Modeling the potential effects of rooftop solar impacts on household energy burden

Sydney P. Forrester, Cristina Crespo Montañés, Eric O'Shaughnessy, Galen Barbose

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ENERGY TECHNOLOGIES AREA | ENERGY ANALYSIS AND ENVIRONMENTAL IMPACTS DIVISION

Outline

- Background and motivation
- Data and methods
- Results
- Discussion

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Takeaways

- Solar adoption reduced energy burden for three quarters of adopters across the U.S. even when considering the cost of paying back the system

- Energy burden reduction was more pronounced for LMI adopters, though high burdens persisted for roughly half of low-income adopters, demonstrating the importance of pairing solar with other complementary interventions such as weatherization and bill assistance where necessary

- Results varied by region
  - In the West, high electricity prices and good solar resource led to the greatest burden reduction
  - The only increase of burden was seen in the South due to low electricity prices limiting bill reduction
  - The Northeast saw sizeable percentage point reduction, though burdens remain high due to prevalence of propane and fuel oil as a primary heating fuel and solar's limited ability to impact non-electric energy burden
  - The Midwest saw burden reduction, though at a lower level than in the West or Northeast

Background: Terminology

$$energy\ burden\ (EB)[\%] = \frac{Total\ Household\ Energy\ Costs}{Total\ Household\ Gross\ Income}$$

→ "High" energy burden at or above 6%

→ "Severe" energy burden at or above 10%

Background: Motivation

- Equity as a whole and energy burden as a metric/target is becoming more common in executive goals, legislation, and program targets and low-income solar in particular
  - Energy affordability, clean energy technologies are distributed unevenly across U.S. households
  - Energy burden indicators and evaluation metrics are being used to target programs

- Energy burden reduction potential of various interventions have been researched, but gaps persist
  - Analyses have focused on traditional, effective strategies of bill assistance and weatherization, but only recently on solar
  - Challenges with data availability
    - Use of aggregated data or assumptions
    - Primarily/exclusively rely on modeled data
    - Empirical analyses focus on a specific geography
  - Analyses do not always account for net financial impacts on the household (consequent costs and benefits *off bill* such as renewable energy credits, solar or efficiency loan payments, etc.)

- Our analysis incorporates bill impacts, cost of adoption, and incentives to quantify energy burden holistically. We combine household-level empirical and modeled data to measure solar impacts on energy burden across U.S. homes for 2021.

