Energy-Related Changes in Education Buildings Following the COVID-19 Pandemic

December 2024

Independent Statistics and Analysis
U.S. Energy Information Administration

www.eia.gov
U.S. Department of Energy
Washington, DC 20585

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Executive Summary

This report describes changes to 48 education buildings and their energy-using equipment and practices following the COVID-19 pandemic. The data come from an exploratory, web-only survey conducted in 2023 with a convenience sample.[1] Education buildings were the second-most prevalent building type after office buildings in our responding sample. We conducted the survey to learn about changes to commercial buildings brought about by the COVID-19 pandemic. The results inform questionnaire development for the next *Commercial Buildings Energy Consumption Survey* (CBECS). The results do not represent the commercial building population in the United States.

Although almost half of the education buildings in our responding sample were on campuses, no two buildings were on the same campus or had the same respondent. The responding sample of education buildings included fewer small-sized education buildings than we would expect, given that more than one-half of all education buildings in 2018 were less than 10,000 square feet, according to CBECS. The results in this report suggest patterns predominately in medium-sized and large-sized education buildings.

We found that education buildings in our responding sample, more so than other commercial buildings, made changes to increase air quality. Such changes included increased air filtration, the addition of portable air cleaners or air purifiers, more use of outdoor space, and opening windows to let in fresh air. Education buildings were more likely than all other buildings in the responding sample to make heating, ventilation, and air-conditioning (HVAC) system changes because of the pandemic. Some respondents reported that state or local government mandates influenced these changes. We do not know to what degree these changes persist.

Increased air filtration was more common among education buildings than all other buildings in our responding sample. Almost one-half of the education building respondents in our sample reported that Minimum Efficiency Reporting Value (MERV)-rated filters had been upgraded. The most common ratings reported by respondents were upgrades from MERV ratings of 8 to 13, which is consistent with American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE) recommendations. Although some upgraded filters may continue to be used, we do not know how often buildings have reverted to lower MERV filters.

Like air filtration, adding portable air cleaners was more common among education buildings than in all other buildings in our responding sample. Respondents for almost one-half of education buildings in the responding sample reported the addition of at least one portable air cleaner. Schools that added portable air cleaners often reported adding more than 20. Although we did not ask explicitly about air purifiers and we do not know whether respondents were using the term synonymously with portable air cleaners, one respondent indicated that portable air purifiers had contributed to increased energy costs.

[1] A convenience sample is a nonprobability-based sample in which sample units are chosen because they are easily accessible, available, or willing. The starting sample used for this survey included about 16,000 commercial building addresses, but we only had email addresses for about 8,000 of these. Email addresses made it easy to contact respondents.

A higher proportion of respondents answering for elementary, middle, and high school buildings reported changes to exterior space than respondents for all other commercial buildings. These respondents described pandemic-inspired outdoor learning activities and classrooms. Although two of the respondents stated that such activities have now returned inside, we are unsure if the other six buildings have also shifted outdoor activities back inside. One respondent noted the addition of Wi-Fi access outdoors, which suggests a more permanent investment in infrastructure for outdoor activities.

Education buildings were more likely than all other buildings in our responding sample to report opening windows during business hours. Over one-third of education building respondents reported opening windows at least some of the time, whereas less than one-quarter of respondents for other commercial buildings reported opening windows. Most of the education buildings with open windows were in the mixed mild and cool climate zones.

One-third of education building respondents reported changes to HVAC that were made specifically because of the COVID-19 pandemic. Education buildings were more likely than all other buildings in the responding sample to make HVAC changes because of the pandemic. One respondent noted mandates on HVAC settings related to ventilation, and other respondents mentioned health and safety reasons for making HVAC changes. The majority of the education buildings that made HVAC changes because of the COVID-19 pandemic reported ventilation changes. More respondents reported increasing the use of outdoor air beyond minimum settings and running outside airflow for about two hours before and after the building was occupied compared with other ways to increase ventilation.

Most respondents indicated that the number of office devices stayed about the same since before the pandemic. Online learning was commonly mentioned in write-in responses about office devices.

Background and Motivation

The COVID-19 pandemic may have brought about lasting changes in commercial buildings, so we want to make sure that our questionnaire for the next *Commercial Buildings Energy Consumption Survey* (CBECS) includes relevant measures. We administered this survey to prepare for the next CBECS collection. The exploratory survey had two primary goals:

- To learn about changes in commercial building equipment, space usage, and practices that affect energy consumption patterns
- To learn what information is difficult for commercial building respondents to provide

The responding sample contained 271 buildings, and education buildings were the second-most prevalent building type after office buildings. To read results related to offices, see Energy-Related Changes in Office Buildings Following the COVID-19 Pandemic. In this report, like in the office buildings report, we compile major findings from the data related to education buildings in our responding sample (n=48) to share with the public.

