cost savings are generally contingent on holistic building upgrades. Tenants may see an increase in utility bills after a heat pump is installed if the building envelope is leaky or otherwise inefficient. But installation of the technology provides an opportune time for building owners to think comprehensively about energy efficiency upgrades.

FIGURE 6. SAVINGS FROM SWITCHING TO HEAT PUMPS

Current Heating Equipment	Average Annual Savings
Natural gas furnace	$105
Electric furnace	$815
Propane furnace	$855
Baseboard heaters	$1,287
Fuel oil boiler	$929
Fuel oil furnace	$947
Natural gas boiler	$199

Note: Estimate of the average annual savings of switching to heat pumps for residential property owners based on their current heating system. The amount varies based on size of the property and energy efficiency of the envelope; these numbers were calculated using the National Renewable Energy Laboratory's ResStock Analysis Tool.

Source: Carbon Switch.

PROJECT PROFILE

601 LEXINGTON AVENUE BY BXP

NEW YORK CITY

KEY FACTS

- Retrofit, high-rise commercial building in midtown Manhattan
- 59 stories and 1.7 million square feet
- Built in 1974
- Heat recovery implemented through water-source heat pumps

This property, at 601 Lexington Avenue, anchors BXP's Midtown Manhattan campus and the New York City skyline, with a globally recognized triangular silhouette. The former Citicorp Tower is a 1.7 million-square-foot property owned by BXP that includes premier workplace and retail originally built in 1974. The building's infrastructure is typical for New York City commercial high-rises of its vintage. Heating systems are served with district steam, and cooling is provided by a central plant with electric chillers and rooftop cooling towers.

The 601 Lexington Avenue heat pump retrofit project is part of New York State's $50 million Empire Building Challenge (EBC) along with several other real estate projects committed to decarbonize heating and domestic water energy use in existing high-rise buildings. The building is undergoing resource-efficient electrification measures as part of the challenge. "The implementation of heat pumps into new construction and existing buildings retrofits has become a very important part of our decarbonization strategy," says Ben Myers, senior vice president of sustainability for BXP.

BXP

601 Lexington Avenue in Manhattan is being retrofitted with water-source heat pumps.

One of the potential benefits of participating in the EBC is compliance with Local Law 97's greenhouse gas emission caps, which go into effect in 2024. Building owners will face fines of $268 per ton of CO_2e for emissions over the cap. The 601 Lexington Avenue retrofit project adds to performance improvements resulting from energy conservation measures already implemented at the property and demonstrates a replicable decarbonization solution in existing commercial high-rise buildings.

In New York City, most high-rises have a condenser water loop tied to a building-based cooling system and any supplemental tenant cooling systems (e.g., a tenant's information technology closet that requires constant cooling). The building's existing condenser water system carries heat from tenant supplemental systems to the cooling towers, where it is emitted into the atmosphere. Much of this heat is constant in commercial office buildings and available year-round for recovery. Through the retrofit project, water-to-water heat pumps (water-source heat pumps) are being installed. They will replace the function of the cooling towers during the heating season and reclaim heat from the condenser water loop for beneficial use. An automated bypass valve will divert condenser water from the cooling towers, retaining as much heat in the building as possible for recovery by the heat pumps. The heat recovered will be reused in the building's heating systems and will significantly offset reliance on fossil fuel–based steam. This measure will reduce annual steam consumption by an estimated 30 percent.

The 601 Lexington Avenue project is an example of a relatively short-term payback endeavor using existing heat pump technology to decrease indirect greenhouse gas emissions from a purchased utility—in this case, steam.

"We will continue to pursue incentive programs and heat pump technologies for space heating as systems reach [their] end of useful life," says Myers. "The partnership with [the New York State Energy Research and Development Authority (NYSERDA)] and involvement in the Empire Building Challenge have supported BXP and our business case for accelerating these efforts."

MYTH 2

Heat pumps are not a viable option for properties in cold climates.

FACT

The highest per capita installation rates of heat pumps are found in cold climates. Heat pump technology can efficiently generate heat in very cold areas, and the regional operating range continues to expand, due in part to significant technological advances in recent years. Modern low-temperature heat pumps have refrigerant injection systems and other features that allow them to operate efficiently at below-freezing temperatures (commonly as low as −10 degrees Fahrenheit).

Advances in variable speed inverter-drive compressor technology are the key innovation that allows for the subzero effectiveness. This crucial driver of usability was not offered commercially as recently as 10 years ago; since its inception, it has allowed heat pumps to flourish in a wide range of geographies.

Popular misconceptions around heat pump efficacy in cold climates can be attributed to outdated information: models from the 1980s were unable to operate outside of moderate climates, such as the Southeastern United States. However, that limitation is no longer true.

