

Green MBS Impact Report 2023





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Executive Letter



Freddie Mac's Green Mortgage-Backed Security (MBS) is a natural extension of our corporate focus on the environmental, social and governance (ESG) aspects of our business. We are a mission-driven company, providing liquidity, stability and affordability to the housing market.

During 2023 we worked to solidify the advances we made in our Green MBS in the two prior years. In 2021, we issued our first Green MBS backed by GreenCHOICE Mortgages[®] refinance loans that funded solar panel improvements, and in 2022 we published our Green Bond Framework (the Framework) and added new construction loans on properties with a qualifying Home Energy Rating System (HERS) Index score as eligible collateral for our Green MBS.

In 2023, we built on this progress by scaling our market footprint in the space. We began to include loans backed by newly constructed homes with a renewable energy source in our Green MBS issuance. In addition, the dollar value of our issuance of Green MBS increased by over 35% in 2023 from the prior year, even as overall mortgage market volumes declined. Expressed as a proportion of our total MBS issuance by unpaid principal balance (UPB), Green MBS issuance more than doubled in 2023, as securitization of Green MBS transitions from a fledgling program to a core part of our business.

As we strive for continuous improvement, we are preparing for the further expansion of our Green MBS program. In 2024 we plan to update our Green Bond Framework and are exploring additional types of eligible collateral for our Green MBS offering. As part of this update, we plan to tighten our HERS score requirements because, as building standards continue to improve, we want to ensure that the energy efficiency of homes backing loans included in our Green MBS represents a clear benefit to the environment.

Outside of our Framework updates, we are planning to allow lenders to form and market their own Green MBS that meet the criteria of our Framework. Providing lenders with their own pool formation ability for Green MBS issuance will help scale the business and move it from a niche market to a widely adopted standard.

The common theme surrounding all of these developments is the maturing of the Freddie Mac Green MBS issuance program. Whereas our first couple of years of Green MBS issuance were focused on determining our place in the market and developing new features and offerings to support that positioning, now we are working to refine requirements, streamline offerings and establish standards to facilitate the long-term growth of our offerings and the market, overall.

Barbara Pak
Vice President
Single-Family Securitization



About Freddie Mac

Freddie Mac’s mission is to make home possible for families across the nation. Since 1970, we have helped tens of millions of families buy, rent or keep their home.

What We Do

We are a congressionally chartered corporation with a public mission to promote liquidity, stability and affordability in the housing market throughout all economic cycles.



Liquidity

We keep mortgage money flowing through the housing market in communities from coast to coast, including cities, rural areas and underserved areas.



Stability

Our support for the housing market in all economic environments helps families buy, rent and keep homes they can afford.



Affordability

We are committed to creating a more affordable, sustainable and equitable housing finance system. We are also working on ways to address the lack of affordable housing supply through creation, preservation and rehabilitation.

Freddie Mac operates in the U.S. secondary mortgage market, buying responsible, sustainable mortgages from approved single-family and multifamily lenders. We then pool the mortgages into securities and sell them to a diverse set of investors from all over the world. This process enables us to buy more loans from lenders who can in turn help more families buy or rent a home. We serve this role throughout the economic cycle, in good times and bad.



Our Mission and Strategic Priorities

Freddie Mac has four strategic priorities, each of which was created to ensure we fully serve our mission:

- Deliver on affordable housing.
- Identify, assess and manage our risks.
- Grow, develop and empower talent – for today and tomorrow.
- Build financial strength to serve our mission.

These strategic priorities help us create a more liquid, stable, affordable and equitable housing finance system that serves lenders, families and the housing market as a whole. And, as with any mission-driven company, our people are at the center of all we do.



Freddie Mac Sustainability Strategy

In a changing world, our sustainability efforts help ensure we can continue to make home possible equitably and responsibly for families across the nation. To that end, Freddie Mac has implemented an enterprise-wide sustainability strategy that supports the continued success and longevity of our business, the housing industry and the planet. See our [2022 Sustainability Report](#) for more details.

Sustainability Strategic Framework

Our Sustainability focus areas are interconnected and designed to play a distinct part in accomplishing our Corporate Strategic priorities and all three long-term Sustainability goals.





Our 2023 Impact

In a year with significant volatility and a challenging macroeconomic environment, Freddie Mac helped more than 1.4 million families buy, refinance or rent a home while delivering solid financial results. That included¹:

Providing approximately
\$348 billion
in liquidity to the
housing market through
more than 1,000 lenders.

Financing approximately
800,000 home purchases,
with 51% of those who
purchased a primary
residence being first-
time homebuyers,
the highest percentage
since the company
started tracking that
statistic three
decades ago.

Financing more than
447,000 rental units,
92% of which were
affordable to families
earning no more than
120% of area median
income (AMI).

¹ Results presented in this section refer to results from Freddie Mac's business, in its entirety, not limited to Green MBS issuance.



Our Business

Since 2008, Freddie Mac has been operating in conservatorship, with the Federal Housing Finance Agency (FHFA) as conservator. FHFA is also our regulator. For more information, see “Conservatorship and Related Matters” in our [2023 Annual Report on Form 10-K](#) (2023 Annual Report).

We execute on our mission and sustainability strategy through two business segments:



Freddie Mac
SINGLE-FAMILY



Freddie Mac
MULTIFAMILY

For more information, see “Our Business Segments” in our 2023 Annual Report. Additional information about sustainability activities in our Multifamily segment can be found in our [Multifamily 2023 Impact Bonds Report](#).

