

Recent Trends in U.S. Energy Burdens

Eric Scheier¹
 escheier@unc.edu
 Dr. Noah Kittner¹
¹University of North Carolina at Chapel Hill

Introduction

Energy burden (household energy expenditure as percentage of income) exhibits profound geographic disparities and temporal heterogeneity. National burden decreased 13.9% (2018-2022), yet county-level changes ranged from 50%+ improvements to 200%+ increases. Multi-level analysis of the United States reveals disparity magnifies at finer scales: national averages mask critical local trends.

Methods

Data Source: U.S. Department of Energy (DOE) Low-Income Energy Affordability Data (LEAD) Tool, providing census tract-level home energy expenditure (electric, methane, fuel oil, etc.) and income estimates for 2018 and 2022 from Iterative Proportional Fitting. LEAD covers all U.S. states, territories, and the District of Columbia.

Sample: 3,222 counties, 195 utilities, 50 states across both time periods.

Geographic Aggregation: Census tract data aggregated to multiple geographic scales via population-weighted means:

- County-level:** Census tracts within each county
- Utility-level:** Counties within each utility service territory
- State-level:** Counties within each state

$$EB = \frac{S}{G} \rightarrow N_h = \frac{G-S}{S} \rightarrow EB = \frac{1}{N_h + 1}$$

where S = total energy spending, G = gross income, N_h = number of income units per energy spending unit.

Urbanicity Classification: Counties classified using USDA Rural-Urban Continuum Codes (RUCC):

- Large Metro:** RUCC 1-2 (metro areas $\geq 1M$ population)
- Medium/Small Metro:** RUCC 3-5 (metro areas $< 1M$ population)
- Nonmetro/Rural:** RUCC 6-9 (nonmetropolitan counties)

Regional Definitions: Geographic regions based on North American Electric Reliability Corporation (NERC) grid boundaries via state-to-NERC crosswalk from EPA eGRID data.

Analysis Methods: Counties ranked by percent change (2018-2022). Top 10 increases/decreases identified for geographic pattern analysis. IHS (Inverse Hyperbolic Sine) transformation applied to visualize percent change, compressing extremes while preserving differences near zero.

Results

(1) Geographic Heterogeneity

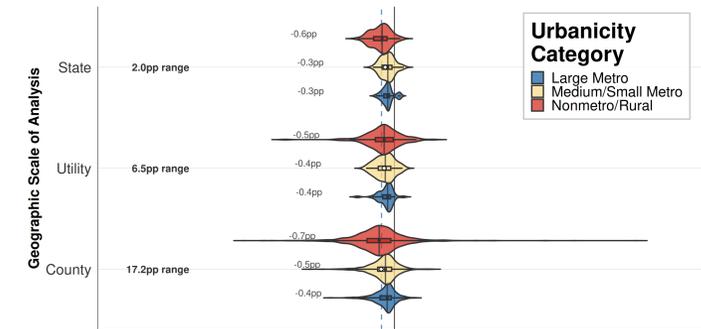
Choropleth map displays percentage change in energy burden by county using an IHS-transformed color scale within state and regional grid boundaries. Blue indicates decrease, green indicates minimal change, and red indicates increase. Alaska and Midwest show concentrated positive changes; North and South show concentrated negative changes; East, West, and Puerto Rico show mixed changes.

(2) Geographic Scale Effects

Violin plots display the distribution of energy burden changes (percentage points) across three geographic scales: County (n=3,222), Utility (n=195), State (n=50), stratified by urbanicity classification (Large Metro: blue, Medium/Small Metro: yellow, Nonmetro/Rural: red). Box plots indicate interquartile ranges; white diamonds mark mean values; zero line represents no change. Distribution variance is higher at finer geographic scales, and nonmetro areas exhibit systematically greater mean decreases in energy burden compared to metropolitan areas across all scales.

Distribution of Energy Burden Changes by Geographic Scale and Urbanicity, 2018-2022

