RMI

Financing US Building Decarbonization

Leveraging a Sector-Wide Emissions Model to Prioritize Capital Flows

Report / March 2024

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About RMI

RMI is an independent nonprofit, founded in 1982 as Rocky Mountain Institute, that transforms global energy systems through market-driven solutions to align with a 1.5°C future and secure a clean, prosperous, zero-carbon future for all. We work in the world's most critical geographies and engage businesses, policymakers, communities, and nongovernmental organizations to identify and scale energy system interventions that will cut greenhouse gas emissions at least 50 percent by 2030. RMI has offices in Basalt and Boulder, Colorado; New York City; Oakland, California; Washington, D.C.; and Beijing.

RMI values collaboration and aims to accelerate the energy transition through sharing knowledge and insights. We therefore allow interested parties to reference, share, and cite our work through the Creative Commons CC BY-SA 4.0 license. **https://creativecommons.org/licenses/by-sa/4.0/**.

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Executive Summary

Real estate actors across the United States are at the precipice of a major climate opportunity. The recently passed Inflation Reduction Act (IRA), and the increased focus by investors, lenders, regulators, and policymakers on building decarbonization, positions the sector to take meaningful action.

To inform this opportunity, RMI conducted a bottom-up carbon analysis of the US building stock to determine the relative operational emissions for each segment.[i] This is the most detailed US buildings emissions model created to date to the knowledge of RMI. RMI also studied the ownership and capital flows for each segment to assess opportunities for accelerating investment in building decarbonization given consolidation of ownership or investment activity.

This report provides a breakdown of US building carbon emissions by segment, subsegment, and building size and identifies the building types with the greatest opportunity for emissions reductions.

The report also proposes actions that lenders, investors, and regulators can take to increase the flow of capital to segments responsible for the greatest proportion of emissions. These ideas were solicited from finance experts to stimulate greater study and exploration; they have not yet been honed and piloted within the industry.

Key report findings:

1. Building operations generate 23% of US annual carbon emissions.
2. Existing buildings represent the majority of US building emissions. The annual rate of addition or renovation to the existing building stock is less than 1%.
3. Single-family homes contribute 58% of US building emissions.
4. Commercial buildings contribute 37% of US building emissions. Over half of these emissions (56%) are from small and medium-sized buildings.
5. Green capital flows are nowhere near adequate to what is required to decarbonize the sector.

These findings lead us to the following conclusions:

- Investors, lenders, and regulators seeking to decarbonize the real estate sector should target dollars toward the retrofit of existing buildings.
- Decarbonizing single-family homes is critically important to reaching US climate goals and this segment should attract a larger share of climate-aligned investment and financing support than it currently receives.

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i Our analysis did not include embodied carbon (Scope 3) emissions for the US real estate sector. Embodied carbon emissions from equipment and material replacements in existing buildings have not been quantified.

- Although large buildings in the commercial segment currently attract the most climate-aligned investment and capital, more climate-aligned investment should target small and medium-sized commercial buildings to produce meaningful reductions in US real estate carbon emissions.

Recommendations

Regulatory Actions

Government-sponsored enterprises (GSEs) — specifically Fannie Mae and Freddie Mac — provide 50% of single-family home financing. Because both GSEs are under conservatorship, their regulator, the Federal Housing Finance Agency (FHFA), has the authority to direct Fannie Mae and Freddie Mac to decarbonize their portfolios. We recommend that the FHFA direct Fannie Mae and Freddie Mac to develop a zero-carbon strategy to decarbonize their portfolios by 2050.

Fannie Mae and Freddie Mac are also the largest source of financing for the multifamily market and should include this segment in their net-zero strategies.

Single-Family Financing Solutions

The IRA provides significant subsidies and rebates for decarbonizing residential real estate; however, the rebates and credits often lag the outlay of capital by homeowners. Lenders could augment the impact of the subsidies by integrating IRA tax credits and rebates into their loan products and underwriting.

Commercial Financing Solutions

Three commercial financing opportunities include:

1. Lenders could require a cost-benefit analysis of making efficiency upgrades and replacing fossil fuel technologies with renewable technologies as part of their underwriting process.

2. Lenders should allow replacement reserves to be used for deep efficiency upgrades and replacing fossil fuel technologies with renewable technologies.

3. Rather than favoring high-performance (i.e., energy-efficient) buildings exclusively, lenders should incent energy performance improvements by offering inefficient buildings lower rates or improved terms contingent on energy improvements.

Introduction

Prior to this report, no breakdown of US real estate carbon emissions by segment, subsegment, or building size existed. Although large commercial and multifamily buildings have attracted the most carbon regulation and decarbonization investment, there has been limited understanding of their relative contribution to overall US real estate sector emissions.

RMI and its lender partners believed a breakdown of US building carbon emissions is necessary to steer investors, lenders, and regulators toward the market segments contributing the highest share of emissions. To fill this gap, RMI created a comprehensive bottom-up model of all building emissions within the United States. The results were then validated with the US Environmental Protection Agency (EPA) and the US Department of Energy. A summary of the data sets and methodology can be found in Appendix B.

Report Overview

The report begins with a detailed description of our emissions model findings. It then summarizes our research on real estate sector ownership and capitalization. From there we outline strategies for harnessing capital to catalyze decarbonization of the largest emitting segments given these ownership and capitalization themes. Finally, we conclude with areas for further research. A note on measurement and disclosure, and details on our emissions modeling methodology can be found in the appendices.

A note on data sets

In some data sets, multifamily properties (residential buildings with five or more housing units) are included in commercial data sets. In other data sets, multifamily is included with single-family homes. RMI has attempted to provide as much clarity for the reader as possible when which case applies, although at times certain trends for multifamily housing will straddle residential and commercial narratives.

US Buildings Sector Emissions Model Findings

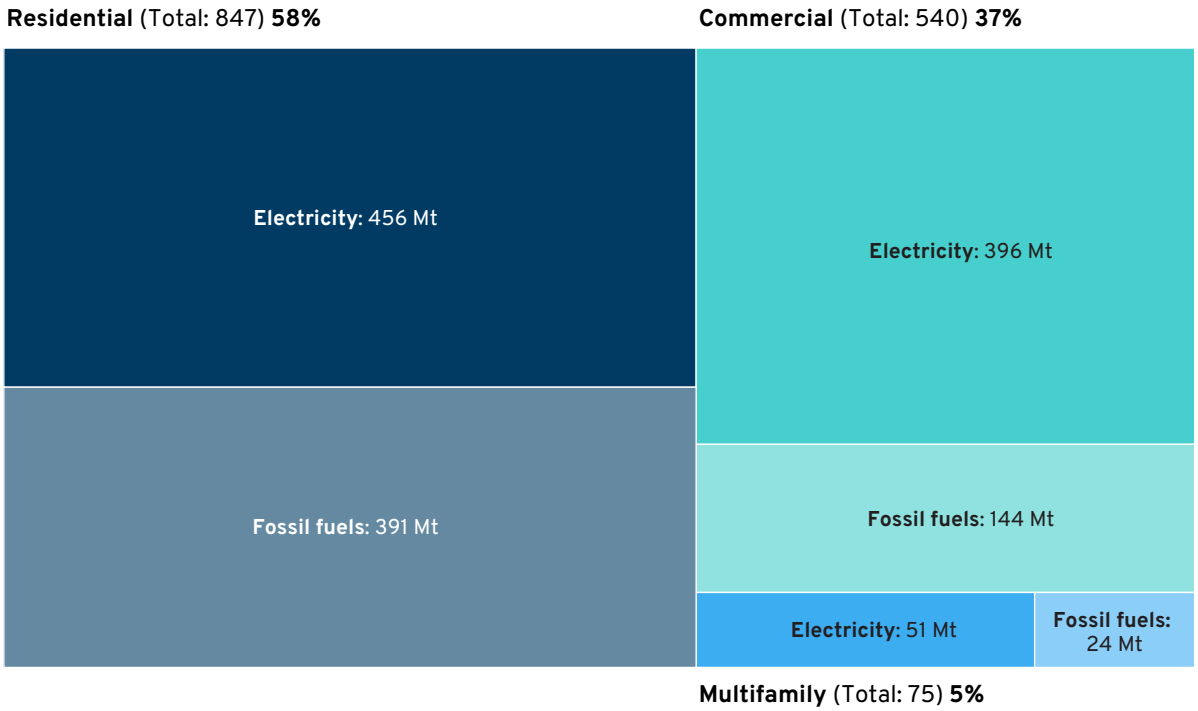
Buildings Generate 23% of US Carbon Emissions

Using this bottom-up approach, our model found that the real estate sector generates operational carbon dioxide equivalents of approximately 1.5 gigatons on an annual basis. According to the EPA, total US carbon emissions in 2021 amounted to 6.3 gigatons, meaning roughly 23% of total US emissions come from real estate.[ii]

Single-family homes, which in our analysis we define as buildings with less than five housing units, generate 58% of all building operational carbon emissions or 13.3% of total US emissions (see Exhibit 1). Commercial buildings generate 37% of US buildings emissions or about 8.5% of total US emissions.