Single-Family Segment

Our Single-Family segment provides liquidity and support to the single-family mortgage market through a variety of activities that include the purchase, securitization and guarantee of single-family loans originated by lenders. Central to our mission is our commitment to helping families attain affordable and sustainable housing and to increasing equitable access to housing finance.

The U.S. residential mortgage market consists of a primary mortgage market that links homebuyers and lenders and a secondary mortgage market that links lenders and investors. The size of the U.S. residential mortgage market is affected by many factors, including changes in interest rates, unemployment rates, homeownership rates, house prices, the supply of housing, lender preferences regarding credit risk and borrower preferences regarding mortgage debt.

In accordance with our [Charter](#), we participate in the secondary mortgage market. The mix of loan products we purchase is affected by several factors, including the volume of loans meeting the requirements of our Charter, the volume meeting our risk appetite and originated according to our purchase standards, and the loan purchase and securitization activity of other financial institutions.

Our primary business model is to acquire loans that lenders originate and then pool those loans into guaranteed mortgage-related securities that transfer interest-rate, prepayment and liquidity risk to investors



and can be sold in the capital markets. We consolidate most of our single-family securitization trusts and, therefore, we recognize the loans held by such trusts and the debt securities issued by such trusts on our balance sheet and recognize the guarantee fees we receive as net interest income. To reduce our exposure under our guarantees, we transfer credit risk on a portion of our single-family mortgage portfolio to the private market in certain instances. The returns we generate from our business activities are primarily derived from the guarantee fees we receive in exchange for providing our guarantee of the principal and interest payments of the issued mortgage-related securities.

Freddie Mac Governance

We are committed to best practices in corporate governance. Our Board of Directors adopted Corporate Governance Guidelines that embody many of our long-standing practices, policies and procedures. Our Board of Directors reviews the Guidelines annually and regularly assesses them against the regulatory and legislative environment in which we operate, as well as evolving best practices. For more information, see “Corporate Governance” in our [2023 Annual Report](#).





Single-Family Green Bond Framework

Freddie Mac’s Single-Family Green MBS program finances the purchase of mortgages that align with the International Capital Market Association’s (ICMA) Green Project categories, including renewable energy and energy efficiency, that contribute to climate change mitigation and adaptation.

Launched in early 2022, our [Single-Family Green Bond Framework](#) received a Light Green Second Opinion rating from CICERO Shades of Green (CICERO). CICERO provides second opinions on institutions’ frameworks and independent reviews of green bonds. The Light Green rating is allocated to transition activities that do not lock in emissions. These projects reduce emissions or have other environmental benefits in the near term rather than representing low carbon and climate resilient long-term solutions. More information on CICERO ratings can be found at <https://cicero.green/green-bonds>.²

In its second opinion on our Framework, CICERO noted that, “the framework supports investment in new and existing homes with installed renewable energy systems ... helping to align the U.S. housing stock’s energy usage with a 1.5-degree climate scenario.” CICERO noted that, “allowing consumers to use mortgage proceeds to pay for or refinance renewable energy systems helps them overcome the barrier of upfront costs. Consumers’ alternative would be to finance renewable energy systems with personal loans or through leasing arrangements, which could be inaccessible or very expensive if consumers do not have high enough credit ratings.” In relation to our homes with an energy efficiency rating CICERO said, “Improving building energy efficiency is an important aspect of the low carbon transition.”

The Framework addresses the four core components of ICMA’s Green Bonds Principles:



**Use of
Proceeds**



**Process
for Project
Evaluation and
Selection**



**Management
of Proceeds**



**Transparency
through Regular
Reporting**

Promoting housing affordability is fundamental to Freddie Mac’s mission and reducing the environmental impact of housing further aligns with our mission focus. Freddie Mac has a team of experts across the company supporting the Framework. The [Single-Family Green Bond Framework](#) and associated [CICERO Second Opinion](#) are available at [FreddieMac.com](https://www.freddiemac.com).

² Since providing the Second Opinion, CICERO has been acquired by S&P Global.



Use of Proceeds

In 2019, Single-Family created the GreenCHOICE Mortgage offering to finance energy-efficient home improvements, helping more families attain and maintain affordability and reduce environmental impacts.

In April 2021, Single-Family issued our first Green MBS. Each Single-Family Green MBS issued in 2021 was backed by GreenCHOICE Mortgages, where borrowers used refinance proceeds to finance energy efficient home improvements.

Specifically, the proceeds or a portion thereof from each refinance mortgage backing these Single-Family Green MBS paid off existing debt that was used to finance the purchase and installation of solar panels as a renewable energy source. By refinancing a consumer loan into a mortgage loan, borrowers are likely to achieve cost savings with less expensive, more efficient financing. Our initial Single-Family Green MBS issuances focused on financing energy efficient improvements made to existing homes.

With the publication of our Framework in January 2022, we expanded the Single-Family Green MBS eligibility criteria to include new construction with a renewable energy source or a qualifying energy efficiency rating. In the Single-Family Green MBS issued in 2022, we included mortgages backed by newly constructed homes with a HERS Index Score of 60 or less, in addition to refinance mortgages that paid off existing debt that was used to finance the purchase and installation of solar panels.