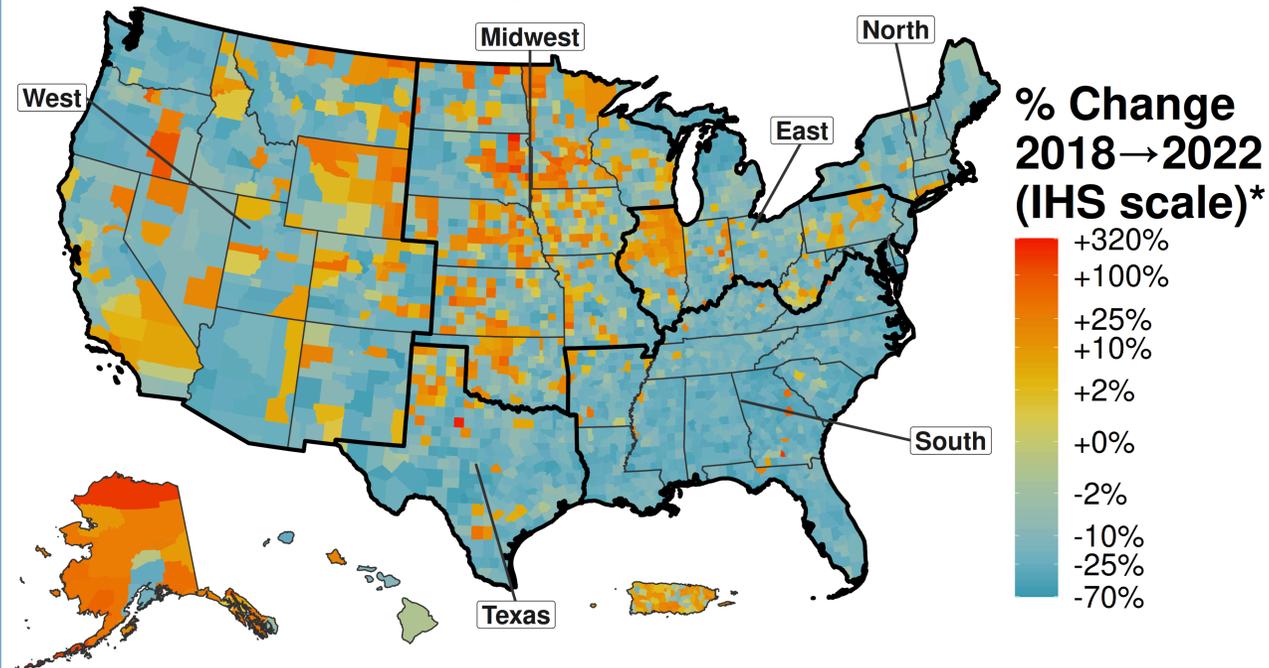
County-level analysis shows wider distribution (17.2pp range) compared to state-level aggregation (2.0pp range). Nonmetro areas show greater mean decreases (improvements) across all scales relative to metro areas.



Violin width represents distribution density. Box plots show interquartile range (IQR). White diamonds indicate mean values. Gray solid line: zero (no change). Blue dashed line: national mean change. Distribution variance decreases with geographic aggregation.

Spatial Distribution of Energy Burden Change, 2018-2022

County-level percentage change across the United States (National mean: -14%)



*IHS = Inverse Hyperbolic Sine transformation (compresses extreme values, preserves differences near zero) | Region boundaries represent NERC grid regions

National Energy Burden Trends (2018-2022)

Metric	2018	2022	Δ Change	% Change
Energy Burden - Mean (%)	4.02	3.46	-0.56	-13.9%
Energy Burden - Median (%)	3.94	3.37	-0.57	-14.4%
Energy Burden - Std Dev (%)	1.32	1.15	-0.17	-13.1%
Household Income (\$)	82,997	100,319	17,322	20.9%
Energy Cost (\$)	2,099	2,236	138	6.6%

