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Two Decades of ENERGY STAR®: A Retrospective Study of EPA's ENERGY STAR Office Buildings Score and Certification

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Introduction

For more than 20 years, the U.S. Environmental Protection Agency's ENERGY STAR program has enabled organizations across the country to benchmark the energy performance of their buildings and recognized those that demonstrate superior energy performance. EPA introduced ENERGY STAR Portfolio Manager® software in 1999 as the platform initially used to benchmark the energy performance of roughly 2,000 office buildings, of which 90 went on to earn ENERGY STAR certification. Today, more than 280,000 buildings comprising over 27 billion square feet of space (25% of U.S. commercial floorspace) across 15 building types routinely use Portfolio Manager, and more than 36,000 buildings now proudly display the ENERGY STAR label for excellence in energy performance. Over that time, ENERGY STAR has evolved to include industrial facilities, new building design, multifamily buildings, tenant spaces, and Canadian commercial buildings. Today, ENERGY STAR metrics help inform building efficiency in retrofit decisions and outcomes, financial transactions, corporate sustainability, and city and state policies.

While EPA's efforts have realized measurable results, significant challenges remain. Between the CBECS surveys conducted in 1995 and 2012, the U.S. commercial building footprint grew 48%, with a corresponding 31% growth in total energy use. Today, the energy use of commercial buildings accounts for 17% of national CO_{2e} emissions. A continued focus on energy efficiency is critical to reducing this impact and to ensuring that the U.S. can meet the necessary growth in clean electricity to achieve its carbon goals.

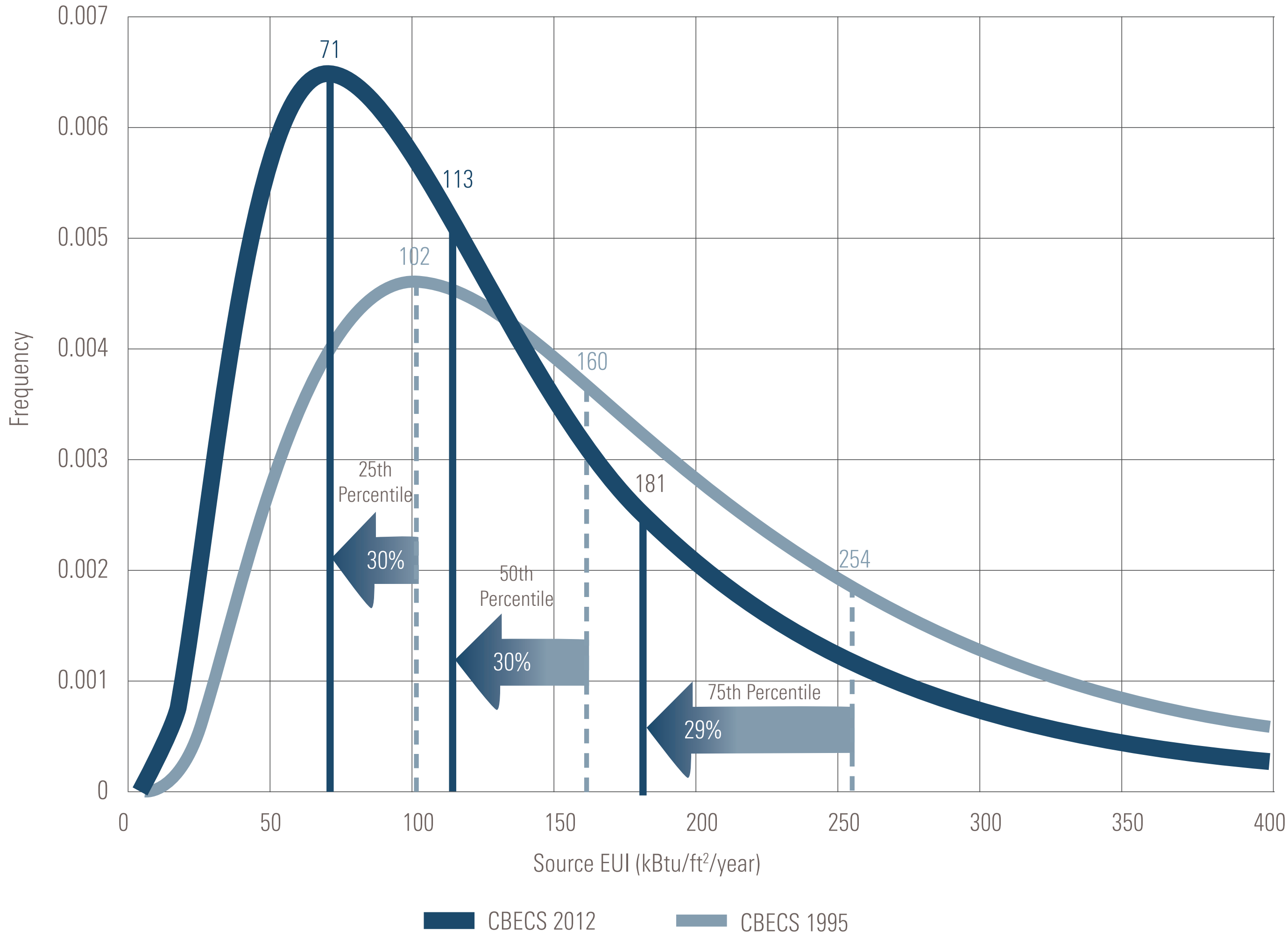
Looking ahead, the next two decades call for an ever-increasing focus on deeper energy reductions and decarbonization. The U.S. goal of a zero-carbon economy by 2050 will require significant contributions from the building stock. This ambitious goal reinforces a continued need for simple performance evaluation of commercial buildings around a common language of baselining, tracking, and recognition of excellence shared by policy makers, building owners and operators, and services providers alike.

How the Energy Use of U.S. Office Buildings Has Changed

This study evaluates energy trends in office buildings over the last 20 years, from the energy use of the U.S. office building stock, to how those changes are reflected in the ENERGY STAR score, and how each ENERGY STAR certified office class performs against that standard. To understand changes from the class of 1999 to the class of 2019 ENERGY STAR certified office buildings, we first look at the CBECS surveys that form the basis for these scores.

The following frequency distribution depicts the energy use for all office buildings in the U.S., as characterized by the 1995 and 2012 CBECS surveys. These surveys form the peer datasets used to produce the ENERGY STAR scoring models in effect in 1999 and 2019, which in turn establish the top 25% threshold for energy performance required for ENERGY STAR certification. Building energy consumption is plotted as annual energy use per square foot per year (Energy Use Intensity, or EUI), in order to normalize for building size, which is the most significant driver of energy consumption for any building type. As source energy combines both building and energy system impacts to

Figure 1. Distribution of Source Energy Use Intensity in U.S. Office Buildings. Source: EIA.



