Title

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Insights from Mapping Electrification of Existing Commercial & Multifamily Buildings

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Phasing out fossil fuels in buildings is critical to achieving climate goals. New construction allows designers far more flexibility to optimize the design to achieve these goals. However, in electrification retrofits stakeholders must navigate the building's existing conditions and associated constraints. To understand how the industry is tackling this challenge, we conducted a literature review of case studies, interviewed designers and did extensive outreach to document electrification retrofits across the U.S. and Canada, yielding 142 projects across 39 states and territories.

The data set captures a wide range of project types, climates and building typologies. Compared to a 2022 version of this map that included 45 projects, we found that demand for electrification is growing, albeit slowly, primarily due to public and private mandates, along with government and utility incentives. We identified common drivers and barriers to electrification and shared insight from projects that were explored but not pursued.

Up-front and operating costs remain major obstacles in many locations, alongside space, structural, mechanical and electrical constraints. Successful projects are often completed in response to corporate or government mandates, have an internal champion and rely on outside incentives. We compiled the data set into an open-access map, offering examples of electrification retrofits.

Introduction

Retrofitting fossil-fueled building systems in existing buildings is critical to reach climate goals, as 51% of the estimated U.S. commercial square footage in 2050 is in buildings that already exist today.[1] Over 69% of existing commercial buildings and 63% of multifamily

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buildings rely on site combustion of fossil fuels for energy in the United States, primarily for space and water heating.[2,3] Large buildings are especially important to consider, as they often have complex systems for heating, cooling and ventilation and require coordination among many stakeholders, including building owners, designers, maintenance teams and tenants.

Our research lab first created the Electrification Retrofit Map in 2022, collecting 45 projects across the United States and Canada. Over the following three years, industry discussion of decarbonization and electrification have grown, supported by many factors, including upcoming compliance deadlines for building emission reduction policies, the enactment of decarbonization goals and an increase in available incentives for electrification. Another map of electrified buildings has also been developed by the New Buildings Institute and AIA California.[4] It provides a high-level narrative description of electrification projects and allows filtering by use type and property names for projects across the U.S.

Further accelerating this market are building performance standards (BPS), an emerging policy tool for decarbonization. BPS are "a set of standards designed to reduce carbon emissions in buildings by improving energy, gas and water use and peak demand. These standards become stricter over time, driving continuous, long-term improvement in the building stock and complementing building energy codes."[5] ASHRAE has contributed to the adoption of BPS in the form of technical guides as well as ANSI/ASHRAE/IES Standard 100, *Energy and Emissions Building Performance Standard for Existing Buildings*, of which the 2024 version is a model BPS.[6,7] These policies differ from traditional energy codes, as they are based on measured energy use from existing buildings.

Many large cities in the United States have implemented BPS with an emissions reduction requirement, including New York City, Washington D.C., Boston and Seattle. Statewide BPS have also been adopted in Maryland, Oregon, Washington and Colorado. While many BPS require reductions in building site energy use intensity, longer-term BPS

FIGURE 1 Center for the Built Environment's Electrification Retrofit Map user interface.

