DETROIT-UPPER PENINSULA ENERGY BURDEN SURVEY: A RESEARCH PROJECT REPORT AND INITIAL ANALYSIS OF RESULTS

by

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Abstract

We Want Green Too, a Detroit-based non-profit organization, conceived and conducted a survey of residents of the City of Detroit (with a focus on the east side) and six counties in Michigan's Upper Peninsula regarding energy burden and home-energy-related experiences. This survey was motivated by problems of inequity, unaffordability, and unreliability of energy service and resources for households in these geographic areas. The design of the survey occurred over the summer of 2020, and the planning for the survey period took place during the fall of 2020. Data collection was completed in January and February of 2021 via a phone bank operation that dialed a randomly selected set of phone numbers that were associated with registered voters in the target geographies. We collected 653 total complete responses (701 total partial responses) across all geographies.

Initial analysis suggests that energy unreliability is associated with energy burden. Those spending a greater share of their income appear to experience detrimental energy reliability outcomes and energy unreliability impacts at higher rates than those who spend a smaller share of their income on energy. Those with high energy burdens who are Black/African American appear to experience detrimental energy reliability outcomes and energy unreliability impacts at higher rates than white respondents with similar energy burdens. Similarly, Detroit respondents appear to experience detrimental energy reliability outcomes and energy unreliability impacts at higher rates than Upper Peninsula respondents with similar high energy burdens.

We conclude that these associations are evidence of environmental racism playing out in our state's energy system. Combating environmental injustice and structural racism must be a priority for Michigan's public officials, and policies that are meant to target these problems must account for inequities such as these within our state's energy system. Furthermore, while the worst impacts appear to correlate with Black/African American and highly energy burdened communities, the persistence of energy affordability and unreliability problems across race and geography indicate the state energy system is failing to meet basic needs related to energy statewide.

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Executive Summary

We Want Green Too, a Detroit-based non-profit organization, conceived and conducted a survey of residents of the City of Detroit (with a focus on the east side) and six counties in Michigan's Upper Peninsula regarding energy burden and home-energy-related experiences. This survey was motivated by problems of inequity, unaffordability, and unreliability of energy service and resources for households in these geographic areas. The survey was proposed to the University of Michigan School for Environment and Sustainability as a master's student capstone project and was accepted as a single-student practicum (student: Kate Hutchens; faculty advisor: Dr. Tony Reames).

The survey -- intended to capture a broad range of information regarding households' experiences with their home energy -- was designed collaboratively as a partnership among We Want Green Too, the Michigan Environmental Justice Coalition, We the People of Michigan-Upper Peninsula, and the University of Michigan academic participants. The design of the survey occurred over the summer of 2020, and the planning for the survey period took place during the fall of 2020. Data collection was completed in January and February of 2021 via a phone bank operation that dialed a randomly selected set of phone numbers that were associated with registered voters in the target geographies. We collected 653 total complete responses (701 total partial responses) across all geographies.

Our analysis suggests that energy unreliability is associated with energy burden. **Those spending a greater share of their income appear to experience detrimental energy**

reliability outcomes and energy unreliability impacts at higher rates than those who spend a smaller share of their income on energy. Of particular note is the effect of energy burden on outage lengths: for all respondents and for the subset of Detroit respondents, households with energy burdens of 6% or more experienced, on average, a significantly longer power outage than those with energy burdens less than 6%. Reliability outcomes and unreliability impacts also appear associated with both respondent race and geography. Because our race and geography categories overlap to such a great extent, further analysis would be needed to determine whether one of these factors has a stronger effect than the other. These combined factors do appear to mediate the effect of energy burden on energy unreliability. **Those with high energy burdens who are Black/African American appear to experience detrimental energy reliability outcomes and energy unreliability impacts at higher rates than white respondents with similar energy burdens.** Similarly, **Detroit respondents appear to experience detrimental energy reliability outcomes and energy unreliability impacts at higher rates than Upper Peninsula respondents with similar high energy burdens.** Also, Black/African-American respondents experienced high energy burden at much higher rates than white respondents, and Detroit respondents' high energy burden rates were higher than those for UP respondents.

Furthermore, in the case of outages or other emergencies, Black/African American respondents had less access to backup heat and electricity options for their homes than white respondents with similar energy burdens.

We conclude that these associations are evidence of environmental racism playing out in our state's energy system. Combating environmental injustice and structural racism must be a priority for Michigan's public officials, and policies that are meant to target these problems must account for inequities such as these within our state's energy system. Furthermore, while the worst impacts appear to correlate with Black/African American and highly energy burdened communities, the persistence of energy affordability and unreliability problems across race and geography indicate the state energy system is failing to meet basic needs related to energy statewide.

Background and Introduction

This project was proposed by the organization We Want Green Too in order to "survey residents directly about the energy system, knowledge of, perception and impacts of energy systems, and... mobilize participants to engage more directly in energy decision-making to improve policy outcomes for low-income people of color." The goal has been to support energy policy advocacy with rigorous evidence of energy users' and utility customers' experiences and needs regarding the energy service they receive and the impacts of unreliable and/or unaffordable energy services. The initial proposal included a community-based participatory research (CBPR) framework involving a door-to-door survey methodology in the neighborhood where We Want Green Too focuses its work, which is on the eastside of Detroit (generally in the 48214 ZIP code area - which also includes the wealthier Historic Indian Village). The project design's initial priorities included community outreach and events and education in support of residents' engagement in these issues so as to move toward a more just energy system in Detroit, one that better embodies the principles of energy democracy.

With the onset of the COVID-19 pandemic and emergency stay-at-home orders in Michigan as the project was kicking off in March of 2020, the team realized that the constraints that made the intended door-to-door methods impossible opened new possibilities for investigating residents' experiences with the energy system across a broader geography. At this point, the team expanded to include researchers working on energy issues in Michigan's Upper Peninsula (UP) rural and Indigenous communities. The scope of the survey was expanded to include 6 counties in the UP in pursuit of an understanding of these communities' experiences in an energy context that is very different in some ways (for example, much greater reliance on propane), very similar in others (for example, mainly served by an investor-owned utility), and yet under the same state energy regulatory regime as the Detroit residents of the survey's initial focus.

