



ENERGY STAR®

PortfolioManager®

DataTrends

Commercial Buildings and Onsite Renewable Energy



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About ENERGY STAR Portfolio Manager

EPA's free online ENERGY STAR Portfolio Manager® tool is the industry standard for measuring and tracking energy performance within commercial buildings. In fact, the commercial buildings market has used Portfolio Manager to benchmark billions of square feet of commercial floor space across hundreds of thousands of buildings. The tool provides dozens of energy performance metrics, and some buildings can also receive a 1 – 100 ENERGY STAR score, which rates energy performance in comparison to similar buildings across the country. Learn more about benchmarking at energystar.gov/benchmark.



INTRODUCTION

DataTrends is an ongoing series of original research and analysis from the U.S. Environmental Protection Agency (EPA) using data from the ENERGY STAR® Portfolio Manager® tool. Hundreds of thousands of buildings use Portfolio Manager to track their energy use. We've compiled our observations from this vast database with the hope that this information will help inform and advance the industry. This paper looks at the buildings that report onsite generation of renewable energy, including their type, location, and ENERGY STAR scores—as well as how they have changed over the past decade. We also explain current trends in energy metering and the challenges of properly tracking onsite renewable energy use to understand the energy efficiency of buildings.

METHODOLOGY AND LIMITATIONS

This is a compilation of data on commercial properties with onsite renewable energy entered in Portfolio Manager. Little public data is available on the topic, while Portfolio Manager contains a wealth of information that could help fill the gaps in our understanding.

To develop this report, we pulled data for all properties in Portfolio Manager that reported any onsite solar or onsite wind generation and use as of the end of 2019. We

EPA's Green Power Partnership

EPA's Green Power Partnership is a free, voluntary program that encourages organizations to buy green power as a way to reduce the environmental impacts associated with purchased electricity use. Started in 2001, the Partnership currently works with more than one thousand partners voluntarily purchasing billions of kilowatt-hours of green power annually. Identify which organizations are both consuming and generating the most green power at epa.gov/greenpower.

then applied the following filters: source energy greater than 0 kBtu/ft²; source energy use intensity (EUI) less than 50,000 kBtu/ft²; gross floor area between 100 ft² and 10 million ft² (as calculated by EPA); and total onsite electricity greater than 0 kWh. In the end, we included data for 263,865 properties encompassing 23 billion square feet of floor space.

We recommend that readers approach the following report with an understanding of its limitations. First, keep in mind that this data may not be representative of the commercial building population as a whole, or of particular sectors. Second, all data in Portfolio Manager accounts is self-reported and mostly unverified. Finally, as we'll outline in Section II, there may be inaccuracies in renewable energy meter data due to inconsistencies between what gets reported to customers and what Portfolio Manager requires for benchmarking.

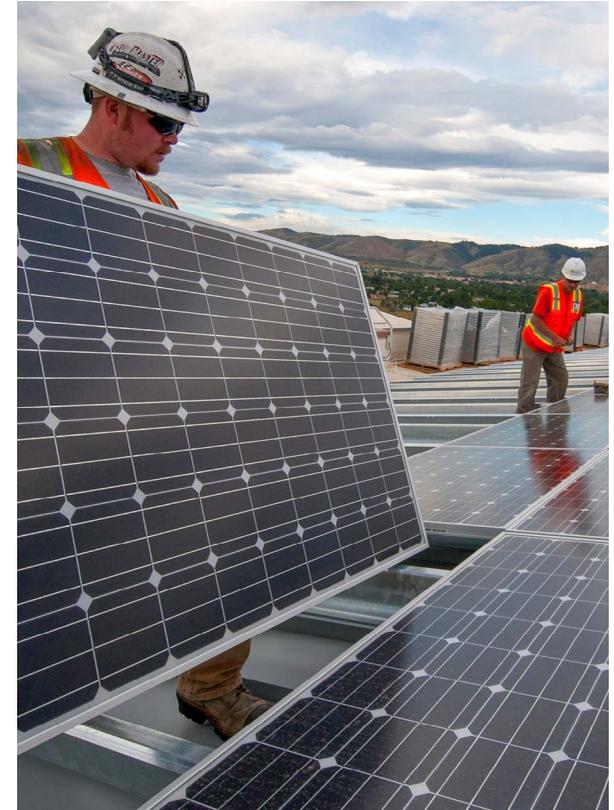
SECTION 1: CHARACTERISTICS OF PROPERTIES WITH ONSITE RENEWABLE ENERGY SYSTEMS

Among the 263,865 properties in Portfolio Manager whose data is included in this report, 2,447 (0.93%) are currently generating onsite renewable energy. The table below shows the 10 most common property types with onsite renewable energy. Subsequent pages highlight details on building types, geography, historical trends, impacts on ENERGY STAR score, and metering.

Properties with onsite renewable energy systems

Primary Property Type	# of properties	% of total properties of that type	Average 1–100 ENERGY STAR score	Average % of electricity needs met
Retail Store	553	1.2%	83	36%
K-12 School	491	2.4%	69	25%
Office	405	1.0%	71	23%
Multifamily Housing	281	0.5%	77	25%
Warehouse/Storage	181	1.6%	60	51%
Public Services	111	0.8%	64	26%
Entertainment/Assembly	64	1.0%	n/a*	30%
Worship Facility	31	2.4%	57	29%
College/University	30	0.8%	n/a*	17%
Hospital	30	1.1%	76	7%