The [HERS Index](#) was created and is maintained by the [Residential Energy Services Network](#) (RESNET). The HERS Index is an industry standard for measuring a home's energy efficiency and is recognized by the U.S. Department of Energy (DOE) and the Environmental Protection Agency (EPA). As of January 2024, over 4 million homes in the United States have been issued a HERS Index Score.³

³ <https://www.hersindex.com/>



The process for obtaining a HERS Index Score includes a certified RESNET HERS Rater assessing the energy efficiency of a home using energy modeling software which produces a relative performance score. The lower the number, the more energy-efficient the home. A home built to the 2006 International Energy Conservation Code (IECC) is awarded a rating of 100 and serves as the baseline. A home with a HERS Index Score of 60 is roughly 40% more energy efficient than the reference home built to the 2006 IECC.

The HERS Index was chosen because of its industry recognition and the foundational basis it serves for other energy certifications. In addition to being recognized by the DOE and EPA, the rating is used as an input for Energy Star certification. RESNET also maintains a national registry of all HERS ratings and can connect with entities to share that information, so the standard is scalable. Freddie Mac chose the HERS Index level of 60 because it is comparable to the efficiency associated with the Energy Star v3.1 certification, which has a target range that generally corresponds to HERS scores between 55 and 65⁴.



In 2023, we issued approximately **\$1.9 billion** in **Single-Family Green MBS**, bringing our total issuance since 2021 to **\$3.8 billion**.



In 2023, we also included mortgages backed by newly constructed homes with a renewable energy source as collateral for our Green MBS. This type of collateral was designated as eligible collateral in our Framework but no such mortgages were included in any Green MBS issued in 2022. In our 2023 Green MBS issuance, the loans backed by newly constructed homes with a renewable energy source were all backed by homes with solar panels. Loans backed by these homes are eligible for inclusion in Green MBS whether or not the homes have a HERS score.

Freddie Mac's Single-Family Green MBS issuance is a natural extension of our role in providing standards and scale to the nation's housing markets. By devoting resources specifically to encourage green construction and energy efficiency home improvements, we believe we can help expand availability and market demand. In 2023, we issued approximately \$1.9 billion in Single-Family Green MBS, bringing our total issuance since 2021 to \$3.8 billion.

⁴ https://www.energystar.gov/sites/default/files/tools/2021.09.27_Raising%20the%20Bar.pdf



Process for Project Evaluation and Selection

All Green MBS issued in 2023 were backed by (i) mortgages secured by newly constructed homes with a qualifying HERS score, (ii) mortgages secured by newly constructed homes with solar panels or (iii) GreenCHOICE Mortgages where the proceeds or portion thereof from each refinanced mortgage paid off existing debt that was used to finance the purchase and installation of solar panels.

- For mortgages backed by newly constructed homes with a qualifying HERS score, our Sellers represented to Freddie Mac that the home received a qualifying HERS score. Before we pool and issue new Green MBS, we validate the required HERS scores on the properties securing each of the mortgages to be pooled in a Single-Family Green MBS.
- For mortgages backed by newly constructed homes with a renewable energy source, our Sellers represented to Freddie Mac that the home has a renewable energy source. Prior to issuing new Green MBS, we confirm the presence of a renewable energy source installed on each property that secures each of the mortgages included in Single-Family Green MBS.
- For GreenCHOICE Mortgages, our Sellers represented to Freddie Mac that the refinance proceeds were used to pay off debt used to finance renewable energy improvements. We validate the presence of a renewable energy source installed on each property that secures each of the mortgages included in Single-Family Green MBS.





Management of Proceeds

The management of proceeds for Freddie Mac Single-Family Green MBS is consistent with the management of proceeds across all of Freddie Mac's Single-Family MBS. Like all of our MBS offerings, our Single-Family Green MBS only contain mortgages that comply with the Freddie Mac *Single-Family Seller/ Servicer Guide* (Guide). The mortgages backing our Single-Family Green MBS leverage Freddie Mac's existing mortgage purchase process to ensure adherence to the Guide. Once the mortgages are acquired, they are securitized into Single-Family Green MBS per the criteria described in the Framework, and the securitized mortgages are sold to the MBS investment community. Freddie Mac's proceeds from sales of Single-Family MBS (including Single-Family Green MBS) are used to help finance additional purchases of mortgages that meet the criteria described in the Guide, including additional purchases of GreenCHOICE Mortgages or other mortgages to be used for future issuances of Single-Family Green MBS.

2023 Freddie Mac Single-Family Green MBS Issuance

	Number of Securities	Number of Loans	Original Unpaid Principal Balance (\$M)
January-23	6	469	\$199
February-23	8	239	\$105
March-23	7	301	\$125
April-23	6	350	\$152
May-23	5	364	\$158
June-23	6	429	\$178
July-23	5	464	\$209
August-23	6	312	\$143
September-23	6	312	\$135
October-23	6	478	\$204
November-23	0	0	0
December-23	7	571	\$249
TOTAL 2023	68	4,289	\$1,856
Total 2022	62	3,982	\$1,372
% Change 2022 to 2023	10%	8%	35%
Total 2021	84	2,454	\$617
% Change 2021 to 2022	-26%	62%	122%
GRAND TOTAL	214	10,725	\$3,845



Summary of Estimated 2023 Impact⁵



**211,468 MMBtu
of estimated
source energy
saved annually.**

This is enough energy to power 2,051 homes and represents an estimated 28% average decrease in total source energy consumed by these homes.⁶



**11,434 metric
tons of estimated
GHG emissions
avoided annually.**

This is equivalent to removing 2,721 gasoline powered passenger vehicles from the road for a year and represents an estimated 34% decrease in total GHG emissions resulting from energy consumption at these homes.⁷



**\$698 of estimated
average annual
utility cost savings
for homeowners.**

This represents an estimated 30% average decrease in total annual utility bills for these borrowers.

