Combined Energy Burdens: Estimating Total Home and Transportation Energy Burdens

MAY 2024

Key findings

Combined energy burdens include both home energy and transportation fuel costs as a share of income in order to provide a holistic picture of household energy expenditure.

- In 2022, **U.S. households spent on average 5.6% of their income on energy,** with **transportation fuel making up over half of this spending.**
- **Low-income households spent on average 17.8% of their income on energy** alone, almost four times the national average.
- **Roughly one in four households** experienced high combined energy burdens (spent more than 12% of their income just on energy) and **a staggering three in four low-income households** experienced high combined burdens.
- **Rural households** had an average combined burden nearly 50% higher than urban households.
- **Black households** spent on average 6% of their income on energy, roughly 10% above the national average.
- **Hispanic households** spent on average 7.9% of their income on energy, roughly 42% above the national average.
- The **increasing adoption of electric vehicles** will cause home electric energy burdens to increase while decreasing transportation fuel burdens, making the tracking of combined energy burdens more important.

Introduction

For decades, home energy burdens have served as a key metric of household energy affordability for researchers and policymakers alike. A home energy burden is defined as home energy expenditures as a share of household income. Research showing that low-income households experience disproportionately higher home energy burdens has informed a myriad of home energy efficiency and energy assistance programs designed to improve energy affordability. Such programs include the U.S. Weatherization Assistance Program (WAP) and the Low-Income Home Energy Assistance Program (LIHEAP) (Shields 2020, DOE 2021, Hernández and Bird 2010).[1] Home energy burdens have also been

[1] For example, the Department of Energy (DOE) Low-Income Energy Affordability (LEAD) tool provides home energy burden data to inform energy policies (DOE 2020).

core to ACEEE's research on racial and ethnic inequities in accessing home energy efficiency (Drehobl, Ross, and Ayala 2020). More recently, research has highlighted *transportation* energy burdens, or spending on gasoline as a share of household income, as a central element of a household's overall energy burden (Vaidyanathan, Huether, and Jennings 2021; Zhou, Aeschliman, and Gohlke 2020). However, efforts to collect transportation energy burdens have been hamstrung by infrequent or discontinued data collection. **This report presents findings from an analysis of combined energy burdens, which includes expenditures on both home and transportation energy as a share of income across U.S. households in 2022**.[2] While broader analyses of housing and transportation burdens include other costs such as rent, transit cost, and maintenance costs, this report is focused specifically on energy burdens and their relevance to energy efficiency policies. The underlying data are sourced from the Bureau of Labor Statistics Consumer Expenditure Surveys (CE), the most comprehensive public dataset on household expenditures (BLS 2022). This analysis is the first of its kind to rely on a single survey to estimate combined burdens. Similar estimates of combined energy burdens are available through the National Renewal Energy Laboratory's (NREL) State and Local Planning for Energy (SLOPE) tool. However, this metric used in SLOPE is derived by combining two distinct datasets (American Housing Survey for home energy data, and the National Household Travel Survey for transportation fuel costs), with expenditures reported only for 2017 (NREL 2024).

The analysis below provides insight on combined energy burdens. This measure allows for a more comprehensive understanding of a household's true overall energy burden and can better inform well-rounded efficiency policies that consider all household energy expenditures in unison. Combined burdens also provide a better look at a household's lived experience given that energy costs are not experienced in isolation. Installing electric vehicle charging, for example, may increase a home's electric bill, but will likely ameliorate the combined burden for that household. The method and findings sections below detail the analytical approach and report out key findings. The discussion section focuses primarily on the suitability of CE data for measuring combined energy burdens, touches briefly on policy implications, and outlines future research needs.

Methodology

We estimate combined home and transportation energy burdens (hereafter "combined energy burdens" or "combined household energy burdens") using publicly available survey data collected through the CE. The CE collects self-reported expenditure data from a nationally representative sample. This analysis relies on the CE Interview Survey, which asks consumer units (similar to households) to recall their previous three months of expenditures on big ticket items and recurring purchases (BLS 2022).[3,4]

[2] Here, transportation energy expenditures are limited to transportation fuel expenditures as calculated by the CE "GASMOPQ" variable, which includes gasoline, diesel, and motor oil. Expenditure on electricity for home electric vehicle charging is included in home energy expenditures. CE collects data on expenditures for electric vehicle charging outside of the home, but these data are not included in the analysis due to the limited sample size.

