Enercare

GUIDE TO COMMERCIAL AIR CONDITIONING EFFICIENCY

2022

In this Enercare PDF guide,the American Council for an Energy-Efficient Economy details specific commercial air conditioning efficiency requirements. Uncover the specifics of high-efficiency equipment, including mechanical efficiency, advanced controls and features, relative energy savings, and cost-effectiveness.

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2019 Efficiency Programs: Promoting High-Efficiency Commercial Air Conditioners

High-efficiency packaged commercial air conditioners, primarily rooftop units (RTUs), represent a small fraction of packaged units sold in the market, while the vast majority are low-to-medium efficiency. A 2015 analysis of product shipments showed that 65% of small and 61% of large commercial packaged air conditioners shipped met only minimally compliant baseline levels (DOE 2015).[1] However recent initiatives have demonstrated the impressive energy- and cost-saving capabilities of the most advanced commercial packaged air conditioners over minimally compliant equipment.[2] The right nudge from efficiency programs could push these high-efficiency units into the mainstream and help to transform the commercial packaged air conditioner market.

> Energy efficiency program administrators should consider using a midstream approach in 2019 programs to include high-efficiency commercial air handling units (i.e., ~17 IEER and above) equipped with advanced controls and analytics.

High-Efficiency Equipment

Mechanical Efficiency

The Consortium for Energy Efficiency (CEE) is composed primarily of efficiency program administrators from across the United States and Canada. Members leverage individual efforts by working together to accelerate energy-efficient products and services in targeted markets. As part of their High Efficiency Commercial Air-Conditioning and Heat Pumps Initiative (CEE 2016), CEE developed three tiers (1, 2, and Advanced) for energy efficiency program administrators to consider incorporating into their program offerings. This brief focuses on the highest-efficiency tier of the voluntary specification, CEE's Advanced Tier, shown below in table 1. This equipment, typically at least 17–18 integrated energy efficiency ratio (IEER)—although very large equipment is lower—represents some of the most efficient rooftop equipment in the market today.[3]

Table 1. Advanced Tier efficiency ratings for unitary air conditioners (IEER only)

	Small	Large	Very Large
Electric resistance heat (or none)	18 IEER	17 IEER	(14.5 IEER)*
All other heat	17.8 IEER	16.8 IEER	(14.3 IEER)*

Small: ≥65,000 Btu/h and <135,000 Btu/h; large: ≥135,000 Btu/h and <240,000 Btu/h; very large: ≥240,000 Btu/h and <760,000 Btu/h. *The CEE Advanced Tier values for very large unitary air-conditioning equipment are currently under revision. The values shown here for very large units are ACEEE recommendations based on market research; the current CEE values are 13.5 and 13.3 IEER (for electric resistance heat and all other heat, respectively). *Source:* CEE 2016.

Advanced Controls and Features

In addition to improved mechanical cooling efficiency, new technologies enable even greater savings in commercial packaged rooftop equipment. For instance, the Department of Energy included operational fault detection and direct digital control (DDC) capabilities (as well as high IEER) in its High Performance Rooftop Unit Challenge (DOE 2012).[4] Units with fault detection capabilities can identify common operational energy-wasting conditions, such as dirty filters or simultaneous heating and cooling. Likewise, some building owners may be interested in installing DDC with wireless CO_2 sensors to help control indoor air quality. Wireless sensors are becoming increasingly affordable, some as low as $30–50 per sensor with battery lives of 10 years (B. Coflan, vice president, digital services platform: IoT and digital

1 Minimally compliant equipment is considered 11.0–11.4 IEER depending on size and heating type.
2 For example, DOE's High Performance Rooftop Unit Challenge. More information can be found at www1.eere.energy.gov/buildings/alliances/rooftop_specification.html
3 IEER expresses air conditioner cooling performance by measuring energy efficiency ratio (EER) weighted at different part-load conditions (EPA 2010).
4 Direct digital controls are a system used to control HVAC processes and manage energy consumption in a building using software, hardware, and networks (UW-Madison 2018).

transformation, Schneider Electric, pers. comm., October 31, 2017).

