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An Analysis of County Level Energy Burdens in Mississippi

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Abstract

The United States is facing an energy affordability crisis, as households across the U.S. are struggling to pay energy bills and are often forgoing necessities such as food and medicine to maintain access to energy. A household's energy burden (defined as the percent of income spent on energy) is a critical metric for visualizing and measuring energy affordability. While research conducted nationally shows that energy burdens depend on factors such as household income and race, little research has been conducted to analyze the impacts of these specific factors on energy burdens in Mississippi. With few policies addressing energy affordability in Mississippi, energy burden research is critical to identifying affordability disparities, as communities are at risk of losing access to energy. This report uses data from the Low-Income Energy Affordability Tool and the U.S. Census Bureau to analyze the impact of a county's median household income, percentage of minority population, and percent of housing units built before 2000 on the average energy burden of a county in Mississippi. The results show that median household income and race have a statistically significant impact on a county's energy burden, whereas the pattern for construction year is not significant. The analysis finds that higher income communities have lower energy burdens, and as a county's minority population rises above 44%, the energy burden increases. This report is consistent with observed national patterns and provides a strong foundation on which further household level research can be conducted which can be used to drive solutions to reduce energy burdens across the state and address the energy affordability crisis.

High energy burdens for households of all incomes directly lead to higher levels of energy insecurity, and "high burdens are associated with adverse effects on physical and mental health, nutrition, and local economic development" (ACEEE, 2020, 5). With households across the U.S. forgoing necessities to pay energy bills, costly energy bills force households to make decisions that impact overall health and long-term well-being. The constant fear and uncertainty surrounding access to energy, the complexity of navigating payment assistance programs, and the inability to control energy costs can lead to chronic stress, anxiety, and depression (Hernández, Phillip, and Siegel 2016). Households with high energy burdens are also more likely to fall victim to cycles of poverty (ACEEE, 2020). Bohr and McCreery (2019) found that, on average, after controlling for common predictors of poverty such as income loss, education, and health, energy burdened households are 1.75-2 times as likely to remain in poverty for a longer period of time compared to non-energy burdened households. The various health and socio-economic impacts of energy burdens are crippling for households and communities, and while the general factors that drive energy burdens as seen in Fig. 1 are critical for understanding the source of the problem, they do not paint a complete picture of smaller regions. For example, the general drivers of energy burden are not equally responsible for the high burdens in the East South Central region, and little research exists to document the key factors that affect energy burden in smaller states and communities.

This report focuses specifically on the State of Mississippi, a state from the East South Central region with an above average median energy burden. Not enough research has been conducted to understand the largest causes of high energy burdens in the state. This analysis remains critical, as identifying structural problems will enable policymakers and relevant stakeholders to implement the necessary programs to reduce energy burdens across the state.

Introduction

In 2015, all United Nations Member States adopted the '2030 Agenda for Sustainable Development', which outlines a plan of action for governments across the world to bring peace and prosperity for the people and the planet. This agenda calls upon all countries and stakeholders to work collaboratively to enact systemic change and free humanity from poverty and improve the condition of our planet (UN, 2015). This bold agenda is built on decades of research and work, and it recognizes that the challenges facing humanity today lie at the intersection of various social, political, economic, and technical factors. Eradicating poverty, eliminating inequality in access to healthcare and education, and fighting climate change are a small sample of these challenges, and their solutions must go hand in hand, as no system exists in a vacuum. The broad agenda is divided into 17 Sustainable Development Goals (SDGs), which are urgent calls to action in each critical sector. Energy is one of the target sectors, and the 2030 goal is codified under SDG 7: ensure access to affordable, reliable, sustainable, and modern energy for all (UN, n.d.). While SDG 7 is broad in its scope, this paper focuses on the first portion of the goal – energy affordability (the ability to afford energy bills). Access to affordable energy is a human right, and a consistent source of affordable energy is essential to maintaining the health and well-being of communities (ACEEE, 2020).