[3] BLS reports data by "consumer units." A consumer unit could be a family in one household, an individual living alone or with non-family members (such as roommates), or individuals who live together and make joint financial decisions. This report will refer to consumer units as households for simplicity.

[4]The other component is the Diary Survey, in which consumer units record daily expenditures for a two-week period. It is designed to collect data on small ticket items, such as specific food items (e.g., rice or chuck steak) for which respondents will

Data limitations

Previous ACEEE research on energy burdens has relied on data from the U.S. Census Bureau's American Housing Survey (AHS) to estimate home energy burdens and, separately, transportation energy burdens (Drehobl, Ross, and Ayala 2020; Vaidyanathan, Huether, and Jennings 2021). However, the AHS ceased collecting data on transportation energy costs in 2013. The CE is one of the only national surveys that collects data on both home and transportation energy expenditures.

CE relies entirely on self-reported expenditure data on both home and transportation energy.[5] Self-reported data can introduce reporting errors, such as a "rounding strategy" where respondents are likely to round their responses and to do so idiosyncratically over time (Pudney 2008, Bohr and McCreery, Do Energy Burdens Contribute to Economic Poverty 2020). Self-reported data on gasoline spending are likely especially prone to this reporting error, as gasoline expenditure is often more inconsistent, and prices vary more frequently. Consistent with this logic, CE gasoline expenditures appear to coalesce around specific, round data points (see Appendix C: Consumer Expenditure Data for illustrative data).

While AHS had relied on self-reported gasoline expenditures, it differed by using modeled energy costs to estimate expenditures on home energy. This fact, in addition to other variations in definitions, as well differences in survey methods, mean that findings from this report will not be directly comparable to previous results from the AHS. Despite these differences, the two data sources have generally compared well historically (BLS 2023a).[6]

Defining combined burdens

We define spending on home energy as any expenditure on electricity, natural gas, delivered fuels, or wood for a primary residence. Transportation energy expenditure is defined as expenditure on gasoline and diesel, with the exception of spending on these fuels for vacation-related travel.[7] Income is defined as the before-tax household income for the previous 12 months. The analysis below is limited to respondents that:

- Reported a household income greater than zero; and
- Reported their home energy expenditures; and
- Reported transportation energy expenditures; and
- Had a combined energy burden that did not exceed 100%.

Table 1 provides a summary of the sample used. Additional detail on the CE variables used can be found in Appendix B.

not likely recall expenditures for any length of time. The surveys are independently administered, so that the likelihood that a consumer unit is selected for participation in both the Interview and Diary Surveys is virtually zero.

[5] In limited cases, BLS imputes home energy expenditures when respondents do not provide this information.

[6] The AHS has historically estimated higher household incomes and utility expenditures compared to the CE, though the trends over time are comparable.

[7] The CE recently began collecting data on expenditure on charging electric vehicles away from home. This analysis does not include those expenditures. We expect these expenditures to be minimal for 2022.

Table 1. Summary statistics

	Q1 (2022)	Q2 (2022)	Q3 (2022)	Q4 (2022)	Annual value used
Households (population)	110,008,067	110,068,826	109,566,269	111,024,200	n/a
Households (sample)	1,435	1,336	1,338	1,345	n/a
Annual income (mean)*	$98,623	$100,802	$104,425	$106,375	$106,375
Annual income (median)	$73,154	$73,466	$77,653	$79,875	n/a
Home energy expenditure (mean)	$670	$586	$659	$673	$2,589
Transportation energy expenditure (mean)	$788	$1,017	$816	$728	$3,350

Dollar amounts are in 2022 dollars, unadjusted from survey responses.
*Survey respondents report their previous 12 months of income.

CE data are collected monthly, using a rotating panel of respondents for each quarter of the year referred to as "waves." In each wave, respondents may be surveyed in any of the three months of the quarter, when they are asked to report their previous three months of spending and previous 12 months of income. To control for any seasonal variation, this analysis includes only CE Interview Survey respondents who provided data for a full quarter of calendar year 2022. For additional details, see table B1.

