Pump it Up! Accelerating Advanced RTU Adoption in Commercial Buildings

Guidehouse: Chris Sullivan-Trainor, Bill Goetzler, Jim Young[1],
Rachel Lebedinsky, Maureen Lippitt
National Laboratory of the Rockies: Michael Deru, Grant Wheeler, Dipika Kishore

ABSTRACT

Space conditioning accounts for 40% of United States commercial building energy use (EIA 2023). Next generation rooftop units (RTUs) can increase energy efficiency in buildings and lower energy bills by up to 50% compared to conventional RTUs (PNNL 2013). Recent case study participants reported site energy savings of 17%-70%. However, heating performance of most commercially available and installed RTUs has not improved since 2011, and heat pump and dual fuel RTU technology has low adoption in commercial buildings. As part of the U.S. Department of Energy's Better Buildings & Better Plants Initiative, the Commercial Building HVAC Accelerator (Accelerator) aims to increase adoption of advanced RTUs in commercial buildings through a Campaign to address market barriers. The Accelerator also initiated a Challenge to develop next-generation RTUs with superior performance.

This paper discusses the status of these efforts, including updates on 12 prototype next-generation RTUs installed for validation in real buildings, and common barriers and takeaways from 9 case studies on advanced RTUs that are commercially available. Adopters faced common barriers to installation that included equipment lead times, permitting delays, and contractor inexperience with both dual fuel and all-electric systems. The paper highlights successful strategies used to overcome these barriers—such as proactive planning, clear communication, and team continuity—and shares lessons learned from the case studies. It will also explore how these findings are shaping future retrofit strategies and building momentum toward a more resilient building stock with lower operating costs.

Introduction

Residential and commercial buildings account for 75% of annual electricity consumption and 40% of total energy consumption in the U.S. today, leading to over $300 billion in annual utility bills for American consumers and businesses (Langevin and Wilson 2025). Building heating, ventilation, and air conditioning (HVAC) systems account for almost half of commercial energy loads (Figure 1) and are critical technologies to maintain comfortable and safe indoor environment for building occupants and goods. Commercial rooftop units or RTUs are a common HVAC solution for low- and mid-rise commercial buildings in North America that combine space heating, space cooling, and ventilation systems in a single combined package. Roughly half of commercial floor space today is heated by an RTUs (CBECS 2018). RTUs are typically installed by a crane on the building's roof or on the ground next to the building. Products are available from a long list of manufacturers, who offer a wide variety of capacities, efficiency levels, and system configurations to meet the project's specific needs.

[1] Formerly with Guidehouse

© 2026 ACEEE Summer Study on Energy Efficiency in Buildings

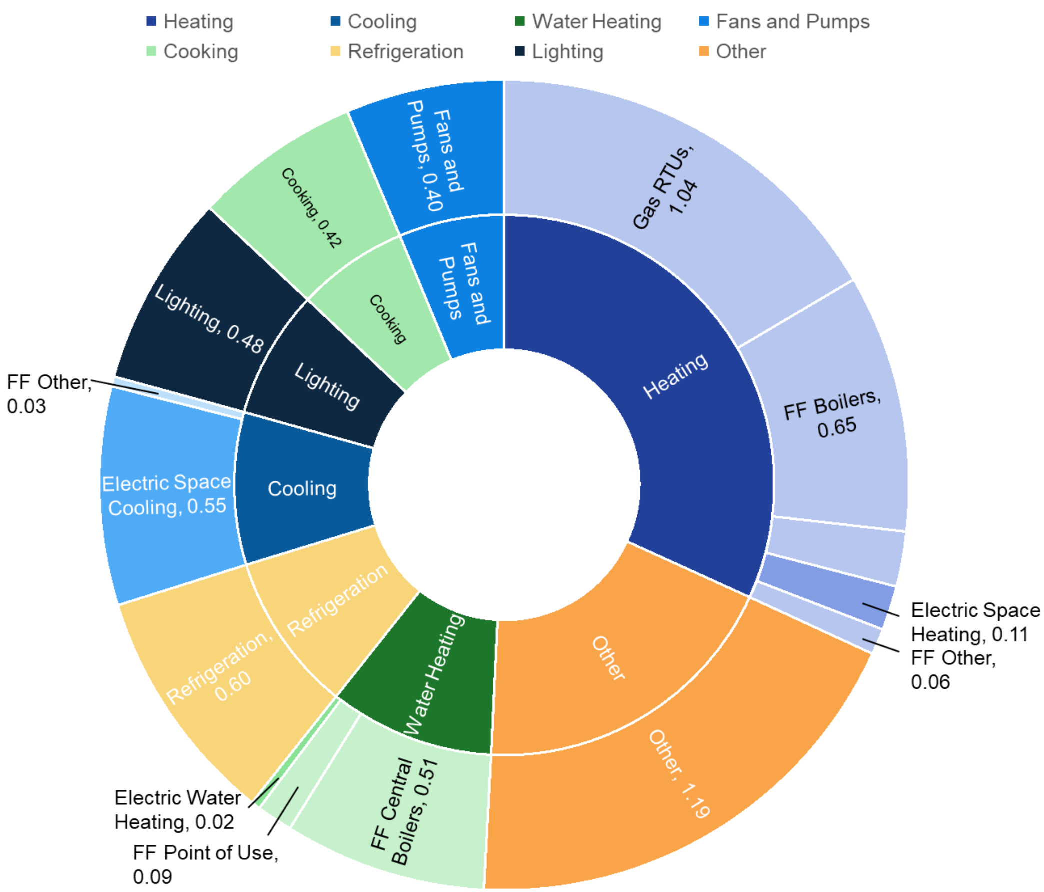

Figure 1. Commercial Building Energy Consumption and HVAC Share including electric and fossil fuel (FF) appliances. *Source:* Langevin and Wilson 2025.