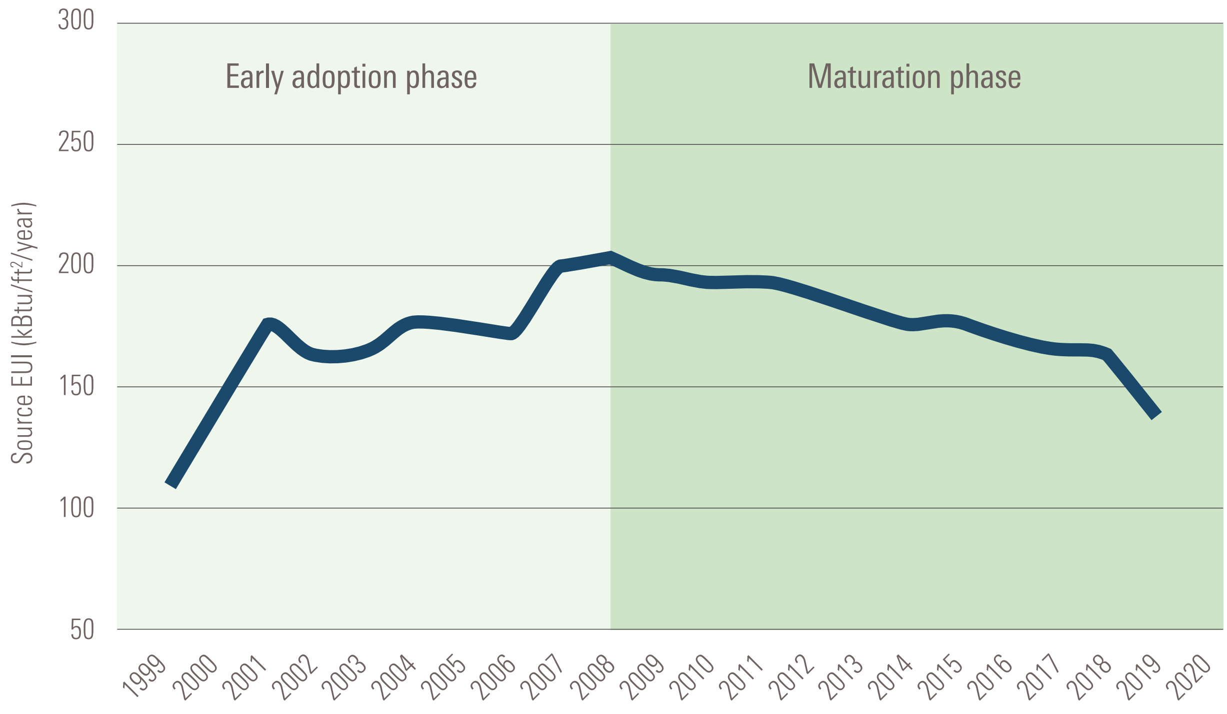
indicate the true and full energy requirements of a building, it serves as the basis for the ENERGY STAR score and is used for all the subsequent energy use comparisons.

Over the 17 years separating these surveys, the U.S. office building sector as characterized by EIA has become less energy intensive on a source EUI basis, with a 30% reduction in the median value of energy use intensity (as shown in Figure 1 above). Similarly, the 25th percentile value for EUI decreased by 30% and the 75th percentile decreased by 29%. As one might expect, the rising tide of efficiency brought about by improvement in building energy codes, commercial equipment and appliance standards, the investment of public benefit funds through energy utilities, and voluntary programs such as ENERGY STAR have reduced the energy intensity of all office buildings as a whole. This shift and tightening of energy use in the population illustrates achievement of the classical market transformation goal from these combined interventions.

The Energy Use and Performance of ENERGY STAR Office Buildings

Having examined the evolution of energy use in commercial office buildings, we turn our attention to the energy use of ENERGY STAR certified office buildings. First, we present the EUI trends of certified office buildings over time are presented and evaluated with regard to the growth and updates in the ENERGY STAR program. Then, we compare the EUI of certified office buildings is compared to the U.S. stock of office buildings. In order to make a more meaningful comparison of energy performance beyond simple EUI comparisons, we identify and normalize for the differences of key drivers of energy use between these two groups.

Figure 2. Average Source EUI of ENERGY STAR Office Buildings. Source: EPA.



The Energy Use of Certified Office Buildings Over Time

The CBECS surveys offer snapshots of commercial office building energy use at specific points in time. As noted earlier, the source EUI of U.S. office buildings has decreased roughly 30% from 1999 to 2019. The energy use intensity of ENERGY STAR certified office buildings can be tracked on a more granular annual basis and exhibits more complex trends. There has been a steady decrease in the EUI of these buildings over the past decade, but there are periods of increasing, stagnant, and decreasing EUI. A closer examination of these changes illustrates the impacts of program uptake and evolution over time. Figure 2 uses shading to distinguish two broad trends that can be thought of as different stages in the evolution of the ENERGY STAR certification program for office buildings.

First, the left half of Figure 2 shows an upward trend in the EUI of ENERGY STAR office buildings over the period of 1999 to 2008. This period can be thought of as the early adopter stage of ENERGY STAR certification marked by low certification numbers until a period of rapid growth in the number of buildings applying for and obtaining ENERGY STAR certification. The increasing trend in EUI during the early years of the ENERGY STAR program can be better understood by examining the number of ENERGY STAR certified office buildings in each of those years. As shown in Figure 3, below, the first class of 1999 was small (<100 buildings) and gradually grew until experiencing large growth in 2007 and 2008 (889 and 1,902 certified office buildings). These early classes most likely represented early adopters with high-performing, high-profile office buildings. As interest in benchmarking and ENERGY STAR certification grew, the increase in average EUI reflects a larger representation of buildings across the top 25% of energy performance, rather than an increase in the EUI of individual buildings over time.

Second, Figure 2 also shows a period from 2009 to 2019 that can be thought of as the maturation of ENERGY STAR certification for office buildings, reaching a critical mass of program participation. The average source EUI of certified office buildings decreased by a total of 30% over this decade. Finally, the impact of the third major revision to the ENERGY STAR office

Figure 3. Number of Certified Office Buildings and Average Source EUI by Year. Source: EPA.

