

# Smart City Research Cluster

## Final Research Report, Part 1

FedEx Institute of Technology

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Prepare a report that includes the following elements and submit to [casanto@memphis.edu](mailto:casanto@memphis.edu) or [smishra3@memphis.edu](mailto:smishra3@memphis.edu) by December 31, 2017.

1. Provide a Research Executive Summary that includes the purpose of your research, your methodology, and key findings. (500 words)
2. Describe any next steps in your research agenda that have emerged from this project. (E.g., Revisions to methodology, new research questions, etc.) (250 words)
3. List external funding that has been/could be leveraged by this project. Include grants/contracts awarded as well as pending funding opportunities.
4. List any publications / conference presentations that have stemmed from this project.
5. Summarize any student involvement in the project (e.g., classes that participated in the project, graduate assistants, PhD students, etc.) and list the number of students involved. Note whether the project has been connected to any doctoral dissertations.

# Linking Home Energy Insecurity to the Built Environment and Population Health in Memphis

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## 1. Research Executive Summary

**Objectives.** Memphis has been challenged with issues of poverty, housing, and health disparities. Memphis has the highest home energy burden in the U.S.; however, no further study has examined the disparities in energy burden within the city and its link to health outcomes. This study aimed to assess the linkage of energy burden with the built environment and health outcomes in Memphis. Specifically, we aimed to:

- (1) Determine the effects of area-based socioeconomic status (SES) and racial variables on household energy burden.
- (2) Assess associations of household energy burden with respiratory health outcomes.

**Methodology.** Household energy burden was calculated by dividing electricity and gas costs to household income at the zip-code level. Detailed utility bill data at the zip-code level were obtained from Memphis Light, Gas, and Water (MLGW) for year 2014. Socioeconomic status (SES), demographic, and housing data were obtained from American Community Survey (ACS). Prevalence of current asthma and chronic obstructive pulmonary disease (COPD) was obtained from CDC's 500 Cities Project. The multiple variables were first examined using correlation matrix, cluster analysis, and factor analysis. This step identified the key SES factors, including residence type, percent of African Americans, percent of aged 65 and above, percent of female headed households, percent of U.S. citizens, and the total population. The relationship among energy burden, SES, and health outcomes were then determined using multivariable regressions in SAS and visualized using geographic information system (ArcGIS, Esri Inc.).

**Key findings.** We obtained the following results:

- (1) Household energy burden, expressed as percentage of energy use in the total household income, averaged 3.7% (range 1.9 – 10.3%) in Shelby County. These numbers were lower than those estimated by a national analysis based purely on ACS.
- (2) Household energy burden averaged 2.1% (range 0 – 4.3%) for renters, and 4.2% (range 0.7 – 7.3 %) for house owners in Shelby County. Their difference was statistically significant ( $p < 0.0001$ ), accounting for other factors. The higher energy burden in self-owned households was opposite to that observed in the national survey.
- (3) Energy burden increased in zip-code areas with higher percentage of African Americans ( $p < 0.0001$ , Figures 1 & 2), lower incomes ( $P < 0.0001$ ), and old people (aged  $\geq 65$ ,  $p = 0.002$ ).
- (4) Energy burden is a key determinant of current asthma prevalence in Memphis ( $p < 0.0001$ ), even after accounting for other SES, demographic, and housing factors.
- (5) Energy burden is a key determinant of COPD prevalence in Memphis ( $p < 0.0001$ ), even after accounting for other SES, demographic, and housing factors.

**Conclusions.** Household energy burden displayed significant socioeconomic and racial disparities, and was a key determinant of respiratory diseases in Memphis. Rental apartments have lower energy burden than self-owned houses, possibly due to better energy use strategies. Some results were opposite to those from a national analysis based on ACS data, suggesting the need for comprehensive utility data for energy burden analysis.