Methods and Limitations

We used a convenience sample[2] to conduct the survey. The results from the survey are generalizable neither to the U.S. commercial building stock nor to U.S. education buildings.

We used data we gathered during the 2018 CBECS to send the survey invitations. We contacted people to complete the survey who were affiliated with sampled commercial buildings from the 2018 CBECS for whom we had an email address. Contacts to about 3% of all email addresses resulted in a survey response.

We had an email address if interviewers for the 2018 CBECS collected one while visiting the building. Because interviewers for the 2018 CBECS were often in contact with people at sampled buildings who ultimately refused to participate, almost one-half of the email addresses (44%) corresponded to a nonresponding sample unit from the 2018 CBECS collection.

We programmed and administered the survey using Qualtrics, an online survey software. In the first month of data collection, we sent email invitations to over 8,000 people using the primary or only email address on file for CBECS sample buildings. In the second month of data collection, we sent email invitations to secondary email addresses, when available, for buildings for which we had not received a response. In some cases, the secondary email addresses were for a second person affiliated with the building. In other cases, the secondary email addresses were alternative spellings or second email addresses for the same person we contacted in the first month. No two email addresses were contacted about the same building in the same month. For most people, we knew the corresponding building address. When we had the building address, we included it in survey invitation emails.

[2] A convenience sample is a nonprobability-based sample in which sample units are chosen because they are easily accessible, available, or willing. The starting sample used for this survey included about 16,000 commercial building addresses, but we only had email addresses for about 8,000 of these. Email addresses made it easy to contact respondents.

As a convenience sample, the survey sample was not designed to represent all commercial buildings or their respondents. Buildings that were easier to contact for CBECS are in the sample because we have email addresses for them. Further, we received more responses from people who responded to the 2018 CBECS collection than from people who had not responded. You can find more information about the CBECS sample on our web page How We Chose Buildings for the 2018 CBECS. If we had compiled the convenience sample for the survey in another way, the results in this report may have been different.

One other limitation of these results relates to measurement error. We designed our survey to measure persistent changes in buildings, that is, changes that have continued since the COVID-19 pandemic. However, several write-in responses led us to conclude that the reference period for questions was not consistently interpreted among respondents. Some respondents reported to us in open-ended responses that the changes in building practices that they had identified in the closed-ended questions were no longer taking place. Because we have no measure of how consistently respondents interpreted the intended reference period of the survey, we cannot quantify this potential measurement error.

Characteristics of education buildings in the responding sample

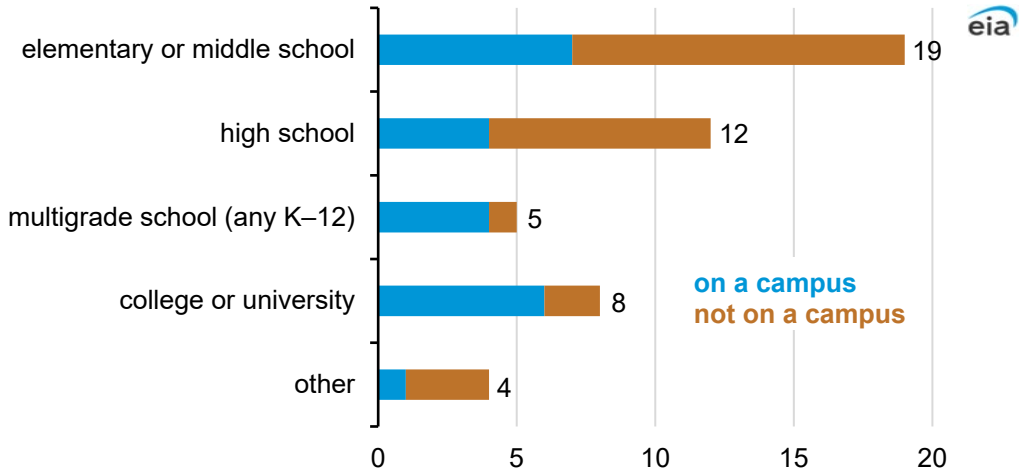
The results in this report represent only the sample of 48 sufficiently completed surveys[3] about education buildings that we received. These results do not represent the U.S. education building stock.

The largest proportion of the education buildings (19 of 48) were elementary and middle school buildings. Twelve buildings were high schools and eight were college or university classroom buildings. The smallest proportion of the sample consisted of other education buildings (4 of 48). Other education buildings include preschools, religious education buildings, and career or vocational training buildings.

