# Short-Term Energy Outlook: Small-Scale Solar Forecasts

Concepts, Data Sources, and Techniques
Handbook of Energy Modeling Methods

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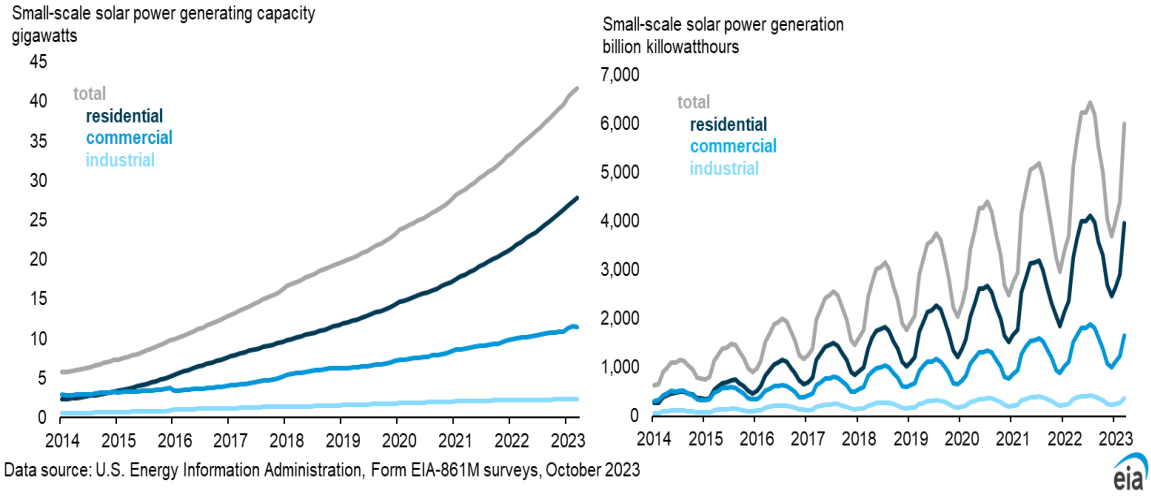
# 1. Introduction

Small-scale solar photovoltaic (PV) systems either can be interconnected with local electric distribution lines and send excess power onto the grid (net-metering), or they can provide power on-site only. We define small-scale solar PV systems as smaller than 1 megawatt (MW)[1] in size, typically installed on the rooftops of residences or businesses. Small-scale solar PV systems also include ground-mounted or other types of commercial and industrial solar systems less than 1 MW. They are also referred to as *distributed generation systems* to distinguish them from electric generating units at centrally located power plants.

We publish forecasts of small-scale solar PV electric generating capacity in the *Short-Term Energy Outlook* (STEO). STEO Table 7e shows small-scale solar PV capacity forecasts for residential, commercial, and industrial sectors. The estimates of U.S. electricity generation presented in STEO Table 7a show historical data and forecasts for small-scale solar generation by sector, as measured in billion kilowatthours. The renewable energy historical data and forecasts for generation and capacity are also accessible through the STEO custom table builder, our Microsoft Excel add-in, and the EIA Application Programming Interface (API). In addition, we have provided annual estimates of capacity and generation for distributed PV systems at the national level in the *Annual Energy Outlook*.

The small-scale solar PV component of the STEO model is designed to provide monthly forecasts of U.S. capacity for the residential sector and the non-residential (commercial and industrial) sectors. We use sector-level econometric regression equations to develop the projections, based on historical data that we publish.

**Figure 1. U.S. small-scale solar power generating capacity and generation**




Data source: U.S. Energy Information Administration, Form EIA-861M surveys, October 2023