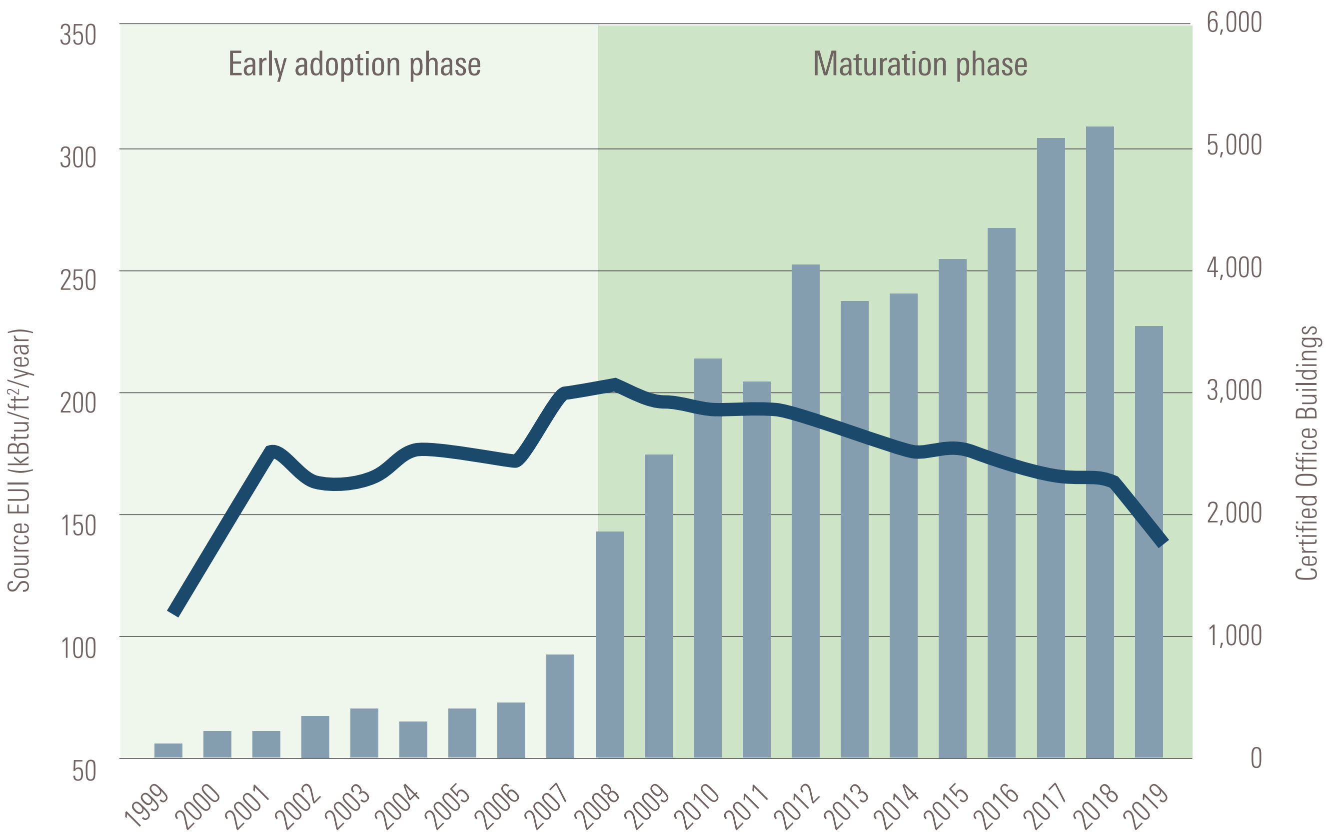
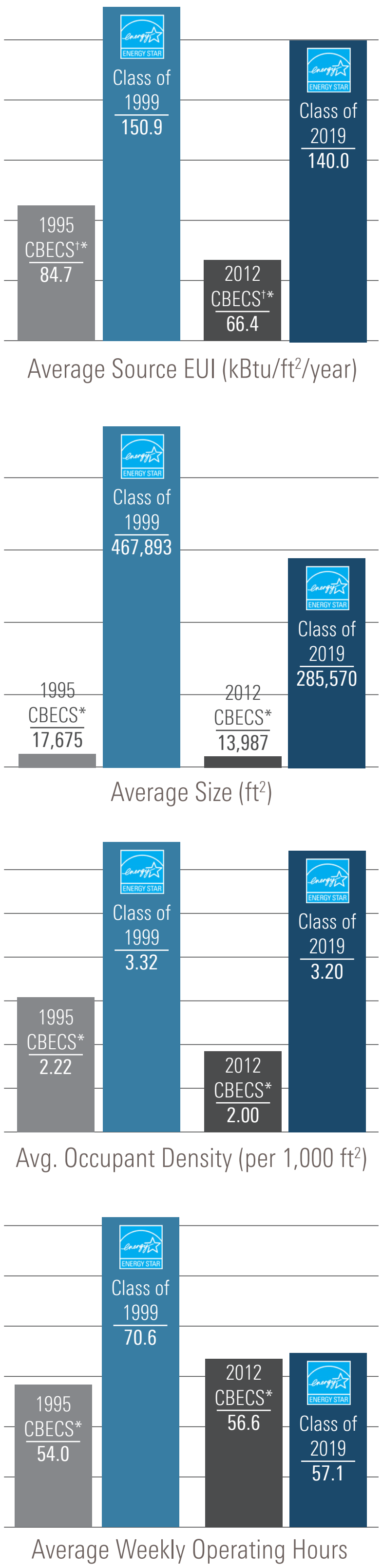


Figure 4. Comparison of Average Source EUI, Building Size, Occupant Density, and Operating Hours. Sources: EPA and EIA.



† Unnormalized Source EUI
*Buildings with scores greater than or equal to 75

ENERGY STAR certified office buildings are more energy intensive than the average building.

2019 ENERGY STAR certified office buildings were smaller, on average, than their 1999 predecessors, but they still continue to be significantly larger than the average building.

ENERGY STAR certified office buildings continue to be much more densely occupied than the average building.

ENERGY STAR certified office buildings used to be open longer hours than the average building, although there is no longer much of a difference.

building score model based on the 2012 CBECS (following a long gap in data due to the cancellation of the 2007 CBECS release) can be seen in the significant EUI change from 2018 to 2019. This occurred alongside an update to the source-site energy ratio for electricity (from 3.14 to 2.80) which together significantly raised the bar for certification. This is evidenced in a reduction in source EUI for certified office buildings from 163 in 2018 to 140 in 2019, as well as a significant decrease in the number of buildings able to meet the new certification threshold (from 5,311 to 3,490).