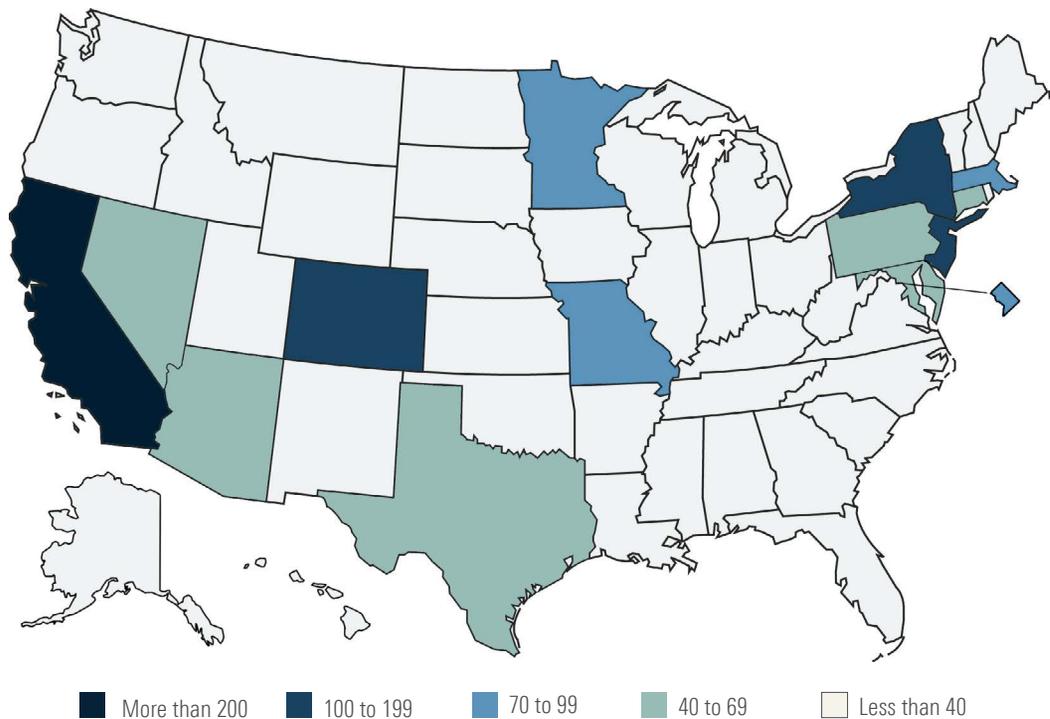
**The 1–100 ENERGY STAR score is not currently available for these property types.*



Where is onsite renewable energy commonly found?

California, Colorado, New York, and New Jersey had the most properties using onsite renewable energy in our data set, while Nevada has the highest percent of properties using onsite renewable energy. In addition to population density, this could be caused by several factors, such as supportive state-level policies and differences in building density or type among states represented in the data.

Number of properties with onsite renewable energy systems by state



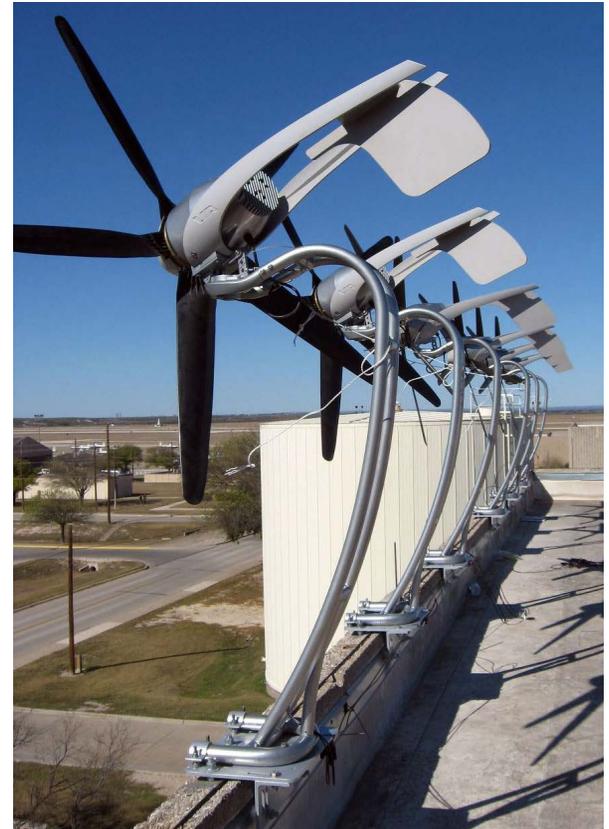
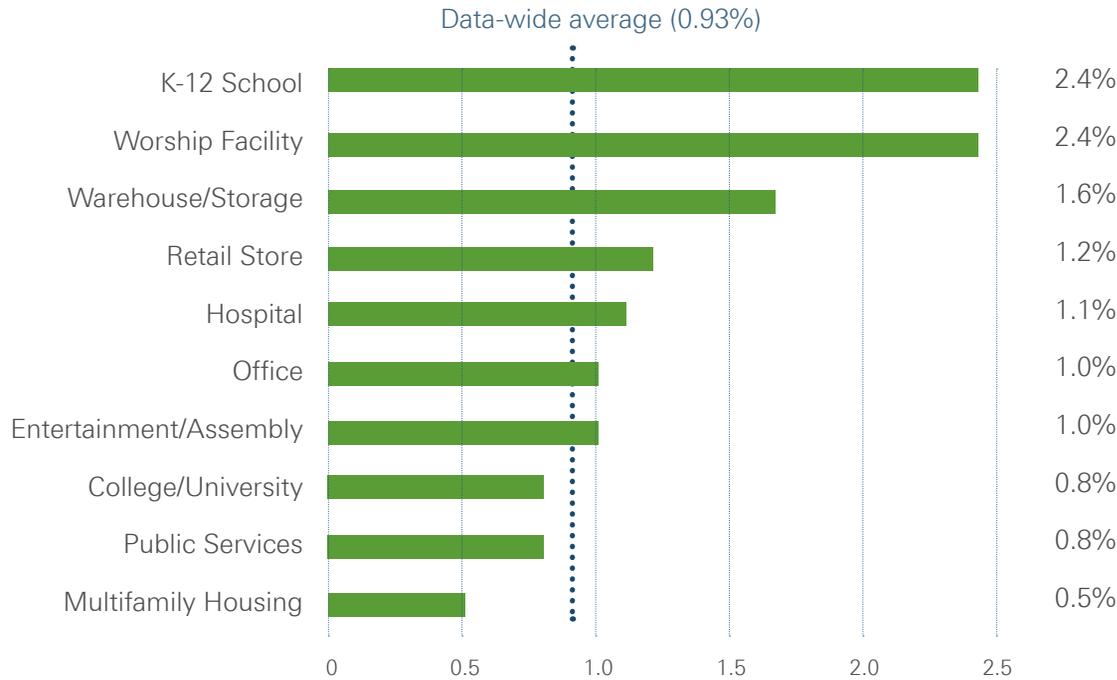
State*	# of properties	% of all those benchmarking in that state
California	981	2.0%
Colorado	164	2.1%
New York	151	0.4%
New Jersey	122	2.8%
Minnesota	97	1.3%
Massachusetts	83	1.1%
Missouri	78	2.0%
Washington, DC	73	2.7%
Nevada	64	3.2%
Connecticut	58	1.8%
Texas	52	0.3%
Maryland	49	1.0%
Arizona	49	1.2%
Pennsylvania	40	0.5%

