Residential Solar-Adopter Income and Demographic Trends: 2023 Update

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Report Outline

1. Introduction, Data, and Methods

- Overview and key findings
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- Low-to-moderate income shares of adopters

3. Solar Installation Attributes by Income

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- Rural vs. urban
- Location in disadvantaged community
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- Housing type and tenure
- Education
- Occupation
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Overview

Describes income and demographic trends among U.S. residential solar photovoltaic (PV) adopters

- Pairs Berkeley Lab's *Tracking the Sun* dataset and other sources of PV addresses with *household-level* income and demographic data
- Unique in its market coverage and granularity
- Descriptive and data-oriented; complements and informs other related work at Berkeley Lab

For related research at Berkeley Lab:
solardemographics.lbl.gov

What's New?

- Data on systems installed through 2022
- More emphasis on comparing PV adopters specifically to owner-occupied households
- Additional trends on third-party ownership, race and ethnicity, and multifamily and renters

Related Berkeley Lab Resources

- Online data visualization tool allowing users to further explore the underlying dataset
- In depth topical studies on issues related to solar energy access and equity
- Analytical support to external organizations, by request

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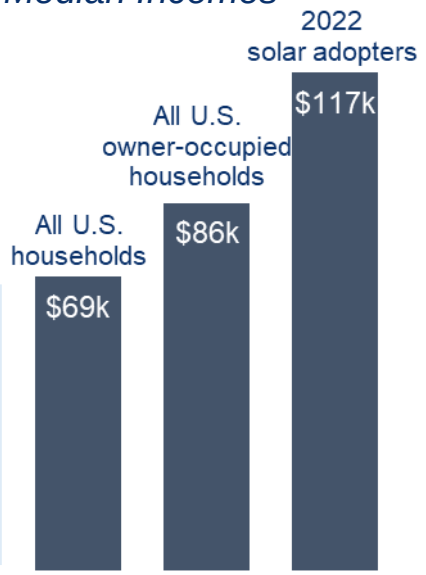
High-Level Findings

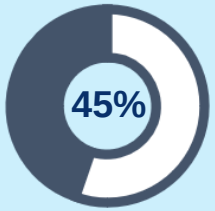
Solar-adopter incomes vary considerably, but are generally higher than population averages

- The disparity in national median incomes is partly driven by the concentration of U.S. PV markets in high-income states
- Differences are smaller in many states and also when comparing to only owner-occupied households

Median Incomes



LMI Adoption

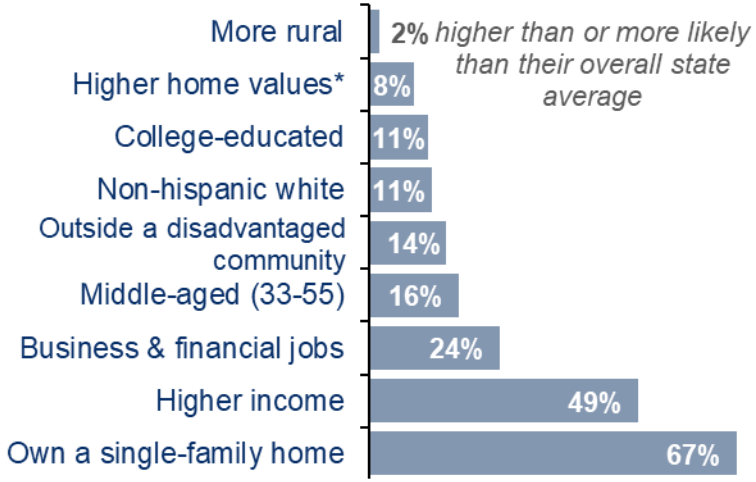


While solar adoption skews toward high-income households, low- and moderate-income (LMI) households are also adopting. In 2022, about 45% of adopters earned less than 120% of their area's median income. (120% is a threshold sometimes used to include both low and moderate income)

Solar adopters vary along other socio-economic dimensions as well

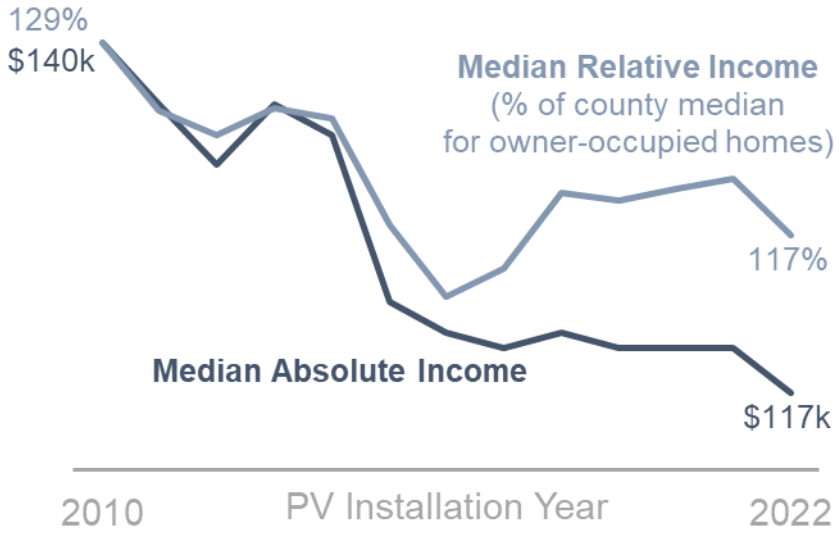
- Solar adopters are diverse, but tend to differ from the broader population in many respects
- The largest differences relate to housing type and tenure, but differences also exist with respect to age, education, race, and other factors
- As with income, these differences are generally diminishing over time

Compared all households in their respective state, 2022 solar adopters tend to be or have...



The rooftop solar market is becoming more equitable over time

*Solar-Adopter Current Household Income**



** Based on estimated household incomes in the year 2023*

- Rooftop solar is **broadening** by expanding into states with generally lower income levels
- Rooftop solar is also **deepening** by reaching less-affluent households and disadvantaged communities in established markets
- Reflects falling solar prices and the emergence of policies and business models that support broader adoption, among other factors

Data Sources

PV Street Addresses & System Data

- Berkeley Lab's ***Tracking the Sun*** is the primary data source; addresses and other data for ~2.4M systems, primarily from utilities & state agencies
- **BuildZoom** and **Ohm Analytics**: Purchased PV permit data; provides supplementary PV street addresses for an additional 1.0M systems

Income & Other Socio-Economic Data

- **Experian ConsumerView**: Purchased dataset providing modeled household-level income estimates for solar adopters and for population as a whole; as well as household data on other socio-economic attributes
- **U.S. Census** and **Bureau of Labor Statistics**: Used for comparison purposes to characterize demographics of total U.S. population

See appendix slides 48-49 for further details on income and other socio-economic data sources

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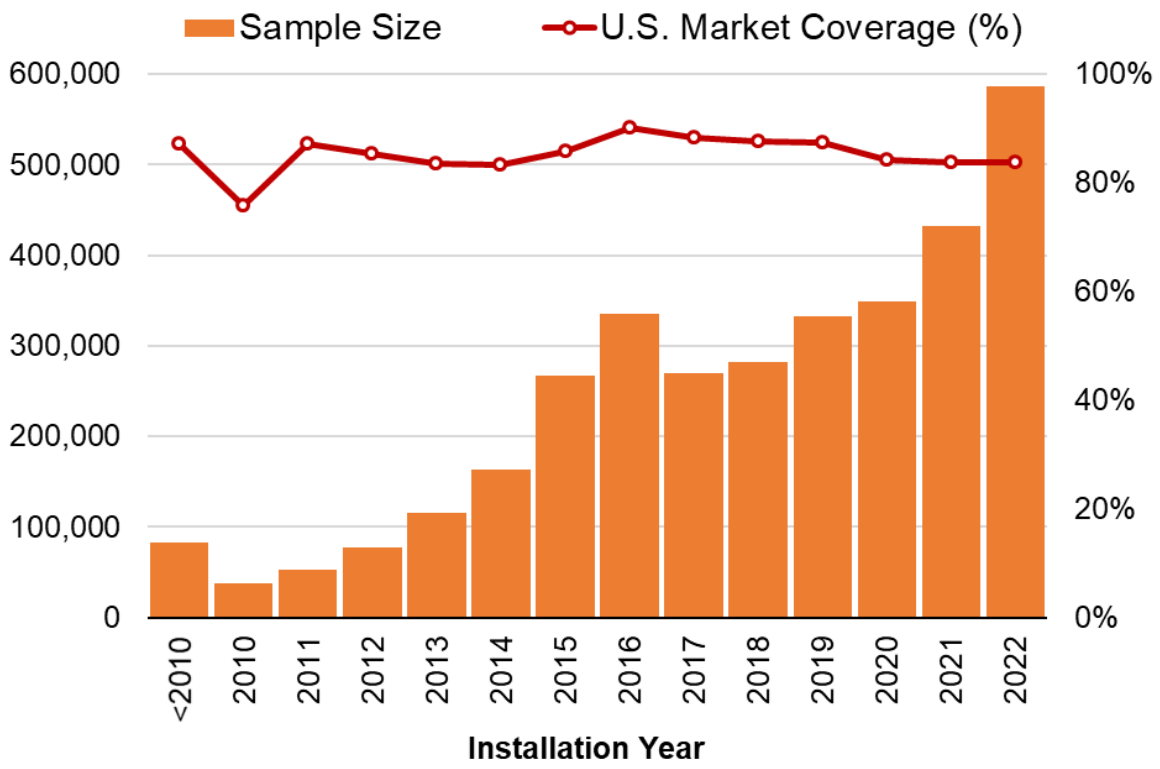
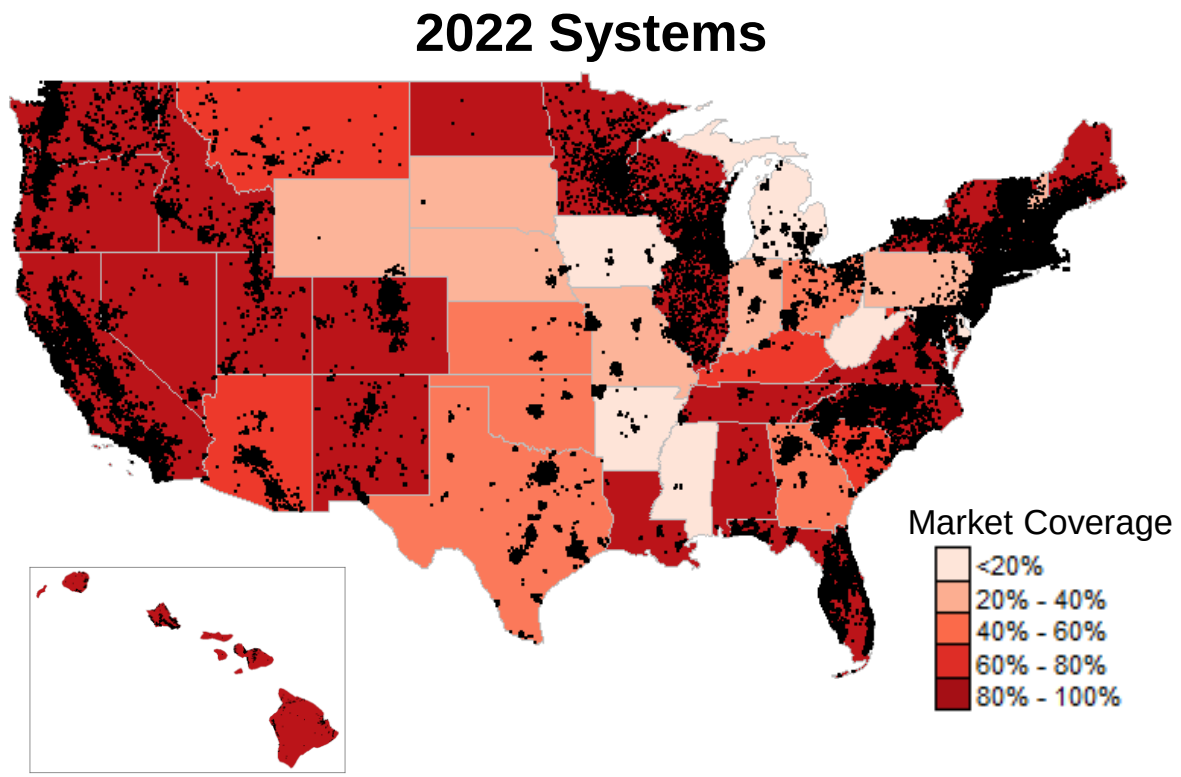
Sample Coverage

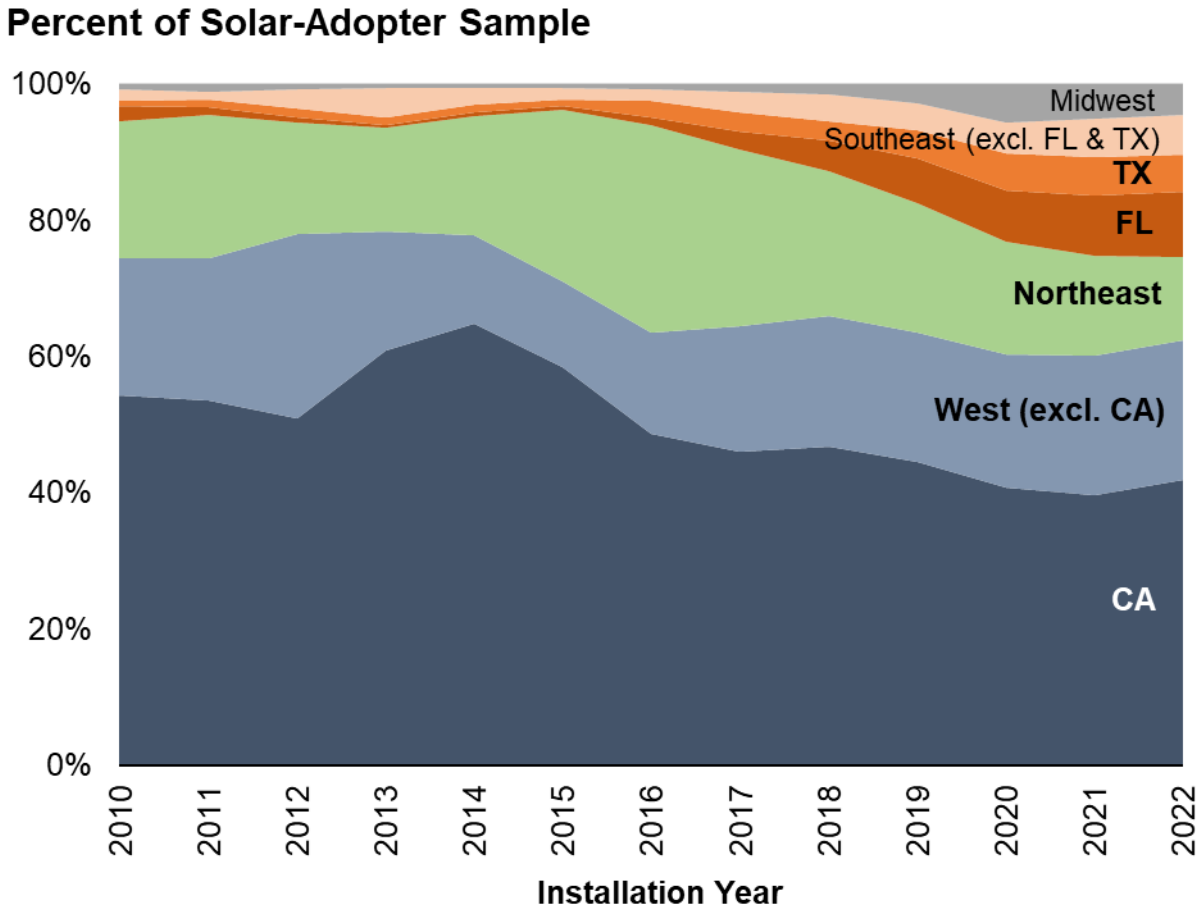




- Our sample consists of **3.4M systems**, covering roughly **86%** of all U.S. residential systems through 2022 and **84%** of systems installed in 2022
- State-level market coverage varies widely, but is over 40% in most states for 2022

*****See appendix slides 51-52 for tabular details on sample sizes*****

Sample Distribution over Time



Notes: The figure represents the distribution of the solar-adopter sample used in this analysis, which covers 86% of the total U.S. market, but as shown on the previous slide, coverage for midwestern and southeastern states is somewhat lower than for other regions.