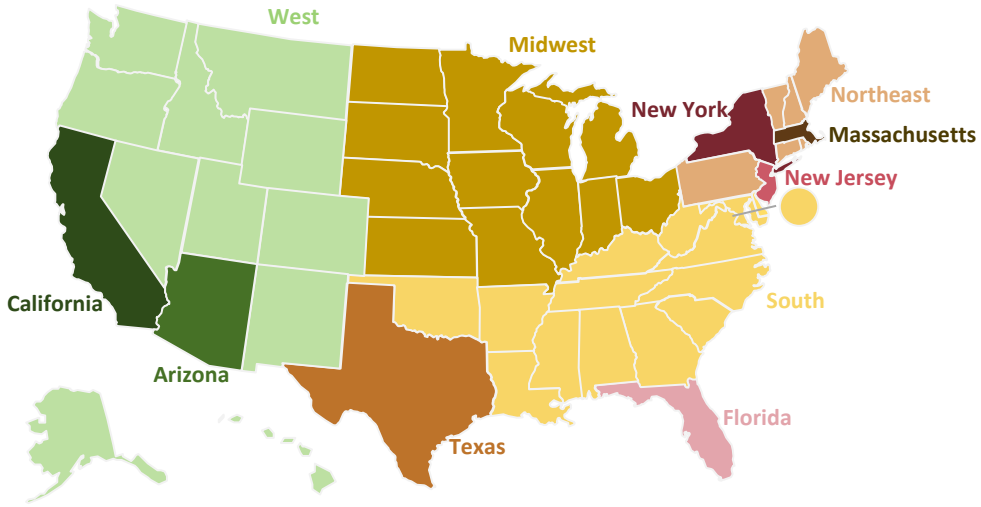
[1] STEO publications generally report generating capacity data for all energy sources in alternating current (AC) electricity terms. The purpose of this threshold is to include PV capacity and generation that is otherwise not collected on Form EIA-860 and Form EIA-923, which collects data from utility-scale electricity generation systems.

# 2. Model Outputs

The model estimates the small-scale solar capacity in the STEO forecast data series for each U.S. region. It produces monthly capacity estimates for 11 total regions (comprising 4 regions and 7 states) and 3 sectors (residential, commercial and industrial) and then adds the regional totals to obtain the United States small-scale solar capacity forecast. Some are individual states that have 2 gigawatts (GW) or more of installed sectoral capacity (as of the October 2023 Form EIA-861M, *Monthly Electric Power Industry Report*). The remaining states have less than 2 GW and are aggregated into four census regions (Northeast, Midwest, South, West). The series below are estimated by month and are reported in STEO Table 7e.

- Residential small-scale solar generating capacity estimates
- Commercial small-scale solar generating capacity estimates
- Industrial small-scale solar generating capacity estimates

**Figure 2. Forecast regions for small-scale solar generating capacity**




Data source: U.S. Energy Information Administration, Form EIA-861M surveys, May 2023
Note: The different colors in the map represent the small-scale solar generating capacity forecast regions. Individual states have 2 gigawatts or more of installed capacity as of the October 2023 EIA-861M.

In 2023, more than one-third of the residential small-scale solar PV capacity in the United States was in California, followed by Arizona with 8%. California is not only the most populous state but also has a long history of policies and state characteristics that encourage distributed PV generation. Texas and Florida were in third place, with 7% of the installed residential small-scale solar capacity, and New York had 4%. The rest of the states had smaller individual shares of installed small-scale solar capacity and were grouped in four regions to account for the remaining residential installed capacity. The Northeast region without New York had 13% of the installed residential small-scale solar capacity, followed by the West region without Arizona and California, with 12% of the small-scale solar capacity installations; the South without Florida and Texas, with 8%; and lastly the Midwest, with 5%.

Small-scale solar systems can serve different purposes. Each electricity market in the United States accounts differently for distributed generation. Smaller power systems connected to the distribution network can supply power to the grid when needed. Some systems are unregistered with Regional Transmission Organizations (RTOs); these systems are typically rooftop solar systems owned by residential customers and smaller than 1 MW. Other systems, such as the ones that offer supplemental generation at business locations, can provide backup power and are dispatched by the resource owner. When registered with the RTOs, they can contribute to electricity supply in the United States. Distributed registered systems reporting more than 1 MW of installed capacity on our *Monthly Update to the Annual Electric Generator Report* (Form EIA-860M) are included in the STEO electricity supply model.

Capacity factors are expressed as the ratio of the average power generated over a period compared with the maximum possible output. So, the number of times a power plant can run for a particular period is expressed as a percentage and is used to calculate the actual energy generated by a power plant. For example, actual energy generated in a plant (measured in megawatthours) is obtained by multiplying installed capacity (megawatts) by the time period (hours) by the capacity factor (percentage).