*Does not include the full list of states represented in the data set

Is onsite renewable energy more prevalent on certain types of buildings?

Among all the buildings in the data set, nearly 1 percent reported onsite renewable energy generation. However, there is a wide dispersion of renewable energy penetration across building types, as we show below.

Percentage of buildings that generate renewable energy onsite



Do buildings with onsite renewable energy systems have higher ENERGY STAR scores?

The average ENERGY STAR score for properties reporting onsite renewable energy is higher when compared to all properties. Why? For one, the source energy conversion factor is lower for onsite renewable energy (see more below). Even accounting for this, the higher scores may indicate that these buildings invested in energy efficiency prior to investing in onsite renewables.

Average ENERGY STAR score

59

vs.

74



All buildings in Portfolio Manager



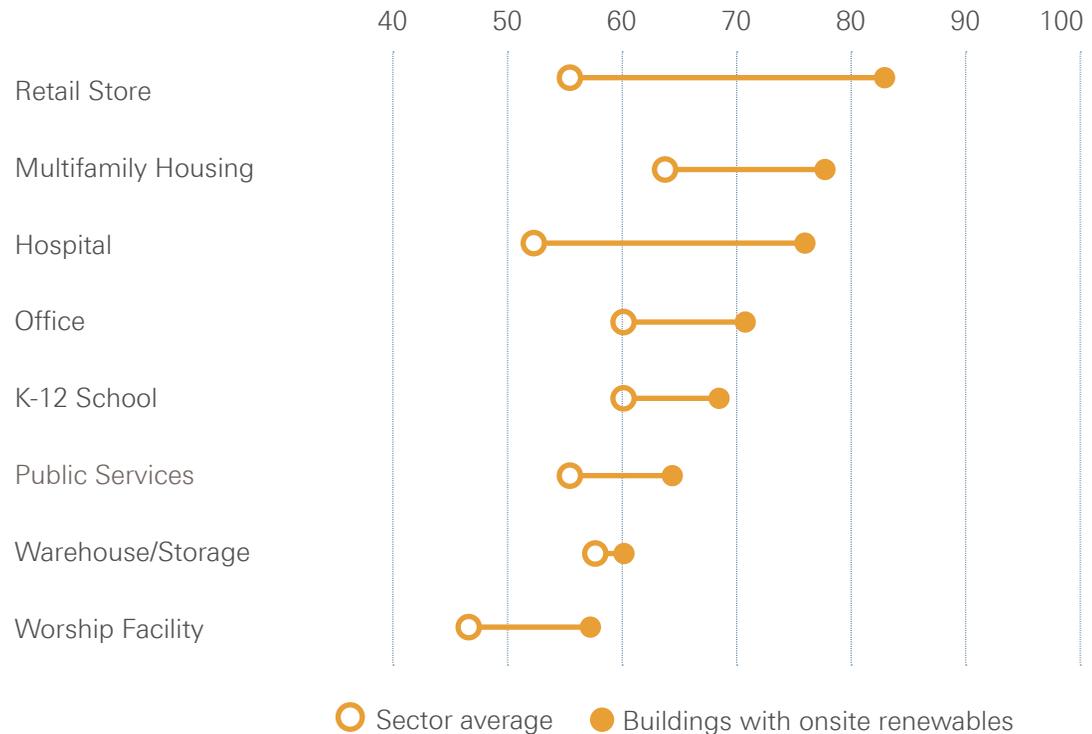
Buildings with onsite renewables

Source energy conversion factors

To allow for a fair comparison of buildings using different fuel types, the ENERGY STAR score is calculated based on the source energy of buildings. EPA assigns a lower source energy conversion factor to energy from onsite renewable systems than energy from the grid, resulting in lower source energy use intensity and a higher ENERGY STAR score.