- The geographical distribution of the sample and shifts over time provide important context for understanding demographic trends shown later
- California represents 42% of systems installed in 2022, but its share has declined over time
- Other Western states' share of the sample has grown over the past decade, comprising 21% of the 2022 sample
- Northeastern states have declined in their share over time, representing 12% of the 2022 sample
- Florida, Texas, and other Southeastern states have all grown in their sample share and together represent 21% of the 2022 sample
- Midwestern states have grown but remain a small share (3%) of the sample

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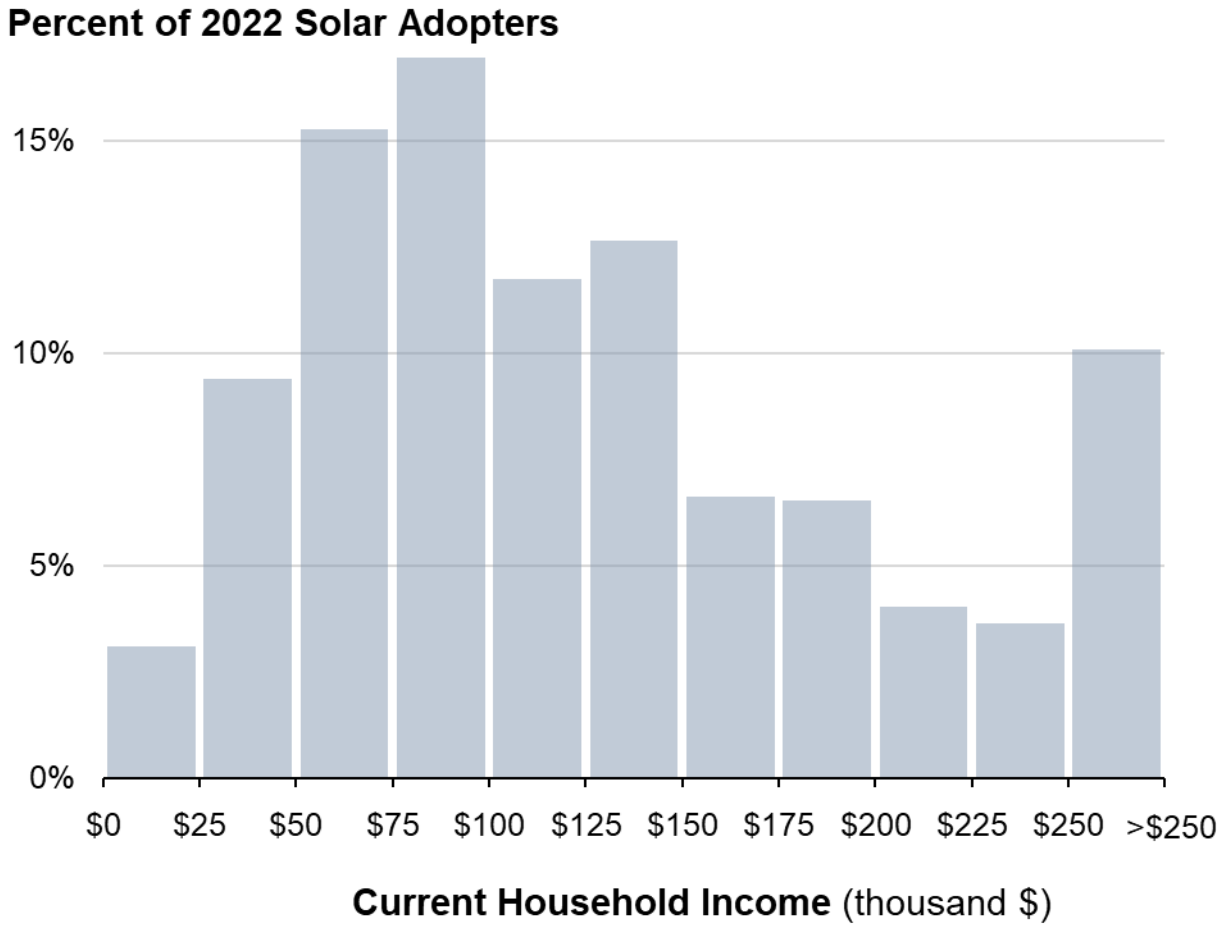
Key Points on the Data and Methods

- We focus here on national and state-level trends, with an emphasis on PV systems installed from 2010-2022; additional data, including county- and Census tract-level trends, as well as data for earlier years, are available through Berkeley Lab's online solar demographics tool
- Income estimates refer to total household income, while most of the other demographic attributes (race, occupation, education) are based on the primary householder; regardless, we describe trends in terms of "households" as the relevant unit for PV adoption
- PV adopter income and demographic data reflect *current* values based on Experian ConsumerView data obtained in Q3 2023, rather than at time of adoption; the data therefore may not be representative of the household at the time of adoption (especially if the home since sold)
- Unless otherwise noted, we present state-level data only if the underlying sample consists of at least 100 systems and at least 10% market coverage for the applicable state and year
- Sample sizes vary across different elements of the analysis, depending on the underlying data sources and completeness of the associated data fields; see appendix slide 52 for details

Solar-Adopter Income Trends

Solar-Adopter Income Distribution



- Solar adopters span all household (HH) income levels, from less than $25k to more than $250k
- A large fraction of solar adopters in 2022 could be considered “middle income”: for example, one-third (31%) have HH incomes in the $50-100k range
  - 12% of adopters are below that range, while 55% are above it
- The distribution has a long upper tail, with 18% of adopters above $200k and 10% above $250k
  - Experian does not disaggregate incomes estimates >$250k, leading to the spike on the right-hand side of the distribution

** Notes: Experian does not differentiate income estimates >$250k, thus all households above that level are aggregated, leading to the spike on the right-hand side of the distribution*

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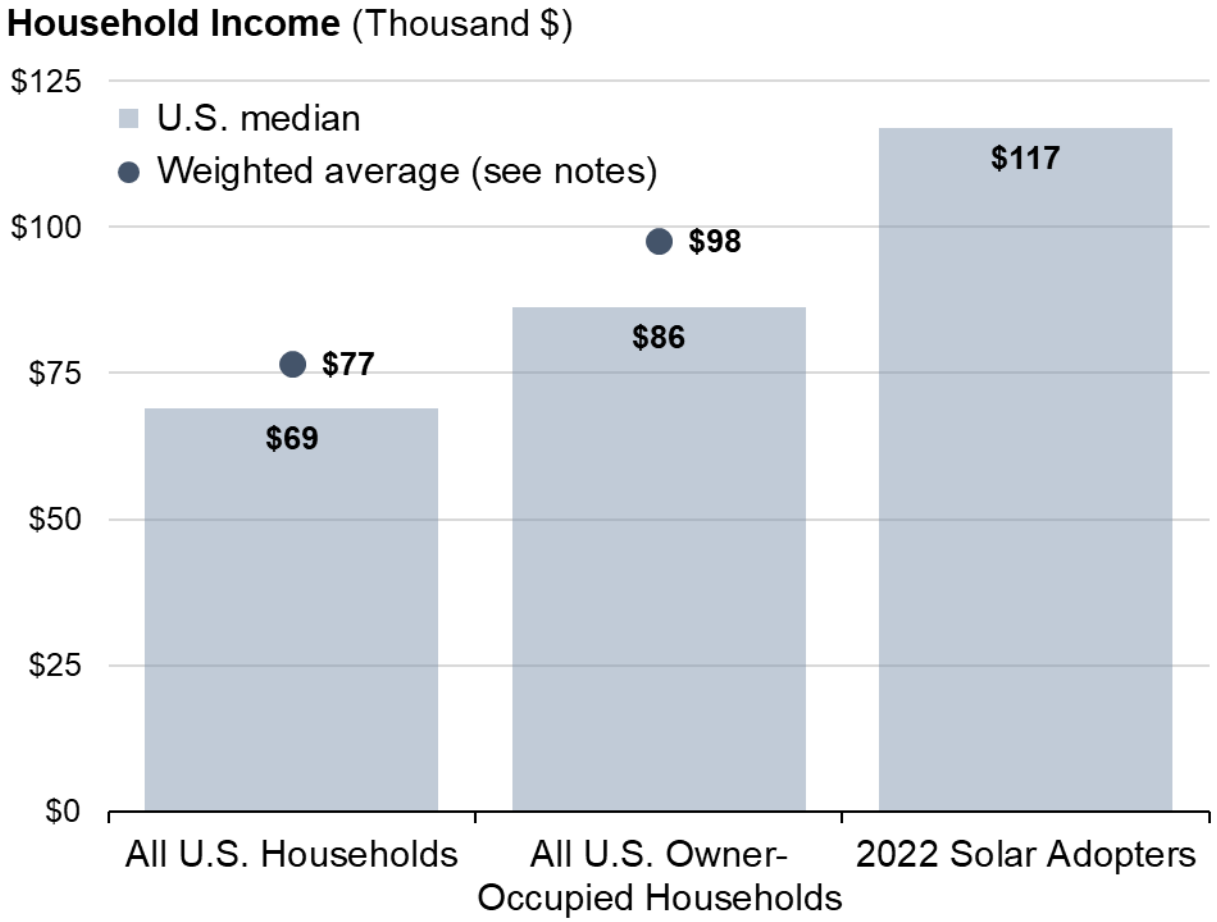
Solar-Adopter Incomes Compared to Total U.S. Population



Notes: The weighted averages are based on the median income of all HHs or all OO-HHs in each state, weighted by the number of 2022 solar adopters in each state.

- Solar-adopter incomes skew high, but the degree of skew is highly dependent on how the comparison population is defined
- The median income of 2022 solar adopters ($117k) was **70%** higher than for all U.S. households ($69k)
- Onsite solar adopters are almost all owner-occupied households (OO-HHs); the percent difference is only half as large (**36%**) if comparing to only OO-HHs ($86k)
- Solar adopters are disproportionately located in high-income states (e.g., CA); median adopter incomes were **20%** higher if comparing to a solar-adopter weighted-average of state median incomes for OO-HHs (see figure notes)

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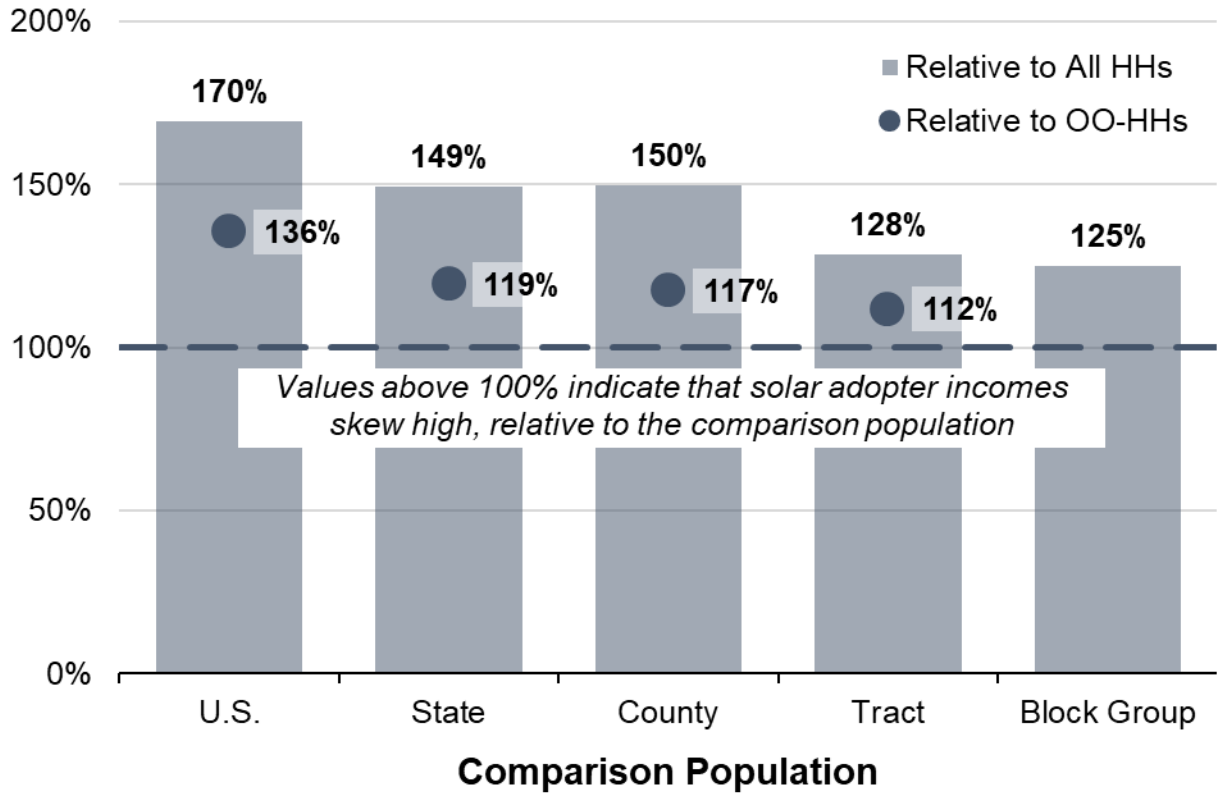
Solar-Adopter "Relative Income"

Median Solar-Adopter Relative Income (2022 Adopters)
Percent of Comparison-Population Current Median Income



Notes: To calculate these values, we first calculate each solar adopter's household income as a percentage of the median household income for the given comparison population, and then take the median of those percentage values across all solar adopters. At the block group level, median incomes are available only for all HHs, but not for OO-HHs.

Relative Income: Solar-adopter HH income *as a percentage* of the median income across all HHs in the comparison population

- This is the metric used throughout the report to describe the skew in solar-adopter incomes
- Comparison population can be defined at different geographical scales (from U.S. down to block group) and for either all HHs or only OO-HHs
- As shown, solar-adopter income skew is smaller the more localized the comparison and when comparing to only OO-HHs

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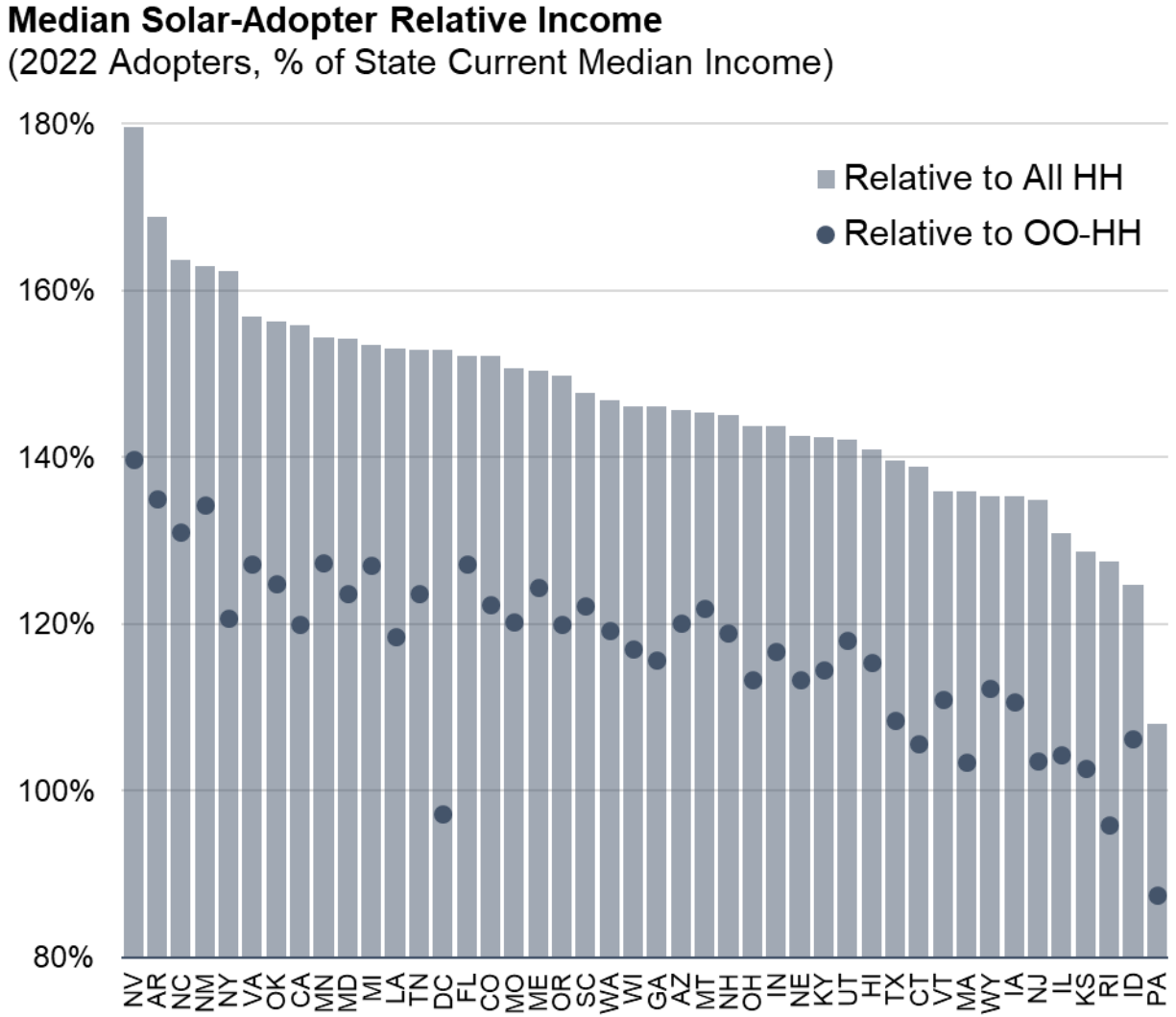
Solar-Adopter Income Trends across States



- Solar adopter incomes in all states skew high compared to the general population, with median relative incomes ranging from 108-180% of the state median income for all households
- Skew in CA is relatively high, pulling the national median up; most states have greater adoption equity
- A number of states (DC, MA, NJ. IL, KS, PA) are at or near income parity when compared to just owner-occupied households
- Varying degrees of income skew across states reflects differences in solar market maturity; solar policies and programs; and broader socio-economic factors (overall income inequality, cost of living, educational levels, etc.)

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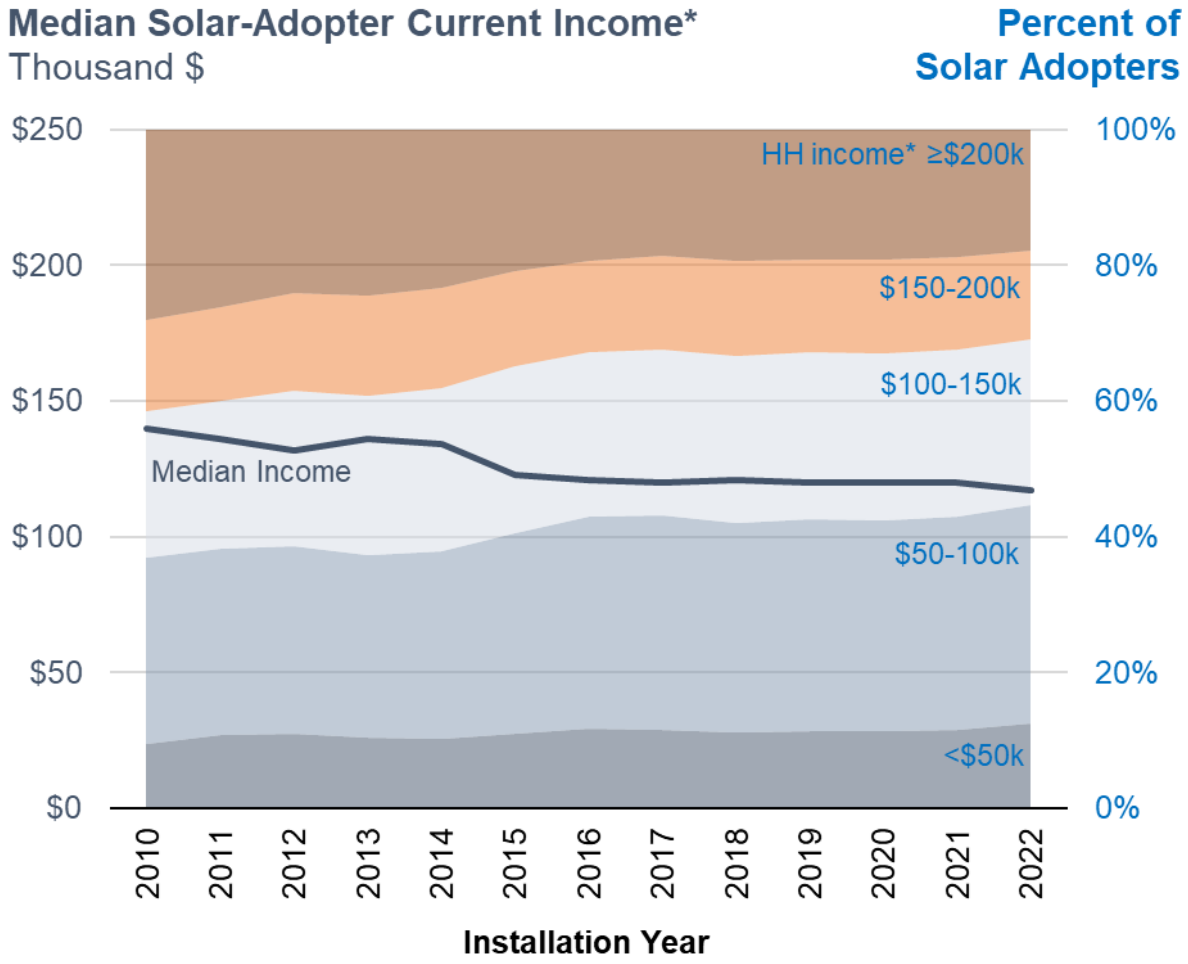
Solar-Adopter Income Trends over Time