In her 2021 book, *Revolutionary Power: An Activist's Guide to the Energy Transition*, Shalanda H. Baker - currently the Secretarial Advisor on Equity and Deputy Director for Energy Justice at the U.S. Department of Energy - describes energy democracy:

> *Energy democracy refers to the collective ownership, governance, and control of the electricity grid and grid assets, as well as the ability of individuals to have a say in the design of the system itself. Energy democracy holds promise as a possible framework for energy policies that help mitigate the vulnerabilities within the current, centralized power system.*

Many studies that evaluate issues of energy justice and equity in utility service rely primarily on data provided by utilities as their evidence[1], or on data from national-scale surveys conducted by United States federal agencies[2]. This project takes energy democracy as a core principle for both the lines of inquiry and the methodologies and implementation. To this end, the research team collaboratively developed a tailored survey instrument to understand the specific energy issues in particular Michigan communities, and conducted survey interviews with care and attention to the context and sensitivity to the perspectives of interviews.

Outputs of this survey project

This survey project has generated a dataset with 653 completed interviews (701 partial interviews), collected from residents of the City of Detroit (369 interviews) and 6 counties in Michigan's Upper Peninsula (332 interviews): Alger, Baraga, Delta, Houghton, Marquette, and Schoolcraft. The cleaned and compiled dataset contains a total of 170 variables, including survey interviewee responses and added variables that compile or additionally code those responses for analysis. This dataset, paired with a detailed codebook that describes each variable in the dataset, is a rich resource that has significant potential for detailed and

[1] Two examples of studies primarily relying on utility-provided data: 1) Liévanos, R. S., & Horne, C. (2017). Unequal resilience: The duration of electricity outages. *Energy Policy*, *108*, 201–211. https://doi.org/10.1016/j.enpol.2017.05.058 ; and 2) Tong, K., et al. (2021). Measuring social equity in urban energy use and interventions using fine-scale data. *Proceedings of the National Academy of Sciences*, *118* (24) e2023554118. https://doi.org/10.1073/pnas.2023554118.

[2] For example: Bednar, D. J., Reames, T. G., & Keoleian, G. A. (2017). The intersection of energy and justice: Modeling the spatial, racial/ethnic and socioeconomic patterns of urban residential heating consumption and efficiency in Detroit, Michigan. *Energy and Buildings*, *143*, 25–34. https://doi.org/10.1016/j.enbuild.2017.03.028 ; also, Hernández, D., & Laird, J. (2021). Surviving a Shut-Off: U.S. Households at Greatest Risk of Utility Disconnections and How They Cope. *American Behavioral Scientist*, 000276422110134. https://doi.org/10.1177/00027642211013401

refined analysis based on household demographics, geography, types and means of access to energy service, and households' experiences of particular impacts as well as "bundled hardships"[3] associated with unreliability or unaffordable energy.

This report offers high-level findings regarding the association of two broad predictor variables - **race/ethnicity** and **geography** - and one presumed mediating variable - **energy burden (EB)**[4] - with outcomes in the topical categories of **energy (un)reliability**, **energy burden impacts**, and **energy insecurity**. These most general findings from the data described below suggest many paths for further refined and detailed analysis, such as regressions to determine the statistical significance of differences in proportions of outcomes (i.e., the likelihood that these outcomes are really associated with the predictors versus the likelihood that differences in proportions of outcomes are attributable to chance). The data also warrants further attempts to determine the relative strength of relationships between outcomes and the predator variables, as currently there appears to be significant overlap or "confounding" among the predictor variables as offered in this report.

In addition to this report, this project has produced many tables of one-to-one cross-tabulations or associations between predictor variables and outcome variables, including estimates of the statistical significance of these associations.

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[3] Jessel, S., Sawyer, S., & Hernández, D. (2019). Energy, Poverty, and Health in Climate Change: A Comprehensive Review of an Emerging Literature. *Frontiers in Public Health*, *7*, 357. https://doi.org/10.3389/fpubh.2019.00357

[4] Energy burden is the proportion of a household's income that is represented by energy costs, typically expressed as a percentage.

Methods

The survey instrument was developed collaboratively, with approval of the final version made with a fist-to-five consensus vote among the study team. Survey questions were drawn from previously established or published surveys covering home energy insecurity, costs, and use, including the US Energy Information Administration's Residential Energy Consumption Survey, the US CDC CASPER toolkit, the We the People of Detroit Community Research Collective's community water survey[5], and others. The study team took questions from these sources, made adjustments to ensure they could be easily understood and responded to via phone calls, and tailored them to fit the anecdotally-known framing of energy issues and concerns in the study communities. The survey was tested with two students with the University of Michigan Urban Energy Justice Lab and reviewed by individuals within the study team member organizations to ensure reasonable timing, interview flow, and comprehensibility of the questions and response options. The study - including the survey instrument, data storage procedures, and interview protocols - was granted an exemption from monitoring by the University of Michigan's Institutional Review Board (HUM00183160).