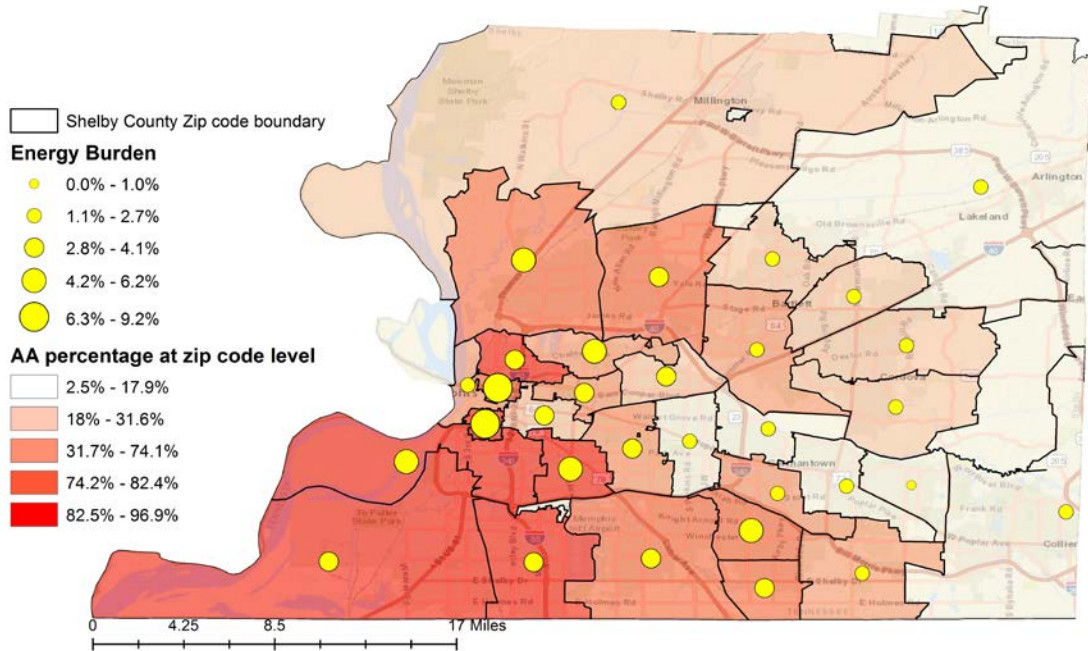


Figure 1. Energy burden of rental housing and racial composition (% of African American) in Shelby County, TN