Data and Methods

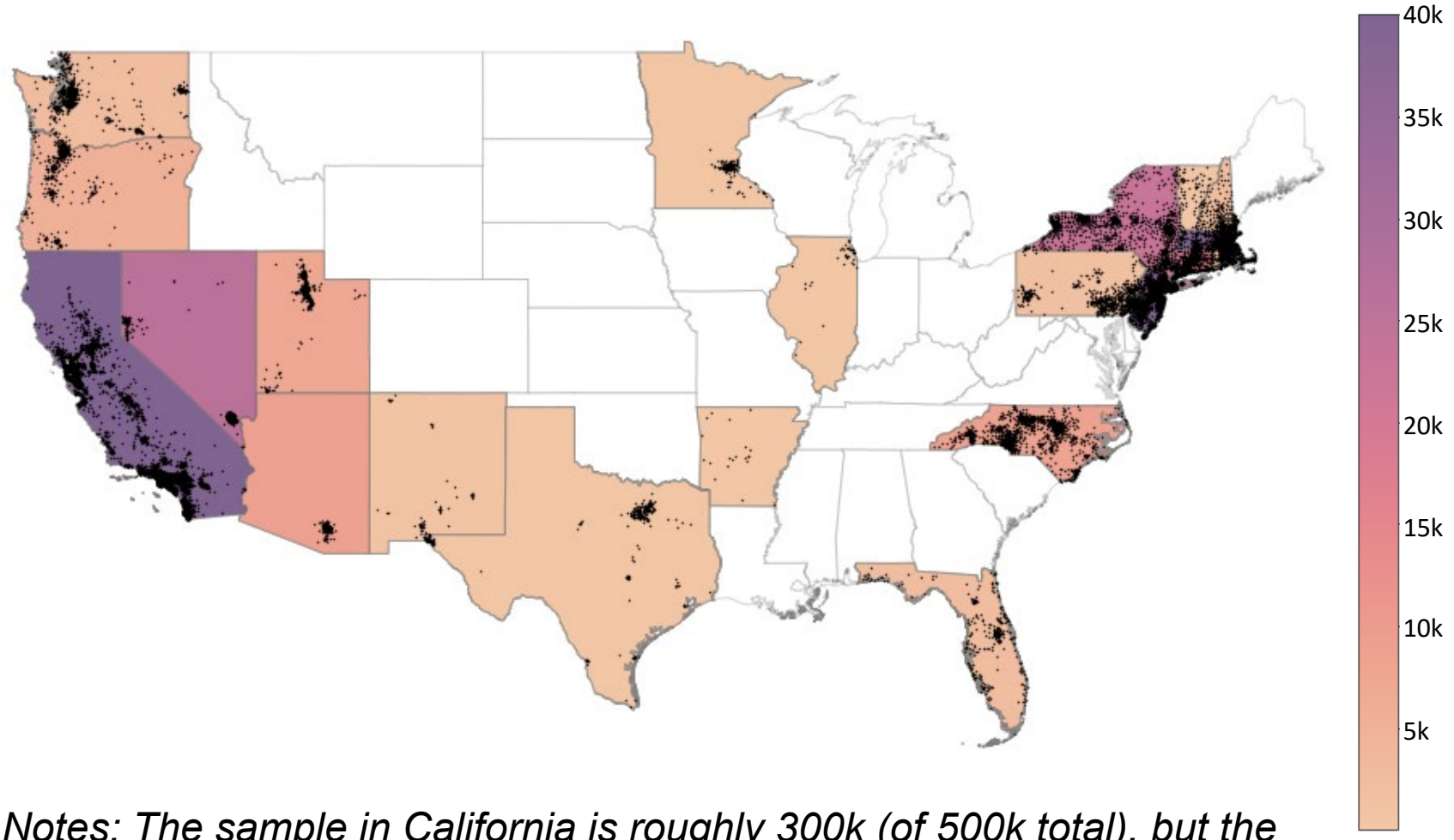
Methods & Data

Steps

1. Filtering, merging household-level data
2. Estimating hourly solar generation and hourly household load
3. Calculating energy bills
4. Solar adoption costs and incentives

	Data	Granularity	Description	Source
Step 1	Solar system specs.	Household	System size, street address, cost, incentive levels, installation date, the use of third-party financing, and other system attributes. Estimated income in 2021 at a household level modeled by Experian.	LBNL's Solar Demographics Report[1]
	Property details	Building	Empirical building properties such as square footage, number of stories, heating fuel type, and more	CoreLogic[2]
Step 2	Hourly end-use energy demand	Building model	Closest-neighbor, modeled hourly load profiles determined by matching empirical building characteristics with NREL's ResStock building models	NREL End-Use Load Profiles[3]
	Hourly solar production	County	Hourly kWh production for the centroid of each county, scaled by respective solar system installed capacity	NREL System Advisor Model[4]
Step 3	Electricity tariff	Zip code	Each zip code's most-likely residential tariff pre- and post-solar for 2021, including both fixed and volumetric costs on an hourly basis	Genability[5]
	Heating fuel costs	State	Costs of non-electric heating fuel costs including utility natural gas, propane, and fuel oil, based on state (or region) and month (or year)	U.S. EIA
Step 4	Solar loan and lease terms	State	Typical financial terms developed from aggregated and summarized loan and lease offerings, by state and year.	EnergySage