Exhibit 1

Carbon Footprint by Major Real Estate Segment for Existing Buildings (million tons [Mt])



RMI Graphic. Source: RMI analysis

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ii This differs from the EPA's breakdown of real estate sector emissions as a share of total US emissions by roughly 7%. The difference is a function of differing accounting methodologies, which are explained in further detail in Appendix B.

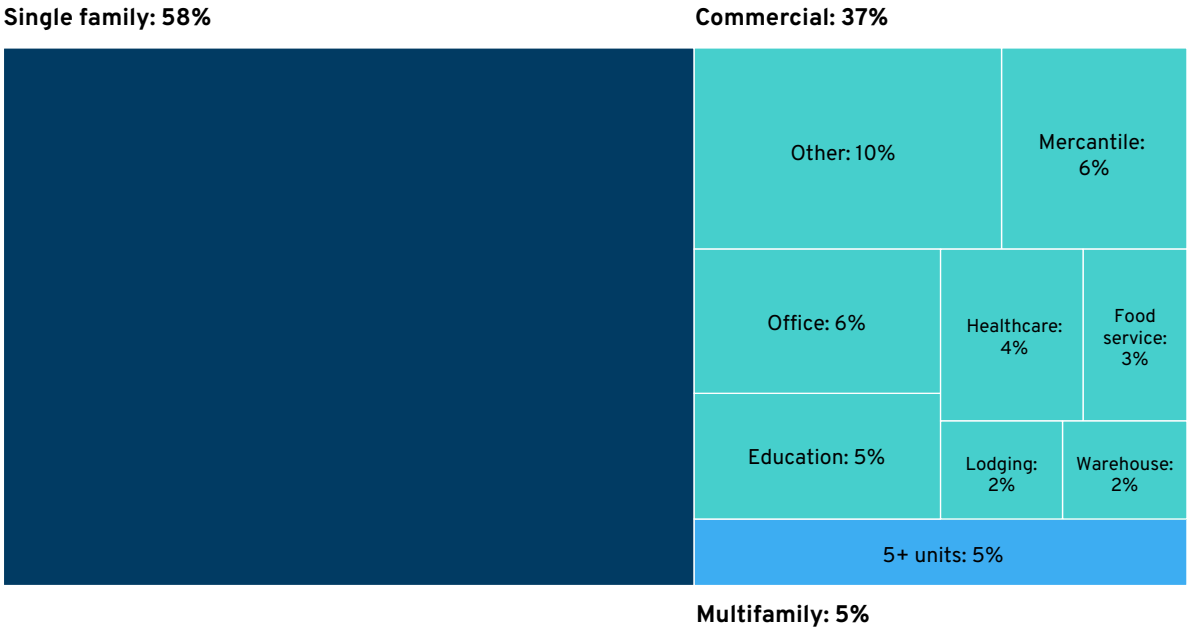
Looking at the relative use of fossil fuels in each sector indicates the potential for electrification to reduce carbon emissions:

- Sector-wide, 38% of US building emissions result from on-site fossil fuel combustion and 62% are associated with grid-supplied electricity.
- For the single-family segment, 47% of carbon emissions result from on-site fossil fuel combustion with the balance from grid-supplied electricity.
- For the commercial building segment, only 27% of carbon emissions result from on-site fossil fuel combustion with the balance from grid-supplied electricity.

These statistics reinforce the need to electrify single-family homes and decarbonize the power grid.

Exhibit 2 shows a further breakdown of operational carbon by subsegments of commercial properties. The reader will notice "Other" is one of the largest subsegments. This subsegment covers nontraditional commercial building uses including storage, airplane hangars, broadcasting studios, crematoriums, labs, telephone switching, agriculture with some retail space, manufacturing/industrial with some retail space, data centers, and public restrooms/lockers/changing areas. The EPA's Inventory of US Greenhouse Gas (GHG) Emissions includes these nontraditional commercial uses in its "Commercial Building" category whereas RMI's model, which is based on the National Renewable Energy Laboratory's (NREL's) Commercial Buildings Energy Consumption Survey (CBECS), does not.

Exhibit 2 Proportion of Operational Building Sector Emissions by Subsegment

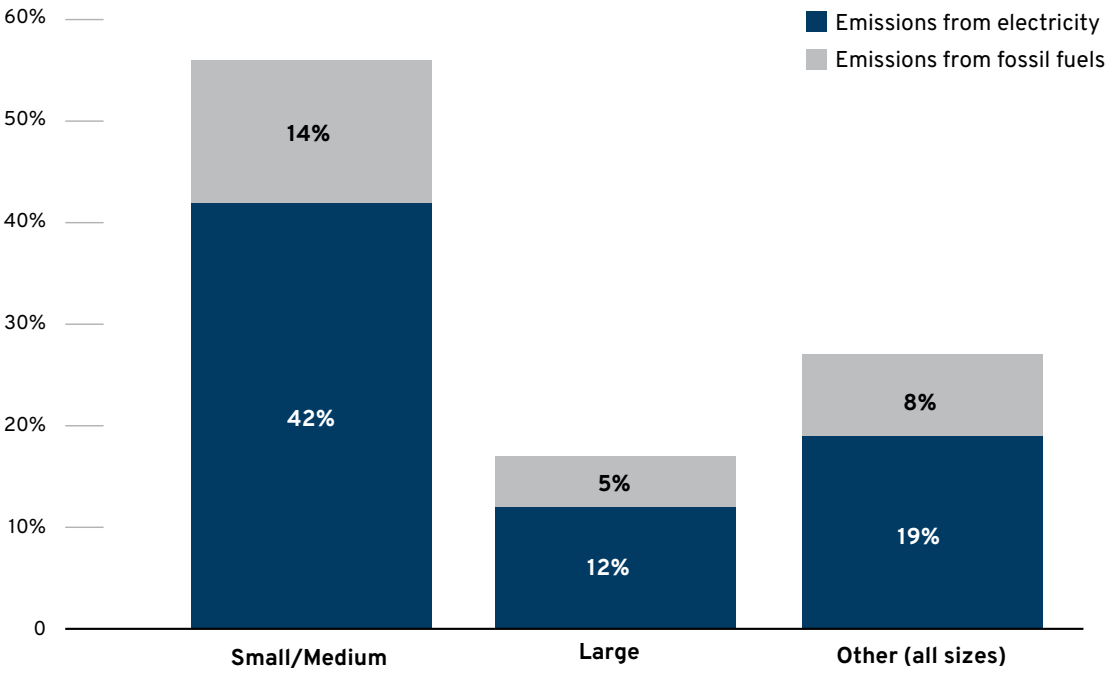


Note: The "Other" category includes storage facilities, airplane hangars, broadcasting studios, crematoriums, labs, telephone switching, agriculture with some retail space, manufacturing/industrial with some retail space, data centers, and public restrooms/lockers/changing areas.

RMI Graphic. Source: RMI analysis

Although conventional wisdom assumes the largest share of building carbon emissions are generated by very large properties, in reality, as shown in Exhibit 3, small and medium-sized commercial buildings generate a larger share of emissions than large buildings. Large commercial buildings (>200,000 square feet) represent 17% of commercial real estate emissions or about 6% of total buildings' emissions. In contrast, small and medium-sized commercial buildings account for 56% of all commercial real estate emissions and over 20% of total US building emissions.