Most commercial RTUs today use on-board electric space cooling and natural gas or electric resistance for space heating.[2] Heat pump (HP) RTUs utilize the same electrically driven vapor compression cycle for space heating as well as space cooling and have been commercially available for decades. HP RTU technologies have seen increased interest in recent years from building portfolio owners, utilities, governments, and manufacturers to support energy consumption, utility bill, and emissions savings with fifty-five partners signing on to support the adoption of this technology and other advanced HVAC solutions to date per the Accelerator website[3] (U.S. Department of Energy 2024a). Additionally, newer RTU technologies include more dual fuel options and show increased cold climate heating performance. HP RTUs (coefficient of performance [COP] of roughly 3) will always provide energy efficiency and operating cost savings relative to RTUs using electric resistance heating (COP of 1). When comparing HP RTUs with RTUs using natural gas heat, the relative price of natural gas vs. electricity from local utilities, the performance of the HP at different outdoor temperatures, as well as the amount of ventilation air being conditioned will affect the operating cost comparison.

[2] Some RTUs use hydronic heating and/or cooling coils that are served by the building's central chiller and boiler distribution systems.

[3] https://betterbuildingssolutioncenter.energy.gov/accelerators/commercial-building-hvac

Due to the significant importance of RTUs in the country's commercial buildings and utility bills, the U.S. Department of Energy (DOE) has supported RTU research, development, and demonstration (RD&D) for decades. BB & BP is an initiative of DOE designed to improve the lives of American people by driving leadership in energy innovation (U.S. Department of Energy 2026a). Many BB & BP activities are organized around collaborative initiatives with partners, including the Technology Research Teams and Sector Teams organized around key topics or the BB & BP Challenges in which organizations set 10-year energy reduction goals, track their progress, and share their learnings with others (BB & BP 2025).

Although models are available today from all major RTU manufacturers, adoption of HP RTUs is low across U.S. commercial buildings, and lags adoption in homes, providing space heating for approximately 11% of commercial buildings or 15% of total commercial building floor area (CBECs 2018). Key reasons for low adoption, drawn from Better Buildings & Better Plants (BB & BP) partner interviews, case studies (U.S. Department of Energy 2024a), modeling (NLR n.d.), and supported by literature (CalMTA 2025) include:

- **Upfront Cost**: Traditional HP RTU models carry a modest price premium over those with electric resistance or natural gas heating. Cold climate models carry a substantial cost premium accounting for their more sophisticated components and designs. Many commercial building owners focus solely on first cost if the operating costs are a tenant's responsibility, even if there is an attractive payback period.
- **Operating Cost**: Depending on the region and utility, natural gas heating is often less expensive than electric space heating, especially at colder temperatures.
- **Availability**: Many RTU sales are emergency replacements when the existing system fails, rather than planned replacements. Local availability is a key consideration in system selection. HVAC distributors stock equipment that sells locally, so HP models may not be stocked locally if there are few projects in the region to date.
- **Performance**: Historically, HP RTUs have faced performance challenges for high-bay applications and those with high outdoor air rates due to the lower heating supply temperature from the HP compared with natural gas heating. Also, HP RTUs often take longer to recover in the morning from night setback scheduling (Douglas and Rushton 2024). This challenge can be addressed by adjusting controls sequencing or avoiding nighttime setbacks, but any change to traditional operations can be a barrier.
- **Infrastructure**: HP RTUs, especially all-electric or cold climate models, may require additional structural evaluation or curb adaptors, and have higher electrical capacity needs than existing systems. The need for infrastructure evaluation and upgrades adds cost and is often a reason for many replacement projects to choose a like-for-like replacement.
- **Policy**: Many states restrict utility energy efficiency programs from incentivizing fuel switching measures (e.g., replacing RTUs with natural gas heating with HP models) (ACEEE 2026). HP RTUs replacing electric resistance models will be allowed because this swap is more traditional energy efficiency with the same energy source.
- **Awareness**: Building owners, HVAC design teams, and other key decision makers may not be aware of the wide range of HP RTU offerings today, including dual fuel, cold climate, and dedicated outdoor air system (DOAS) models.

© 2026 ACEEE Summer Study on Energy Efficiency in Buildings

Commercial Building HVAC Accelerator Framework

the DOE launched the Commercial Building HVAC Accelerator in 2024 to advance the development and deployment of next-generation, high-efficiency RTU technologies, including cold climate and dual fuel HP technologies (U.S. Department of Energy 2024a). Building portfolio owners identified product attributes and capabilities they thought could be best addressed through industry-wide collaboration and engagement with manufacturers. Discussions from 2022-2023 between DOE, the national laboratories, and contractors, building portfolio owners, RTU manufacturers, utilities, and other industry stakeholders suggested that the time was right to launch an updated DOE-lead initiative to collectively move RTU technologies and market transformation efforts forward. In May 2024, drawing upon past successes with the 2011 RTU Challenge (2011 Challenge) (Deru et al. 2021) and the 2011 Advanced RTU Campaign (2011 Campaign) (U.S. Department of Energy 2016), DOE launched the Commercial Building HVAC Accelerator (Accelerator) in 2024 with an initial set of stakeholders to accelerate the development and adoption of advanced RTUs, reduce energy costs, and achieve greater comfort in commercial buildings.