Annual and quarterly estimates

The quarterly structure of the sample population prevents the estimation of an *annual* energy burden for any given household. Instead, this analysis relies on an **average annual energy burden** calculated from the sum of quarterly mean expenditures as a share of the mean annual income—in other words taking the ratio of two means.[8] Results of **median quarterly energy burdens** are reported primarily in Appendix A, which rely on three months of energy expenditure data as a share of income (annual income divided by four)—in other words the median of household-level ratios.

Defining high combined energy burdens

Home energy burdens are considered "high" when home energy costs exceed 6% of the household before-tax annual income, and "severe" when they exceed 10% (Drehobl, Ross, and Ayala 2020). While previous research has coalesced around cutoffs for total transportation burdens—burdens associated with all transportation costs, including insurance, maintenance, transit, and so on—it has not defined a universal cutoff for high transportation energy burdens (Vaidyanathan, Huether, and Jennings 2021). NREL's SLOPE tool, for example, uses 4.2% as a threshold for high transportation energy burdens, based on literature that suggests a possible range from 2% to 7% (NREL 2024; Zhou, Aeschliman, and Gohlke 2020). For the purposes of this analysis, we consider combined energy burdens to be high if they exceed 12% of household income, and severe burdens as exceeding 20%.

[8] Average annual income is based on the income reported in the fourth quarter as this represents the average income for calendar year 2022. Respondents are asked to report their previous 12 months of income.

Findings

Combined household energy burdens

This analysis found an average combined energy burden of 5.6% across all U.S. households in 2022. Consistent with previous research on home and transportation energy burdens research, these findings varied substantially based on the racial, ethnic, structural, and locational makeup of households. For example, Black households had an average combined burden of 6.1%, Hispanic households 7.9%, and White non--Hispanic households 5.4%. Low-income households, defined here as those earning less than 200% of the federal poverty level, appear to have a combined energy burden of 17.8%, nearly four times the national average.[9] Table 2 below provides additional results.

Table 2. Average annual combined energy burdens (2022)

Household type	Average combined energy burden
All households	**5.6%**
White, non-Hispanic households	5.4%
Black households	6.1%
Hispanic households	7.9%
Low-Income	17.8%
Renters	5.6%
Owners	5.6%
Single-family homes	5.5%
Multifamily homes	4.8%
Manufactured homes	11.7%
Rural	7.6%
Urban	5.2%
South	6.2%
West	5.6%
Midwest	5.4%
Northeast	5.0%

Figure 1 shows the average home energy burden of 2.4%, while the comparable measure for transportation energy was 3.1%, yielding a national combined burden of 5.6%, on average.[10] Notably,

[9] Some households, such as those with self-employed members, may report incomes that meet this threshold due to business losses, though are able to draw on savings. However, this is unlikely to meaningfully skew the results. See Appendix C for further information on the income variable used.

[10] Burdens do not sum to 5.6% due to rounding.

Hispanic households experienced the highest combined energy burdens among racial or ethnic groups, driven predominantly by a higher transportation energy burden of 5.1% (as compared to the national average of 3.1%). This is consistent with Hispanic households facing higher overall gasoline expenditures, likely as a result of their concentration in the South and Southwest (areas with inconsistent access to public transportation or other alternatives), increasing migration to rural areas, and concentration in industries that require substantial driving to access (FRED 2024; Madrid 2012; RHI hub 2023; USDA 2020).