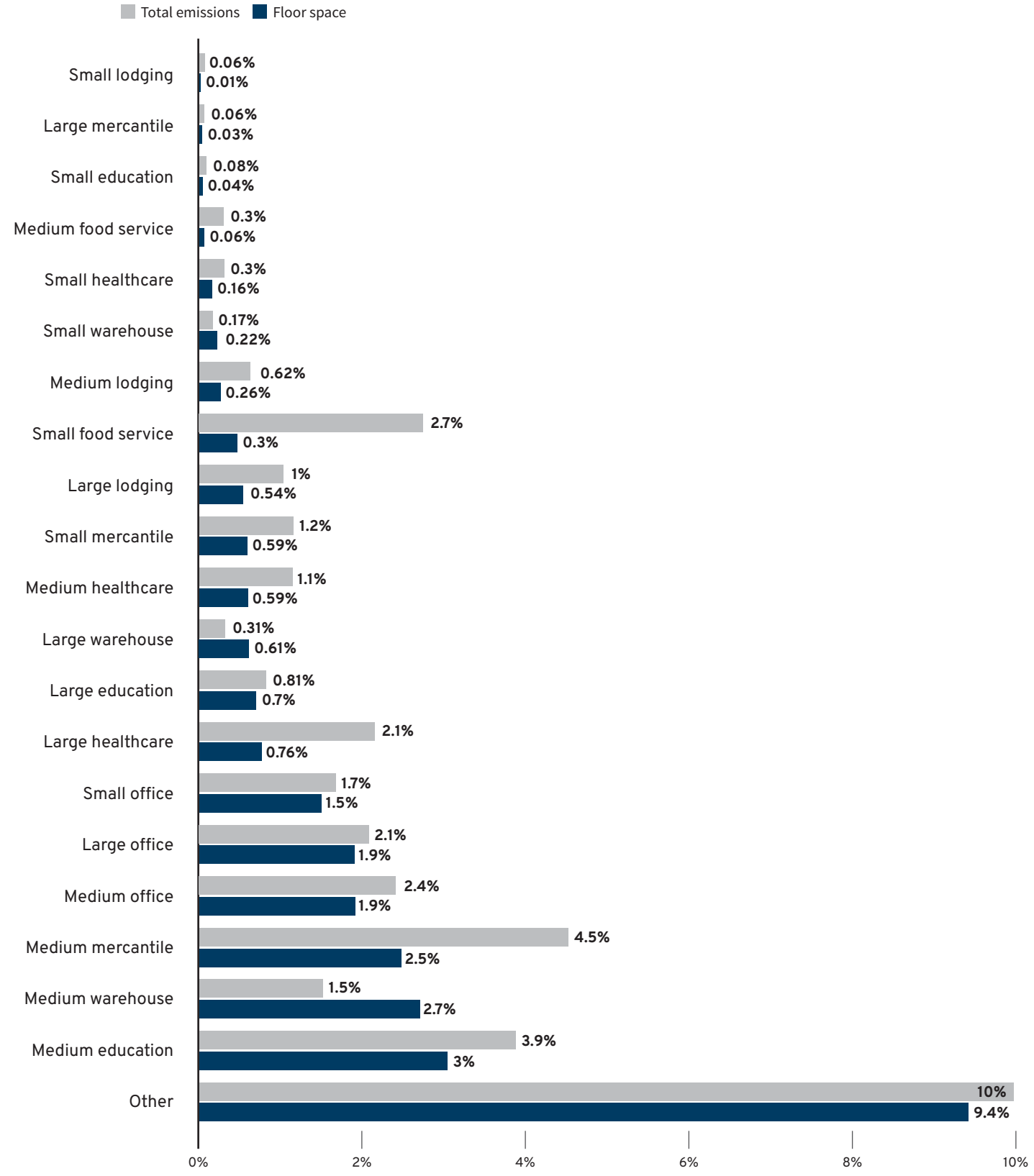
Exhibit 3 Percentage of US Commercial Building Emissions by Building Size



RMI Graphic. Source: RMI analysis

When divided by subsegment and size, the picture of which buildings to prioritize for decarbonization comes into even greater focus (see Exhibit 4). Within the commercial sector, medium-sized mercantile (strip malls), medium-sized education, and small food service buildings are significant carbon emissions contributors. Medium mercantile generates significantly more carbon than its percentage of US real estate floor area would suggest.

Exhibit 4 Percentage of US Commercial Building Emissions by Subsegment and Building Size



RMI Graphic. Source: RMI analysis

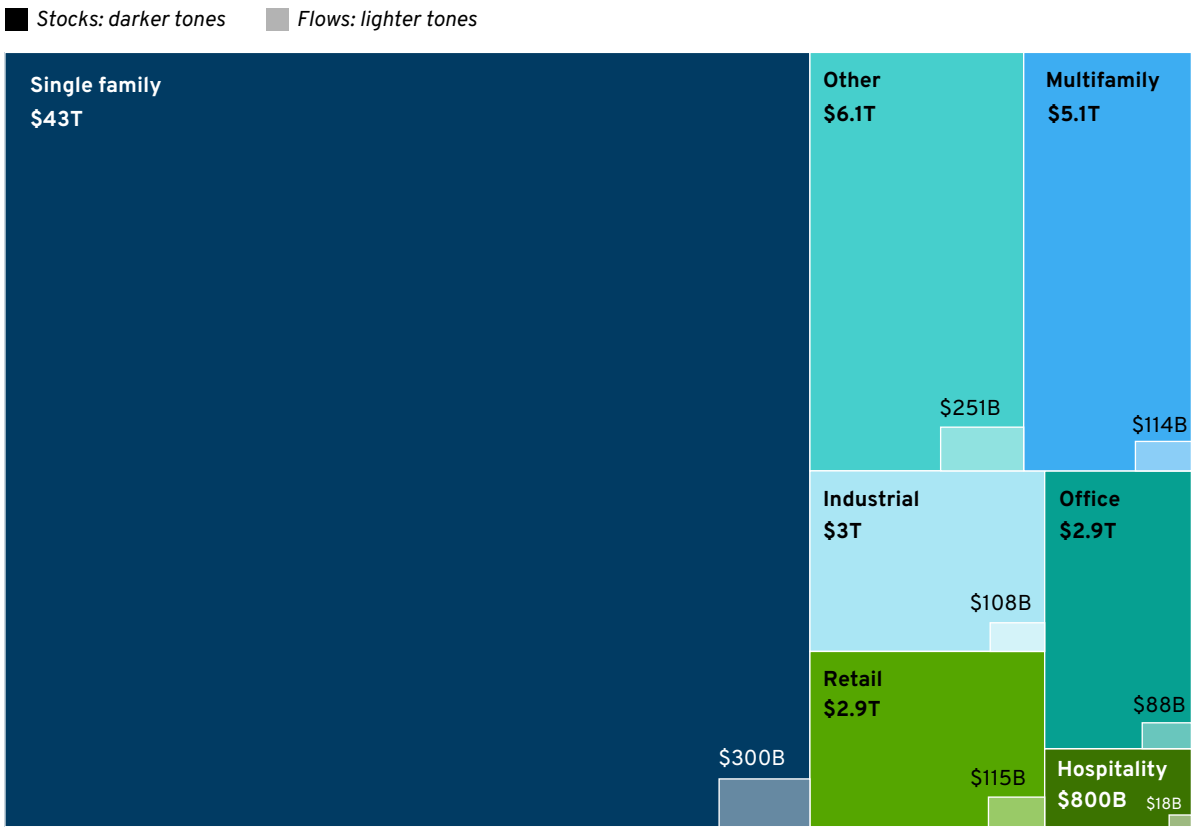
Real Estate Sector Review

Market Size

When talking about the real estate sector, it can be helpful to think of the sector in terms of "stocks" and "flows" with existing buildings being the stock and new construction being the flow. The existing US single-family and commercial building stock is worth over $43 trillion and $15 trillion,[1] respectively (see Exhibit 5). The construction markets for single-family and commercial buildings are estimated at $300 billion and $580 billion annually,[2] respectively. This amounts to a flow that is roughly 0.6 % (single family) and 3.7% (commercial) of market cap relative to the stock.[iii]

Exhibit 5

Existing Buildings' Market Capitalization Versus Annual New Construction Activity



Note: B = billion; T = trillion. Flow (i.e., new construction).

RMI Graphic. Source: RMI analysis

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iii Single-family new construction was estimated using US Energy Information Administration's single-family home increases multiplied by the average cost of construction for a US single-family home in 2022 (average value of public and private construction put in place from 2019 to 2022). To calculate the total value of commercial construction, several categories of Census Bureau data were excluded. The excluded categories are communication, power, sewage and waste disposal, water supply, highway and street, and conservation and development.

The size of the existing building stock, the relatively small amount of annual construction, and the fact that building stock turns over extremely slowly — about 80% of global buildings standing today will still exist in 2050[3] — mean decarbonizing real estate will require much more than decarbonizing new construction. It will require retrofitting existing buildings to be low or zero carbon.

