Analyzing the long-term effects of building age on commercial building energy use and floorspace

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ABSTRACT

What share of commercial buildings that exist today will still exist in 2050? We use the latest data from the 2018 *Commercial Buildings Energy Consumption Survey* (CBECS) and the 2012 CBECS to analyze the relationship between building age, building size, and energy consumption. We also use the National Energy Modeling System (NEMS) to produce building floorspace survival assumptions and retirement rates, estimated from CBECS data, and we explore how changes in building stock turnover affect projected commercial floorspace growth and energy use in U.S. commercial buildings.

In this analysis, we use unreleased, discrete year of construction data and present aggregated results. Using CBECS data, we develop NEMS modeling sensitivities to demonstrate an approach to estimate what share of commercial floorspace that exists today will exist in the coming decades. Based on the methodology described here, NEMS results indicate that 34%–66% of buildings that existed in 2023 will exist in 2050. According to the U.S. Energy Information Administration's (EIA) AEO2023 Reference case, the maximum point of this estimate is consistent with EIA's *Annual Energy Outlook 2023* (AEO) Reference case.

This paper offers a set of commercial floorspace and energy use projections through 2050 and gives a first look into how NEMS' Commercial Demand Module uses 2018 CBECS data. This analysis informs a major model base year update for AEO2025. We also provide a description of CBECS variables and transformation approaches used in NEMS modeling.

Introduction

Over the course of a commercial building's lifetime, the way it uses energy changes based on the price of energy, occupant behavior, investment decisions, and the availability of energy-efficient equipment. Even a building's purpose can change as it transitions to meet another commercial need. At the end of its commercial life, a building is demolished or repurposed. Recent work explores the effect of building lifetimes or age on life cycle costs (Andersen and Negendahl 2023) and on energy use and climate impacts (Mohammed, Smith, et. al. 2021). NREL's end-use load shapes use Comstock's building vintages as a vector to account for the effect of building age on energy use (NREL 2023). Huuhka and Lahdensivu explore the relationship between demolition and construction activity in the context of demographic development and find that non-residential buildings are retired at a younger age than residential buildings in the limited geographic area they studied (2014).

EIA's CBECS is a national sample survey of commercial buildings that collects data on energy-related characteristics and energy usage in the sampled buildings (EIA 2024). CBECS is the only independent national-level data source for this information. The survey is required by Congress and has been conducted periodically by EIA since 1979. The latest survey data available are from the 2018 CBECS.

Building-level observations in each survey year cannot be directly compared with observations from earlier surveys. For each survey year, EIA updates the survey frame and draws a new sample so that responses are statistically representative of the entire U.S. building stock. Looking at aggregate differences across survey years, however, can indicate broad shifts in building use, energy consumption, and behavior.

This paper examines differences in average building ages, floorspace, associated energy use, and the intensity of energy use across the 2012 and 2018 CBECS. We use the latest CBECS to develop NEMS base-year characteristics of the U.S. commercial building stock, equipment penetrations, and associated energy use. We present aspects of EIA's methodology for modeling building retirements and resulting floorspace changes over time and discuss how NEMS uses CBECS data to define building retirement parameters. We explore impacts on commercial floorspace and energy use.

Comparing the 2012 CBECS to the 2018 CBECS

Although CBECS observations cannot be compared survey year to survey year, it is useful to examine average differences from survey to survey, as long as we consider methodological changes between survey years as a potential explanatory factor for differences.

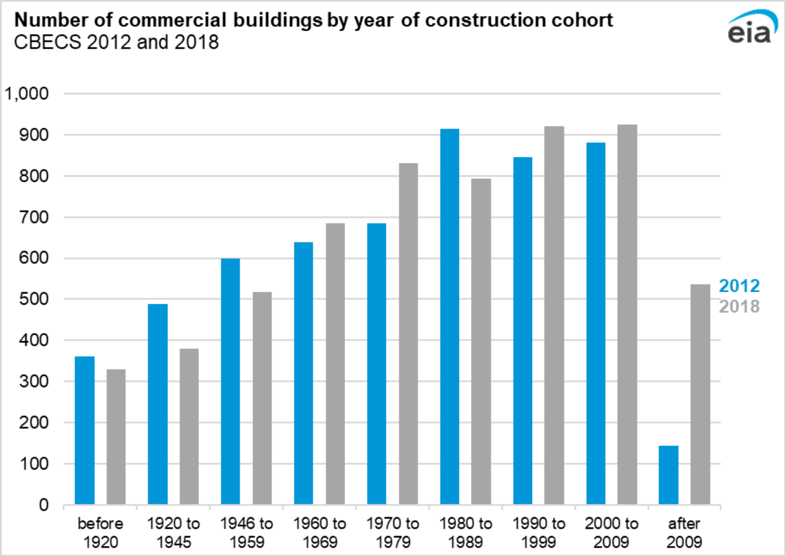

Figure 1. Number of commercial buildings by construction years, CBECS years 2012 and 2018 *Source*: EIA 2012 and 2018 CBECS data.

The 2012 CBECS cycle collected data for 6,720 completed building cases representing an estimated 5.6 million total buildings, and the 2018 CBECS collected data for 6,436 buildings representing an estimated 5.9 million total buildings. The 2018 survey captured buildings characteristics and energy use data for a higher number of newer buildings for almost every construction decade since 1960 (Figure 1). The 7% increase in number of buildings from 2012 to 2018 was not statistically significant, meaning that this difference is not particularly notable or could otherwise be explained as a sampling difference.

