

Commercial Buildings in Communities with Different Income and Racial Characteristics: A Comparison of Energy Efficiency and Fuel Sources

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ABSTRACT

Achieving an equitable and just transition to an energy efficient, decarbonized commercial and multifamily building sector will require that the benefits of improved building performance and clean energy are distributed equitably across all communities, including low-income communities and communities of color burdened by disinvestment, who are as a result, often underserved and under-resourced.

This study analyzes a large, national commercial building dataset to understand differences in building performance, the proliferation of all-electric buildings, the use of heating oil, and on-site renewable energy technologies across communities in the United States with different race and income characteristics. Understanding race and income-based differences in building performance and fuel sources can provide information regarding community readiness to move forward on the pathway to decarbonize the commercial and multifamily building stock.

The goal of this paper is to inform discussions regarding policies and programs to achieve equitable performance and technology outcomes in the buildings that provide important services to the communities in which they are located. Limited public information is available that brings together data on demographic characteristics, building performance, and fuel sources. The sample of buildings analyzed herein is limited to those in the database of the U.S. Environmental Protection Agency's ENERGY STAR® Portfolio Manager® energy management and tracking tool for commercial buildings. While this is a limitation, the results of this analysis will contribute to filling a gap in public understanding.

Introduction

The analysis summarized in this paper is part of an ongoing series of research and analysis from the U.S. Environmental Protection Agency (EPA) using data from the ENERGY STAR® Portfolio Manager® tool (<https://www.energystar.gov/buildings/benchmark>). Hundreds of thousands of buildings use Portfolio Manager to track their energy use. EPA periodically compiles and shares observations from this extensive database, with the hope that the information will inform and advance public understanding of the commercial building sector. This analysis compares building performance, the prevalence of all-electric buildings, those using heating oil, and the use of on-site renewable energy at buildings across communities using characteristics defined by U.S. census block group parameters.

The sample of buildings analyzed is limited to those in the database of the U.S. Environmental Protection Agency's ENERGY STAR® Portfolio Manager® energy management and tracking tool for commercial buildings. It is important that readers approach the findings with an understanding of the limitations of the data in Portfolio Manager and how they might impact the outcomes. Results from the analysis of this data should not be assumed to reflect the national building stock.

Achieving an equitable and just transition to an energy efficient, decarbonized commercial building sector will require that the benefits of improved building performance and clean energy sources are distributed equitably across all communities. Particular attention is therefore paid to communities of color and low-income communities, which often encounter financial disinvestment and additional market barriers. EPA’s goal in conducting this analysis is to provide data that can inform discussions regarding policies and programs to achieve equitable performance and technology outcomes in the buildings that provide important services to the communities in which they are located.

Methodology and Limitations

The all-buildings results in this paper reflect data from the 85 building types included in Portfolio Manager. In addition, sector-specific observations are highlighted for the four commercial building types most frequently benchmarked using Portfolio Manager: K-12 schools, multifamily housing, offices, and retail stores.¹ The data includes 242,098 buildings spanning all 85 building types in Portfolio Manager and encompassing over 20 billion square feet of floor space. The analysis of energy performance using the ENERGY STAR score utilizes a subset of 160,033 buildings of 22 different types for which a 1-100 score was calculated in Portfolio Manager.

Portfolio Manager data was merged with census block group-level data from EPA’s Environmental Justice Screening and Mapping Tool, EJSCREEN (<https://www.epa.gov/ejscreen>), to create a combined dataset where buildings are organized on the basis of demographic and socioeconomic characteristics of the communities in which they are located. There are a variety of indicators used by researchers to represent the demographic and socioeconomic characteristics of a population. The two EJSCREEN demographics used in this analysis are consistent with factors used across other EPA and U.S. government research efforts (Office of Management and Budget 2021):

1. **Low Income:** The percentage of a community’s residential population where the total income is less than or equal to twice the federal poverty level (EPA 2019). We define a low-income community as a community where the majority (51 to 100 percent) of residents are low-income.
2. **Community of Color:** The percentage of individuals in a community who list their racial status as other than white alone and/or list their ethnicity as Hispanic or Latino. That is, all people other than non-Hispanic, white-alone individuals. The word “alone” in this case indicates that the person is of a single race, since multiracial individuals are tabulated in another category – for example, a non-Hispanic individual who is half white and half American Indian would be counted as a person of color by this definition (EPA 2019). This analysis defines a community of color as one where the majority (51 to 100 percent) of residents are people of color.