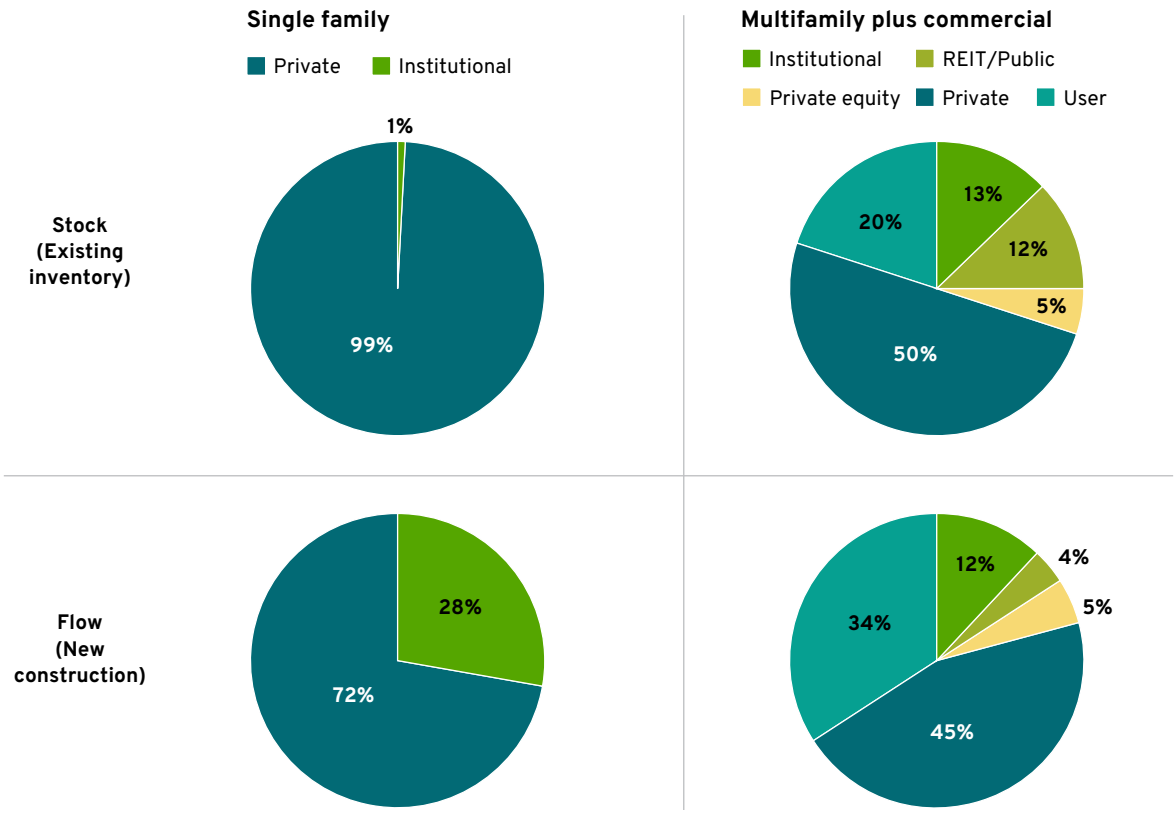
Sector Ownership

Single-family real estate has the most fragmented ownership structure in the market, with nearly every building owned by a separate individual (see Exhibit 6). Institutional ownership of single-family homes has grown rapidly in the past few years, but still accounts for less than 0.75% of the overall stock.[4],[iv]

The construction market for single-family real estate is similarly fragmented. There is some concentration at the top of the market — the largest homebuilder controls over 7% of new home construction and publicly traded single-family builders produce over 25% of all new homes.[5] However, out of over 60,000 residential homebuilders, only the top 200 largest firms build more than 200 homes a year.[6]

Exhibit 6

Building Sector Ownership



RMI Graphic. Source: Nuveen Real Estate, https://commercialobserver.com/2022/03/single-family-rentals-strong-future-demand-drivers-to-propel-sector-outperformance/; National Association of Home Builders, https://www.nahb.org/news-and-economics/press-releases/2022/01/single-family-starts-post-double-digit-percentage-gain-in-2021; Builder, https://www.builderonline.com/builder-100/builder-100-list/2022/; and CoStar

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iv This statistic was derived by combining the percentage of single-family rental housing that institutional owners hold relative to the stock of single-family inventory as published by NREL.

For the commercial and multifamily building segments, large institutional investors and real estate investment trusts (REITs) receive much of the market's attention, but private owners[v] — representing a broad range of individuals, trusts, and developers — hold half of all multifamily and commercial real estate. Owner-operators control the next largest share.[vi] Although the ownership of multifamily and commercial real estate is more concentrated than single-family real estate, the single largest private owner of commercial real estate controls less than 1% of the $20 trillion market.[7]

Large institutional or public owners control even less of the commercial and multifamily new construction market. Owner-occupiers play a larger role. With a bit more consolidation, the largest multifamily developer holds just 3% of the market, while the top 10 largest developers make up about 15% of the market (by number of units started).[8] Multifamily is the highest growth segment currently.

Due to the lack of consolidated ownership or development of single-family, commercial, and multifamily housing, intervening at the individual owner or developer level is a difficult path for scaling decarbonization. Capital flows for these segments show more promise.

Sector Capital Flows

Financing for real estate is relatively concentrated compared with ownership and development, and thus provides a promising avenue for influencing the market.

Single Family

Single-family mortgage financing is dominated by the GSEs Fannie Mae and Freddie Mac, which provide 50% of mortgage debt (see Exhibit 7). Single-family mortgages are delineated between "conforming mortgages" (those that meet the requirements to be purchased by GSEs) and "nonconforming mortgages." The majority of nonconforming loans are jumbo loans, which are more than the GSEs' maximum loan amount. Nonconforming loans are predominantly held by banks and credit unions.

Almost all conforming loans are purchased and securitized by Fannie Mae, Freddie Mac, or the Federal Housing Administration (FHA). Because control of mortgage financing resides with the GSEs and the remaining participants in the mortgage market are dependent on GSE capital, there is considerable opportunity for GSEs to incentivize residential building decarbonization.

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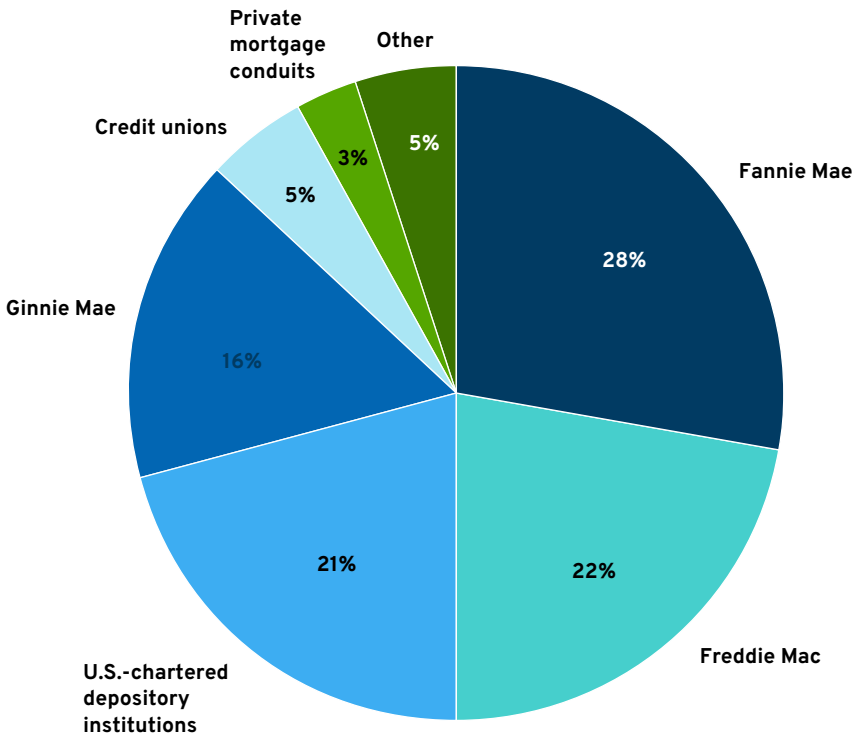
v CoStar's "Private" category includes owners such as individuals, trusts, developer-owners, tenants in common, private REITs, and "others."

vi The CoStar category "User" encompasses the following building owner-operators: governments, nonprofit organizations, educational institutions, corporate users, religious institutions, and medical buildings.

Exhibit 7 Single-Family Mortgage Debt Outstanding, Q4 2021



Note: "Other" includes state and local governments, REITs, finance companies, households, nonprofit organizations, federal home loan banks, life insurance companies, nonfinancial corporate businesses, nonfinancial noncorporate businesses, FHA and Department of Veterans Affairs, Farmers Home Administration, banks in US affiliated areas, federal land banks, state and local government employee defined benefit retirement funds, foreign banking offices in the United States, private pension funds, and the Federal Deposit Insurance Corporation.

RMI Graphic. Source: Federal Reserve Economic Data, https://fred.stlouisfed.org/release/tables?rid=52&eid=1192326&od=2021-10-01