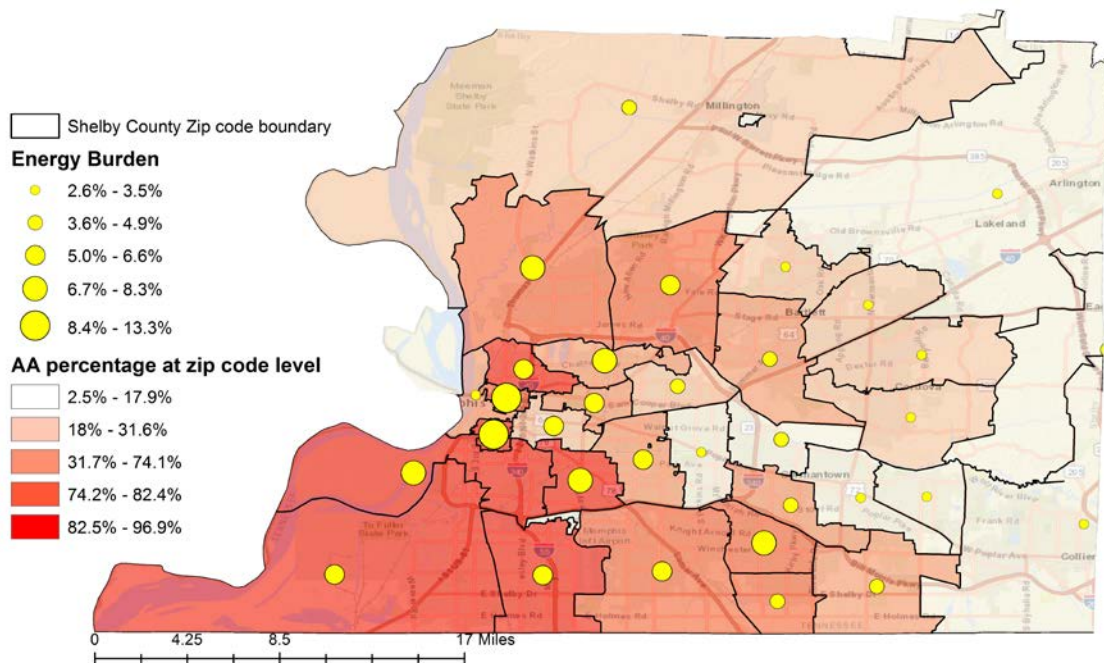


Figure 2. Energy burden of owned housing and racial composition (% of African American) in Shelby County, TN

**2. Describe any next steps in your research agenda that have emerged from this project. (E.g., Revisions to methodology, new research questions, etc.) (250 words)**

This is a cross-sectional study with an ecologic analysis. It could be improved if more data were available. (1) We were only able to obtain utility bill data in Year 2014. It would be helpful to examine the trends with multiple years' of data. (2) The geographic unit for analyses was zip-code level, which reflects mixed SES and racial compositions. The analyses could be greatly improved if census-tract level data were available, as the SES is often homogeneous within a census tract. (3) Energy burden may be linked to more health outcomes, e.g., children's health including mental developments, childhood asthma, and low birth weight.

Additional research and initiatives are needed to more comprehensively define energy insecurity (EI) and better measure and collect data. EI is a three dimensional construct consisting of economic, physical and behavioral EI. This study examined only the economic EI using the concept of energy burden, due to the time and resource limitations. We suggest larger survey at the individual household level to obtain a more comprehensive understanding of EI and various health outcomes pertaining to overall health and in particular respiratory and mental health.

It is also notable that low-income families face multiple challenges, e.g., the "heat or eat" dilemma. Research is warranted to explore relationship of and coping strategies for EI and food insecurity. The findings are expected to help develop provisions that buffer vulnerable families and children from the harmful effects of energy and food insecurity.

**3. List external funding that has been/could be leveraged by this project. Include grants/contracts awarded as well as pending funding opportunities.**

This project has been leveraged by the following projects:

HUD Diana Hernandez (PI) 11/01/16-10/30/19  
Evaluating Compliance and Refining Enforcement of Smoke-free Housing Policy in Low-  
Income Multiple Unit Housing  
Total budget: \$700,000; Sub-contract: \$30,000  
Role: Co-investigator

EPA XA-00D42616 Shelby County Health Department (PI) 05/12/16-09/30/18  
Characterizing Community Exposure to Polycyclic Aromatic Hydrocarbons (PAHs) in a Tri-State  
Area  
Total budget: \$594,407; Subcontract budget: \$545,407  
Role: Subcontract PI

JPB Foundation-Harvard University Jia (PI) 10/01/14-06/30/18  
Fellow of JPB Environmental Health Fellowship Program  
Budget: \$350,000  
Role: PI

**4. List any publications / conference presentations that have stemmed from this project.**

Not yet. One manuscript is in preparation.

The executive summary of this study will be posted on the author's website:

[www.memphisair.org](http://www.memphisair.org)

**5. Summarize any student involvement in the project (e.g., classes that participated in the project, graduate assistants, PhD students, etc.) and list the number of students involved. Note whether the project has been connected to any doctoral dissertations.**

(1) This project financially supported a graduate assistant for 6 months.

(2) The following students were involved:

Zhuqing Xue, PhD student in Epidemiology

Bhavin Chauhan, MPH student with Environmental Health Concentration

Fariha Sultana, MPH student with Environmental Health Concentration

(3) The data analysis techniques and ideas have been connected to Zhuqing Xue's doctoral dissertation.