¹ To develop this paper, data was pulled for all buildings in Portfolio Manager that benchmarked their energy use in 2019. We then applied the following filters to the dataset: source energy use intensity (EUI) between 5 and 2,000 kBtu/ft², grid electricity use greater than 0 kBtu, site EUI greater than 0 kBtu/ft², and building gross floor area greater than 1,000 square feet.

While limited public data are available on community demographics and commercial buildings, Portfolio Manager contains information that can help to inform public understanding of this topic. However, it is important to understand the limitations of the data in Portfolio Manager. The data are self-reported and largely unverified. And, the data may not be comprehensively representative of the national commercial building stock, all regions of the U.S., or of particular sectors. Therefore, the results from the analysis of the data should not be assumed to reflect the national building stock. In addition, data on energy costs are not required by Portfolio Manager. As a result, the data available are insufficient to enable an evaluation of energy cost burdens in a manner that would parallel existing analyses of cost burdens in U.S. households. Lastly, this analysis does not include comparisons of the buildings in Portfolio Manager to the total building stock within each community due to data limitations.

The analysis of all-electric buildings does not attempt to account for a broader range of considerations tied to beneficial electrification, such as the cost-effectiveness of various heating sources or specific technology choice decisions. This paper includes an analysis of cold and moderate climates, where fossil fuels are most commonly used for space heating, and a separate analysis of warm climates.

Section 1: Building Energy Performance

How does building performance differ across communities?

The ENERGY STAR score, calculated on a scale of 1-100 points, is a simple, powerful tool to compare a building's energy performance to similar buildings nationwide while accounting for differences in operating conditions, and regional climate and weather. Buildings with higher ENERGY STAR scores are more energy efficient, have lower utility bills, create less onsite air pollution, and produce fewer greenhouse gas emissions compared to their peers.

This analysis of Portfolio Manager data showed that buildings in communities of color score an average of **1.3 points lower** than all other buildings, a 2% difference. Buildings in low-income communities score an average of **2.3 points lower** than other buildings, a 4% difference (Figures 1 through 4). **K-12 schools** and **multifamily housing** buildings show the largest differences in average ENERGY STAR scores across both race and income, nearly a 9% difference. Differences in average score considering race and income were statistically significant for all building types and for each of the building types listed on the graphs below (see Appendix D for a breakdown of number of properties in each community and Appendix B for details on the statistical tests used to evaluate score differences).

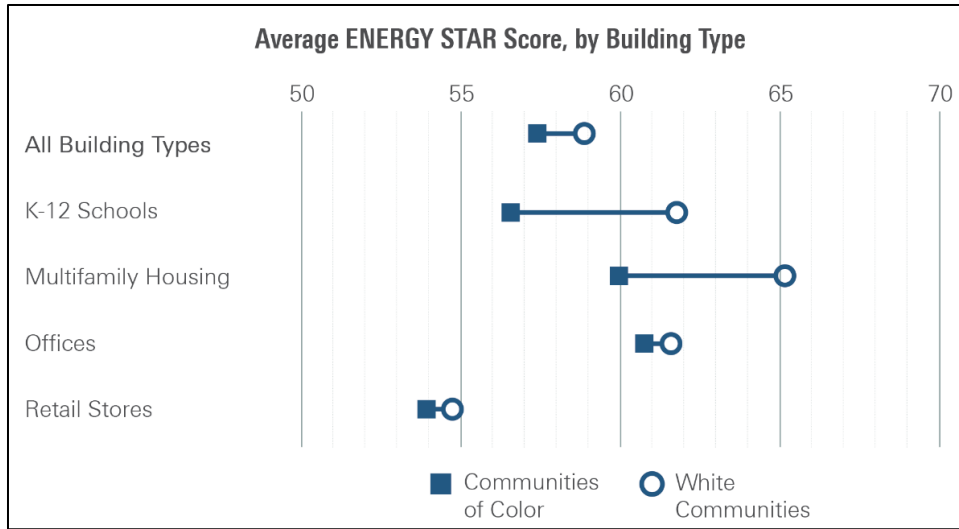


Figure 1. Average ENERGY STAR Score by building type in communities of color and white communities. *Source:* EPA Energy Star Portfolio Manager Benchmarked Buildings Data 2022.