For both survey cycles, principal building activity (PBA) was classified by the primary activity carried out by the sampled building. CBECS PBA is defined as "the activity or function occupying the most floorspace in a building" (EIA 2024a). How the question was asked in 2012 differs slightly from how it was asked in 2018. In 2012, the respondent was asked whether one single activity accounts for 75% or more of the floorspace, and if so, which one. In 2018, the respondent was asked which activity accounts for the majority of space in the building and then asked if 75% or more of the floorspace is used for that activity. Both iterations of the survey contained the same initial building categories. (EIA 2024b).

The 2018 end-use estimation procedures were updated from procedures used in the 2012 CBECS. New questions on the 2018 survey cycle were incorporated into the models, and we incorporated updated efficiency and intensity factors for our end-use modeling. In 2018, the calibrated final end uses were based more heavily on the engineering estimates than in 2012 (EIA 2023). Figure 2 shows differences in the total commercial building square footage by the year of construction. From the 2012 to 2018 CBECS, the total commercial floorspace increased by 11%. Although there were no significant changes in energy consumption, commercial buildings overall consumed 12% less energy per square foot of floorspace (EIA 2022). The major fuels energy intensity decreased from 80.0 thousand British thermal units per square foot (MBtu/sf) to 70.4 MBtu/sf. Another paper has also noted a large decrease in energy intensity, specifically in the U.S. office building sector (Burgess et al. 2022). Health-care buildings, large offices, and education buildings all have observed statistically significant decreases in energy intensity, indicating improvement in buildings energy efficiency over time.

Working with building age data from CBECS

The CBECS has an exact year of construction variable (YRCON) and a categorical variable that places the year of construction into categories (YRCONC). CBECS respondents are asked to report the year that the largest portion of the building was completed. Both the 2012 and 2018 CBECS cycles were collected under the authority of the Confidential Information Protection and Statistical Efficiency Act (CIPSEA). To protect the identities of individual buildings included in CBECS, the specific YRCON data in the public use microdata file and other data have been masked using various disclosure avoidance techniques, including publishing a categorical variable, or range of values, rather than a specific value. The exact techniques implemented to avoid disclosure of information can differ by survey cycle. The 2012 CBECS omitted the exact year of construction for any building constructed before 1946 (EIA 2016). The 2018 CBECS withheld the exact year of construction for all buildings and provided only the categorical variable (EIA 2023a). For this analysis, we used the unmasked YRCON data and present aggregated results.

Comparing 2012 with 2018 buildings

The largest buildings, on average, for both 2012 and 2018 were in-patient health-care buildings. In 2012, these buildings had an average size of 247,800 square feet and a median age of 36 years. In 2018, the average in-patient health-care building size was 264,800 square feet with a median age of 35 years. The average change in square footage was not statistically significant between the two cycles, but the difference in energy intensity for in-patient health-care buildings between the two cycles was statistically significant. Overall, the energy intensity of in-patient health-care buildings decreased by 16% from 2012 to 2018, from 231.1 MBtu/sf to 193.3 MBtu/sf. Large office buildings, on average, were the second-largest buildings in both 2012 and 2018. These buildings had a median age of 28 years and 33 years, respectively. The major fuels energy intensity decreased from 92.2 MBtu/sf to 70.9 MBtu/sf (Figure 3).

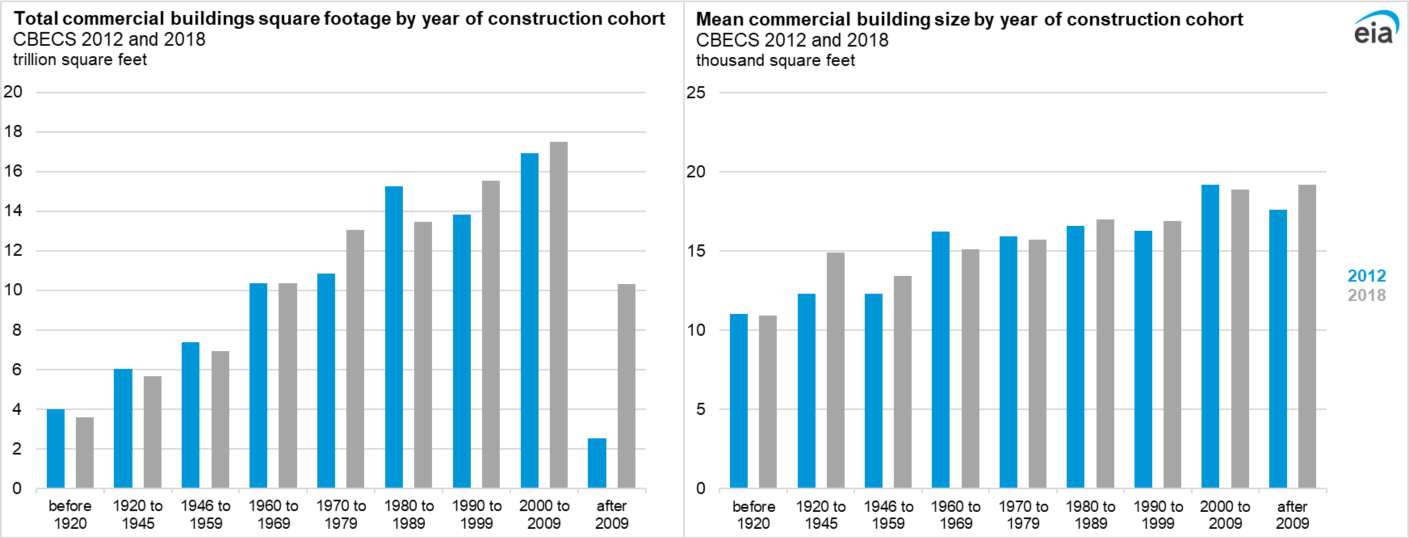

Figure 2. Total commercial buildings square footage by year of construction category (CBECS years 2012 and 2018) and mean commercial building size by year of construction category (CBECS years 2012 and 2018) *Source*: EIA 2012 and 2018 CBECS data.