While the overall reduction in the EUI of certified office buildings is reflective of the magnitude of energy reduction seen in the larger commercial office building market, the variability demonstrates the importance of maintaining a progressive performance goal in a dynamic market. Regular model updates that reflect a more efficient population of buildings, new operating conditions, and a rapidly transitioning electric power grid are necessary to effectively raise the bar for energy efficiency and lower carbon intensity for both newly certified office buildings and those wanting to maintain their certification.

Comparing the Energy Use of Certified Office Buildings to the Office Buildings Market

An initial comparison of source EUI of ENERGY STAR certified office buildings in 1999 and 2019 (blue bars) to the national stock of U.S. office buildings, as represented by the relevant CBECS dataset (1995 and 2012) used for the scoring model for the given certification year (Figure 4) shows the average source EUI of ENERGY STAR office buildings is notably higher.

ENERGY STAR certified buildings using more energy per square foot than the population may seem counter intuitive. However, EUI only accounts for building size and not for other significant drivers of energy use, such as conditions outside of the owner-occupant's control (e.g., climate, weather) and business demands served by the building (e.g., occupant density, operating hours). Buildings that are larger, more densely occupied, open longer, located in very hot or cold climates, and those that experience extreme annual weather conditions use more energy. This is in fact what we find in ENERGY STAR office buildings as shown in Figure 4; certified office buildings are much larger, contain more workers, and are open longer than the top 25% of U.S. office buildings based on energy performance as represented by CBECS, so they would be expected to use more energy in service of these business demands.

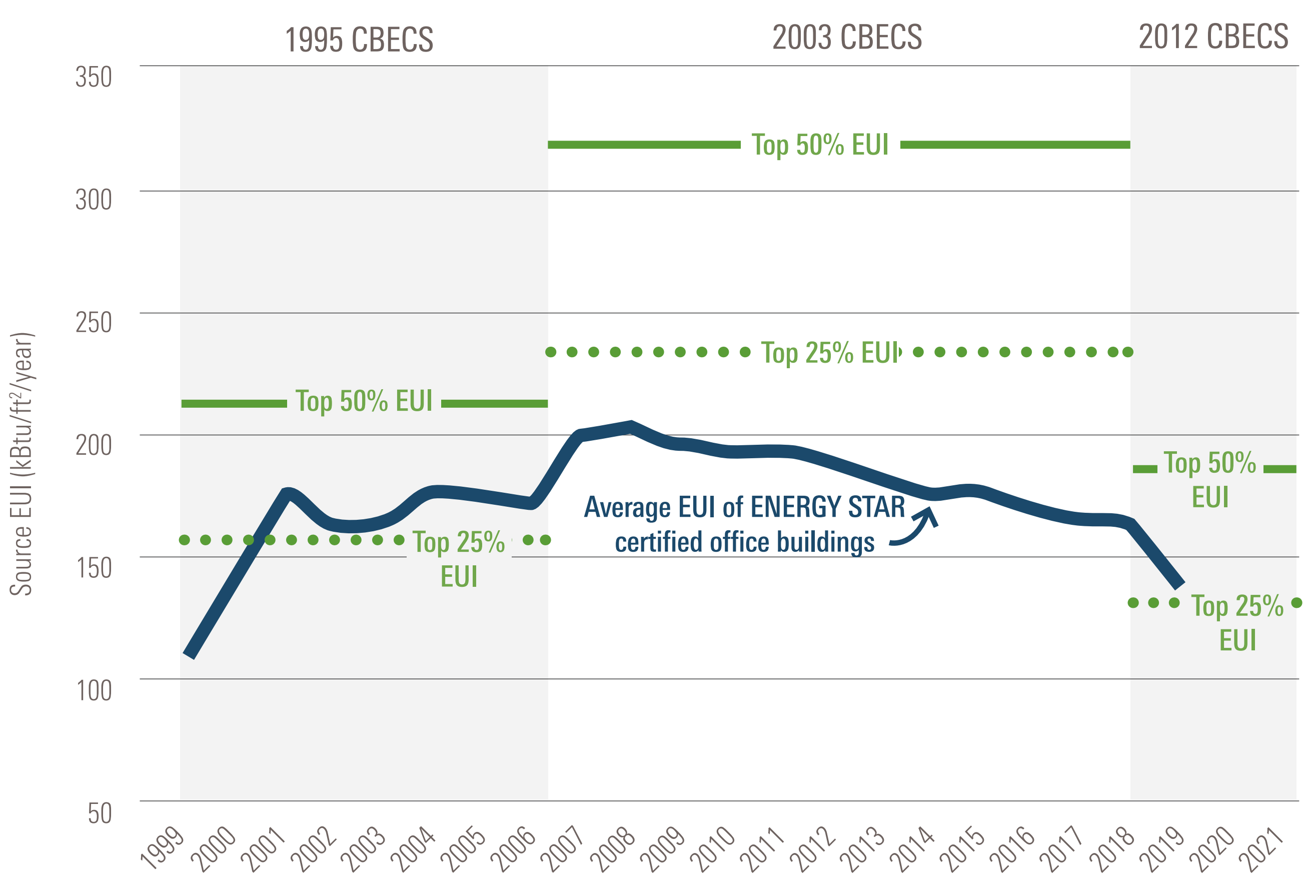
To facilitate a more equitable comparison of energy use as it relates to energy performance, we apply the ENERGY STAR score calculation to normalize the energy use of the building stock represented by the CBECS data as though it had size, climate, weather, and business activities comparable with ENERGY STAR certified office buildings. When we adjust for these drivers of energy consumption, we can plot the distribution of the building stock performance by normalized EUI, rather than by EUI alone, which allows us to examine the energy efficiency of ENERGY STAR certified office buildings against their peers.

Figure 5 below plots the average source EUI of each class/year of ENERGY STAR certified office buildings from 1999 to 2019 (blue line) against the normalized EUI of the national stock of U.S. office buildings, as represented by the relevant CBECS dataset (1995, 2003, or 2012) used for the scoring model for the given certification year. For context we include the median CBECS EUI (solid green line) and the 25th percentile value for EUI (dotted green line); the 25th percentile value can be interpreted as an office building consuming less energy per square foot than 75% of peer buildings.

This creates a more meaningful peer comparison of building efficiency. For over a decade the average source EUI of ENERGY STAR certified office buildings has been below or right at the normalized CBECS 25th percentile of EUI. In other words, the ENERGY STAR program has been and continues to be effective in setting the bar for and recognizing buildings that achieve excellence in energy performance relative to the building stock.

Having examined the evolution of energy use of the broader office buildings market in general and ENERGY STAR office

Figure 5. Average Source EUI of ENERGY STAR Office buildings vs. the Normalized U.S. Office Buildings Market. Sources: EPA and EIA.