We use the aggregated U.S. capacity factors for utility-scale solar forecasts in the STEO electricity supply model to compute U.S. small-scale solar electricity generation. The series below are reported in STEO Table 7a.

- Residential small-scale solar electric power generation
- Commercial small-scale solar electric power generation
- Industrial small-scale solar electric power generation

Small-scale solar capacity estimates are not included in the STEO electricity supply model.

# 3. Data Sources

The historical values for small-scale solar generation and capacity in STEO are based on net metering and non-net-metering distributed data collected in our *Annual Electric Power Industry Report* (Form EIA-861) and our *Monthly Electric Power Industry Report* (Form EIA-861M). Detailed state-level and regional data for both generation and capacity are available by month from Form EIA-861M. We have published capacity and generation estimates from small-scale solar installations since 2015. Starting in 2020, we added *Annual Electric Power Industry Report* (Form EIA-861S) respondents to the estimates of small-scale solar. Our Form EIA-861S survey collects information about utilities with small annual sales not included in Form EIA-861.

Small-scale solar data are collected and estimated from net-metering and non-net-metering distributed PV data using formulas and adjustments described in the *technical notes* of the *Electric Power Monthly* (EPM). Owners of the small-scale net-metered systems can be reimbursed by electric utilities for supplying electricity to the grid. Since 2014, we have published historical small-scale solar generating capacity and power generation for various regional divisions in our EPM.

Currently, STEO incorporates historical small-scale solar PV data from Form EIA-861M and forecasts monthly U.S. generation and capacity values through the end of the STEO forecast horizon (12–24 months) for the residential, commercial, and industrial sectors.

# 4. Regional Fixed Effects for Small-Scale Solar Generating Capacity Estimates

To estimate small-scale solar power capacity, we use fixed-effects panel data methods, which involve a mathematical transformation to remove the unobserved heterogeneous factors that vary across states prior to estimation. For example, the installation of solar panels varies with state-specific characteristics that are not observed in the data, such as different local policies incentivizing the use of residential solar electricity. Fixed-effects panel data methods work similarly to linear regressions and estimate a different monthly slope (average growth) for each state and economic sector.

## 4.1 Small-scale solar power generating capacity

The model's econometric regression equations are structured using fixed-effects panel data structures, which are designed to use variables that differ across regions or states to account for unobserved or omitted factors that are constant over time. In this case, we are relying on state fixed effects, which account for differences in state characteristics, especially different policies that incentivize the growth in small-scale solar generation. The model also captures socioeconomic differences across states.

U.S. electric generating capacity data are by month and are measured in megawatts for the residential, commercial, and industrial sectors. We estimate one regression model for each sector: residential and non-residential (commercial and industrial). Each model returns nine different growth or regional paths for each sector. The regional composition corresponds to seven states and four aggregated regions as documented above. **Table 1** presents the residential historical small-scale generating capacity estimates, as of October 2023. Except for California, most of the states have less than 25 GW of residential installed capacity.

The econometric models for generating capacity rely on the growth of the previous month's capacity and other explanatory variables. Other covariates are included in the regression to account for exogenous variation within the regions, such as the households' ability to purchase solar PV systems. The explanatory variables in the residential capacity regression model include:

- The monthly counts of households in the state registered in the U.S. Census data, measured in thousands, and its forecast (S&P Market Intelligence)
- Historical data on personal income, measured in millions of dollars by state or region, and its monthly forecast (S&P Market Intelligence)

**Table 1. Small-scale solar electric generating capacity by region (megawatts)**

| Region | Residential | Non-residential |
|---|---|---|
| Midwest | 1,721 | 1,441 |
| Northeast (without Massachusetts, New Jersey, and New York) | 2,428 | 1,550 |
| Massachusetts | 1,159 | 1,457 |
| New Jersey | 1,311 | 1,194 |
| New York | 1,355 | 1,518 |
| South (without Florida and Texas) | 1,764 | 626 |
| Florida | 2,012 | 200 |
| Texas | 2,439 | 300 |
| West (without Arizona and California) | 3,583 | 961 |
| Arizona | 2,031 | 354 |
| California | 11,140 | 4,749 |