The survey sample was drawn from public voter registration files for the City of Detroit and the Michigan counties of Alger, Baraga, Delta, Houghton, Marquette, and Schoolcraft, as supplied by nonprofit Michigan Voice, with phone numbers for chosen files supplemented by firm Change Media Group. The study utilized a two-strata sample, divided evenly between

[5] Special thanks is owed to the We the People of Detroit Community Research Collective in sharing example questionnaires and implementation wisdom from their city-wide community assessing impacts water survey.

the two study geographies. We drew five replicate samples of 6,600 total registered voter file contacts each (for a total of 33,000 total contacts) from the City of Detroit, and did the same for registered voter file contacts from the six Upper Peninsula counties. Within these strata, the sample was further subdivided. For the City of Detroit, due to the study's priority of focusing on the city's east side neighborhoods, we aimed for half of this stratum to be drawn from contacts with ZIP codes 48207 and 48214; however, the total number of contacts for these ZIP codes did not add up to a large enough number of contacts, and as a result, each contact for these ZIP codes was added to the sample. The remaining substratum of 33,000 contacts was drawn from registered voter files for the City of Detroit as a whole. For the U.P. stratum, the 5 replicates were drawn with random contacts from each county proportional to that county's population. Upon recognizing that Native American/Indigenous respondents were not being reached at the desired rate, 1,842 contacts were drawn from the list of registered voter files for U.P. counties for the final two weeks of data collection. These were geographically targeted by using addresses located in neighborhoods and on roads where Native/Indigenous households were predicted to be more likely to reside, according to one of the study team members' lived experience in these communities.

Surveys were administered via telephone by a trained team of 11 paid staff interviewers from January 10, 2021, through February 28, 2021, using the dialer/call management platform ThruTalk. Calling shifts were scheduled for weekday afternoons and evenings, as well as weekend mornings, afternoons, and evenings. The minimum number of call attempts for each contact was 1 call (3.94% of contacts), and the maximum number of attempts was 8 (0.02% of contacts), while most contacts (77.33%) received 5 call attempts, spread across calling shifts (days of week, time) to the greatest extent that was manageable. For sample contacts that included both a cell phone and a landline, the cell phone was loaded into the dialer for the first six weeks cycling the sample through the dialer, after which point landline numbers were loaded for subsequent calls to those contacts for the remaining two weeks of data collection and call attempts. The overall response rate, calculating the AAPOR's Response Rate 1, was 6.00%.

Interviewers began all calls with a brief explanation of the organizations involved in the study, the study's goals, the geographies of interest, and details of compensation for an individual's participation (a $20 Visa gift card to be sent via mail). Eligibility for study participation was confirmed with screening questions regarding age and area of residence. All eligible respondents that interviewers reached via phone were invited to participate, without regard to whether the respondent was the individual specified as associated with the phone number in the sample. Informed consent was verbally obtained for each respondent before commencing with the survey interview. The survey instrument questionnaire was administered using the Qualtrics survey platform. Interviewers recorded response selections and captured qualitative responses.

Analysis Methods

The proportions of responses by category/group were calculated using Microsoft Excel (version: Microsoft 365 MSO (16.0.14131.20278) 64-bit). Calculations used the following pivot table functions: row filters, value counts, and value counts displayed as percentages of column totals. For statistical tests, all data filtering, coding, and analysis were conducted using the statistical software application *R,* version 4.0.2. Welch's two-sample t-tests were conducted using the "t.test()" function (in *R* package "stats"). Pearson's Chi-squared tests were conducted with the "chisq.test()" function (also in *R* package "stats").

High-level Findings Statement

Vocabulary note: Throughout the below paragraphs, we use detrimental outcomes, or more specific forms such as "detrimental reliability outcomes", to refer to outcomes that the study's framework designates as harmful or compounding of harm for respondents and/or their households. Examples of detrimental outcomes include longer outages, lack of access to backup electricity or heating methods, high/higher energy burden, and higher frequencies of worry about energy costs. We use "benign outcomes" to refer to outcomes that our framework designates as arguably neutral or beneficial to respondents and/or their households. Examples of benign outcomes include shorter outages, access to backup electricity or heating methods, low/lower energy burden, and lower frequencies of worry about costs.

Energy Reliability Outcomes

Overall

Out of all respondents, 68.7% (n=354) experienced an outage lasting 4 hours or more in the previous year, and 74.9% of respondents who reported any outages experienced outages lasting 4 hours or more. Longer outages were experienced more than once in the last year by

57.1% of respondents (n=202). The mean duration of respondents' longest outage in the past year was 28.5 hours. 14.7% of respondents (n=76) experienced an emergency situation during a power outage, and 19.6% (n=101) needed to evacuate or leave home during an outage. The mean duration of respondents' time away from home when they had to evacuate was 52.9 hours. Overall, 17.3% (n=89) of respondents lost access to medical equipment/devices requiring electricity during an outage in the past year, and 34.3% (n=175) of respondents lost perishable goods/products as a result of a power outage. In case of emergency or disruption of energy access, 31.6% (n=212) of respondents had access to a backup source of electricity, and 40.2% (n=271) had access to a backup method for heating their home.

Associations with race/ethnicity

White respondents experienced detrimental energy reliability outcomes and unreliability impact outcomes at rates notably below the rates these were experienced by respondents, overall. Conversely, Black respondents experienced detrimental energy reliability outcomes and unreliability impact outcomes at rates above the rates these were experienced by respondents, overall (see below table).

Black respondents also had rates of access to backup heat (29.93%, n=82) and backup electrical sources (20.36%, n=56) below the overall rates of access to backup sources reported by all respondents (heat: 40.21%, n=271; electric: 31.59% n=212), whereas white respondents had higher rates of access to backup sources (heat: 49.38%, n=160; electric: 40.00%, n=128).

Black respondents had mean lengths of longest outage (41.5 hours) and evacuation (54.01 hours) that were above the overall mean lengths for both variables (outage: 28.51 hours; evacuation: 52.89 hours). White respondents had mean lengths of longest outage (15.22 hours) and evacuation (20.61 hours) that were below the overall mean lengths for both variables. Respondents of other races/ethnicities[6] were above the overall mean for both longest outage (34.48 hours) and evacuation (64.92 hours).

