September 18, 2025

Ms. Lisa Felice
Michigan Public Service Commission
7109 W. Saginaw Hwy.
P. O. Box 30221
Lansing, MI 48909

RE: MPSC Case No. U-20140

Dear Ms. Felice:

Please see attached the Comments by the Ecology Center, Environmental Law & Policy Center, Union of Concerned Scientists, and Vote Solar (collectively the Clean Energy Organizations ("CEO")).

Sincerely,

Daniel Abrams (P87696)
Environmental Law & Policy Center
35 E Wacker Dr., Ste. 1600
Chicago, IL 60601
312-673-6500
dabrams@elpc.org

STATE OF MICHIGAN

MICHIGAN PUBLIC SERVICE COMMISSION

In the matter, on the Commission's own motion, regarding extreme weather condition policies filed in compliance with Michigan Administrative Code R 460.134.	))))	Case No. U-20140

COMMENTS BY

THE ECOLOGY CENTER, THE ENVIRONMENTAL LAW & POLICY CENTER, UNION OF CONCERNED SCIENTISTS, AND VOTE SOLAR

September 18, 2025

Introduction

The Ecology Center, Environmental Law & Policy Center, Union of Concerned Scientists, and Vote Solar, collectively the Clean Energy Organizations or "CEO", appreciate the opportunity to submit comments in this docket and address issues around extreme weather protection policies. In the Michigan Public Service Commission ("MPSC") meeting on August 7, 2025, the MPSC sought input in this docket and provided a set of questions for interested parties to answer. The CEO will not attempt to answer all the questions listed, but the CEO will provide a regional perspective on weather-related shutoff protections and Michigan-specific examples for the Commission to consider. Overall, the CEO believe that the Commission should enact a uniform weather-related policy (including our recommendations below) for Michigan utilities. This would help simplify the tracking of disconnections, create a consistent set of rules and definitions for the utilities, and provide a clear set of steps for utilities to follow. The CEO's answers are below.

Commission Questions and CEO Responses

1. The existing extreme weather condition policies vary by utility, with some suspending disconnections at a temperature threshold and others using National Weather Service (NWS) heat and cold advisory warnings. Are each utility's extreme weather condition policies appropriate for setting shutoff and customer protections? If not, what other thresholds should be considered? What is the most appropriate threshold for utilities in Michigan?

   CEO Reply: First, the CEO wish to highlight CEO Witness Boratha Tan's testimony in the most recent 2024 Consumers Energy Electric Rate Case, MPSC Docket No. U-21585. In Witness Tan's rebuttal testimony, he analyzed Consumers Energy's 2023 residential disconnections (aggregated to census tracts). Holding area median income constant, a census tract with a 100% BIPOC population experienced 120 more disconnections than a census tract with a 0% BIPOC population.[1] This finding is significant because it shows that there is a correlation between increasing disconnections and race. In other words, the disconnection data signals potential disparities in how the Company shuts off customers. Second, the CEO wish to highlight the current DTE Electric Rate Case, Docket No. U-21860. CEO Witness Tan ran a similar disconnection analysis, using DTE's 2024 residential disconnections count (but aggregated to zip codes).[2] The same correlation occurs here: the rate of disconnection increases with the percentage of BIPOC population in a given zip code. While statistical analyses such as regression require nuanced approaches to better understand its results, the CEO believe that these trends need to be addressed seriously. If a utility's disconnection policies, in general, do not treat customers fairly and equitably, then certain communities will be harmed significantly more than others. Any extreme weather protection policy must be built upon a fair and equitable shutoff policy.

In Minnesota, members of the CEO worked with Dr. Gabriel Chan and Dr. Bhavin Pradhan to run a more detailed regression analysis on Xcel Energy's disconnection data. Xcel Energy ran their own analysis, and they came to the same conclusion; holding various income levels, financial assistance, and housing stock information constant, BIPOC communities still experienced more shutoffs. Because of these results, Xcel Energy agreed to work with stakeholders and the

[1] MPSC Docket No. U-21585, CEO Witness Boratha Tan Rebuttal Testimony at 7. https://mi-psc.my.site.com/sfc/servlet.shepherd/version/download/068cs00000BusXLAAZ.
[2] MPSC Docket No. U-21860, CEO Witness Boratha Tan Direct Testimony at 22. https://mi-psc.my.site.com/sfc/servlet.shepherd/version/download/068cs000016rwhrAAA.

Minnesota PUC Staff to address disparate disconnection rates. These studies and results are attached to our comments as CEO Exhibits 1 and 2.[3, 4]

With these results in mind, the CEO request the Commission review both DTE's and Consumers Energy's current disconnection policies, inclusive of any extreme weather protections. Specifically, the Commission should investigate if there are disparate impacts of disconnections with race, and if any extreme weather protections are affected by said disparate impacts. Finally, both DTE and Consumers should work with interested stakeholders in addressing such disconnection patterns, similar to Xcel Energy in Minnesota.

2. Should the extreme weather condition policies be consistent across utilities or continue to vary by utility?

   CEO Reply: The CEO do not have a reply.

3. How long should protections be in place after an extreme weather event? For example, should utilities be prohibited from instituting shutoffs for 72 hours after the event if the high/low temperature threshold or NWS heat/cold advisory warning is forecasted for any time in the 48 hours following the event?

   CEO Reply: The CEO believe that the Commission should explore a blanket shutoff moratorium during the hottest weeks of summer. While we do not have a formula to determine what the thresholds of temperature are, we believe the Commission should explore various options, such as: using a three-year average of hottest temperatures to benchmark, three-year average number of heat waves, etc.

[3] CEO Exhibit 1 Pradhan-Chan - Racial and Economic Disparities in Electric Reliability and Service Quality in Xcel Energy's MN Service Area.pdf.
[4] CEO Exhibit 2 Xcel Energy Summary of TRC report and solutions, 24-27.pdf.

A blanket shutoff moratorium during a long stretch of hot/cold weather will be critical to maintaining safe temperatures for vulnerable households (households with seniors, children, medical equipment), while also providing a simple, straightforward policy. Understanding recent historical temperatures can help utilities pre-emptively activate extreme weather protections before such extreme temperatures occur, helping vulnerable households survive through the extreme heat or cold. Additionally, understanding how many heat waves occurred in previous years can help utilities plan for future heat waves in a certain year. Averaging across several years ensures that a reasonable policy is applied, while using a relatively short span of three years will better reflect the impact of climate change.

4. What protections do other states with similar climates have in place during extreme weather that the Commission should consider? How effective are they? What extreme weather thresholds are used?