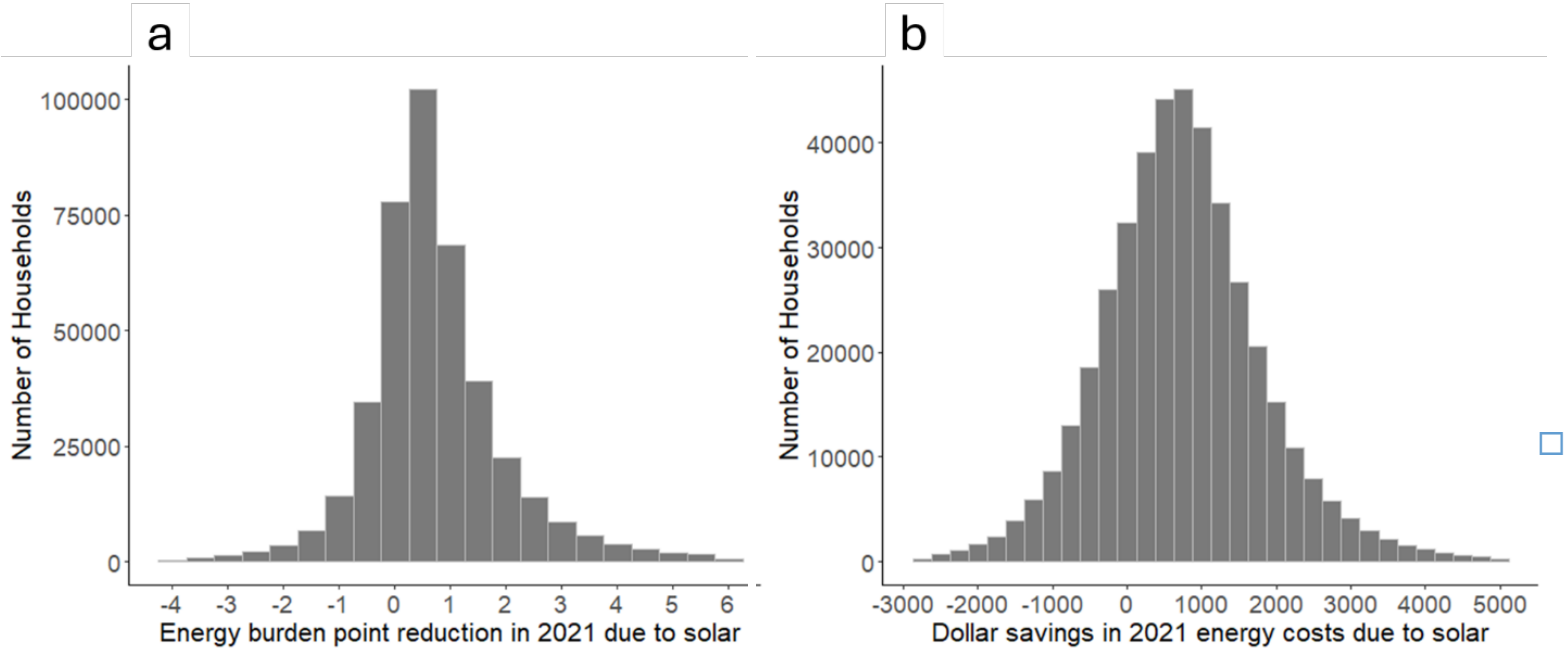
Data: Geographic coverage



Notes: The sample in California is roughly 300k (of 500k total), but the saturation is structured to better see the rest of the states