Respondents of other races/ethnicities experienced rates of detrimental energy reliability outcomes more similar to Black respondents than white respondents on a handful of variables. Black respondents and respondents of other races/ethnicities had differences of less than 4% in rates of experiencing outages 4 hours or more (Black: 77.29%, n=160; other race/ethnicity: 75.0%, n=33), experiencing these longers outages more than once in the last year (Black: 63.75%, n=102; other race/ethnicity: 66.67%, n=22), experiencing an emergency situation during an outage (Black: 23.9%, n=49; other race/ethnicity: 20.0%, n=9), and losing access to medical devices or equipment that required electricity due to an outage (Black: 23.76%, n=48; other race/ethnicity 20.45%, n=9).

However, access to backup heat and electric sources was notably different between Black respondents (heat: 29.93%, n=82; electric: 20.36%, n=56) and respondents of other races/ethnicities (heat: 43.20%, n=25; electric: 39.66%, n=23). In fact, these rates of access to both forms of backup energy were more similar between respondents of other

[6] Respondents who indicated any single or multiple racial/ethnicity categories other than "Black / African American" or "White" for themselves, individually. The survey also asked about other racial/ethnic identities present in the respondents' household, though analysis on households with multiple races or ethnicities has not yet been done.

races/ethnicities and white respondents (heat: 49.38%, n=160; electric: 40.00%, n=128). The difference in access to a backup electrical source is one of two most-different proportions between Black respondents (20.36%, n=56) and respondents of other races/ethnicities (39.66%, n=23).

The other greatest difference between Black respondents and respondents with other races/ethnicities for this set of outcomes was observed for losing perishable goods/products due to an outage (Black: 57.43%, n=116; other race/ethnicity: 38.64%, n=17).

The greatest differences in energy reliability and impacts outcomes between Black and white respondents were observed in the share of each group that experienced losing perishable goods/products due to an outage (Black: 57.43%, n=116; white: 14.16%, n=36), and needing to evacuate or leave home due to an outage (Black: 35.92%, n=74; white: 3.6%, n=9).

See Appendix A, Table 1 for calculations.

Associations with geography

Comparing Detroit and Upper Peninsula counties

Detroit respondents experienced each of the detrimental energy reliability outcomes and energy unreliability impacts at rates above the overall respondent rates. Detroit respondents also had lower rates of access to backup heat (31.32%, n=109) and electric sources (21.84%, n=76) than the overall set of respondents (heat: 40.21%, n=271; electric: 31.59%, n=212).

Conversely, respondents from the study's 6 Upper Peninsula counties experienced detrimental energy reliability outcomes and energy unreliability impacts at rates below the overall respondent rates. This group also had higher rates of access to backup heat (49.85%, n=162) and electric sources (42.24%, n=136) than the overall set of respondents.

Detroit respondents also experienced longer mean lengths of longest outages (39.21 hours) and outage evacuations (56.67 hours) than the overall mean lengths for these variables (outage: 28.51 hours; evacuation: 52.89 hours). Respondents from the UP counties, on the other hand, experienced shorter mean lengths for longest outages (17.93 hours) and outage evacuations (29.61 hours).

Two of these reliability and reliability impact variables had especially notable differences in rates between Detroit and the Upper Peninsula counties. The share of Detroit respondents who lost perishable goods or products as a result of an outage was 54.12% (n=138), whereas 14.52% (37) of UP County respondents experienced this. Additionally, while only 5.45% (n=14) of UP County respondents had to evacuate or leave home during a power outage in the last year, 33.59% (n=87) of Detroit respondents experienced this detrimental energy reliability impact.

Comparing Detroit ZIP code 48214 to the rest of Detroit

Detroit respondents with ZIP code 48214 experienced the most detrimental energy reliability outcomes and energy unreliability impacts at rates lower than those of respondents from the rest of Detroit. The greatest difference of proportions was observed in the share of respondents who experienced outages of 4 hours or longer (48214: 67.85%, n=38; rest of

Detroit: 80.49%, n=165), with the next greatest difference observed in the share of respondents who had to evacuate or leave home due to an outage (48214: 25.86%, n=15; rest of Detroit: 35.82%, n=72).

Respondents from 48214 experienced longer mean longest outages (45.32 hours) than respondents from the rest of Detroit (37.55 hours), as well as longer mean evacuations due to outages (48214: 84.67 hours; rest of Detroit: 50.76 hours).

A greater share of respondents in 48214 (26.92%, n=21) had access to a backup source of electricity than in the rest of Detroit (20.37%, n=55). However, 48214 respondents had a lower rate of access to a backup heat source (27.63%, n=21) than did respondents from the rest of Detroit (32.35%, n=88).

See Appendix A, Table 2 for further calculations.

Associations with energy burden

All respondents for which energy burden estimates were available were assigned group coding for low (<=4%), medium (4%-10%), and high (>=10%) energy burden (EB) groups. Lower, mid-range and higher rates of detrimental energy reliability outcomes were observed to be mostly associated with corresponding levels of energy burden. The largest difference in proportions for low and high energy burden groups was observed for losing perishable goods/products due to an outage (low EB: 19.58%, n=28; high EB: 51.68%, n=77), followed by the second largest difference being observed for needing to evacuate or leave home during an outage (low EB: 5.56%, n=8; high EB: 29.53%, n=44). A large difference was also observed in the proportions of the groups that lost access to medical equipment or devices that required electricity due to an outage (low EB: 4.83%, n=7; high EB: 28.38%, n=42). An exception to the association of higher EB with a greater incidence of detrimental energy reliability outcomes was observed for the proportion that experienced outages of 4 hours or more than once in the last year, for which the medium EB group experienced a slightly higher rate (63.04%, n=58) than the high EB group (60.87%, n=70); the low EB group experienced the lowest incidence of this outcome (40.96%, n=34).

The mean length of the longest outage was greatest for the high EB group (43.28 hours) and lowest for the low EB group (18.86 hours). Conversely, the mean length of evacuation due to an outage was greatest for the low EB group (69 hours) and least for the high EB group (53.35 hours).