Despite being one of the richest countries in the world, the United States is facing an energy insecurity crisis. Energy insecurity is defined as the "inability to adequately meet basic household heating, cooling, and energy needs over time", and it is directly affected by energy affordability (ACEE, 2020, 1). The Energy Information Administration (EIA), a federal entity responsible for providing statistics regarding energy, reported that almost one in three U.S. households (31%) faced challenges in paying their energy bills or ensuring an adequate, consistent supply of heating and cooling in 2015 (EIA, 2018). Additionally, the same report showed that one in five (20%) U.S. households reported reducing or eliminating their consumption of necessities such as food and medicine to pay their energy bills (EIA, 2018). The statistics from 2015 paint a bleak picture. Energy is essential for survival, and no household should be struggling to pay energy bills or face challenges in maintaining a safe living environment throughout the year. People should not be forced to make a choice between providing food and essential medications and ensuring access to electricity and adequate heating and cooling.

Unfortunately, even today, energy insecurity continues to remain an issue. In a review of the U.S. Census Bureau's Household Pulse Survey, a survey designed to track how people's lives have been impacted by the pandemic, it was found that in 2021, about one in five (20%) U.S. households struggled to pay their energy bills in full at least once and more than 28% of households skipped a basic expense to pay their energy bills (Reinicke, 2021). More households are now forgoing other necessities and the problems with affording energy bills persists. In 2021, nominal retail prices for electricity rose at their fastest rate since 2008, increasing at a rate of 4.3%, with the increase being primarily attributed to the rise in prices for power generation fuels such as natural gas (EIA, 2022). Nominal prices are used instead of retail prices as that is the value that customers pay for electricity, and rising prices have outpaced inflation and the rate at which wages have increased, which has remained flat, raising the overall cost of electricity (EPI, 2022). This trend is not projected to reverse, as the EIA predicts further increases in electricity prices over the course of 2022. Price increases are also visible in the heating and cooling fuels sector, as EIA also accurately predicted a price increase in Winter 2021 for every U.S. household, regardless of the fuel used to heat and cool the house (EIA, 2022). With the current state of energy prices and future outlooks, energy affordability and energy insecurity remain as critical challenges to tackle for policymakers and relevant stakeholders in the U.S. as they move to achieve the goals of SDG 7.

With energy affordability serving as a key contributor to energy insecurity, it is critical to identify the factors driving energy affordability. Household energy burden, defined as the percentage of annual household income spent on energy bills, is an important metric that enables policymakers to visualize energy affordability (ACEEE, 2020). Energy burden as a metric allows researchers to identify which groups shoulder higher energy burdens and enables targeted policymaking to reduce energy burdens. Researchers determined that the threshold for a high energy burden is needing to spend more than 6% of household income on energy (ACEEE, 2020). It is estimated that housing costs should be "no more than 30% of household income", and "household energy costs should be no more than 20% of housing costs", so when energy costs are calculated as a fraction of household income, a value of 6% is obtained (ACEEE, 2020). While 6% of household income is the threshold for high energy burden, 10% of household income is the threshold for severe energy burdens (ACEEE, 2020). There are multiple intersectional factors that affect a household's energy burden, ranging from income and inefficient heating and cooling systems to extreme weather events and lack of education regarding energy payment assistance programs. Figure 1, taken from an energy burden study conducted by the American Council on an Energy-Efficient Economy (ACEEE), summarizes and provides examples of the key drivers of energy burden.

Drivers	Examples of factors that affect energy burden
Physical	Housing age (i.e., older homes are often less energy efficient)
	Housing type (e.g., manufactured homes, single family, and multifamily)
	Heating and cooling system (e.g., system type, fuel type, and fuel cost)
	Building envelope (e.g., poor insulation, leaky roofs, inefficient and/or poorly maintained poorly maintained heating and cooling systems (HVAC), and/or inadequate air sealing)
	Appliances and lighting efficiency (e.g., large-scale appliances such as refrigerators, washing machines, and dishwashers)
	Topography and location (e.g., climate, urban heat islands)
	Climate change and weather extremes that raise the need for heating and cooling
Socioeconomic	Chronic economic hardship due to persistent low income
	Sudden economic hardship (e.g., severe illness, unemployment, or disaster event)
	Inability to afford (or difficulty affording) up-front costs of energy efficiency investments
	Difficulty qualifying for credit or financing options to make efficiency investments due to financial and other systemic barriers
	Systemic inequalities relating to race and/or ethnicity, income, disability, and other factors
Behavioral	Information barriers relating to available bill assistance and energy efficiency programs and relating to knowledge of energy conservation measures
	Lack of trust and/or uncertainty about investments and/or savings
	Lack of cultural competence in outreach and education programs
	Increased energy use due to occupant age, number of people in the household, health-related needs, or disability
Policy-related	Insufficient or inaccessible policies and programs for bill assistance, energy efficiency, and weatherization for low-income households
	Utility rate design practices, such as high customer fixed charges, that limit customers' ability to respond to high bills through energy efficiency or conservation