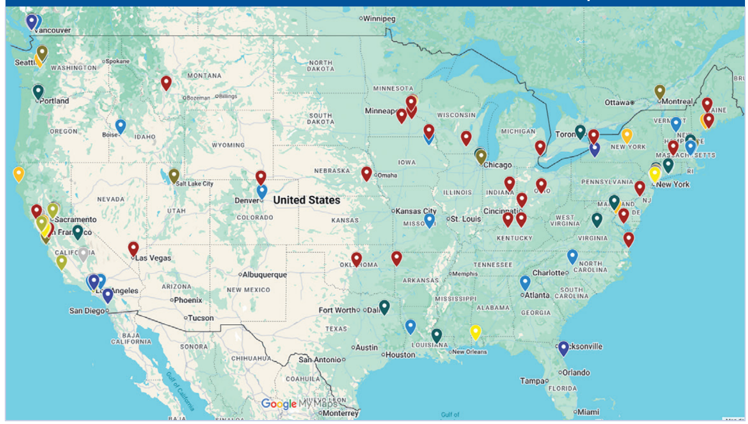
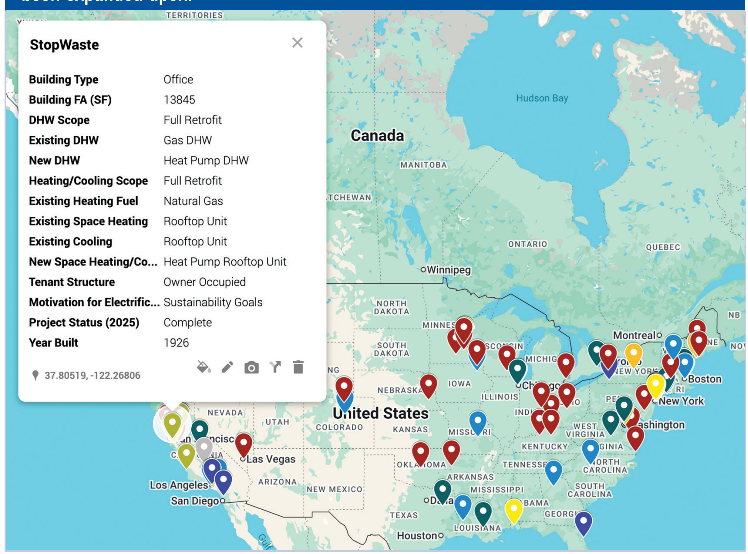


FIGURE 2 A sample of typical information available for projects on the map. Some projects have less complete data, while others with more in-depth case studies have been expanded upon.



targets will eventually require electrification of building equipment to meet stringent targets, frequently net zero operational emissions. These policies are already driving electrification retrofits, many of which are documented virtually as a part of programs like NYSERDA's Empire State Building Challenge. Several more jurisdictions are developing BPS policies that will continue to shape this emerging market, including California.

Updating the map three years later provides an opportunity to take stock of the real-world progress of electrification in existing buildings. It helps us understand what is driving the projects underway and what barriers still prevent widespread deployment of electrification retrofits.

The building sample documented in the map is not statistically representative because it is not a random sample of the full and unknown distribution of electrification retrofit projects, but rather a sample of convenience. The information we have collected could differ significantly from the full distribution of projects due to unintentional bias. Despite this, we are able to take a glimpse at the picture of existing building electrification through the gathered projects. The map is available via the Center for the Built Environment's website as an open-access tool, shown in *Figure 1* and *Figure 2*.[8] The intent is for the map to serve as an overall reference for the state of electrification in North America generally, with details about each building's specific retrofit available for owners and designers seeking direct comparisons. When available, case studies with further background information have been linked in the map.

FIGURE 3 Building floor area distribution for the projects represented on the map.

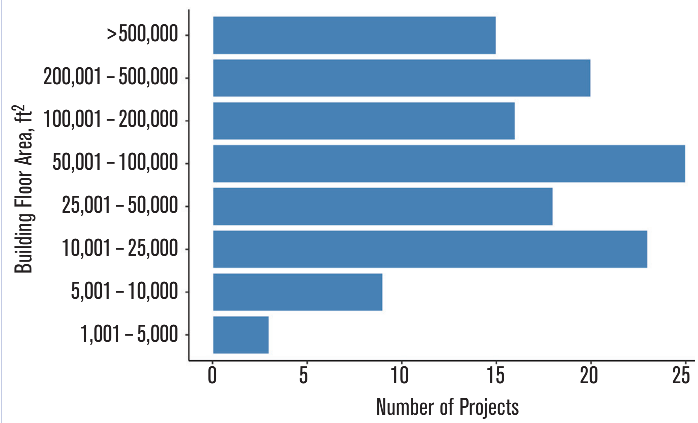
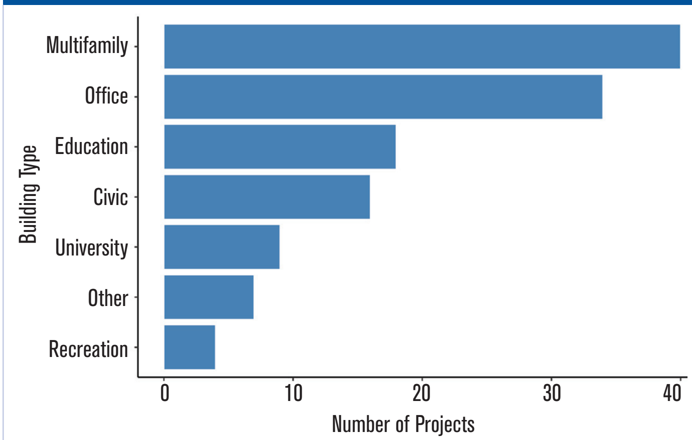