The high EB groups had the lowest rates of access to backup energy sources (heat: 27.75%, n=53; electric: 23.56%, n=45). The rates of access to backup electricity were very similar between the low EB group (34.92%, n=66) and the medium EB group (35.45%, n=67), whereas for access to backup heat, the low EB group had a higher rate (48.42%, n=92) than the medium EB group (42.63%, n=81), and the difference in these proportions was slightly greater.

Among unreliability outcomes, energy burden's effect on outage length is particularly notable. Across all respondents, a T-test revealed that the average length of the longest outage for households with energy burden estimated at greater than or equal to 6% was significantly greater than the average length of longest outages for households with an estimated energy burden less than 6% (T=4.0156, p= <.001). A similarly significant difference was observed for Detroit respondents (T=3.4876, p= <.001), though the difference for UP respondents was not significant (T=0.93, p= <.352).

See Appendix A, Table 3, and Table 4 for further calculations.

Energy Burden Outcomes

Overall

Energy burden (EB) group codes are only reported for respondents for which EB estimates were available/possible, meaning that they had offered their household's range of costs for energy and range of income. All respondents for which EB estimates were available were assigned group coding for low (<=4%), medium (4%-10%), and high (>=10%) EB groups. These value ranges represent a division of the full set of responses for which EB estimates were available into three nearly equal-sized groups: low EB, n=190; medium EB, n=191; high EB, n=192. Therefore, the overall proportions of respondents in these groups are artificially equivalent.

In the last year, 22.44% of respondents (n=149) were always or usually worried about having enough money to pay their home energy costs, while 41.27% (n=274) were never worried about this. When asked to imagine energy prices going up 10% next month, 64.59% of respondents (n=425) indicated that they would be either somewhat stressed or very stressed, while the remaining 35.41% (n=233) responded that they would not be stressed by this hypothetical price hike. Respondents were asked to rate the overall impact of Michigan's generally increasing energy prices on their household, on a scale from 1 ("minimal impact") to 5 ("crisis-level impact"), and the overall mean value for this rating was 2.58.

Associations with race/ethnicity

For all energy burden outcomes, white respondents experienced benign outcomes at the highest rates and detrimental outcomes at the lowest rates. Black respondents experienced benign outcomes at the lowest rates and detrimental outcomes at the highest rates. Respondents of other races/ethnicities consistently experienced both benign and detrimental outcomes at rates between those for white and Black respondents.

White respondents had the highest proportion in the low energy burden group (47.2%, n=101), and the lowest proportion in the high energy burden group (17.76%, n=38). Black respondents had the highest proportion in the high energy burden group (53.89%, n=90), and the lowest proportion in the low energy burden group (17.37%, n=29). Respondents of other races/ethnicities also had the highest proportion in the high energy burden group (38.89%, n=14), and lowest proportion in the low energy burden group (27.78%, n=10), but the difference in highest and lowest proportions was less than for either the white or Black respondent groups. In sum, people of color[7], overall, were more likely to have higher energy burdens, than white respondents, and Black respondents were much more likely to have high energy burdens than white respondents. Furthermore, white respondents were much more

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[7] For this analysis, this includes all respondents who selected a race/ethnicity category other than "white."

likely to have low energy burdens than either respondents of other race/ethnicity or Black respondents.

The share of Black respondents (33.96%, n=91) who were "always" or "usually" worried in the last year about having enough money to pay energy costs was slightly higher than the share of respondents of other races/ethnicities (29.82%, n=17), and much higher than the share of white respondents (10.60%, n=34). More than half of white respondents (56.07%, n=180) indicated they were "never" worried about these costs, whereas only 22.76% of Black respondents (n=61) and 42.11% (n=24) of respondents of other races/ethnicities were "never" worried.

The share of Black respondents (22.26%, n=59) who indicated they would be "not stressed" by a hypothetical 10% increase in energy prices the next month was slightly lower than the share of respondents of other races/ethnicities (23.21%, n=13), and much lower than the share of white respondents (48.28%, n=154).

The mean value for white respondents' rating of the impact of generally increasing energy prices was 1.98, compared to 3.28 for Black respondents and 2.68 for respondents of other races/ethnicities.

See Appendix B, Table 5 for further calculations.

Associations with geography

Comparing Detroit and Upper Peninsula counties

Detroit respondents experienced high EB at rates that are approximately inverse of the rates for UP respondents. The share of UP respondents with low EB (48.57%, n=136) is very similar to the share of Detroit respondents in the high EB group (48.97%, n=143), while the share of UP respondents with high EB (17.5%, n=49) is also very similar to the share of Detroit respondents in the low EB group (18.49%, n=54).

The proportion of UP respondents who were "never" worried about having enough money to pay their home energy costs was 57.63% (n=185), whereas only 26.02% (n=89) of Detroit respondents indicated that they were never worried. Similarly, only 24.63% (n=83) of Detroit respondents reported they would not be stressed by a hypothetical 10% increase in energy prices the next month, while 46.88% (n=150) of UP respondents said they would not be stressed.

Detroit respondents' gave a mean rating of 3.13 to the impact on their household of generally increasing energy prices, while UP respondents gave this impact a mean rating of only 2.00.

Comparing Detroit's 48214 ZIP code to the rest of Detroit

The greatest share of respondents from both 48214 and the rest of Detroit were in the high EB group (48214: 42.86%, n=27; rest of Detroit: 50.66%, n=116), followed by the proportions in the medium EB group (48214: 30.16%, n=19; rest of Detroit: 33.19%, n=76), and with the smallest share of both geographic groups in the low EB group (48214: 26.98%, n=17; rest of Detroit: 16.16%, n=37). Respondents from 48214 had a larger proportion in the low EB group than did the rest of Detroit, as well as a smaller proportion in the high EB group.

Of respondents from 48214, 31.58% (n=24) were never worried about having enough money to pay their home energy costs, while only 22.93% (n=61) of respondents from the rest of Detroit were never worried. A similar difference was observed in the proportions of respondents who would not be stressed by a hypothetical 10% increase in energy costs the next month: 32.00% (n=24) of 48214 indicated this, compared to only 22.52% (n=59) for the respondents from the rest of Detroit.