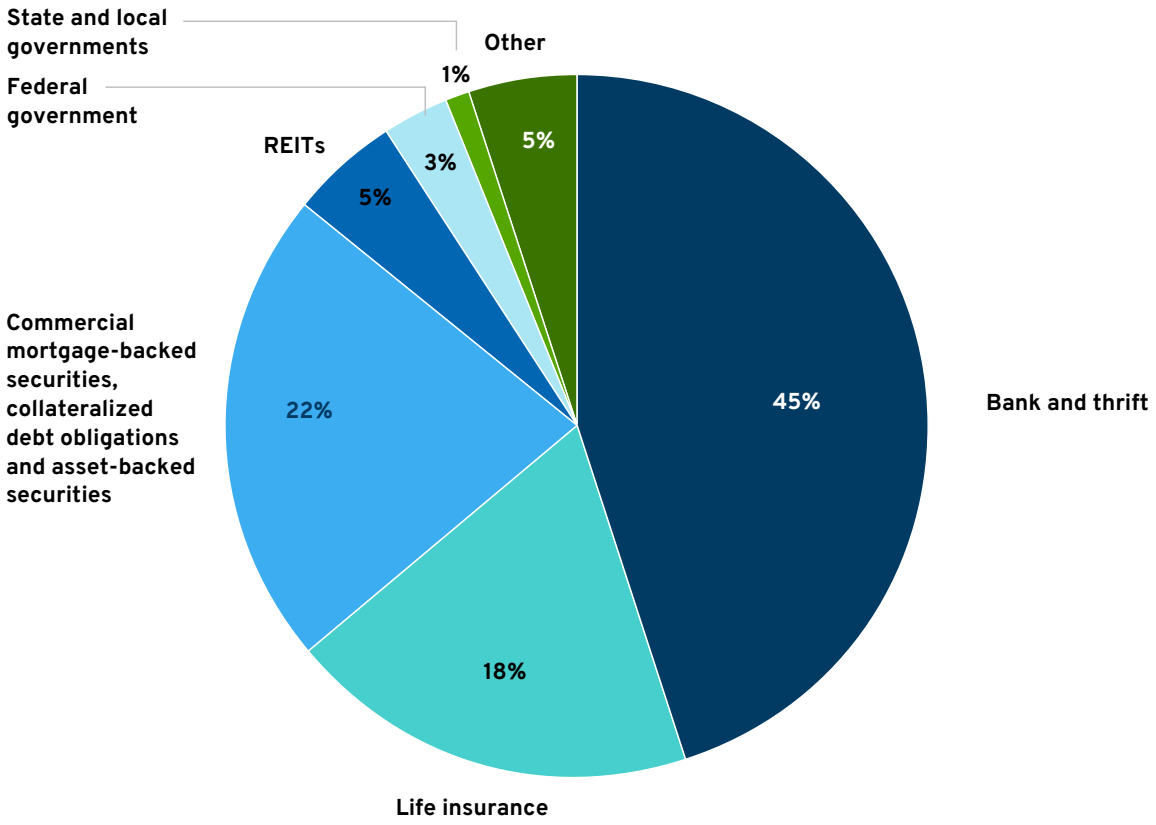
Note that there is considerable consolidation in multifamily mortgage financing as well. It is similarly dominated by GSEs, which provide nearly half of multifamily mortgage debt outstanding.[9]

Commercial

Commercial real estate debt comes from a variety of sources including banks, insurance companies, and the capital markets (see Exhibit 8).[10] Commercial banks hold about 45% of commercial real estate debt, with the nine largest banks controlling roughly 15% of the market.[11, vii] Financial experts who RMI consulted considered 15% to be adequate market share to create a tipping point in lending activity.

vii RMI pulled disclosure statements from the nine largest banks and calculated their commercial mortgage holdings to determine this market share.

Exhibit 8 Commercial Mortgage Debt Outstanding, Q1 2022



The "Other" category includes nonfarm noncorporate business, finance companies, other insurance companies, nonfinancial corporate business, private pension funds, state and local government retirement funds, and household sector.

RMI Graphic. Source: Mortgage Bankers Association, https://www.mba.org/news-and-research/newsroom/blog-post/2022-q1-quarterly-databook

Decarbonization Capital Flows

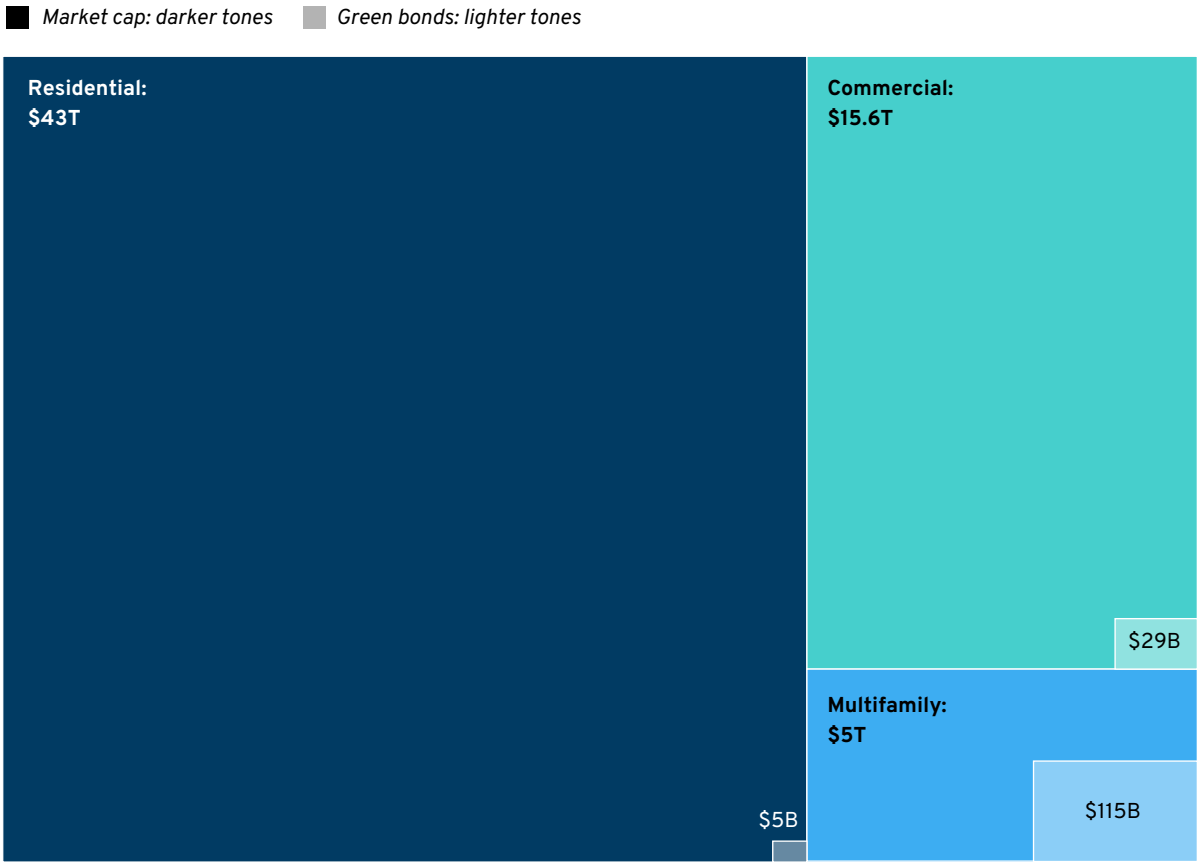
Although data on financial flows that are conditional on reducing carbon emissions ("green debt" or "green bonds") have inconsistent definitions, review of available indicators show that:

1. Total green financial flows are insufficient to bring the sector in line with the US goal of a net-zero emissions economy by 2050 (see Exhibit 9).

2. Green capital flows are disproportionate to the building segments that generate the most emissions (see Exhibit 10).

Exhibit 9

Green Bond Issuance Relative to Existing Buildings Market Capitalization

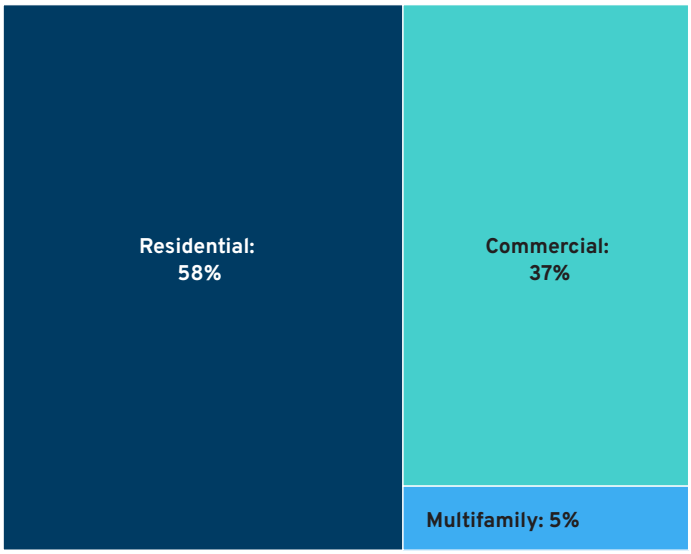


Note: B = billion. T = trillion. Green bond issuance figures not drawn to scale for ease of visibility.