FIGURE 4 Building type (use) for the projects represented on the map. The "Other" category consists of building types that didn't fit into a simple description. Included on the list with less than four entries are mixed-use, laboratory, religious, recreation, hotel, retail, military, medical and airport.



Methods

First, the original projects from the 2022 version of the map were examined and updated pending new information. Of the 45 projects originally included, 24 were not complete as of the first publishing of the map. A review of these projects found that seven either were not pursued, or the relevant project contacts could not be reached for an update. At least five projects that had been abandoned or could not be updated were removed from the updated map. Of the 142 projects in the 2025 update to the map, 107 were complete, 32 were in either active design or construction, three projects had no update from 2022 and one project has been fully designed but not yet pursued. Adding new projects to the map involved a multifaceted approach, including literature review, keyword searches, email outreach and designer interviews. The projects added to the map following an unstructured literature review were collected from several sources, including mechanical and architectural designer websites and formally published case studies. Several regional organizations also document and share electrification retrofit projects in their respective jurisdictions. Email outreach was conducted to municipalities with sustainability departments and local ASHRAE Chapters, yielding a handful of projects. Interviews were conducted with representatives from a wide range of design engineering firms.

These projects are represented in two virtual maps, one created with Google Maps and the other with Awesome Table. Few published case studies were available that reported the results of electrification retrofits in available resources. Several designers we spoke to expressed interest in evaluating post-retrofit data in their projects, but cited lack of time and budget as limitations. Failing to evaluate the operation of new electric systems risks leaving emissions savings on the table when the new system is not performing optimally.

Results

The map now contains 142 projects across 39 U.S. states and Canadian territories. The data set spans a broad range of building types, sizes, systems, locations and motivations. Small commercial buildings of less than 10,000 ft^2 (929 m^2) are represented, along with campus projects electrifying several million square feet of floor area (*Figure 3*).

Figure 4 presents the variation in building use. *Figure 5* presents the climate zones for the mapped projects, while *Figure 6* represents project states and territories. Categories with less than three entries on the map were excluded. Projects were most commonly found in California and New York, with the two states making up 64 of the projects (45%) on the map. Natural gas is the dominant preretrofit heating fuel, used in 89 projects.

As expected, boilers are the most common preretrofit space heating system, with more than 56 projects mentioning some form of boiler out of the 130 projects where space heating was retrofitted. Of these, hot water boilers were the most common in this data set, with 33 mentions. Other common existing space heating systems include rooftop units; district steam and radiators; and distributed PTAC, furnace and electric resistance systems. For 17 projects, specific details of the space heating were not available. All existing systems were fossil fuel-powered either at the building or campus plant-level preretrofit. Eighty-nine projects had natural gas as the original system fuel. More than 28 distinct new electric mechanical systems are represented in the data set, ranging from in-unit packaged systems to campus-scale geothermal plants. *Figure 7* presents the relationship between existing and new space heating systems. The majority of air-to-water heat pumps previously used heating hot water systems, although many heating hot water systems were also retrofitted to other electric systems. Other common trends include converting from steam to ground source heat pumps, many projects of which are campus conversions.