Just under half of the education buildings (22 of 48) were on a campus, but no two buildings were on the same campus or had the same respondent. Multigrade K–12 and college or university buildings were the most common education types to be part of a campus (Figure 1).

[3] All but 8 of the 48 education building respondents completed all questions in the survey. Six respondents stopped the survey about one-quarter of the way through, after answering a question about renovations and upgrades to the building. Two respondents stopped the survey about three-quarters of the way through.

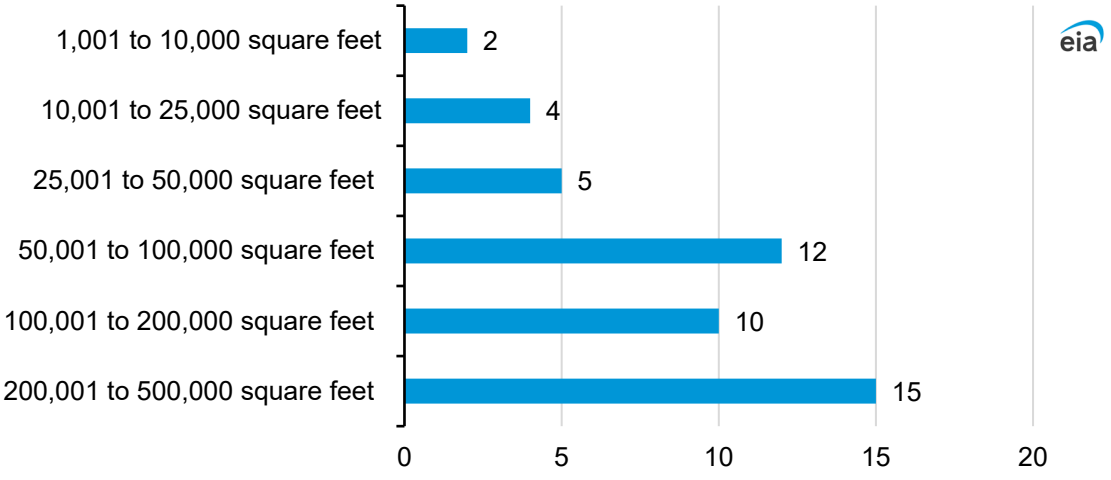
Figure 1. Types of education buildings in responding sample
number of buildings



Data source: U.S. Energy Information Administration, 2023 exploratory web survey conducted by the *Commercial Buildings Energy Consumption Survey* program

Most education buildings in the responding sample were in the medium-to-large size categories, between 50,001 and 500,000 square feet. Few small education buildings were represented in the responding sample. Only 2 of 48 buildings were 10,000 square feet or less (Figure 2). According to the 2018 CBECS, more than one-half (56%) of all education buildings were less than 10,000 square feet. On average, education buildings were 31,100 square feet per building. Therefore, the results of this survey describe larger education buildings than average.

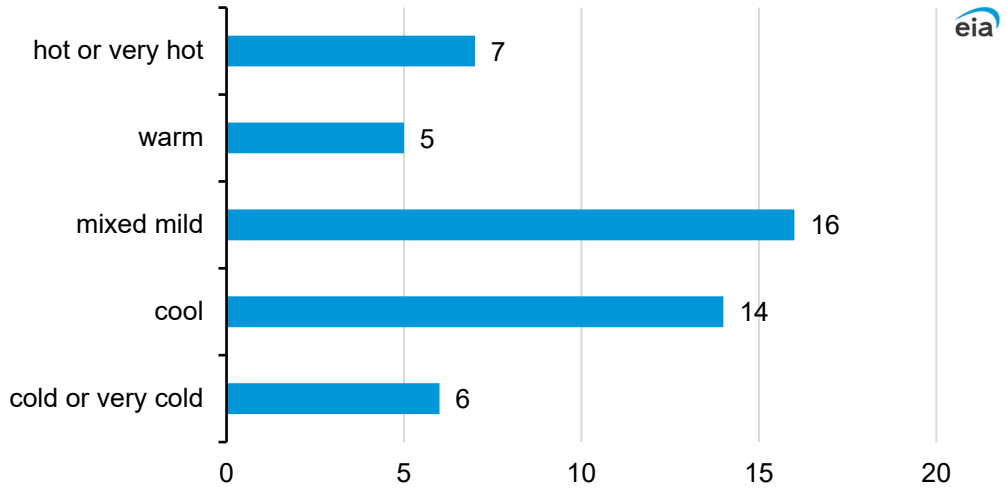
Figure 2. Size categories of education buildings in responding sample
number of buildings



Data source: U.S. Energy Information Administration, 2023 exploratory web survey conducted by the *Commercial Buildings Energy Consumption Survey* program

We used the same approach we used in the 2018 CBECS to classify building climate zones.[4] Fewer buildings were in the more extreme climate zones—hot or very hot (7 of 48) and cold or very cold (6 of 48)—when compared with the mixed mild climate zone (16 of 48). The warm climate zone had the least number of buildings (5 of 48) (Figure 3).