Average ENERGY STAR Score	
Communities of Color	White Communities
57.5	58.8

Figure 2. Average ENERGY STAR Score for all building types in communities of color and white communities. *Source:* EPA Energy Star Portfolio Manager Benchmarked Buildings Data 2022.

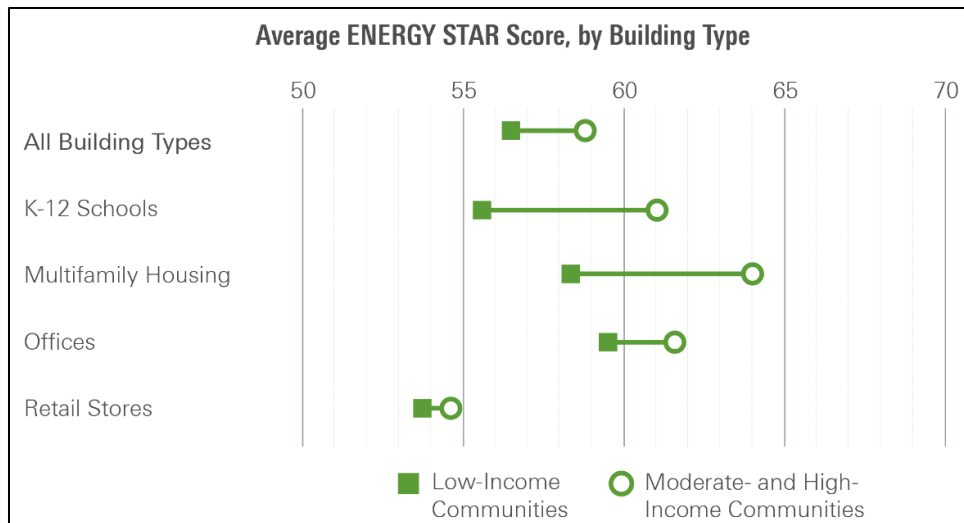


Figure 3. Average ENERGY STAR Score by building type in low-income and moderate- and high-income communities. *Source:* EPA Energy Star Portfolio Manager Benchmarked Buildings Data 2022.

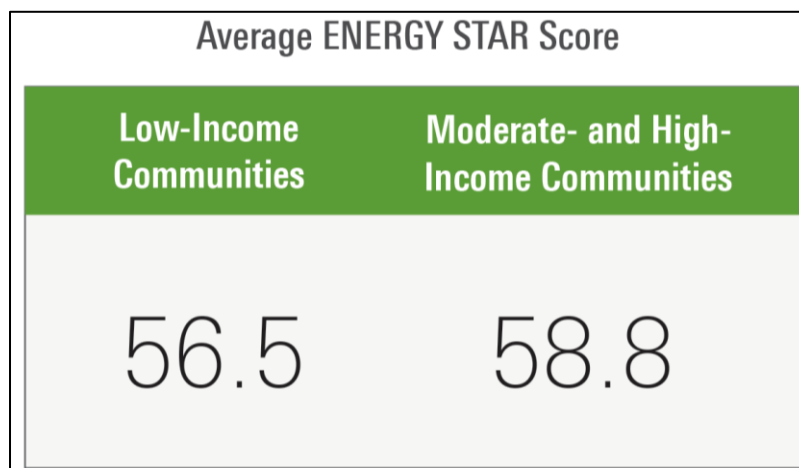


Figure 4. Average ENERGY STAR Score for All Building Types in Low-Income and Moderate- and High-Income Communities. *Source:* EPA Energy Star Portfolio Manager Benchmarked Buildings Data 2022.

Section 2: Fuel Source

Which communities have the most all-electric buildings?

Increased adoption of electric heating technologies in commercial buildings, along with decarbonization of the electric grid, will both be required priorities of communities to reduce carbon emissions from the buildings sector. This analysis compares the prevalence of existing fully electrified buildings among communities. Importantly, the analysis does not include efficiency or cost data for electric heating or other end-use technologies. The analysis looks separately at buildings in cold or moderate climates from those in warm climates, as the prevalence of all-electric buildings varies substantially in relation to heating needs. In warm climates, all-electric heating systems are wide-spread and more feasible economically. In fact,

all-electric buildings in Portfolio Manager are about twice as common in warm climates as in cold and moderate climates (approximately 40% vs 19%).