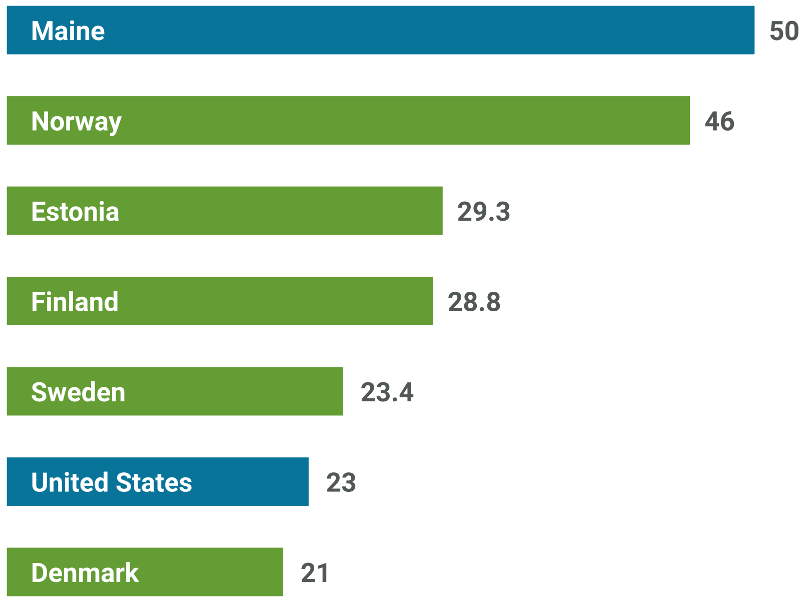
ERIN FOWLER

Heat pump storefronts are seen in Ellsworth and Brunswick, Maine.

Evidence of the effectiveness of modern heat pumps in cold climates can be seen in states like Maine, where the heat pump business is booming. In 2022 alone, approximately 28,000 heat pumps were installed across the state. That means 2 percent of Maine's entire population installed a heat pump in one year. This rapid adoption can be attributed in part to Governor Janet Mills' climate action plan, which aims to incentivize building owners to install 245,000 heat pumps (48 percent of the housing stock) by 2030. Rebate programs have been established to help the state reach its goal.

Beyond the United States, heat pumps have been proliferating across cold-climate countries in Europe for many years. Figure 7 illustrates how countries such as Norway, Estonia, Finland, and Sweden have some of the highest heat pump adoption rates across Europe, proving the technology's viability in diverse climates.

FIGURE 7. HEAT PUMPS SOLD PER 1,000 HOUSEHOLDS IN NORTHERN EUROPE, MAINE, AND THE UNITED STATES



Source: Data from the European Heat Pump Association, State of Maine, and AHRI. Graph adapted from Carbon Switch.

PROJECT PROFILE

ALL-ELECTRIC CAMPUS BY MORGAN CREEK VENTURES

BOULDER, COLORADO

KEY FACTS

- 12 mixed-use, commercial, and multifamily buildings
- 426,000 square feet
- $252 million invested
- Design begun in 2016, delivered in phases between 2017 and 2024
- Mid-rise, four stories
- VRF heat pump systems throughout

The founder of Morgan Creek Ventures, Andy Bush, has been implementing heat pumps in new construction for some time. In the last five years, watching the pricing and technology improvements, he says heat pumps have gotten more efficient every year. He estimates a 10 percent efficiency increase in that time frame; they both cost less to operate and better operate on colder days. “This is the path we are on with heat pumps—they are getting less expensive over time and performing increasingly better,” says Bush.

“Natural gas is still cheaper at the moment, but if you put it in the context of future-proofing buildings, it makes more sense. Our total operational costs are going down while our competitors’ are going up, long term.”

The decision to implement VRF heat pumps into the all-electric campus in the Boulder Junction neighborhood was made because the technology was the most robust and efficient. The technology also works for all the building types that Morgan Creek Ventures is developing for the campus, ranging from mixed-use office with ground-floor retail to mixed-use multifamily/retail and multifamily-only buildings.

MORGAN CREEK VENTURES/FORTEM MEDIA

A multifamily building in the Morgan Creek Ventures development sits at 3200 Bluff Street.

MORGAN CREEK VENTURES/BRUCE DAMONTE

Two of the mixed-use office/retail buildings on the campus are at 2440 and 2490 Junction Place.

Across the development, the VRF system condensing units sit on the first floor or on rooftops with line sets like traditional AC units, running heating and cooling to the interior spaces. These units lead to individual cassettes that allow occupants to heat and cool individual rooms.