** Notes: Incomes are based on the year 2023, regardless of when the PV system was installed, with no inflation adjustments.*

- Solar adoption has gradually shifted over time toward progressively less affluent HHs, though trends since 2015 have slowed
- Median solar adopter incomes correspondingly fell from $140k for HHs that installed PV in 2010 to $117k for HHs installing PV in 2022
- Long-term trends driven by falling PV prices, expanded financing options, LMI-focused programs, and general market maturation, among other factors
- As shown on the next two slides, these factors reflect both a "broadening" of solar markets into less affluent regions, as well as a “deepening” of solar markets as adoption increasingly reaches less affluent households in each region

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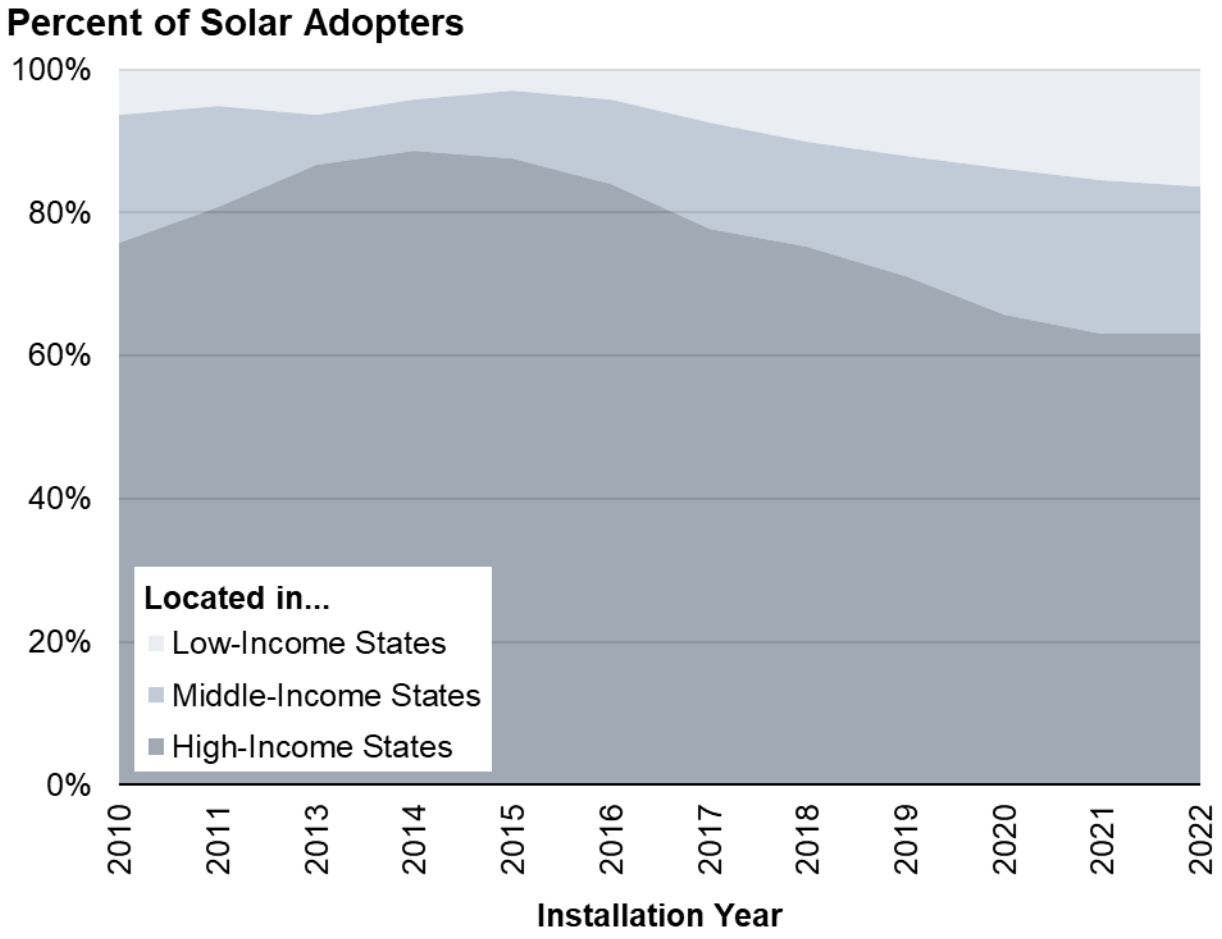
Solar Market Broadening Trends



Notes: States are grouped based on whether they fall into the lower, middle, or upper third of all U.S. states, in terms of state median income of all households. States are sorted into the three groups so that each group represents roughly one-third of the U.S. population.

- The U.S. market has been steadily broadening into low- and middle-income states (see figure notes for definitions) since 2015, reaching 16% and 21% of 2022 installs, respectively
- The vast majority (~80%) of growth in market share among low- and middle-income states is associated with FL (low-income) and TX (middle-income)
- Annual installs in high-income states were fairly flat, in absolute volume, from 2015-2021
- To be sure, high-income states still comprise a disproportionate share of the market (63% in 2022); for comparison, these states represent roughly one-third of the U.S. population

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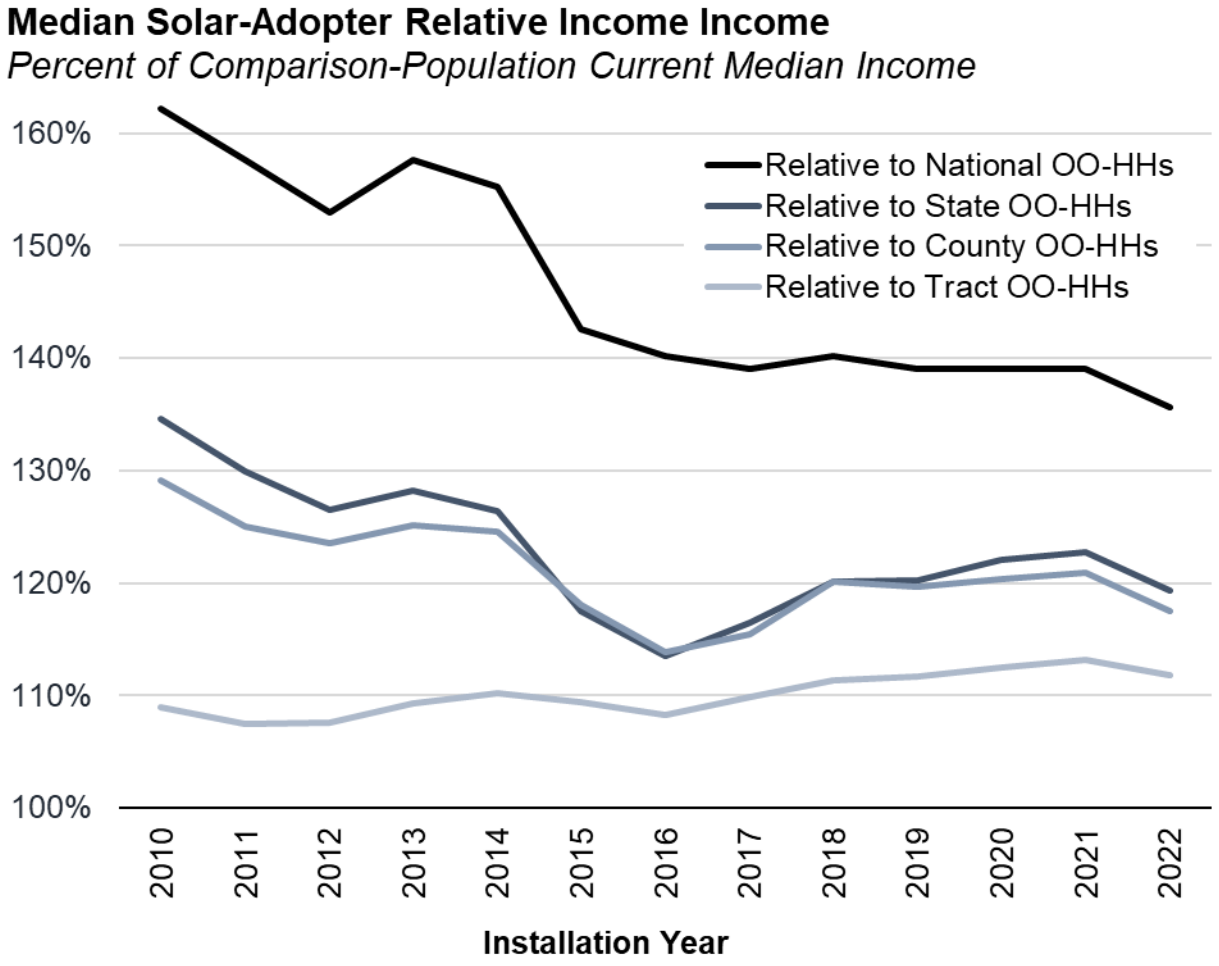
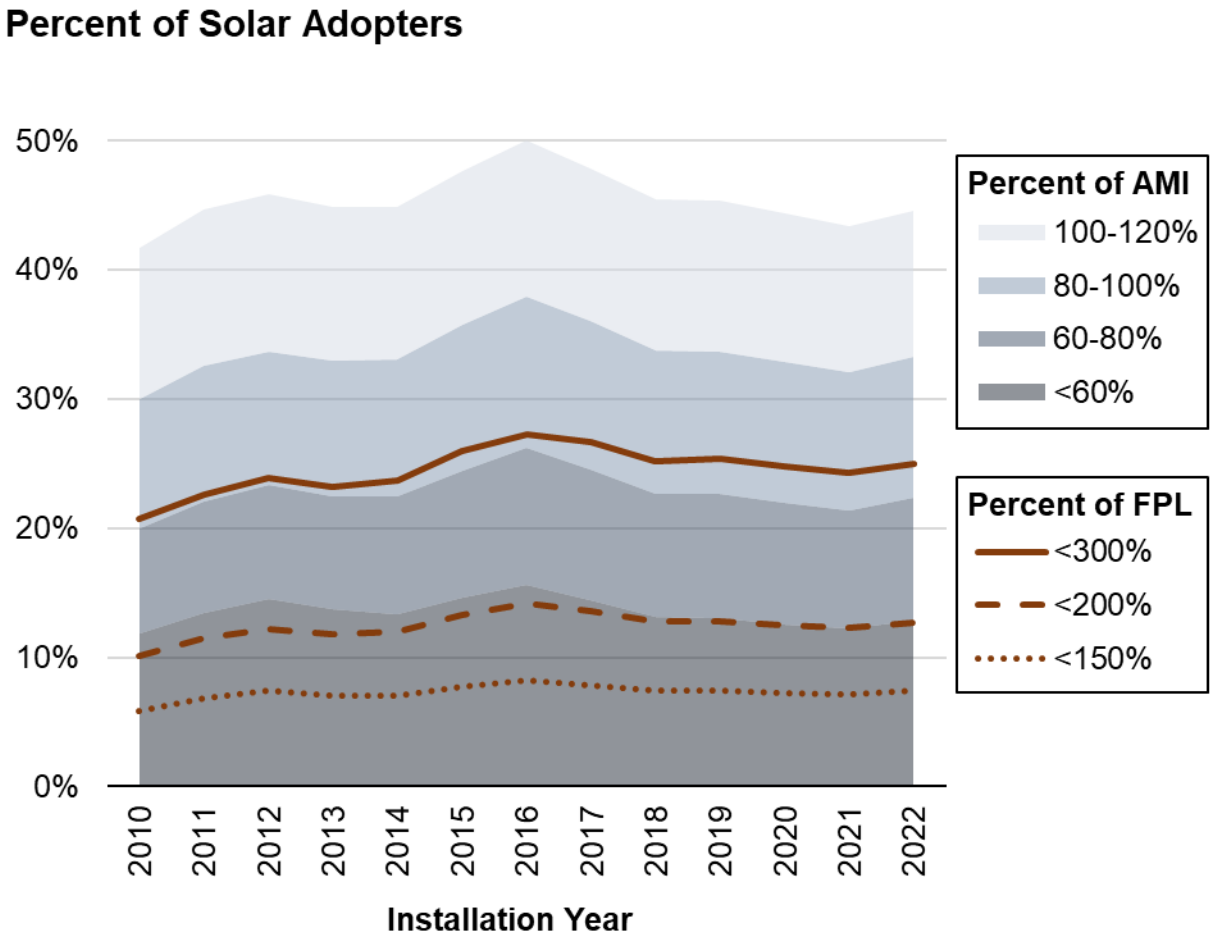
Solar Market Deepening Trends



- Solar market deepening refers to a shift in adoption toward progressively less affluent households within a given region
- We can measure deepening (albeit imprecisely) by trends in solar-adopter relative incomes
- Over the long term, relative incomes have fallen at the national, state, and county levels; those trends stalled out in recent years, but picked up again in 2022
- Relative incomes at the tract level, however, have steadily risen: as adoption shifts into new neighborhoods, early adopters tend to be relatively affluent compared to immediate neighbors, even if they are less affluent compared to others in the broader market

LMI Share of U.S. Solar Adopters over Time



Notes: "Area" refers to the applicable U.S. Census Core-Based Statistical Area or county (for rural areas). Both AMI and FPL vary by household size. For a family of three, the FPL for the contiguous 48 states was $23,030 in 2022.

Various income metrics and thresholds can be used to define "low-to-moderate income" (LMI):

- 150-200% of Federal Poverty Level (FPL) is common, especially in low-income federal energy programs
- 80% of Area Median Income (AMI) is also often used
- Higher thresholds (e.g., 120% of AMI, 300% of FPL) are sometimes used to include "moderate" income

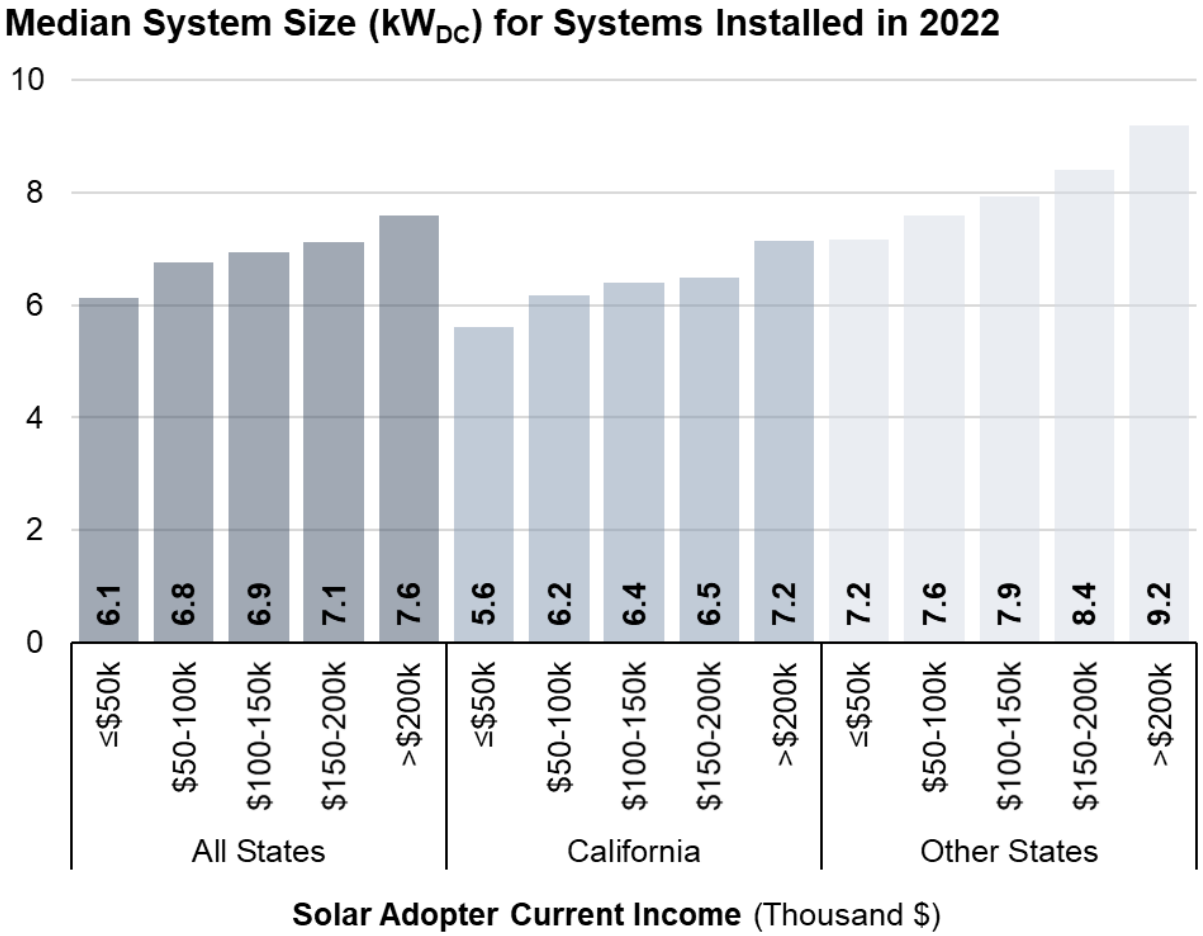
- Regardless of how it is defined, LMI shares of U.S. solar adopters are trending up over time
- Across all U.S. solar adopters in 2022:
  - **AMI:** 23% were <80% of AMI, 45% were <120% of AMI
  - **FPL:** 7% were <150% of FPL, 25% were <300% of FPL
- State-level data accessible online via Berkeley Lab's solar demographics tool