Rooftop Unit Market

High-efficiency equipment represents a niche of the current commercial air conditioner market. A 2014 shipments analysis shows small[5] air-cooled commercial packaged air conditioners rated 14 IEER and higher represented just 3% of the market. Similarly, large[6] air-cooled commercial packaged air conditioners rated 13.3 IEER and higher represented just 3% of the market (DOE 2015).[7] Since 2014, some additional high-efficiency models have entered the market; however 17 and 18 IEER equipment still has not achieved significant market penetration. An evaluation of over 1 million commercial rooftop units sold in the Northeast and Mid-Atlantic regions revealed only 0.15% of the units met high-performance efficiency levels (NEEP 2016). Figure 1 shows a scatter plot representing DOE's analysis of the equipment available in the marketplace.

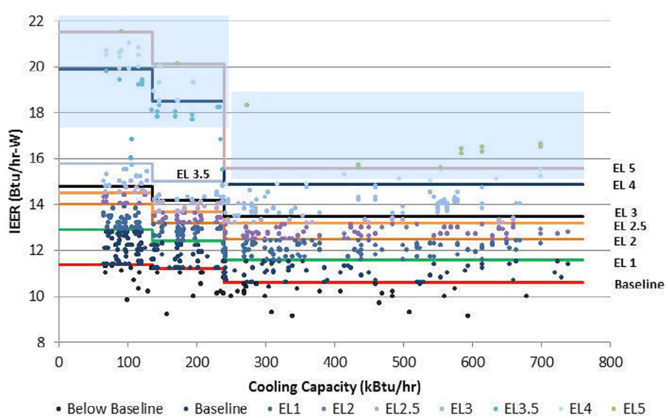

Figure 1. Distribution of IEER levels for commercial unitary air-conditioning equipment. The blue windows approximately identify equipment that falls within CEE Advanced Tier ranges. We used the ACEEE recommendation of 14.3 IEER for very large equipment. *Source:* DOE 2015, based on the Air-Conditioning, Heating, and Refrigeration Institute (AHRI) *Directory of Certified Product Performance.*

A review of AHRI's directory on March 19, 2018, found examples of high-efficiency equipment as follows:

Table 2. High-efficiency unitary air conditioners

Manufacturer	Cooling capacity (Btu/hr)
Aaon	150,000
Carrier	70,000, 89,000, 101,000, 102,000, 116,000, 146,000, 170,000, 172,000, 192,000, 194,000, 230,000, 232,000, 268,000, 270,000, 272,000, 274,000
Daikin	89,000, 90,000, 174,000, 176,000, 242,000, 244,000, 246,000, 276,000, 278,000, 280,000, 510,000, 580,000
Lennox	92,000, 116,000, 136,000, 138,000, 180,000, 234,000, 300,000, 420,000, 470,000
Johnson Controls	254,000
Trane	70,000, 90,000, 99,000, 148,000, 172,000, 196,000, 274,000, 304,000, 360,000, 435,000, 460,000, 545,000, 580,000, 585,000, 615,000, 700,000

We considered equipment high-efficiency if it met CEE's Advanced Tier efficiency rating for products less than 240,000 Btu/hr and ACEEE's recommendation of 14.3 IEER for equipment greater than or equal to 240,000 Btu/hr. Trane includes American Standard products. *Source:* AHRI commercial unitary equipment database.

Energy Savings

Packaged rooftops can be found throughout the United States, cooling an estimated 57% of air-conditioned commercial floor space (EIA 2016). A comprehensive study by Lawrence Berkeley National Laboratory estimated that these units use about one quadrillion Btus (quad) of source energy per year and found that replacing baseline commercial unitary air-conditioning equipment with the highest-efficiency products would save approximately 2.5 quads of energy cumulatively over a 30-year period (Desroches and Garbesi 2011).

According to the Department of Energy's 2015 analysis, equipment that meets the CEE Advanced Tier can save 23–45% over a minimally compliant baseline. Table 3 lists estimated energy savings for each size class.