The Accelerator is comprised of 2 complementary efforts (Figure 2) to advance RTU technology and increase adoption to lower energy costs for building owners and tenants. The Commercial Building HVAC Technology Challenge (referred to hereafter as “the 2024 Challenge”) involves the collaborative development of a next-generation HP RTU specification, followed by laboratory and field testing of prototype technologies at partner locations to support technology introduction. The Commercial Building HVAC Campaign (referred to hereafter as “the 2024 Campaign”) supports greater awareness and adoption of today’s HP RTU technologies and primes the market for the anticipated introduction of the 2024 Challenge units. The 2024 Challenge HP RTU methodology for laboratory and field testing is described in greater detail in subsequent sections, as well as a separate ACEEE 2026 Summer Study on Energy Efficiency in Buildings paper titled “Field Validation of Next-Generation Rooftop Units: Balancing Affordability, Reliability, and Energy Performance in Commercial Buildings.” The Commercial Building HVAC Accelerator currently has over 50 building owner, manufacturer, and industry partners who support this initiative, a list of which can be found on the Accelerator website[4] (U.S. Department of Energy 2024a).

Figure 2. Commercial Building HVAC Accelerator complementary efforts – Technology Challenge & Campaign. *Source:* Guidehouse.

[4] https://betterbuildingssolutioncenter.energy.gov/accelerators/commercial-building-hvac

© 2026 ACEEE Summer Study on Energy Efficiency in Buildings

Commercial Building HVAC Technology Challenge (2024 Challenge)

There has been steady improvement in the cooling and ventilation performance of RTUs in recent years (Deru et al. 2021); however, there have not been similar improvements for heating efficiency. Around 75% of RTUs use a gas furnace with 80% heating. Several efforts to implement condensing gas heating coils in RTUs have been tried with limited success efficiency (Eschenback et al. 2024). While a condensing gas furnace can increase the heating efficiency to over 90%, it also produces a slightly acidic condensate that must be managed. The condensate must be piped to a drain and neutralized, which can be very expensive for large buildings with multiple RTUs. Furthermore, the secondary condensing heat exchanger increases the fan pressure requirements and associated energy consumption during non-heating seasons and diminishes the economic savings potential (NEEA 2020). As such, condensing furnace technologies are largely found only for large make-up air (MUA) units in colder regions, and not the wider RTU market with manufacturers only offering them by special order. Recent advances in compressor technology with invertor driven compressors and vapor injection, offer opportunities for substantial improvements to HP performance under cold weather conditions (Deru et al. 2026).

At the same time, many commercial building owners and utilities have shared through Better Buildings Better Plants discussions that they have aggressive energy efficiency and reliability goals that are driving a growing demand for affordable high-efficiency heating solutions for commercial buildings for all climates. Finding cost effective solutions to meet this growing demand is a high priority for these stakeholders. The 2024 Challenge builds on the success of the 2011 Challenge and more recent Residential Cold Climate Heat Pump (CCHP) Challenge (U.S. Department of Energy 2021), with a greater focus on cold climate heating performance. The primary objectives of the 2024 Challenge are to:

- Develop affordable heating solutions with currently available technologies.
- Increase heating capacity at low ambient temperatures.
- Raise efficiency at low ambient temperatures.
- Implement load flexible controls.
- Focus on 10–20-ton capacity RTUs.
- Start with building portfolio owners with direct relationships with manufacturers.

The 2024 Challenge specification included the following considerations:

- Minimize electrical capacity upgrade requirements.
- Minimize peak demand impacts.
- Enable dual fuel operations.

Per the discussions with DOE, national labs, and other stakeholders, BB & BP building owners found there were no RTUs available on the market to meet their needs. The supply had not caught up and there was not a consistent or unified ask for manufacturers to invest in developing new RTU technology to meet the uncertain demand. DOE saw an opportunity to work with the key building owners and manufacturers to accelerate the development of new RTU technology through a national technical challenge. The purpose of a technical challenge is to harness the power, ingenuity, and competitiveness of U.S. industry to solve a well-defined challenge that satisfies a market need. DOE has conducted successful technical challenges (2011 Challenge) and technical prize competitions (Golden Carrot for Residential Refrigerators [CEE 2026], L-Prize for residential LED lighting (Ledbetter 2014), American Made Program [U.S. Department of Energy 2026b]). A technical prize competition is similar with the addition of a cash prize for motivation in addition to the potential sales due to a growing market for the new products developed through a technical challenge. Therefore, it is important for the 2024 Challenge team to understand, develop, and promote the market for the new products.

Based on previous DOE experience, the key steps for a successful technical challenge to support the Accelerator and ultimately ensure new technology meets customer needs include:

- Gather and distill market challenges and interests to inform the performance requirements of the challenge.
- Build market demand for the resulting new technology by working closely with leading building owners, utilities, and efficiency organizations.
- Leverage funding, knowledge, and ingenuity of manufacturers to develop technology breakthroughs.
- Create market competition between manufacturers to further drive innovation and increase overall value to customers and society.
- Identify and address technical and market barriers to encourage adoption of the new technology.

DOE officially launched the 2024 Challenge at the Better Buildings Summit on April 3, 2024 led by the National Laboratory of the Rockies (NLR) and includes Pacific Northwest National Laboratory (PNNL), Oak Ridge National Laboratory (ORNL), Argonne National Laboratory (ANL), and Guidehouse with input from Lawarence Berkeley National Laboratory (LBNL) and Minnesota Center for Energy Efficiency. The 2024 Challenge also included industry partners and collaborators. The 2024 Challenge team consulted with several building owners about the performance and features in RTUs they would like to see align with their operation standards and meet their corporate performance goals. A subset of these companies volunteered as participants to host 1-2 years of field testing of the prototype RTUs as listed in Table 1. Eight HVAC manufacturers participated in the 2024 Challenge and produced prototype RTUs as listed in Table 2.