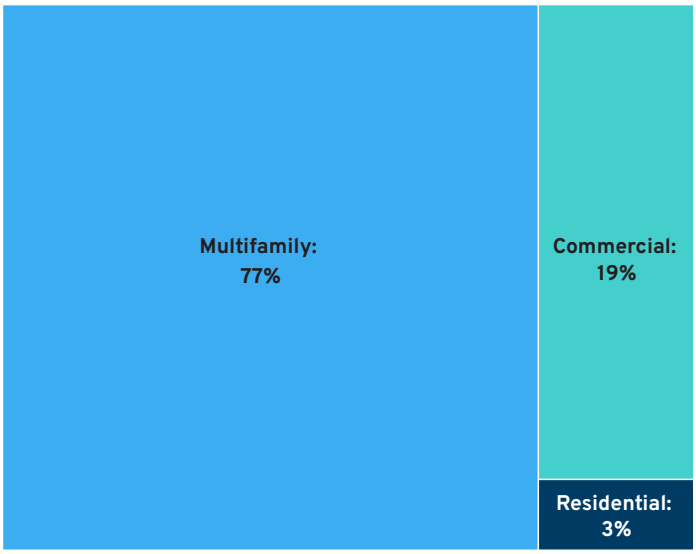
RMI Graphic. Sources: Fannie Mae, https://capitalmarkets.fanniemae.com/media/20881/display#:~:text=The%20mission%20of%20Fannie%20Mae's,MBS%20issuances%20have%20exceeded%20%24110; Fannie Mae, https://capitalmarkets.fanniemae.com/sustainable-bonds/green-bonds/single-family-green-mbs; Freddie Mac, https://capitalmarkets.freddiemac.com/mbs/green-sfmbs; Freddie Mac, https://mf.freddiemac.com/docs/2022_impact_bonds_report.pdf; Housing Finance Policy Center, https://www.urban.org/sites/default/files/2022-09/Housing%20Finance%20At%20A%20Glance%20Chartbook%20September%202022.pdf; and C. Hudgins, https://www.spglobal.com/marketintelligence/en/news-insights/latest-news-headlines/green-bond-issuance-by-us-reits-grew-in-2021-68335451

Exhibit 10 Green Bond Issuance Relative to Emissions

Proportion of building sector emissions



Proportion of cumulative green mortgage backed securities



RMI Graphic. Sources: Fannie Mae, https://capitalmarkets.fanniemae.com/media/20881/display#:~:text=The%20mission%20of%20Fannie%20Mae's,MBS%20issuances%20have%20exceeded%20%24110; Fannie Mae, https://capitalmarkets.fanniemae.com/sustainable-bonds/green-bonds/single-family-green-mbs; Freddie Mac, https://capitalmarkets.freddiemac.com/mbs/green-sfmbs; Freddie Mac, https://mf.freddiemac.com/docs/2022_impact_bonds_report.pdf; Housing Finance Policy Center, https://www.urban.org/sites/default/files/2022-09/Housing%20Finance%20At%20A%20Glance%20Chartbook%20September%202022.pdf; and C. Hudgins, https://www.spglobal.com/marketintelligence/en/news-insights/latest-news-headlines/green-bond-issuance-by-us-reits-grew-in-2021-68335451

Single Family

Both Freddie Mac and Fannie Mae issue green mortgage-backed securities (MBS) backed by single-family mortgages on homes that are energy efficient and/or have green building certifications.[viii] But the extent of green single-family MBS is minuscule. In 2021 GSEs issued roughly $1.13 billion in single-family green MBS, representing only 0.04% of their $2.7 trillion in total MBS issuances for that year.[12] Combined, the two agencies have issued less than $5 billion in single-family green MBS since their programs' inceptions.[ix]

The numbers are better for multifamily. In 2022, the two agencies issued a cumulative of $115 billion in multifamily green lending.[13] For Fannie Mae that accounted for about 25% of its multifamily production between 2014 and 2020, demonstrating that increasing green production is feasible.[14]

Commercial

Some indicators of increased capital flow toward commercial real estate decarbonization are visible. For example, the green bond market has expanded significantly in recent years and buildings have represented a substantial portion of the use of proceeds. US REIT green bond issuances totaled roughly $30 billion since

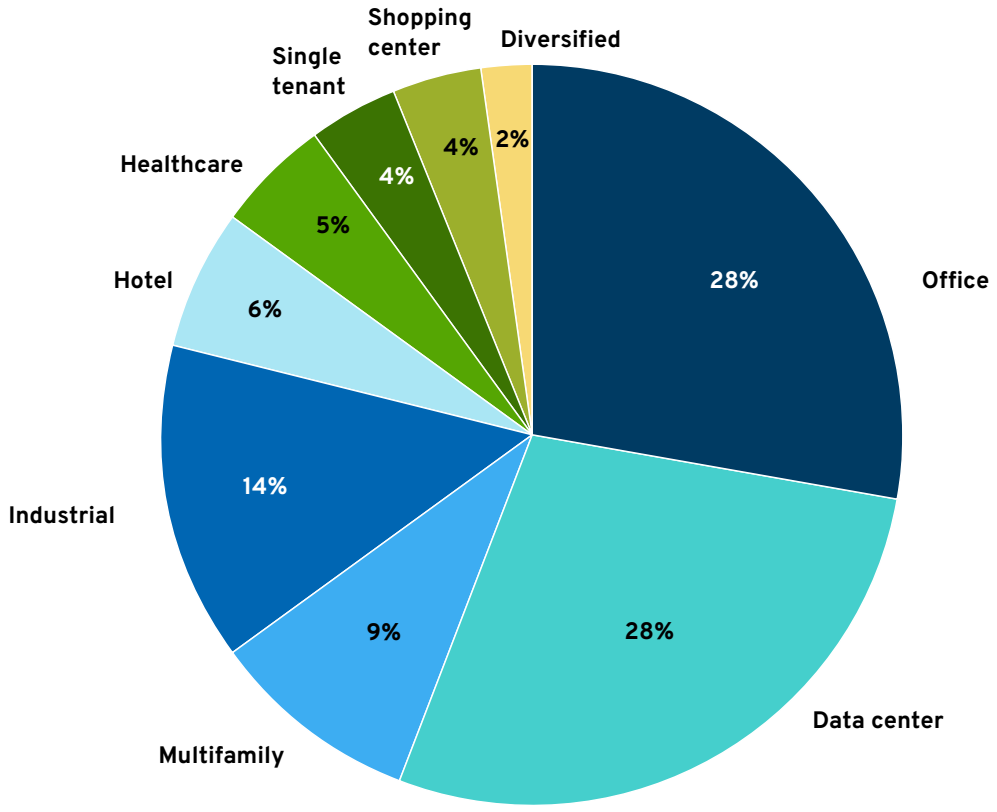
viii MBS are "debt obligations that represent claims to the cash flows from pools of mortgage loans, most commonly on residential property." For further information, see the US Securities and Exchange Commission's website.

ix Green MBS issuance through March 2023. Fannie Mae's single-family green MBS issuances began in April 2020, while Freddie Mac's began in April 2021.

2014 and were nearly $12 billion in 2021 alone.[15],[x] This represents over twice the relative cumulative single-family issuance, even though the commercial sector represents less than two-thirds of the equivalent carbon emissions. However, volumes still represent a small percentage of overall issuance, comprising 16% of annual bond issuance in 2021.[16] Furthermore, REITs tend to own larger commercial buildings, so investment in small and medium-sized commercial properties is small relative to this subsector's full extent of carbon emissions.

As shown in Exhibit 11, 28% of commercial green debt issued by REITs was allocated to office buildings. Office buildings are only responsible for 16% of commercial building carbon emissions. Similarly, although healthcare contributes roughly 11% of commercial building carbon emissions, only 5% of green bond activity has been in the healthcare segment.

Exhibit 11 Allocation of US REIT Green Bond Proceeds Issued 2014-2021



RMI Graphic. Source: C. Hudgins, https://www.spglobal.com/marketintelligence/en/news-insights/latest-news-headlines/green-bond-issuance-by-us-reits-grew-in-2021-68335451

x Due to differing methodologies between Climate Bonds Initiative and S&P Global Market Intelligence, the total green bond issuance data cannot be summed across the two sources.

Specific Actions to Advance Decarbonization

Key findings from RMI's buildings emissions model suggest that the predominant decarbonization focus should be on (1) existing buildings, (2) single-family homes, and (3) small and medium-sized commercial buildings. This section summarizes ideas and recommendations that RMI solicited from financial experts concerning the engagement of lenders, investors, and regulators to capitalize and promote energy retrofits.

Regulatory Actions

FHFA should instruct GSEs to develop a net-zero strategy in compliance with Executive Order 14057. No credible path toward zero carbon can be achieved without decarbonizing residential properties; therefore, it is imperative that the FHFA, the conservator of Fannie Mae and Freddie Mac, work with the GSEs to develop a strategy to decarbonize their portfolios by 2050.[17] As of late 2021, Fannie Mae and Freddie Mac financed 50% of all existing one- to four-family residential mortgages. This means they also financed 30% of US real estate emissions and roughly 7% of all US carbon emissions.[18],[xi] Fannie Mae and Freddie Mac are also the largest source of financing for the multifamily market, and this segment should be included in their net-zero strategies.

This strategy could include applicable changes to the GSEs' underwriting standards, automated underwriting platforms, and MBS disclosure. FHFA should adapt the GSE's annual scorecard to ensure that this goal is met.[19] The strategy should address:

- Steps that can be taken to decarbonize the GSEs' existing portfolios
- A time line for requiring any new mortgages funded by GSEs to be zero-carbon aligned
- Assurances that the strategy would address and help alleviate climate justice issues including:
    - Lack of affordability for first-time homebuyers
    - Historic inequity in the housing stock

By acting now, FHFA could avoid potential industry disruptions by giving GSEs the time needed to work with their lender partners, as well as with the broader housing industry, to achieve climate goals.