Figure 1: Key Drivers of Energy Burden (ACEEE, 2020)

These factors affect different regions of the U.S. in varied ways, since every state has different median household incomes, systemic inequalities, policies that promote energy efficiency, support structures for low-income households, etc. Nationally, research shows that low-income and minority communities have disproportionately higher energy burdens than the average household (ACEEE, 2020). Studies also show that "Black, Indigenous, and People of Color (BIPOC) communities often experience the highest energy burdens when compared to more affluent or white households" (ACEEE, 2020, 2). Even after controlling for income, "BIPOC households experience higher energy burdens than non-Hispanic white households" (ACEEE, 2020, 3). The median energy burden of Black households is 43% higher and the median energy burden of Hispanic households is 20% higher than that of white (non-Hispanic) households (ACEEE, 2020). When considering income, the median energy burden of low-income households is three times higher than that of non-low-income households (ACEEE, 2020, 11). Energy efficient buildings also play a key role, as new constructions are often more energy efficient, cutting down energy usage for a household and driving down costs. These factors, along with poverty rates, the stability of energy infrastructure, and other key drivers of energy affordability shape energy burdens nationally. The Low-Income Energy Affordability Data (LEAD) tool from the Department of Energy calculates the average energy burden (by percent income) for the U.S. and its various regions, and it is instrumental in visualizing the differences in average energy burden across the country. Figure 2 shows the distribution of the average energy burden of each state across the U.S. while accounting for every income in relation to the Federal Poverty Level (FPL), every heating fuel, and all building types and ages, painting a comprehensive picture.

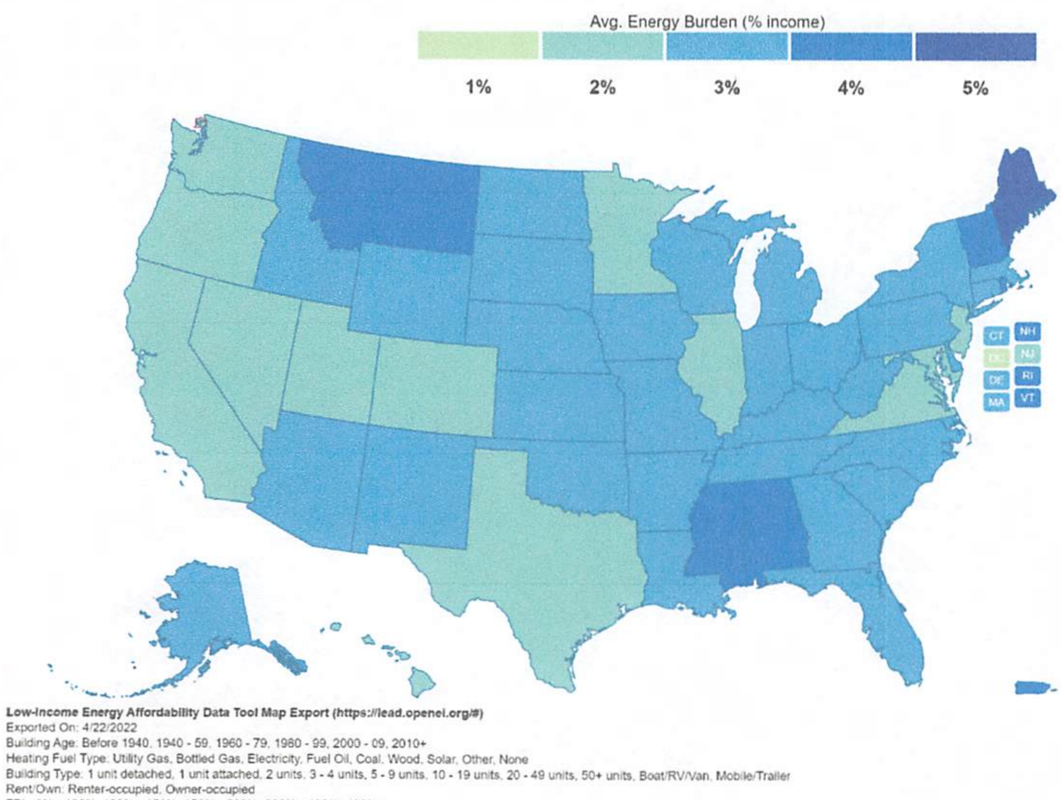

Figure 2: Average Energy Burden of Each State in the U.S. (LEAD Infographic, 2020)