For both the 2012 and 2018 CBECS, more than half of the buildings were built between 1960 and 1999. The median age of buildings is 32 years for the 2012 cycle and 36 years for the 2018 cycle. Overall, the 2018 CBECS survey indicates older floorspace than the 2012 survey, and total square footage has increased. However, differences in average building size are not statistically significant for most building types and all age cohorts (Figure 2). The 2018 CBECS shows buildings constructed since 2000 are significantly larger than those constructed before 1960 (EIA 2022a). The average floorspace for a building constructed between 2000 and 2018 was 19,000 square feet, which is a 44% increase in building size from buildings constructed before 1960. The newest buildings—those constructed since 2000— have a mean energy intensity of 76.2 MBtu/sf, which is 13% higher than in the oldest buildings.

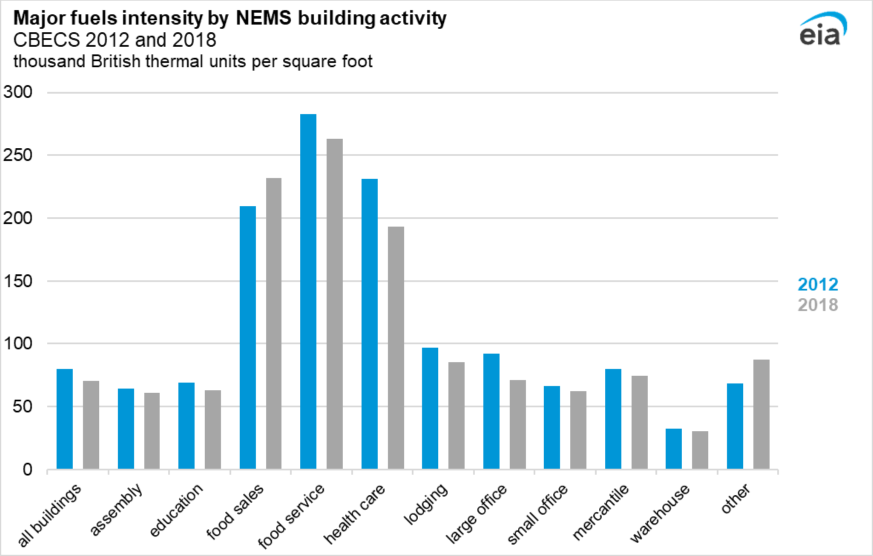

Figure 3. Major fuels intensity by NEMS building activity, CBECS years 2012 and 2018. *Source:* EIA 2012 and 2018 CBECS data

Modeling the evolution of building stock age and floorspace survival over time

The National Energy Modeling System

The National Energy Modeling System (NEMS) projects energy consumption, energy prices, efficiency, floorspace, and more. NEMS does not converge to a specific targeted outcome for any sector or series, nor does it forecast a preferred or probable near future. NEMS long-term projections are based on historical data and the observed historical relationships between supply, demand, and macroeconomic drivers. Projections are affected by assumptions based on current laws and regulations, resource availability and costs, behaviors, technology cost and performance characteristics, and purchase decisions. NEMS produces a general equilibrium solution, balancing energy supply and demand in U.S. energy markets. Laws and regulations we model are discussed in our annual assumptions documentation (EIA 2023b).

The NEMS Commercial Demand Module (CDM) models commercial sector energy demand at the census-division level for 11 distinct commercial building types. We use the CDM to develop long-term energy consumption and efficiency projections through 2050. We use CBECS to characterize base-year building characteristics, energy intensities and fuel use, and estimated market shares of energy-consuming equipment. As a first step, we map CBECS principal building type (PBA) to an aggregate building type category for use in NEMS (Appendix B).

Developing a Reference case for EIA's *Annual Energy Outlook*

In NEMS CDM, energy prices, building codes, and macroeconomic drivers such as floorspace growth and investment decisions affect energy use over time. This analysis addresses the effects of building age and retirement assumptions on energy use, based on policies modeled in the AEO2023 Reference case. This analysis is not a prediction of what may happen in the future. In the sensitivity design for these model runs, we kept all assumptions about behavior and policy consistent with the AEO2023 Reference case.[1] We also held projected floorspace growth rates for each NEMS building type consistent with the AEO2023 Reference case. Long-term floorspace growth rates were developed for the AEO2023-based floorspace in part on indicators of U.S. macroeconomic activity, such as commercial sector growth, interest rates, and GDP (EIA 2023c).

Defining a representation of the U.S. building stock based on CBECS

We compute base-year levels of commercial floorspace for each of the 11 NEMS building types, defined in Appendix B, and 10 age ranges, or construction cohorts, in each U.S. census division. For AEO2023, we used the 2012 CBECS to establish our base-year floorspace. In the upcoming AEO2025, we will use the 2018 CBECS to define our base-year floorspace stocks.