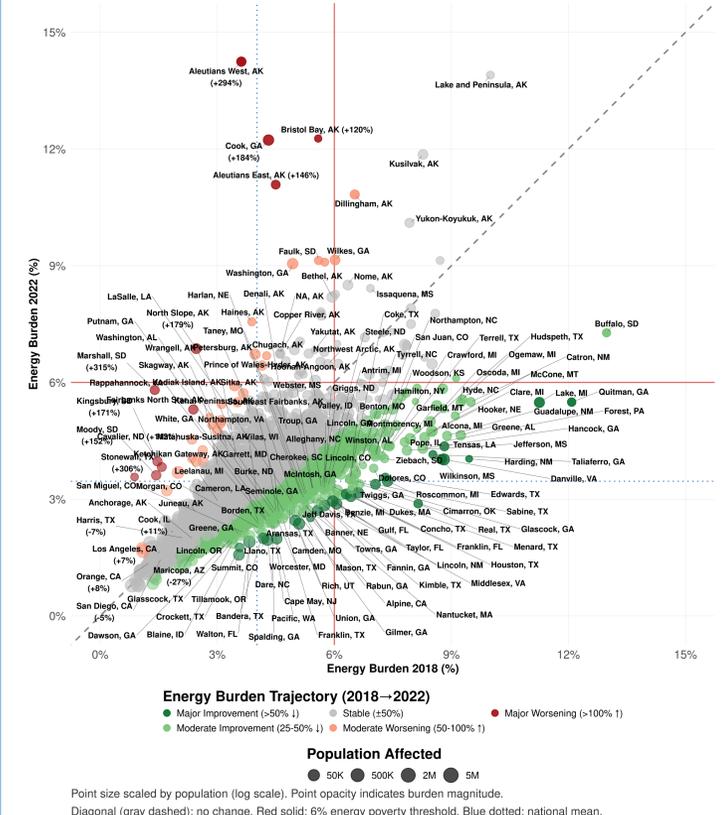
Largest Increases				Largest Decreases					
#	County	Region	Δ Change	% Change	#	County	Region	Δ Change	% Change
1	Marshall, SD	Midwest	+4.41 pp	+315%	1	Real, TX	Texas	-5.26 pp	-65%
2	Stonewall, TX	Texas	+2.69 pp	+306%	2	Harding, NM	West	-5.42 pp	-57%
3	Aleutians West, AK	Non-grid	+10.63 pp	+294%	3	Pacific, WA	West	-2.54 pp	-56%
4	Cook, GA	South	+7.92 pp	+184%	4	Summit, CO	West	-1.99 pp	-56%
5	North Slope, AK	Non-grid	+4.41 pp	+179%	5	Quitman, GA	South	-6.59 pp	-55%
6	Kingsbury, SD	Midwest	+2.51 pp	+171%	6	Dare, NC	South	-2.34 pp	-55%
7	Moody, SD	Midwest	+2.18 pp	+152%	7	Danville, VA	South	-4.79 pp	-54%
8	Aleutians East, AK	Non-grid	+6.59 pp	+146%	8	Wilkinson, MS	South	-4.72 pp	-54%
9	Cavalier, ND	Midwest	+2.25 pp	+142%	9	Camden, MO	Midwest	-2.73 pp	-54%
10	Day, SD	Midwest	+2.92 pp	+122%	10	Alpine, CA	West	-2.87 pp	-53%

(3) Temporal Heterogeneity

Scatterplot displays 2018 energy burden (x-axis) versus 2022 energy burden (y-axis) for each county. Point size is scaled by population (log scale). Color indicates magnitude of change: green (decrease >50%), light green (decrease 25-50%), gray (change $\pm 25\%$), orange (increase 50-100%), red (increase >100%). Reference lines: gray diagonal (no change; points above indicate increase, below indicate decrease), red solid lines (6% energy poverty threshold on both axes), blue dotted lines (national means for 2018 and 2022). Labels identify counties with largest absolute changes or high population. Alaska and Deep South counties cluster in the upper region; Southeast counties show concentration in the lower region.

Temporal Change in County-Level Energy Burdens, 2018-2022

27 counties decreased >50%, 11 increased >100%, 2467 changed $\pm 50\%$. Point opacity reflects burden magnitude (2018 for decreases, 2022 for increases). 163 counties with largest changes labeled.



Energy Burden Trajectory (2018-2022)
 Major Improvement (<50% ↓) Stable (±50%) Major Worsening (>100% ↑)
 Moderate Improvement (25-50% ↓) Moderate Worsening (50-100% ↑)

Population Affected
 50K 500K 2M 5M

Point size scaled by population (log scale). Point opacity indicates burden magnitude. Diagonal (gray dashed): no change. Red solid: 6% energy poverty threshold. Blue dotted: national mean.

Discussion

National energy burden decreased 13.9% (2018-2022), yet profound geographic heterogeneity reveals divergent local trajectories. Alaska counties exemplify vulnerability: Aleutians West increased 259% (3.91% to 14.02%) driven by diesel dependency and 2022 fuel price spikes. Conversely, Southeast cooperatives achieved dramatic reductions: Quitman County, GA decreased 54% and Cape Hatteras Electric 62% through efficiency programs and grid modernization. EIA data indicate distribution infrastructure costs are the primary driver of rate increases nationwide, with aging infrastructure and extreme weather resilience requirements disproportionately impacting small, remote utilities and their customers.

These patterns reveal systematic vulnerabilities (diesel dependence, geographic isolation, small scale) and proven intervention pathways (utility efficiency programs, infrastructure investment, regional integration). Multi-level policy responses are needed: federal support for diesel-dependent communities, state rate reforms, and utility-scale efficiency programs. The bimodal rural distribution (10 of top 10 worsening, 10 of top 10 improving are rural) indicates heterogeneous contexts requiring tailored approaches. Future research should examine utility governance structures, infrastructure investment strategies, and climate vulnerability to inform targeted burden reduction interventions. County-level analysis reveals heterogeneity masked by state aggregation, an essential insight for effective policy design.

References

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Contact: escheier@unc.edu | Data: DOE LEAD Tool (2018-2022)
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