Figure 3. Climate zones of education buildings in responding sample
number of buildings



Data source: U.S. Energy Information Administration, 2023 exploratory web survey conducted by the *Commercial Buildings Energy Consumption Survey* program

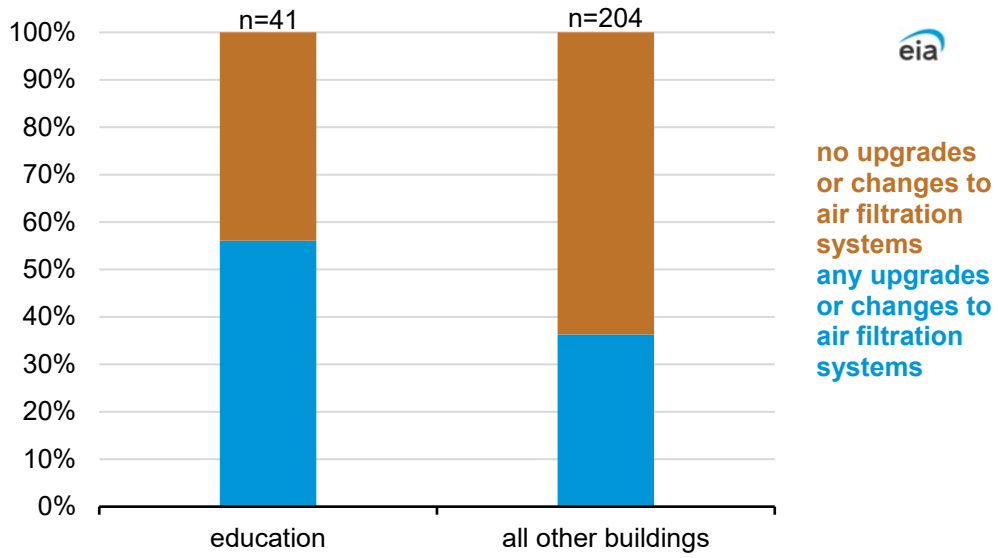
Results

Air filtration

We asked, "Since 2019, have there been upgrades or changes to the type of air filtration systems or air filters used in this building?" Of the 41 education building respondents who answered the question, over one-half (23 of 41) answered yes. In comparison, about one-third of respondents in the 204 other commercial buildings in the responding sample answered yes to this question (Figure 4).

[4] For 2018, CBECS used climate zone categories based on groups created by the American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) as designated in ANSI/ASHRAE Standard 169-2021, *Climatic Data for Building Design Standards*.

Figure 4. Percentage of buildings where upgrades or changes to air filtration systems were reported for education buildings compared with all other buildings
percentage



Data source: U.S. Energy Information Administration, 2023 exploratory web survey conducted by the *Commercial Buildings Energy Consumption Survey* program

State and school district mandates provide one possible explanation for the relatively high rates of changes in air filtration systems in education buildings compared with other commercial buildings. The data suggest that public schools in some states were mandated to upgrade air filtration. One respondent wrote, "In [my state], school districts were mandated to use [Minimum Efficiency Reporting Value] MERV-13 filters."

MERV filter ratings

MERV ratings are helpful in comparing the performance of different filters; the higher the MERV rating, the better the filter is at trapping specific types of particles. All 23 education building respondents who reported a change in air filtration or air filters indicated that their building's filters had MERV ratings. All but one of these (22 of 23) reported that at least one filter in the building had been upgraded to a higher MERV rating and 19 respondents were able to provide the ratings.

When asked for the old and new MERV ratings for the most recently replaced filter, most respondents who could provide the information (13 of 19) reported that filters had been upgraded to MERV rating 13, which is consistent with ASHRAE recommendations. Seven of these 13 respondents indicated that the old filter ratings were MERV 8, while other responses for the old filter ratings were "Don't know" or were values between 9 and 11. Among other respondents reporting MERV filter ratings, three upgraded from filters with ratings of 8 to ratings of 11. Two upgraded to filters with a MERV rating of 14.