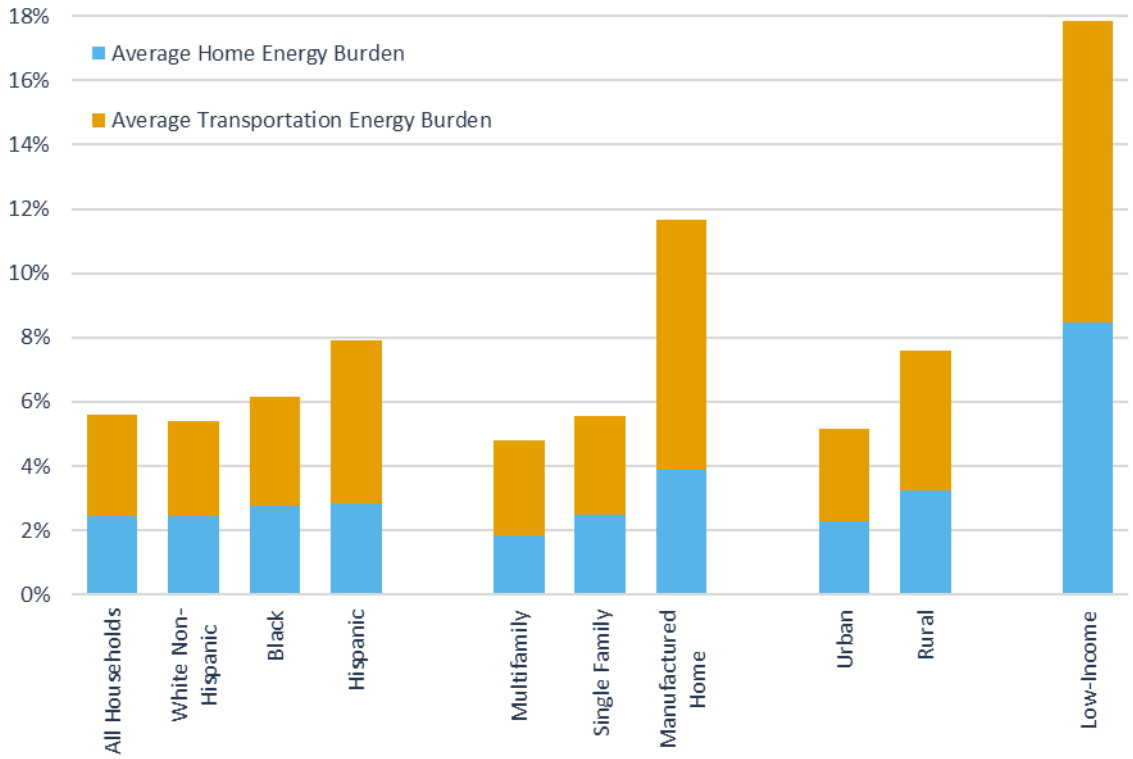

Figure 1. Average combined energy burdens in 2022, by group. Combined burdens are broken out by home and transportation energy burdens.

Rural households had substantially higher combined burdens than urban households. Rural home energy burdens were roughly one percentage point higher than urban ones (3.2% compared to 2.3%), and transportation energy burdens were even higher, at 1.5 percentage points above urban households (4.4% compared to 2.9%). Combined, rural households experienced an average burden of 7.6% compared to the urban household's 5.2%.[11] This is consistent with the fact that rural residents typically have limited-to-no access to transit options and are required to drive relatively high mileage in personal vehicles. Rural residents also have lower incomes; in the sample used, rural residents had a mean household income of $91,000, and urban households had a mean household income of $110,000.

This difference is magnified for residents of manufactured homes, who experienced the highest average home energy burden of any building type (3.9%, compared to the site-built single-family home average of 2.5%), as well as one the highest transportation energy burdens among any group. This is likely due to

[11] This analysis relies on the newly adopted CES definition of rural and urban areas, designed to aligned more closely with the Census Bureau's definition (Curtin 2023).

several factors. Residents of manufactured homes have an average income of $60,000, just over half of the national average. These homes are also more often located in rural areas, located far from municipal centers or essential services, more inefficient than their site-built counterparts, and residents are more likely to have older and more inefficient vehicles (BLS 2023b).

Quarterly burdens

CE data are collected from four distinct waves of survey respondents throughout the year, so estimating an *annual* median burden is not possible. However, median burdens can be reported by quarter. Table 3 presents median energy burdens by quarter for 2022. The U.S. median combined burden ranges from 6.4% in Q4 to 7.1% in Q2, both notably higher than the average annual combined burden of 5.6% reported in table 2. Estimating median energy burdens may provide a more realistic insight into the experience of a typical household, while the average income and expenditure estimates used in the previous section may be prone to skew based on extremes in the income distribution. Additionally, quarterly data may provide new insight into the household experience of energy burdens throughout the year, including through specific seasons. For example, gasoline prices spiked in the second quarter of 2022, likely leading to an elevated transportation energy burden seen in Q2 (EIA 2024). Additional quarterly results and discussion are reported in Appendix A.