5 ≥65,000 Btu/h and <135,000 Btu/h cooling capacity
6 ≥135,000 Btu/h and <240,000 Btu/h cooling capacity
7 The Department of Energy also provided base case market share estimates for commercial unitary ACs in 2019. These estimates show that CEE Advanced Tier equipment is projected to represent roughly 20% of the market share of small and large variable air volume (VAV) air conditioners.

Table 3. Annual site energy savings from CEE Advanced Tier over minimum compliance product (kWh/unit)

	Small	Large	Very large
Energy Savings	5,790 kWh	17,700 kWh	19,300 kWh

Small: ≥65,000 Btu/h and <135,000 Btu/h; large: ≥135,000 Btu/h and <240,000 Btu/h; very large: ≥240,000 Btu/h and <760,000 Btu/h. We interpolated between TSLs to estimate energy use for CEE Advanced Tier equipment, using 17.8 for small equipment, 16.8 IEER for large equipment, and 14.3 for very large equipment. Source: DOE 2015.

A recent Northeast Energy Efficiency Partnerships (NEEP 2016) study provides a regional perspective, estimating that moving all new sales in the Northeast from baseline efficiency (i.e., 10.6–11.4 IEER) to a max tech level (i.e., 15.6–21.5 IEER) would save 147 GWh annually and reduce demand by 193 MWs. This equates to customer savings of $8.3 million for the reduced consumption plus $27 million for the reduced demand.

Cost and Cost Effectiveness

A Minnesota study of rooftop units claims the incremental cost of high performance products is the most significant barrier to achieving market penetration. This particular study estimated that an average code-compliant RTU costs $1,100/ton, while a high-performance RTU costs approximately $1,500/ton (Schuetter, LeZaks, and Lord 2016). Similarly, DOE cost analysis from the 2014–16 rulemaking to update commercial HVAC efficiency standards shows an average incremental installed cost for Advanced Tier-level equipment over baseline equipment of $13,200 for an average small unit (7.5 tons), $21,100 for an average large unit (15 tons), and $31,500 for an average very large unit (30 tons) (DOE 2015).

Using the Minnesota and DOE estimates of costs and DOE's estimate of savings (table 3), the average cost per kWh saved can be calculated. Table 4 summarizes results.

Table 4. Representative annual site energy savings from CEE Advanced Tier

	Small	Large	Very large
Cooling capacity (tons)	7.5	15	30
Average annual energy savings (kWh)	5,789	17,719	19,333
Incremental installed costs (2017$)			
Minnesota	$3,000	$6,000	$12,000
DOE	$13,200	$21,100	$31,500
Equipment life (years)	21.1	22.6	33.7
Levelized cost from program administrator perspective if program pays 50% of incremental costs			
DOE	$0.11	$0.05	$0.06
Minnesota	$0.03	$0.02	$0.02

Small: ≥65,000 Btu/h and <135,000 Btu/h; large: ≥135,000 Btu/h and <240,000 Btu/h; very large: ≥240,000 Btu/h and <760,000 Btu/h. We calculated levelized cost from the program administrator perspective by annualizing costs using the loan payment function in Microsoft Excel (PMT) and dividing by annual kWh saved. Assumptions include: half the incremental cost paid by program administrator, program administration costs are 20% of incentive costs, a 5% real discount rate, and cost estimates adjusted to 2017$ using the Federal Reserve Implicit Price Deflator. Incremental energy savings and measure life from DOE rulemaking. We interpolated between TSLs to estimate energy use for CEE Advanced Tier equipment for small and large equipment (17.8 and 16.8 IEER, respectively), as well as very large equipment for ACEEE's recommendation of 14.5 IEER. *Sources:* Cooling capacity, average equipment life, annual energy savings, DOE costs: DOE 2015; Minnesota costs: Schuetter, LeZaks, and Lord 2016.

These calculations show that the cost of saved energy to the program administrator varies from about 2 to 11 cents per kWh saved depending on the cost assumptions (Minnesota costs are less than half the DOE estimates) and equipment size (larger equipment is more cost effective).