Solar Installation Attributes by Adopter Income Level

Solar Installation Attributes by Adopter Income Level

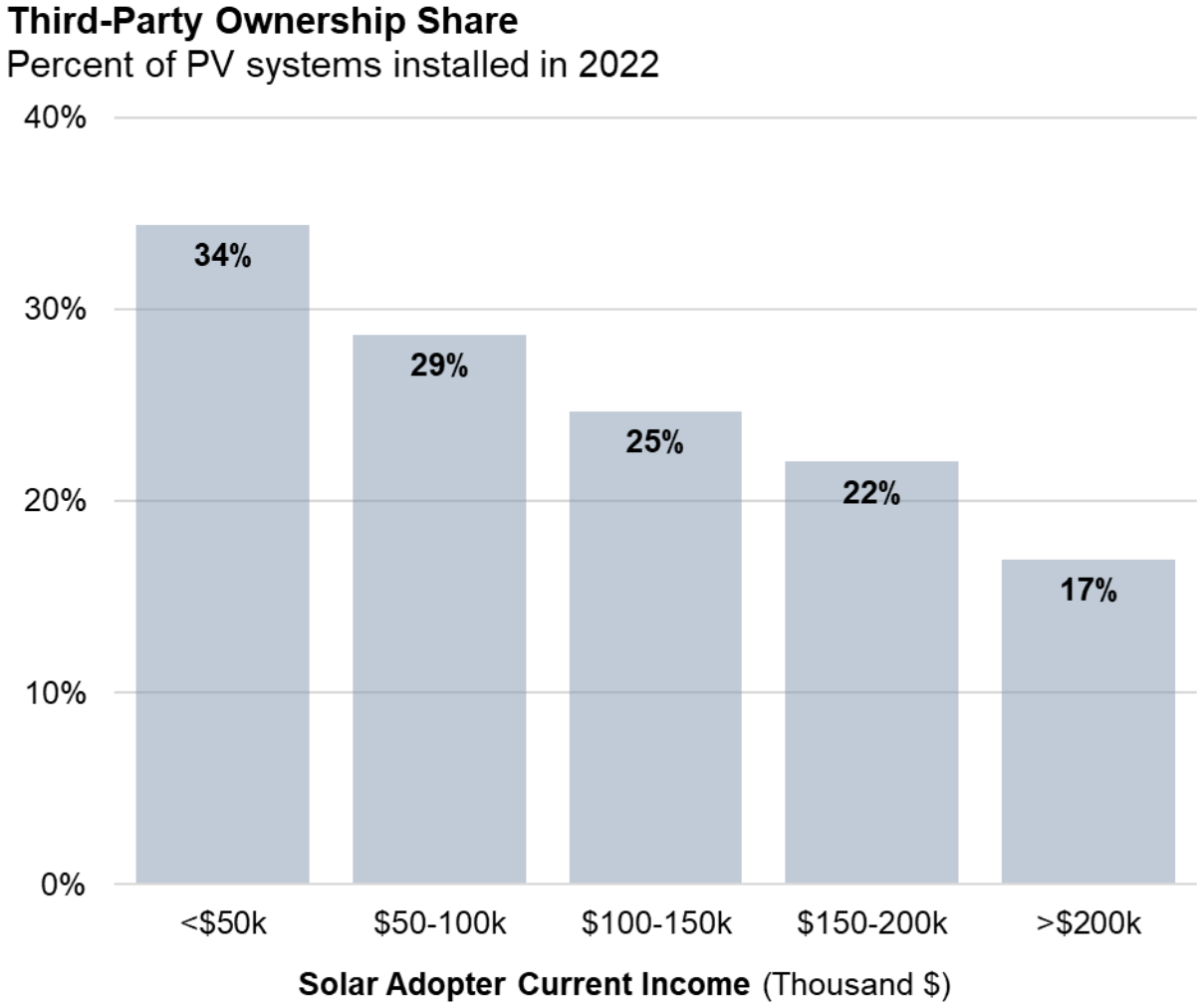
- Beyond looking at how solar-adopter incomes vary over time and geography, we can also evaluate the characteristics of the systems themselves may vary based on household income level
- Here, we focus on several solar installation attributes:
  - System size
  - Third-party owned (TPO) vs. host-owned systems
  - Paired PV+storage vs. stand-alone PV systems
  - Size of solar installer firm
- These comparisons are based primarily on the subset of the PV adopter dataset originating from *Tracking the Sun*, which provides PV system attributes (see slides 51-52 for applicable sample sizes)

System Size by Income Level



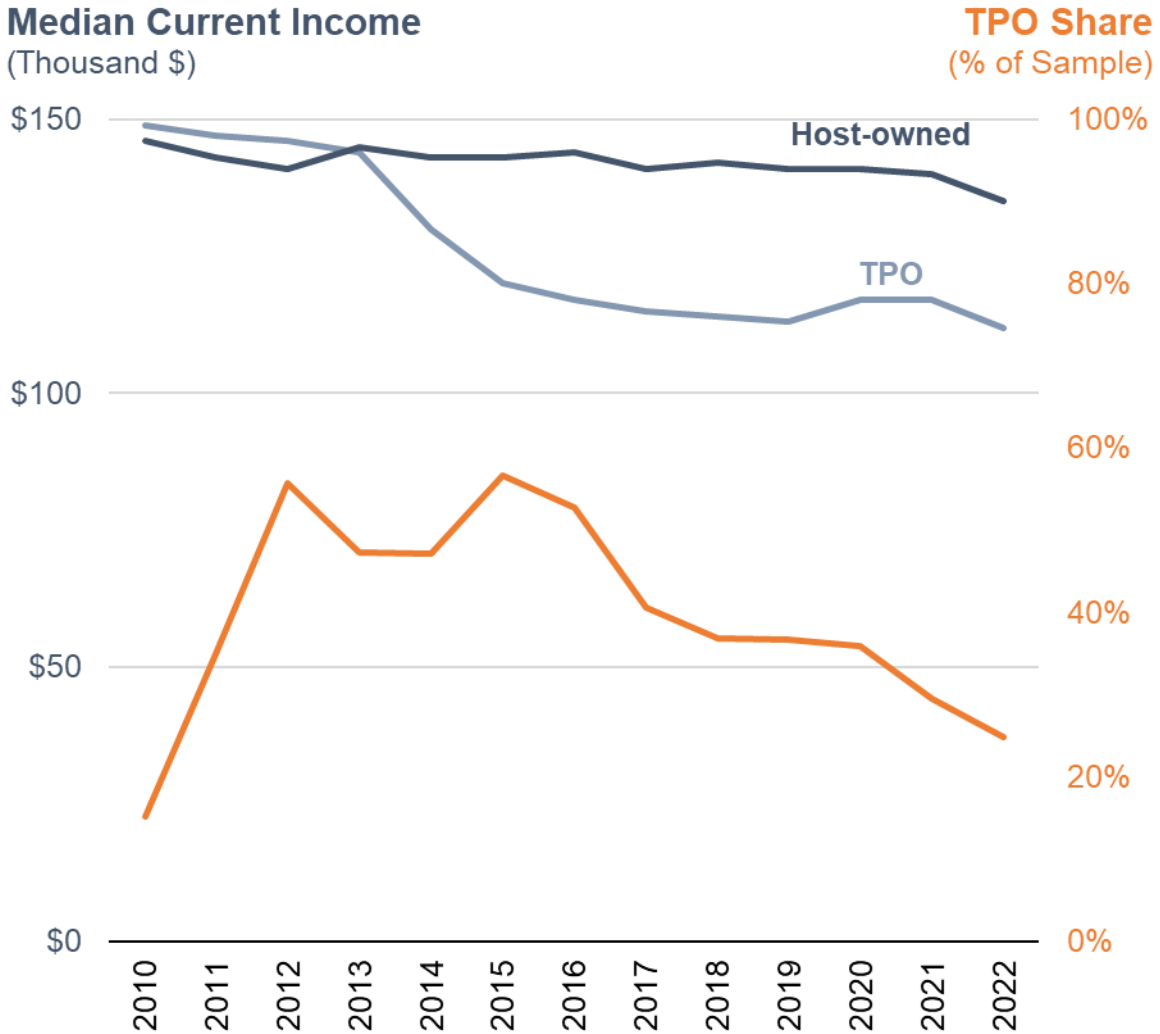
- Higher income households install larger systems
- Across the sample, systems installed by the highest-income households were 24% larger than those of the lowest-income households, based on median system sizes (7.6 vs. 6.1 kW)
- California systems are relatively small overall, pulling median system sizes down for the sample, but the same trends in system size across income levels are evident in CA and in other states as well
- Trends explained by the fact that larger systems cost more, and that higher-income households tend to have larger homes with larger roof area and to have higher electricity consumption

Third-Party Ownership Rates by Income Level



- Third-party ownership (TPO) through leases or power purchase agreements is one way to address up-front cost barriers to PV adoption
- TPO shares are consistently higher for progressively lower-income households: roughly 2x for households in the lowest vs. the highest income group in 2022
- O'Shaughnessy et al. (2021) found that TPO has driven adoption by lower income HHs (as opposed to simply attracting LMI HHs that would otherwise install host-owned PV)
- The general trend in solar adoption toward lower income solar adopters can thus be partially attributed to expanded access to TPO

Third-Party vs. Host-Owned Systems



- Median incomes for TPO adopters has declined over time, as TPO has become progressively more accessible for less affluent households
- In contrast, the income profile of host-owned adopters has remained relatively flat
- As such, the general trend away from TPO (and towards loans) may be dampening the overall shift in PV adoption toward lower incomes
- Solar loan financing can address up-front cost barriers, similar to TPO, but data are not currently available to show uptake of solar loans among lower income households

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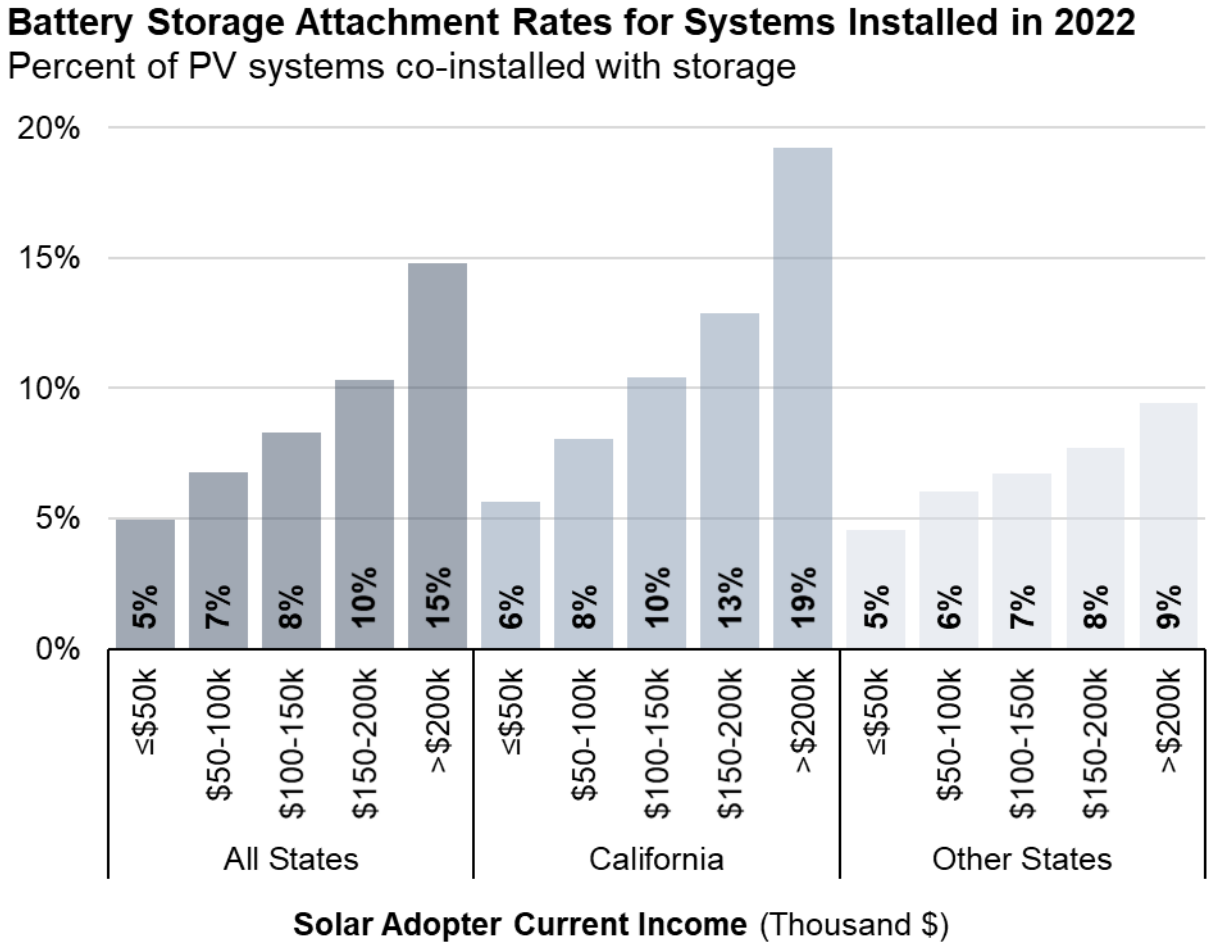
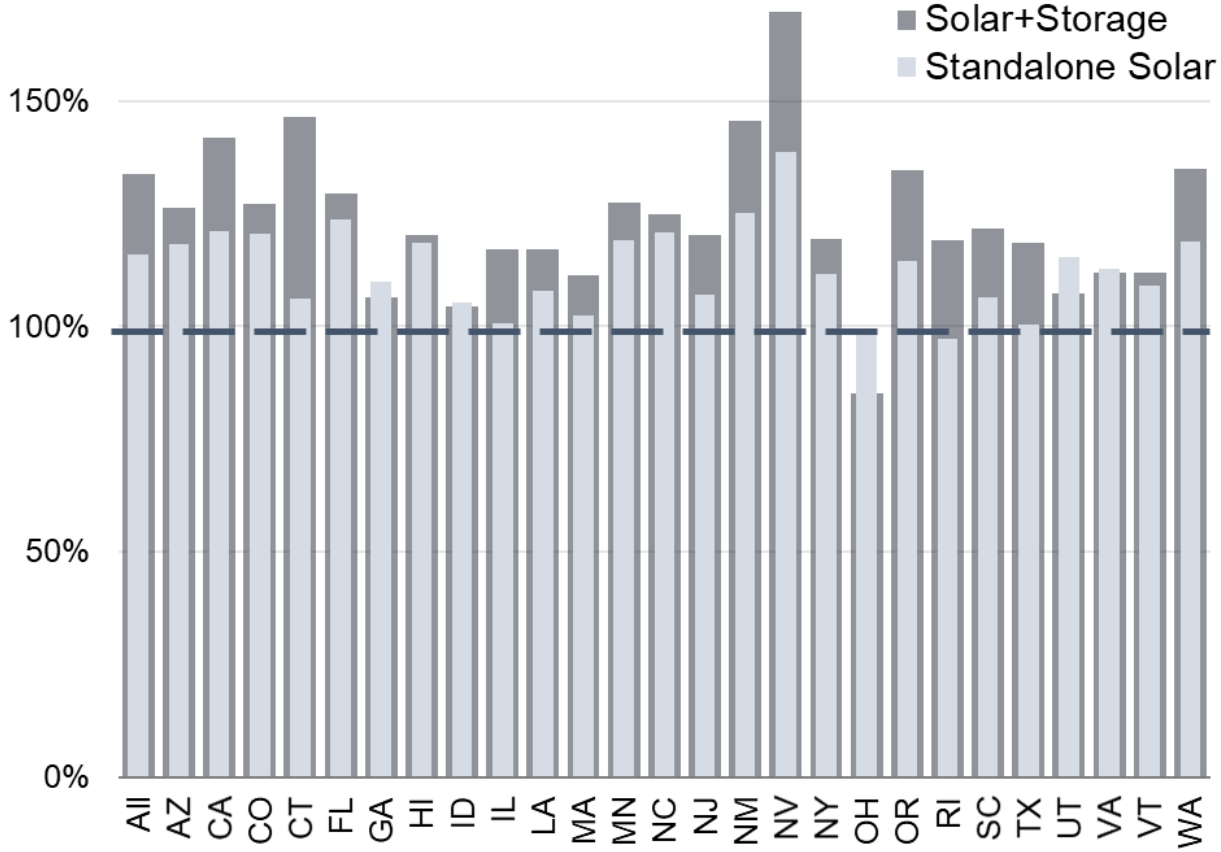
Storage Attachment Rates



- Storage attachment rates are consistently higher for higher income households
  - Storage equipment adds cost, but also provides additional benefits (bill savings, resiliency)
- The difference in attachment rates between the highest and lowest income groups are especially pronounced in California compared to other states (a 13 point spread, compared to a 4 point spread in other states)
  - CA comprises more than half of all paired solar+storage systems in 2022, and has generally higher attachment rates

Solar-Adopter Incomes for Paired Solar+Storage vs. Stand-alone Solar

Median Solar-Adopter Relative Income
(2022 Systems, % of County Current Median Income for OO-HHs)



Notes: Figure includes states with at least 30 systems within each group.

- Paired solar+storage adopters generally have higher incomes than stand-alone solar adopters—as expected, given the additional cost of storage—though there are exceptions
- In CA, solar+storage adopter incomes were notably higher than standalone solar adopters, despite the availability of incentives covering most/all of the cost of adding storage to PV for LMI households
  - Suggests that other factors beyond cost may be impacting solar+storage adoption by lower income HHs

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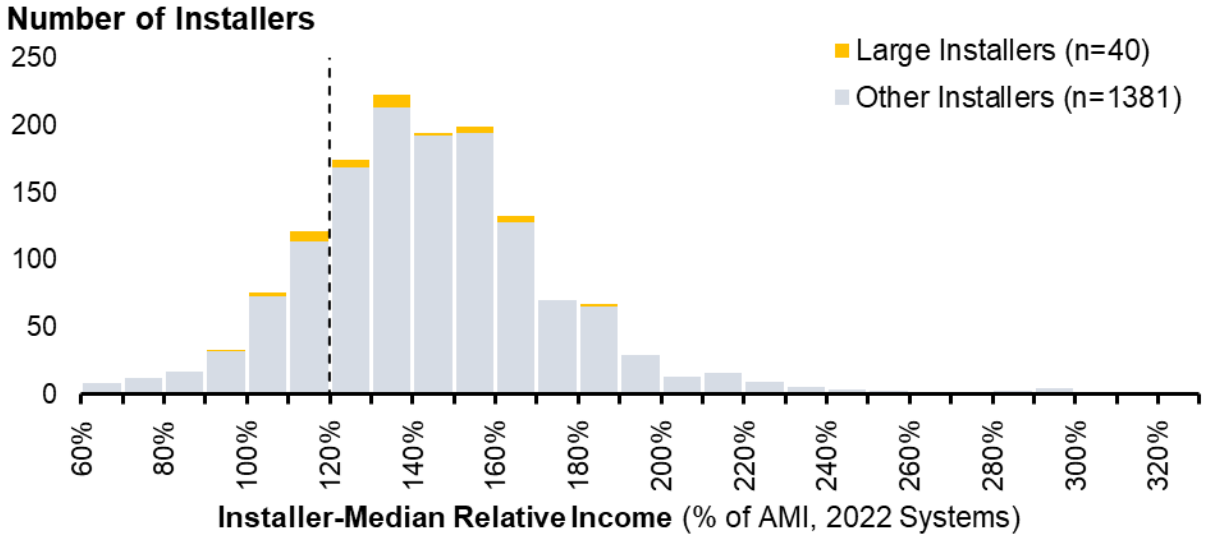
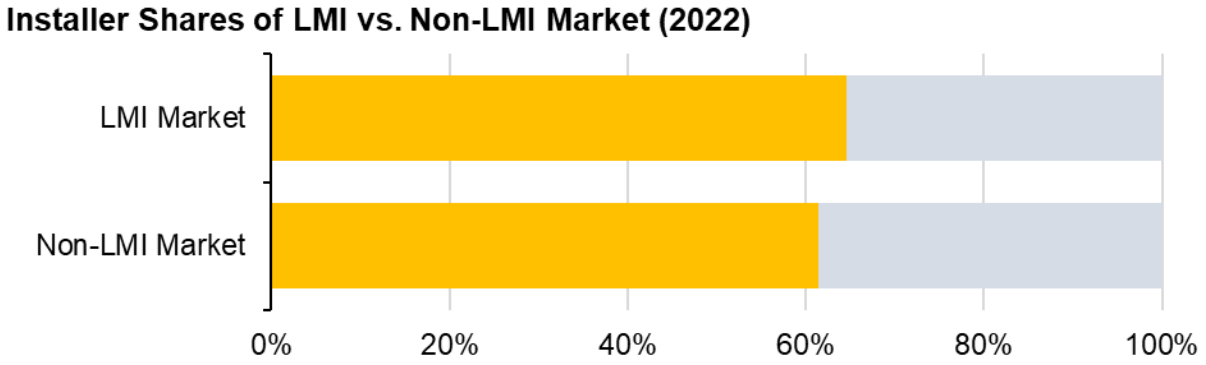
Installer-Level Trends





Notes: The histogram is based on installers with at least 10 systems installed in 2022. Large installers are those with more than 1,000 systems completed in 2022. LMI market is defined as PV adopters with household incomes less than 120% of AMI.