The existing and new systems have been abstracted for simplicity, and more detail is available in the map data set. The existing system types have been abstracted to a high level as they were frequently not reported in detail in available case studies, which often primarily focus on the new system. While the existing system often informs the new system selected in retrofits, many other factors play a role, including geographic location. Some trends may be observable in the map data, but a clean geographic

FIGURE 5 Figure 5. IECC Climate Zones with three or more entries for the projects represented on the map.

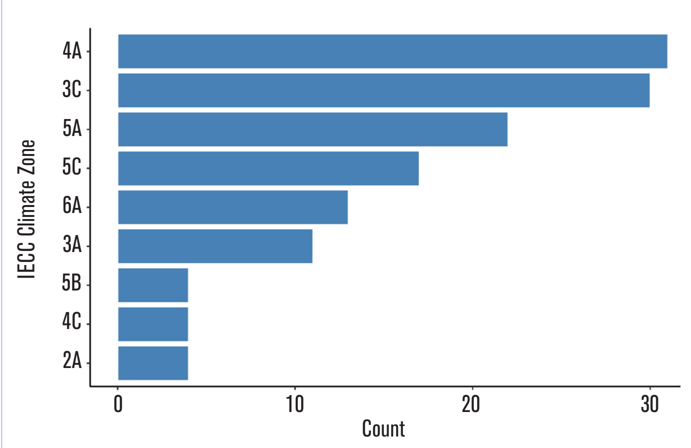


FIGURE 6 U.S. states and territories with three or more entries for the projects represented on the map.

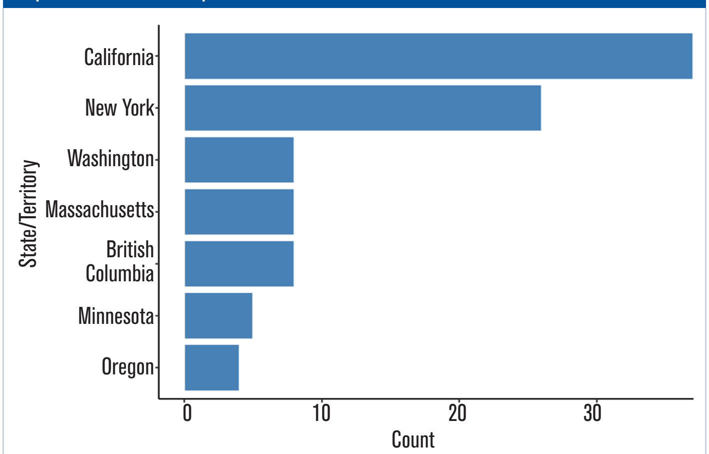
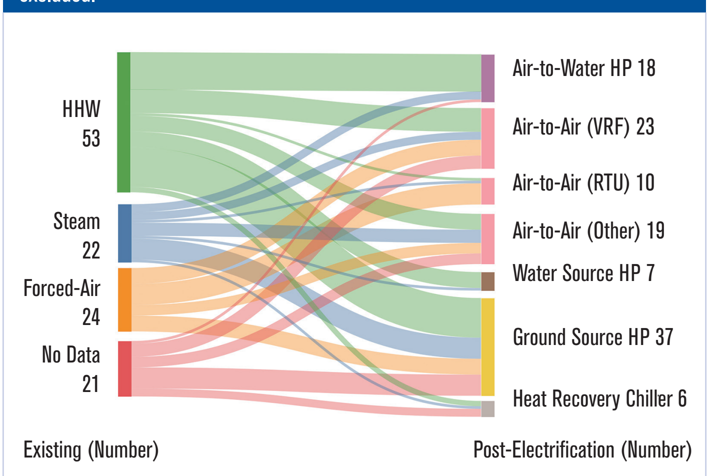