Table 3. Median combined energy burdens for all U.S. households, by quarter (2022)

	Median home energy burden	Median transportation energy burden	Median combined burden
Q1	3.1%	3.4%	7.0%
Q2	2.7%	3.9%	7.1%
Q3	3.0%	3.2%	6.7%
Q4	2.9%	2.9%	6.4%

High and severe combined burdens

Table 4 presents the share of households with high combined burdens (energy expenditures meet or exceed 12% of household income) and severe household burdens (energy expenditures meet or exceed 20% of household income) by quarter. While roughly a quarter of U.S. households experienced combined energy burdens above 12% (high combined burdens), the share of households with such burdens nearly triples to 70% for low-income households. Similarly, roughly 10% of U.S. households experience severe combined burdens (burdens above 20%) and closer to 35% of low-income households experience the same. See Appendix B for additional results.

Table 4. Total share of households with high or severe energy burdens, by quarter (2022)

	Percentage of households with combined burdens over 12% (high burdens)	Percentage of households with combined burdens over 20% (severe burdens)
All households		
Q1	24.7	11.0
Q2	25.3	10.6
Q3	24.8	11.4
Q4	22.9	8.3
Low-income (under 200% of federal poverty line)		
Q1	67.1	35.2
Q2	67.4	37.3
Q3	72.2	43.1
Q4	74.2	34.7

Notably, high combined energy burdens do not necessarily correlate with high energy usage. Figure 2 below shows that while higher income households tend to spend more on (and presumably use more) energy, they typically experience the lowest combined energy burdens. The reverse trend holds for lower-income households.

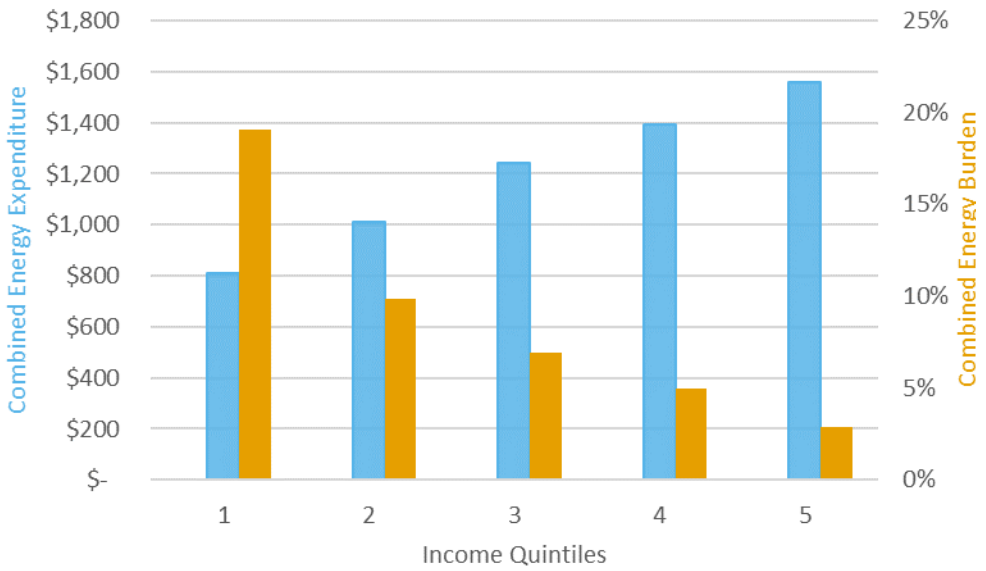

Figure 2. Median combined energy expenditure in Q4 (left axis) and median combined energy burdens in Q4 (right axis)

Discussion

Is the Consumer Expenditure Survey the right fit for measuring combined energy burdens?

The limitations of CE data present a number of challenges to energy burden research. As discussed above, the quarterly sampling used by the CE complicates the calculation of annual energy burdens. However, the CE contains necessary data to calculate combined burdens on a quarterly basis, which can be used to construct annual estimates. However, these annual estimates may restrict more granular analysis such as observing the distribution of combined energy burdens, or the number of high or severe burdens. Conversely, CE public use microdata are collected in four waves of respondents throughout the year published twice a year, which allows for closer measurement of changes over time.