Although measuring occupant comfort is not a formal part of the company's current metrics, Bush explains that it is a contributor. For a commercial space, the goal is to cool a specific conference room when it is filled with 20 people without cooling all the surrounding office space. Enhanced filtration systems within these heat pumps also contribute to healthier spaces. "We can say to potential office tenants that, for these comfort and design reasons, we expect you will have at least 1 percent better employee attraction, retention, and productivity. Even if it's slight, it makes a difference," says Bush.

MYTH 3

Heat pumps are not commercially proven; they are too new.

FACT

Heat pumps are not a new technology and have been ubiquitous outside the United States for decades. Heat pump adoption has been particularly widespread in Asia Pacific and Europe regions. Significant innovations have further improved the technology in the past 10 years.

In Japan, 90 percent of households (where the stock is largely multifamily) already have heat pumps for heating and cooling; and more heat pumps were sold in China in 2022 than in any other country globally.

The high market penetration of heat pumps in Japan—which first peaked in 1991—underscores that manufacturers can produce and distribute this energy-efficient technology at a large scale. Mini-splits are the most common form of heat pump found in Japan. Their unobtrusive design is well suited for small interior environments where only one may be needed to heat and cool a space due to limited thermal zones. In larger spaces, multiple mini-splits across different rooms contribute to improved occupant comfort with more precise temperature controls.

Additionally, Japanese adoption of heat pumps proves that homeowners and tenants across the country find them sufficient to meet their HVAC needs. Winter temperatures in Japan typically range from 25–45 degrees Fahrenheit, making their climate comparable to many American states.

Heat pump adoption across Europe has also been underway for a long time. Within the European Union, according to Carbon Brief, national heat pump markets can be grouped into three categories: mature, emerging, and dormant. In mature markets—which include some of the coldest climates in Europe, such as Denmark, Norway, Finland, Sweden, and France—high numbers of heat pumps have been installed for many years; thus, annual growth tends to be lower.

In Norway, air-source heat pumps were introduced in the 1970s and began to flourish in the 1990s and early 2000s. Now, most buildings in the country are powered by heat pumps; even so, the country saw a 25 percent growth in heat pump sales in 2022. This widespread heat pump adoption in Norway can be attributed to many factors, the main reason being that historically electricity prices have been comparatively low.

Norway is one of the world's leading countries in the production of renewable energy, most of which comes from hydropower. Since hydropower is plentiful in the country, electricity is often more competitively priced than natural gas, making heat pumps an obvious choice.

In addition to widely available renewable energy, CO_2 taxes for fossil fuels have been steadily climbing in Norway since 2012. Then, incentives were doubled for 2018–2019 to help those interested in replacing oil burners with electric heat pumps.

In recent years, the war in Ukraine and the COVID-19 pandemic have led to steep increases in gas prices. These unpredictable global market conditions demonstrate another reason that electric heat pumps can offer more stability in pricing for occupants of a commercial or multifamily building.

Other mature growth markets, such as Finland, still saw extraordinary growth of heat pump adoption in 2022, with sales up 50 percent. Importantly, emerging heat pump markets—such as Germany, Poland, and the Netherlands—saw significant adoption increases of 58 percent, 120 percent, and 52 percent, respectively, in 2022.

These countries serve as a model to building owners and developers in the United States: investing in and implementing heat pump technology is commercially proven to work and, judging by recent growth globally, is expected to become standard where it is not already.

MYTH 4

Heat pumps are only for single-family homes or small commercial and don't work for mid-rise, high-rise, or industrial properties.

FACT

Heat pumps are well suited to all asset classes. Given the range of heat pumps available, owners can choose from a variety of solutions to fit individual building needs. Heat pump types include ducted and ductless, and they use various energy sources (air, water, ground).

Mini-split or multi-split systems are a strong candidate for mid-rise buildings that have smaller floorplans. Mini-splits are well suited to a single thermal zone; if a building comprises mostly multi-bedroom units, then multi-split systems (one outdoor unit that can serve two to six moderately sized apartments or condominiums) could be a viable option. One limitation for high-rise or larger buildings is finding the outdoor space needed for the exterior part of the heat pump unit.

For bigger buildings, VRF heat pump systems are often very effective because of their commercial grade and ability to handle differentiated loads. However, since VRF systems are by far the most efficient and complex, they require a higher upfront cost. The risks of refrigerant leakage also play into the decision to use this particular technology.

Current hydrofluorocarbon-based refrigerants in air-conditioning and heat pump equipment have very high global warming potential, and their leakage in buildings and end-of-life disposal is a target for building decarbonization efforts and government regulations. While several alternative refrigerants have been introduced by heat pump manufacturers, some of them are mildly flammable, requiring specialized system design and installation practices.