The mean rating of the impact on their household of generally increasing energy costs for 48214 respondents was 2.97, lower than the mean rating given by respondents from the rest of Detroit (3.18).

See Appendix B, Table 6 for further calculations.

Conclusion

Decades of scholarship and research have demonstrated that race and income are contributing factors in environmental injustice. Our evidence supports this, and suggests that, in regards to households' experiences with their home energy, race may yet be a more influential factor. Further research is needed to understand the nuanced interplay between geography, race, income, and outcomes for energy reliability and affordability. Additionally, the justice implications of the structures of entities authorized by regulators to provide energy service to Michigan households warrant further examination; subsequent research should include assessing the association of these structures (investor-owned utility, co-operative electric utility, or municipal utility) with energy reliability and energy affordability outcomes.

We conclude that the associations found in our study are evidence of environmental racism playing out in our energy system. Combating environmental injustice and structural racism must be a priority for Michigan's public officials, and policies that are meant to target these problems must counteract these demonstrated inequities within our state's energy system.

Appendix A: Energy Reliability Outcomes Tables

Table 1: Energy Reliability Outcomes by Race/Ethnicity Group				
Except where noted, proportions below reflect share of respondents who experienced any outages (74.9%, n=522)	**Overall**	**White alone (respondent)**	**Black alone (respondent)**	**All other race/ethnicity**
Proportion experiencing an outage lasting 4 hours or more in last year	68.73% (354)	59.76% (147)	77.29% (160)	75% (33)
Proportion experiencing outages monthly or more than monthly in last year (of those who had longer outages, n=354)	57.06% (202)	46.26% (68)	63.75% (102)	66.67% (22)
Mean length of respondent's longest outage (hours) in last year	28.51	15.22	41.5	34.48
Proportion experiencing an "emergency situation" as a result of a power outage in the last year	14.67% (76)	5.98% (15)	23.9% (49)	20% (9)
Proportion who had to evacuate or leave their home due to a power outage in last year	19.57% (101)	3.60% (9)	35.92% (74)	28.89% (13)
Mean length of time away from home (hours) due to an outage in last year (of those who reported evacuating/leaving due to an outage, n=101)	52.89	20.61	54.01	64.92
Proportion who lost access to medical equipment or devices that require electricity due to an outage in last year	17.34% (89)	10.36% (26)	23.76% (48)	20.45% (9)

Proportion who lost perishable products or goods due to a power outage in last year	34.25% (175)	14.46% (36)	57.43% (116)	38.64% (17)
Proportion who have access to a backup source of electricity in case of emergency / outage	31.59% (212)	40.00% (128)	20.36% (56)	39.66% (23)
Proportion who have access to a backup source of home heating in case of emergency / outage	40.21% (271)	49.38% (160)	29.93% (82)	43.10% (25)

Table 2: Energy Reliability Outcomes by Geography Group					
Except where noted, proportions are of respondents who experienced any outages	**Overall**	**All Detroit**	**UP counties**	**Detroit outside 48214**	**Detroit 48214**
Proportion experiencing an outage lasting 4 hours or more in last year	68.73% (354)	77.78% (203)	59.68% (151)	80.49% (165)	67.86% (38)
Proportion experiencing outages of 4 hours or longer monthly or more than monthly in last year (of those who had longer outages, n=354)	57.06% (202)	63.55% (129)	74.17% (224)	64.85% (107)	57.89% (22)
Mean length of respondent's longest outage (hours) in last year	28.51	39.21	17.93	37.55	45.32
Proportion experiencing an "emergency situation" as a result of a power outage in the last year	14.67% (76)	22.78% (59)	6.59% (17)	23.38% (47)	20.69% (12)
Proportion who had to evacuate or leave their home due to a power outage in last year	19.57% (101)	33.59% (87)	5.45% (14)	35.82% (72)	25.86% (15)
Mean length of time away from home (hours) due to an outage in last year (of those who reported evacuating/leaving due to an outage, n=101)	52.89	56.67	29.61	50.76	84.67
Proportion who lost access to medical equipment or devices that require electricity due to an outage in last year	17.34% (89)	24.71% (63)	10.12% (26)	25.38% (50)	22.41% (13)

Proportion who lost perishable products or goods due to a power outage in last year	34.25% (175)	54.12% (138)	14.51% (37)	54.82% (108)	51.72% (30)
Proportion who have access to a backup source of electricity in case of emergency / outage	31.59% (212)	21.84% (76)	42.24% (136)	20.37% (55)	26.92% (21)
Proportion who have access to a backup source of home heating in case of emergency / outage	40.21% (271)	31.32% (109)	49.85% (162)	32.35% (88)	27.63% (21)

Table 3: Energy Reliability Outcomes by Energy Burden Group

Except where noted, proportions are of respondents who experienced any outages	**Overall**	**Low Energy Burden (<=4%)**	**Medium Energy Burden (4-10%)**	**High Energy Burden (>=10%)**
Proportion experiencing an outage lasting 4 hours or more in last year	68.73% (354)	58.04% (83)	67.15% (92)	78.23% (115)
Proportion experiencing outages of 4 hours or longer monthly or more than monthly in last year (of those who had longer outages, n=354)	57.06% (202)	40.96% (34)	63.04% (58)	60.87% (70)
Mean length of respondent's longest outage (hours) in last year	28.51	18.86	19.15	43.28
Proportion experiencing an "emergency situation" as a result of a power outage in the last year	14.67% (76)	7.59% (11)	10.00% (14)	20.81% (31)
Proportion who had to evacuate or leave their home due to a power outage in last year	19.57% (101)	5.56% (8)	18.44% (26)	29.53% (44)
Mean length of time away from home (hours) due to an outage in last year (of those who reported evacuating/leaving due to an outage, n=101)	52.89	69	33.08	52.35
Proportion who lost access to medical equipment or devices that require electricity due to an outage in last year	17.34% (89)	4.83% (7)	16.43% (23)	28.38% (42)
Proportion who lost perishable products or goods due to a power outage in last year	34.25% (175)	19.58% (28)	30.94% (43)	51.68% (77)