CEO Reply: In Minnesota, Xcel Energy agreed with Minnesota CUB (Citizens Utility Board) and other stakeholders to implement additional disconnection measures. Not only are customers eligible for modified payment plans to avoid disconnections, but Xcel also proposed to reconnect any disconnected customers during extreme weather.[5]

The CEO also understand that the Abrams Environmental Law Clinic of the University of Chicago Law School addressed this question. The Clinic analyzed various states' extreme weather protection policies and provided specific

[5] Minnesota CUB Press Release: https://cubminnesota.org/xcel-agrees-to-cub-requests-to-substantially-improve-disconnection-practices.

recommendations for the Commission. The CEO support the Clinic's recommendations, including the use of the National Weather Service's heat advisories to initiate protections, and starting shutoff moratoriums a certain number of hours or days before the extreme weather event occurs.

5. What process improvements might be considered for extreme weather condition policies?

    <u>CEO Reply</u>: The CEO do not have a reply.

6. Should utilities provide more data or file reports on a regular basis related to extreme weather condition policies? If so, how often and what should be included? What purpose would the reports serve?

    <u>CEO Reply</u>: Yes, the CEO believe that utilities should provide data and reports on a regular basis. Specifically, the CEO request that disconnection data aggregated to census tracts be available. The utilities should also regularly analyze their respective disconnection data with respect to various census demographics. For example, Consumers Energy already analyzed their disconnection data for the U-21870 Rate Case.[6] This analysis and report should be readily available on the MPSC's Utility Customer Data Website.

7. Should the extreme weather condition policies be updated or evaluated on a specific timeline, to ensure they remain effective and responsive to changing weather patterns and emerging challenges? Or should another trigger (other than time) be used for the update or reevaluation?

    <u>CEO Reply</u>: The CEO do not have a reply.

[6] MPSC Docket No. U-21870 Consumers Energy Witness Michael P. Kelly Direct Testimony, Exhibit A-138 (MPK-28).

8. If applicable, what public engagement process should utilities utilize to update their respective extreme weather condition policies?

CEO Reply: The CEO do not have a reply.

9. Should utilities be required to notify the Commission when their extreme weather protections are triggered?

CEO Reply: The CEO do not have a reply. However, we do support the Abrams Law Clinic's recommendations requiring utilities to submit twice-yearly reports.

10. What assistance measures are utilities providing to customers during extreme weather (e.g., information on cooling/heating centers and resilience hubs, pallets of water bottles, etc.)? How is this assistance communicated to customers? What other entities are utilities coordinating with? Are there additional assistance measures that should be considered?

CEO Reply: The CEO do not have a reply.

11. What else should utilities and the Commission consider when reviewing and updating the extreme weather condition policies?

CEO Reply: There are two recent papers that the CEO would like the Commission to consider. The first is a paper around utility disconnections, authored by Memmott, Carley, Graff, and Konsiky.[7] In this paper, the authors analyze shutoff protections during the COVID-19 pandemic, and what impacts low-income families felt during this time. The second is a paper on energy insecurity, authored by Carley and Konsiky.[8] In this paper, the authors address energy insecurity and extreme heat impacts on low-income families. Both are attached as CEO Exhibits 3 and 4 to our comments.

[7] CEO Exhibit 3 Utility Disconnections Memmott Carley Graff Konsiky.pdf.
[8] CEO Exhibit 4 Energy Insecurity Carley Konsiky.pdf.

Conclusions

The CEO, again, thank the Commission for allowing stakeholders to comment on this extremely important topic. The CEO believe that our disconnection analyses in the DTE and Consumers Rate Cases, along with the attached Exhibits would provide the MPSC with important information to consider in this docket. Finally, we believe that a uniform weather-related disconnection policy should be implemented so that the policy can be streamlined for implementation.

CENTER FOR SCIENCE, TECHNOLOGY, AND ENVIRONMENTAL POLICY

Racial and Economic Disparities in Electric Reliability and Service Quality in Xcel Energy's Minnesota Service Area

Bhavin Pradhan, Postdoctoral Associate
Gabriel Chan*, Associate Professor

* Corresponding author: gabechan@umn.edu

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HUMPHREY SCHOOL OF PUBLIC AFFAIRS
UNIVERSITY OF MINNESOTA

301 19th Avenue South
Minneapolis, MN 55455

612.626.3292
hhh.umn.edu/cstep/

CENTER FOR SCIENCE, TECHNOLOGY, AND ENVIRONMENTAL POLICY

Center for Science, Technology, and Environmental Policy

University of Minnesota – Twin Cities

301 19th Avenue South

Minneapolis, MN 55455

www.hhh.umn.edu/cstep/

Table of Contents

Abstract

This paper asks whether disparities exist in access to shared infrastructure systems, focusing on the electric system, an essential service delivered by heavily regulated public utilities. We examine disparities in access to electricity service in the service area of Xcel Energy across three dimensions: utility disconnection, service reliability, and grid availability to host distributed energy resources. We quantify disparities across Census block groups by leveraging unique, high-resolution datasets of service quality and grid conditions that have only recently been made publicly available. We find significant and pervasive evidence of the disparities among different demographic groups across utility disconnection and service reliability. Across a battery of regression models, we find that living in poorer neighborhoods with a greater concentration of people of color is associated with a statistically and practically significant difference in the likelihood of disconnection from service due to non-payment and the experience of extended power outages. We also find evidence that hosting capacity for distributed generation is higher in disadvantaged communities and communities with high populations of people of color. These findings underscore the opportunity for policy initiatives to rectify deep-seated inequalities through affirmative investments and safety net programs that ensure all communities, regardless of their racial or economic composition, have equitable access to universal basic utility service and reliable, clean energy.

Keywords: racial equity; disconnection; distributional justice; grid hosting capacity; energy justice

1. Introduction

The impact of household energy insecurity on the physical, mental, and economic well-being of struggling families has been well documented (Harker Steele and Bergstrom, 2021; Hernández, 2016; Konisky et al., 2022; Memmott et al., 2021). In this paper, we look at multiple indicators that affect energy insecurity: involuntary disconnection from service, long-duration outages, and availability of the grid to interconnect consumer-owned energy resources. Utility disconnection can cause extreme economic distress (Baker et al., 2021; Flaherty et al., 2020). Utility disconnection can cascade into long-term financial hardship, homelessness, and even severe health-related issues (Flaherty et al., 2020). From 2019 to 2020, around 4.7 million U.S. households at or below 200 percent of the federal poverty line could not pay their energy bills, 4.8 million received a utility disconnection notice, and 2 million were disconnected from their electricity service (Memmott et al., 2021). Difficulty affording energy costs can create situations of "energy insecurity" that cause households into dilemmas, such as choosing between food and heat, especially during extreme weather events (Hernández, 2016).