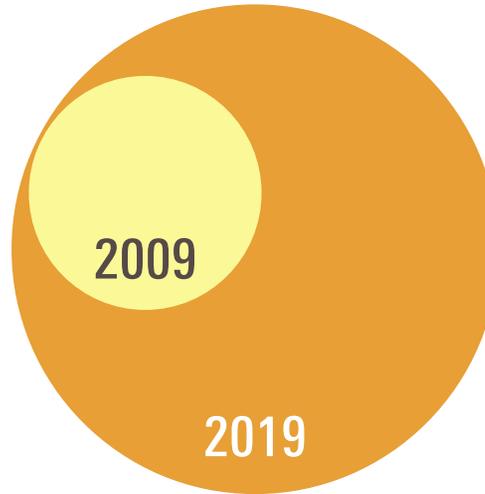
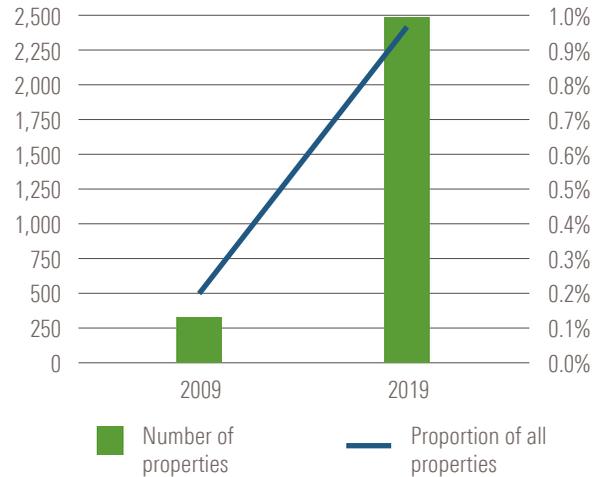
Learn more at: energystar.gov/sourceenergy.

Average ENERGY STAR scores of properties with onsite renewables vs. sector average



How has the use of onsite renewables changed over the past decade?

Within Portfolio Manager, the number of properties reporting onsite generation of renewable energy has increased nearly ten-fold (although still only accounting for 1% of all properties), and onsite renewables are supplying more than six times as much energy as they did in 2009. This may suggest a trend towards smaller onsite systems over the past decade, as decreases in technology costs have increased accessibility to smaller projects.



The number of properties reporting onsite renewable energy has increased nearly ten-fold in the past decade (264 to 2,447). They now make up nearly 1% of all properties benchmarking in Portfolio Manager, whereas ten years ago they only made up two-tenths of one percent.

Onsite renewables are supplying more than six times more of the site energy for properties benchmarking in Portfolio Manager as compared to a decade ago.



HOSPITALS

0% had onsite RE in 2009
1.14% have onsite RE in 2019



WORSHIP FACILITIES

0.16% had onsite RE in 2009
2.4% have onsite RE in 2019



ENTERTAINMENT/ASSEMBLY

0.11% had onsite RE in 2009
1.01% have onsite RE in 2019



K-12 SCHOOLS

0.21% had onsite RE in 2009
2.4% have onsite RE in 2019

We see the highest proportional growth among hospitals, worship facilities, entertainment/assembly buildings, and K-12 schools.

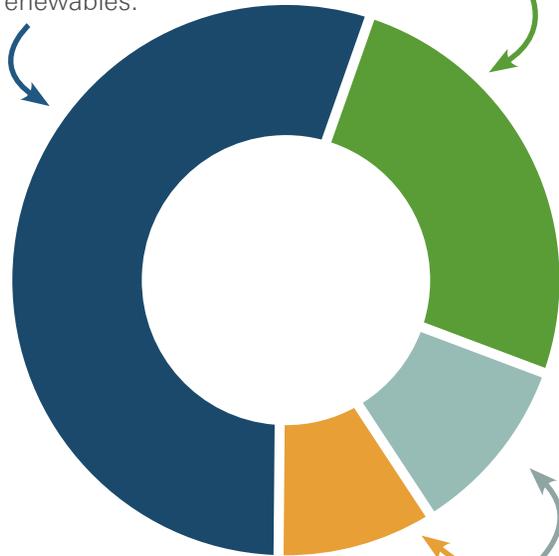


How much electricity are onsite renewable energy systems providing?

About 20% of buildings with onsite renewable energy systems use the energy generated to meet more than half of their total electricity needs. Most, though, are using it to meet a much smaller proportion of their electricity needs: 55% of buildings meet less than a quarter of their electricity consumption from onsite renewables.

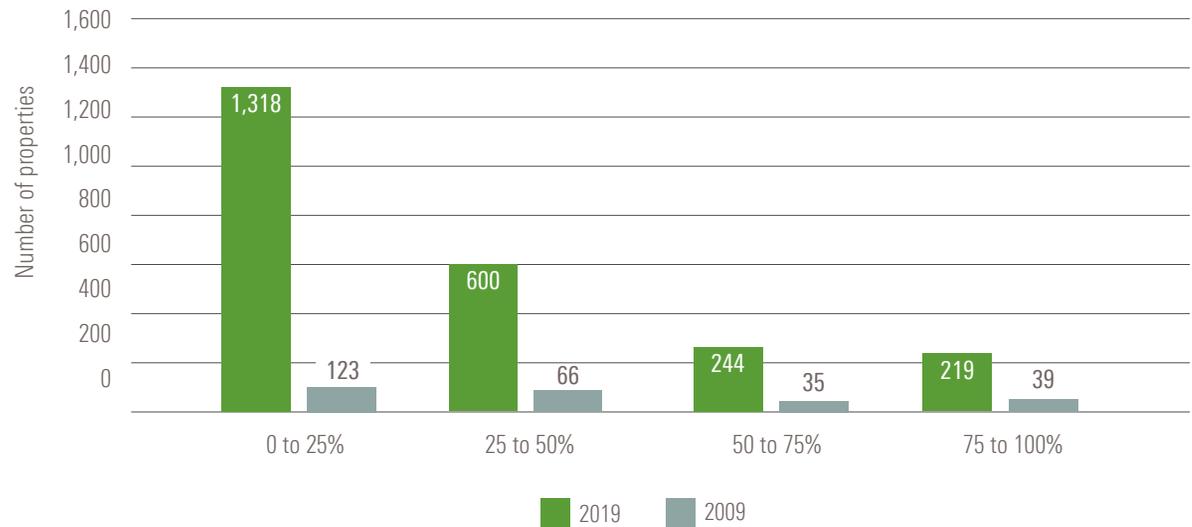
The majority of properties are meeting 25% or less of their electricity needs through their onsite renewables.