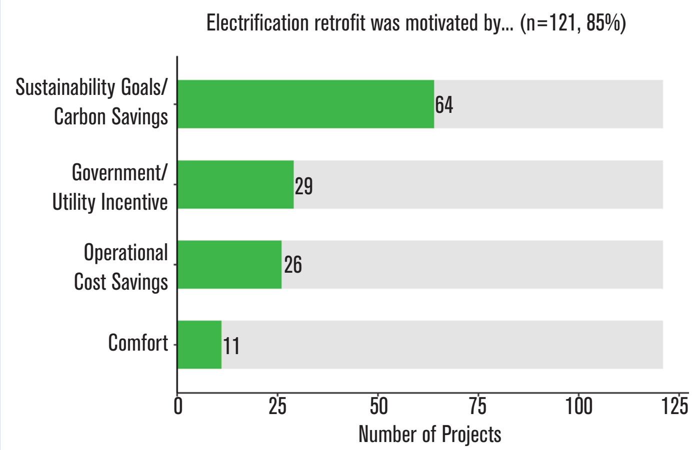
FIGURE 7 Diagram showing the relationship between existing fossil-fueled and new electric HVAC systems in the retrofit projects documented. Projects that only electrified domestic hot water or with insufficient system information have been excluded.



comparison cannot be made.

When available, the owner's motivation for electrification retrofits has been collected for the mapped projects (*Figure 8*). The largest motivator by far is sustainability goals or carbon emissions savings, reported as a motivating factor for 64 projects. This includes internal organizational sustainability goals and decarbonization in response to building performance standards on the state or local level or retrofits of public buildings in alignment with jurisdictional sustainability goals. The next most common motivator is the availability of incentives from utility companies or government agencies, listed as a motivating factor in 29 projects. The range of programs and incentives varies widely, from large state-funded programs to smaller local utility rebates for electric equipment. Another common motivator was improving comfort, whether due to upgrading old mechanical systems that weren't operating optimally or pairing electrification with envelope improvements to reduce perimeter discomfort.

FIGURE 8 Motivating factors for electrification retrofit projects included in the map. Projects that had multiple motivations may be represented in more than one category.



Twenty-six projects were motivated by the potential to reduce operating costs over the existing fossil fuel-based system. Of these, 20 reported having achieved these savings, while the remaining six fell short or did not report post-retrofit outcomes in any capacity. Up-front costs mostly went unmentioned in the projects collected. When simple payback was calculated, payback periods ranged from four to 46 years, with some projects including incentives. In these projects, simple payback was calculated as the payback period for operational savings over the preretrofit system to cover project costs. The first-cost comparison of replacing the conventional systems already present was not incorporated. Project case studies in the *Retrofit Playbook for Large Buildings*, published by NYSERDA, typically compared the electrification and decarbonization strategies implemented to a business-as-usual case, highlighting cost savings or increases in comparison to the standard operating procedure, including avoided penalties under the building performance standard in New York City.

Interviewing designers provided additional insight into what electrification retrofit projects are happening and not happening and why. One design engineer mentioned that several complete electrification retrofits have been plagued with heat pump compressor failures. While they were largely able to be replaced under warranty, this can still create disruptions and hinder post-retrofit operation of new electric systems. These observations were anecdotal, and no quantitative comparison of the failure rates of compressors to conventional heating and cooling equipment has been made. Another design engineer said that the biggest reasons electrification retrofits aren't happening are high up-front costs, space constraints, increased operational costs and electrical infrastructure limitations on the building and grid sides. One example was provided where a university wanted to explore electrifying domestic hot water in alignment with their sustainability goals, but couldn't find the space for hot water storage needed for heat pump systems and also couldn't justify electric resistance water heating. Other institutional clients were unable to shoulder the up-front costs of electrification, despite internal will and alignment with long-term sustainability goals.

Discussion and Conclusions

The results of the Electrification Retrofit map and designer interviews paint a clearer picture of the state of existing building decarbonization. From 2022 to 2025, we found that demand is growing for electrification retrofits, but not exponentially. The collected sample is biased toward jurisdictions or organizations that publish online case studies of retrofit projects and our lab's established connections in the industry. Despite this, an effort was made to build a geographically and systematically diverse data set that gives a glimpse of the national and North America electrification landscape.