Many low-income households and communities of color face significant, pervasive, and persistent conditions of energy insecurity due to their inability to afford energy bills and living in fear of being disconnected from their utility services (Graff and Carley, 2020; Hernández et al., 2014). To reduce their energy bills and to mitigate their utility-related issues, families use various coping strategies, such as keeping indoor temperatures at a unsafe or undesirable level, using gas stoves to heat living spaces, abstaining from air-conditioning, and delaying bill payments and arrearages (Carley et al., 2022; Cong et al., 2022; Hernández, 2016; Hernández et al., 2014). Turning down the heat and living in cold and damp housing—due to poor housing conditions or high energy prices—has been shown to have significant associations with decreased respiratory, mental, and sleep outcomes (Hernández and Siegel, 2019; Liddell and Guiney, 2015). However, the present-day household energy insecurity is not merely a function of affordability, housing condition, employment, home efficiency, poverty, or energy prices– but instead, deeply rooted in how cities and neighborhoods evolved over the century (Swope et al., 2022).

As the energy transition accelerates to meet climate goals and integrate distributed energy resources (DERs), such as rooftop solar and electric vehicles, scholars, policymakers, and advocates have identified opportunities to advance energy justice goals (Carley and Konisky, 2020; Chan and Klass, 2022; Elmallah et al., 2022; Welton and Eisen, 2019). Yet currently, adoption of DERs reflects existing inequalities across race and income, and addressing historic injustices in infrastructure investment will likely require careful implementation of justice-oriented infrastructure policy (Schott and Whyte, 2023).

In this paper, our research question is: *Is there evidence of neighborhood-level disparities across income and race in the electric service quality, involuntary disconnection, and access to the grid to interconnect distributed energy resources?*

We explore this question by looking at three outcome metrics in a large Midwestern utility using a unique compilation of datasets that report average service quality and distribution grid hosting capacity at a fine geographic scale. We link these datasets with demographic characteristics to quantify disparities across race, income, poverty rates, and population density in involuntary disconnections, long-duration electric outages, and hosting capacity on the local grid for DERs. We find robust, statistically significant associations between race, poverty, utility disconnection, and long-term service disruption in Minnesota. We also identify correlations that suggest neighborhoods with a higher proportion of people of color, lower income, and lower population density tend to have increased DER hosting capacity availability. However, this observation is not consistent across all models. The greater availability of DER hosting capacity in these more disadvantaged communities may reflect a lower adoption rate of DER among low-income populations in communities of color who live in densely populated areas, contributing to the expanding research in this area.

The results do not imply causality, as conventional quantitative methods that purport to estimate counterfactuals of race are often inconsistent with social-constructivist theories of racialization (Graetz et al., 2022). Instead, our analysis shows the critical associations between socioeconomic factors, including race, and key indicators related to advancing energy justice. It is important to distinguish that our findings do not necessarily imply deliberate racial bias on the part of energy system planners. Instead, the findings underscore how multiple systemic causes of economic hardship are reflected in yet another critical infrastructure system (Swope et al., 2022). The results point to a valuable opportunity to correct these inequalities through deliberate investments in the energy transition that affirmatively prioritize disadvantaged communities, low-income neighborhoods, and communities of color. By doing so, a more equitable energy system that provides reliable, high-quality utility services and equal opportunity to benefit from the energy transition for all people can be fostered, regardless of socioeconomic status or racial background. And further, grid planners have an opportunity to prioritize investments in communities that are at greatest risk for energy insecurity.

The paper is structured as follows: Section 2 describes the paper's data sources. Section 3 provides an overview of the methodology applied, Section 4 presents the results of the paper, and Section 5 concludes.

2. Data

Our study integrates three distinct data sources at the Census block group-level covering the service area of Xcel Energy, the largest electric utility in Minnesota: the U.S. Census American Community Survey's demographic and household estimates, the Council on Environmental Quality's Climate and Economic Justice Screening Tool (CEJST) map of disadvantaged communities, Xcel Energy's Minnesota Electric Service Quality Interactive Maps estimates of service quality and involuntary disconnections, and Xcel Energy's Hosting Capacity Analysis for Generation (Gen-HCA) estimates of distribution grid capacity to host DERs.

2.1. American Community Survey and Climate and Economic Justice Screening Tool

The unit of analysis for our study is a Census block group (CBG). A CBG is the "smallest geographic entity for which the decennial census tabulates and publishes sample data" and generally contains between 600-3,000 people (Bureau of the Census, 1994). The average CBG in our dataset has a population of approximately 1,250 people. We extract CBG-level average demographic and household characteristics from the 5-year American Community Survey (ACS) for variables such as building composition and age, race/ethnicity of the head of household, income and poverty level, education, unemployment rate, population density (a proxy for electric grid topology), and homeownership type.

We also integrate data from the Council on Environmental Quality's Climate and Economic Justice Screening Tool (CEJST). The CEJST map provides binary indicators of whether a census tract meets the definition of a "disadvantaged community" pursuant to Executive Order 14008, "Tackling the Climate Crisis at Home and Abroad." Federal agencies use the CEJST definition of disadvantaged communities to seek to deliver 40% of the overall benefits of certain investments in climate and clean energy to disadvantaged communities under the Justice40 Initiative. The CEJST identification of disadvantaged communities is based on indicators in eight categories: climate change, energy, health, housing, legacy pollution, transportation, water and wastewater, and workforce development.

2.2. Disconnection and Service Quality Data

Our study leverages unique publicly available data on involuntary disconnections and service interruptions from Xcel Energy's Minnesota Electric Service Quality Interactive Maps published from 2019-2022 and covering data from 2017-2022. Xcel Energy is the largest electric utility in Minnesota and serves 38 percent of residential customers in some of the most densely populated areas of the state, including the Minneapolis-St. Paul metropolitan area (see Figure 1).

The dataset reports CBG-level averages of utility disconnection and service quality across Xcel Energy's service area. Utility disconnection is reported as ratio of the number of disconnected premises to the total number of premises in a CBG.

Service quality is reported in two metrics, CEMI-6 and CELI-12. CEMI-6 is the percent of customers in a CBG that experience 6 or more sustained outages per year. CELI-12 is the percent of customers in a CBG that experience an outage with a duration of 12 hours or more per year. For each year from 2019-2022, disconnection, CEMI-6, and CELI-12 rates are reported as three-year averages: 2017-2019 for the 2019 map, 2018-2020 for the 2020 map, and so on. Table 1 shows average yearly rates of disconnection, CELI-12, and CEMI-6 across CBGs.

Table 1. Disconnection and Service Quality Statistics for Xcel Energy's service areas from 2017-2022. All the numbers are per 1,000 households and standard deviations are included inside the brackets.