The FPL provides a national baseline with which incomes and subsequently, energy burdens can be compared, and the results clearly depict certain states having higher average energy burdens. The national median energy burden is 3.1%, and there are seven states whose averages exceed that (ACEEE, 2020). While Montana, Alabama, Mississippi, Vermont, New Hampshire, and Rhode Island all have an average energy burden of 4%, Maine possesses the highest average energy burden at 5%. Further analysis of state level energy burdens reveals that across the nine census regions, the East South-Central Region (consisting of Alabama, Kentucky, Mississippi, and Tennessee) has the highest median energy burden at 4.4% and a high median low-income energy burden at 9.1% (ACEEE, 2020). Figure 3 depicts the median energy burdens and median low-income energy burdens across the nine census regions in the U.S.

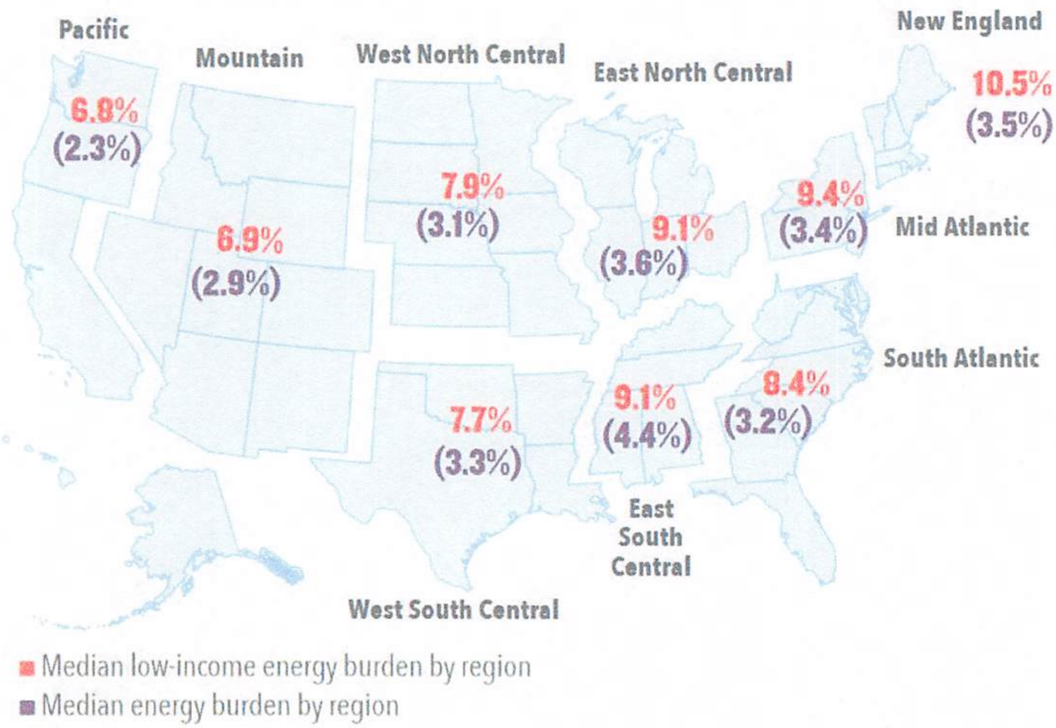

Figure 3: Median Low-Income and Median Energy Burden by Census Region (ACEEE, 2020)

With race, income, and energy efficiency being prominent in research conducted nationally, it remains to be seen if these factors affect the state of Mississippi similarly, if they do so at all. The analysis presented in this report aims to tackle that challenge, as it studies the impact of median household income, race, and the year that a home was constructed on the median energy burden of counties in Mississippi. An Ordinary Least Squares (OLS) regression method is used to analyze the marginal impacts of these factors on median energy burdens and to determine their magnitude and statistical significance.