In NEMS, we calculate the median age of *floorspace*, which is a distinct calculation from the median weighted year of construction for building observations reflected in CBECS Table

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[1] More information about the *Annual Energy Outlook 2023* policy assumptions can be found in our *Summary of Legislation and Regulations* report (March 2023), as well as our module-specific reports.

B2 (EIA 2022b). For the purposes of this analysis, we will call the weighted age of commercial floorspace the median building age.

First, we weight the floorspace of each observation using CBECS factors to account for the number of similar U.S. buildings the observation represents. Then, for each census division, we group CBECS observations by NEMS building type based on CBECS PBA and by age range or construction cohort. Finally, we calculate the median age of floorspace for each group.

Designing the modeling sensitivities

We used the AEO2023 Reference case version of the CDM and all other NEMS modules to run the sensitivities examined in this analysis. Differences from the AEO2023 Reference case indicate how building lifetimes and the tendency to retire around the median age of commercial building stock affect the composition of commercial floorspace and energy use. To isolate these effects, the following parameters and assumptions were held consistent with the AEO2023 Reference case across these sensitivities:

- Macroeconomic drivers, including floorspace growth rates in projection years
- Base-year end-use intensities consistent with the 2012 CBECS microdata
- Energy-efficiency policies, regulations, and standards
- Technology choice motivations or decision types
- Equipment costs, lifetimes, and efficiencies

Note that stock efficiencies overall will vary across cases based on changes in opportunities to select newer, more efficient equipment as buildings retire sooner and fewer existing buildings survive through 2050.

Retiring floorspace and modeling surviving floorspace in NEMS

After we estimate a median age of floorspace for all construction cohorts for every building type and census division, we examine building age variance. Variance governs the rate at which buildings retire near the estimated median lifetime.[2] We use the average variance in floorspace age across historical survey years, including the latest survey year, to develop retirement rates for each NEMS commercial building type.

Within each building age segment, we calculate two factors: median age of floorspace and the variance of building age across the segment. The smaller the variance parameter, the more evenly floorspace retirements will be distributed across average building lifetimes. The larger the variance parameter, the greater amount of floorspace will retire at or very near the average lifetime. The survival function takes the following form:

$$Surviving\ Proportion = \frac{1}{\left(1 + \left(\frac{Building\ Age}{Median\ lifetime}\right)^{y}\right)}$$

where y is a measure of building age variance across CBECS surveys.

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[2] The CDM documentation represents variance as the variable *gamma*. We use the word variance here, rather than *gamma factor*, to simplify the discussion relative to the module documentation (EIA 2022c).

CBECS continues to indicate meaningful variance in building age, suggesting non-uniform retirement rates in the real world. Simply put, commercial buildings do not tend to retire consistently near the estimated median lifetime. Shorter average estimated building lifetimes increase new construction and increase the share of energy-efficient equipment operating in commercial buildings over time. Slower retirement rates and longer average lifetimes provide fewer opportunities to introduce newer, more energy efficient equipment into the market, all else being equal. The survival curves for different median age and variance estimates are depicted in Figure 5.

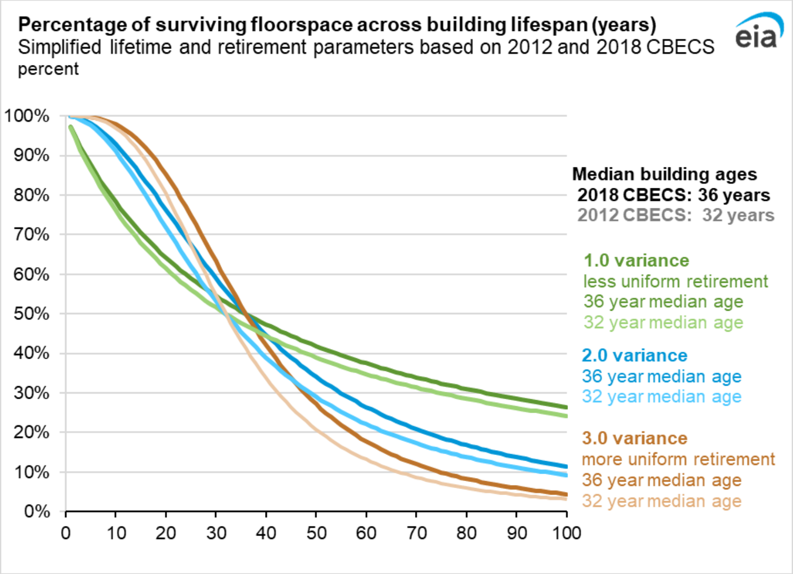

Figure 5. Projected commercial building survival shares as building stock ages. *Source:* U.S. Energy Information Administration, author analysis based on modified building age and retirement parameters.

Higher variance parameters give rise to an uneven distribution of retirements across the building lifetimes and result in retirements occurring at or near the median age. Higher variance parameters allow a higher share of existing floorspace to survive in the immediate future, but a lower share of existing floorspace to exist relative to the 1.0 variance curves as the building stock ages beyond the median. In Figure 5, we illustrate this pattern using both the 32 or 36 median ages indicated in the 2012 and 2018 CBECS surveys, respectively. A lower median building age will result in earlier retirement than a higher median building age, all else being equal, and less surviving floorspace than floorspace shaped by a survival curve with a higher median age.