The application and size of the project are important determinants in assessing which product to use. For new construction, for example, the heat pump installation strategy would be different from a retrofit that does not have existing ductwork. Despite these differences, both can be excellent candidates for heat pumps.

Another key opportunity to leverage heat pumps in greenfield or large-scale master planned projects is through a ground-source, district heating network that can connect across buildings in a given geographic area.

Changes in energy-efficient development best practices will continue to contribute to heat pump ubiquity across mid-rise and high-rise buildings. For example, in 2021, the U.S. Department of Energy launched the Residential Cold Climate Heat Pump Challenge. The program aims to accelerate deployment of cold-climate heat pumps; to do so, the agency is partnering with manufacturers, utilities, and state governments to ensure cold-climate heat pumps are made available to more developers and builders going forward. The plan is to deploy these strategies in 2024, which means these products will be even more widely available for developers.

Industrial heat pumps can also be effective in settings beyond mid-rise and high-rise buildings. According to research conducted by the American Council for an Energy-Efficient Economy, industrial heat pumps can be three to eight times as energy efficient as traditional heating, leading to significantly lower energy use and operating costs. In particular, research shows that food and beverage production, wood processing, and consumer goods manufacturing facilities have seen success in transitioning their operations to heat pumps. Industrial heat pumps can operate at higher supply temperatures and are often used in district heating systems across Europe.

PROJECT PROFILE

PLATFORM 16 BY BXP

SAN JOSE, CALIFORNIA

KEY FACTS

- Commercial new construction
- Air-source heat pumps, all-electric buildings
- 1.1 million-square-foot "urban campus"
- Six floors, three buildings

Platform 16 is currently in phase one of construction and will ultimately be a three-building commercial campus along the Guadalupe River Park in San Jose, California. The development is directly adjacent to the Google transit village.

The decision to implement heat pumps in lieu of gas boilers came down to market factors and the technology availability. "California is leading the country in carbon emission reductions through electrification, and tenants expect that new buildings are 'green' in this regard," says Nick Ryder, senior construction manager with BXP, who is working on the Platform 16 project. Meeting tenant expectations was critical for the team.

Another reason for the high-efficiency design was that San Jose now mandates all-electric for new buildings. The Platform 16 team obtained its building permits before this ordinance went into effect. However, the team saw the direction the city was heading and made the proactive decision to futureproof the building. "Over the next 20 years, gas rates are expected to rise as gas usage drops," says Ryder. So, it made sense for the team to consider the best long-term decision for the urban campus.

The air-source heat pump system was picked by the team's Leadership in Energy and Environmental Design (LEED) consultant. The main considerations were lower upfront costs (when compared with VRF systems), commercially proven, simply designed controls, and the knowledge from other projects that this type of system is effective in California.


BXP
The rendering shows the crosswalk between two buildings at Platform 16.

MYTH 5

Heat pumps can only be implemented in new construction, not in retrofits.

FACT

Although every retrofit has unique needs depending on the existing condition of the building and myriad other measurable variables, heat pump retrofits are a viable solution for many owners looking to make electrification improvements.

Further evidence is the number of households switching to heat pumps. In the United States, as of 2020, 18 million households were using heat pumps—an increase of 50 percent compared with 2015 numbers. These numbers will likely continue to increase given the Inflation Reduction Act's High Efficiency Electric Home Rebate program, which could fund another 2.5 million heat pump retrofits.

When replacing traditional HVAC systems in older buildings in very cold climates, if a high-efficiency cold-climate heat pump cannot be purchased, then a backup gas or oil source may be needed—sometimes, but not always. This is known as a dual-fuel system, in which gas lines and a furnace are installed for extremely low–temperature days. In these instances, the heat pump would provide heat until the temperature drops too low for it to operate efficiently. At that point, the gas furnace would become the heating mechanism.

Cold-weather heat pumps have the capacity to heat down to −10 degrees Fahrenheit effectively, saving the building owner (and tenant) significantly. The left-over capital can be reinvested into other energy upgrades throughout the building.

PROJECT PROFILE

EASTBROOK APARTMENTS BY WINNCOMPANIES

SPRINGFIELD, MASSACHUSETTS

KEY FACTS

- Two-story garden-style apartments
- Built in 1974
- Twelve of 160 total units converted from gas furnaces to ducted air-source heat pumps
- Implemented August–October 2021

WinnCompanies converted 12 of the 160 units in its Eastbrook Apartments—a garden-style multifamily project in Springfield, Massachusetts—from gas furnaces to air-source heat pumps as a pilot project for retrofits in its portfolio. The firm also implemented site-wide energy efficiency upgrades, including attic insulation and air sealing, smart thermostats, and heating system replacements. In addition, WinnCompanies worked with Action for Boston Community Development, Eversource, and Paradigm Energy Services to select two pilot buildings to demonstrate the impacts of injection foam and air-source heat pumps as deeper decarbonization measures. Each unit received new injection foam insulation in the exterior wall cavities to improve thermal performance, reduce air infiltration, and lower heating demand.