We do not know how long education buildings will continue to use MERV 13s. One respondent wrote, "Pre-COVID we used 9 MERV, and at the onset of COVID we upgraded to 13 MERV. However, now, post-COVID, we are back to 9 MERV."

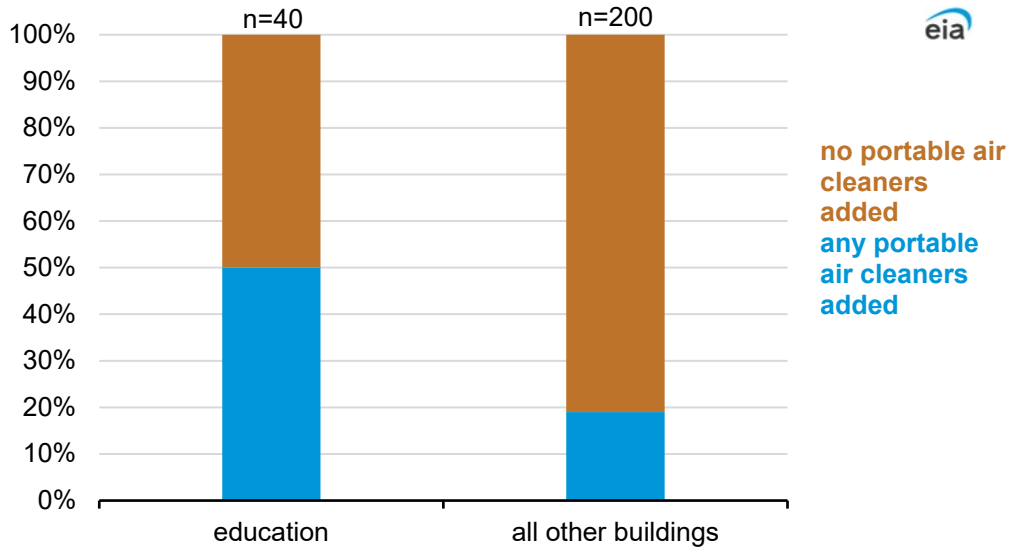
Another respondent noted that using MERV 13 filters increased energy consumption, but that change is hard to measure. The respondent wrote, “Upgrading to MERV 13 filters undoubtedly added load to ventilation systems, but we don't have the granularity with submetering to see this at a system level.”

Portable air cleaners and air purifiers

We asked, “Since 2019, how many portable air cleaners have been added in the building, if any?” Among those education building respondents who could provide an answer, one-half reported that at least one portable air cleaner was added (20 of 40), while the other half reported no portable air cleaners. A higher proportion of education buildings than all other buildings in our responding sample added portable air cleaners. Among all other buildings who could provide an answer to this question, less than one-fifth of building respondents reported adding at least one portable air cleaner (38 of 200) (Figure 5).

Figure 5. Percentage of buildings where at least one portable air cleaner was added for education buildings compared with all other buildings

percentage



Data source: U.S. Energy Information Administration, 2023 exploratory web survey conducted by the *Commercial Buildings Energy Consumption Survey* program

All the education buildings that added any portable air cleaners added more than one. Almost one-half of them added more than 20 portable air cleaners (9 of the 20 that added any), which was more than all other commercial buildings in our responding sample. Only 7 of the 38 other commercial buildings that added any portable air cleaners added more than 20.

The data suggest that adding portable air cleaners was more common for K–12 schools than for other types of education buildings. All education buildings in which portable air cleaners were reported were elementary schools, middle schools, high schools, or multigrade K–12 schools. None of the respondents for the 12 college or university or other education buildings in our responding sample reported adding portable air cleaners.

Technically, portable air cleaners and air purifiers differ because cleaners trap particles while purifiers sanitize the air. However, the terms are often used interchangeably. Although the survey did not ask about air purifiers, they were mentioned in a section of the survey about energy bills. We asked, "Please describe in your own words the changes in this building that you think had the most impact on the change in energy bills." One respondent wrote that increases in energy bills were affected by "the distribution of air purifiers into the classrooms and offices, and the increased hours of operation of HVAC equipment prior to and following daily occupancy to meet the school district's ventilation standards."

Exterior space

We asked, "Since 2019, has use of exterior space changed for this building due at least partly to the COVID-19 pandemic? *This includes, for example, the addition of outdoor seating, a drive-thru or walk-up window, different parking or drop-off options, and changes to outdoor lighting.*" Almost one-fifth of respondents for education buildings who responded to this question (8 of 42) answered yes. In comparison, less than one-tenth of respondents in all other commercial buildings who responded to this question answered yes.