Single-Family Financing Solutions

Financing solutions could include lenders integrating IRA tax credits and rebates for financing energy efficient technologies into their existing home improvement loans.

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xi The math is based on Fannie Mae and Freddie Mac financing half of the US mortgage debt outstanding for one- to four-family residences. Emissions attribution assumptions come from our building emissions model; we take the total existing residential stock emissions for one- to four-family residences, divide it by 2, then multiply by 77% (the rate of mortgaged homeownership in the United States). Then we take that number as a percentage of total US buildings' emissions (from our emissions model), and total US carbon (from the EPA), respectively.

Some estimates indicate that the electrification and efficiency improvements market could be worth half a trillion dollars, with just the market for replacing fossil fuel-powered appliances with electric ones ranging between $30 billion to $40 billion a year.[20] In addition to increasing their financing for electrification, efficiency, and on-site renewables, lenders could offer bridge loans for the rebate or tax credit amounts, until borrowers receive them from the government. They could also offer lower interest on the rebate amount portion of the loan, given the shorter period of repayment time.

Commercial Financing Solutions

Based on our findings that most US commercial real estate emissions reside in small and medium-sized buildings, lenders and investors can offer specific financing solutions for their clients that incentivize the decarbonization of those properties.

1. Lenders could require a cost-benefit analysis of making efficiency upgrades and replacing fossil fuel technologies with renewable technologies as part of their underwriting process. Nearly every lender already requires a physical needs assessment as part of their loan due diligence process.

   Analysis of this kind may seem less beneficial from a cost-benefit perspective for some building types; however, the assessment could give lenders and borrowers a clearer understanding of building systems' conditions and establish a time line for their replacement. It holds the potential advantage of putting green replacement costs on a required schedule and utilizing existing IRA tax credits and rebates to design financing packages. Similar to home improvement loans, the lender could offer additional bridge loans for green building improvements until the IRA rebate or credit is collected, and/or they could offer discounts on the shorter-term portions of the loan to incentivize adoption.

2. Lenders could utilize replacement reserves for efficiency upgrades. Lenders are already holding billions of dollars in replacement reserves for commercial properties, with the purpose of updating building systems that have reached the end of their useful life.

   Typically, replacement reserves assume "like for like" replacement — if a building has a gas heating system, the reserves assume replacement with a new gas system. Instead, lenders could proactively work with borrowers to replace fossil fuel–powered systems with higher-efficiency electric systems. In some cases, leveraging the IRA subsidies for these replacements would lower or eliminate any incremental cost to the borrower in choosing the green system replacements. Lenders could also offer favorable financing terms to address any remaining incremental costs.

3. Rather than focusing only on financing high-efficiency buildings, lenders should target poorly performing buildings and incentivize improved energy performance through lower rates or improved terms. As described above, building decarbonization capital flows in the United States often focus on investing in a relatively small number of low-carbon transactions and reducing exposure to higher-carbon transactions, which disincentivizes decarbonization of existing buildings.

   However, alternative approaches that target emissions reduction in less efficient existing properties have been piloted in other markets. One example is ING's pilot product in the Netherlands, which offers discounted loans to low-performing commercial properties to improve their energy performance to the standard currently required by the government.[21] Another example is offering retrofit financing at discounted rates dependent on GHG emissions reductions, like Bank of Montreal's retrofit program, conducted in partnership with the Canada Infrastructure Bank and energy service companies.[22]

Opportunities for Future Research

Given the complexity of the real estate sector, there were many potentially relevant elements that fell outside the scope of our current work and remain areas of future research. They can be broadly divided into four categories.

1. **Inclusion of embodied carbon.** Our model focused on operational emissions but can be expanded to include embodied carbon. This inclusion would allow for a better understanding of the relative impact of renovations on overall building decarbonization. As the scale of building retrofits increases, embodied carbon will become a larger percentage of total carbon and therefore a more important area to examine. Please see RMI's *Transforming Existing Buildings from Climate Liabilities to Climate Assets* for preliminary research on the embodied carbon implications of retrofits.[23] For an analysis of embodied carbon emissions in new residential construction, please see RMI's *The Hidden Climate Impact of Residential Construction*.[24]

2. **Inclusion of on-site renewables.** Our analysis assumes that all electricity came from the grid. Current penetration percentages for on-site renewables are in the low single digits but are expected to grow exponentially in the coming years, due in large part to the passage of the IRA. Future iterations of the model should include on-site renewable production and its relative impact on buildings' carbon.

3. **Cost analysis.** Our model addresses buildings' operational carbon emissions but does not detail the many cost implications of decarbonizing the building stock and their relationship to building value. For example, we reiterate the importance of increased building retrofits, but need additional analysis on the cost and availability of those retrofits for developers and homeowners to provide a fuller picture. Analysis on the cost of smaller commercial retrofits was recently released by RMI as one step.[25] More work is also needed on the impact of the IRA and how its incentives will affect the delivered cost of retrofits for developers and homeowners alike.

4. **Equity commitments.** Much of the building decarbonization movement has been driven by equity holders' pursuit of sustainability objectives in their portfolios. But aggressive target setting has been limited. Net-zero commitments by the largest real estate owners and investors are increasingly common — seven of the top 10 REITs have set some type of emissions reduction target, many approved by the Science Based Targets initiative.[26] In spite of this, Prologis is the only top 10 REIT to have made a commitment to net-zero emissions by 2050 or sooner.

Although trending positively, net-zero commitments from building owners tend to vary by building type. For example, seven of the top 10 largest office owners and six of the top 10 retail building owners have committed to net-zero emissions by 2050.[xii] Conversely, none of the top 10 largest multifamily owners and just two of the top 10 hospitality owners have made net-zero commitments.[27] More needs to be understood about what can further accelerate equity commitments to decarbonization, further aligning debt and equity holders' decarbonization interests.

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xii By owned square footage.

Appendix A – Measurement and Disclosure

Challenges for Lenders in Target Setting for Real Estate Decarbonization

Lenders are key actors in catalyzing capital flows to decarbonize real estate. For net-zero-committed lenders, real estate sector portfolio targets are typically the first step in implementing such commitments. Partnership for Carbon Accounting Financials (PCAF) is the most robust carbon accounting methodology available for lenders to establish emissions baselines on which to set real estate portfolio targets. However, the structures used to finance real estate in the United States result in a disconnect between reductions in attributable carbon (as measured by PCAF) and the real economy decarbonization of the sector. As a result, lenders may set net-zero strategies that are aligned with PCAF definitions but that do not meaningfully reduce carbon emissions.

In addition, targets among financial institutions are likely to be of limited comparability because they can vary significantly depending on the data and accounting methodologies used. As described below, this is largely due to structural challenges around data availability and the Scope 3 accounting methodology.

1. **Data availability.** Building Scope 3 data is difficult to obtain for most lenders for the majority of building segments. Although equity investors can rely on organizations such as GRESB and its extensive asset-level surveys to access building-level data, lenders do not have access to any similar database for the buildings they finance. Therefore, they need to either acquire data from each client or rely on external vendors and data proxies.

   In addition, PCAF advises financial institutions to estimate the energy consumption data they cannot acquire directly. No verification is required, aside from mandating disclosure of how much data was estimated and by which method, and asking that financial institutions develop a path forward for using actual data in the future. This leaves space for lower quality data to be used, especially when addressing small and medium-sized buildings; this data may not come close to estimating actual financed emissions.

   Such data issues are also related to available choices for calculating financed emissions in the PCAF guidance. Some proxy options available (e.g., using economic activity–based emissions) can be very far removed from actual building emissions and may highly underestimate carbon emissions of buildings in financial institutions' portfolios.

2. **Scope 3 accounting methodology**. Much of commercial real estate is occupied through lease structures. A literal interpretation of PCAF would require lenders to analyze every lease to determine operational control between their borrower and the building tenants in order to assign emissions to Scopes 1, 2, or 3. The infeasibility of this approach, especially for large portfolios, implies that emissions are likely attributed differently by different lenders and calculations are therefore likely to be of limited comparability.

These issues limit the utility of target setting for US real estate portfolios. First, they sever the link between carbon accounting for real estate portfolios and taking actions to decarbonize real estate portfolios through actions such as client engagement and deployment of green financing products to existing clients. Second, carbon accounting based on proxy data disincentivizes deeper client engagement and leaves divestment as a plausible solution for addressing portfolio emissions. Although divesting from high-emitting assets and building green stock may improve portfolio emissions profiles by reducing the amount of financed emissions in their disclosures, it will not support economy-wide decarbonization and could have negative equity implications. Third, although current carbon accounting methods offer a general sense of the financed emissions at portfolio level, they will not identify hot spots most in need of capital.