Years	Average disconnection rate (per 1,000 households)	CELI-12: Average number of households experiencing an outage longer than 12 hours (per 1,000 households)	CEMI-6: Average number of households experiencing 6 or more outages per year (per 1,000 households)
2017-2019	11.9 (14.2)	6.36 (28.7)	23.6 (57.7)
2018-2020	4.06 (6.06)	24.4 (55.7)	7.56 (30.3)
2019-2021	4.27 (6.16)	24.4 (55.3)	6.89 (28.0)
2020-2022	6.62 (10.6)	33.0 (70.4)	8.12 (31.0)
Overall	6.82 (10.51)	23.0 (57.19)	11.38 (38.97)

2.3. DER Hosting Capacity

We extract a CBG's DER hosting capacity from the publicly available 2023 Hosting Capacity Analysis for Generation (Gen-HCA) maps published by Xcel Energy. The Gen-HCA maps are used as a first-pass tool for developers to assist in site-selection processes for new DER generation, such as distributed solar, wind, and batteries. The Gen-HCA map is displayed as a heat map for a distribution feeder-line in most of Xcel Energy's service area in Minnesota. Hosting data was accessed in late 2023, representing a snapshot of current hosting capacity. Xcel Energy updates its hosting capacity analysis at each feeder at least once annually. Table 2 summarizes service area-wide descriptive statistics used in the regression.

Table 2. Descriptive Statistics of the variables used in the analysis.

Variable	Mean	S.D.	Min	Max
POC (0-100%)	25.09	23.04	0.00	99.54
Poverty (0-100%)	21.32	17.36	0.00	95.30
Median HH Income ($)	81,145	39,461	0	250,001
Population Density (1,000 households per sq. mile)	4.94	6.46	0.00	148.83
Unemployment Rate (0-100%)	4.08	4.53	0.00	56.72
Renters (0-100%)	30.16	25.60	0.00	100.00
Built after 90s (0-100%)	22.84	22.87	0.00	100.00
Disconnections (per 1,000 homes)	6.82	10.51	0.00	121.40
CELI-12: Average number of households experiencing an outage longer than 12 hours (per 1,000 households)	23.00	57.19	0.00	681.90
CEMI-6: Average number of households experiencing 6 or more outages per year (per 1,000 households)	11.38	38.97	0.00	525.50
Average Maximum Hosting Capacity Per Household (kW/household)	1.78	1.61	0.00	14.83
Maximum Area Hosting Capacity (kW)	801.37	605.52	0.00	4370.1

Unlike hosting capacity maps for used in previous research in states like California (Brockway et al., 2021), Gen-HCA maps intentionally omit specific details of distribution feeder lines due to security concerns, instead providing generalized representations as "blurred" spatial heat polygons. These polygons reflect only a snapshot of data and do not disclose the precise locations of the distribution lines. Based on the maximum area method, we execute a spatial overlay, aligning the 2010 Census Block Group (CBG) boundaries with the Gen-HCA maps. This process assigns unique CBG identifiers to each polygon, effectively integrating the two data sets.

Xcel's Gen-HCA polygons incorporate a variable denoting diverse hosting capacities along the distribution line; however, many polygons within the dataset have multiple hosting capacities. The Xcel Gen-HCA map uses the maximum value of each polygon to classify the available hosting capacity range (> 1 MW, 751-1 MW, 501-750 MW, 251-500 MW, 1-250 MW, 0 MW). To extrapolate the polygon data to a CBG level, we utilize the highest hosting capacity value from the Gen-HCA polygons, averaging these figures to derive a single hosting capacity metric for each CBG– this is the Maximum

Area Hosting Capacity (kW). Dividing this number by the total number of housing units in the CBG gives the Average Maximum Hosting Capacity per household (kW per household). This approach is conceptually consistent with the visual representation of the Gen-HCA map in the web interface. When polygons intersect with multiple CBGs, we attribute the polygon to the CBG covering the largest segment of the polygon, ensuring a representative allocation. To calculate per household hosting capacity i.e. Average Maximum Hosting Capacity per household (kW per household). for each CBG, we divide the calculated CBG hosting capacity by the total housing units in the CBG (excluding the two CBGs with fewer than 10 reported housing units). To remove outliers, we limit the average maximum hosting capacity per household value to 15 kW.

We note that our approach to averaging hosting capacity within a CBG could obscure more micro-level dynamics in hosting capacity within a CBG. Hosting capacity is a complex function of grid topology and depends on highly context-specific, often trade-secret characteristics of the grid. Nevertheless, our approach is still able to provide a high-level estimate of hosting capacity that approximates what could be considered a "screening" type of hosting capacity assessment. Detailed and accurate hosting capacity data could help in refining energy justice assessments by highlighting the disparities in access to DERs. The granular data would enable utilities to pinpoint underserved areas for targeted grid improvements, or even pinpoint areas with a high availability of hosting capacity to integrate DERs. Such data-driven strategies can inform nuanced energy policies that address unique community barriers to DER adoption, facilitating a more inclusive and justice-focused energy transition.

2.4. Descriptive Analysis

In this section, we present a descriptive analysis of disparities across our key outcome variables. Figure 1 shows maps that present spatial representation of key variables in our dataset, showing the resolution of our CBG-level data for the two largest counties in Xcel Energy's service area, Hennepin and Ramsey counties.