- Installers vary considerably in terms of their customers' relative income levels
  - Roughly 30% of installers serve primarily LMI customers (defined here as <120% of AMI)
  - A much smaller subset of installers (3%) primarily serve low-income (<80% of AMI) households, in some cases as a core part of their business model
- There is no substantial difference between installer size and their propensity to serve LMI customers
  - Large installers (with >1000 installs in 2022) account for 65% of all LMI systems, roughly in line with their share of the non-LMI market

Other Socio-Economic Trends for Solar Adopters

Approach to Describing Other Socio-Economic Trends

We describe trends in other socio-economic attributes of solar adopters*:

- Location in a Disadvantaged Community (DAC)
- Race and Ethnicity
- Rural vs. Urban
- Home Value
- Housing Type and Tenure
- Education Level
- Occupation
- Age

In some cases also describing how those trends align with income

To characterize equity, we can compare to the broader U.S. population on both an absolute and also a *weighted-average* basis

***Weighted averages*:** For any given attribute (e.g., race and ethnicity), take the average across all states, weighted by the number of PV adopters in each state; provides a benchmark that controls for broad geographical patterns in the U.S. PV market

** Based in most cases on the primary householder; see slides 48-49 for definitions and sources*

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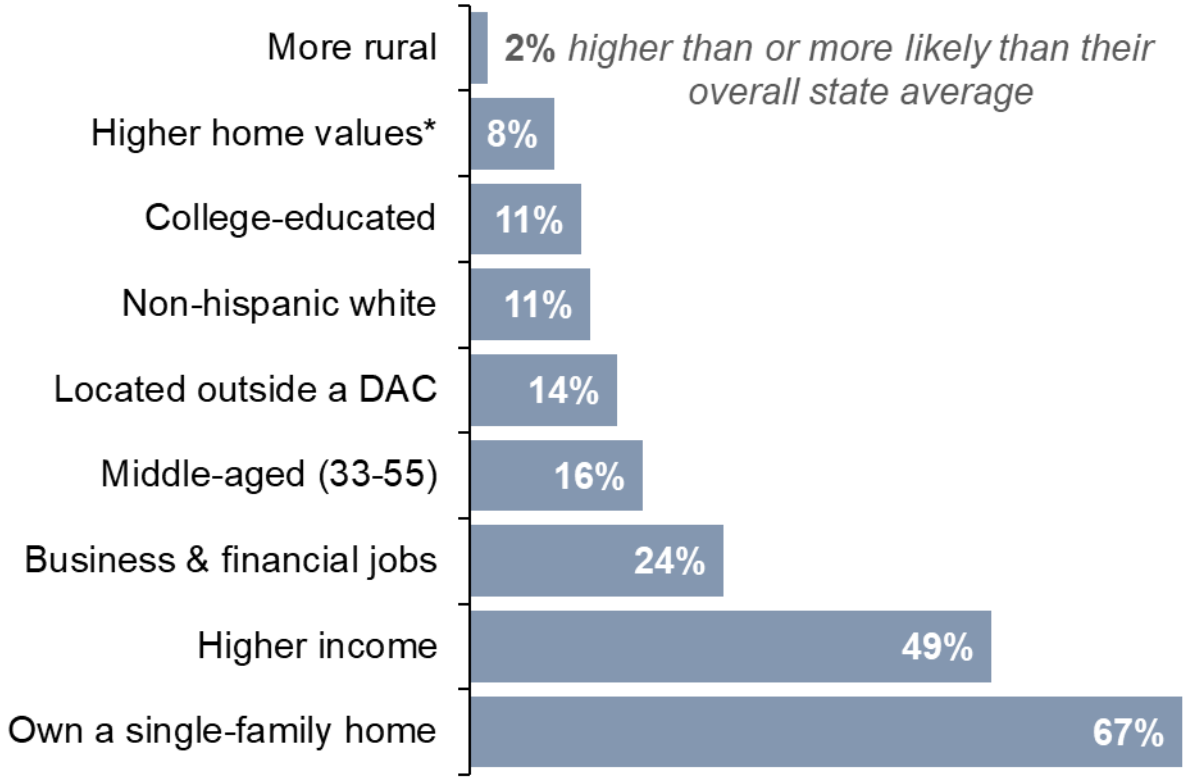
Summary of Solar-Adopter Socio-Economic Attributes

Compared to all households in their respective state, 2022 solar adopters tend to be or have...



Notes: The percentages were calculated by comparing PV adopters to all households in their respective state. The only exception is for home value, where, for reasons of data availability, the comparisons are to all households in the same county.

- The figure shows how 2022 solar adopters compare to all HHs in their respective state (further details provided on the following slides)
- Skew is greatest for housing type/tenure (single family, owner-occupied homes) and income
- In contrast, rurality of PV adopters, on average, is quite similar to their respective state
- As shown elsewhere, the skew for some attributes can differ significantly if comparing to only OO-HHs (particularly notable for race and ethnicity, where the directionality flips)

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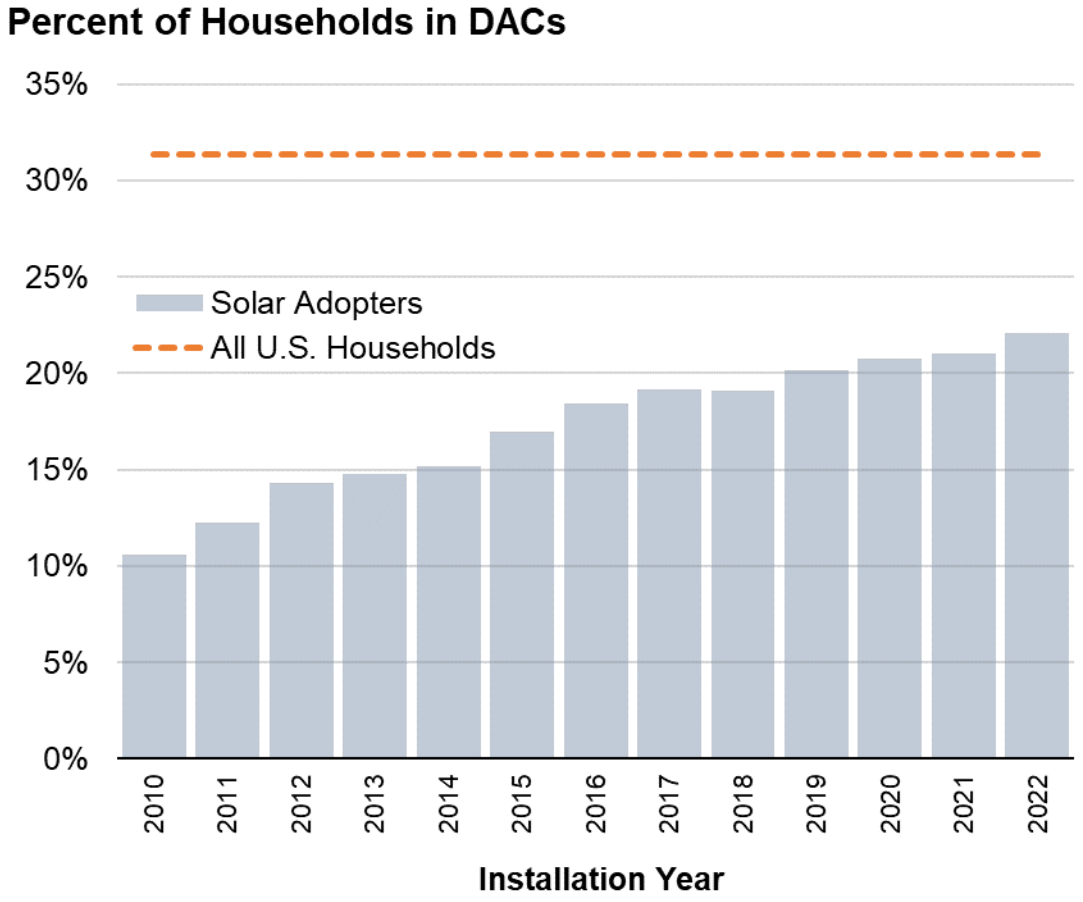
DAC Share of U.S. Solar Adoption over Time

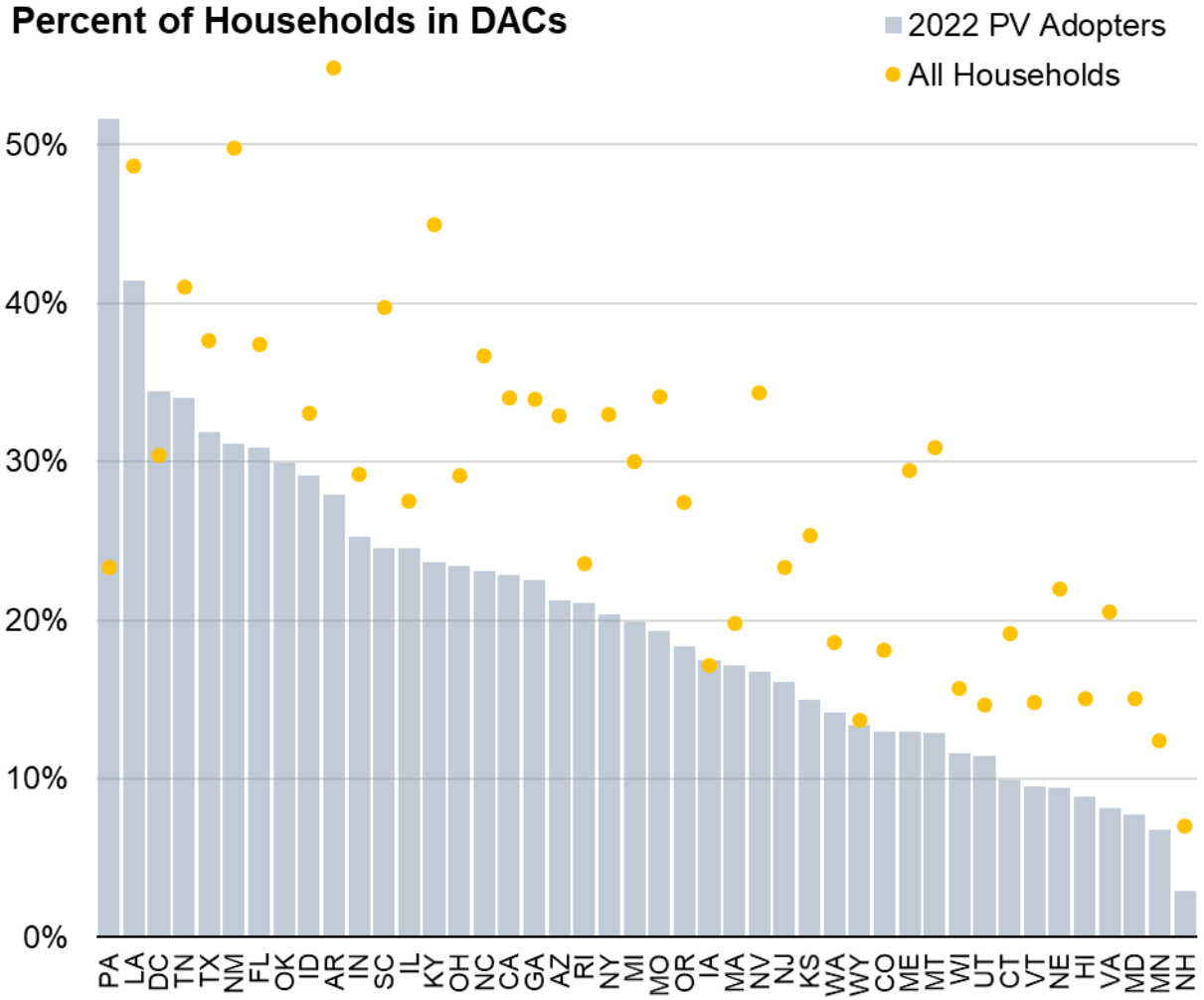


Notes: Each Census tract's DAC determination was made using the CEJST version 1.0 released November 2022. The percentage of all households in DACs was determined by summing the number of occupied dwelling units in DAC tracts versus those outside of DAC tracts using the ACS 2021 5-year survey.

The U.S. Council on Environmental Quality's Climate and Economic Justice Screening Tool (CEJST) designates "disadvantaged communities" (DACs) based on a broad set of criteria related to climate change, energy, health, housing, legacy pollution, transportation, water and wastewater, workforce development, income, and tribes. Similar designations have been developed by others (e.g., EPA's EJScreen, CalEnviroScreen).

- Percent of PV adopters in DACs has been rising over time, from 11% in 2010 to 22% in 2022
- But DACs remain under-represented among solar adopters, relative to their overall share of all U.S. households (31% on absolute basis, or 32% if calculated as a weighted average based on PV adopter distribution across states)

DAC Share of Solar Adoption by State



- At the state level, the share of PV adoption in DACs varies widely, reflecting underlying differences in the share of the overall population located in DACs
- In almost all states, DACs are under-represented among PV adopters in 2022
  - On average, 10 percentage points lower than their share of the overall population
- There are exceptions where PV adopters are equally or even more-concentrated in DACs than the population at large
  - Most notably, PA and DC, where most PV adopters are located in metro areas with large share of population in DACs

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Race and Ethnicity: Notes on Data and Methodology

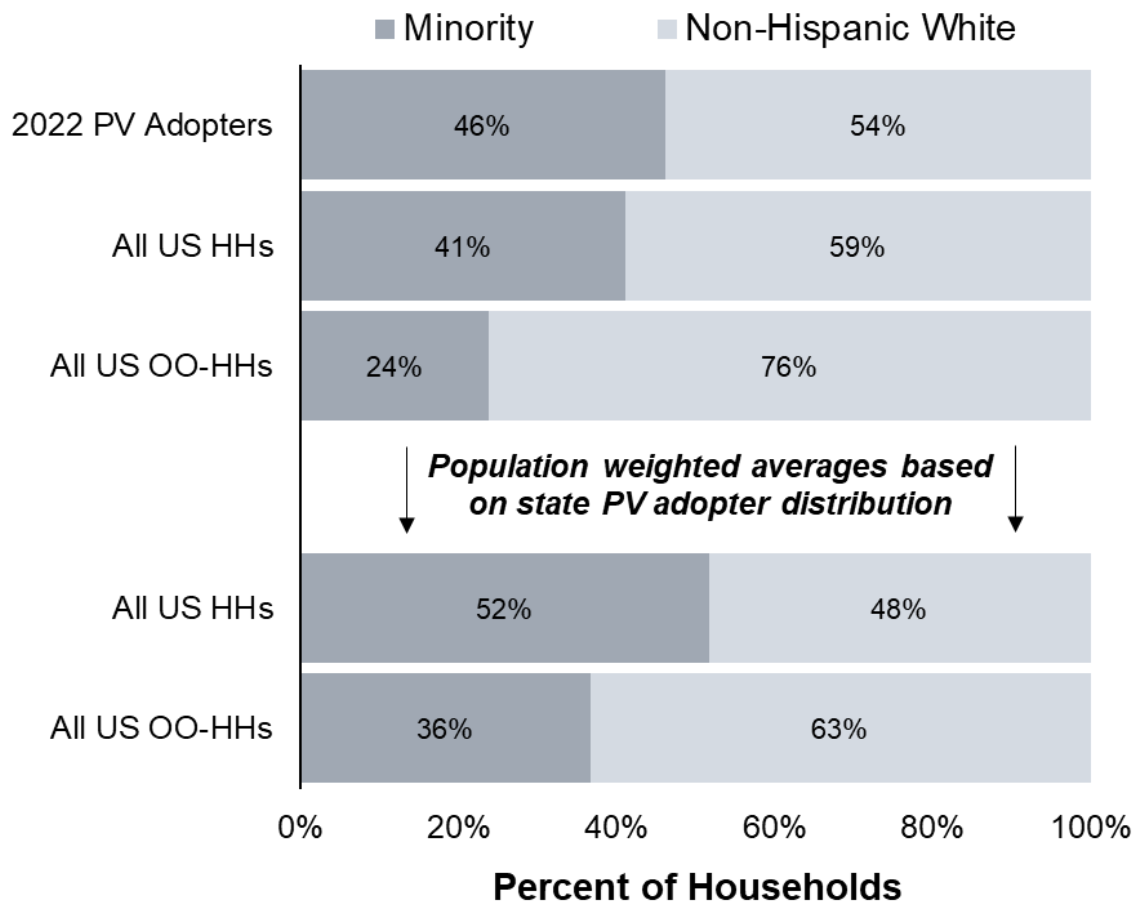
- **Race and ethnicity of PV adopters is inferred**
  - Using an open-source algorithm that predicts household race based on the household's Census tract and the name of the primary householder (Khanna et al. 2022)[1]
  - Output consists of probabilities for Hispanic and non-Hispanic White, Asian, Black, and Other; results used only if probability >50%
  - Predictions tested for ~1500 surveyed LMI PV adopters[2] and found to accurately predict reported race/ethnicity 79% of the time, but overpredicted Hispanic and underpredicted Asian and Other households
  - ***For that reason, the results focus on the distinction between "Non-Hispanic White" vs. "Minority"*** *(i.e., Hispanic and/or non-white)*
- Race and ethnicity of comparison populations:
  - All OO-HHs: estimated by applying the same predictive algorithm to property data obtained from CoreLogic; used this approach for consistency with PV adopters, but distribution closely resembles Census data
  - All HHs: based on US Census Data (ACS), as CoreLogic data provides surnames only for property owners, thus can't be used to infer race/ethnicity for rental property