Data and Methodology

The average energy burden data (as % of income) is taken from the Low-Income Energy Affordability Data (LEAD) tool as provided by the Department of Energy. Similar to the national energy burden data, the data for Mississippi includes every income in relation to the Federal Poverty Level (FPL), every heating fuel, and all building types and ages. Figure 4 as shown below depicts the average energy burden of each county in Mississippi.

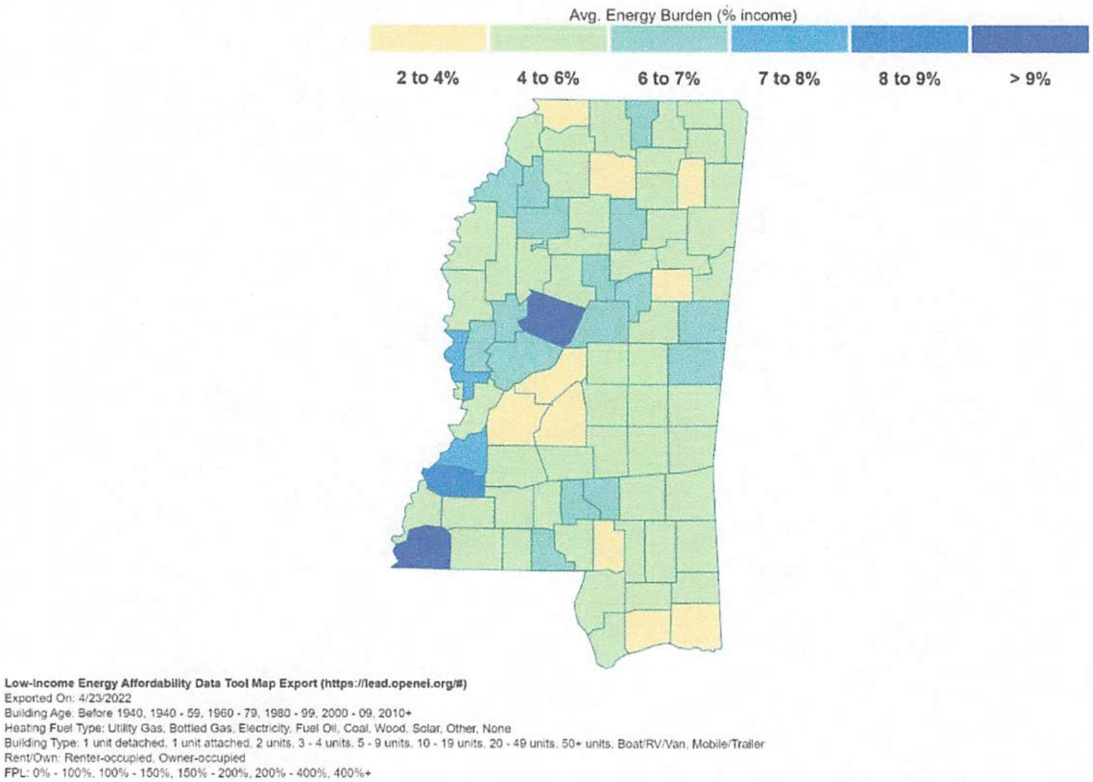

Figure 4: Average Energy Burden for Counties in Mississippi (LEAD Infographic, 2020)

To analyze the marginal impact of incomes on energy burden, the median household income for each county was used. This data is taken from the 2020 Small Area Income and Poverty Estimates Program, a U.S. Census Bureau program that produces single-year estimates of income and poverty for all U.S. states and counties (U.S. Census, 2020). For race, the data for the percentage of minority population in a county is taken from the 2020 Decennial Census' Redistricting Data (U.S. Census, 2020). Finally, the data for the year the dwellings were constructed is obtained from the 2020 American Community Survey's 5-year data estimates (U.S. Census, 2020). While prior studies set 1980 as the cutoff year for the construction of housing units, this study uses 2000 as the cutoff date to update the analysis and analyzes the impact of the percentage of houses built during and after 2000 on the county's average energy burden. 2000 is used as the cutoff date because an EIA survey from 2013 showed that homes built after 2000 use similar amounts of energy despite being 30% larger, indicating that homes built after 2000 are more energy efficient (EIA, 2013). Modern energy codes, "which require higher levels of insulation, reduced duct leakage in HVAC systems, and lower leakage of air outside the building envelope" contribute to the higher efficiencies seen in newer constructions (Wogan, 2013). Since the data for energy efficiency of households across a county is not readily available, the next closest metric, construction year, must be used. Table 1 below shows the three counties with the highest and lowest energy burdens and their relevant statistics in comparison to the average for Mississippi.