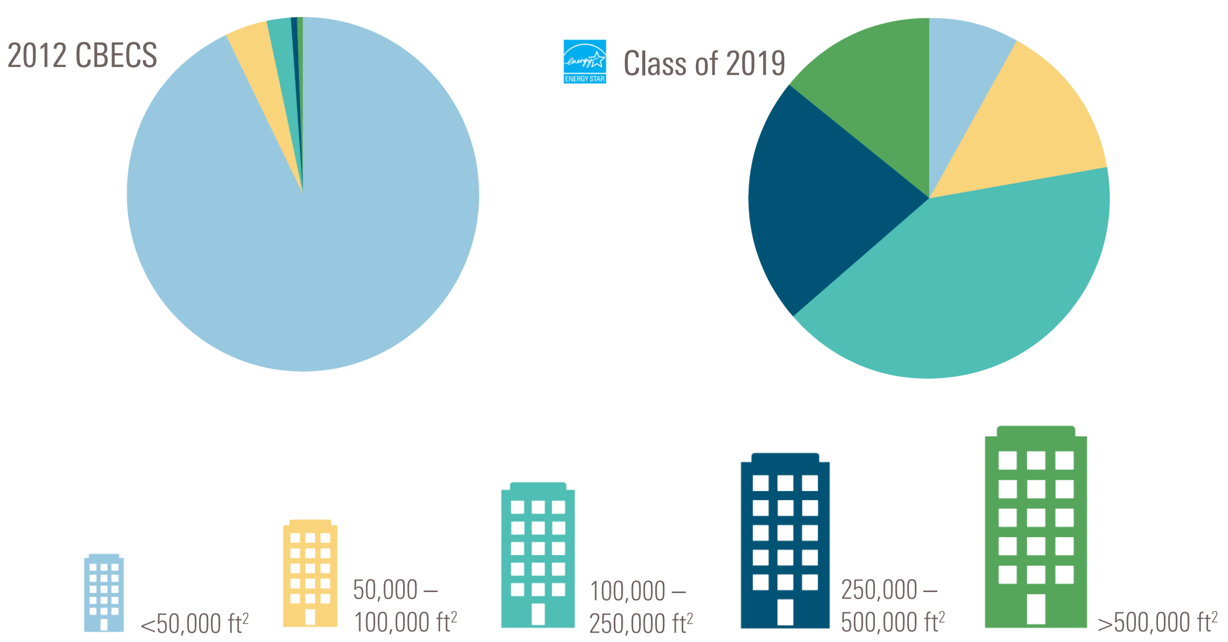
buildings specifically, and how energy use translates to our comparative energy performance score, we now focus on the characteristics of these groups. Closer examination of the ENERGY STAR office buildings compared to the larger building stock reveals similarities over time in both the size and fuel mix characteristics of all ENERGY STAR office buildings. More detailed technology and operating characteristics collected from a survey of buildings also present a collective case study into the components that produce that excellence. Both trends suggest what is working well in our program, as well as opportunities for the ENERGY STAR program to continue to push energy excellence; both are discussed in the next section.

Comparing the Characteristics of Certified Office Buildings

Two broad trends are observed across all ENERGY STAR certified office buildings: 1) the relative size of buildings and 2) electrification. First, as shown in Figure 4 and in Appendix 1, buildings that received ENERGY STAR certification were much larger than similarly performing U.S. office buildings in 1999 and continued to be larger in 2019. While buildings certified in the class of 2019 are nearly 40% smaller than the 1999 class, with an average size of over 285,000 ft^2, ENERGY STAR certified offices are still 18 times larger than similar buildings across the country as represented by CBECS. This bias towards large buildings represents a significant opportunity to expand certification to smaller and mid-sized buildings; buildings less than 50,000 ft^2 represent 93% of all office buildings in the U.S., but only 8% of the class of 2019 (Figure 6 below).

Scaling the impact of the program through greater participation of smaller and mid-size buildings remains a challenge. EPA initiated a program to promote architects and engineers offering pro-bono verification in 2016, lowered the size eligibility for office certification in 2018 from 5,000 to 1,000 square feet, and continues to develop new strategies for engagement and partnership with the owners, operators, and service providers for these smaller buildings. New and expanding state and local benchmarking, performance, and disclosure mandates are also expected to introduce smaller buildings to benchmarking and certification. Reaching national decarbonization goals, however, will require much greater participation from this hard-to-reach audience.

Figure 6. Distribution of the Class of 2019 and the Office Buildings Market by Size. Sources: EPA and EIA.



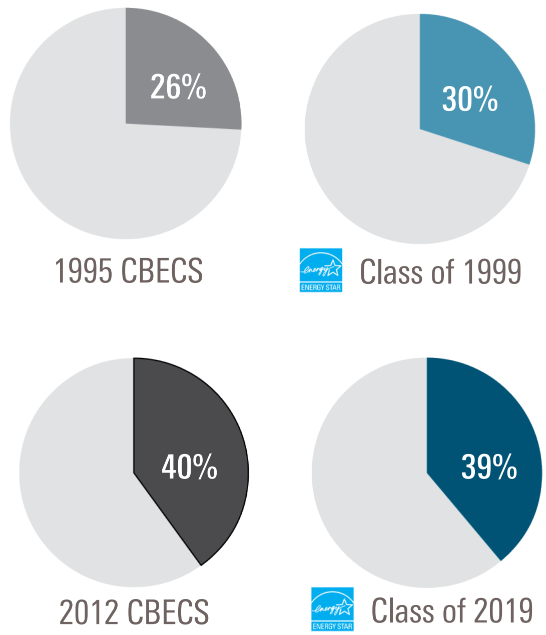
Electrification of fuel use is becoming more common. As shown in Figure 7, almost 40% of ENERGY STAR office buildings are now all-electric, up from 30% in our first class; the percentage of buildings that are all-electric is roughly the same among ENERGY STAR certified office buildings and similarly efficient buildings across the country. This finding is important for two reasons.

First, it reconfirms evidence presented from the first ENERGY STAR class evaluation to refute the notion that using source energy consumption as the basis of an efficiency performance metric disadvantages an all-electric building from top-performance recognition. While it is true that a source energy perspective values grid-supplied electricity as more thermodynamically intensive than site energy (2.8 times based on the current source energy conversion factor), our latest class demonstrates that all-electric buildings are no more or less likely to demonstrate top energy performance. Put another way, when source energy is used to evaluate energy performance, an individual building's ability to earn ENERGY STAR does not depend on the mix of fuels it uses but rather how efficiently it uses them.