All eight of the respondents who reported changes to exterior space were for elementary, middle, and high school buildings. They all commented that the school added outdoor activities, although two of these respondents explicitly stated that classroom activity was indoors again. For the other education buildings with respondents reporting changes to exterior space, we are unsure about whether the shift to outdoor activities persisted.

Outdoor activities included the addition of "outdoor learning areas" and "outdoor classrooms," "outdoor gardening activities with students," and "lunches and assemblies…held at least partially outdoors." One respondent reported that the school "increased outdoor areas with Wi-Fi access for classroom instruction during times when weather allows." Another respondent reported that a walk-up window was added for people to pick up food.

Doors and windows

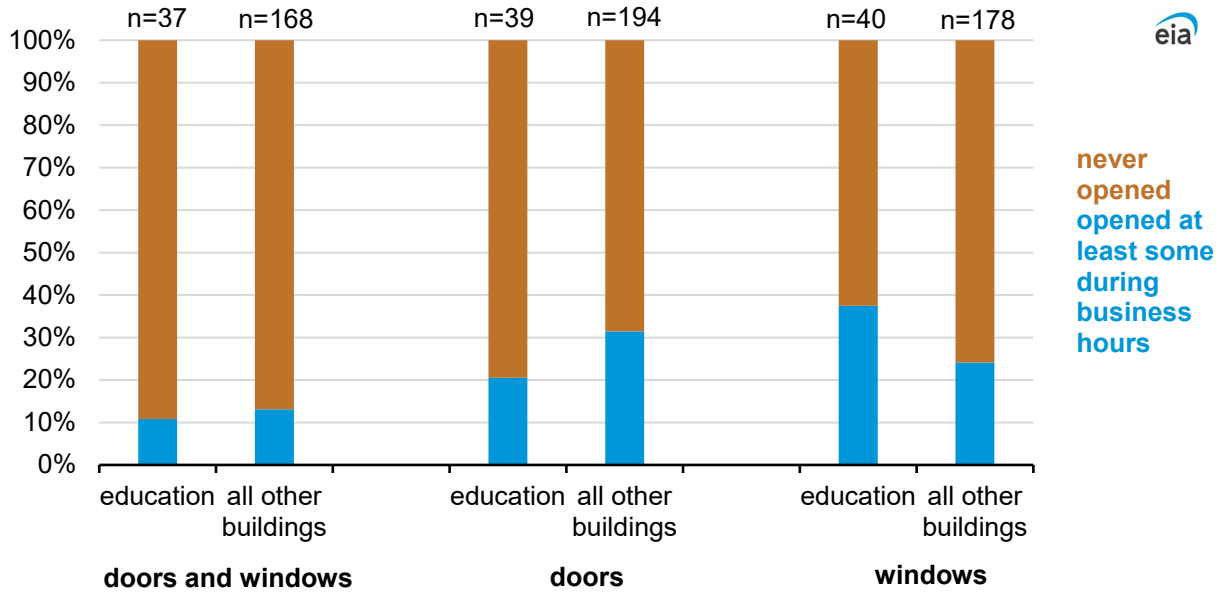
We also asked respondents about opening doors and windows. We asked, "During an average year, how often are any doors or windows kept open during business hours? *For example, occupants may open doors or windows to let in fresh air or may prop open a door to invite customers to enter.*" For doors and windows separately, we gave respondents the following response options:

- Never
- Less than 1 month
- 1–3 months
- 4–6 months
- 7–9 months
- 10–12 months
- Don't know
- Not applicable

Approximately one-tenth of respondents who answered the question for education buildings in our responding sample (4 of 37) reported that both doors and windows were opened. This proportion was slightly less than that for respondents for all other commercial buildings (22 of 168). For the education building respondents who reported opening doors and windows, three were high schools and one was a multigrade K–12 school.

A smaller proportion of education building respondents than respondents from all other commercial buildings in our responding sample reported opening doors (8 of 39 education building respondents compared with 61 out of 194 respondents for all other commercial buildings). However, a larger proportion of education building respondents (15 of 40) than respondents for all other buildings (43 of 178) reported opening windows (Figure 6).