Table 1. 2024 Challenge partners who volunteered to host 1-2 years of field testing *Source:* NLR.

Building Owner Field Test Participants (ABC)
Amazon
Columbia Association
Life Time
Lowes
Prologis
Target

© 2026 ACEEE Summer Study on Energy Efficiency in Buildings

Table 2. 2024 Challenge RTU manufacturers tested. *Source:* NLR.

Manufacturer Participants (ABC)
Aaon
Bosch/York
Carrier
Daikin
Lennox
LG
Rheem
Trane

The 2024 Challenge consists of the phases outlined in the timeline in Figure 3 plus the first action (not shown in the timeline) to draft a performance specification (U.S. Department of Energy 2025) that defined the requirements for cooling, heating, controls, and load flexibility. The heating performance is the primary focus of this 2024 Challenge as shown in Table 3. There are tradeoffs for cold climate HP performance between capacity and efficiency, and the specification was written with heating capacity as the primary target while maintaining minimum efficiency levels. The capacity ratio is defined as the heating capacity at the given temperature divided by the cooling capacity at 95°F. So, the units must provide at least the same heating capacity at 5°F as cooling capacity at 95°F. The specification uses the performance metrics defined in AHRI 1340 set to be implemented by January 1, 2029 (AHRI 2024). The heating metrics are the coefficient of performance 2 (COP2) and integrated ventilation and heating efficiency for cold climates (IVHEc) (AHRI 2024). IVHEc was developed using weighting factors for climate zones 5, 6, and 7. Manufacturers could develop prototypes for one or both of the capacity categories: 10-14 ton or 15-25 tons.

Advanced control and grid-interactive capabilities to support load flexibility and account for building owner needs to meet their organizational goals were also part of the performance specification (U.S. Department of Energy 2025). A part of the testing for the challenge is to verify the capability of advanced controls on the challenge units to minimize need for electrical capacity upgrades, minimize peak demand impacts, minimize backup heat runtime in cold conditions, and enable electric resistance and gas backup heat.

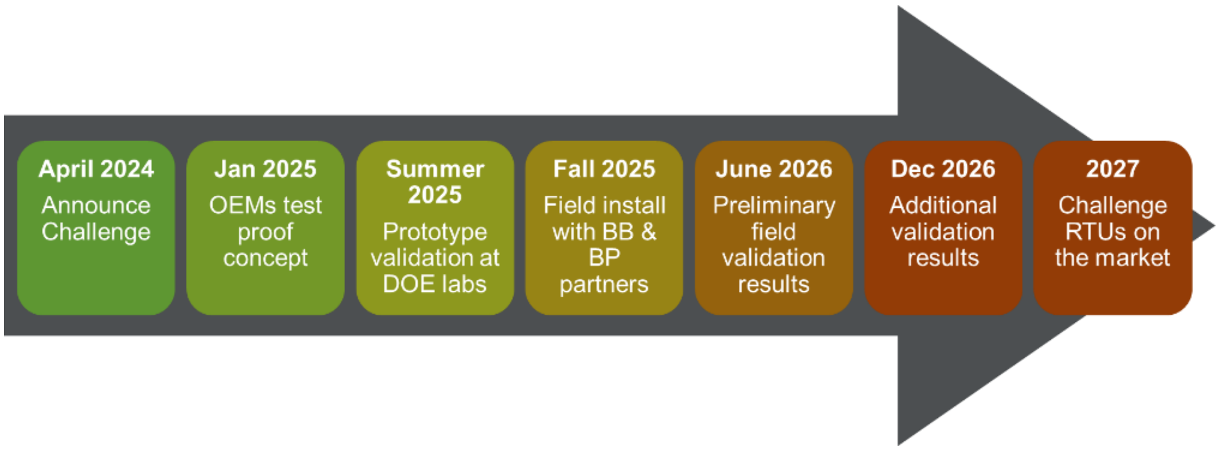

Figure 3. The timeline for the Commercial Building HVAC Technology Challenge. *Source:* U.S. Department of Energy 2024a.

Table 3. Commercial Building HVAC Technology Challenge Heating Requirements
Source: U.S. Department of Energy 2025.

<table>
<tr><th rowspan="2">HP Nominal Capacity (Btu/h)</th><th colspan="2">Outdoor Air T: -10°F</th><th colspan="2">Outdoor Air T: 5°F</th><th rowspan="2">Min IVHEc</th></tr>
<tr><th>COP2</th><th>Min. Capacity Ratio</th><th>COP2</th><th>Min. Capacity Ratio</th></tr>
<tr><td>≥65,000 & < 135,000</td><td rowspan="3">1.3</td><td rowspan="3">0.7</td><td rowspan="3">1.7</td><td rowspan="3">1.0</td><td>7.1</td></tr>
<tr><td>≥135,000 & < 240,000</td><td>6.9</td></tr>
<tr><td>≥240,000 & < 760,000</td><td>6.7</td></tr>
</table>

There are 3 steps to execute performance validation of the new prototype RTUs within the 2024 Challenge: 1) proof-of-concept submission from the manufacturers, 2) laboratory validation by DOE and the national laboratories, and 3) field validation. The proof-of-concept submission consisted of a description of the new RTU and performance estimates based on calculations and manufacturer laboratory measurements. The second validation step required the manufacturers to submit their prototype RTUs to DOE for laboratory validation. The laboratory evaluation followed a method of test that included standard steady-state tests and 4 controls verification procedure tests to gauge how the unit and controls will perform under realistic operating conditions. Ten prototype RTUs were submitted from the 8 manufacturers. Two manufacturers submitted 2 prototypes, one for each size range (10-14 tons and 15-25 tons). The laboratory validation was completed across 6 laboratories including one national laboratory, 2 commercial testing laboratories, and 3 manufacturer facilities. All testing was conducted in collaboration with engineers from NLR to ensure a consistent methodology was followed and to verify the results. After some iterations in testing, all prototypes met or exceeded the 2024 Challenge specification performance requirements. The average heating metric results for all prototypes are shown in Table 4.