Results

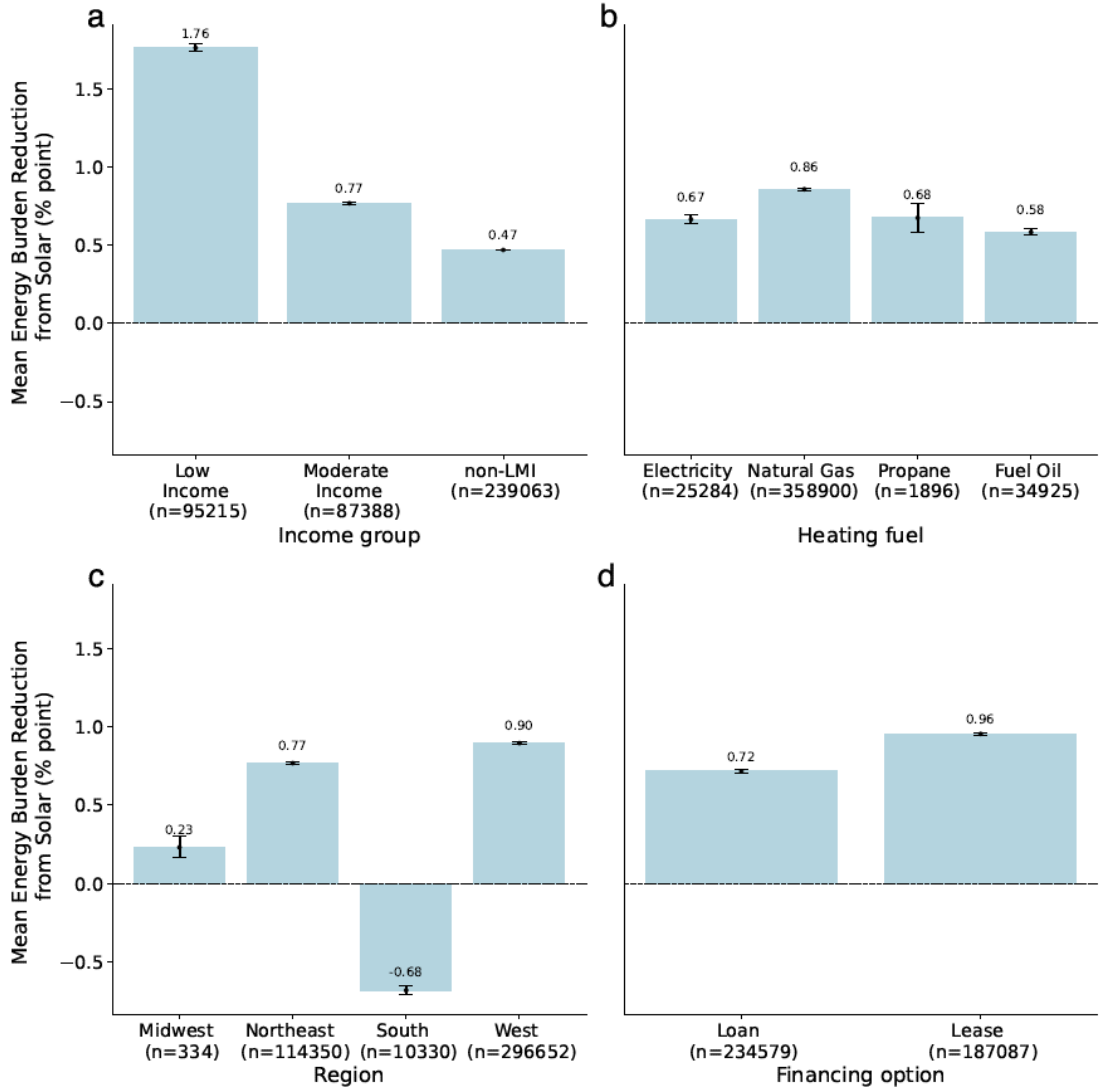
Solar decreased energy burden for the majority of adopters



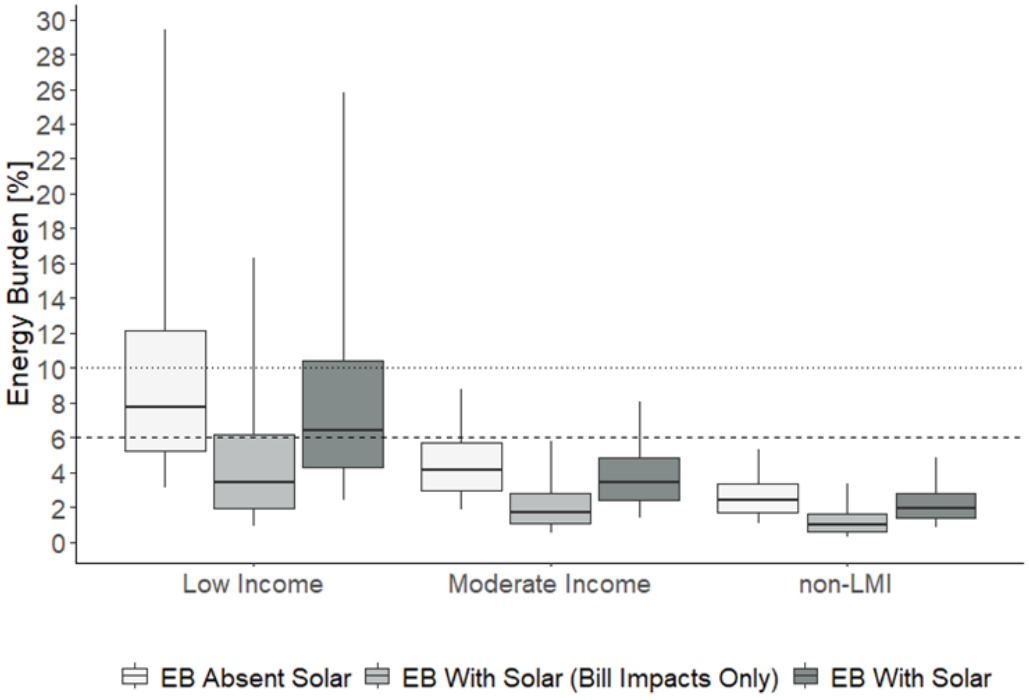
- The average customer saw a 0.6 point reduction in energy burden ($691 annually in savings)
  - Note that, if loan or lease repayment was ignored and only bill impacts were considered, these values would erroneously indicate a 1.7 point/$1,987 reduction)
- Not all installations generated savings that surpassed costs (i.e., households with values < 0 in figures)
  - More often for households with low electricity prices, more expensive per-Watt solar costs, and higher income