Data source: U.S. Energy Information Administration, Form EIA-861M, *Monthly Electric Power Industry Report*, October 2023

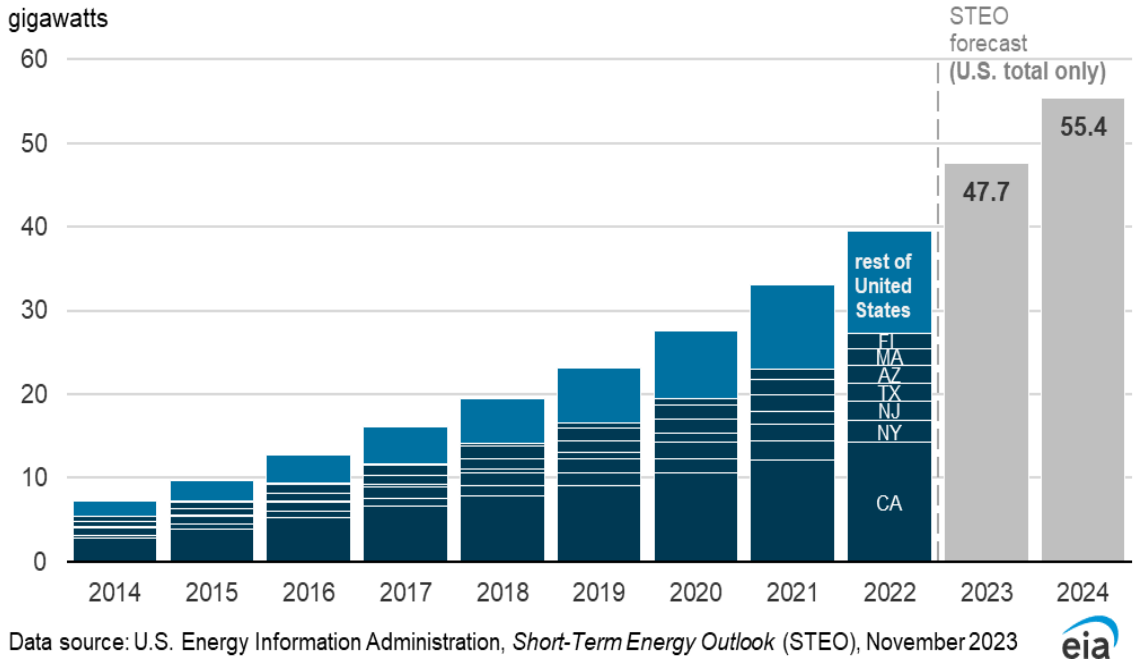
The U.S. non-residential capacity forecast follows a similar approach as the state fixed effects panel data model. We forecast the growth in commercial and industrial solar PV installation based on past growth—specifically, installed capacity in the previous month and three months prior.

Explanatory variables are also included to approximate industrial and commercial economic activity:

- Employment in the private sector (measured in thousands) and its forecast (S&P Market Intelligence)
- State populations (measured in thousands) and their forecasts (S&P Market Intelligence)

Other regression models are used to estimate the amount of small-scale solar PV capacity in the commercial sector and industrial sector based on the initial non-residential total. The commercial sector is represented in the model as a share of non-residential capacity that is calculated monthly based on the most recent historical data. Forecast capacity for the industrial sector is then calculated as the difference between the forecast non-residential and commercial sector capacities.

**Figure 3. U.S. small-scale solar capacity (2014–2024)**




## 4.2 Small-scale solar power generation

We develop small-scale solar electric power generation forecasts by state or aggregated region. The estimates of electric power generation rely on the estimates of capacity. The capacity forecasts are then used in other econometric regression equations to produce forecasts of monthly electricity generation for the residential and nonresidential sectors. The small-scale solar electric power generation estimates are based on historical seasonal patterns in the utilization rate of small-scale solar PV capacity and capacity factors.

All equations in the small-scale solar model are estimated using monthly data from January 2014 through the most recent available month. We periodically re-estimate the coefficients in each equation to capture the effect of recent data. We re-evaluate the specification of regression models in the STEO to reflect the current market and regulatory structure of the industry.