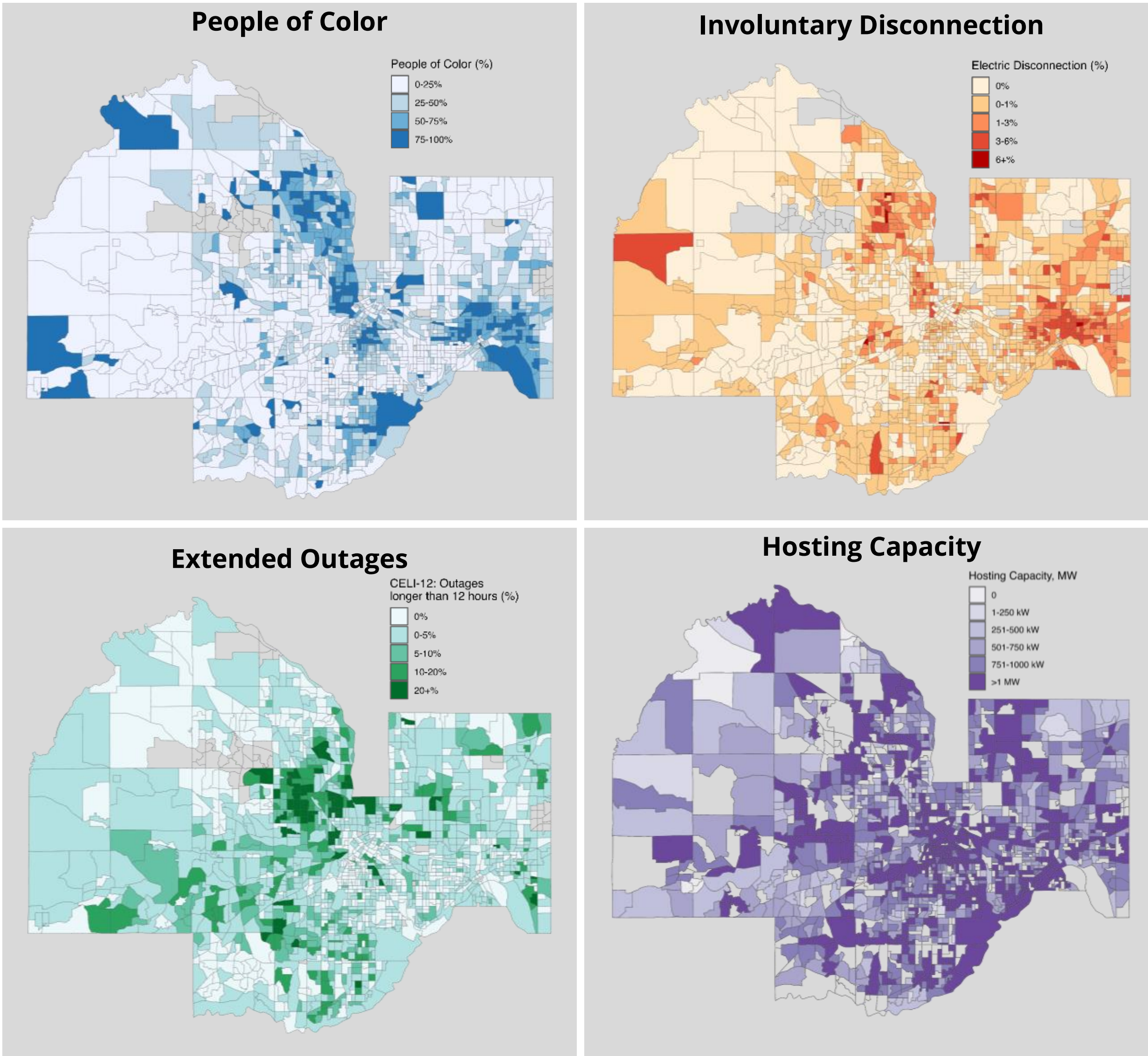

Figure 1. Illustration of data resolution. Maps display relative magnitude of key variables in the dataset at the Census block group-level for Hennepin and Ramsey counties (encompassing Minneapolis and St Paul and the majority of customers in Xcel Energy's service area). Top left: people of color as percent of population. Top right: involuntary disconnections as a percent of customers. Bottom left: extended outages over 12 hours per year as a percent of customers. Bottom right: hosting capacity of the distribution grid as percent of population.

2.4.1. Descriptive Analysis of Disconnections

The first line of inquiry is to explore the relationships between a CBG's percentage of people of color and the number of customers disconnected due to non-payment every year. Figure 2 shows scatterplots for the proportion of households disconnected due to non-payment across three-year periods with moving averages by a CBG's percent people of color. The figure shows upward trends across all three-year periods with communities with a higher percentage of people of color experiencing higher rates of electric disconnection. We display disparities in disconnection rates in CEJST-designated disadvantaged communities compared to other communities in Figure 3. And we affirm the relationship between disconnections and race shown in Figure 2 again in Figure 4, emphasizing the higher disconnection rate in the CBGs in the top 10% of population of people of color.

Our data covers a period during which Minnesota implemented a moratorium on utility disconnections that applied to Xcel Energy during the COVID-19 pandemic, which was in place from the start of the pandemic in early 2020 through August 2021 (Baker et al., 2021). The impact of the disconnection moratorium can be seen in the lower average disconnection rates in the periods with greater overlap with the moratorium. Yet we still see visually apparent upward trends between a CBG's population of color and disconnection rates.