Energy-efficient equipment upgrades can and do happen after the point of construction. NEMS accounts for the average lifetime of installed equipment, as well as different decision types regarding how equipment is replaced. For this analysis, we did not modify any assumptions regarding technology lifetimes or replacement decision parameters.

Estimating the energy intensity of end uses

Commercial major end uses in NEMS include space heating, space cooling, water heating, ventilation, cooking, lighting, and refrigeration. Other electric uses include computing and other office equipment as well as miscellaneous electric loads. We aggregate weighted energy consumption values for each major commercial end use by fuel type in each building type and census division characterized in the CBECS microdata. We divide aggregate energy use by floorspace in each census division and building type to develop average end-use intensities (EUIs), thousand British thermal units consumed per square foot of floorspace.

Service demand intensity, energy demanded per square foot of commercial floorspace, varies over time based on changes in stock efficiency, floorspace, and energy prices. Energy prices and energy use converge across NEMS run cycles. Changes in energy use examined in this analysis result from changes in the age composition of floorspace and resulting changes in equipment stocks and energy prices. Earlier retirement and more uniform retirements relative to the AEO2023 Reference case affect the cadence and frequency of opportunities for newer, energy-efficient equipment to enter the market and to characterize a greater share of commercial buildings energy use. More efficient equipment requires less energy, putting downward pressure on prices, all else being equal.

NEMS run setup: Vary floorspace retirement rates and median lifetimes

To estimate the share of existing buildings that could continue to exist in the future, subject to AEO2023 Reference case macroeconomic conditions and assumptions, we estimate the share of projected commercial floorspace in 2023 that survives under different floorspace or building age and retirement rate assumptions through 2050.[3] Tables 1 and 2 describe differences across two modeling sensitivities explored in this analysis. Appendix C describes all sensitivities.

Table 1. AEO2023 Reference case age and retirement parameters

CDM building type	Median building age	Variance
Assembly	55	1.21
Education	62	1.38
Food sales	55	1.02
Food service	50	1.43
Health care	55	1.39
Lodging	53	1.40
Large office (50,001 square feet and larger)	65	1.98
Small office (50,000 square feet and smaller)	58	1.45
Mercantile and service	50	1.26
Warehouse	58	1.31
Other	60	1.29

Source: U.S. Energy Information Administration Commercial Demand Module (CDM) input file KBLDG.txt (EIA 2023d).

Table 2. Modeling sensitivity based on 2018 CBECS floorspace microdata

CDM building type	Median building age	Variance
Assembly	38	1.42
Education	40	2.36
Food sales	23	1.93
Food service	30	1.43
Health care	36	2.73
Lodging	31	1.74
Large office (50,001 square feet and larger)	33	1.89
Small office (50,000 square feet and smaller)	35	1.70
Mercantile and service	29	1.88
Warehouse	27	2.13
Other	35	1.86

Source: U.S. Energy Information Administration CDM input file KBLDG.txt, building age sensitivity runs (sensitivity e).

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[3] Note that use of the term "building age" is our convention for discussing the median age of commercial floorspace; it is not to be understood as the median year of construction for observations in CBECS published Table B2.

The AEO2023 Reference case varies median building lifetimes and age variance factors by building type. The 2018 CBECS sensitivity explores alternative median building lifetime assumptions based on incorporating only the latest YRCON data. The remaining sensitivities use different assumptions about median building lifetimes and gamma factors for each building type, as specified in Appendix C.

Model results: What share of buildings floorspace that existed in 2023 is projected to exist in 2050?

Between 34% and 66% of 2023 floorspace survives through 2050 across sensitivity results

By 2050, 32.9 billion square feet to 63.2 billion square feet of existing floorspace in 2023 is projected to survive across these model sensitivities, representing 34% to 66% of floorspace that existed in 2023. As a share of total commercial floorspace in 2050, surviving 2023 floorspace represents as little as 27% and as much as 51% of total floorspace.

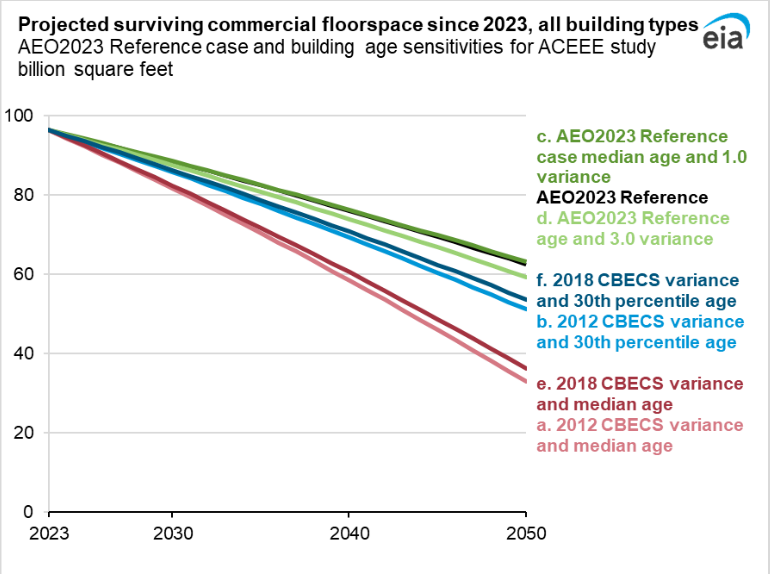

Figure 6. Projected commercial building floorspace in 2023 that survives as building stock ages. *Source:* U.S. Energy Information Administration, based on AEO2023 Reference case with modified building age and retirement parameters.