Figure 6. Percentage of buildings where doors and windows were opened during business hours for education buildings compared with all other buildings

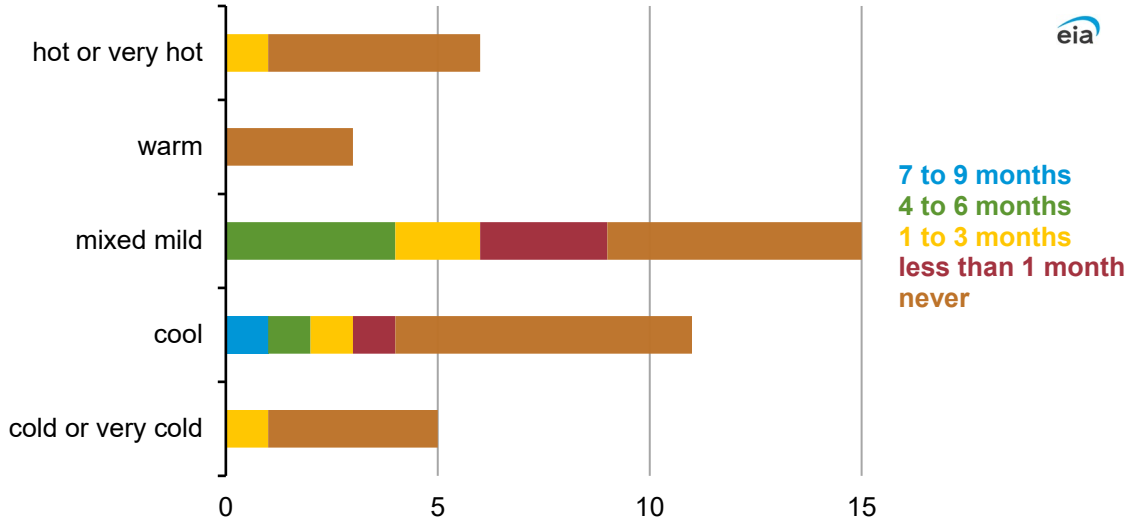


Data source: U.S. Energy Information Administration, 2023 exploratory web survey conducted by the *Commercial Buildings Energy Consumption Survey* program

We expect that security protocols prevent some schools from keeping doors open. We also assume that teachers and administrators use windows to ventilate and cool the air in classrooms, particularly in mild climate zones. Over half of the education buildings where respondents reported opening windows were in the mixed mild climate region (9 out of 15). Four were in the cool climate region (Figure 7).

Although one respondent reported that windows were opened for seven to nine months of the year, most respondents reported that windows were opened for four to six months (5 of 15), one to three months (5 of 15), or less than one month (4 of 15).

Figure 7. Number of education buildings where windows were reported to be opened, by climate zone and number of months opened
number of buildings



Data source: U.S. Energy Information Administration, 2023 exploratory web survey conducted by the *Commercial Buildings Energy Consumption Survey* program

Among the respondents that reported opening windows, most were reported for high schools (6 of 15) or for elementary or middle schools (5 of 15). Two were reported for college or university education buildings. Over half of the buildings where windows were reported to be opened were 200,001 to 500,000 square feet (8 of 15). The remainder were in smaller size categories.

HVAC changes

We saw that ventilation influenced HVAC changes in some education buildings. We asked, "These next questions are about renovations, upgrades, and replacements. Since 2019, which types of renovations and upgrades have been done at this building? *Please select all that apply or, if none, select the last option.*" We provided 13 response options plus the option to select "None of the above renovations, upgrades, or replacements since 2019."

More than half of the education buildings in our responding sample (31 out of 48) reported changes to HVAC equipment or settings by selecting the response, "HVAC (heating, ventilation, or air conditioning) equipment upgrade, replacement, or change in settings (Example: changing HVAC settings to increase air flow)." One-third (16 of 48) reported that the changes to HVAC were made specifically because of the COVID-19 pandemic. Education buildings were more likely than all other buildings in the responding sample to make HVAC changes because of the pandemic; among the 223 buildings in the sample that were not education, changes to HVAC equipment or settings were made in 113 buildings and only 25 of those were specifically because of the pandemic.

Half of education buildings where HVAC changes were made due to the pandemic were larger than 200,000 square feet (8 out of 16). About one-half of education buildings making changes to HVAC due to

the pandemic were high school buildings (7 out of 16). None of the eight college education buildings reported that changes in HVAC were due to the COVID-19 pandemic.

Reasons for HVAC changes in response to the COVID-19 pandemic

We showed respondents a list of all the upgrades, renovations, and building changes they reported that were made at least partially because of the COVID-19 pandemic and asked, "Listed below are all the building renovations and upgrades that you mentioned were related to the COVID-19 pandemic. In the space below, please briefly explain how each renovation/upgrade was related to the pandemic." Among the 16 respondents with HVAC changes due to the pandemic, 12 answered this question. Ten of the respondents discussed changes related to ventilation or filtration. One of those respondents mentioned following recommendations by the state government. He wrote, "The settings were changed. Per the [state] Governor, we went to a 30% minimum outside air setting." Two respondents mentioned health and safety concerns and ultraviolet sanitation.