DOE has a long history of overestimating costs (Nadel and deLaski 2013), but the Minnesota costs may not include the extra costs of more complex installations. These cost-of-saved-energy calculations are for all savings over a year; for rooftop ACs, many of these savings will be during peak and mid-peak periods when the cost of power is higher than the average annual cost. Increasing the market share of high-efficiency equipment could influence a future DOE minimum-efficiency standard on this equipment; in some states utilities receive credit for new efficiency standards if they contribute towards these new standards.

Physical Size Can Represent a Barrier to Retrofit

The physical size of high-efficiency units can present an additional barrier, especially in retrofit settings. A Pacific Northwest National Laboratory (PNNL) field evaluation of a grocery store retrofit with a high-efficiency rooftop unit identified curb modification as one of the installation problems.[8] In this case, the PNNL team used a curb adapter to fit the new unit in the previous unit's footprint; however, even with the modification, the unit was still suspended over the front of the base and had to be supported by blocks (Wang et al. 2015). NEEP identified curb modification as one of the "hidden costs" of high-performance RTU adoption that could in some cases exceed incremental costs (NEEP 2016).

Successful Midstream Rooftop Unit Efficiency Programs

Rooftop unit programs tend to achieve a greater level of success at the midstream level (i.e., targeting distributors), rather than downstream (i.e., targeting customers). Starting in 1998, the firm Energy Solutions developed and implemented a new midstream program for Pacific Gas & Electric. Since then, they have expanded the program to other California utilities, as well as Xcel Energy in Colorado and Mass Save® in Massachusetts (Cody 2016).

Midstream programs are typically structured using different efficiency tiers. For instance, a mid-size rooftop unit between 135,000 and 240,000 kBtu may have three different IEER incentive tiers (e.g., 13, 14, and 17). These programs provide greater incentives for higher efficiency products, so a 17 IEER product receives the most incentive money. In particular, in ACEEE's view, programs should focus efforts on developing incentives for the highest tier in order to increase market share and (hopefully) contribute to price reductions. Since energy savings at lower tiers are more modest, program administrators could consider either lower incentives for these tiers and/or not providing incentives for one or both of the lower CEE tiers.

Kim Spickard of Xcel Energy Colorado manages a program recognized by DOE's Better Building Program for selling the most high-efficiency RTUs in 2016: 2,484 RTUs with an estimated energy savings of 2.3 million kWh or $230,000 (DOE 2017).[9] He claimed one of the keys to the success of the Xcel Energy Colorado program was giving the distributor some discretion. In other words, Xcel Energy does not dictate how the distributor uses his or her RTU incentives. Therefore, distributors may use the incentive to stock high-efficiency units, invest in training staff to upsell units, or they can pass all or part of the incentive along to consumers through discounts. Spickard estimated that on average, the distributor passes along about 50% of the incentive to the customer. In addition, Xcel provides reports that rank each distributor on how many incentives they received for each product size category relative to their competitors (without revealing the competitors' names). This has been helpful in promoting healthy competition between distributors (K. Spickard, senior product portfolio manager, Xcel Colorado, pers. comm., March 9, 2018).

Recommendations

Midstream programs appear to have the greatest success for high-efficiency HVAC equipment, provided local distributors are willing to participate in programs. In cases where this type of program has been implemented, it has outperformed traditional downstream customer rebate programs by 500–1,000% (Cody 2016). Other energy efficiency program administrators could benefit from implementing a similar model in their 2019 programs.

Instead of trying to persuade end users to invest in high-efficiency commercial packaged air conditioners, programs should consider incentivizing distributors to stock and promote high-efficiency products. In addition, they should allow distributors the freedom to decide how to spend and/or pass along the incentive money. Programs would also benefit from providing additional resources to help with hidden costs of high performance equipment, such as the cost of modifying curbs to allow for the replacement of older, lower-efficiency units with high-efficiency models, which can often be larger in size. This could be the recipe that catapults high-efficiency commercial air conditioners into a substantial market share.

8 This was done as part of DOE's High Performance Rooftop Unit Challenge. More information can be found at www1.eere.energy.gov/buildings/alliances/rooftop_specification.html.

9 DOE recognized Mass Save's® high-efficiency RTU program for 2017, with nearly 6,500 units sold, equating to over 9.6 million kWh, or nearly $1.5 million (Mass Save 2018).

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