Status	Region	Energy Burden	Median Household Income	Percent of Minority Population	Percent of Housing Units Built Before 2000
High Burden	Holmes County	9%	$30,003	86.01%	84.2%
	Wilkinson County	9%	$35,394	70.53%	80.4%
	Jefferson County	8%	$32,683	87.69%	88.3%
State Average	Mississippi	4%	$47,368	43.98%	76.4%
Low Burden	Madison County	2%	$67,151	44.27%	63.6%
	Rankin County	2%	$68,583	28.12%	66.5%
	DeSoto County	3%	$66,532	40.61%	61.3%

Table 1: Snapshot of County Energy Burden

Table 1 provides key insight into the status of factors in counties with energy burdens on both ends of the spectrum. While key differences in median household income, percent of minority population, and the percent of housing units constructed before 2000 can be seen in Table 1, it does not provide information if those patterns persist throughout the state. Table 2 below provides the summary statistics for the data as it spans across the state, which will be critical in the analysis for this report.

Variable	Variable Description	Mean Value	Minimum Value	Maximum Value
E	Energy Burden (% of income)	4.878	2	9
I	Income ($1000s)	43,867	30,003	68,583
M	Minority Population (% of population)	46.29	7.96	89.34
H	Housing Units (% of units constructed before 2000)	80.09	55.40	95.20

Table 2: Summary Statistics for Key Variables

The data sources used in this analysis are consistent with prior reports conducted on energy burden analysis, which use Census data from the American Housing Survey (AHS). Since 2020 estimates for Mississippi are unavailable through the AHS, other Census data from the aforementioned surveys was used for this report. The analysis conducted in this report is conducted with an Ordinary Least Squares (OLS) regression model, a method that economists use to analyze the impacts of a small change in independent variables onto the dependent variable (also known as a marginal effect). Prior research has also used regression models to calculate impacts on energy burdens, and a study conducted by Lyubich (2020) uses a regression model to determine the race gap in energy expenditures in the U.S. For simplicity, this report uses the OLS model which provides a cursory analysis of median energy burdens and the impact of small changes in income, race, and home construction year on energy burdens. The OLS model uses parameters (specific and fixed numbers that specify the relationship between variables) to determine the marginal effects. For this analysis, various regression models, which placed each variable through different orders and variations, were iterated through before the final model was created. The iterative process resulted in a model that allowed for the variables to impact energy burden in varied ways and revealed how the factors in question impact the average energy burden of a county in Mississippi. Equation 1 below shows the final OLS model as analyzed in R, and the β values denote the parameters for each individual variable, with β_0 denoting the intercept of the regression model.

$$E = \beta_0 + \beta_1 * I + \beta_2 * M + \beta_3 * M^2 + \beta_4 * H$$

Equation 1: OLS Model

The final OLS model includes all the relevant variables to ensure that the key research questions are answered through the analysis.

Results

Once the OLS model was analyzed using R, an estimate of the parameters with their respective p-values was calculated. The results are shown in Table 3 below.

Parameter	Parameter Estimate	P-Value
β_0	9.133	$1.59 * 10^{-5}$***
β_1	$-9.313 * 10^{-5}$	$2.31 * 10^{-6}$***
β_2	$-4.985 * 10^{-2}$	0.0283*
β_3	$5.616 * 10^{-4}$	0.0122*
β_4	$8.934 * 10^{-3}$	0.5867

Table 3: Parameter Estimates of OLS Model

The results show that every parameter, except for β_4, is statistically significant, as their p-values are below 0.05 (as denoted by the asterisks). Since β_4 is not statistically significant, it can be concluded that the variable associated with β_4, the percent of housing units constructed before 2000 in a county, does not have a statistically significant impact on the average energy burden of a county. β_1, the parameter impacting the marginal effect of income, is statistically significant, and its impact on energy burden can be represented as shown in Equation 2.

$$\frac{\partial E}{\partial I} = -9.313 * 10^{-5}$$

Equation 2: The Marginal Effect of Income on Average Energy Burden

As Eq. 2 shows, an increase in income leads to a decrease in average energy burden, and the parameter depicts the change in percent energy burden as a result of a $1 increase in income.