In our second year of Green MBS issuance including mortgages backed by newly constructed homes with a qualifying HERS score, the actual energy efficiency of these HERS-rated homes exceeded the threshold set forth in our Framework and the average HERS score of loans pooled in Green MBS improved year over year. **Across all 4,222 homes with qualifying HERS scores backing mortgages included in Green MBS issued in 2023, the average HERS score was 52, 57% of these loans had a score of 55 or lower and 24% had a score of 50 or lower.** This is an improvement from 2022 when the average score of HERS-rated homes included in Green MBS was 54.

It should be noted that, over time, the concentration of different types of eligible collateral backing our Green MBS has changed because of the changing market environment. Our initial Green MBS issuance in 2021 was backed entirely by refinance loans (i.e., GreenCHOICE mortgages) where a portion of the proceeds was used to pay off debt used to finance renewable energy improvements. This was during a period of heavy refinance activity which continued into early 2022. At the beginning of 2022 we started to include mortgages backed by newly constructed homes with a qualifying HERS score in our Green MBS. Over the course of the year, refinance volumes tapered off and mortgages backed by HERS-rated collateral came to represent the preponderance of the collateral backing our Green MBS issuance. For that year, mortgages backed by HERS-rated collateral represented 79% of the collateral backing Green MBS. This trend continued in 2023 as only three GreenCHOICE refinance loans were included in Green MBS issued during the year.

⁵ Estimated impacts related to Single-Family Green MBS issued in 2023. All estimated impact statistics are calculated using the methodology described in the Appendix.

⁶ In 2022 the average annual electricity consumption for a U.S. residential utility customer was 10,791 kilowatt hours (kWh), an average of about 899 kWh per month (<https://www.eia.gov/tools/faqs/faq.php?id=97&t=3>).

⁷ Calculated using EPA GHG Equivalencies Calculator (<https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator>).



To that was added another 95⁸ loans backed by newly constructed homes with a renewable energy source and the remaining 4,191 loans were backed by newly constructed homes with a qualifying HERS score.

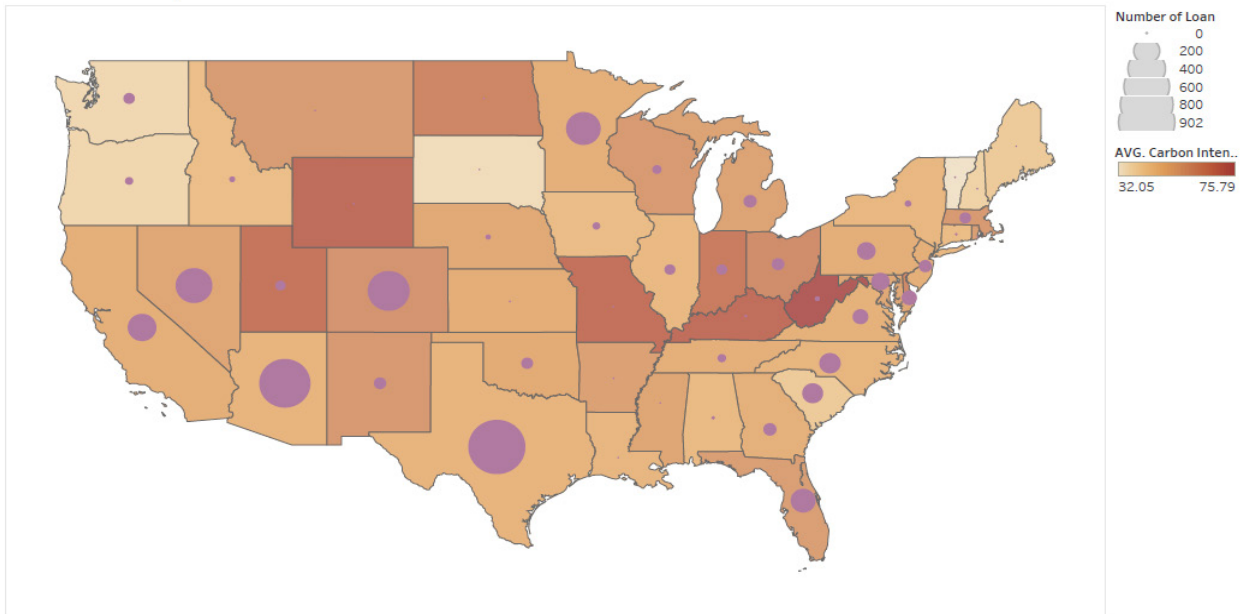
Benefits of Green Improvements

While energy efficiency improvements reduce environmental impact regardless of where the property is located, the impact from such improvements will be greater in certain markets. For example, greenhouse gas (GHG) emissions reduction due to energy-saving improvements will be greater in cases where the property’s source energy comes from a more carbon-intensive generation mix, such as coal or natural gas. The utility cost savings of home energy improvements for individual families can also be greater in markets where energy costs are higher.

Environmental Impact Based on Carbon Intensity of Energy Supply⁹

Each state has a unique profile of the types of fuel sources used to produce energy. Carbon-producing fuel sources such as coal, petroleum and natural gas vary in the amount of carbon produced to generate energy and a state’s mix of such fuel sources will directly impact the state’s total energy-related carbon dioxide (CO₂) emissions.