[1] *Khanna K, Bertelsen B, Olivella S, Rosenman E, Imai K (2022). "_wru: Who are You? Bayesian Prediction of Racial Category Using Surname, First Name, Middle Name, and Geolocation_". R package version 1.0.1, <https://CRAN.R-project.org/package=wru>.*

[2] *Yozwiak et al. (forthcoming), "Residential Solar's Effect on Household Energy Insecurity among Low-to-Moderate Income Households"*

Race and Ethnicity

National comparison of PV adopters to all HHs and all OO-HHs

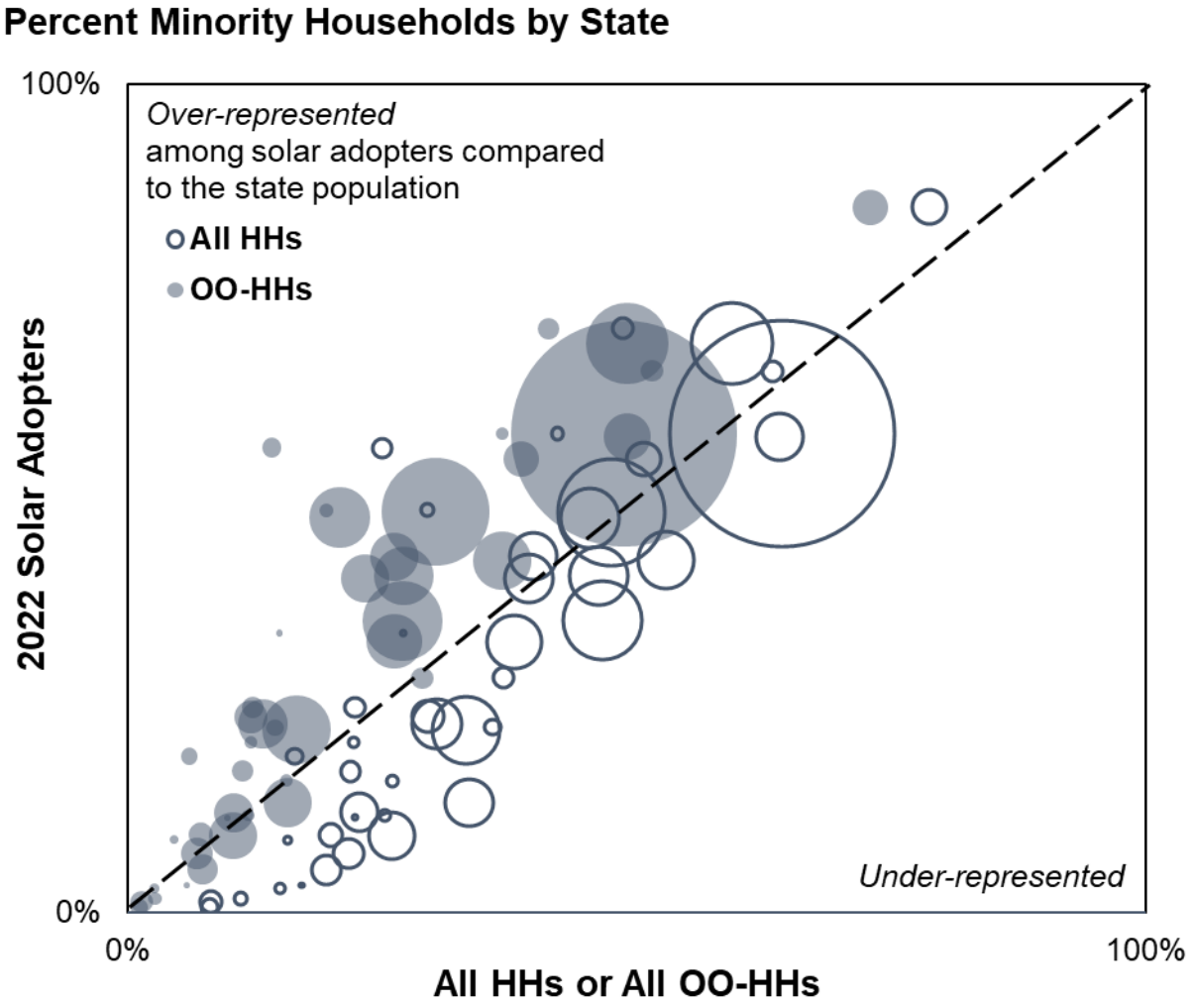


Notes: Weighted averages are calculated by taking the race/ethnicity breakdown of all HHs or all OO-HHs in each state and calculating the weighted average based on the number of PV adopters in each state (within our PV adopter dataset).

- PV adopters in 2022 had a larger Minority HH share (46%) than the general population of all U.S. HHs (41%) and OO-HHs (24%)
- Reflects broad geographical patterns where PV markets have taken hold (e.g., CA and sunbelt states with high Hispanic populations)
- When we "control" for this by comparing to a weighted average of U.S. households based on the distribution of PV adopters, adopters skew toward a lower minority share when comparing to all HHs (46% vs. 52%), but still have a higher Minority share when comparing to only OO-HHs (46% vs. 36%)
- Results show how racial disparities in PV adoption mirror (and may partly derive from) disparities in home ownership

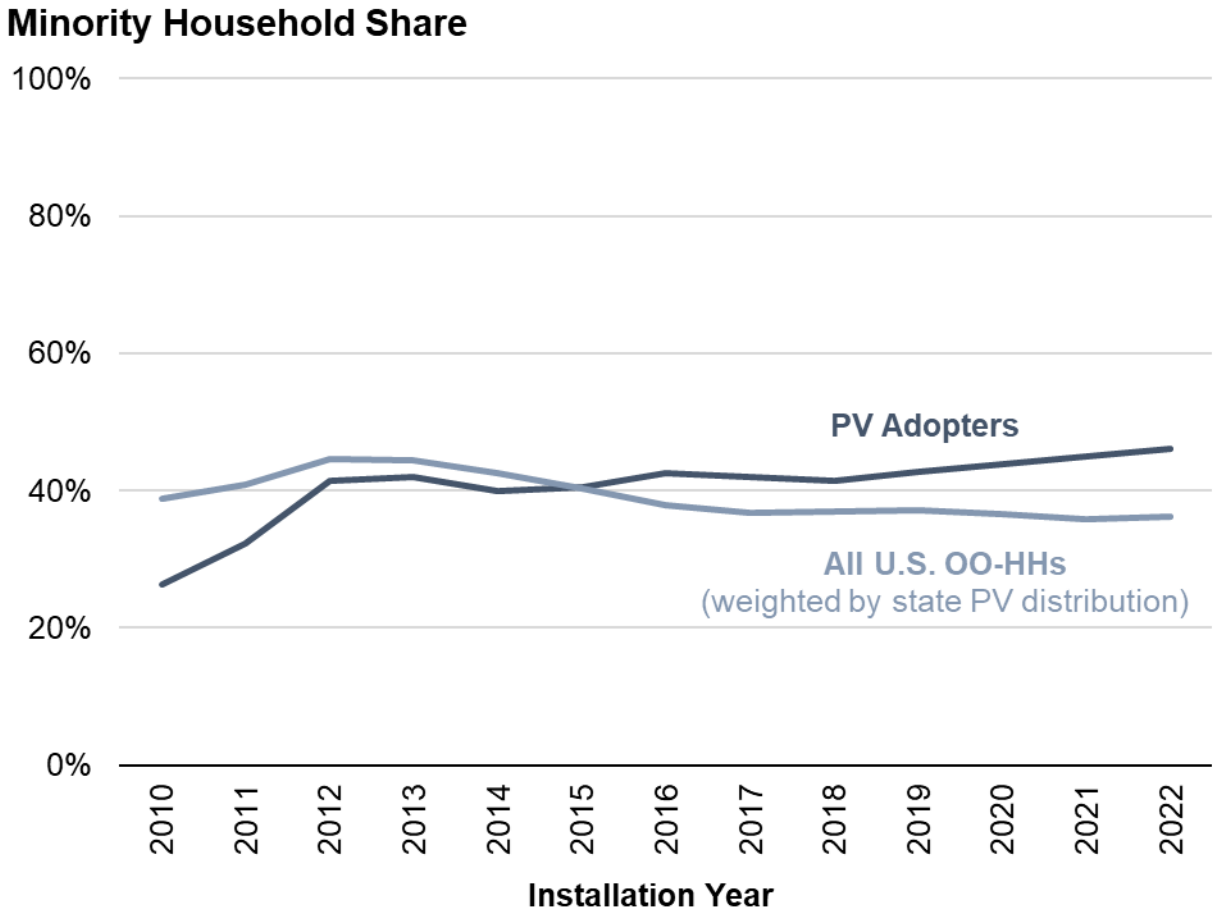
Race and Ethnicity

State-level comparisons: 2022 PV adopters vs. all HHs and all OO-HHs



- State level trends mirror the national trends
- Minority households are under-represented among solar adopters when comparing to all HHs in most states (the open circles)
- But the trends reverse if comparing to only OO-HHs (bubbles shift to the left), where solar adopters have *higher* minority representation than the broader population of OO-HHs in most states (solid circles)
- Results suggest that, among OO-HHs, minority households collectively have a greater propensity to adopt than non-Hispanic White households; further research would be needed to understand the specific drivers

Race and Ethnicity:
National trends over time



Notes: The line for All U.S. OO-HHs is calculated by taking the race/ethnicity breakdown of all OO-HHs in each state and calculating the weighted average based on the number of PV adopters in each state in each year.

- Nationally, PV adoption has been shifting toward greater representation among minority households over time
  - A rather dramatic uptick from 2010-2012, followed by a slow but steady upward trend
- In contrast, the benchmark weighted average minority share of all U.S. OO-HHs has been flat since 2016
  - In other words, PV markets have *not* been shifting systematically towards states with either higher or lower minority shares of OO-HHs
  - The steady growth in the minority share of PV adopters therefore is not obviously the result of larger geographical shifts in PV markets; other factors are likely at play

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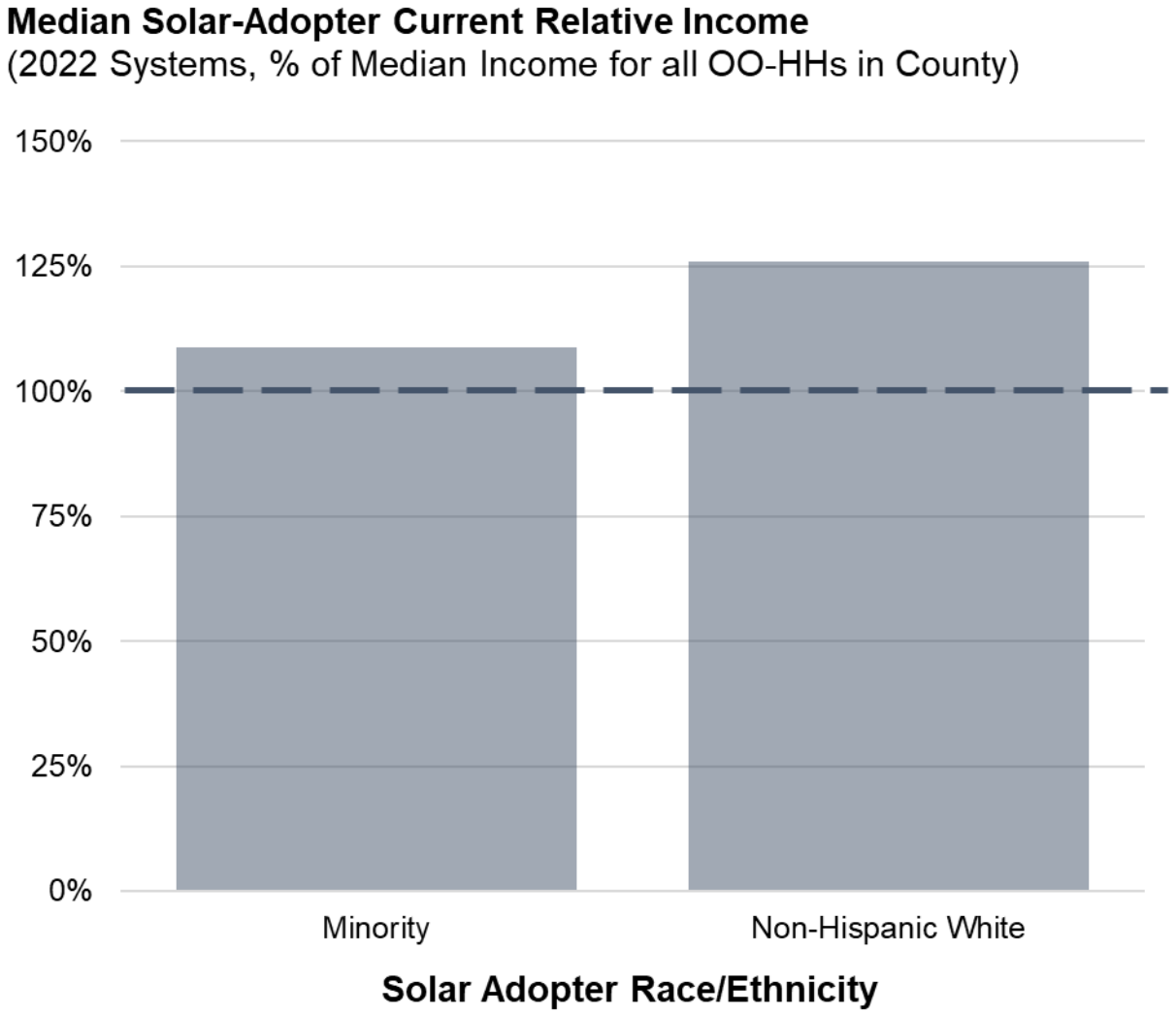
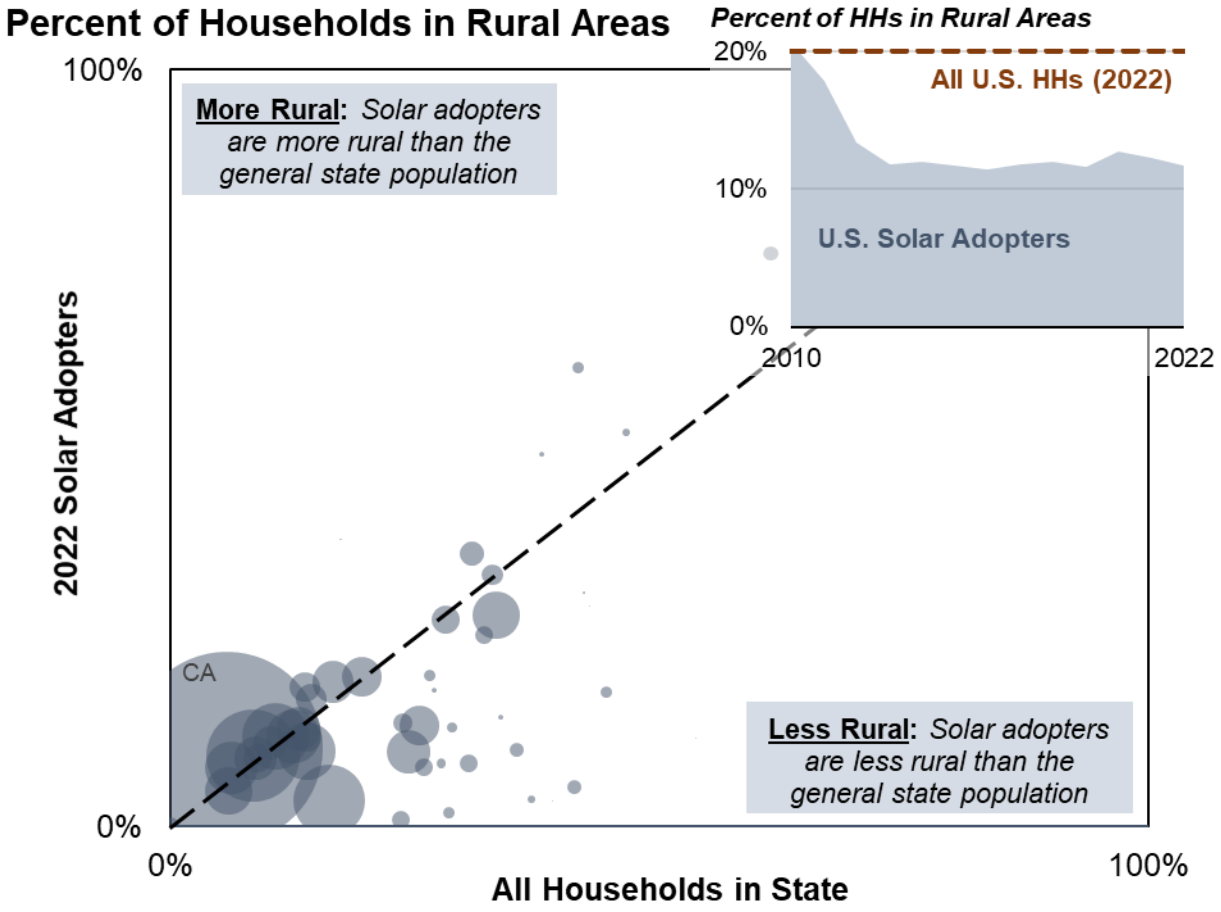
Solar-Adopter Relative Incomes by Race and Ethnicity



- Both minority and non-Hispanic White solar adopters tend to have higher incomes than other OO-HHs in the same county
- But the degree of skew is considerably less for minority solar adopters (9% higher than the county median, compared to 26% higher for non-Hispanic White adopters)
- Suggestive that efforts to address racial disparities in solar adoption could help to address income disparities as well

Rural vs. Urban

State comparisons and national trends over time



- Nationally, solar adoption is concentrated in less rural states, most notably California
- As a result, U.S. solar adopters are less rural overall (12% of 2022 adopters) than the U.S. as a whole (20% of all households)—see insert
- However, at the individual state level (bubble plot), solar adopters may be either *more* or *less* rural than their respective state population
- On a weighted average basis, PV adoption mirrors the distribution of households between rural and urban areas at the state level

Notes: Urban/rural classification is based on the 2020 US Census definitions, which rely on population density and land use, among other factors.