A quarter of properties are getting between 25%-50%.



The remaining 20% are split between those getting between 50 and 75%... and those getting more than 75%.

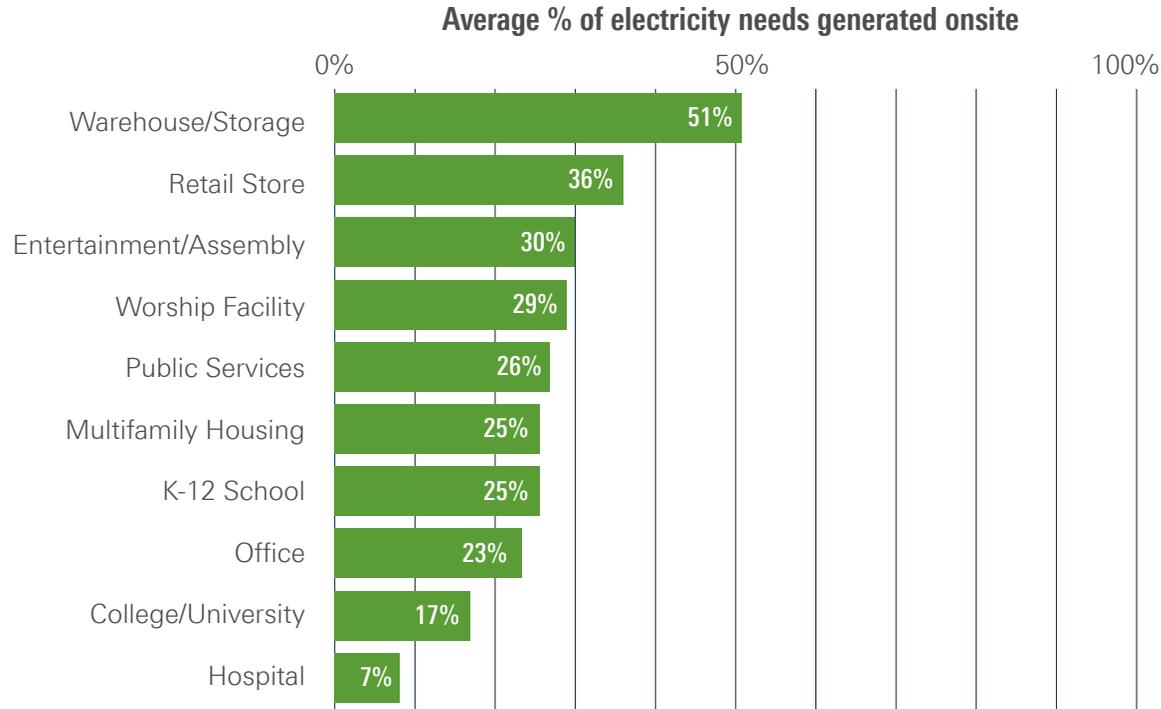
Percentage of total site electricity needs met by onsite renewable systems



In 2019, the majority of buildings with onsite renewable energy used it to meet less than 25% of their electricity needs. We see a similar trend in 2009, but not as pronounced.

Do certain building types cover more of their electricity needs than others?

Building types in our sample differed by what percentage of electricity needs they generated. Factors such as total energy use and the ratio of roof size to floor area may play a role.



Self-storage facilities (a subset of the “Warehouse/Storage” category) generate, on average, 60% of all their electricity needs from onsite renewables.