Proportion who have access to a backup source of electricity in case of emergency / outage	31.59% (212)	34.92% (66)	35.45% (67)	23.56% (45)
Proportion who have access to a backup source of home heating in case of emergency / outage	40.21% (271)	48.42% (92)	42.63% (81)	27.75% (53)

Table 4: Differences in Mean Outage Lengths by Energy Burden

	Energy burden >=6%	Energy burden <6%	Difference
All respondents	35.2 hours	18.0 hours	17.2 hours***
Detroit respondents	43.8 hours	21.5 hours	22.3 hours***
UP respondents	20.7 hours	16.4 hours	4.3 hours

*** *p <.001*

Appendix B: Energy Burden Outcomes Tables

Table 5: Energy Burden Outcomes by Race/Ethnicity Group

	Overall	**White alone (respondent)**	**Black alone (respondent)**	**Other Race/Ethnicity (Respondent)**
Low energy burden (<= 4%)	33.16% (190)	47.2% (101)	17.37% (29)	27.78% (10)
Medium energy burden (4%-10%)	33.33% (191)	35.05% (75)	28.74% (48)	33.33% (12)
High energy burden (>= 10%)	33.51% (192)	17.76% (38)	53.89% (90)	38.89% (14)
Proportion of respondents "always" or "usually" worried about having enough money to pay energy costs	22.44% (149)	10.60% (34)	33.96% (91)	29.82% (17)
Proportion of respondents "never" worried about having enough money to pay energy costs	41.27% (274)	56.07% (180)	22.76% (61)	42.11% (24)
Proportion of respondents "somewhat stressed" or "very stressed" by hypothetical 10% energy cost hike	64.59% (425)	51.72% (165)	77.74% (206)	76.79% (43)
Proportion of respondents "not stressed" by hypothetical 10% energy cost hike	35.41% (233)	48.28% (154)	22.26% (59)	23.21% (13)
Mean value of rating (on 1-5 scale) of impact on household of Michigan's generally increasing energy costs	2.58	1.98	3.28	2.68

Table 6: Energy Burden Outcomes by Geography Group	Overall	All Detroit	UP Counties	Detroit outside 48214	Detroit 48214
Low energy burden (<= 4%)	33.16% (190)	18.49% (54)	48.57% (136)	16.16% (37)	26.98% (17)
Medium energy burden (4%-10%)	33.33% (191)	32.53% (95)	33.93% (95)	33.19% (76)	30.16% (19)
High energy burden (>= 10%)	33.51% (192)	48.97% (143)	17.5% (49)	50.66% (116)	42.86% (27)
Proportion of respondents "always" or "usually" worried about having enough money to pay energy costs	22.44% (149)	32.75% (112)	11.53% (37)	33.09% (88)	31.58% (24)
Proportion of respondents "never" worried about having enough money to pay energy costs	41.27% (274)	26.02% (89)	57.63% (185)	22.93% (61)	36.84% (28)
Proportion of respondents "somewhat stressed" or "very stressed" by hypothetical 10% energy cost hike	64.59% (425)	75.37% (254)	53.12% (170)	77.48% (203)	68.00% (51)
Proportion of respondents "not stressed" by hypothetical 10% energy cost hike	35.41% (233)	24.63% (83)	46.88% (150)	22.52% (59)	32.00% (24)
Mean value of rating (on 1-5 scale) of impact on household of Michigan's generally increasing energy costs	2.58	3.13	2	3.18	2.97

Appendix C: Energy Insecurity Outcomes Tables

The above report does not include narrative description of these tables (as are included for the tables in Appendix A or Appendix B).

Table 7: Energy Insecurity Outcomes by Race/Ethnicity

Except shutoff impacts, each cell contains "proportion of available responses (n)"	**Overall**	**White alone**	**Black alone**	**Other race/ethnicity**
%yes oven for heat	8.13% (57)	3.36% (11)	13.65% (40)	6.67% (4)
%yes recent shutoff	8.14% (54)	3.13% (10)	13.75% (37)	8.77% (5)
% moderate shutoff impacts (% of total responses /% of those who had a shutoff)	2% / 26.92% (14)	0.92% / 33.33% (3)	2.05% / 16.67% (6)	6.67% / 80.00% (4)
% severe shutoff impacts (% of total responses /% of those who had a shutoff)	5.42% / 73.08% (38)	1.83% / 66.67% (6)	10.24% / 83.33% (30)	1.67% / 20.00% (1)

Table 8: Energy Insecurity Outcomes by Geography

Except shutoff impacts, each cell contains "proportion of available responses (n)"	Overall	Detroit 48214	Detroit outside 48214	UP Counties	All Detroit
%yes oven for heat	8.13% (57)	12.5% (10)	12.03% (35)	3.65% (12)	12.13% (45)
%yes recent shutoff	8.14% (54)	12.99% (10)	12.93% (34)	2.8% (9)	12.94% (44)
% moderate shutoff impacts (% of total responses /% of those who had a shutoff)	2% / 26.92% (14)	2.50% / 20.00% (2)	2.41%/21.21% (7)	1.22%/50.00% (4)	2.43%/20.93 % (9)
% severe shutoff impacts (% of total responses /% of those who had a shutoff)	5.42% / 73.08% (38)	10.00% / 80.00% (8)	8.93% / 78.79% (26)	1.22% / 50.00% (4)	9.16% / 79.07% (34)