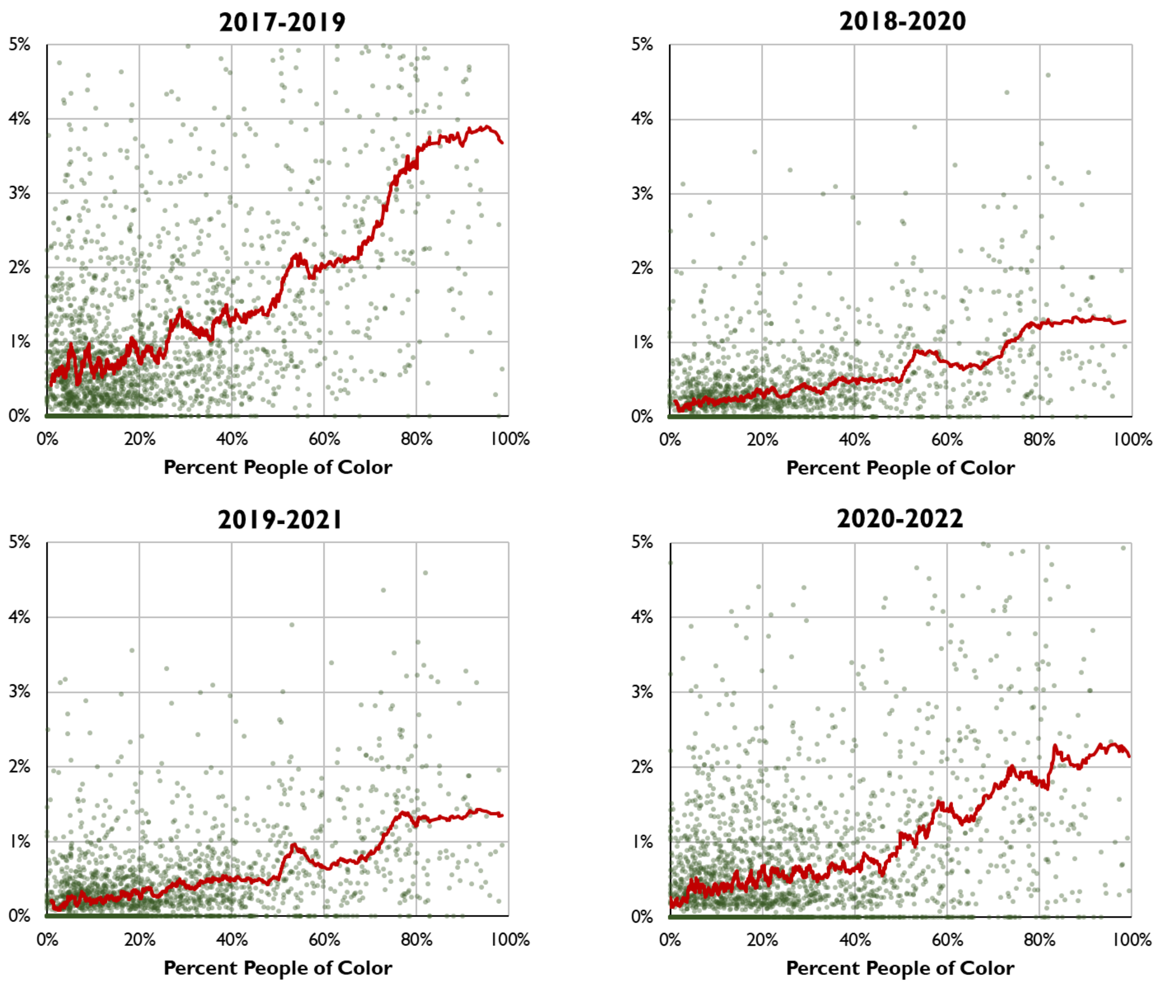

Figure 2. The relationship between CBG average disconnection rates compared to its percent people of color, 2019-2022. The moving average line shows a clear positive relationship for all years.

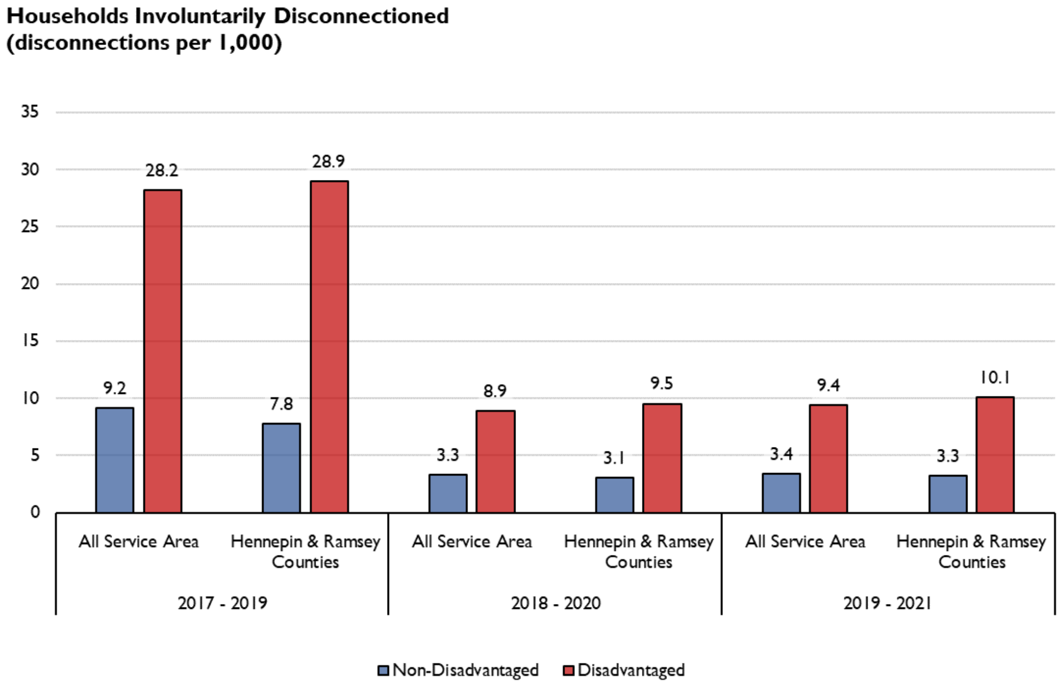

Figure 3. Disconnected households, comparing non-disadvantaged versus disadvantaged CBGs in Xcel Energy's service area and in Hennepin and Ramsey Counties from 2017-2021.

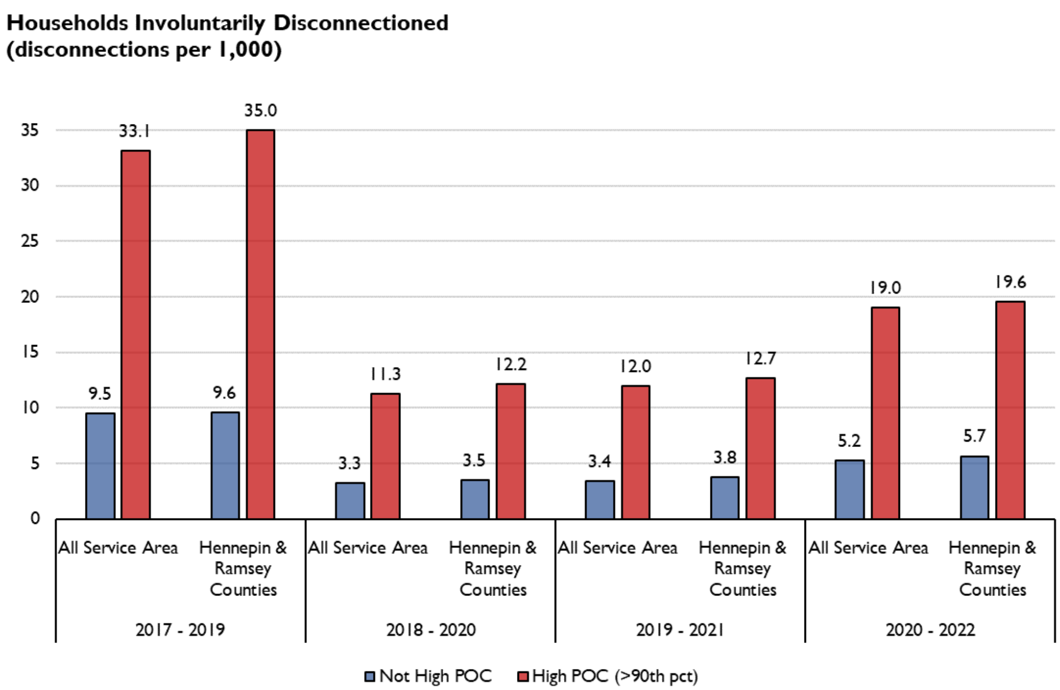

Figure 4. Disconnected households, comparing CBGs with high percentage of people of color (POC) with others in Xcel Energy's Service Area and in Hennepin and Ramsey Counties from 2017-2022.

One possible explanation for the positive association between a CBG's percent people of color and disconnection rate is confounding by income. To address this possibility, Figure 5 shows disconnection rates within bands of CBG median household income and bands of percent people of color. The figure shows that the upward association between disconnection rates and percent people of color holds even within CBG's with low income. Potential confounding is addressed more holistically in the regression analysis presented in Section 4.1.