The ducted gas furnaces were removed and replaced with high-efficiency air-source heat pumps, which reused the existing ductwork distribution for cost savings. The existing through-wall air conditioners and sleeves were removed and infilled as well, for improved cooling efficiencies from the new heat pump units. Christina McPike, vice president of energy and sustainability with WinnCompanies, noted that heat pumps are now fully the standard for the firm's new construction projects. She said that although implementing heat pumps in retrofits can be a challenge, it can be done, especially in conjunction with exterior envelope improvements to reduce heating demand. "It was challenging to locate the outdoor condensers," says McPike. "They took up landscaped areas, and refrigerant lines had to be somewhat awkwardly located on the building façade. But the installer was able to make it look as neat and professional as possible."

The solutions are worthwhile for residents. The average low temperature in January in Springfield, Massachusetts, is 15 degrees Fahrenheit. "We had no complaints this winter," says McPike. "Residents expressed improved comfort."

WINNCOMPANIES

Heat pumps line up outside Eastbrook Apartments in Springfield, Massachusetts.

MYTH 6

Electric heat pumps do not heat as well as gas systems.

FACT

Heat pumps offer better and more precise occupant comfort and heating than their traditional gas counterparts with multispeed operation.

In a 2022 survey of 670 European households that had recently switched from traditional heating to a heat pump, 88 percent said they were satisfied with the switch and kept adequately warm and cool by the system; 81 percent said their level of comfort had improved.

Further, while both gas furnaces and heat pumps can heat buildings well, heat pumps circulate naturally humid air, in contrast to a furnace's dry air. This means heat pumps can offer improved heating experiences for building occupants.

The myth that heat pumps do not heat as well as gas systems may partially come from retrofits that replace traditional HVAC systems with a heat pump without making any other energy efficiency upgrades, such as window or wall insulation. The building envelope is crucial to a heat pump's effectiveness and must be considered when building improvements are contemplated. A tight building envelope is necessary to make the heat pump as efficient and comfortable for tenants as possible.

PROJECT PROFILE

140 KENDRICK STREET BY BXP

NEEDHAM, MASSACHUSETTS

KEY FACTS

- 444,000-square-foot premier workplace campus in Needham, Massachusetts, with three office buildings (A, B, C) and the Exchange, an amenities center
- Net zero retrofit of Building A, a 106,000-square-foot office building
- Built in 2000
- Upgraded from gas-fired heating to VRF heat pump systems
- LEED certifications being pursued

The property at 140 Kendrick Street is a 20-plus-year-old suburban workplace campus in Needham, Massachusetts. BXP implemented a comprehensive net zero retrofit of Building A. The retrofit included full electrification, building envelope improvements, advanced energy recovery systems, mechanical system modernization (installation of VRF heat pumps), and the addition of on-site renewable energy generation.

In partnership with Wellington Management, BXP decided to pursue net zero repositioning of Building A in between tenant leases of the property. BXP recognized that some of the building systems were at the end of their useful life, so they conducted a holistic energy evaluation of the building. The net zero repositioning included a deep energy retrofit, full electrification of gas-fired systems, HVAC modernization to heat pumps—including advanced heat recovery—and on-site renewable energy generation from solar.

“The heat pump conversation should begin with a conversation about the building envelope,” says Ben Myers, senior vice president of sustainability for BXP. “There’s not an elegant mechanical solution to net zero—the best solutions approach architectural and energy systems holistically.”

A core focus of the Building A retrofit was improving the original building’s energy performance to enable a net zero solution. The team aimed for a 40 percent reduction in energy use intensity, resource conservation, and improved efficiency. Improvements were made by insulating the building envelope (walls and roof) and improving air infiltration by replacing and adding window seals. “A good question to ask your engineer in the beginning of a retrofit is, what impact do a building’s envelope and internal loads have on the heating and cooling needs, and how much waste heat can we recover?” says Neetu Siddarth, sustainability manager for energy and utilities at BXP.


BXP

BXP's retrofit of 140 Kendrick Street in Needham, Massachusetts, included VRF heat pumps.