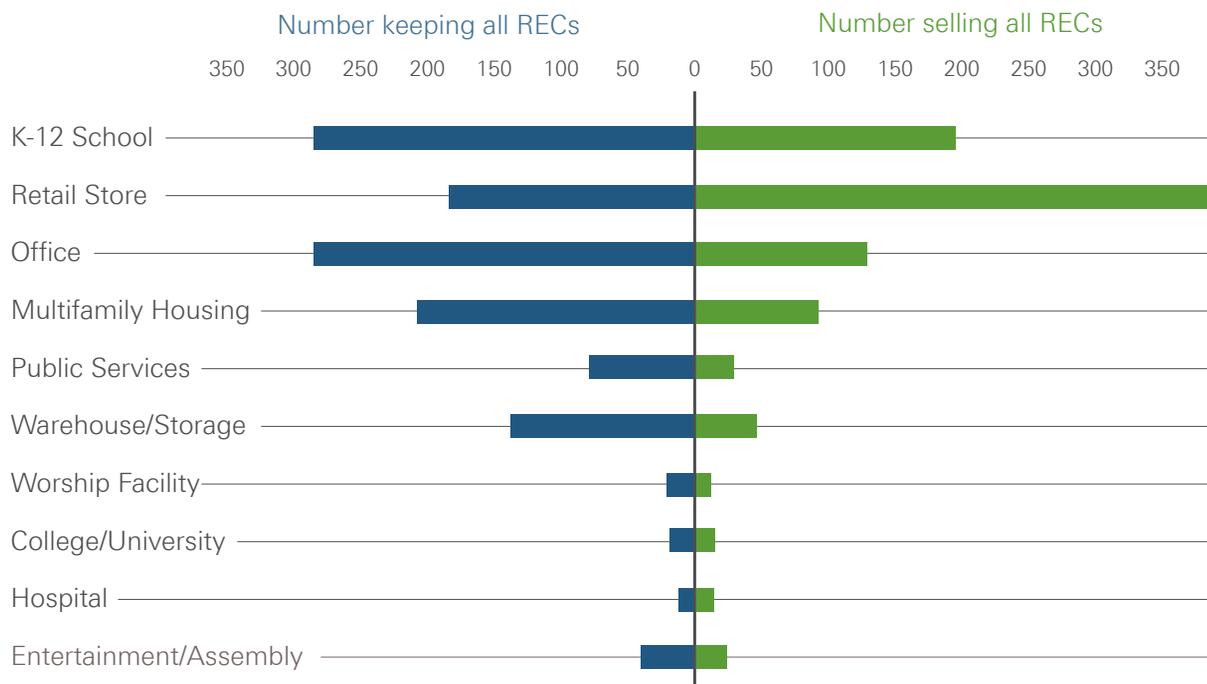


Hospitals generate only 7% of their (very high) electricity needs from onsite renewables.

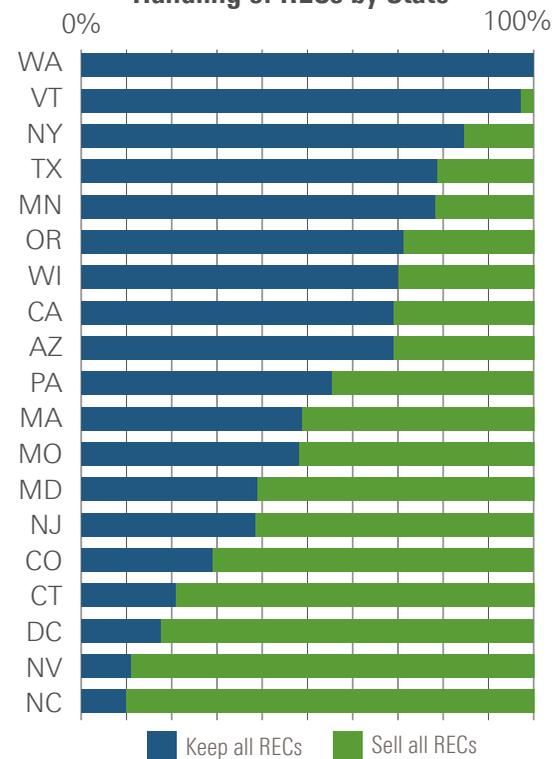
What are buildings doing with their renewable energy certificates (RECs)?

RECs represent the rights to the environmental attributes of renewable electricity. RECs are issued when one megawatt-hour of electricity is generated from a renewable energy resource and delivered to the grid. Among buildings in our data set, 60% retained all the environmental claims (RECs) associated with their renewable systems' electricity production. Practices vary considerably by building type and also by state, which may reflect state-level policies.

Handling of RECs by Building Type



Handling of RECs by State

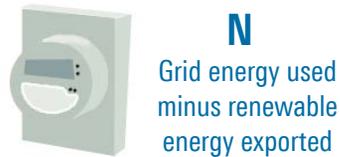


SECTION 2: METERING CHALLENGES AND CONSIDERATIONS

There are three primary types of meters that electric distribution utilities provide for their customers. The type is determined by the local utility's interconnection standards and policies, contractual agreements, and the building electrical system. This section will examine the information provided (or not provided), and, in the case of the latter, the impacts that this lack of information has on energy benchmarking and energy efficiency goals. First, a look at three common metering systems.

Net meters

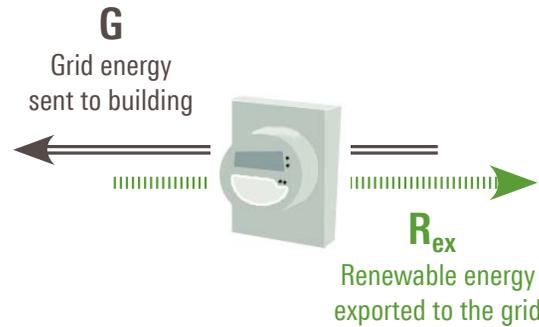
Net meters can spin forward or backward, showing the net consumption of power. They won't tell you exactly what you imported and what you exported. They only indicate the difference between the two, or net usage (N).



Net meters are most closely aligned with utility billing systems. These systems only require a measure of net usage to calculate bill amounts.

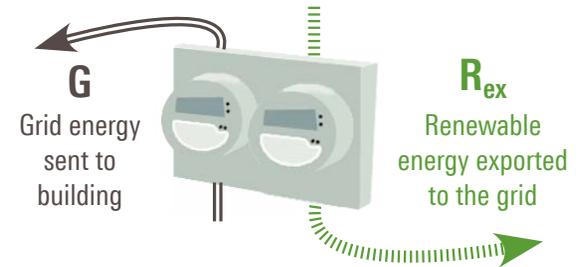
Bi-directional meters

Bi-directional meters tell you how much grid energy you imported (G) and how much renewable energy you exported (R_{ex}). Utilities may share these two values with the customer, or they may only share the difference, or "net" usage.