Not all sensitivities were designed to be equally credible projections for commercial floorspace stock survivability. For example, a variance parameter of 3.0 (sensitivity d) results in stock survival that is similar to the AEO2023 Reference case but reflects a level of uniformity in building retirements that does not exist in the United States. In the real world and in current and historical AEO Reference cases, building lifetimes vary, and variance factors rarely exceed 2.0, based on CBECS microdata. The AEO2023 Reference case uses historical surveys since 1986, and additional sources discussed in the module documentation (EIA 2022c). Using *only* the 2018 CBECS data (sensitivities e and f) or *only* the 2012 CBECS data (sensitivities a and b) to shape survival curves results in a lower retirement age (and so more retirements, less survival) compared with the AEO2023 Reference case. The strictly 2018 or 2012 CBECS sensitivities result in less surviving floorspace than even the sensitivities where we arranged cumulative floorspace by age, oldest to newest, and used the 30th percentile of weighted floorspace in the survey sample to define our parameters (sensitivities b and f).

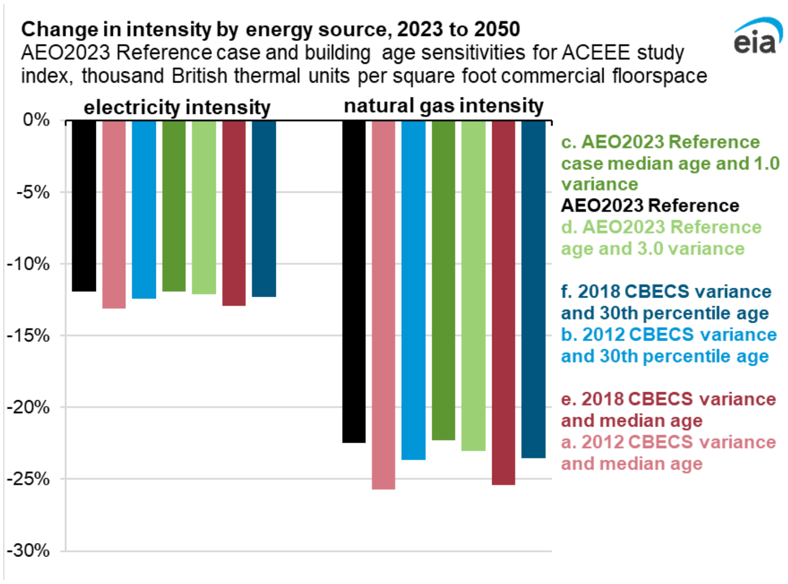

Figure 7. Change in intensity by energy source, 2023 to 2050. *Source:* U.S. Energy Information Administration, based on AEO2023 Reference case with modified building age and retirement parameters (building age sensitivities). *Note:* Indexed to 2023. Energy intensity reductions are calculated based on thousand British thermal units delivered and consumed per square foot of floorspace.

Across all sensitivities, energy use does not keep pace with increases in floorspace. That is, delivered energy intensity declines between 2023 and 2050 due to the role of energy efficiency and stable energy prices. But the rate of the decline varies by building stock age assumptions, building type, and fuel type. We examine changes in energy intensity here rather than consumption alone so as not to conflate the effect of reduced floorspace across the sensitivities relative to the AEO2023 Reference case. In the AEO2023 Reference case and these sensitivities, the intensity of natural gas use declines faster in commercial buildings than the intensity of electricity use. But across both of these major fuels, a younger median age of the floorspace creates more opportunity for newer, more efficient building stock to take the place of less efficient floorspace, which results in faster declines in energy consumption over time.

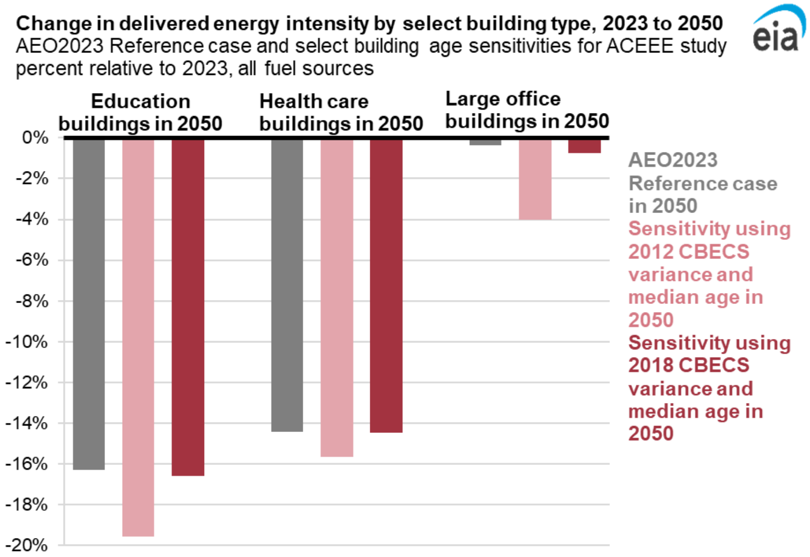

Figure 8. Change in delivered energy intensity by select building type, 2023 to 2050. *Source:* U.S. Energy Information Administration, based on AEO2023 Reference case with modified building age and retirement parameters (building age sensitivities). *Note:* Indexed to 2023. Energy intensity reductions are estimated based on thousand British thermal units consumed for all fuels per square foot of floorspace for each building type.