Data reliability, especially for self-reported gasoline expenditure, is of special concern. While self-reported data allow for more "real-world" data, it also creates the risk of substantial measurement error, especially for more frequent and variable expenses such as gasoline, though the likely direction of the error is not clear. Additionally, sample sizes in the CE are comparatively small; controlling for our desired subset of households yields less than 1,500 survey respondents each quarter (see table 1). This limits the ability to analyze subsets of the population, while AHS data for a similar universe of households exceeds 20,000 survey respondents (Drehobl, Ross, and Ayala 2020; Vaidyanathan, Huether and Jennings 2021).

Energy efficiency policy implications

The findings above highlight the need to broaden energy affordability policy analysis to incorporate transportation energy burdens. As highlighted in previous ACEEE research, disparities in energy burdens point to the need for targeted efficiency policy at all levels of government. As certain regions or groups begin to electrify their personal vehicles, the dynamics of combined home and transportation energy burdens must be tracked. For example, households that switch to electric vehicles will likely experience an increased home energy burden as their electric use increases, but a decrease in their combined energy burden as their overall transportation efficiency has improved. The tracking of combined energy burdens will ensure that the full picture of their energy costs is captured in energy affordability policy analysis, which will be particularly important if low-income or otherwise disadvantaged households are left behind by transportation electrification (Vega-Perkins, Newell, and Keoleian 2023). Simultaneous consideration of transportation and home energy costs will contribute to a more holistic understanding of energy insecurity—which is typically limited to home energy access—and its myriad social and health impacts (Hernández 2016).

With a more comprehensive analysis of total household energy costs, energy affordability policy can focus not just on home efficiency measures as a tool to reduce energy burdens, but also efficient transportation policies such as continued investment in public transportation, subsidized access to efficient transportation, incentivized affordable housing near transit, and the promotion of efficient vehicles through standards and incentives. Combined burdens are also an important metric in the context of overall housing affordability. For example, housing might be more affordable further from a major city or economic hub, but transportation costs may increase substantially. For a non-energy specific approach to measuring housing and transportation affordability, see the Center for Neighborhood Technology's Housing and Transportation's H+T Index (The Center for Neighborhood Technology's Housing and Transportation (CNT)).

Future research

Future research could provide valuable insight to policymakers by tracking combined energy over time, or by exploring certain groups in more detail. This paper does not explore a host of other variables provided in the CE, such as detailed spending on fuel types, vehicle type, home equipment, whether a resident pays their own heating bill, or detailed income data. More detailed geographic analysis would provide valuable insight into local policy, including neighborhood effects or examining the relationship of building age and location, though CE data may not be the best source for Metropolitan Statistical Area (MSA) or census-tract level research on spending due to small sample sizes at the local level. However, CE data could also be used to explore detailed energy spending data using methods other than the energy burden, such as the use of regression analysis to analyze racial or other discrepancies in household expenditures or the impact of energy burdens in keeping a household in poverty (Bohr and McCreery 2020; Lyubich 2020). Other data sources, such as the Panel Study on Income Dynamics (PSID) might also provide further insight on combined energy burdens (University of Michigan Institute for Social Research 2024).

Further research on combined energy burdens can support energy efficiency, housing, and transportation policymakers in designing policies that address the full impact of home and transportation energy costs on families.

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Appendix A: Quarterly Energy Burdens

Table A1 presents median energy burdens by quarter for 2022. As discussed in the methodology section above, the quarterly and annual energy burdens in this report are calculated using the same underlying expenditure data. However, because the CE data are collected from independent (though sometimes partially overlapping) samples for each quarter, median burdens can only be reported by quarter.

The median burden results are observably higher than the average burdens. This difference is likely because incomes tend to have greater skewness than energy expenditures, so the group mean income is typically substantially higher than the median household income. For example, in Q1 the median income was $73,000 and the median home energy expenditure was $590. On the other hand, the average income was $98,000 and the average home energy expenditure was $670. In other words, average burdens will have comparatively higher denominators.

Additionally, while the median burdens rely on incomes reported in each quarter, the average burdens reported above rely only on the annual incomes reported by respondents in Q4. In the CES data, income increased faster over the four quarters than energy expenditures did.