The second step was to determine the best solution to electrify the building to improve efficiency and reduce energy use. The building had gas-fired rooftop units, which had reached the end of their useful life, so it made sense to replace them with modernized units. Updates included the installation of two new rooftop units with advanced Superblock heat recovery, estimated to recover 90 percent of the building's heat, and electrifying the building's HVAC with a VRF heat pump system. A VRF heat pump system made the most sense because of its commercial-grade efficiency and ability to heat efficiently in very cold temperatures, which are common during a Massachusetts winter. VRF systems carry a higher upfront cost but provide long-term savings by reducing the HVAC system's energy consumption; in addition, supporting projects achieve higher energy performance goals.

MYTH 7

There is only one type of heat pump.

FACT

There are numerous types of heat pumps available to fit the needs of specific buildings in different geographies and asset types. Figure 2 outlines the types of heat pumps available, and an engineer can help assess what type of heat pump is best suited to a particular project.

CUTTING EDGE INNOVATIONS IN HEAT PUMPS

In 2023, Lendlease, a leading global real estate and investment management group, announced plans to build the largest multifamily project in New York State to use a geothermal heat exchange system. The effort is being undertaken with a $4 million grant from NYSERDA.

The property, at 1 Java Street in Brooklyn, will include five interconnected buildings. Two of the buildings are 37- and 20-story towers, making the project a strong candidate for a large-scale heat pump system. Lendlease obtained grant funding from NYSERDA as part of the Community Heat Pump Systems Pilot Program, and the project will allow Lendlease to meet Local Law 97 targets.

The geothermal heat pump system is a vertical closed-loop system with underground pipes that will circulate a water solution cooled or heated by the ground.

MYTH 8

Heat pumps are too loud and take up too much space.

FACT

The noise emitted from an air-source heat pump is roughly equal to that of a standard household refrigerator. This is a slightly lower sound output than a gas boiler, making the heat pump a quieter option.

The different sizes and configurations of heat pumps available allow owners and developers to find the best one to meet their needs. A mini-split system, for example, takes up little space on a wall; but installing one in every unit of a large multifamily building does add up and may not be practical. A commercial-grade VRF system, typically installed on the rooftop, might be a better option in this instance. Depending on the type of project, heat pumps could be stored in, on top of, or adjacent to the building.

PROJECT PROFILE

SECOND + DELAWARE BY ARNOLD DEVELOPMENT GROUP

KANSAS CITY, MISSOURI

KEY FACTS

- Multifamily complex
- 321,000 square feet
- $100 million invested
- Opened fall 2020
- Mid-rise, six stories
- VRF heat pump systems

Second + Delaware is a residential market-rate multifamily community in Kansas City, Missouri, developed by the Arnold Development Group. This 276-unit project includes a below-grade garage and 117 rooftop garden plots. The building is the seventh largest passive structure in North America by the Passive House Institute US. It is highly energy efficient and uses 80–90 percent less energy than a conventional building. This high efficiency, mostly due to the design of the building's envelope, contributed to the design team's decision to use VRF heat pumps instead of conventional heating and cooling systems. The VRF heat pumps also increase the efficiency of the overall building given their higher efficiency compared with a conventional HVAC system.

ARNOLD DEVELOPMENT GROUP

The Second + Delaware project has common areas for outdoor activities.

Jonathan Arnold, principal of Arnold Development Group, emphasized the importance of "systems thinking" during the design phase of the project. Systems thinking includes—at a minimum—financial, design, and spatial tradeoffs. Developers should approach efficiency as a system in which different components interact with each other. Even though greater efficiency can eventually lead to diminishing returns (that is, initial improvements to an extremely inefficient building produce significant savings; as the building becomes more efficient, each incremental improvement produces less savings because there is less efficiency to be gained), efficiency improvements are a sound investment. The upfront costs will likely be repaid in reduced energy loads and overall operational cost savings. At Second + Delaware, lower energy loads were expected to reduce demand on the HVAC equipment, so less VRF heat pump equipment was needed to meet heating and cooling needs. Moreover, VRF heat pumps have a smaller footprint than traditional HVAC equipment, so significantly less heating and cooling equipment was needed compared to a traditional build.

The cost to build comparable conventional buildings in this neighborhood area is $222/square foot. Second + Delaware incurred a cost of $245/square foot. However, operational savings end up covering this initial premium. At Second + Delaware, these savings were achieved by focusing on the building envelope design and the VRF heat pump system. Both helped drop the building's operational energy loads to the point at which the HVAC equipment's operational energy savings outweighed the extra upfront costs. As Arnold put it, "Rather than costing more, it actually costs less. You have a building with more value for the investment you've made. Your yield is higher."