In cold and moderate climates, the proportion of all-electric buildings in low-income communities is **4.7 percentage points lower** than in moderate- and high-income communities. In warm climates, the difference is less than 1% (Figure 5).

Proportion of All-Electric Buildings		
	Low-Income Communities	Moderate- and High-Income Communities
 Cold and Moderate Climates	15.3%	20.0%
 Warm Climates	39.5%	39.8%

Figure 5. Proportion of all electric buildings in cold and moderate climates and warm climates by income. *Source:* EPA Energy Star Portfolio Manager Benchmarked Buildings Data 2022.

In cold and moderate climates, the proportion of all-electric buildings is **5.4 percentage points lower** among buildings in communities of color (as defined on page 4) compared to white communities. Within warm climates, the difference is 4% (Figure 6).

Proportion of All-Electric Buildings		
	Communities of Color	White Communities
 Cold and Moderate Climates	15.2%	20.6%
 Warm Climates	37.8%	41.8%

Figure 6. Proportion of all electric buildings in cold and moderate climates and warm climates by race. *Source:* EPA Energy Star Portfolio Manager Benchmarked Buildings Data 2022.

The average difference among communities is even greater when examined using quartile data on race. Only **11.5 percent** of buildings in communities with 75-100% percent residents of color are fully electrified (Figure 7). This figure is substantially lower than the percentage of all-electric buildings in communities with fewer than 75 percent residents of color.

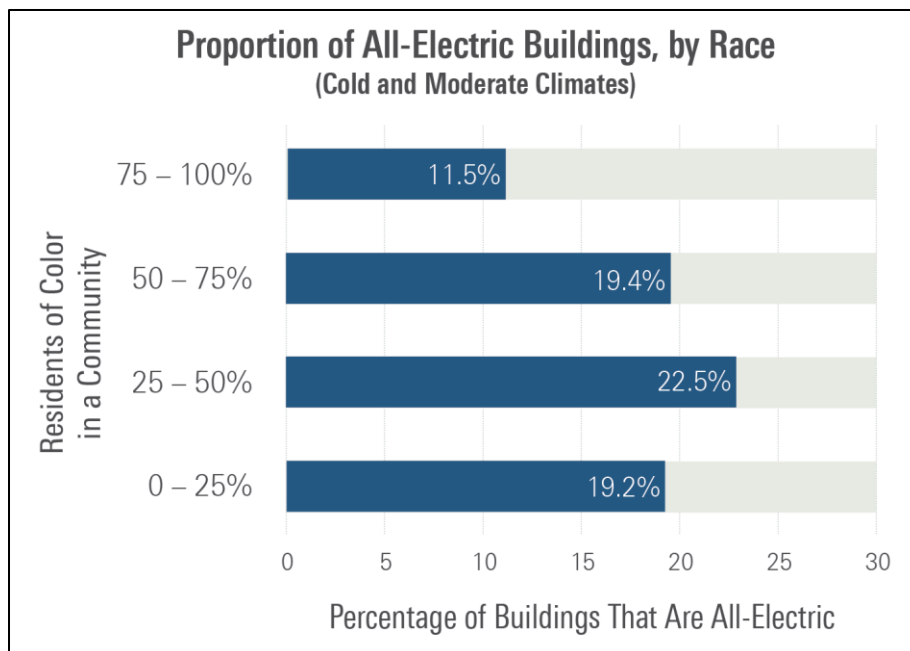


Figure 7. Percent of all electric buildings in cold and moderate climates by race quartile.
Source: EPA Energy Star Portfolio Manager Benchmarked Buildings Data 2022.

Sector Highlight: Building electrification and multifamily housing.

While this study examined the incidence of fully electrified buildings across all Portfolio Manager buildings, the unique electrification challenges facing multifamily buildings and pronounced trends in the data and warranted a deeper exploration.

The data revealed a greater proportion of all-electric multifamily buildings in white communities compared to communities of color. In cold and moderate climates, the proportion of all-electric multifamily buildings in communities with a majority of residents of color is close to half the proportion in majority white communities. (Figure 8).

Proportion of All-Electric Multifamily Buildings		
	Communities of Color	White Communities
 Cold and Moderate Climates	9.9%	18.9%
 Warm Climates	23.4%	28.3%

Figure 8. Proportion of all electric multifamily buildings in cold and moderate climates and warm climates by race. *Source:* EPA Energy Star Portfolio Manager Benchmarked Buildings Data 2022.