Health care buildings, large offices, and education buildings had statistically significant decreases in energy intensity between the 2012 and 2018 CBECS. Model results show that the sensitivity based on building age parameters exclusively from the 2012 CBECS result in faster reductions in energy intensity relative to the AEO2023 Reference case in 2050. Of these three building types, large office buildings' energy intensity reductions are least pronounced. This less sensitive response is, in part, because data center energy use is modeled as a portion of large office floorspace in the AEO2023 Reference case, for which energy consumption is expected to increase over time.

The AEO2023 Reference case uses a data-driven estimate of approximate building-type retirement patterns. The value of various building age model sensitivities is that the results demonstrate how uniformity in retirement and the durability of existing buildings—or the potential that they will survive past estimated median lifetimes−affect the potential for energy efficiency opportunities in the commercial sector. Although newer buildings create efficiency opportunities and reduce the intensity of energy use, existing buildings remain the dominant source of commercial energy demand regardless of building age assumptions. Most of the reduction in energy intensity from 2023 to 2050 will be due to behavior and technological change in existing commercial spaces.

Conclusion and future directions for research

Projections of commercial floorspace survivability cannot be considered predictions of what the building stock will look like in the future. However, given the long-lived nature of commercial buildings and the energy-consuming equipment used across the sector, modeled approaches to characterizing energy efficiency must consider foundational assumptions about existing floorspace and retirement rates. This analysis offers a range of floorspace compositions and shows that even minor changes in the share of new floorspace affect the energy intensity of commercial buildings. The 2012 CBECS median building ages and variance sensitivity resulted in the most notable impacts on floorspace and energy intensity projections relative to the AEO2023 Reference case.

Variance in year of construction data is a useful parameter with which to explore potential impacts of policies that affect building codes and construction practices. Retiring building stock earlier results in lower long-term energy use, as the construction of new floorspace creates additional opportunities to install the latest, most energy-efficient equipment. This paper should not be considered, however, an endorsement of knocking down existing buildings simply to create those opportunities; costs associated with building demolition and new construction aside, this paper does not address emissions. EIA does not estimate emissions associated with the construction industry as part of the commercial sector, nor account for emissions embodied in existing buildings. Related work could explore the effects of faster-than-observed evolution of floorspace on energy-related and non-energy-related emissions in the buildings sector. This work could be supported by additional data around building demolitions and the repurposing of commercial spaces and by qualitative information about demolition or repurposing decisions. As we work toward understanding how post-pandemic changes to commercial building availability and behavioral changes may affect energy use, this analysis could be used as a starting point to examine the cross-sector effects of moving commercial floorspace out of the sector and into the residential sector, for example.

Appendices

Appendix A: Comparison of 2012 to 2018 *Commercial Buildings Energy Consumption Survey* (CBECS) data

CBECS Series	2012 CBECS	2018 CBECS	% Difference	Statistically significant
Number of buildings (thousand)	5,557	5,918	7%	No
Total floorspace (million square feet)	87,093	96,423	11%	Yes
Total energy consumption (trillion British thermal units, Btu)	6,963	6,787	-3%	No
Average building size per building (thousand square feet)	15,700	16,300	4%	No
Major fuels energy intensity (thousand Btu Per square foot)	80.0	70.4	-12%	Yes
Large office buildings (thousand Btu per square foot) (more than 50,000 square feet)	92.2	70.9	-23%	Yes
Health-care buildings (thousand Btu per square foot)	231.1	193.3	-16%	Yes
Education buildings (thousand Btu per square foot)	68.8	62.7	-9%	Yes

Source: U.S. Energy Information Administration, 2012 *Commercial Buildings Energy Consumption Survey (EIA 2016a) and 2018 CBECS (EIA 2022d).*

Appendix B. CBECS principal building activity (PBA) to Commercial Demand Module (CDM) building type mapping

CBECS PBA	CBECS PBA description	CDM index	CDM building type
12	Religious worship	1	Assembly
13	Public assembly	1	Assembly
14	Education	2	Education
6	Food sales	3	Food sales
15	Food service	4	Food service
16	Inpatient health care	5	Health care
17	Nursing	6	Lodging
18	Lodging	6	Lodging
2	Office	7	Large office (more than 50,000 square feet)
8	Outpatient health care	7	Large office (more than 50,000 square feet)
2	Office	8	Small office (less than or equal to 50,000 square feet)
8	Outpatient health care	8	Small office (less than or equal to 50,000 square feet)
23	Strip shopping center	9	Mercantile and service
24	Enclosed mall	9	Mercantile and service
25	Retail other than mall	9	Mercantile and service
26	Service	9	Mercantile and service
5	Nonrefrigerated warehouse	10	Warehouse
11	Refrigerated warehouse	10	Warehouse
1	Vacant	11	Other
4	Laboratory	11	Other
7	Public order and safety	11	Other
91	Other	11	Other

Source: U.S. Energy Information Administration, mapping developed for NEMS CDM base year updates.