Carbon Intensity



8 Includes 31 new construction homes with both HERS scores and solar panels.

9 Source: Freddie Mac tabulation of 2021 U.S. Energy Information Administration Energy-Related Carbon Dioxide Emissions by State data <https://www.eia.gov/environment/emissions/state/>. Information presented excludes two loans on properties located in Hawaii.



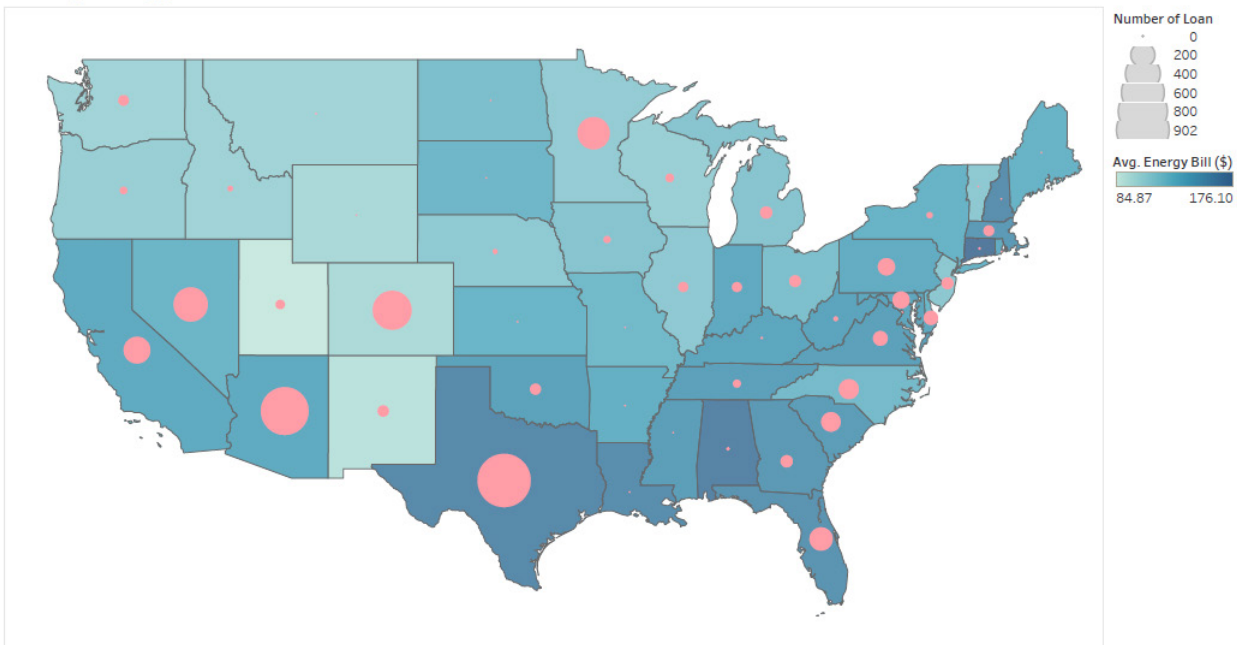
The map above shows the location of properties related to mortgages backing the Single-Family Green MBS issued in 2023, relative to the carbon intensity of the energy supply within that state. States with a more carbon-intensive energy supply are shaded in dark brown and states with a less carbon-intensive energy supply are shaded in light brown. The circle within each state represents the number of properties within that state that relate to loans included in Green MBS.

We found that **1,432** properties, representing **33%** of properties with mortgages included in Green MBS issued in 2023, were in states with a carbon intensity of energy supply greater than the national average of **50.2 kg** of CO₂ per million Btu (kg CO₂/MMBtu). In addition, **652**, or **15%**, of these properties were in states that were among the 10 highest in terms of carbon intensity of energy supply, with an average carbon intensity of energy supply over **57.5 kg** CO₂/MMBtu. For comparison, 33% of properties with mortgages included in Green MBS issued in 2022 were in states with a carbon intensity of energy production greater than the national average and 6% were in states that were among the 10 highest in terms of carbon intensity of energy production. Improvements made on properties located in areas with a higher carbon intensity of energy supply can be expected to have a greater contribution to the community's overall health and provide a greater impact on GHG emissions than improvements made on properties in states where the carbon intensity of the energy supply is lower.

Utility Cost Savings in Areas of High Electricity Costs¹⁰

The map below shows the average monthly electric utility bills by state, relative to the location of the properties related to mortgages backing our Green MBS issued in 2023. States with the most expensive electricity bills are shaded in dark blue and those with the least expensive bills are shaded in light blue.

Average Energy Bill



¹⁰ Source: Freddie Mac tabulation of 2022 U.S. Energy Information Administration Residential Energy Bill by State-by-State data https://www.eia.gov/electricity/sales_revenue_price/pdf/table_5A.pdf. Information presented excluded two loans on properties located in Hawaii.



The national average electric utility bill is **\$135** per month. By comparison, the average electric utility bill for the **10** states with the most expensive electricity bills is \$157 per month, or **16%** higher than the national average. A total of 60% (2,570 loans) of the mortgages included in Green MBS issued in 2023 were made to borrowers who live in states with above average electricity bills. Our analysis shows that **1,378 mortgages, or 30% of mortgages included in Green MBS issued in 2023**, were made to borrowers in the 10 states with the highest average electricity bills. For comparison, 58% of properties with mortgages included in Green MBS issued in 2022 were in states with above average energy bills and 40% were in states that were among the 10 highest in terms of average electricity bills.