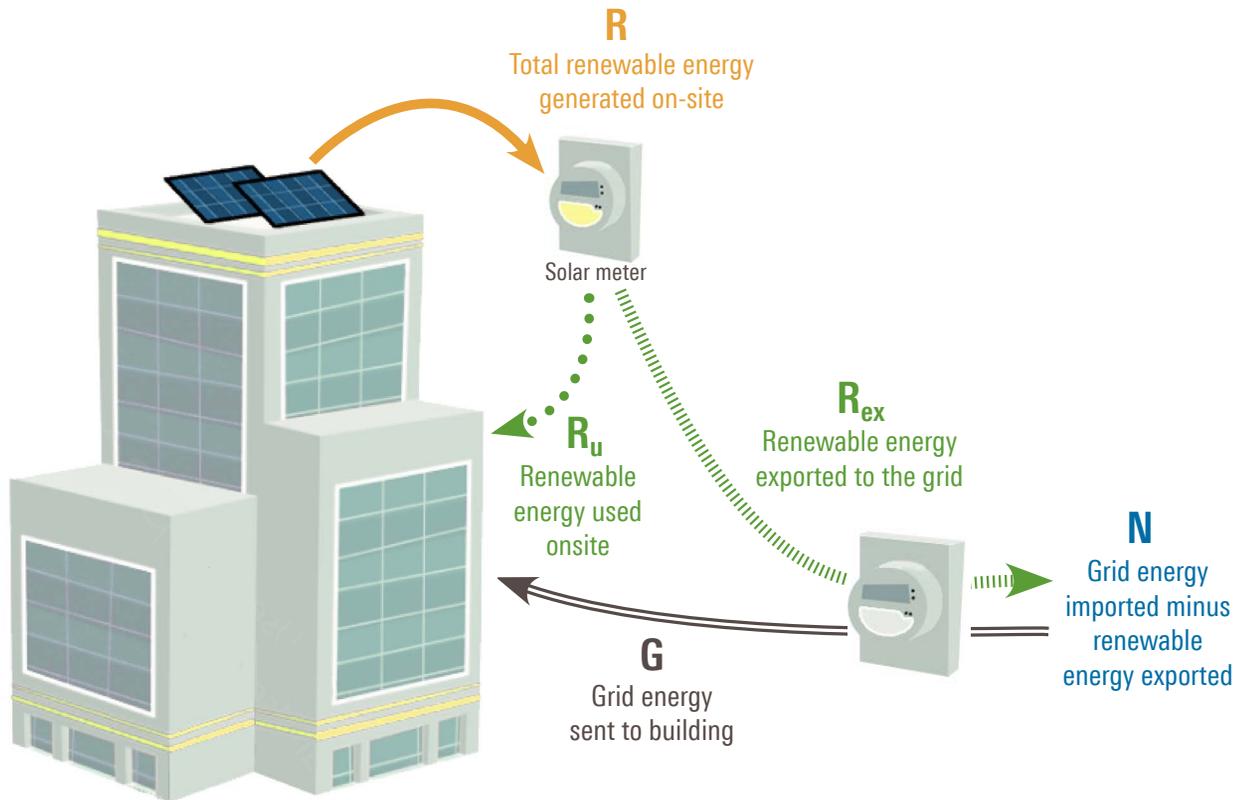
Dual meters

With dual metering, a traditional usage meter measures how much grid energy you imported (G), while a separate meter measures how much renewable energy you exported (R_{ex}). Utilities may share these two values with the customer, or they may only share the difference, or "net" usage. This is far less common than net meters and bi-directional meters.



Understanding energy flows

The diagram below shows how energy moves between an onsite renewable energy system and the grid. Insight into these flows is critical to understanding a building's energy performance, but several of them are often not reported to the customer.



R: **Total amount of renewable energy generated onsite**
Properties with onsite renewables should have access to this quantity

R_{ex}: **Renewable energy generated onsite, exported back to grid**
Availability depends on metering (utility meter or owner submeter)

R_u: **Renewable energy generated onsite, used onsite**
Can be calculated as $R - R_{ex}$.

G: **Grid energy sent to building**
Availability depends on metering (utility meter or owner submeter)

N: **Net consumption of grid energy, accounting for exports**
Shows what a customer owes on utility bills. Equal to $G - R_{ex}$.

Total site energy required to operate the building: Equal to $R_u + G$ or $N + R$.

Total source energy required to operate the building: Must be calculated as $R_u + G$.

Billing and metering practices: Obstacles to accurate energy benchmarking?

Utility-provided data that includes only net consumption—either because of net meters or utility billing practices—makes it difficult for owners and managers to benchmark their energy performance because they don't know how much energy their building is using. What are the barriers, and how can they be overcome?

How Portfolio Manager incorporates onsite renewables into efficiency calculations

To assess a building's energy performance, you must know all of its energy use, regardless of the source. For properties with onsite renewable systems, Portfolio Manager requires the values of R_{EX} , R_U , and G in order to benchmark accurately. Users must allocate them across two meters: one for grid electricity and one for onsite renewable electricity. These two meters are necessary to accurately estimate the energy performance and environmental impacts associated with the building's various electricity uses.

Onsite renewable meter		Grid meter	
Rex	<input type="text"/>	Ru	<input type="text"/>
		G	<input type="text"/>

Portfolio Manager then assigns source energy conversion factors to each of these values (1.0 for onsite renewable energy and 2.80 for grid electricity*). The final source energy values are then used to rate a building's efficiency.

*As of 2020. Source conversion factors apply to U.S. buildings only.

Net billing and Portfolio Manager

Most buildings with net meters or utility bills providing net consumption only have access to R and N . These buildings may choose not to benchmark, or else find workarounds that will lead to inaccurate benchmarking results, as we'll outline on the next page.

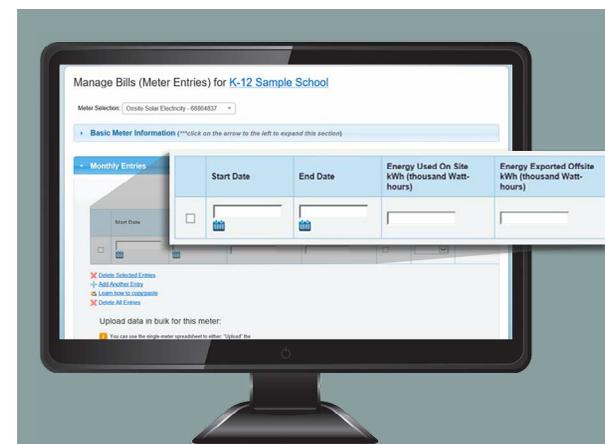
Possible solutions

Buildings may be able to find R_{EX} and G elsewhere (e.g., metering installed by the solar developer or through an energy management system). Utilities may find R_{EX} and G within non-billing systems (e.g., meter data management systems) and find a way to provide them to customers.