Table 4. Average Commercial Building HVAC Technology Prototype RTU Performance
Source: NLR.

HP Nominal Capacity (Btu/h)	Outdoor Air T: -10°F		Outdoor Air T: 5°F		Min IVHEc
	COP2	Min Capacity Ratio	COP2	Min Capacity Ratio	
Challenge Specification	1.3	0.70	1.70	1.00	7.00
Prototype Average	1.6	0.87	1.92	1.08	7.59
Percent Improvement	23%	24%	13%	8%	8%

For the field validation stage, 12 2024 Challenge prototype RTUs were installed in commercial buildings owned by building owner participants (listed in Table 1) starting in the fall of 2025 for field evaluation through the fall of 2027. More units will be installed at field sites in the spring of 2026. Four of the RTUs are dual fuel units and 8 are all-electric units. The installations occurred in climate zones 4, 5, and 6. All units were instrumented following a field validation plan developed by NLR.

Commercial Building HVAC Campaign (2024 Campaign) Highlights and Key Findings

The Commercial Building HVAC Campaign helps commercial building owners reduce operating costs by increasing the adoption of innovative advanced HVAC technologies. Leveraging the BB & BP network and previous accelerators, DOE provides building owners with resources to support installations and highlights their success stories. The 2024 Campaign consists of highlighting organizations adopting advanced HVAC technologies, showcasing the insights and lessons learned from successful adoption of these technologies in case studies (U.S. Department of Energy 2026a), and providing resources and direct technical support to help building owners understand their options when evaluating adoption of advanced HVAC technologies. The 2024 Campaign aims to increase adoption of the currently available advanced HVAC technologies where there is a good fit, consolidate insights and lessons learned to help lower future adoption barriers, and prepare stakeholders for emerging HVAC technologies.

The case studies describe how organizations overcame project specific barriers to adopt HP RTU solutions, their experiences with the technology, and financial implications in different scenarios. Two case studies are published on the BB & BP website (U.S. Department of Energy 2026a), 7 are under development, and the 2024 Campaign continues to work with partners to identify opportunities to cover more technology solutions, climate zones, and building types. Case studies that are published or currently under development are highlighted in Figure 4.

Figure 4. Case Studies Identified to Date. *Source:* Guidehouse.

The case studies and engagement with 2024 Campaign partners to date convey the effectiveness of existing, commercially available advanced RTUs to help organizations meet their goals as well as highlight the need for site-specific considerations. Specifically, commercially available all-electric and dual fuel RTU technologies can address a wide variety of building types in the same way as conventional RTU solutions. Based on these case studies and BB & BP partner engagement, building owners who have existing building performance or organizational goals (such as meeting climate and sustainability targets, reducing operational energy costs, and meeting building performance standards) are an optimal fit for the current solutions, as their internal objectives allow for proactive planning, clear communication, and straightforward product selection. These internal goals, along with financial incentives, local regulations, and the condition of the existing equipment all serve as motivators for the adoption of advanced HVAC solutions.

While many of the case study sites replaced existing conventional RTUs with advanced solutions, some were new construction. One case study included replacing a central steam system that was no longer needed, demonstrating the versatility of applications for advanced RTUs. All sites with cost saving data reported cost savings over their previous or projected alternative HVAC solutions, ranging from 17-70%. All sites with available performance data had comparable lifecycle costs and occupant comfort to conventional RTU solutions and reported lower noise during operation.

Case study sites experienced both common cross-cutting and site-specific challenges. More common challenges included (1) high upfront capital requirements, (2) difficulty ensuring correct equipment sizing, (3) additional structural evaluation and costs associated with the increased weight of advanced RTU units, and (4) coordinating installation with normal building operations due to longer lead times and less familiarity with the units compared to conventional solutions, particularly at sites serving clients or customers.

Based on input from 2024 Campaign partners and case study participants, local incentive programs were available in all cases to reduce the incremental cost. These savings, combined with efficiency gains to offset the upfront costs, result in lifetime savings for four of the five cases studies where operational cost data was included.

Some site-specific challenges included (1) limited availability of larger capacity options (e.g., >25 tons heating/cooling), (2) procurement delays, (3) controls set up for the newer units leading to challenges like increased fan-noise while the units were optimized to the space, and (4) installation quality control.

Figure 5 summarizes the high-level findings and barriers from the case studies conducted to date (including those under development).