The smaller amount of HVAC equipment needed on site allowed the design team to use the extra floorspace for additional amenities for residents. Resident amenities include landscaped courtyards in the center of the building and rooftop gardens. The courtyard space is available for individual use as well as events. The rental fee for events is another way to offset the cost of upfront efficiency improvements.

ARNOLD DEVELOPMENT GROUP

Amenities include rooftop gardens.

Residents' rent includes a market-rate utility fee as part of the gross lease, so operating at the highest possible energy efficiency minimizes monthly utility costs to the owner and directly benefits the owner's bottom line. A direct comparison is possible with a neighboring conventional multifamily development. At the neighboring property, residents pay $1,700 per month plus utilities. Second + Delaware charges $1,900 with utilities included. Initial monthly operating utilities averaged $73.39 per unit, much lower than the market rate $200 per unit included in rents.

Additionally, the all-electric building is noncombustible, leading to significant annual insurance savings of $215,000 compared with a traditional build's insurance costs. Overall, Second + Delaware was able to secure an additional $8 million in operational profit compared with the lowest-possible-cost build, which more than offsets the development's higher upfront energy efficiency costs.

Questions to Ask Design Professionals for Heat Pump Retrofits

Heat pumps in new construction are becoming the real estate industry standard. Proper ductwork and designation of the space for heat pump equipment can be integrated into the design process and incorporated seamlessly into a project's delivery. The viability of the technology in retrofits of older buildings, however, depends on a constellation of different factors. Heat pumps can be intimidating and complicated for developers and owners not used to choosing them. Considerations such as climate, nearby energy sources, and existing conditions of a building envelope and energy load must all be weighed when deciding whether heat pump implementation is the optimal solution.

The following guide is intended to equip developers, investors, building owners, and other real estate professionals with the questions to ask a consulting engineer who can help determine whether a heat pump is an effective solution for a retrofit.

Note:

Green denotes questions for larger—four-story or taller—buildings with central applied equipment.

Orange denotes questions for smaller—one- to three-story buildings with packaged unitary equipment.

Blue denotes questions for any size building.

1. **How can my building site accommodate a heat pump installation?**
   - ☐ Is there sufficient space for new equipment in the central equipment room?
   - ☐ Is there sufficient space for new outdoor condensing units?

2. **What type of heat pump system would be best for the building?**
   - ☐ Does the building have a central system with chiller and boiler?
   - ☐ Does the building have rooftop air handling units?
   - ☐ Does the building have packaged terminal units or fan coil units?
   - ☐ Does the existing building use hot water (radiant) heating?
   - ☐ What is the hot water supply temperature?
   - ☐ Does the building have a furnace for air heating?

3. How can potential obstacles that could complicate the installation process be addressed?
   - ☐ Does the building have sufficient access for large, central equipment?
   - ☐ Is there adequate space to provide separation between units for airflow?
   - ☐ Does the building have sufficient electrical service capacity to support heat pumps?
   - ☐ Does my current switchgear support either adding the connected load of heat pumps or replacing chillers with heat recovery chillers or heat pumps within the electrical constraints of my building?
   - ☐ Is there a package of heat recovery measures, which would help reduce peak heating demand, allowing for smaller heat pumps to be used?

4. What are the expected energy savings and greenhouse gas emissions reductions from a heat pump installation?
   - ☐ How do the energy savings compare between heat pumps and electric resistance heating for this specific project?
   - ☐ How do the energy cost savings compare between electric heat pumps and gas heating?

5. What local or state regulations need to be taken into consideration?
   - ☐ Do any codes or regulations in place or planned encourage heat pump adoption or limit alternatives?
   - ☐ Do any state or local building performance standards in place (or planned) limit building energy use or carbon emissions?

6. Are there any incentives or rebates available for installing a heat pump system?
   - ☐ Are there any local, state, or national government incentives for heat pump installations or replacements?
   - ☐ Are there any local utility rebates or incentives for heat pump installations or replacements?

7. What type of training or support is required and available for operating and maintaining the heat pump system?
   - ☐ How will heat pumps impact current maintenance practices?
   - ☐ How should I evaluate local mechanical, electrical, and building service contractors’ ability to support heat pump installation and service?
   - ☐ What additional training (if any) will my building operations staff require?

8. What other energy-saving options should be considered in addition to a heat pump system?
   - ☐ Should thermal storage be considered as a way to reduce heat pump capacity requirements?
   - ☐ What energy efficiency improvements should be considered before installing heat pumps?
   - ☐ Should I upgrade building controls when installing heat pumps to improve efficiency and load flexibility?
   - ☐ What considerations around refrigerants should I manage?
   - ☐ When should air or water heat recovery be considered to improve energy efficiency and heating capacity?
   - ☐ Is there an opportunity to install on-site renewable energy to reduce emissions and offset any increased electricity use?
   - ☐ Are there other available heat/energy recovery measures that I could deploy (e.g., wastewater energy recovery in multifamily properties, or fume hood heat recovery in laboratories)?