Transparency to Investors

To maintain transparency for the investment community, Freddie Mac provides securities disclosures, including detailed pool-level and loan-level disclosures. Freddie Mac's [Single-Family Green MBS website](#) serves as a centralized source of information related to our Single-Family Green MBS program. This webpage contains an overview of eligible collateral, as well as links to our Framework and Second Opinion.

In March 2024 Freddie Mac began disclosing new pool-level attributes that describe certain environmentally friendly attributes of collateral backing our Green MBS. These attributes include a Green indicator that identifies pools that are issued under our Framework, as well as stratifications that identify the share of loans in each pool secured by properties with Green Building Certifications, Energy Rating Indices and Renewable Energy sources.

Freddie Mac is also making available the estimated impacts by security for all of our Single-Family Green MBS issued in 2023 in a downloadable Excel format ([Estimated Impact File](#)). For each Green MBS security, the Estimated Impact File provides:

- Estimated annual savings in source energy (based on estimated energy produced by photovoltaic (PV) systems or estimated energy saved due to the energy efficiency of properties with HERS scores);
- Estimated annual GHG emissions avoided; and
- Estimated annual utility cost savings for borrowers.





Appendix Methodology¹¹

To calculate the metrics provided in this report and in the Estimated Impact File, Earth Advantage® developed a methodology in consultation with Freddie Mac. Earth Advantage also developed a web-based tool to calculate such metrics at the individual property and security level for all of the Freddie Mac Single-Family Green MBS issued in 2023.¹²

Earth Advantage is a 501(c)(3) nonprofit focused on accelerating the adoption of high-performance and green residential renovation and construction. Founded in 2005 as a spin-off from the electric utility Portland General Electric, the organization provides certification, training, research and IT product development for the building industry. To date, Earth Advantage has green-certified over 20,000 single-family and 20,000 multifamily residences and has provided professional training to over 19,000 real estate agents, appraisers, builders, home performance contractors and architects across the country. Since its inception, Earth Advantage has also consulted with federal, state and local municipalities on green home valuation, residential energy labeling and Home Energy Score delivery. In 2017 Earth Advantage launched the software as a service (SaaS) platform Green Building Registry® to provide a single source for building performance data across the U.S.

Our methodology analyzed and calculated the estimated impact of (i) solar energy production systems located at single-family residential properties for which a mortgage has been originated that repaid a consumer loan that had financed the homeowner-owned system or for which a mortgage has been originated on a new construction home with a renewable energy source and (ii) energy efficiency features on single-family new construction homes with a qualifying HERS rating. As there is no single standard for GHG accounting, in keeping with best practices outlined in [Handbook: Harmonized Framework for Impact Reporting](#) published in June 2023 by ICMA, we are making the methodology publicly available and transparent.

Estimation of the Energy Production and Energy Savings in kWh and Dollar Value of Estimated Utility Cost Savings for Borrowers

To estimate the amount of energy produced by the solar systems on the relevant homes, the methodology used calculations from PVWatts®, a tool developed by the National Renewable Energy Laboratory (NREL)¹³, which has become a standard of the solar industry to estimate the annual energy production from a solar installation given the system's location and basic description. PVWatts considers the physical characteristics of a solar array, including the rated capacity of the solar array in kW, the tilt of the panels, the azimuth of the array, any shading affecting the array and the efficiency of the system. Additionally, PVWatts accounts for the amount of solar energy that reaches a given geographical area on an average basis. Solar installers in the United States generally utilize PVWatts to predict solar energy production for their customers as part of the system design and sales activity of a solar installation. Installers then track the "power factor" of systems in kWh/kW which represents the estimated amount of energy actually produced by the system divided by the nameplate production capacity of the system in kW.

For some properties, detailed solar system information was available from the Green Building Registry (GBR), a database sourced from solar incentive programs that records certain characteristics of solar installations. For these properties, system age and energy production estimates were taken directly from GBR or the solar system's capacity was processed through PVWatts to calculate the estimated energy production for the system.

In the absence of detailed information on a solar system, the average power factor and system size provided by the Berkeley Tracking the Sun Program was used to estimate the energy production of the installed solar system. The Tracking the Sun public data file contains the characteristics of over 2.2 million residential PV systems. For regions of the country where an average power factor was not reported by Tracking the Sun, the PVWatts tool was utilized with the default values for tilt, azimuth and efficiency provided by NREL. Due to the lack of verified information on the characteristics of the solar systems, the estimate of energy production for each solar system was discounted to provide a conservative value.

The age of the system was used to calculate the degradation of the system's energy production capacity as part of the PVWatts tool's calculation. PVWatts estimates system degradation at 1.5% of the system's nameplate capacity in year one and then a 0.5% degradation for each year thereafter. With the knowledge that some solar systems will be less than one year old at the time of the closing of the mortgage and that a large percentage of the systems will likely be less than two years old, this methodology used a typical age of four years to supply a conservative margin of error for the energy production calculation. The four-year age assumption will cause the PVWatts tool to degrade the nameplate capacity of each system by 3%. This four-year age assumption was also used to determine the size of the solar system. This, again, is a conservative assumption, as the Tracking the Sun data indicates that system sizes have generally increased over time.

11 The discussion in this section is based on materials provided to us by Earth Advantage. Freddie Mac has not independently verified any of the information provided in this section.