In cold and moderate climates, the proportion of all-electric multifamily buildings in low-income communities is substantially lower than that in moderate and high-income communities. Conversely, in warm climates, the prevalence of all-electric buildings is slightly higher in low-income communities relative to moderate and high-income communities (Figure 9).

Proportion of All-Electric Multifamily Buildings		
	Low-Income Communities	Moderate- and High-Income Communities
 Cold and Moderate Climates	10.8%	16.0%
 Warm Climates	26.2%	24.8%

Figure 9. Proportion of all electric multifamily buildings in cold and moderate climates and warm climates by income. *Source:* EPA Energy Star Portfolio Manager Benchmarked Buildings Data 2022.

In which communities are buildings most reliant on heating oil?

Beneficial electrification of building-level heating systems is a critical step toward a low-carbon commercial building stock. As fossil fuels used for heating are combusted in buildings, they release greenhouse gas emissions. Of the most common fossil fuel heating sources in the United States—natural gas, propane, and heating oil (EIA 2021a; 2021b; 2022)—combustion of

heating oil has the highest carbon emissions intensity (EPA 2021) and is therefore often a focus of beneficial electrification initiatives. Use of heating oil is primarily found in cold and moderate climates.

Analysis of Portfolio Manager buildings using heating oil in moderate and cold climates² found that they are **evenly distributed** across communities with varying proportions of low-income residents (Figure 10). However, **use of heating fuel is disproportionately concentrated in communities with a large percentage of residents of color**. Weaker trends emerged regarding heating oil use across communities when analyzing other individual building types.

Proportion of Buildings Using Heating Oil			
Communities of Color		White Communities	
9.1%		5.8%	
Low-Income Communities		Moderate- and High-Income Communities	
6.5%		6.8%	

Figure 10. Proportion of buildings using heating oil in cold and moderate climates by income and race. *Source:* EPA Energy Star Portfolio Manager Benchmarked Buildings Data 2022.

In communities with 75 to 100 percent residents of color, **11.5 percent overall** use heating oil in cold and moderate climates. In contrast, buildings in communities with fewer than 75 percent residents of color, heating oil usage ranges from **5.1 percent to 6.4 percent** (Figure 11).

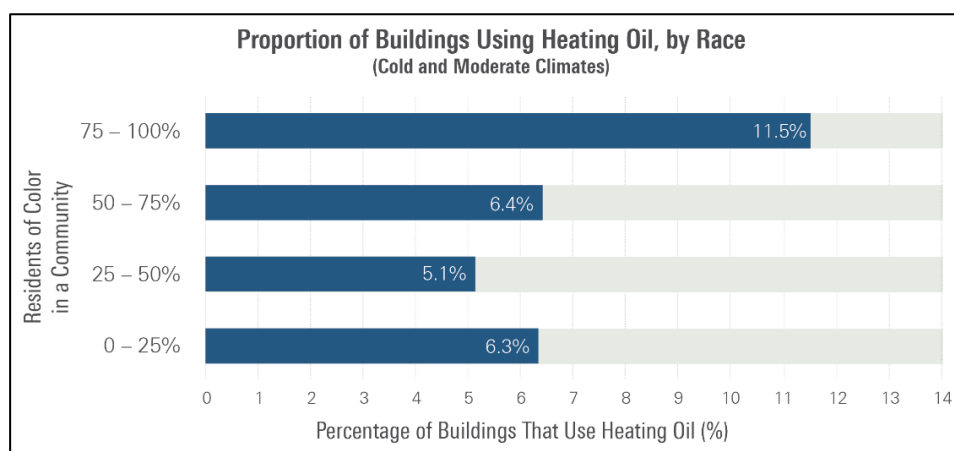


Figure 11. Percent of buildings using heating oil in cold and moderate climates by race quartile. *Source:* EPA Energy Star Portfolio Manager Benchmarked Buildings Data 2022.

²A degree days-based climate filtering process was used to account for regional differences in the use of heating oil. See Appendix A for further details on the climate filtering process.

Sector Highlight: Heating Oil and K-12 Schools.

K-12 schools show the greatest differences among communities in heating oil use. In cold and moderate climates, the proportion of K-12 schools using heating oil is **1.5 percentage points** higher in low-income communities than in moderate- and high-income communities, while the proportion using heating oil in communities of color is 11.5 percentage points higher—or more than double—than in white communities (Figure 12).