9. Should I electrify my building in phases, or should I do it all at once?
   - ☐ Should I replace central water chillers with heat recovery chillers at end-of-life or before?
   - ☐ Should I replace packaged air-conditioning units with heat pumps at end-of-life or before?
   - ☐ Should I replace a single piece of heating equipment with a heat pump?
   - ☐ Should I retain some fossil-fuel heating equipment for supplemental and backup heating?

10. What approach would you recommend for developing a long-term plan for building electrification and decarbonization that is aligned with my capital investment and equipment replacement plans?
   - ☐ Can you conduct an energy audit or a decarbonization audit for my building?
   - ☐ How would you incorporate projections of future grid emissions in my decarbonization plans?
   - ☐ How would you include projections of future electricity and fossil energy costs in decarbonization plans?

11. Do any new heat pump technologies make it easier to retrofit commercial buildings?

- ☐ Are there high temperature heat pumps designed for large commercial building space and water heating, including retrofits of existing hydronic systems?
- ☐ Are any heat pumps designed specifically for multifamily-building domestic hot water heating?
- ☐ When should cold climate heat pumps be considered for small commercial building space heating?
- ☐ Are any heat pumps designed for commercial building domestic hot water heating?

12. How can I minimize HVAC distribution system component replacement to accommodate central system heat pumps?

- ☐ Will I have to change air flow rates in air handling units?
- ☐ Will I have to change hot water or electric heating coils in air terminal units?
- ☐ Will I have to change control sequences?

13. How can I consider the impact of embodied carbon emissions of new and replacement building systems and equipment in building renovations?

- ☐ How can I estimate (and minimize) the embodied and life-cycle carbon emissions of new heat pump and HVAC equipment?
- ☐ How can I estimate the life-cycle carbon emission impact for potential early replacement of HVAC equipment?

14. Should I consider designing a "heat pump ready" or hybrid heat pump system for a new construction project?

- ☐ When should I consider a hybrid heat pump system, using fossil fuel or electric resistance heating for supplemental heating?
- ☐ Are there space constraints that should be considered for future heat pump conversion?

Conclusion

The real estate industry is inevitably moving to carbon neutral building solutions, and heat pumps are a leading technology in that movement. The built environment is not only an outsized contributor to climate change; it is also disproportionately impacted by the effects of climate change. As temperatures rise and weather patterns become more unpredictable, the consensus on electrification of heating and cooling mechanisms is strong and growing. Indeed, electrification is imperative to reduce greenhouse gas emissions by 50 percent by 2030 and to achieve net zero carbon operations by 2050.

As demonstrated by the number of places in cold climates around the globe that have utilized heat pump technology for years—a number that has only grown in recent decades—these energy-efficient systems can revolutionize real estate's journey to net zero in both new construction and retrofits.

Although many players will have to come together to create widespread adoption in the United States, the first step is overcoming the myths that have stigmatized heat pumps in America up to this point. As Christina McPike puts it, "We're building with heat pumps because that is where the industry is going." Developers, owners, investors, and other real estate practitioners should speak with engineers about implementing heat pumps in new construction as well as existing buildings where gas heating technology is reaching its natural end of life. Now is the time to go forth and create an all-electric future.

Tools and Resources

This primer is intended to introduce the viability of heat pumps and address common misconceptions around the technology for real estate and land use practitioners. The following tools and resources can help explain how to further understand and operationalize heat pumps.

- ACEEE's 2024 Hot Water Forum & Hot Air Forum
- Building Energy Exchange, NYSERDA, and Steven Winter Associates' Heat Pump Planner: Clean Heating, Cooling, and Water Heating Options for Homes
- Department of Energy's Better Climate Challenge: GHG Emissions Reduction Audit – A Checklist for Owners
- Energy Efficiency Council's Harnessing Heat Pumps for Net Zero: The Role of Heat Pumps in Saving Energy and Cutting Emissions
- International Energy Agency's guide to Demonstrating the Potential of Heat Pumps in Multi-Family Buildings
- Natural Resources Defense Council's Heat Pump Retrofit Strategies for Multifamily Buildings
- New Buildings Institute's Advanced Water Heating Initiative
- NYSERDA's Clean Heating & Cooling Solutions: Heat Pumps for Multifamily & Mixed-Use Buildings
- Rocky Mountain Institute's State-Level Building Electrification Fact Sheets

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