Second, the growing prevalence of all-electric fuel use in these top-performing buildings positions them to use renewable energy to drive further energy efficiency and carbon reduction. Achieving deep decarbonization in buildings relies on the use of zero-carbon fuels. Efficiently using electricity to meet 100% of energy needs positions a good portion of these ENERGY STAR office buildings to take advantage of onsite renewable systems to improve their source energy performance and/or add offsite green power purchases to achieve decarbonization goals.

Evaluating to what extent ENERGY STAR office buildings are pursuing green power supply opportunities is difficult due to limited comparative data, but we can make several observations. Approximately 1.5% of the class of 2019 reports electricity generation from onsite solar and/or wind systems, compared to 1% of the broader office building population benchmarking in Portfolio Manager and 4.8 % reported for the CBECS mean. We find an even lower reported use of offsite renewable electricity (RECS bundled with grid-sourced electricity, or direct purchase from an offsite renewable plant), where less than 1% of the class of 2019 report purchasing green power for their building. We suspect actual use of offsite renewables is higher, given difficulty in apportioning out corporate-purchased RECS to grid electricity use when benchmarking individual buildings. Metering, tracking, and reporting both types of green power remain challenges to effectively measure, manage, and communicate building efficiency and GHG reductions.

Figure 7. Percent of All-Electric Buildings. Sources: EPA and EIA.



What Helps an Office Building Earn the ENERGY STAR

To answer the question of what makes an ENERGY STAR office building, we conducted a survey of the class of 2019 and compared the responses to a similar survey we conducted of the class of 1999. We uncovered interesting trends in building construction, technology adoption, and management practices, which are outlined below. As anticipated, ENERGY STAR office buildings contain a relatively high percentage of efficient technologies, but importantly, two-thirds of respondents primarily attribute their high energy performance to operations and maintenance. This response indicates that good management, combined with good technology, remains critical to superior energy performance.

Survey and Analysis Approach

Our survey of ENERGY STAR certified office buildings in the class of 2019 was designed around the same questions we asked of the class of 1999, which were modeled against the CBECS surveys. This survey approach allows us to collect and compare more detailed building equipment and operational information than our certification process captures. From the responses, we examine what building, technology, and management features are most closely associated with producing ENERGY STAR levels of energy performance.

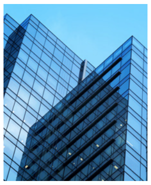
Our design was to survey individuals about only one building each, with the objective of maximizing the response rate by minimizing individual burden, while also producing a geographically and organizationally diverse dataset. This reduced the survey group by about a third (2,169 of the 3,330 office buildings) since some contacts are associated with multiple buildings. This approach yielded responses from 165 widely distributed buildings, producing information directly comparable to our first class and the CBECS surveys characterizing the larger buildings market.

For the purposes of technology-specific comparisons, we limit our comparison to CBECS buildings larger than 50,000 ft^2. ENERGY STAR certified office buildings have typically been larger buildings, with no buildings smaller than 50,000 ft^2 responding to our survey. Because larger buildings tend to use different heating, cooling, and centralized control technology than smaller buildings, filtering the CBECS data allowed for a more apples-to-apples comparison. For full results, see Appendix 2.

Building and Technology Characteristics

Exterior glass: Roughly three-quarters of ENERGY STAR office buildings continue to be Class A buildings (essentially unchanged from 1999), defined by the BOMA building classification system as the most prestigious buildings competing for premier office users with rents above average for the area. Not surprisingly, these buildings retain a very high level of exterior glass (Figure 8). Higher percentages of exterior glass offer both increased viewing amenity and daylight harvesting opportunities, but are traditionally thought to impose larger thermal conditioning energy penalties, so it is informative to see that these buildings can have both a majority glass envelope and high performance.

Figure 8. Exterior Glass



	2019 ENERGY STAR Office Buildings	2012 CBECS Mean
Glass Construction	32%	7%
% Exterior Glass	81%	24%

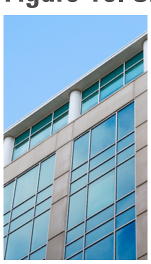
Major upgrades: Ongoing management attention to upgrades within the building are also an ENERGY STAR theme, with large majorities (72% and 83% respectively) pursuing major HVAC and lighting system upgrades, compared to the CBECS mean of just one third (Figure 9).

Figure 9. Major Upgrades

	2019 ENERGY STAR Office Buildings	2012 CBECS Mean
Major HVAC Upgrade	72%	34%
Major Lighting Upgrade	83%	31%

Shell improvements: It is also noteworthy that one-quarter of ENERGY STAR office buildings have pursued shell improvements (insulation and/or window upgrades), which is significantly more than the overall U.S. market (Figure 10). This is suggestive of a whole-building approach to performance given that upgrades to passive systems are often more difficult to justify economically.

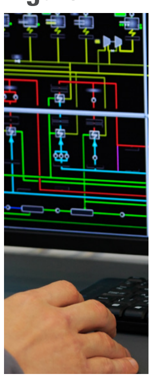
Figure 10. Shell Improvements



	2019 ENERGY STAR Office Buildings	2012 CBECS Mean
Major Insulation Improvements	27%	7%
Major Window Replacement	25%	17%

HVAC and Lighting Controls: Looking at technologies typically installed to achieve performance, ENERGY STAR office buildings continue to deploy higher levels of heating, cooling, and lighting system controls than their peers, as demonstrated by their more frequent use of variable air volume ventilation, building automation systems, economizers, and occupancy sensor controls (Figure 11). Similar to the adoption rates observed in the class of 1999, the use of these technologies also remains very high in 2019 ENERGY STAR office buildings. Back in 1999, we were surprised to see that the highest presence of these controls was in the bottom 25% of energy performers within the CBECS 1995 dataset; the technology choices of ENERGY STAR office buildings looked most like this group. Our interpretation of this non-intuitive finding was that while important to efficiency, the presence of efficient controls alone is not indicative of an energy efficient building. That said, the application of these control systems is more uniformly distributed across the CBECS 2012 dataset, with the highest adoption rates shifted up to the average performance group and more intuitively mirroring ENERGY STAR. This suggests that efficient equipment is helping to drive up the improvements in peer building performance achieved over the last 20 years, as well as remaining an important ingredient of ENERGY STAR.