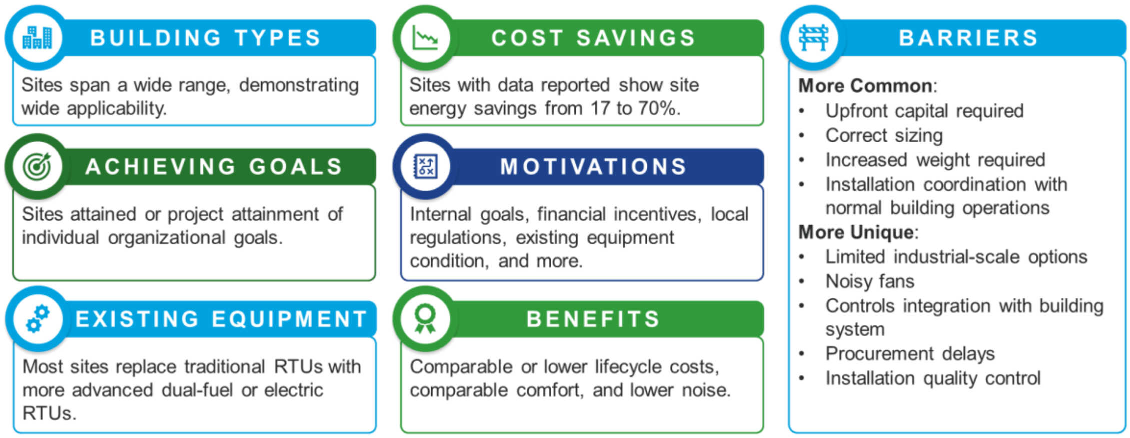

Figure 5. Overview of Findings from Available Case Studies *Source:* Guidehouse.

The case studies in Table 5 highlight both dual fuel and electric backup heating configurations. Most project sites indicated that they will continue to monitor performance of their new units and use the lessons learned to inform future building retrofit projects.

Table 5. Overview of Case Studies *Source:* Guidehouse.

Building Type	Region	Solution	Outcomes
Retail	California	Electric backup	• Lowered total energy use 44%
	Pennsylvania	Dual Fuel	• *Ongoing monitoring – Results not yet available*
Office	California	Electric backup	• Quiet operation • Better temperature control
	New York	Dual Fuel	• 70% less site energy
Industrial	California	Electric backup	• 17% less energy for space conditioning
	New York	Electric backup	• $330,000 lifetime savings
Education	California	Electric backup	• $140,000 savings on monthly utility costs
	Washington	Electric backup	• Reduced fuel costs
Community	Maryland	Dual Fuel	• 70% on-site natural gas demand reduction

Key findings from completed case studies (2 published and 7 under development) are summarized below with full details available on the Commercial Building HVAC Accelerator website (U.S. Department of Energy 2024a):

- In California, the **Los Angeles Unified School District** replaced 65% of their decentralized HVAC units with advanced electric systems, including advanced RTU solutions. These systems covered 13,500 buildings with a total of 70 million square feet

© 2026 ACEEE Summer Study on Energy Efficiency in Buildings

of school building space, and saved an estimated $140,000 per month on utility costs. There was initial concern with increased cost, but LAUSD secured board of education buy-in and utilized grants and critical repair program funding. Additionally, a **warehouse in California** changed their planned conventional RTU solution to instead install advanced RTU units to serve 700,000 square feet of the fulfillment building. The advanced RTU units are projected to reduce space conditioning energy use by 17% and, in line with jurisdiction and organization goals, increase local air quality. One important lesson learned is to order electrical equipment early to avoid delays. The **office site in California** highlighted quieter operation, improved temperature control, and lower energy use by as much as 44% with advanced RTU solutions. The office site worked closely with the manufacturer to ensure proper controls set-up for supplementary heating after installation.

- In New York, a **manufacturing facility** installed 18 new advanced RTUs to replace an existing process heating boiler that provided steam to the previous conventional RTUs. The manufacturing facility no longer needed the process steam due to changes in manufacturing requirements and has an existing electric service agreement for hydropower. The facility is expecting approximately $330,000 in lifetime savings compared to a conventional RTU solution. The facility lowered the upfront cost with local program incentives. Alternatively, a **mixed-use commercial space in New York** opted for a dual fuel advanced RTU solution. Monitoring of these units demonstrated that they satisfied 99% of heating needs in the primary heating mode and consumed 70% less site energy than conventional RTUs. Additional attention was needed to ensure proper control settings for when supplementary heating was used.
- In Washington, a new **university athletic facility** was constructed with advanced RTU units capable of operating using their primary heating mode down to 0 degrees and included on-board energy recovery ventilation to meet site requirements. These units are anticipated to serve over 90% of the annual heating load for the facility and, in line with state and organization goals, reduce natural gas costs. The facility's scale was initially a challenge, but the facility was able to overcome any concerns with thorough planning and coordination to ensure correct sizing for the HP RTU and electrical services.
- In Maryland, the **Columbia Association** plans to replace conventional RTUs, as they fail, with advanced RTU technology. These units will serve both public and community building spaces. In line with the organization's goals, the advanced RTU units are projected to reduce on-site natural gas demand by 70% based on an early pilot. Additionally, the dual fuel solution allowed the Columbia Association to reserve the facility's spare electrical capacity for anticipated mechanical equipment loads in the future. The dual fuel HP RTUs will now be considered the standard for future Columbia Association buildings, as it ensures the ability to meet heating loads even in colder months.

Case study participants highlighted several lessons learned. Building owners need to plan for continuous quality assessment and testing to ensure that equipment is being installed and configured properly in line with the organization's needs. Additionally, to avoid time delays, owners should obtain the equipment and engage with any required permitting departments early in the process, as lead times were significant. Furthermore, the project team should utilize clear communication and goal setting to ensure efficient project flow, manage any turnover, and align

© 2026 ACEEE Summer Study on Energy Efficiency in Buildings

on any relevant organizational goals. Finally, using experienced contractors who are familiar with the system being installed can help avoid problems, particularly with controls set-up. In at least two of the case studies, additional review and adjustment of the controls was necessary to incorporate supplementary heating in line with the building owners' cost and heating needs.