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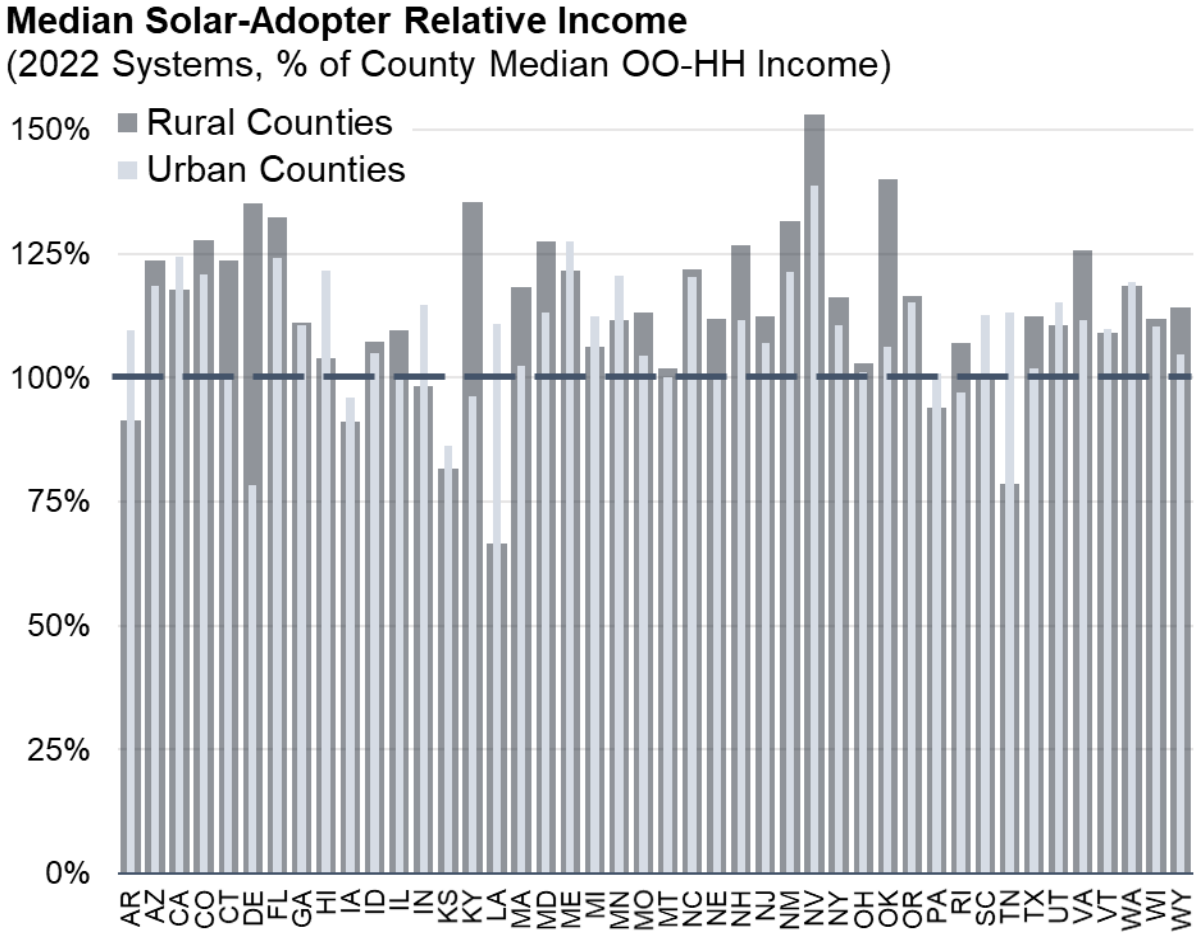
Solar-Adopter Income Trends by Rural/Urban Designation



Notes: Urban/rural classification is based on the 2020 US Census definitions, which rely on population density and land use, among other factors.

- Solar adopters in both rural and urban areas tend to skew toward higher income households, compared to all OO-HHs in the same county
- On the whole, income skew is greater in rural counties, but trends are mixed across states
  - Rural adopters have greater income skew in 28 states, while urban adopters have greater skew in 16 states
- There are a few states where the degree of skew differs significantly between rural vs. urban counties (in either direction)
  - E.g., skew is much lower for rural adopters in LA and TN, but much higher for rural adopters in DE, KY, and OK

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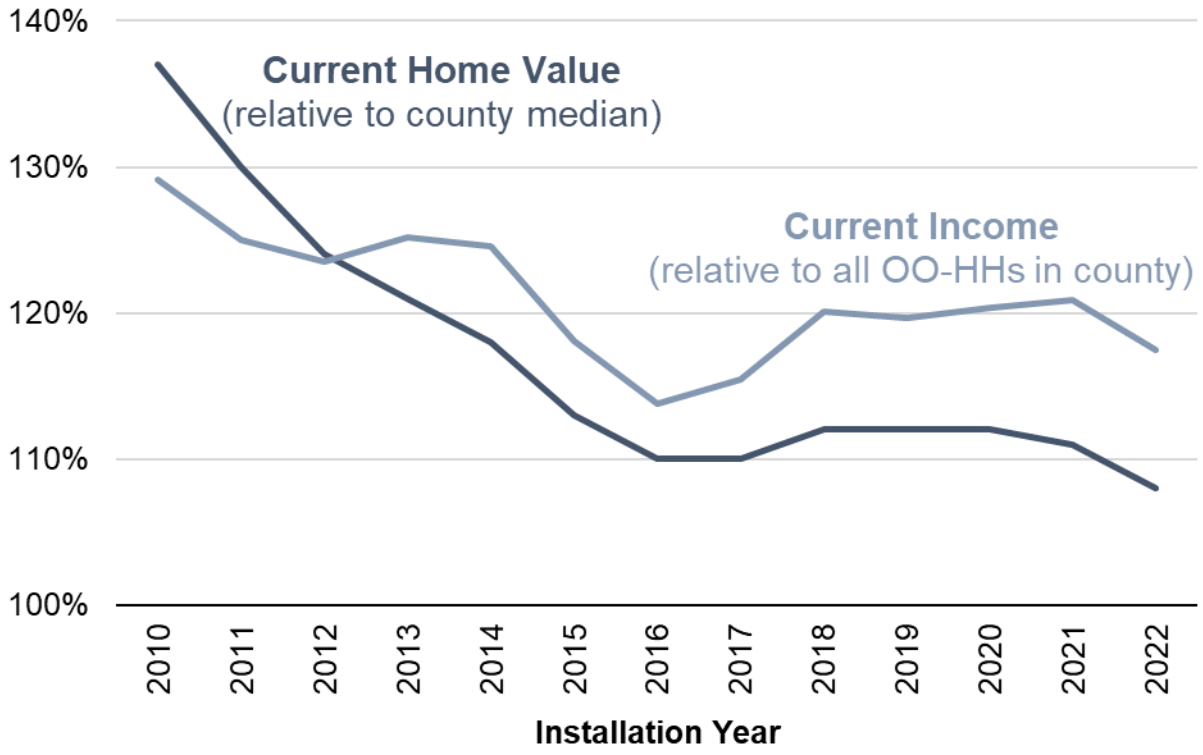
Home Value

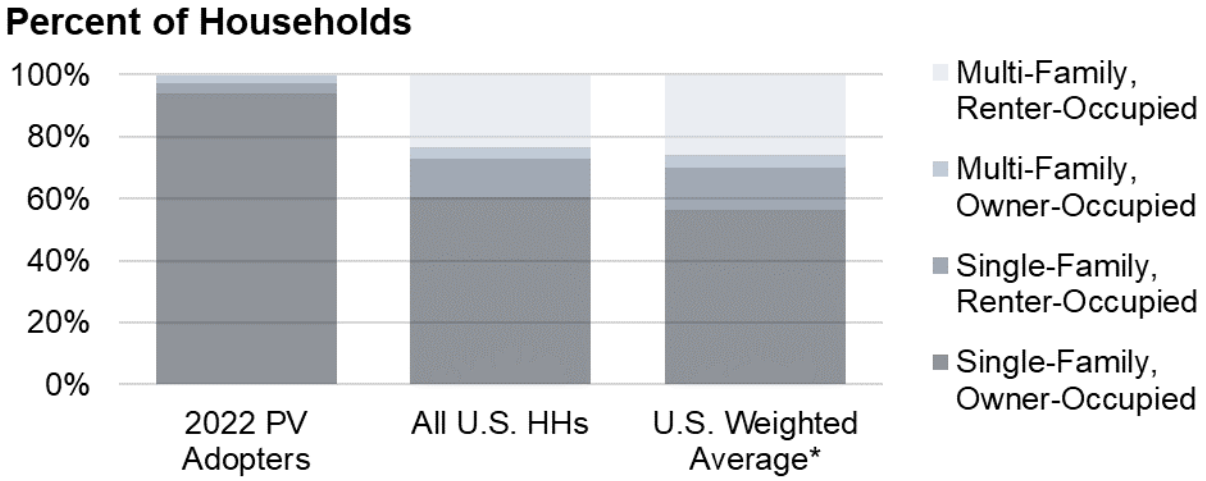
Median Solar-Adopter Current Home Value and Current Income
(% of current county median)

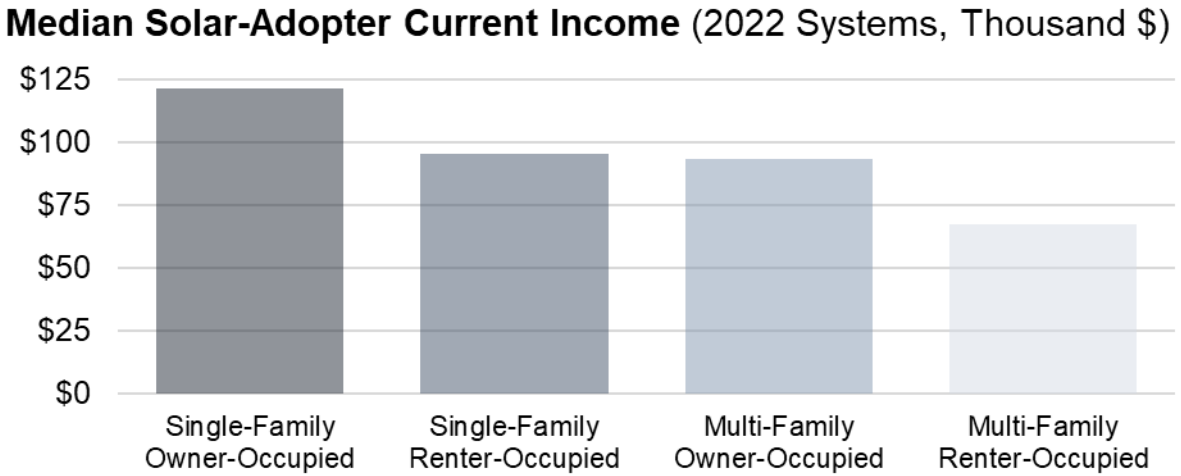


Notes: As with the income estimates, the home value estimates also refer to current values, not the value at the time of solar installation. As such, the skew in solar adopter home values may partly reflect the effect of solar installations on home value.

- Home value provides an indicator of household *wealth*, as distinct from income—albeit only for households that own their home
- Solar-adopter home value data are expressed as a percentage of the respective county median, similar to our relative income metric
- Solar-adopter home values are generally higher than others in the same county, but that skew has declined substantially over time (from 137% of county-median in 2010 to 108% in 2022)
- The skew is less pronounced than for income, suggesting that income is a much stronger contributor to adoption inequities than any broader differences in household wealth (again, beyond the threshold factor of home ownership)

Housing Type and Tenure

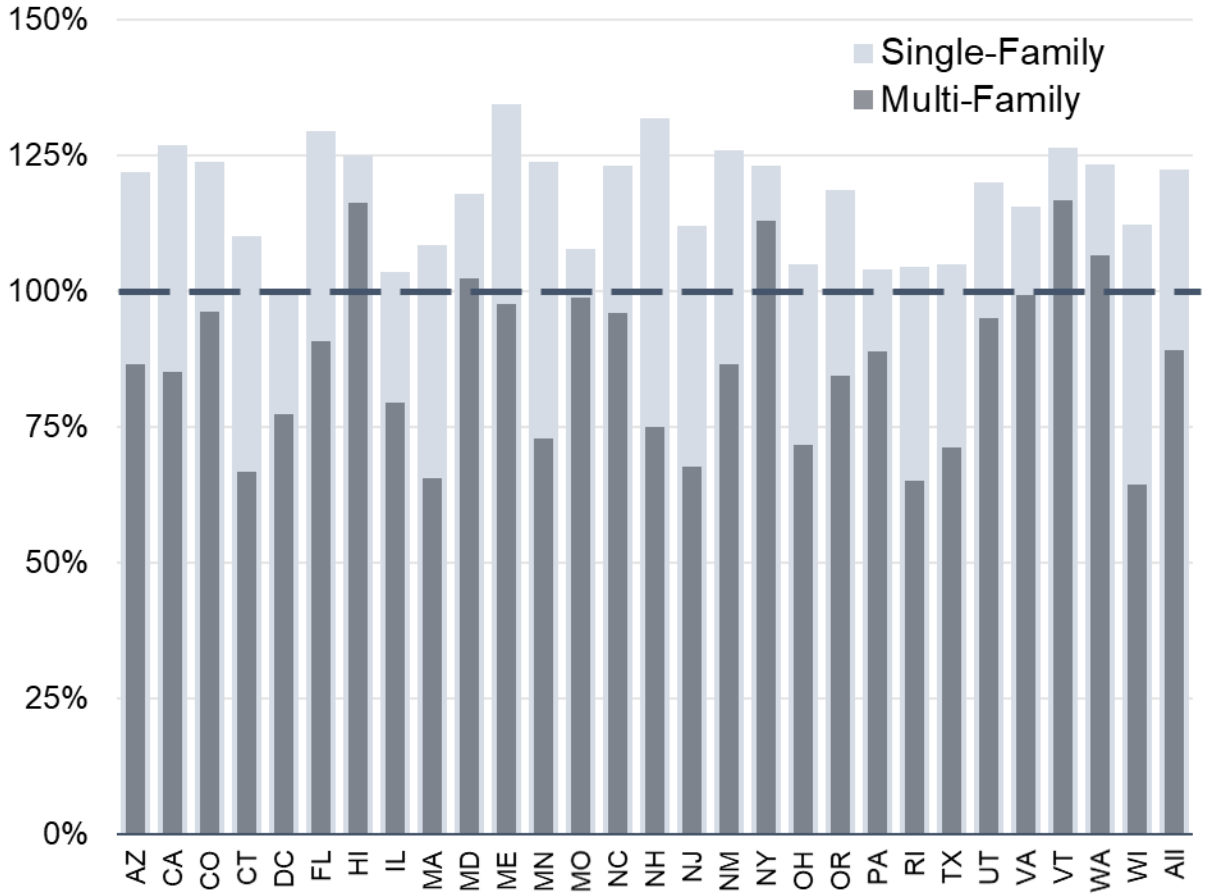




- The vast majority (94%) of 2022 PV systems were installed on single-family, owner-occupied homes
  - The remainder is split evenly between single-family renter-occupied and multi-family owner-occupied
  - A large portion of those multi-family systems are on condos
  - 2022 PV adopters include a negligible share of multi-family renter-occupied systems
- As to be expected, incomes are lower for solar adopters (in this case referring to the occupants) who are renters and/or live in multi-family housing

Solar-Adopter Income Trends by Housing Type

Median Solar-Adopter Relative Income
(2022 Systems, % of County Current Median Income for OO-HHs)



Notes: Figure includes states with at least 30 systems within each group.

- Multi-family adopter incomes are consistently below those of single-family adopters
- But more importantly, multi-family adopter incomes are generally at or below the median income of all OO-HHs in each state
- A small number of states have policies to specifically advance solar in multi-family housing
- The fact that multi-family adopters consistently achieve some measure of income parity suggests that policies and programs targeting solar in multifamily buildings, even if not specific to LMI, can help advance income equity in the solar market

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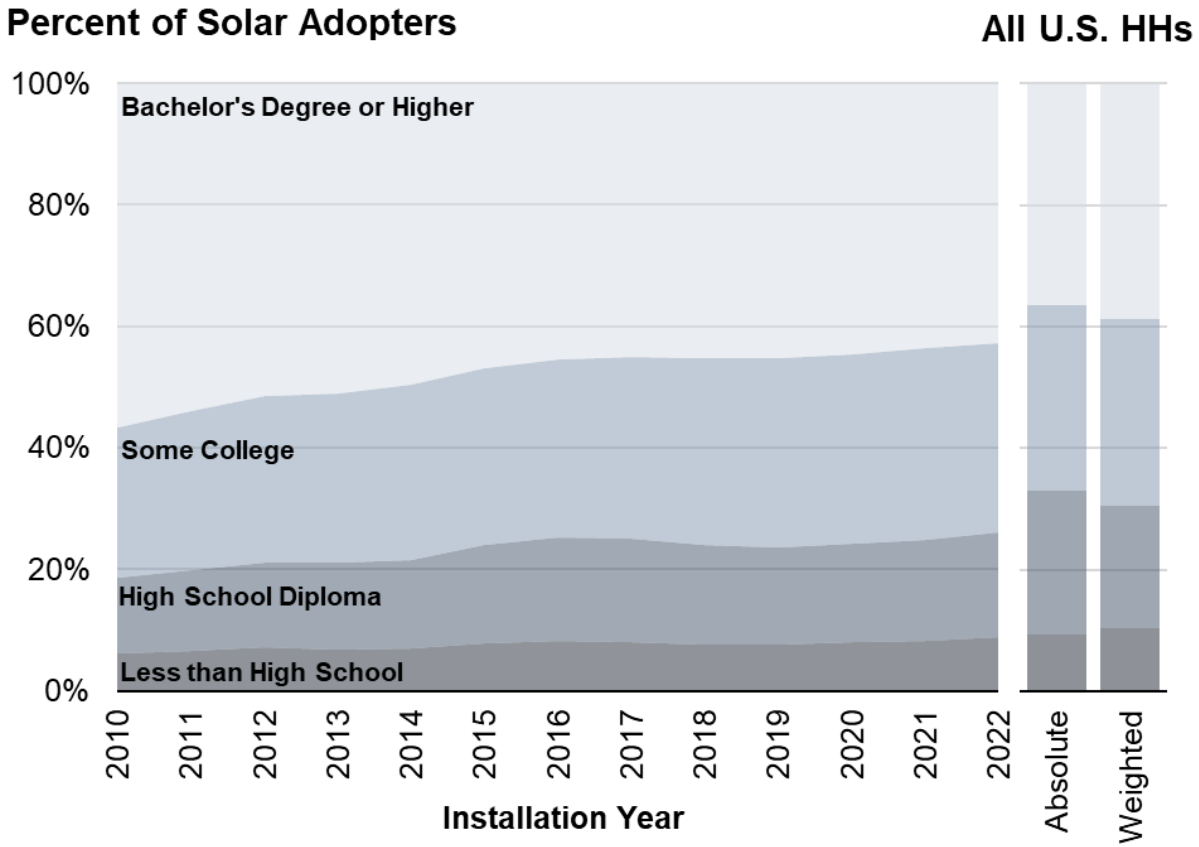
Education Level



Notes: Education level for each solar adopter is based on the highest current education level among adult household members, and for the U.S. population is based on the education level of householders. Absolute values for all U.S. HHs represent the simple distribution across all HHs, while the Weighted values are the averages for all HHs across all states weighted by the 2022 PV adopter sample in each state.