Figure 11. HVAC and Lighting Controls

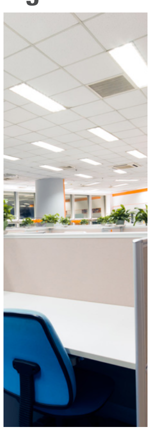


	2019 ENERGY STAR Office Buildings	2012 CBECS Mean
VAV (Heating or Cooling)	83%	70%
Building Automation System	90%	72%
Economizer	67%	57%
Motion Sensors	92%	73%

Advanced controls: Looking at more advanced technologies, it is also apparent that the owners of ENERGY STAR office buildings are deploying more sophisticated control equipment than their peers, as evidenced by higher adoption rates for lighting controls aimed at controlling total use, time of use, daylighting, and tuning (Figure 12). Greater control over lighting, ventilation, and other comfort measures directly impacts occupant satisfaction, which is another indication of interest in providing a high amenity environment. Finally, a much larger interest in plug load controls demonstrates awareness by man-

agement of the need to control the fastest growing, unregulated loads in commercial buildings, which is further evidence of a whole-building performance approach to controlling all energy uses.

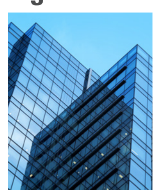
Figure 12. Advanced Controls



Light Scheduling	67%	55%
Multi-level Lighting/Dimming	28%	18%
Daylight Harvesting	40%	5%
Demand-Responsive Lighting	4%	1.8%
Plug load control	10%	1.7%

Lighting: The notable differences in deployment of LEDs vs fluorescent lighting between ENERGY STAR office buildings and the market (Figure 13) highlights both the time lag between these datasets and how fast the lighting market has transformed to solid state lighting, which is now the majority lighting technology in almost half of certified office buildings. This data lag is also somewhat responsible for the differences observed in the adoption of lighting controls, although these solutions are more mature than the rapid development of LED lighting. Understanding the role of fast-moving technologies in relative performance comparisons speaks directly to the importance of frequently conducting these market surveys.

Figure 13. Lighting



	2019 ENERGY STAR Office Buildings	2012 CBECS Mean
Primarily LED	47.5%	*
Primarily fluorescent	52.5%	67%

** Denotes fewer than 5 observations.*

Building Management

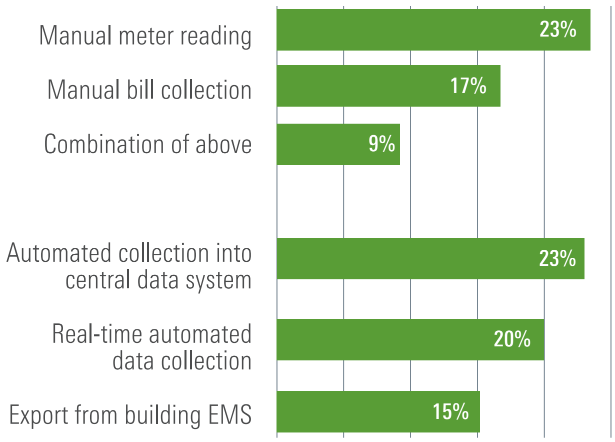
Managing efficient buildings begins with energy data. The ability to benchmark baselines, set performance targets, and track progress depends on access to and routine collection of accurate whole-building energy consumption information. To better understand this, we asked our respondents how they collect and use energy use information for their buildings.[1]

As shown in Figure 14, nearly half of respondents indicated that they rely solely on manual methods to collect their energy data, through either manual meter reading only (23%), manual bill collection only (17%), or a combination of both (9%). This contrasts with the other half who use more sophisticated means to collect their energy data, through automated collection into a central data system (23%), real-time automated

[1] Note again that our survey was designed to query individuals about only one building each, which enabled us to create an organizationally diverse respondent group, but limited responses about certified office buildings in larger portfolios managed by an individual, which may use more centralized and automated data collection tools.

data collection (20%), and/or exporting from a building energy management system (15%). Energy data collected by traditional means of utility bills and meter reading is sufficient for basic benchmarking, goal setting, and tracking performance. However, if evaluated by itself, the periodic nature, time lag, and lack of granularity of this data limits its usefulness in finding and fixing energy waste in buildings.

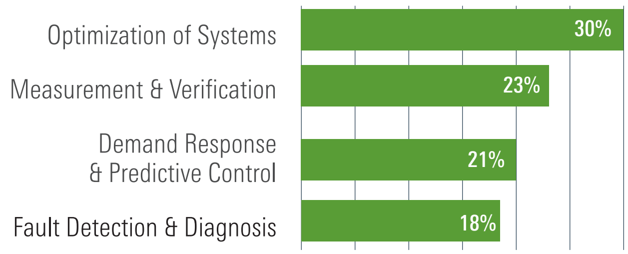
Figure 14. Means of Collecting Energy Data



While most certified office building respondents to our survey rely on manually collected utility meter data alone for their energy management programs, an even larger majority indicate that they have partial-to-no tenant submetering in place (77%). Given the larger relative size and number of tenant businesses, as well as higher occupant and plug load densities found in ENERGY STAR office buildings, this lack of submetering limits visibility of energy usage in the common areas, tenant areas, and base building systems. The ability to identify energy use in these areas requires more uniform submetering, either automated or manually collected, and represents another opportunity to facilitate performance improvement in these already high performing buildings.

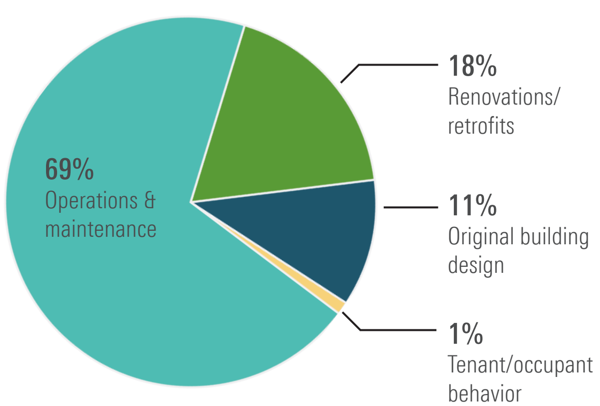
As expected, nearly all respondents use their monthly metered data for managing energy spend and tracking progress (89%). As shown in Figure 15, more sophisticated uses, such as optimization of systems (30%), measurement and verification (23%), demand response and predictive control (21%), and fault detection and diagnosis (18%) are largely dependent on access to more real-time and granular interval data, so it follows that those energy management strategies are limited to buildings using automated collection (51%). Greater use of automated collection of meter data paired with the more advanced control systems installed in these buildings would be a next best practice to optimize energy performance.