Rooftop solar reduced energy burden, on average, across all groups (apart from in the South)

- Solar reduced energy burden (inclusive of costs and incentives) across all incomes, heating fuel types, regions, and financing structures
  - Only exception was in the South where electricity rates are very low, which mutes bill savings of solar



Energy burden reduction shown throughout income groups and notable for LMI households



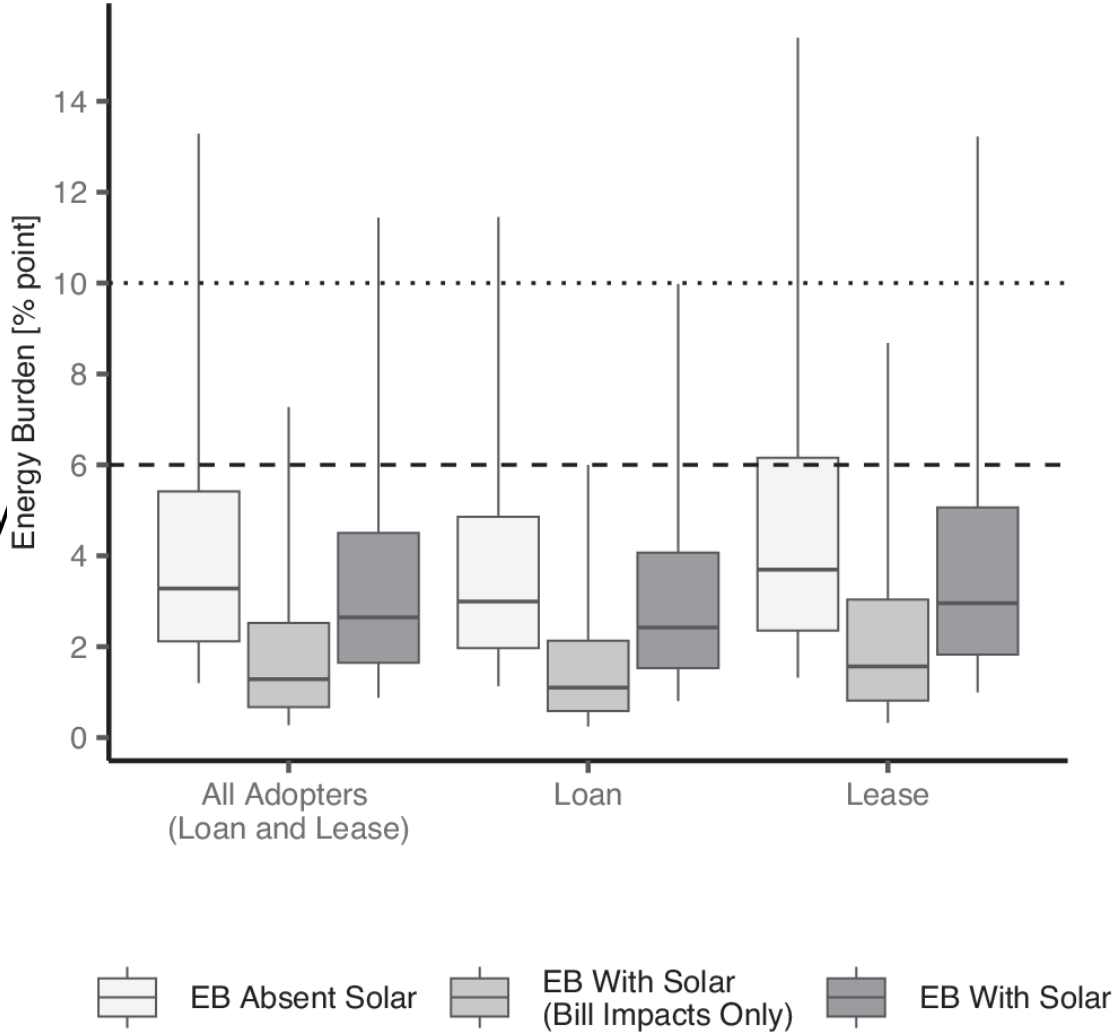
Notes:
Low income defined as having a household AMI at or below 80%; moderate income from 80% AMI to 120% AMI; and non-LMI as above 120% AMI.
Mid-line indicates median, boxes show quartiles, and whiskers show the 5th and 95th percentile. Dotted lines at 6% and 10% reflect "high" and "severe" burden.