12 We have not made any significant changes to the methodology since last year's report. However, certain data used to calculate the metrics or consumed by the underlying tools may have been updated or otherwise changed. As a result, the metrics provided in this report and in the Estimated Impact File are not comparable with the metrics provided in previous reports and Estimated Impact Files.

13 NREL is a national laboratory of the U.S. Department of Energy.



The estimated annual energy production value for each solar system was capped at the estimate of the annual electricity consumption for the home. Although it is possible that homeowners could install solar systems that are sized to produce more electricity than their home will consume, this would be rare because electric utility programs and net metering contracts typically do not offer additional financial incentives for installed systems that produce more energy than the home consumes.

For HERS-rated homes, the estimated energy savings was calculated by comparing (i) the HERS rating of the home with (ii) the estimated HERS rating of a “prototype” home built to the code of the same state. State-specific energy savings rates for improvements in HERS ratings were computed, as described below, with separate rates computed for all-electric and gas-heated homes. That savings rate was applied to the HERS index differential, i.e., the difference between the home’s HERS rating and the estimated HERS rating of the prototype home in the same state to provide an estimate for each home of the energy savings created by the home being built to be more efficient than the state’s energy code requirements.

Some newly constructed homes with solar panels backing Green MBS also had HERS ratings. In such an instance the HERS methodology was used to calculate the impact from the solar panels, along with other efficiency measures present in the house.

To assess the estimated dollar value of the utility cost savings for borrowers of the estimated solar energy production and the estimated energy savings from energy-efficient homes, the energy production estimate for homes with solar panels and the energy savings estimate for energy-efficient homes was multiplied by the local price of electricity based on average energy prices provided by NREL’s Utility Rates Database (URDB). The URDB contains average utility rates and time of use rates from over 3,700 utilities across the United States.

All energy production and savings estimates are expressed as source energy, as described below.

Estimation of the Relative Energy Savings from Each Solar Installation

In order to estimate the relative energy savings from each solar installation, the methodology used annual energy consumption estimates provided by the NREL-Energy Cost Estimator (ECE) tool to provide baseline estimates of the energy consumption of the home, as if there were no solar panels on the home. The NREL-ECE tool was developed as a service that the appraisal, real estate and finance industries could use to estimate the annual energy consumption of any home in the United States given a few data points about the home that those industries typically have available to them.

The tool provides estimates of (i) the annual energy consumption of the home in kWh and (ii) the annual amount of fuel used by the home as the heating fuel. The tool assumes the heating fuel is used for space heating and water heating. Those annual fuel use estimates were converted to British thermal units (Btus)/year as estimates of site energy for use as a common energy metric. The conversion to source energy used the site/source conversion factors described below.

Site Energy:

The estimations of the total annual energy consumption from the NREL-ECE tool and the annual solar energy production from the PVWatts tool are provided as site energy values for each home. While the solar energy production value is always provided as units of electricity (kWhs), the energy consumption estimated by the NREL-ECE tool provides values for each fuel known to be used in the home. Each fuel type has its own unit of measurement which can be converted to Btus for comparison using these conversion factors:

Electricity: 1 kWh = 3,412 Btus
 Gas: 1 therm = 99,976 Btus
 Oil: 1 gallon = 131,890 Btus
 Propane: 1 gallon = 91,500 Btus

The estimate of the total site energy consumption for each home was calculated as the sum of the estimated amounts of each type of fuel used in the home, with each fuel converted to Btus.

Source Energy:

Different fuels consumed at a home are obtained through different systems. Some of those systems have higher rates of overall energy loss than others. Historically, the U.S. electrical grid has used about three units of energy in order to deliver one unit of energy to a customer. The ratio of that energy relationship is referred to as the site/source conversion factor. Currently, the EPA uses an estimated site/source conversion factor of 2.80 for electricity in the United States for use within the [Energy Star Portfolio Manager](#) tool and that figure was used by the methodology. The EPA figures for site/source conversion factors of other fuels were also used.

The dollar value of energy consumption of other fuels was calculated in a similar fashion to the calculation of the dollar value of solar production. Local prices were used when available. Otherwise, state or national prices were used. The default electricity rate is obtained for an individual address from NREL, if available. If not, state averages of electricity rates are obtained from the [U.S. Energy Information Association](#). Natural gas, propane and fuel oil costs were calculated utilizing average local fuel cost data from GBR, if available, or state averages from the U.S. Energy Information Administration.

To provide an estimate of the relative energy savings of the solar system, percent savings were estimated for three metrics that were computed for each home: estimated annual savings in source energy, estimated annual GHG emissions avoided and estimated annual utility cost savings for borrowers. These percentages were computed using the solar production value in the numerator and the total baseline home consumption value in the denominator.



Estimation of the Relative Energy Savings for Each HERS-Rated Home

In order to estimate the relative energy savings of each HERS-rated home, a code reference HERS index value for each state was established by modeling a prototype home in each state to the 301-2019 ANSI/RESNET/ICC standard, which provides a consistent, uniform methodology for evaluating and labeling the energy performance of residences. The prototype was the 3-bedroom, 2-bath home used by Pacific Northwest National Lab for standard analysis of energy code performance.

The energy-related characteristics controlled by state-level codes in effect for 2022 were identified and input into the REM/Rate modeling tool. This software tool has been approved by RESNET for use by certified HERS raters to rate homes. Using this information, the tool calculated a HERS rating for a prototypical home built to code in each state and also generated the associated estimated energy consumption of that prototype home.