In addition to the case studies, the 2024 Campaign continues to develop educational and guidance resources to raise industry awareness of high-efficiency RTU technologies and support decision making in evaluating advanced RTU solutions. Current and future resources are developed with 2024 Campaign partners based upon the challenges and resource needs they identify in their experiences. Over the last 2 years, the team has developed a series of resources available on the BB & BP website (U.S. Department of Energy 2024a). These resources include the following:

- The **Decision Matrix** supports building owners and operators with assessing their current HVAC technology replacement needs, and to plan for the adoption of advanced HVAC solutions. (U.S. Department of Energy 2026c).
- The **RTU Switchover Temperature Guidance Document** addresses challenges partners shared about understanding how to determine the appropriate equipment switchover temperature to meet their specific site needs and goals. (U.S. Department of Energy 2024b).
- The **Fact Sheets** provide simple information on advanced RTU technologies to raise awareness of these solutions and help increase adoption at sites where they may be good fit (U.S. Department of Energy 2024c).
- The **Energy Cost Comparison Estimates** *(on track to be published in 2026 [U.S. Department of Energy 2026a)* provides estimates for different geographic regions based on NLR ComStock modeling of advanced RTU solutions versus existing building stock baseline RTU solutions (NLR n.d.).

Conclusion and Next Steps

Since the launch of the Commercial Building HVAC Accelerator in Spring 2024, over 50 partners have worked together to advance the development, demonstration, awareness, and adoption of high-efficiency HP RTU technologies for commercial building owners and their facilities. The 8 manufacturing partners in the 2024 Challenge have developed and submitted their prototypes for laboratory testing and subsequent field testing at partner building portfolio owner facilities. The DOE team envisions many of these next-generation HP RTU products will be commercialized within 1-2 years. In addition, many of the controls and technology advances from the 2024 Challenge will be incorporated into existing RTU models to improve their performance. DOE and the national laboratories are working with leading building owners on potential additional phases of the Commercial Building HVAC Technology Challenge pushing technology development for affordable high-performance RTUs and for future generations of RTUs. With all 8 manufacturing partners developing models with existing technology that being able to meet the performance specification under laboratory conditions, the 2024 Challenge has demonstrated the feasibility of Next Generation RTUs to support increased energy efficiency to help lower energy bills for building owners across more regions and applications, including cold and very-cold climates. These advances can help support the introduction of lower-cost models that balance building owner needs and equipment costs in the near future by lowering the risk for new entrants and future iterations by 2024 Challenge participants. Additionally, learnings from field installation and monitoring can support lower-cost installations in the future by lowering the risk for contractors and helping building owners and manufacturers understand the nuances of different building sites.

The 2024 Campaign has worked with dozens of current and interested partners to raise awareness of current HP RTU technologies, highlight best practices and case studies for early adopters, and develop resources to encourage others to consider the technologies for their facilities. Going forward, the 2024 Campaign will continue to provide technical and resource support to interested stakeholders, promote the field demonstration results and case studies coming from the 2024 Challenge testing, and potentially expand the scope continue additional advanced HVAC solutions, which could include innovative DOAS and other commercial HVAC technologies. Current resources and information on becoming a partner can be found on the Commercial Building HVAC Accelerator website (U.S. Department of Energy 2024a). Since the Campaign launch in 2024, state and utility programs that support advanced commercial HVAC solutions have continued to grow and evolve, including Chula Vista, Boulder County, City of Denver, Eversource, National Grid, Palo Alto, and Xcel Energy.[5] Currently available solutions continue to be of interest for building owners across the country, but awareness and availability of advanced solutions remain regionally dependent based on partner feedback. The 2024 Campaign will continue to work with current and prospective partners to identify more case studies including dual fuel solutions, develop educational resources, and provide support for ongoing discussions between building owners, design engineers, manufacturers, local programs, and other stakeholders.

References

ACEEE (American Council for an Energy Efficient Economy) 2026, State and Local Policy Database. https://database.aceee.org/state/utilities-summary

AHRI (Air-conditioning, Heating, and Refrigeration Institute) 2024, AHRI 1340-2024: Performance Rating of Commercial and Industrial Unitary Air-Conditioning and Heat Pump Equipment. Arlington VA: Air-Conditioning, Heating, and Refrigeration Institute. https://www.ahrinet.org/search-standards/ahri-1340-i-p-performance-rating-commercial-and-industrial-unitary-air-conditioning-and-heat-pump.

BB & BP (Better Buildings and Better Plants), 2025 Progress Update. U.S. Department of Energy. https://betterbuildingssolutioncenter.energy.gov/sites/default/files/attachments/DOE-PR25-Handout-ProgressUpdate-Final-Digital.pdf

CEE (Consortium for Energy Efficiency). 2026. Golden Carrots: The Beginning. https://cee1.org/influencing-markets/golden-carrots-the-beginning/.

CBECS (Commercial Buildings Energy Consumption Survey) 2018. U.S. Energy Information Administration. December 2022. https://www.eia.gov/consumption/commercial/.

[5] Qualifications and justifications vary by region. Programs for Eversource, National Grid, and Xcel Energy are jurisdiction or state specific.

© 2026 ACEEE Summer Study on Energy Efficiency in Buildings

Deru, M.; Hayes, M; Vrabel, K; Burke, C; Jiron, A; Blazek, C (2021). Long and Winding Road to Higher Efficiency-The RTU Story: Preprint ACEEE Summer Study in Buildings. NREL/CP-5500-77092. Golden, CO: National Renewable Energy Laboratory. https://docs.nrel.gov/docs/fy21osti/77092.pdf.