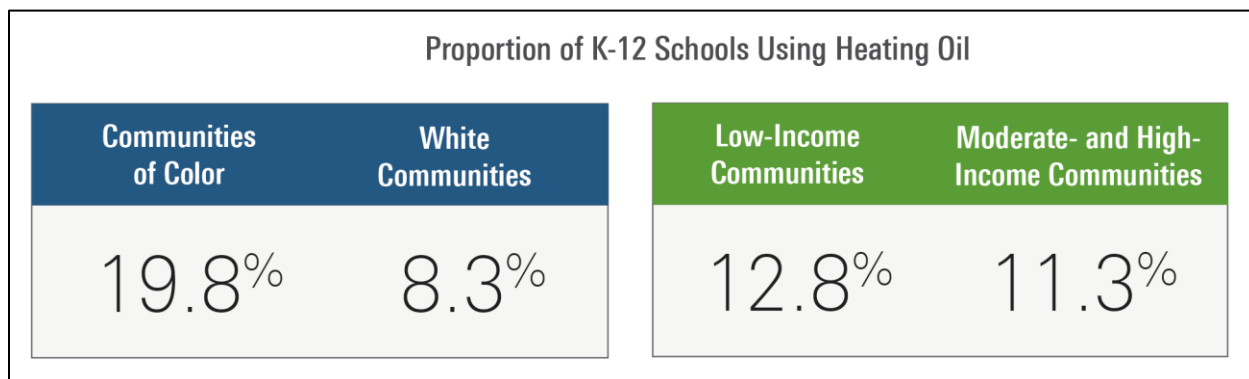


Figure 12. Proportion of K-12 schools using heating oil in cold and moderate climates by income and race.
Source: EPA Energy Star Portfolio Manager Benchmark Buildings Data 2022.

Analysis of data for K-12 schools in cold and moderate climates that use heating oil found that its use is disproportionately concentrated in communities with a high percentage of residents of color (Figure 13). In these communities, heating oil is used in **23.7 percent** of K-12 schools, while in communities with less than 75 percent residents of color, K-12 school buildings utilizing heating oil ranges from **7.8 percent to 13.7 percent**.

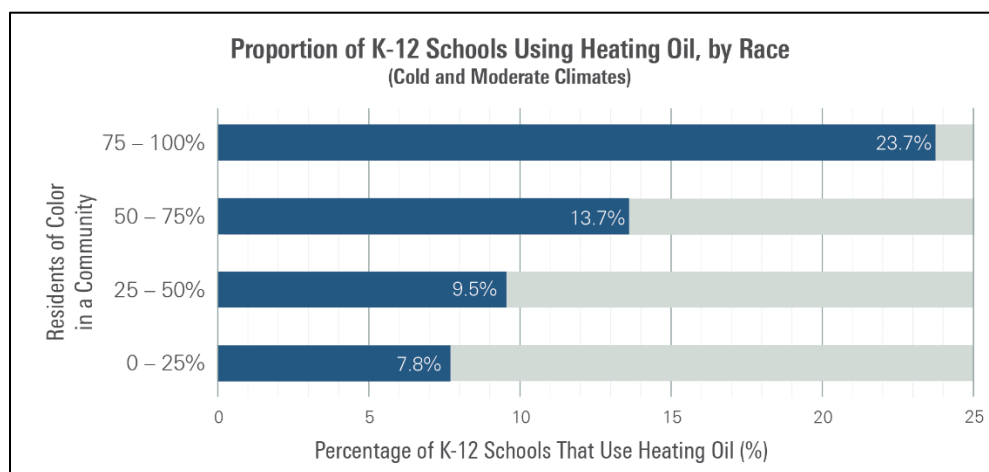


Figure 13. Percent of K-12 schools using heating oil in cold and moderate climates by race quartile. Source: EPA Energy Star Portfolio Manager Benchmark Buildings Data 2022.

Which communities have the most buildings with on-site solar energy?

Data for all buildings show that use of onsite solar energy is evenly distributed across communities with varying proportions of low-income residents and residents of color. (Figure 14).