Developers and utilities may also be willing to retrofit older meters with newer versions capable of measuring and reporting R_{EX} and G .



Find a "how-to" video on correctly entering onsite renewable data into Portfolio Manager at: youtu.be/L9pvzTeruZM



Above: A screenshot from Portfolio Manager shows where users must enter utility bill data for an onsite solar meter. There are fields for energy used onsite (R_U) and energy exported offsite (R_{EX}). Portfolio Manager also asks whether RECs have been retained or sold, which it uses to calculate this building's greenhouse gas emissions.



Billing and metering practices: Obstacles to accurate energy benchmarking? (cont.)

Building owners have come up with several ways to benchmark their buildings despite a lack of data, but these methods each have their own flaws.

Common workarounds and their shortfalls

“All grid” workaround:

Take a conservative approach and simply record all onsite renewable energy as “grid electricity.”

Why this is incorrect:

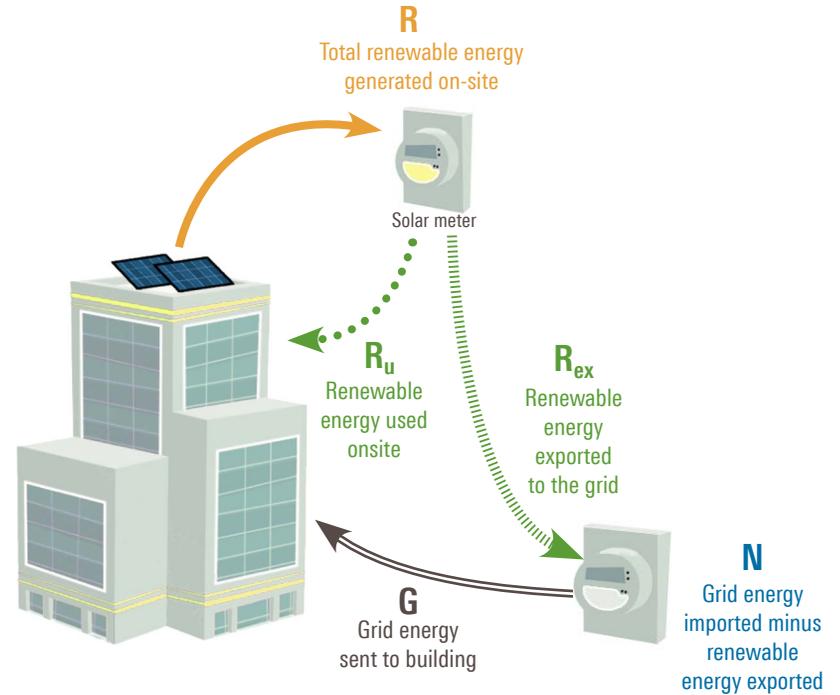
This accurately accounts for site energy. But it ignores the amount of renewable energy used and overstates the amount of energy consumed from the grid. This is problematic because Portfolio Manager metrics are based on *source energy*. Onsite renewable energy has a lower site-source ratio (1.0) than grid electricity (2.80*). As a result, this approach raises source EUI and artificially lowers a building’s ENERGY STAR score.

“R+ N” workaround:

Enter R in “Ru” for onsite renewable meter and N for grid meter. Since $R + N$ is mathematically equivalent to $(R_{ex} + R_u) + (G - R_{ex})$, this workaround accurately reports all the energy used in the building.

Why this is incorrect:

This accurately accounts for site energy. But it overstates the amount of renewable energy used (since any excess is sent back to the grid) and understates the amount of energy consumed from the grid. As a result, this approach lowers source EUI and artificially raises a building’s ENERGY STAR score.



*Source conversion factors apply to U.S. buildings only.

Learn more about site-source energy conversion and how Portfolio Manager calculates scores at: energystar.gov/sourceenergy.



Summary

The number of buildings in Portfolio Manager reporting onsite renewable energy has increased nearly ten-fold in the past decade, now making up nearly 1% of all buildings benchmarking in the tool. They are spread around the country and found on a range of building types. K-12 school buildings and worship facilities have the highest concentration of onsite renewable energy, at 2.4% of such properties.

Fewer than 10% of buildings with onsite renewable energy systems use the energy generated to meet 75% or more of their total electricity need. In fact, the majority use onsite renewable energy to meet a quarter or less of their electricity needs. The proportion of an individual building's electricity needs met with renewable energy generated onsite ranges from over 50% for warehouse/storage buildings to 7% for hospitals.

On average across all building types included in the data set, 60% retain their RECs to substantiate that the electricity they use is renewable. Only among retail stores and hospitals is it more common to sell than retain. The data indicates that many building owners and managers are interested in claiming the environmental benefits from their onsite renewable energy systems.

You can't manage what you don't measure

Development of renewable energy systems on commercial buildings has grown over the past decade, and this trend is expected to continue. Yet building owners and managers may not have reliable information about how much of the energy generated by these systems is being consumed by their buildings. This information is needed for energy benchmarking and other performance indicators to paint a true picture of a building's efficiency and to guide decision-makers to the most cost-effective strategies for improvement.

Looking forward, deployment of meters that support accurate measurement of onsite renewable energy flows—and making that data available to customers—will help stakeholders—including building owners, utilities, and policy-makers—invest in the right mix of strategies to achieve deep emissions reductions.