Deru, M; Dhillon, P; Wheeler, G; Petty, S. (2026). Driving Innovation in Commercial HVAC: DOE's Technology Challenge and Next-Generation RTUs Specification. *International Refrigeration and Air Conditioning Conference*, Paper 2551. Purdue University: Lafayette, IN.

Douglas, C and Rushton, J (2024). Getting Heat Pumps Under Control: The Success of the Heat Pump Revolution Requires Getting Heat Pump Controls and Sizing Right. ACEEE Summer Study in Buildings. https://www.aceee.org/sites/default/files/proceedings/ssb24/pdfs/Getting%20Heat%20Pumps%20Under%20Control%20%20The%20Success%20of%20the%20Heat%20Pump%20Revolution%20Requires%20Getting%20Heat%20Pump%20Controls%20and%20Sizing%20Right.pdf

Eschenbach, B; Collins, C; Hovey, R; Jones, J; Wolgamott, C. No Really, RTU Gas Efficiency is a Decarbonization Strategy. 2024. ACEEE. https://www.aceee.org/sites/default/files/proceedings/ssb24/pdfs/20240722160738421_e66c9207-2cc6-4712-a342-67c1327968d4.pdf

Langevin, J and Wilson, E. 2025. "Technology Innovation Opportunities for the U.S. Buildings Sector." January 2025. U.S. Department of Energy. https://www.energy.gov/sites/default/files/2025-01/bto-tech-innovation-011525.pdf.

Ledbetter, M. 2014. "L Prize." Pacific Northwest National Laboratory. Presented at 2014 U.S. Department of Energy Building Technologies Office Peer Review. https://www.energy.gov/cmei/buildings/articles/solid-state-lighting-l-prize-competition.

NLR (National Laboratory of the Rockies). (n.d.) Comstock Analysis Tool. https://www.nlr.gov/buildings/comstock

NEEA (Northwest Energy Efficiency Alliance). Condensing Rooftop Units Field Study Summary Report. March 2020. Better Bricks. https://betterbricks.com/wp-content/uploads/2025/03/CRTU_pilotSummaryReport_3.23.20.pdf

Olson-Huddle, R; Fiore, N; Sathe, P; Kan, C (2025). Commercial Roof Top Units Market Characterization Report. August 2025. CalMTA. https://calmta.org/wp-content/uploads/2025/09/Market-Characterization-Report-CRTUs.pdf

U.S. Department of Energy. 2016. Advanced Rooftop Unit (RTU) Campaign. https://betterbuildingssolutioncenter.energy.gov/alliance/technology-campaigns/advanced-rooftop-unit-campaign.

U.S. Department of Energy. 2020. Toolkit: Upgrade Your RTU to High-Efficiency. https://betterbuildingssolutioncenter.energy.gov/toolkit-upgrade-your-rtu-high-efficiency.

© 2026 ACEEE Summer Study on Energy Efficiency in Buildings

U.S. Department of Energy. 2021. Residential Cold Climate Heat Pump Challenge. https://www.energy.gov/cmei/buildings/residential-cold-climate-heat-pump-challenge.

U.S. Department of Energy. 2024a. Commercial Building HVAC Accelerator. https://betterbuildingssolutioncenter.energy.gov/accelerators/commercial-building-hvac.

U.S. Department of Energy. 2024b. Heat Pump RTU Switchover Temperature Guidance. https://betterbuildingssolutioncenter.energy.gov/resources/heat-pump-rtu-switchover-temperature-guidance.

U.S. Department of Energy. 2024c. Key Considerations for Adopting Commercial Heat Pump Rooftop Units. https://betterbuildingssolutioncenter.energy.gov/resources/key-considerations-adopting-commercial-heat-pump-rooftop-units.

U.S. Department of Energy. 2025. Commercial Building HVAC Technology Challenge Specification. September 2025. Draft version 2.3. https://betterbuildingssolutioncenter.energy.gov/sites/default/files/attachments/Commercial-Building-HVAC-Technology-Challenge-Specification_0.pdf.

U.S. Department of Energy. 2026a. Better Buildings & Better Plants Solution Center. https://betterbuildingssolutioncenter.energy.gov/.

U.S. Department of Energy. 2026b. American-Made Program. https://www.herox.com/American-Made-Challenges.

U.S. Department of Energy. 2026c. Heat Pump Rooftop Unit Decision Matrix. https://betterbuildingssolutioncenter.energy.gov/resources/heat-pump-rooftop-unit-decision-matrix.

EIA (U.S. Energy Information Administration). 2023. Energy use in commercial buildings. https://www.eia.gov/energyexplained/use-of-energy/commercial-buildings.php.

Acknowledgments

The Commercial Building HVAC Accelerator is led by Sam Petty and Michael Blunschi with the U.S. DOE's Building Technologies Office, and supported by researchers across multiple national laboratories including National Laboratory of the Rockies (NLR), Pacific Northwest National Laboratory (PNNL), Oak Ridge National Laboratory (ORNL), Argonne National Laboratory (ANL) and Guidehouse with input from Lawarence Berkeley National Laboratory (LBNL) and Minnesota Center for Energy Efficiency. The Accelerator is also supported by over 50 organizations, including HVAC manufacturers, building portfolio owners, and industry organizations (U.S. Department of Energy 2024a).

AI-assisted tools used: Copilot.
Used for: editing, summarizing, and researching.
Extent: [light editing and citation research].
Human review: The authors reviewed and verified all content, calculations, and citations.