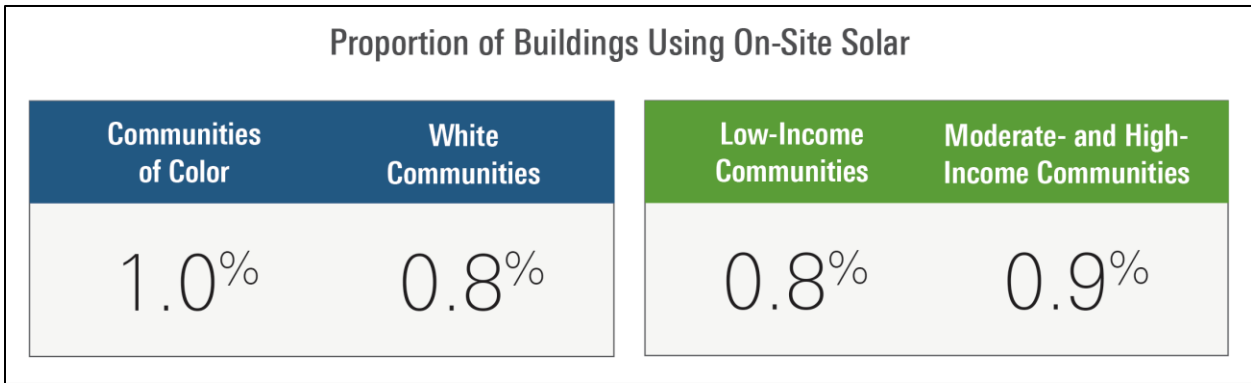


Figure 14. Proportion of buildings using on-site solar by income and race. *Source:* EPA Energy Star Portfolio Manager Benchmarked Buildings Data 2022.

Sector Highlight: Which K-12 schools have on-site solar energy?

Portfolio Manager data of K-12 schools show that both communities with a majority of low-income residents and a majority of residents of color have a lower proportion of schools with onsite solar (Figure 15). Weaker socioeconomic trends emerged regarding onsite solar for the remainder of the building types analyzed.

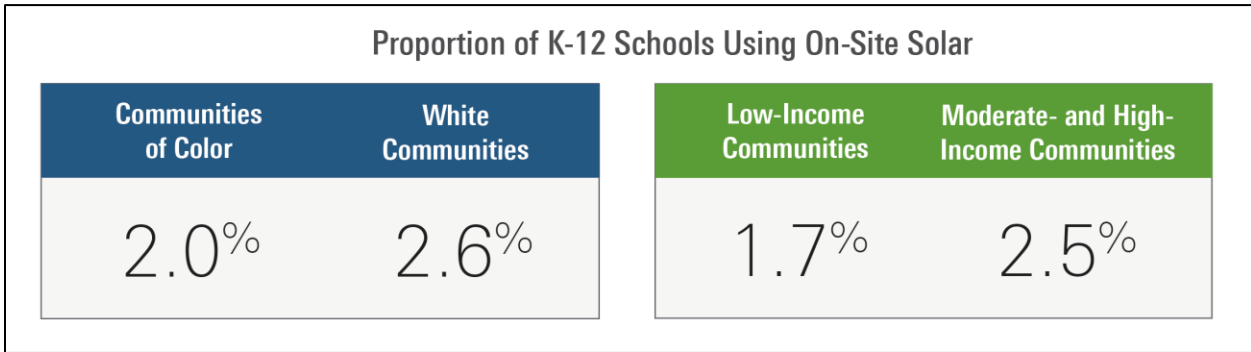


Figure 15. Proportion of K-12 schools using on-site solar by income and race. *Source:* EPA Energy Star Portfolio Manager Benchmarked Buildings Data 2022.

Discussion/Conclusion

This analysis compared building performance, the prevalence of all-electric buildings, reliance on heating oil, and use of on-site renewable energy at benchmarked buildings across communities. These metrics were chosen to provide insights regarding the distribution of these characteristics in buildings across the nation. The results of the ENERGY STAR score analysis demonstrated that buildings in communities of color and low-income communities are on average less energy efficient than buildings in white communities and moderate- to high- income

communities, by 1.3 points and 2.3 points respectively. K-12 schools and multifamily housing buildings represent the largest difference in building performance with regards to both race and income.

For communities in cold to moderate climates with the highest proportion of residents of color (greater than 75%) the data reveal the following relative to communities with fewer residents of color:

- The proportion of all-electric buildings is roughly 50% lower;
- Heating oil is used more frequently, and;
- The proportion of K-12 schools using heating oil is 2 to 3 times higher.