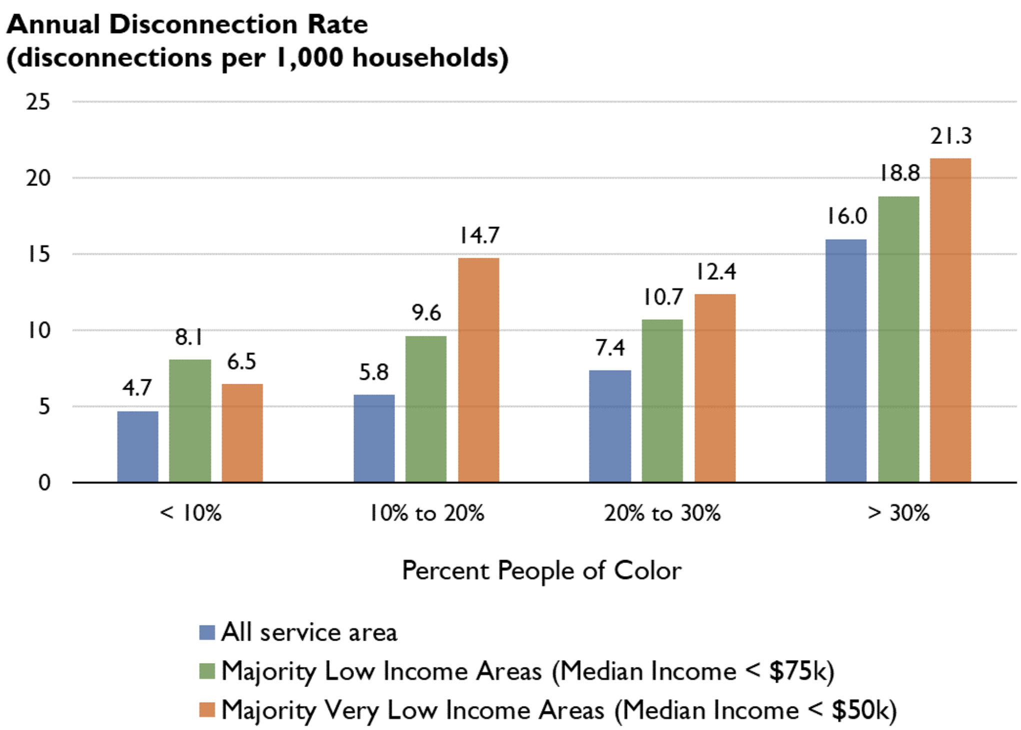

Figure 5. Rate of disconnection by an area's percent people of color overall and below different income levels, 2017-2022. Data for this figure combines data shown in Figure 2 for the period 2017-2019 and 2020-2022 to avoid double counting any years. Note that the time period in this figure covers a moratorium on disconnections during the COVID-19 pandemic, and therefore disparities largely reflect disparities in disconnections from 2017-2019 and in 2022.

2.4.2. Descriptive Analysis of Service Quality

Figure 6 reveals a concerning trend in power outage disparities between non-disadvantaged and disadvantaged communities across Xcel Energy's service area and specifically within Hennepin & Ramsey Counties over consecutive years from 2017 to 2021. We classify CBGs on their disadvantaged community status based on the White House's Climate and Economic Justice Screening Tool (CJEST). Despite fluctuations, there is a discernible pattern where disadvantaged CBGs consistently endure a greater frequency of power outages exceeding 12 hours (CELI-12). For 2018-2020 and 2019-2021, disadvantaged CBGs had a higher incidence of more extended power outages across all service areas and also within Hennepin & Ramsey Counties. This finding suggests potential systemic vulnerabilities or unequal distribution of resources affecting power stability. We do not analyze 2020-2022 because the Xcel service quality maps are based on census 2020 boundaries whereas the CJEST classifications are based on 2010 census boundaries.

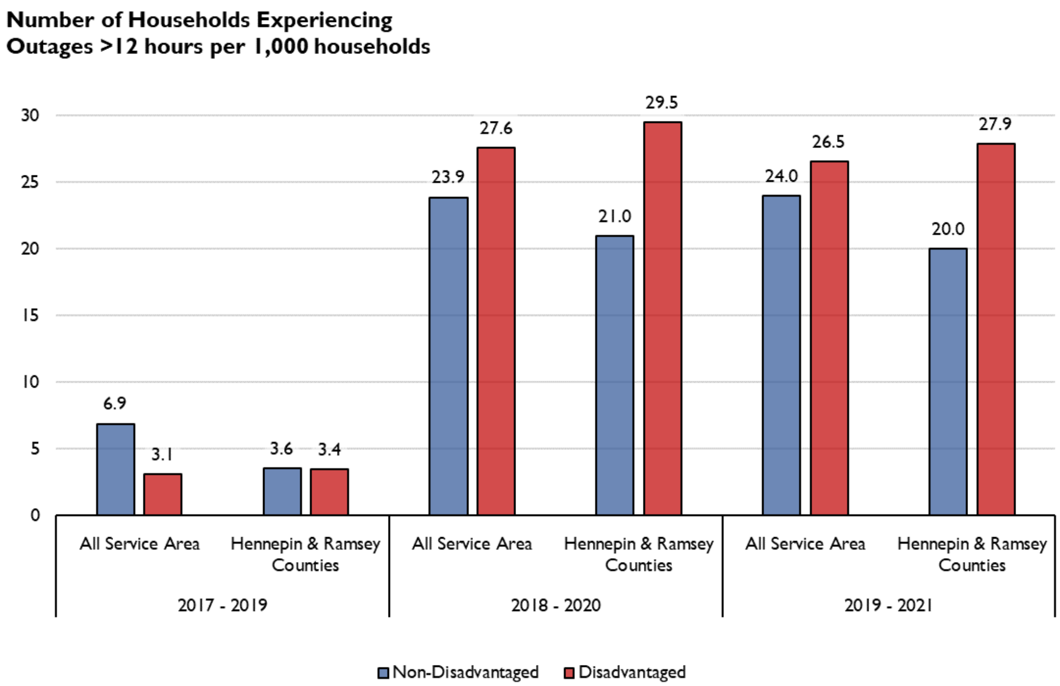

Figure 6. Households experiencing outages longer than 12 hours (CELI-12), comparing non-disadvantaged versus disadvantaged CBGs in Xcel Energy's service area and in Hennepin and Ramsey Counties from 2017-2021.