Alternative Target Setting and Measurement Solutions

The specific decarbonization actions for lenders outlined in this report can directly stimulate decarbonization of the US real estate sector. These activities can have targets and can be quantified and disclosed with a focus on the deployment of green financial solutions in pursuit of net-zero targets. For example, lenders and/or investors could disclose the following in sustainability reports, Task Force on Climate-Related Financial Disclosures reports, transition plans, and other disclosures:

1. GHG emissions reductions, in carbon equivalents, associated with green technology replacements financed

2. Amounts of IRA rebates and tax credits they helped clients leverage

3. Number of buildings, especially small and medium-sized ones, that reached a higher building performance standard certification due to any discounted or targeted green loans or investments offered, and carbon reductions associated with efficiency, electrification, and grid improvements

4. How such efforts may contribute to their net-zero target despite, for example, data limitations

Appendix B – Buildings Emissions Model Technical Appendix

The model developed by RMI relies predominantly on data from the NREL's ResStock and ComStock Analysis Tools, which provide information on energy end use (i.e., fossil fuel use, grid electricity use) at the building subsegment level.[28] In addition, it uses data from the Energy Information Administration's (EIA's) Commercial Buildings Energy Consumption Survey (CBECS) and Residential Energy Consumption Survey (RECS). The output of the model was also reconciled with the EPA's *Inventory of US Greenhouse Gas Emissions and Sinks*.[29] The NREL data considers all electric usage to be generated by the grid, and all on-site energy usage to correspond to fossil fuels and their corresponding emissions including nitrous oxide (N_2O), methane (CH_4), and carbon dioxide (CO_2).[30]

Residential Real Estate

In our resulting analysis, residential real estate is divided into the following six categories:

1. Mobile home
2. Multifamily with 2–4 units
3. Multifamily with 5+ units (1–3 stories)
4. Multifamily with 5+ units (4+ stories)
5. Single-family attached
6. Single-family detached

Each of the above categories is divided into two construction types: masonry or steel frame, and wood frame. Each of these construction types is further divided into three vintage bins: before 1940, between 1940 and 1979, and after 1980.

Multifamily with 5+ units (1–3 stories) and multifamily with 5+ units (4+ stories) are generally considered by the market as commercial real estate categories. NREL, however, typically includes these categories under residential real estate. To avoid confusion, where appropriate, we separate multifamily as a distinct segment, and otherwise note when multifamily is included under residential versus commercial real estate.

Commercial Real Estate

In our resulting analysis, commercial real estate is divided into the following eight categories (also referred to as subsegments):

1. Education
2. Food Service
3. Healthcare
4. Lodging
5. Mercantile
6. Office
7. Warehouse
8. Other[xiii]

Each of the above categories, except for "Other," is further divided into three subcategories: below 25,000 square feet, between 25,000 and 200,000 square feet, and above 200,000 square feet.

Both residential and commercial real estate segments — in the NREL data set and consequently the emissions model that underpins this analysis — are divided into state-by-state data. More specifically, the carbon conversion factors at the state level are based on averages via NREL's 2022 Cambium model.[31],[xiv]

Emissions Factors

Our analysis used average grid emissions factors from NREL's 2022 version of Cambium at the national and state level. These factors are provided in terms of carbon dioxide equivalents (CO_2e) per megawatt hour (MWh), accounting for precombustion emissions (i.e., fuel extraction, processing, and transport — including fugitive emissions), as well as N_2O and CH_4 in terms of CO_2e. Our analysis uses the Mid-Case 95% Grid Decarbonization by 2050 scenario in Cambium. We pulled our fossil fuel combustion factors in units of kg/MMBtu for CO_2 and g/MMBtu for N_2O and CH_4 from Table 8.

In order to determine national-level CO_2e emissions for the United States, we aggregated building CO_2e emissions data by state per category as opposed to aggregating building energy usage (TBtu/year) and applying an average, national-level grid emissions factor. This approach allows us to maintain state-level variations in grid emissions factors. The only exception to this approach is the commercial category "Other" integrated from the EIA's 2018 CBECS, which does not have state-level specificity; thus, we used NREL's Cambium national-level grid emissions factor. Despite this difference, we included this category's building energy usage in our analysis for our aggregate US-level CO_2e emissions results.

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xiii The "Other" category was an addition to the NREL data set from EIA's CBECS. We added this category in order to align our model as closely as possible with top-down carbon numbers, and to make our analysis as complete as possible. It includes storage, airplane hangar, broadcasting studio, crematorium, lab, telephone switching, agriculture with some retail space, manufacturing/industrial with some retail, data center, and public restroom/locker/changing areas.

xiv Mid-Case 95% Grid Decarbonization by 2050 scenario in Cambium.

Exhibit 12 **Data Set Comparison Notes**

	NREL ResStock and ComStock	**EIA** RECS and CBECS	**EPA** EIA Monthly Energy Review
Residential	• 550k building types to model, scales up to 1.8M buildings • Uses American Community Survey data for segments (has vacant and vacation units), therefore more units than RECS • 350k building types modeled, scaled up to 133M dwelling (housing) units • 2018	• RECS only includes units occupied year-round • Only 2015 data was available at the time of our analysis	
Parameters	• Building type, building size, wall structure, vintage bin	• Building types	
Commercial	• Models 70% of floorspace, contains seven categories; 2018; uses CoStar for building types • Includes the "Other" category from EIA's 2018 CBECS (Table C1) for this analysis	• 13 categories, 2018 consumption and expenditures • Other: pulled storage from "Warehouse and Storage," which includes airplane hangar, broadcasting studio, crematorium, laboratory, telephone switching, agriculture with some retail space, manufacturing/ industrial with some retail, data center, public restroom/ locker/changing area	• Includes, generators, sewage treatment, and public works not covered in the other two data sets
Overall	• Does not include Hawaii, Alaska, Washington, D.C., or US territories (only the contiguous 48 US states) • Benchmarked against EPA and EIA	• Benchmarked against EPA and EIA	• Assumes an emissions factor of 387 kg CO_2e/MWh

RMI Graphic. Source: NREL, https://resstock.nrel.gov/page/typology; NREL, https://www.nrel.gov/docs/fy22osti/83063.pdf; and EIA, https://www.eia.gov/consumption/commercial/data/2018/index.php?view=consumption

Discrepancy Between Our Emissions Findings and the EPA's

One of the major findings of our analysis was that emissions from the US built environment were roughly 7% lower than those estimated by the EPA's GHG emissions accounting methods. The primary reason for the discrepancy is the differing approaches in emissions accounting, as we discussed with staff at the EPA as EIA.

The EPA's Inventory of US GHG Emissions relies on energy data from EIA's Monthly Energy Review (MER). MER contains data described as commercial segment consumption (i.e., sales or delivery data provided by energy suppliers). The data sets we used, including NREL's CBECS data, are end-user consumption figures collected directly from the building respondent or from their energy supplier, specifically about the energy used in a specific building.

Suppliers tend to assign categories to their customers based on their rate class or the amount of energy supplied, and not necessarily on the actual type of activity occurring in the building; this leads to potential differences in the definitions of "commercial."

In addition, commercial sales accounts are not associated only with buildings. They may also include energy used for unenclosed equipment (such as motor gasoline used for non-highway vehicles or lawn and garden equipment), exterior lighting, or construction. CBECS specifically excludes any energy use that is outside the building. Worth noting is that emissions from public works, such as wastewater treatment facilities, are also included in the EIA MER (and thus, the EPA's Inventory of US GHG Emissions).

These differences create the gap between our emissions estimate and that of the EPA.

Recommendations for Future Analysis

Improving building classification and taxonomy. One of the analytical challenges the RMI team encountered when building the emissions model and researching US real estate more broadly pertained to issues with data taxonomy. There are no industry-wide conventions for classifying buildings, which makes combining data sources and arriving at consistent conclusions challenging. For instance, some data sources, such as NREL, classify the multifamily category as residential real estate, while others, such as CoStar and CBECS, classify it as commercial. Various data sources have different numbers of building categories and subcategories, and categories representing similar building segments do not always include the same subsegments.

Improving data availability. It is difficult to access current and comprehensive building-level data. NREL's ResStock and ComStock data sets are both dated (ComStock data is from 2018) and pose a trade-off between granularity (building size–level data, data by state) and data availability. ComStock models 70% of commercial floorspace, with seven available categories; this is less than what is covered by EIA's CBECS and EPA's Inventory of US Greenhouse Gas Emissions and Sinks. However, the ComStock data is far more granular. We were able to calculate sector-wide totals by using data from CBECS to incorporate categories not found in ComStock; however, for those categories, we were not able to provide the same level of detail. On the residential side, the RECS data was more comprehensive. Data on construction and embodied carbon, especially for smaller buildings, is scarce if not completely unavailable.

Integration with eGRID. Due to the limitation of the NREL data set, our carbon calculations were limited to state-level averages. Our hope would be to eventually tie our analysis into the EPA's eGRID regions.

Our team encountered a lack of available data to link county and state data from NREL to regions that cut across states and are based off power plant siting, like eGRID. There is limited existing data linking counties to EPA's eGRID subregions, and a state cannot be easily linked to the subregions because it can be covered by multiple eGRID regions.

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