Table A1. 2022 Median energy burdens by quarter

	Median home energy burden	Median transportation energy burden	Median combined burden
All households			
Q1	3.1%	3.4%	7.0%
Q2	2.7%	3.9%	7.1%
Q3	3.0%	3.2%	6.7%
Q4	2.9%	2.9%	6.4%
White non-Hispanic households			
Q1	3.1%	3.2%	6.8%
Q2	2.7%	3.5%	6.7%
Q3	3.1%	3.0%	6.6%
Q4	3.0%	2.7%	6.2%
Black households			
Q1	3.6%	4.0%	7.6%
Q2	2.8%	4.6%	8.0%
Q3	2.8%	3.4%	6.7%
Q4	2.6%	3.0%	6.3%
Hispanic households			
Q1	3.0%	4.4%	7.7%
Q2	3.2%	5.9%	9.2%
Q3	3.1%	4.8%	8.3%
Q4	2.9%	4.8%	8.1%
Low-income (under 200% of federal poverty line)			
Q1	7.6%	7.0%	15.6%
Q2	7.1%	8.6%	15.7%

	Median home energy burden	Median transportation energy burden	Median combined burden
Q3	8.4%	8.2%	17.5%
Q4	7.9%	6.5%	16.4%

Appendix B: High Energy Burdens

Table B1. High and severe burdens (quarterly)

	Share of households with high combined burdens (<12%)	Share of households with severe combined burdens (<20%)
All households		
Q1	24.7	11.0
Q2	25.3	10.6
Q3	24.8	11.4
Q4	22.9	8.3
Low-income (under 200% of federal poverty line)		
Q1	67.1	35.2
Q2	67.4	37.3
Q3	72.2	43.1
Q4	74.2	34.7
White non-Hispanic		
Q1	23.1	9.8
Q2	23.3	10.2
Q3	23.7	10.9
Q4	23.5	8.6
Black		
Q1	28.2	14.1
Q2	20.9	11.3
Q3	27.7	11.0
Q4	18.4	5.0
Hispanic		
Q1	32.0	17.1
Q2	40.2	13.9
Q3	33.0	18.2
Q4	29.3	11.5
Urban		
Q1	23.4	10.3
Q2	23.6	9.3
Q3	23.0	10.5
Q4	20.5	7.3
Rural		
Q1	30.0	13.9

Q2	32.3	16.3
Q3	33.0	15.4
Q4	32.2	12.1

Appendix C: Consumer Expenditure Data

Table C1 provides an overview of the CES files used and their corresponding calendar months.

Table C1. CES interview PUMD files used

Analysis period	**Q1**			**Q2**			**Q3**			**Q4**		
	Jan. 2022	Feb. 2022	Mar. 2022	Apr. 2022	May 2022	June 2022	July 2022	Aug. 2022	Sept. 2022	Oct. 2022	Nov. 2022	Dec. 2022
Corresponding CES interview file	FMLI222			FMLI223			FMLI224			FMLI231		
Interview month	April 2022			July 2022			October 2022			January 2023		
Corresponding CES interview month variable	QINTRVMO=4 only.			QINTRVMO=7 only.			QINTRVMO=10 only.			QINTRVMO=1 only.		
CES weight used	FINLWT21*3			FINLWT21*3			FINLWT21*3			FINLWT21*3		

Data used for analysis are based on CES "PQ" (previous quarter) expenditures variables only.

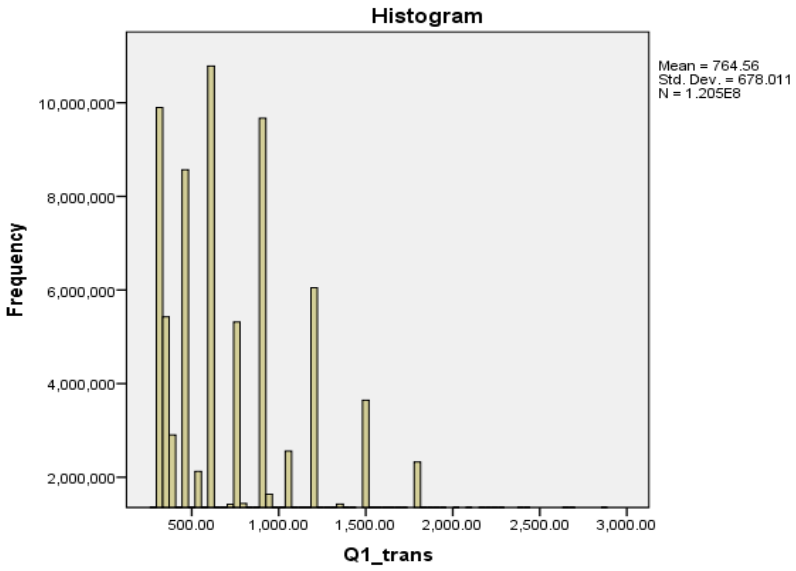
Below, table C2 provides an overview of the key CES variables used.