Several large challenges that exist are mentioned throughout this study as primary barriers to larger growth in electrification retrofits. Often mentioned as the largest barrier is up-front, or first cost. This involves the one-time costs associated with purchasing and installing a new electric system and adapting the existing building conditions to accommodate that new equipment. This includes equipment and installation costs that are typically more expensive than a like-for-like conventional system (i.e., business-as-usual replacement), as well as other costs sometimes associated with electrification retrofits including electrical infrastructure upgrades to accommodate increased loads, structural enhancements to support new equipment and installation costs (e.g., crane costs to lift a larger and heavier heat pump onto a rooftop vs. replacing a boiler that can be transported through the building). Electrical service upgrades in particular represent a challenge unique to electric systems and can be a decisive factor to project feasibility. Several designers in our interviews cited projects where one or more of these up-front cost-related barriers stalled out a project. While electric technology is expected to become more affordable as the market continues to develop, other cost-related challenges to electrifying existing buildings will continue to persist.

Operating costs are the other element of electrification cost often cited as a barrier. As mentioned previously, heat pump technology is more efficient than conventional fossil fuel space and water heating equipment, leading to a potential for energy savings. Boiler and furnace efficiencies vary based on system age and efficiency. They are typically around 80% efficiency, however, and lie within the range of 55% to 98% efficient.[9] Heat pump technology is more efficient, with reported coefficients of performance (COP) varying from 3.1 to 4.1 (310% to 410% efficiency) for Energy Star–certified geothermal heat pumps under laboratory test conditions, though performance depends highly upon the rating conditions. A few studies have also reported measured field performance of air-to-water heat pumps in larger nonresidential applications, with average COPs ranging from 1.5 to 2.5, or 150% to 250% efficiency.[10] These energy savings do not always bear out as cost savings due to the spark gap, or difference in cost of electricity compared to natural gas. At a COP of 2.5, electricity would have to be less than three times the cost of natural gas per unit of energy to see lower operational costs than an 85% efficiency boiler. The difference between gas and electricity varies nationally, but typically does not meet that threshold. Another complicating factor is that utility rates are uncertain over a piece of equipment's lifetime. The 20 projects on the Electrification Retrofit Map that reported operational savings often had additional factors contributing to this result, including switching from alternative fossil fuels like fuel oil, steam and propane; reduction of simultaneous heating and cooling with heat recovery; and pairing electrification of inefficient building systems with holistic energy conservation measures.

Another barrier to electrification cited by designers and unique to existing buildings is space constraints. An air-to-water heat pump (AWHP) designed to meet a similar heating load as a boiler will take up more space, which is often already at a premium in existing buildings. This concern can be addressed to some extent by right-sizing new electric systems in cases where the original system was oversized or by implementing other design-day load-reducing efficiency measures, resulting in lower required heating and cooling capacity.

In other cases, particularly mild heating climates, it can be addressed by replacing existing air-cooled chillers with AWHPs that serve both heating and cooling loads. However, one common thread reported by designers was that each building was unique due to its particular combination of existing conditions and associated constraints.

Successful electrification retrofit projects rely on a confluence of factors. They are typically: 1) motivated by internal or external sustainability goals, which are typically driven by corporate or governmental mandates or other specific policies, 2) partially funded by government or utility incentives, ranging from grants to explore new technology to rebates for installation of proven electric equipment and 3) supported by an internal champion who advocates for the project and makes a business case that goes beyond simple payback. Decarbonization retrofits can appear more financially palatable when compared to a business-as-usual case, incorporating the avoided costs and risks associated with a lack of action and uncertainty around future legislative and utility rate escalation risks. Continuing to scale electrification retrofits will rely on an expansion of these successful strategies, along with a continued focus on addressing major barriers.

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