Appendix C. Parameter descriptions for each modeling sensitivity by building type

Parameter description	Assembly	Education	Food sales	Food service	Health care	Large office	Small office	Lodging	Mercantile & service	Warehouse	Other
a: Median age based on 2012 CBECS	36	33	24	32	34	27	29	30	26	25	33
a: Variance based on 2012 CBECS	1.53	2.01	1.55	1.54	2.63	1.82	1.67	1.5	1.62	1.37	1.8
b: 30th percentile age of weighted floorspace based on 2012 CBECS	51	48	37	52	41	38	44	44	39	37	50
b: Variance based on 2012 CBECS	1.53	2.01	1.55	1.54	2.63	1.82	1.67	1.5	1.62	1.37	1.83
c: Median age based on AEO2023 Reference case	55	62	55	50	55	53	65	58	50	58	60
c: Variance set to 1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
d: Median age based on AEO2023 Reference case	55	62	55	50	55	53	65	58	50	58	60
d: Variance set to 3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
e: Median age based on 2018 survey	38	40	23	30	36	31	33	35	29	27	35
e: Variance based on 2018 survey	1.42	2.36	1.93	1.43	2.73	1.74	1.89	1.70	1.88	2.13	1.86
f: Age of 30th percentile weighted floorspace based on the 2018 CBECS	51	55	38	50	48	44	45	48	43	41	49
f: Variance based on 2018 CBECS	1.42	2.36	1.93	1.43	2.73	1.74	1.89	1.70	1.88	2.13	1.86

Source: U.S. Energy Information Administration, Median building lifetime and variance or gamma parameters from model sensitivities examined for EIA's National Energy Modeling System (NEMS).

References

Andersen, R., and K. Negendahl. 2023. “Lifespan prediction of existing building typologies.” *Journal of Building Engineering* 65: 1–14

Burgess, M., B. Von Neida, S. Lisauskas, and D. Rogers. 2022. “Two Decades of ENERGY STAR®: A Retrospective Study of EPA’s ENERGY STAR Buildings Score and Certification.” In *Proceedings of the 2022 ACEEE Summer Study on Energy Efficiency in Buildings*. 4:1–16. Washington, DC: ACEEE.

EIA (U.S. Energy Information Administration). “About the Commercial Buildings Energy Consumption Survey.” Accessed February 2024. www.eia.gov/consumption/commercial/about.php.

———. 2024a. “CBECS Terminology.” Accessed February 2024. www.eia.gov/consumption/commercial/terminology.php#P.

———. 2024b. “Comparisons across surveys from the 1992 Commercial Buildings Energy Consumption Survey (CBECS) through the 2018 CBECS.” Accessed February 2024. www.eia.gov/consumption/commercial/pdf/Comparison%20across%20CBECS%20surveys%20-%20Table%202.pdf.

———. 2023. “How We Estimated Energy End-Use Consumption in the 2018 CBECS.” www.eia.gov/consumption/commercial/reports/2018/estimated-end-use.php.

———. 2023a. *Commercial Buildings Energy Consumption Survey (CBECS) User’s Guide to the Public Use Microdata File.* Washington, DC: EIA. www.eia.gov/consumption/commercial/data/2018/pdf/Users%20Guide%20to%20the%202018%20CBECS%20Public%20Use%20Microdata%20File.pdf.

———. 2023b. “Assumptions to the *Annual Energy Outlook 2023*.” www.eia.gov/outlooks/aeo/assumptions.

———. 2023c. *Assumptions to the Annual Energy Outlook 2023: Commercial Demand Module.* Washington, DC: EIA. www.eia.gov/outlooks/aeo/assumptions/pdf/CDM_Assumptions.pdf.

———. 2023d. *NEMS* repository on GitHub github.com/EIAgov/NEMS.

———. 2022. *2018 Commercial Buildings Energy Consumption Survey: Consumption and Expenditures Highlights*. Washington, DC: EIA. www.eia.gov/consumption/commercial/data/2018/pdf/CBECS%202018%20CE%20Release%202%20Flipbook.pdf.

———. 2022a. *2018 Commercial Buildings Energy Consumption Survey: Building Characteristics Highlights.* Washington, DC: EIA.

www.eia.gov/consumption/commercial/data/2018/pdf/CBECS_2018_Building_Characteristics_Flipbook.pdf.

———. 2022b. “Table B2. Summary table: total and medians of floorspace, number of workers, and hours of operation, 2018.” www.eia.gov/consumption/commercial/data/2018/bc/pdf/b2.pdf

———. 2022c. “Commercial Demand Module – NEMS Documentation (2022).” www.eia.gov/outlooks/aeo/nems/documentation/commercial/pdf/CDM_2022.pdf.

———. 2022d. “2018 CBECS Survey Data.” www.eia.gov/consumption/commercial/data/2018/index.php?view=microdata.

———. 2016. *Commercial Buildings Energy Consumption Survey (CBECS) User’s Guide to the Public Use Microdata File.* Washington, DC: EIA. www.eia.gov/consumption/commercial/data/2012/pdf/user_guide_public_use_aug2016.pdf.

———. 2016a. “2012 CBECS Survey Data.” www.eia.gov/consumption/commercial/data/2012/index.php?view=microdata.

Huuhka, S., and J. Lahdensivu. 2016. “Statistical and geographical study on demolished buildings”. *Building Research & Information* 44 (1): 73–96.

Mohamed, S., R. Smith, L. Rodrigues, S. Omer, and J. Calautit. 2021. “The correlation of energy performance and building age in UK schools”. *Journal of Building Engineering* 43.

Parker, A., H. Horsey, M. Dahlhausen, M. Praprost, C. CaraDonna, A. LeBar, and L. Klun. 2023. *ComStock Reference Documentation: Version 1*. Golden, CO: National Renewable Energy Laboratory. www.nrel.gov/docs/fy23osti/83819.pdf.