Specifically, holding all else constant, Eq. 2 shows that to decrease a county's average energy burden by one percent, an approximately $10,737 increase in median household income of a county is required. These findings are consistent with national patterns of higher income regions having lower energy burdens. β_2 and β_3, the two parameters governing the impact of the percentage of minority population in a county are also statistically significant, and their impacts on energy burden can be represented as shown in Equation 3.

$$\frac{\partial E}{\partial M} = -4.985 * 10^{-2} + 2(5.616 * 10^{-4}) * M$$

Equation 3: The Marginal Effect of Percent Minority Population on Average Energy Burden

Eq. 3 differs from Eq. 2 as the variable M impacts the marginal effect of minority population percentage on energy burden, whereas the value of I (income) did not impact the marginal effect of income on energy burden. When Eq. 3 is set equal to 0 and solved for M, it is seen that if a county's minority population is above 44.38%, the average energy burden increases, but if it is below the same value, the average energy burden decreases. Holding all else constant, a calculated 10% change in the minority population of a county corresponds to a 0.01% increase in the average energy burden. While the marginal effect of the minority population is not as strong as that of income, the effect still exists and is statistically significant.

Limitations of the Study

This report uses county level data to conduct the analysis on energy burdens across Mississippi, which does not provide an accurate picture of the household energy burdens in Mississippi. The LEAD tool uses the American Community Survey (ACS) sample dataset to calculate energy burdens, where average household energy expenditures (in a census tract) are used and scaled with state electricity sales to cover a particular area (county, city, etc.). This approach does not account for the variation in household energy expenditures in a particular region. This method, combined with the collapsing of household income to fit constraints in the Federal Poverty Level, understates the energy affordability challenges faced by households across a county. This top-down approach does not provide the required granularity to adequately identify households and communities facing disproportionate burdens, and as a result, the model used in this analysis only provides a general overview of trends across Mississippi. More data on household energy expenditure and energy use is critical to identifying and targeting communities to adequately address the energy affordability challenges faced by the state.

Conclusion and Future Work

This report analyzes the marginal impacts of median household income, the percentage of minority population, and the percent of housing units constructed before 2000 on the average energy burdens of each county in Mississippi. Department of Energy data and Census data was used to determine if patterns that are visible in national energy burden studies carry over to the state of Mississippi. Through an OLS regression model, it was found that income and the percentage of minority population have a statistically significant impact on average energy burdens. As the median household income increases, a county's average energy burden decreases, which is consistent with national patterns. Additionally, if a county's minority population is above 44.38%, the average energy burden increases, whereas if the population is below that value, the average energy burden decreases. Both results depict alarming patterns, as they hint at counties with low-income households and minority households facing higher energy burdens. According to the analysis conducted in this report, income has a larger impact on energy burdens than race, however this report is a high-level analysis of basic trends and more granular data on households across the state can provide more insight on the impact of key factors. The results also depict that the percentage of housing units constructed before 2000 do not have a statistically significant impact on a county's average energy burden. This report proves that key trends that are visible nationally in analyzing energy burdens are also present in Mississippi and are statistically significant. The county-level analysis presented in this report provides a foundation that future studies can develop. The data available constrained the scope of this study, as household level energy use data and expenditure data are difficult to obtain. New data collection programs by the state and local utilities or government mandates for transparency of data collected by utilities can ameliorate this problem. The information in this study outlines key trends visible in average energy burdens in Mississippi, and future work can draw comparisons between households between counties and across states and can dive deeper into analyzing the structural barriers that create the inequity in energy burdens visible today. Further research is crucial to understanding the energy burdens faced by households in Mississippi, and their findings will be critical tools that the government and relevant stakeholders can use to alleviate the energy affordability crisis in Mississippi. The findings of this report, combined with future studies, should be used by policymakers to craft important legislation that eradicates structural barriers and increases access to affordable energy across Mississippi. Whether through payment assistance programs or grants to improve energy efficiency across homes, the opportunities are endless, and policymakers can use the knowledge gained from energy burden studies to identify and target communities that need support to afford energy. Through robust data collection programs, public and private partnerships, and targeted policymaking, the state of Mississippi can tackle the energy affordability crisis head on.

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