- Solar reduced median LMI energy burden
  - Low income (23% of sample): 7.7% → 6.2% ($660/yr saved)
  - Moderate income (21% of sample): 4.1% → 3.3% ($674/yr)
  - Non-LMI (57% of sample): 2.4% → 1.9% ($711/yr)

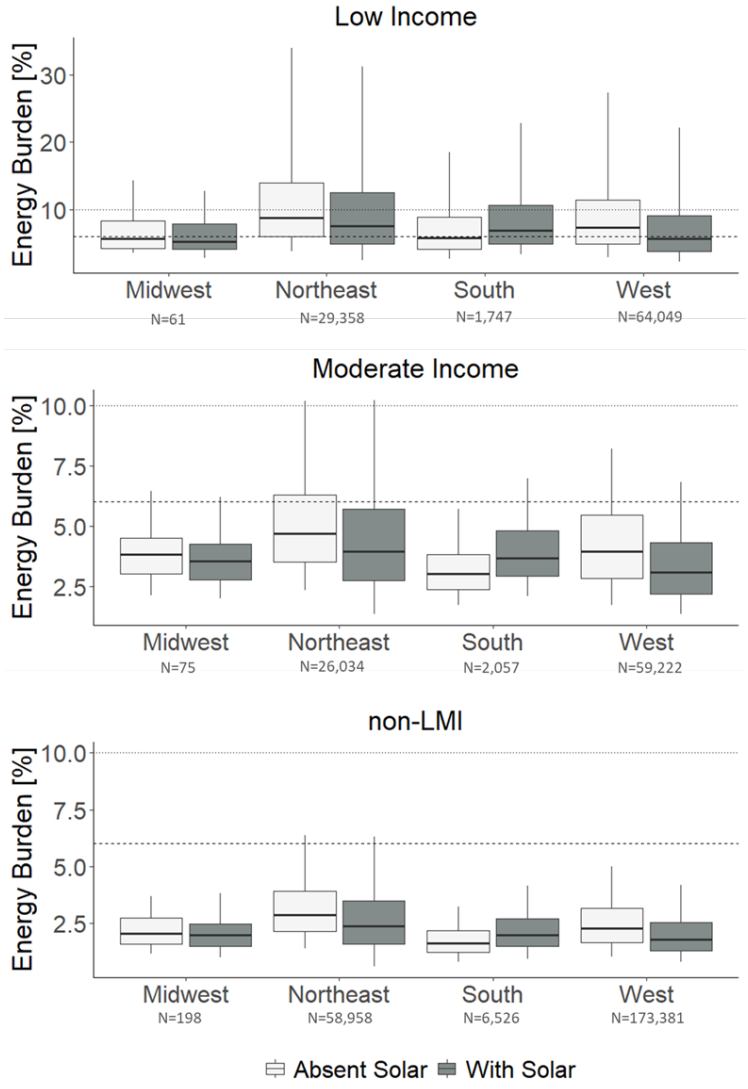
- % of LMI customers with high and severe energy burden decreased after solar adoption
  - Low income: 32% & 34% → 27% & 26%
  - Moderate income: 19% & 3% → 10% & 2%
  - Note that just over half of low-income adopters still have a burden greater than 6%, demonstrating that solar is beneficial, but still may benefit from complementary strategies (e.g., bill assistance, weatherization) or incentives (e.g., targeted low-income solar programs)