HVAC changes to increase ventilation

We provided respondents with a list of eight types of changes that may have been made to the building's HVAC system to increase ventilation and asked them to select all that applied to their building. The majority of the education buildings that reported HVAC changes because of the COVID-19 pandemic (14 of 16) selected at least one of these responses, which come from ASHRAE recommendations. Increasing the use of outdoor air beyond minimum settings and running outside airflow for about two hours before and after the building is occupied were the two most selected responses. Four buildings chose both of those responses. Ten other respondents selected one or two of these six responses:

- Increased the use of outdoor air beyond minimum settings
- Rebalanced or adjusted HVAC to increase total airflow
- Began running HVAC fans continuously even when not heating or cooling or when building is unoccupied
- Began running outside airflow for about 2 hours before and after this building is occupied
- Used fans to increase effectiveness of open windows
- Added Ultraviolet Germicidal Irradiation (UVGI)

Office devices

We asked, "Now we have a few questions about some of the equipment in this building. Since 2019, has the number of office devices such as computers, printers, and photocopiers in this building changed at least partly because of the COVID-19 pandemic?" We provided the response options:

- The number of office devices changed since 2019, but not because of the COVID-19 pandemic.
- The number of office devices changed since 2019 because of the COVID-19 pandemic.
- The number of office devices has stayed about the same since 2019.

The majority of respondents that answered the question reported that the number of office devices stayed about the same (28 out of 41). Eight respondents reported a change due to the pandemic, and five respondents reported a change not due to the pandemic. Most changes in the number of office devices were increases.

Online learning

In a follow-up question, anyone who reported a change in office devices since 2019 was asked, "Please describe in your own words why the changes in the number of computers, printers, photocopiers, and other office devices happened." Five of the eight respondents who reported that this change was because of the COVID-19 pandemic described the reason for the change as online learning. One respondent explained that "during the height of the pandemic, [district] schools implemented remote learning, and distributed laptops to all students to accommodate remote classes. The distribution to students has remained the same even after students and faculty returned to schools in 2021." Another respondent referenced receiving grants that allowed the school to purchase laptops for students to use.

Conclusions

We received responses to our exploratory web survey from enough education building respondents from across the United States to hint at possible impacts of the COVID-19 pandemic on education buildings. Our survey was not designed to produce results that represent commercial buildings, so the patterns we see here may not be present in the entire U.S. education building population. However, the results suggest changes to look for in the next full-scale CBECS because they may characterize important shifts in energy consumption patterns in U.S. education buildings.

We found that education building respondents, more than respondents from all other commercial buildings, reported the following:

- Upgrades or changes to air filtration systems or air filters
- Addition of portable air cleaners
- Opening windows
- Changes to exterior space
- Changes to HVAC at least partly because of the COVID-19 pandemic

For all changes, we are unsure how long they will persist. Although state or local mandates may have prompted changes, education buildings may have already reverted to previous practices or will in the near future.

One of the strongest patterns we observed in our sample of responding education buildings (n=48) was upgrades or changes to air filtration systems. Many of the changes in air filtration systems were from upgrading at least one filter in the building to a higher MERV rating. The relatively high rates of changes in air filtration in education buildings could possibly be linked to state and local mandates.

Among the respondents in our survey, more respondents from K–12 schools than for other types of education buildings reported adding portable air cleaners. They were the only group of education building respondents that reported adding more than 20 portable air cleaners per building.

At several education buildings, occupants took advantage of outdoor spaces to add activities, such as outdoor learning. We also observed that education buildings opened windows at a higher rate and opened doors at a lower rate than other buildings in our sample.

Education building respondents reported changes to HVAC settings in response to the COVID-19 pandemic. Some of these changes included increasing the use of outside air beyond minimum settings and running outside airflow for about two hours before and after the building is occupied.

We found that most education buildings in our sample reported that the number of office devices have stayed about the same. In education buildings where the number of office devices changed due to the COVID-19 pandemic, several respondents reported online learning as the reason for the change. Some K–12 schools provided laptops to each student to accommodate online learning during the pandemic.

We are designing the next CBECS questionnaire. We plan to build on what we learned from this exploratory survey by holding discussions with managers of education buildings about topics such as ventilation and filtration in classrooms, portable air filters, opening school windows, and classroom-level office devices such as student laptops. The exploratory survey and further discussions will help us update the questionnaire to best reflect the landscape of commercial buildings following the height of the COVID-19 pandemic.