The data also revealed that, in both communities with a majority of low-income residents and a majority of residents of color, a lower proportion of K-12 schools have onsite solar.

The results herein illustrate the current landscape of a subset of characteristics in commercial buildings benchmarked in the ENERGY STAR Portfolio Manager tool relevant to future decarbonization policies and programs, as well as demonstrate an approach for measuring inequalities that may exist among communities. As discussed earlier, it is important to keep in mind the limitations of the data in Portfolio Manager and how they might impact the findings. Results from the analysis of this data should not be assumed to reflect the national building stock.

Ultimately, however, the results begin to illustrate how these and similar metrics could be used for measuring and tracking progress toward greater energy equity within the commercial building sector. Similar analytical frameworks could be applied to local, state, or other national energy and demographic datasets to ensure the most applicable data are utilized to inform policy. At all levels of policy making and program implementation, similar analysis would need to be replicated over time to track progress toward greater energy equity and provide a mechanism for accountability.

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Appendices

Appendix A: Climate Filtering.

To account for differences in the use of heating oil and all-electric heating technologies, buildings were grouped and analyzed by climate zones. Buildings with fewer than 4,000 heating degree days (HDD) were categorized as warm-climate buildings and buildings with more than 4,000 HDD were categorized as moderate or cold climate buildings. The 4,000-degree day threshold is determined by the 30-year average annual HDD in each building's zip code. The all-electric and heating oil analyses were then completed on buildings in warm climates and moderate or cold climates separately. For heating oil, this grouping allows for a comparison exclusively in moderate and cold climates where heating oil is commonly used. For all-electric buildings, the moderate and cold climate analysis controls for warm regions where the majority of buildings either do not require space heating or all-electric heating systems are widespread and economically feasible due to lower heating loads.

Appendix B: Statistical Testing.

A series of independent t-test were run to determine the statistical significance of differences in average ENERGY STAR scores on the basis of race and income, across all building types analyzed in this paper. All pooled independent t-tests results were statistically significant at the $P = 0.01$ percent level.

Appendix C: Data Sources.

1. **ENERGY STAR Portfolio Manager:** This analysis uses a summary of Portfolio Manager data from 2019. This period of performance is used to control for abnormal energy consumption patterns caused by changes in building operations during the COVID-19 pandemic.
 - a. Standard program and analytical filters are applied to the Portfolio Manager data to improve quality and robustness of the analysis.
 - b. Following the building taxonomy and quantity of data available in Portfolio Manager, this analysis includes sector-specific results for the following building types most often benchmarked: K-12 schools, multifamily housing, retail, and offices.
2. **EJ SCREEN:** Demographic data from EJ SCREEN (<https://www.epa.gov/ejscreen>) is used to evaluate demographic factors relevant to the census block group that surrounds each Portfolio Manager building.
3. **Geocoding Process:** The Portfolio Manager dataset was geocoded using an address-based software tool to identify latitude and longitude values for each building. This data was used to assign a census block group to each building and merge the EJ SCREEN and Portfolio Manager datasets, using the census block group as the common datapoint.

Appendix D: ENERGY STAR Scores.

Table 1a. ENERGY STAR scores for all buildings, offices, and retail stores by income and race.

	All building types		Offices		Retail stores	
	Total number of buildings	Average ENERGY STAR score	Total number of buildings	Average ENERGY STAR score	Total number of buildings	Average ENERGY STAR score
Community of color	62,326	57.5	8,951	60.8	11,040	54.0
White community	97,707	58.8	16,149	61.6	23,653	54.6
Total	160,033	58.3	25,100	61.3	34,693	54.4
Low-income community	34,657	56.5	4,355	59.5	7,116	53.7
Moderate- and high-income community	125,376	58.8	20,745	61.7	27,577	54.6
Total	160,033	58.3	25,100	61.3	34,693	54.4

Table 1b. ENERGY STAR scores for K-12 schools and multifamily housing by income and race.

	K-12 schools		Multifamily housing	
	Total number of buildings	Average ENERGY STAR score	Total number of buildings	Average ENERGY STAR score
Community of color	7,286	56.6	20,666	59.9
White community	12,561	61.9	18,000	65.3

Total	19,847	59.9	38,666	62.4
Low-income community	4,188	55.6	10,700	58.3
Moderate- and high-income community	15,659	61.1	27,966	64.0
Total	19,847	59.9	38,666	62.4