Table 9: Energy Insecurity Outcomes by Energy Burden Group

	Overall	LowEB (<4%)	Medium EB (4-10%)	High EB (>10%)
Proportion in EB group	--	33.16% (190)	33.33% (191)	33.51% (192)
%yes oven for heat	8.13% (57)	4.74% (9)	3.66% (7)	16.67% (32)
%yes recent shutoff	8.14% (54)	0.53% (1)	3.66% (7)	20.00% (38)
% shutoff impacts: moderate (1 listed impact) (% of total responses /% of those who had a shutoff)	2% / 26.92% (14)	0%/0%	1.57% / 50.00% (3)	3.65% / 18.42% (7)
% shutoff impacts: severe (>1 listed impacts) (% of total responses /% of those who had a shutoff)	5.42% / 73.08% (38)	0.53% / 100.00% (1)	1.57% / 50.00% (3)	16.15% / 81.58% (31)

Appendix D: Key Study Variables and Measurements

Groups	
Energy Burden Group	Energy burden (EB) group codes are only reported for respondents for which EB estimates were available/possible, meaning that they had offered their household's range of costs for energy and range of income.All respondents for which EB estimates were available were assigned group coding for low (<=4%), medium (4%-10%), and high (>=10%) EB groups. Energy burden estimates are calculated based on midpoints of range responses for a household's typical summer and winter monthly energy costs ("In a typical summer month, what is your household's approximate cost for energy (electricity, cooling, etc.) for that month?"), combined with midpoints of range responses for annual household income ("We'd like to ask about the income range for your household. For 2020, which of these ranges applies to the income in your household?"). The formula for calculating estimated energy burden is: (12*([SummerCostsMidpoint]+[WinterCostsMidpoint])/2)/[IncomeMidpoint])
Geography	"UP respondents" = respondents residing in one of 6 Michigan counties (Alger, Baraga, Delta, Houghton, Marquette, Schoolcraft); "Detroit respondents" = respondents residing in the City of Detroit; "Detroit 48214 respondents" = respondents residing in the Detroit ZIP code 48214; "Detroit outside 48214 respondents" = respondents residing in the city of Detroit but in ZIP codes other than 48214.
Race/Ethnicity	"Black, alone" = respondent selected "Black / African American" as the only race/ethnicity category applicable to theirself; "White, alone" = respondent selected "white" as the only race/ethnicity category applicable to theirself; "Other race/ethnicity" = respondent selected any other single or combination of race/ethnicity categories as applicable to theirself.

Energy Reliability and Unreliability Impact Outcomes	
Experience of longer outages	"Yes" response to question: "In the last year, did your household experience a longer power outage, lasting 4 hours or more?"
Outage duration	Response to question "In the last year, what's the longest amount of time you were without power?" Values standardized/compiled based on cleaned/recoded values for reported hours and days
Longer outage frequency	Response to question "In the last year, how frequently have you experienced these longer power outages lasting 4 hours or more? About once in the last year, a few times in the last year, once or more each month, or once or more each week?"
Experiencing an emergency situation due to a power outage	"Yes"/"No" response to question: "In the last year, did you or members of your household experience an emergency situation due to an outage?"
Needing to evacuate leave home during an outage	"Yes"/"No" response to question "In the last year, did you or members of your household have to evacuate or leave your home due to a power outage?"
Length of time away from home for an outage evacuation	Response to question: "How long did you or members of your household stay away from home during this evacuation?" Values standardized/compiled based on cleaned/recoded values for reported hours and days
Loss of access to medical equipment or devices requiring electricity	"Yes"/"No" response to question: "In the last year, did a power disruption cause you or members of your household to lose access to a medical device or medical equipment that requires electricity"
Loss of perishable goods/products	"Yes"/"No" response to question: "In the last year, did your household lose food, medicine, or other perishable products as a result of a power outage?"
Energy Burden Outcomes	
Energy Burden level	See "Energy Burden Group", above.
Worry about energy costs	Response to question: "About how often in the past 12 months would you say you were worried or stressed about having enough money to pay your home energy (electricity, heating, etc.) costs?

	Would you say "Always," "Usually," "Sometimes," "Rarely," or "Never"?"
Rating of impact of increasing energy prices	Response to question: "Energy prices in Michigan have been going up. On a scale of 1 to 5 -- 1 being minimal, and 5 being crisis-level -- how would you rate the impact of these price increases?"
Stressed by hypothetical 10% price increase	Response to question: "If energy prices went up 10 percent next month, would you be stressed? If yes, very stressed or somewhat stressed?"
Energy Insecurity Outcomes	
Shut-offs	"Yes"/"No" response to question: "Has any member of your household recently experienced a shutoff or interruption of home energy (electricity, heating, etc.) because energy costs were more than the household could afford?"
Shut-off impacts	Compiled rating based upon response to question: "What were the impacts of this disruption?" 1 = Staying with family or different lodging, 2 = Affected ability to work paid job, 3 = Affected childcare, education, 4 = Loss of food due to spoiling, 5 = Loss of water access, 6 = Exposure to uncomfortable heat or cold, 7 = Increased expenses for backup energy (generator fuel, batteries, etc.), 8 = Other, please describe, 9 = Prefer not to answer, 10 = Don't know **none** = missing or 0 impacts selected; **moderate** = 1 impact selected; **severe** = 2 or more impacts selected
Using oven for heat	Response to question "How do you usually heat your home? Please answer "yes" or "no" for each…" **YesOven** = "Oven with the door open" selected as one of the methods respondent usually uses for heating their home; **NoOven** = "Oven with the door open" not selected

Appendix E: Figures of cross-tabulations, proportions, chi-squared test results, t-test results

For the following tables/pages, p-values are for statistical tests known as chi-squared tests or t-tests conducted to determine if the difference between outcomes for different groups is likely to have occurred by chance. Low p-values indicate that there is a very low probability of these differences having occurred by chance.

P-values less than 0.01 are considered **statistically significant**: the probability of these differences occurring is sufficiently low to strongly support an interpretation that the difference is meaningful.

For chi-squared tests, the measure of difference is relative to the different proportions in each row of the table shown. For t-tests, the measure of difference is relative to the mean values of an outcome variable as shown in the bar charts.