Table C2. CES variables used

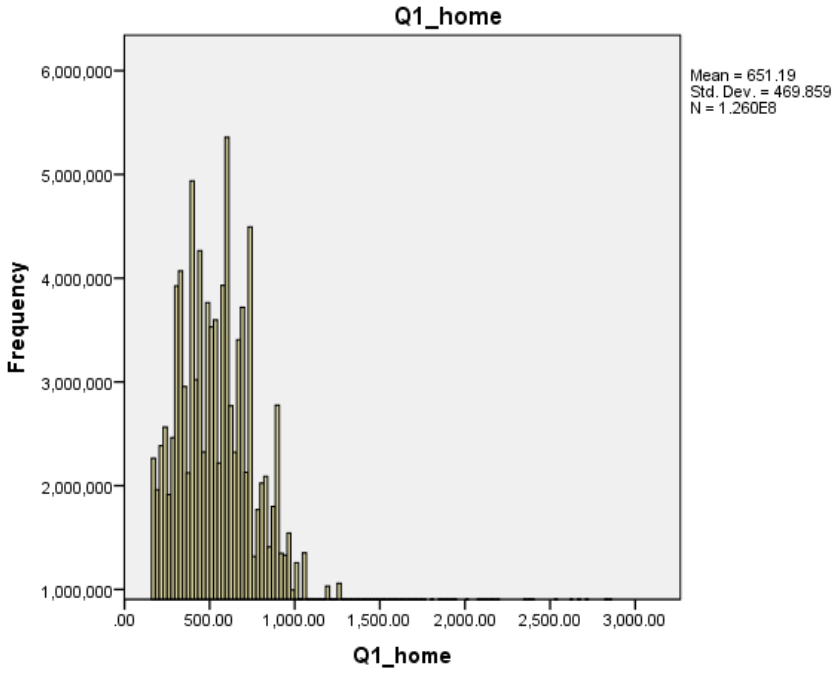
	Variable	**Notes**
Income	FINCBTXM	FINCBTXM includes the before-tax household income from salaries, wages, Social Security, public assistance, job training grants, food stamps, interest, or rental income or losses. FINCBTXM is used to determine households that are under 200% of the 2022 federal poverty line.
Race	REF_RACE	
Hispanic	HISP_REF	
Electric	ELCTRCPQ	Adjusted by subtracting VELECTRP and RELECTRP (expenditure on vacation homes).
Natural gas	NTLGASPQ	VNATLGAP and RNATLGAP.
Other home energy	ALLFULPQ	ROTHRFLP and VOTHRFLP and RFUELOIP and VFUELOIP.
Transportation fuel	GASMOPQ	Adjusted by subtracting TGASMOTC (expenditure on trips).
Urban or rural	URBAN	
Building type	BUILDING	Triplex or larger coded as multifamily, and duplex or smaller as single family.

Figure C1 shows the distribution of transportation energy spending in the first quarter of 2022. The histogram shows unusual concentration around certain spending amounts, such as $300, $450, $900,

and $1,200. A histogram of home energy expenditure is shown for comparison, which appears to be more evenly distributed.



Cases weighted by Adj. weight for 1 month of respondents. Qrtly reporting only (full US pop per quarter)



Cases weighted by Adj. weight for 1 month of respondents. Qrtly reporting only (full US pop per quarter)

Figure C1. Distribution of Q1 transportation energy expenditure (top) and Q1 home energy expenditure (bottom)