There are slight differences in burden reduction by ownership structure

- We assume that a household is paying for their system via a loan (66% of sample are host-owned) or lease (34% of sample is third party owned)
  - Based on empirical data on ownership
  - Loans/host-owned systems have access to additional benefits such as federal and state tax credits, solar renewable energy credits
  - Leased/third-party owned systems see incentives indirectly through pass-throughs
- Leased systems saw a slightly larger burden reduction
  - Note that third party ownership (leased systems) are more prevalent for LMI adopters (see "Solar Demographics" report)
  - Households with leases have higher burdens absent solar *and* with solar, but also see the largest reduction (3.7% → 3.0%, $716/yr savings) compared to loans (3.0% → 2.4%, $660/yr savings)



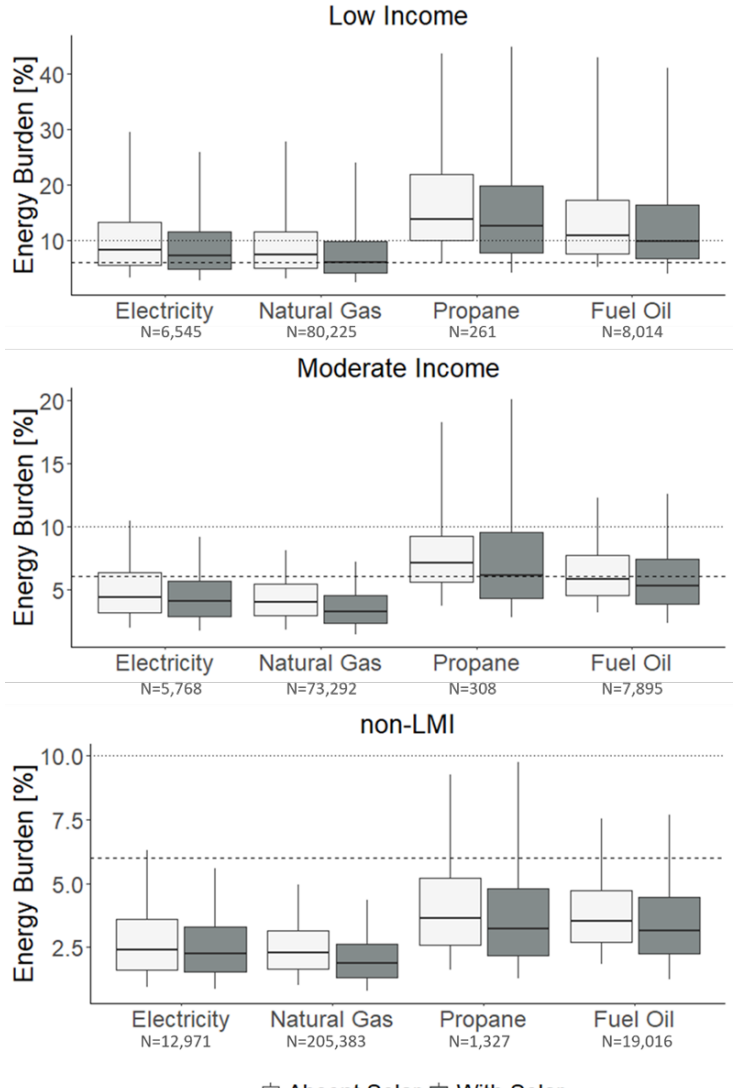
Solar reduces energy burden in all regions but the South



- Low electricity prices in the **South** leads costs of solar to exceed bill benefits in majority of cases in our study (5.8% → 6.9% for low-income households, $435/yr cost)
- Solar reduced median energy burden for low-income **West** (7.3% → 5.7%, $821/yr savings) and **Midwest** households to under 6% (5.7% → 5.2%, $166/yr savings)
  - Low-income households generally saw the largest point reduction in burden of any income group, but only in the West did they also see the largest dollar savings
- Solar led to a large point decrease in the **Northeast** (8.8% → 7.6% for low-income households, $461 savings), however, burden remains high due to more heating degree days and higher prevalence of non-electric heat

Burden reduction limited in fuel oil & propane cases

- Customers with propane and fuel oil have *much* higher energy burdens
  - Note that almost households in the small group of non-LMI solar households with “high” burdens are those that have fuel oil or propane heating
  - Of all low-income solar households with propane and fuel oil heating, 85% and 80% (respectively) maintain high or severe energy burdens even after solar
- Solar is only able to reduce electricity burden on its own and cannot impact non-electric energy costs
  - Complementary role of bill assistance, weatherization, and selective electrification (especially in cases of propane and fuel oil)



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Contacts

Sydney Forrester: spforrester@lbl.gov, (510) 486-4123

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