A code reference HERS index rating provided a comparison against the performance of a reference home built to the 2006 IECC. In general, the assumed HERS Index value of a home built to the 2006 IECC is 100. For this methodology, a 3-bedroom model home was modeled to the 2006 IECC efficiency requirements and a heating fuel-specific 2006 IECC HERS index value was created for a model home built to code in each state, along with estimated energy consumption figures. The HERS index value measures relative energy performance, where a home with a HERS of 60 is thought to have energy performance that is 40% better than the 2006 IECC. That does not necessarily translate to 40% energy savings.

The level of energy savings, and the associated carbon emission reductions, will vary by the state's climate zone and the carbon intensity of the electricity supplied to the home. This methodology used the projected energy savings between the state and fuel-specific 2006 IECC reference home and the state and fuel-specific code reference home to estimate a sliding scale of energy savings by fuel type by state that can be associated with HERS index values of 60 or below. These state and fuel-specific savings coefficients were applied to estimate the savings of each home included in Green MBS by multiplying the applicable coefficient against the HERS index differential between the state code HERS reference index value and the home's confirmed HERS index value.

The relative energy savings for each home was calculated using the coefficients, described above, for each fuel type used in the home, combined with the estimated energy usage for each home from the RESNET registry. Percentage savings measures were then calculated for the same metrics as those calculated for homes with solar installations using projected consumption savings due to energy efficiency as the numerator and the total home consumption value in the denominator.

Methodology for Project GHG Accounting

The methodology estimated the borrower's the scope 2 (indirect) GHG emission reductions from avoided electricity purchases due to the installation of residential solar photovoltaic systems and the construction of energy-efficient homes. The GHG methodology used was based on emission-related data from the EPA.¹⁴

To estimate emissions avoided from a variety of energy savings methods, the EPA has developed the Avoided Emissions and Generation Tool (AVERT) which uses statistical analysis of recent emissions data from electricity generation plants as reported to the EPA's Air Markets Program Data and National Emissions Inventory. AVERT provides emission rates for each subregion of the United States. With the greater insight that hourly analysis provides, AVERT is able to provide estimates of avoided emission rates for six different categories of energy savings: onshore wind energy, offshore wind energy, rooftop-scale photovoltaic installations, utility-scale photovoltaic installations, portfolio energy efficiency (EE) programs and baseload residential EE programs.

The carbon profile of each category is different because the time of day of the electricity production offset varies for each category. The methodology used the subregional emission rates for rooftop-scale photovoltaic installations and baseload residential EE programs. For each installation of solar panels and each HERS-rated home, the estimated annual avoided GHG emissions was calculated as follows:

For homes with solar panels:

$$\text{Annual Avoided GHG (Metric Tons CO}_2\text{e)} = \text{Annual Solar Production (kWh)} \times \text{Emission Rate (Metric Tons CO}_2\text{e/ kWh)}$$

For HERS-rated homes heated by electricity:

$$\text{Annual Avoided GHG (Metric Tons CO}_2\text{e)} = \text{Annual Electric savings (kWh)} \times \text{Emission Rate (Metric Tons CO}_2\text{e/ kWh)}$$

For HERS-rated homes heated by natural gas:

$$\text{Annual Avoided GHG (Metric Tons CO}_2\text{e)} = \text{Annual Electric savings (kWh)} \times \text{Emission Rate (Metric Tons CO}_2\text{e/ kWh)} + \text{Annual gas savings (therm)} \times \text{Emission Rate (Metric Tons CO}_2\text{e/therm)}$$

The Annualized AVERT Emission Rate for any subregion is typically higher than the average emission rate for electricity in that region. This means that a solar system could be sized to produce less than a home's estimated electricity usage and the solar system could have avoided emissions that are higher than the emissions associated with the home's electricity consumption. Similarly, the percentage of emissions avoided due to energy efficiency could be greater than the percentage reduction of energy consumed. The methodology capped the estimated avoided GHG emissions for any given residential solar system at the estimated GHG emissions associated with electricity usage at the home where the system was installed. This issue did not exist for homes with a qualifying HERS rating because, by definition, energy efficiency measures could never result in avoided GHG emissions in excess of those associated with a home's baseline energy consumption.

¹⁴ From Freddie Mac's perspective this would be considered a subset of scope 3 emissions (i.e. financed emissions). Some consider this classification as scope 4 emissions.



Contact Us

For additional information, please contact the Freddie Mac Investor Inquiry team at investor_inquiry@freddiemac.com.

Disclaimers

To calculate the metrics provided in this report and in the Estimated Impact File, Earth Advantage developed a methodology in consultation with Freddie Mac. Earth Advantage also developed a web-based tool to calculate such metrics at the individual property and security level. This web-based tool leverages third-party tools and data that were recommended by Earth Advantage. We had no role in the creation of these tools and data and can make no representations or warranties concerning the proper operation or design of the tools or the accuracy or completeness of the data. We may fail to properly calculate the metrics in accordance with the methodology, due to process or human error or otherwise.

If the relevant properties and systems were evaluated under different methodologies, it is possible that the environmental impact of the green improvements could be less than suggested by the metrics provided in this report and in the Estimated Impact File. The metrics should not be viewed as projections, forecasts, predictions or opinions with respect to future performance of the relevant properties and systems, including those properties and systems related to loans included in Green MBS issued in the future.

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