- Solar adopters in 2022 had slightly higher educational levels than the broader population
  - 43% have a bachelor's degree or higher, compared to 36% of all U.S. HHs (or 39% on a weighted average basis)
- That skew has significantly diminished over time: e.g., 57% of 2010 solar adopters have a bachelors degree
- As with some of the other trends we've seen, much of that shift occurred in the early years of the period shown; the trend since 2016 has been more gradual

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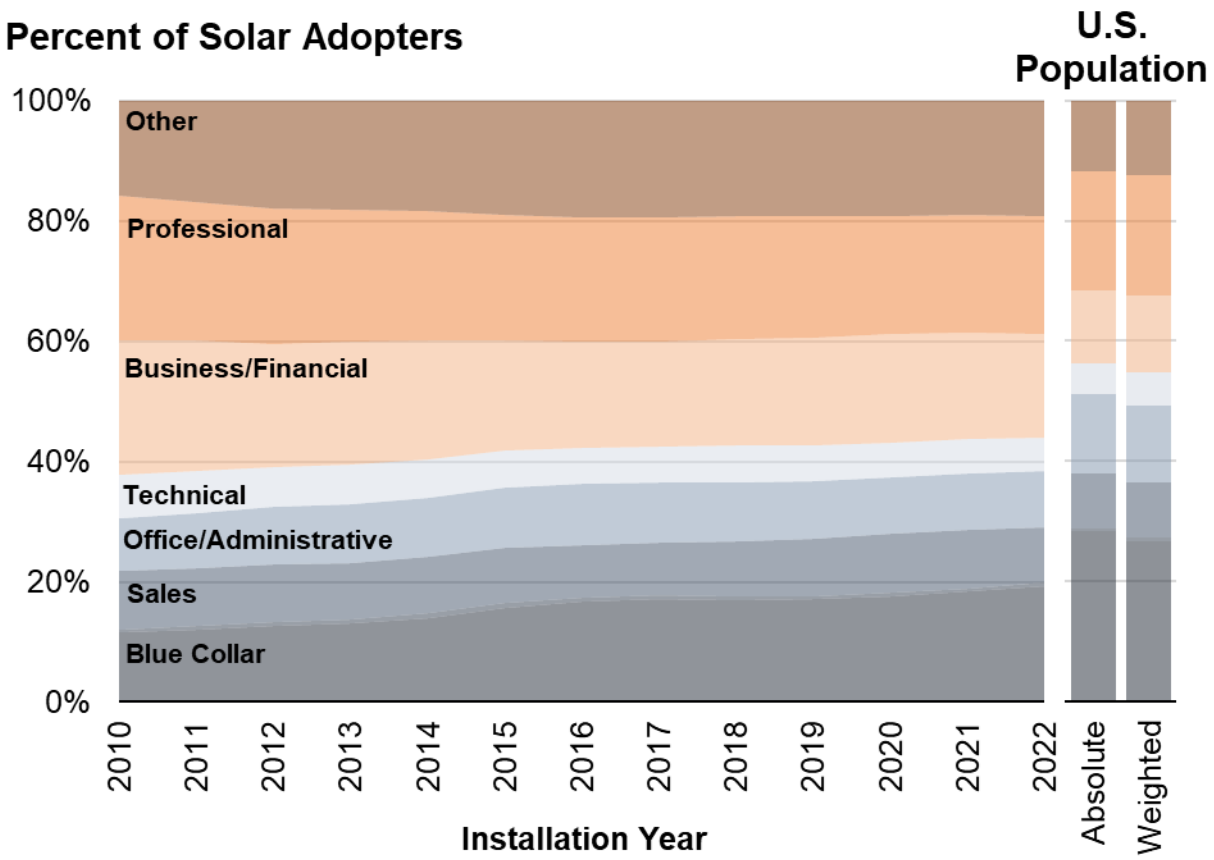
Occupation



Notes: Occupation statistics for solar adopters are based on all adult household members and reflect current occupations. Statistics for U.S. population are based on data from the U.S. Bureau of Labor Statistics, mapped to Experian's occupational categories. Comparison excludes retirees. See Education slide for explanation or Absolute vs. Weighted values for U.S. Population.

- Similar shares of 2022 solar adopters came from professional, business & financial, and blue-collar occupational categories as well as the catch-all "other" category
- Compared to the broader U.S. population, solar adopters are over-represented by business/financial occupations and under-represented by blue collar occupations
- As with other trends, that skew has diminished greatly over time, as the blue-collar share of solar adopters has grown from 12% in 2010 to nearly 20% in 2022

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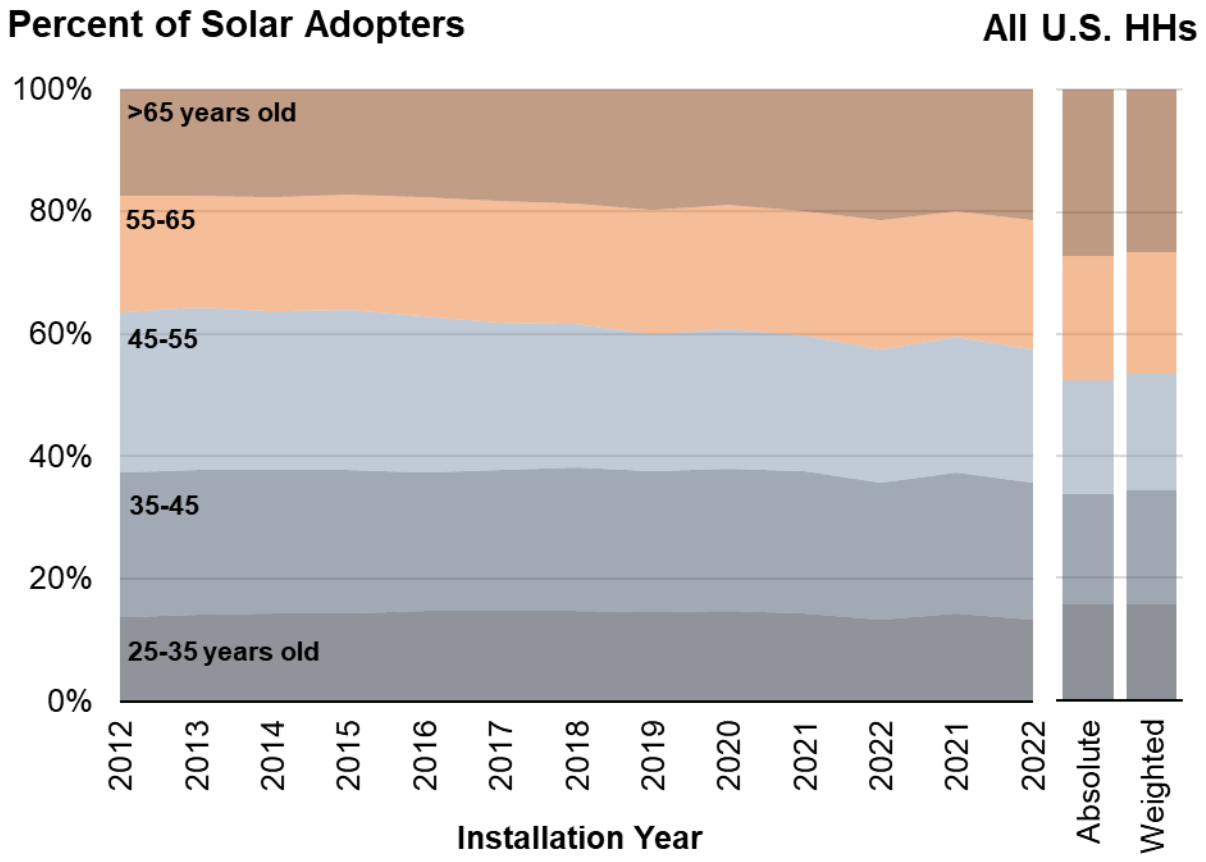
Age at the Time of Adoption



Notes: Ages for solar adopters are based on the primary household member, adjusted to reflect age at the time of adoption, and for the U.S. population are based on the householder. See Education slide for explanation or Absolute vs. Weighted values for U.S. Population.

- Solar adopters are under-represented among the youngest (25-35) and oldest (65+) age groups
- For the youngest group, this likely reflects lower home ownership rates and incomes
- Trends are fairly stable over time, though the share of adopters within the oldest age group (65+) has risen modestly
- That trend among the older group (mostly retirees) is consistent with growing technology acceptance (less perceived risk), and greater availability of financing (key for individuals on fixed-incomes)

Conclusions

Conclusions

- Solar adopters are heterogeneous in terms of their income and demographics
- But in general, solar adopters diverge from the general U.S. population, skewing, for example, toward higher income, Non-Hispanic White, and more educated households
- Those differences are considerably smaller (and in some cases reverse direction) if comparing to only owner-occupied households, which may be the more relevant point of comparison in some contexts
- Data for 2022 show that these differences are continuing to diminish over time, as a result of both a broadening and deepening of the U.S. residential solar market
- Differences between solar adopters and the general population also vary considerably across states, in some cases suggestive of policy-related factors

Appendix

Key Experian Data Elements Used in this Analysis

- **Estimated Household Income**: The total estimated income for a living unit, incorporating several highly predictive individual and household level variables. The income estimation is determined using multiple statistical methodologies to predict the income estimate for the living unit.
- **Dwelling Type:** Each household is assigned a dwelling type code based on United States Postal Service (USPS) information; could be either Single Family Dwelling Units, Multi-Family, Marginal Multi Family, P.O. Boxes, or Unknown.
- **Household Size:** The total number of people on the record, includes count for children, adults.
- **Individual Education:** Compiled from self-reported surveys, derived based on occupational information, or calculated through the application of predictive models.
- **Occupation Group:** Compiled from self-reported surveys, derived from state licensing agencies, or calculated through the application of predictive models.
- **Date of Birth/Combined Adult Age:** Date of Birth is acquired from public and proprietary files. These sources provide, at a minimum, the year of birth. The birth month is provided where available. Estimated ages are acquired from proprietary data sources and Experian models which estimate the adult age.
- **Estimated Current Home Value:** Predicts the current home value. Integrates market-specific data sources that include the most current, complete and relevant home value information available. In addition to public record data, such as deed data, the model will consider all available market information including recent sales and property listings.

Further Details on Experian Income Estimation

The estimated household income model incorporates several highly predictive individual and household level variables to provide accurate estimates for each living unit. Using multiple statistical techniques, the models predicts total estimated household income and assigns each living unit to one of twelve income ranges and income in thousands.

Estimated Income Model Development

To create an optimal solution the income model is based on the most up to date multivariate modeling techniques. For validation, in addition, to utilizing hold out samples from the model target universe, other internal resources were tested to ensure the models accuracy on a variety of populations. Resources include but are not limited to de-identified financial data, syndicated research panels and census data. Significant predictors of the Income include ConsumerView household and individual demographics, housing attributes, transactional purchase data, self-reported and geo level data such as census and IRS salary bands.

The percentage of households that the model predicts accurately was determined overall and at various income cut points. Multiple statistical tests were performed to assess the overall fit of the model.

1. Comparing the income estimates to the income provided by syndicated research
2. Comparing the distribution of ConsumerView households across the estimated income categories to the income distributions reported by the Census at various geo-levels.

ConsumerView Income distributions closely align with national Census distributions.

Key Public Data Elements Used in this Analysis

- **U.S. Census American Community Survey 5-Year Data (2017-2021):**
  - Median household income in the past 12 months (Table B25119);
  - Median household income (B19013);
  - Tenure by household income (Table B25118);
  - Hispanic or Latino origin by race – population (Table B03002);
  - Educational attainment by householder (Table B25013);
  - Age of householder (Table B25007)
- **U.S. Census 2020** Urban-rural classification: Rural and urban populations by state; and definition by latitude/longitude for classification of solar adopters
- **Bureau of Labor and Statistics:** Occupational Employment Statistics Survey, March 2023
- **U.S. Climate and Economic Justice Screening Tool (CEJST):** Disadvantaged Communities (DACs), November 2022

State Sample Sizes (filtered): *TTS=Tracking the Sun, BZ=BuildZoom, Ohm=Ohm Analytics; Market Coverage based on comparison to Wood Mackenzie's Solar Market Insight report*

	All Years					2022 Installations				
State	TTS	Ohm	BZ	Total	Market Coverage	TTS	Ohm	BZ	Total	Market Coverage
AK	0	0	0	0	0%	0	0	0	0	0%
AL	1	84	13	98	51%	0	28	9	37	100%
AR	0	1,035	890	1,925	21%	0	530	410	940	20%
AZ	32,088	77,568	45,242	154,898	63%	7,559	17,482	5,561	30,602	76%
CA	1,509,050	662	93,705	1,603,417	96%	222,745	236	22,194	245,175	95%
CO	1	41,977	58,647	100,625	87%	0	13,431	9,005	22,436	100%
CT	51,152	940	5,990	58,082	80%	3,799	183	1,494	5,476	52%
DC	10,653	1,829	511	12,993	100%	1,174	905	162	2,241	100%
DE	0	59	1,197	1,256	14%	0	17	3	20	1%
FL	9,763	68,813	94,085	172,661	97%	2,371	28,609	24,339	55,319	100%
GA	0	2,722	2,798	5,520	61%	0	914	1,251	2,165	44%
HI	22,073	7,123	56,506	85,702	86%	3,630	1,833	559	6,022	100%
IA	0	919	830	1,749	21%	0	213	131	344	12%
ID	2	9,464	4,764	14,230	88%	0	3,362	1,096	4,458	90%
IL	32,772	4,555	568	37,895	78%	8,425	2,428	347	11,200	86%
IN	2	900	1,288	2,190	31%	1	259	441	701	36%
KS	0	598	1,215	1,813	49%	0	286	423	709	46%
KY	0	593	1,353	1,946	48%	0	400	963	1,363	78%
LA	0	3,436	11,992	15,428	63%	0	821	3	824	100%
MA	124,119	6,606	6,536	137,261	99%	7,290	2,433	2,213	11,936	100%
MD	3	46,065	23,855	69,923	80%	3	3,817	1,949	5,769	78%
ME	8,246	190	2	8,438	99%	1,506	54	2	1,562	100%
MI	1	1,255	3,543	4,799	28%	0	276	484	760	19%
MN	1,113	6,568	8,579	16,260	98%	0	2,926	1,754	4,680	100%
MO	0	4,007	3,817	7,824	31%	0	1,610	583	2,193	29%
MS	0	43	0	43	6%	0	10	0	10	5%

	All Years					2022 Installations				
State	TTS	Ohm	BZ	Total	Market Coverage	TTS	Ohm	BZ	Total	Market Coverage
MT	0	1,482	796	2,278	69%	0	392	143	535	65%
NC	34,981	8,246	3,774	47,001	99%	9,096	3,628	1,632	14,356	100%
ND	0	32	14	46	81%	0	24	2	26	100%
NE	0	33	546	579	35%	0	2	188	190	20%
NH	8,358	427	95	8,880	67%	739	132	29	900	39%
NJ	155,559	2,285	347	158,191	97%	15,433	1,430	11	16,874	91%
NM	38,919	7,513	4,428	50,860	100%	6,712	1,652	2,381	10,745	100%
NV	85,700	2,169	1,560	89,429	92%	14,979	763	356	16,098	93%
NY	109,674	18,340	3,996	132,010	78%	11,605	5,592	240	17,437	100%
OH	2,626	2,972	2,700	8,298	59%	279	1,011	885	2,175	55%
OK	0	1,415	1,032	2,447	46%	0	837	558	1,395	56%
OR	26,039	5,354	9,050	40,443	98%	4,121	3,202	3,376	10,699	100%
PA	5,837	2,617	4,775	13,229	27%	0	1,247	678	1,925	20%
RI	16,196	2,220	88	18,504	99%	4,171	973	50	5,194	100%
SC	1	15,364	5,205	20,570	71%	0	1,718	607	2,325	73%
SD	0	7	13	20	22%	0	2	6	8	25%
TN	0	579	581	1,160	54%	0	120	80	200	100%
TX	2	57,322	64,393	121,717	56%	0	20,029	12,239	32,268	46%
UT	27,568	7,805	8,403	43,776	68%	5,147	1,251	919	7,317	88%
VA	9,614	13,051	12,260	34,925	88%	0	6,369	5,231	11,600	86%
VT	21,103	2,458	1	23,562	100%	2,066	322	0	2,388	100%
WA	7,144	20,964	8,989	37,097	85%	0	8,979	2,355	11,334	100%
WI	9,111	571	811	10,493	88%	1,972	336	414	2,722	100%
WV	0	27	0	27	2%	0	1	0	1	0%
WY	1	114	301	416	22%	1	21	135	157	35%
Total	558,433	173,367	134,158	865,958	86%	76,321	60,033	32,515	168,869	84%

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Sample Sizes (filtered) by Analysis Element

Vary depending on data availability and unit of observation

Analysis Element	Unit of Observation	Sample Size	
		2022	All Years
Income	Household	585,757	3,380,575
TPO vs. host-owned	Household	834,768	2,101,653
Installer name	Household	244,619	n/a
With or without storage	Household	518,884	n/a
Multi- vs. single-family	Household	602,606	n/a
Home Value	Household	579,622	3,356,532
Education	Household	585,757	3,380,575
Occupation	Individuals	1,404,233	8,738,701
Urban vs. Rural	Individuals	1,720,316	10,751,111
Race/Ethnicity	Household	504,832	2,910,036
Age	Household	363,933	2,896,461

General Notes:

- All elements of the study *combine* single and multifamily households
- The unit of observation for most analysis elements is the household, but for several elements (occupation and urban vs. rural), data for the overall U.S. population are available only at the individual level. In those cases, solar adopters summary statistics are based on all individuals in each household in order to allow for comparison to the U.S. population.
- Analysis elements related to TPO, installer name, and battery storage are based almost entirely on solar adopter addresses from Tracking the Sun

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