Figure 15. Advanced Uses of Energy Data



Finally, recognizing that our interpretation of what produces high energy performance in ENERGY STAR office buildings will invariably be limited by the data we can collect, we asked our respondents to give one general reason their building achieved high energy performance. Of note is that even though ENERGY STAR office buildings pursue efficient equipment and major system upgrades more frequently than their peers, more than two-thirds of respondents cite operations and maintenance as the primary reason for why their buildings earned ENERGY STAR certification. This suggests that, while necessary, efficient equipment alone is not sufficient to achieve high performance in commercial buildings.

Figure 16. Perceived cause of ENERGY STAR certification



Conclusions

U.S. office buildings have become more energy efficient, with a 30% reduction in the median source EUI between the 1995 and 2012 CBECS.

The efficiency of the U.S. office building stock improved over these 17 years, as evidenced by a 30% reduction in source energy intensity and a shifting and tightening of the distribution.

The average source EUI of ENERGY STAR certified office buildings decreased by 30% over the past decade alone.

ENERGY STAR certified office buildings have seen standout improvements in energy efficiency, achieving a 30% reduction in source EUI in just a decade.

The ENERGY STAR program continues to be effective in setting the bar for and recognizing buildings that achieve excellence in energy performance.

For over a decade, the average source EUI of ENERGY STAR certified office buildings has been below or right at the normalized CBECS 25th percentile of EUI. While the energy intensity of buildings has improved, the growth in the footprint and total energy use of this sector reinforces the continued need for the ENERGY STAR score and certification in recognizing superior performance. The ENERGY STAR program has grown from a small program of early adopters to recognizing thousands of buildings across the country, but the bar must continue to be raised. The data shows that updating the ENERGY STAR scoring model as the market evolves can raise the stringency of certification and require more of buildings.

Analyzing certified office buildings gives insights into how to continue to grow the program's impact. ENERGY STAR certified office buildings are much larger, more active, and made up of a higher proportion of Class A buildings compared to the office building stock. Expanding participation to include less premier and smaller buildings presents an opportunity and challenge going forward.

The ability to earn the ENERGY STAR does not depend on the mix of fuels, but rather how efficiently it uses them.

Almost 40% of ENERGY STAR certified office buildings are now all-electric, up from 30% in our first class. The percentage of buildings that are all-electric is roughly the same among ENERGY STAR certified office buildings and similarly efficient buildings across the country. This finding reconfirms that using source energy consumption as the basis of an efficiency performance metric does not disadvantage all-electric buildings from top-performance recognition.

ENERGY STAR office buildings contain a relatively high percentage of efficient technologies, but importantly, two-thirds of respondents primarily attribute their high energy performance to operations and maintenance.

The physical, technology, and operational characteristics collected from a survey of certified office buildings provide insight as to what produces ENERGY STAR levels of performance. ENERGY STAR certified office buildings are more likely to have major systems updates, passive shell upgrades, and have greater use of controls for building systems. Despite this, our program participants cite operations and maintenance practices as the single most important reason for achieving ENERGY STAR. This aligns with a common theme that we've continually seen over the past 20 years: Despite the physical characteristics of or technologies employed by a building, how it is operated remains an essential component of energy efficiency.

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Appendix

Appendix 1. Select Building Characteristics of the Classes of 1999 and 2019, and 1995 and 2012 CBECS (Mean)

	Size (ft^2)	Operation (hrs./ wk.)	Occupant Density (Per 1,000 ft^2)	PC Density (Per 1,000 ft^2)	% All Electric
1995 CBECS (Score ≥ 75)	17,675	54.0	2.22	2.59	26%
1999 ENERGY STAR Mean	467,893	70.6	3.32	3.33	30%
2012 CBECS (Score ≥ 75)	13,987	56.6	2.00	2.87	40%
2019 ENERGY STAR Mean	285,570	57.2	3.20	3.33	39%

Appendix 2. Class of 2019 Building, Equipment, and Management Characteristics (Mean)

	2019 ENERGY STAR Office Buildings	2012 CBECS	2012 CBECS (Score ≥75)	2012 CBECS (Score ≤25)
# of Records/Respondents	165	336	89	47
# of Buildings Represented	3,330	36,768	8,617	6,716
Average Size	285,570	16,601	13,987	13,849
Construction				
Year (Median)	1988	1982	1980	1960
Concrete	35%	36%	41%	26%
Masonry	25%	53%	42%	67%
Glass	32%	7%	11%	*
% Exterior Glass	61%	24%	23%	24%
HVAC				
Boiler(s)	42%	48%	32%	62%
Central Chiller(s)	57%	40%	24%	36%
Packaged Heating	10%	52%	47%	27%
VAV (Heating or Cooling)	83%	70%	55%	42%
Controls				
Building Automation System	90%	72%	53%	64%
Economizer	67%	57%	51%	37%
Motion Sensors	92%	73%	60%	77%
Light scheduling	67%	55%	54%	42%
Multi-level lighting or dimming	28%	18%	19%	19%
Daylight harvesting	40%	5%	6%	4%
Plug load control	10%	1.7%	*	*
Demand responsive lighting	4%	1.8%	*	*
Lighting				
Fluorescent as primary	52.5%	67%	62%	84%
LED as Primary	47.5%	*	*	--
Renewable Electricity				
Onsite Generation – Solar	1.5%	4.8%	*	*
Offsite Renewables	1%			
Management				
Regular HVAC Maintenance	100%	97%	100%	85%
Major HVAC Upgrade	72%	34%	15%	33%
Major Lighting Upgrade	83%	31%	22%	42%
Major Insulation improvements	27%	7%	5%	10%
Major Window replacement	25%	17%	11%	23%
Amenities				
Estimated Number of Business-es	7.61	7.26	7.71	5.82
Class A	78%			

* Denotes fewer than five observations.

Appendix 3: Class of 1999 Building, Equipment, and Management Characteristics (Mean)

	1999 ENERGY STAR Office Buildings	1995 CBECS	1995 CBECS (Top 25% of EUI)	1995 CBECS (Bottom 25% of EUI)
# of Records	70	530	144	125
Construction				
Concrete	21%	16%	10%	22%
Masonry	44%	63%	71%	56%
Glass	30%	15%	12%	20%
Year (Median)	1982	1978	1978	1974
HVAC				
Boiler	35%	46%	32%	49%
Chiller	69%	43%	26%	65%
Packaged	25%	59%	70%	47%
VAV	76%	50%	36%	67%
Controls				
EMS	93%	43%	23%	56%
Economizer	79%	55%	29%	73%
VSDs	73%	33%	19%	45%
Motion Sensors	61%	16%	8%	21%
Management				
Energy Audit	79%	24%	23%	36%
Regular O&M	99%	96%	92%	98%
Renovation	65%	--	--	--
Equip. Update	87%	--	--	--
Amenities				
Class A	75%	--	--	--