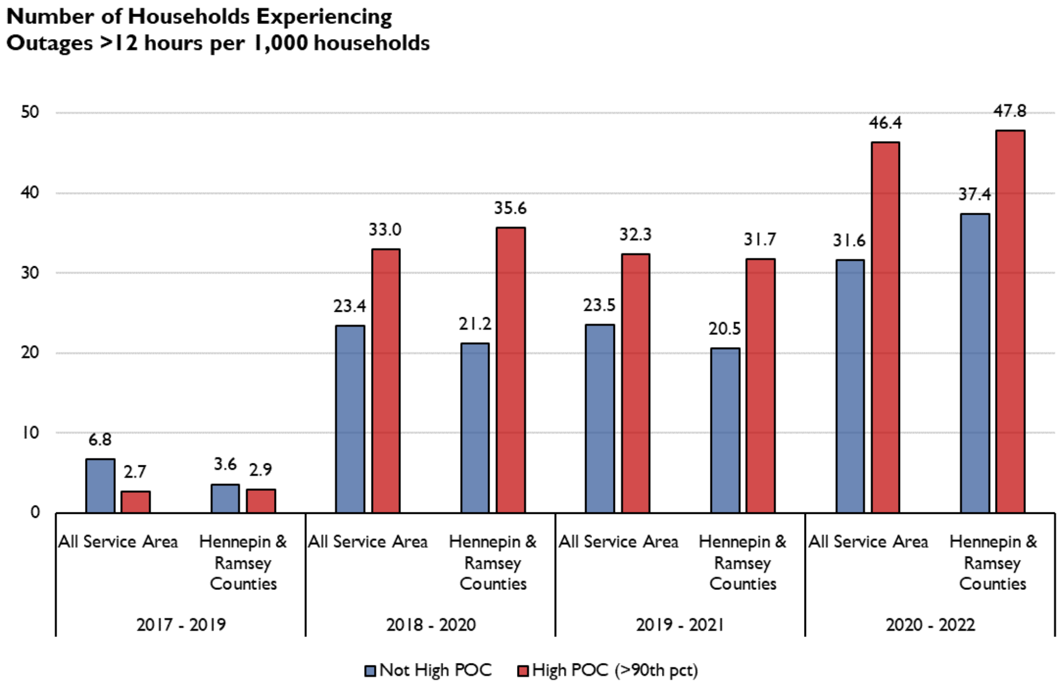

Figure 7. Households experiencing outages longer than 12 hours (CELI-12), comparing CBGs with high percentage of people of color (POC) with other CBGs in Xcel Energy's Service Area and in Hennepin and Ramsey Counties from 2017-2022.

Figure 7 provides a visual analysis of the stark differences in long-duration outages (CELI-12) for CBGs that have a high percentage of people of color (above 90th percentile) and those that do not, by comparing the metrics in Hennepin & Ramsey counties and all of Xcel's service area. The figure shows that, except for 2017-2019, high POC CBGs experienced significantly longer power outages. For instance, in the 2020-2022 period, Hennepin & Ramsey Counties reported nearly 48 outages per 1,000 high POC households, significantly more than the just over 37 outages per 1,000 non-high POC households. This pattern indicates not only a reliability issue within the power infrastructure but also underscores a social equity concern, as the communities with higher percentages of POC are disproportionately affected by power service disruptions.

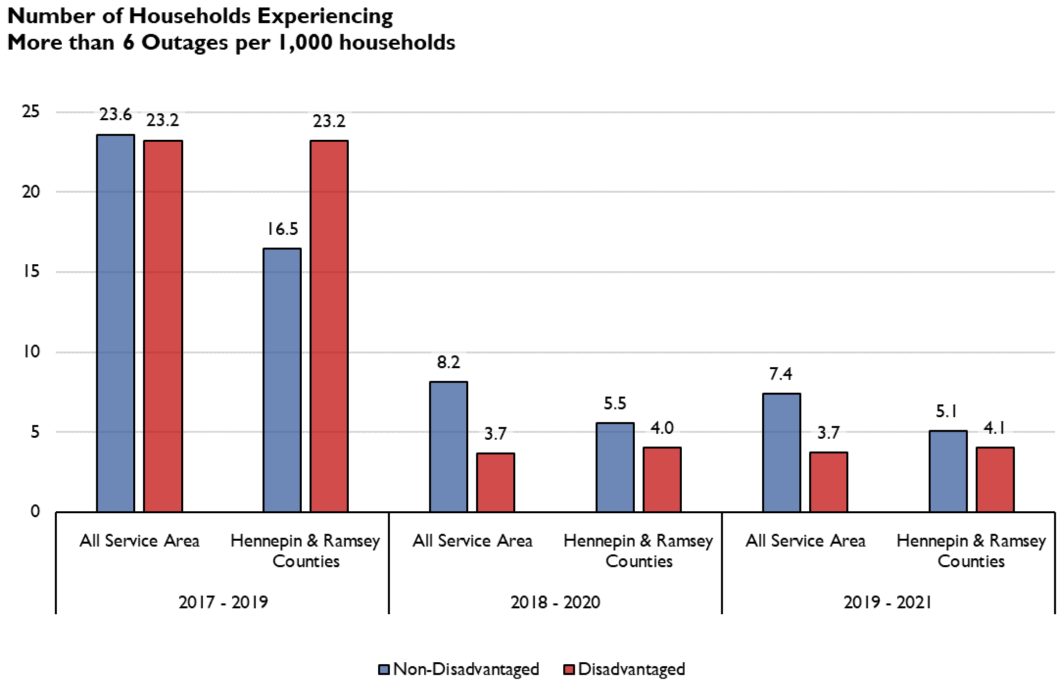

Figure 8. Households experiencing six or more sustained outages per year (CEMI-6), comparing non-disadvantaged versus disadvantaged CBGs in Xcel Energy's service area and in Hennepin and Ramsey Counties from 2017-2021.

Figure 8 shows the number of households per 1,000 experiencing 6 or more sustained outages per year (CEMI-6). Except for outages in Hennepin & Ramsey Counties in 2017-2019, disadvantaged communities in all of Xcel's Service Area and Hennepin & Ramsey Counties had lower incidences of frequent power outages. For disadvantaged communities in Hennepin & Ramsey Counties, the number of households experiencing more than 6 or more sustained outages also reduce significantly–from 23.7 in 1,000 households in 2017-2019 to about 3.7-4.1 per 1,000 households in 2018-2021.

Similarly, Figure 9 shows the number of households per 1,000 experiencing 6 or more sustained outages per year for CBGs classified into either high POC (more than 90th percentile) or not high POC. Like the trend shown in Figure 8, the number of households experiencing more sustained outages is higher for high POC CBGs only in 2017-2019, for all customers. The number of sustained outages experienced by homes in high POC CBGs within Hennepin & Ramsey Counties range from 3.7-6.3 per 1,000 households from 2018-2022. Likewise, 7.1-8.4 per 1,000 households homes (that do not get categorized as high POC) experience frequent outages.

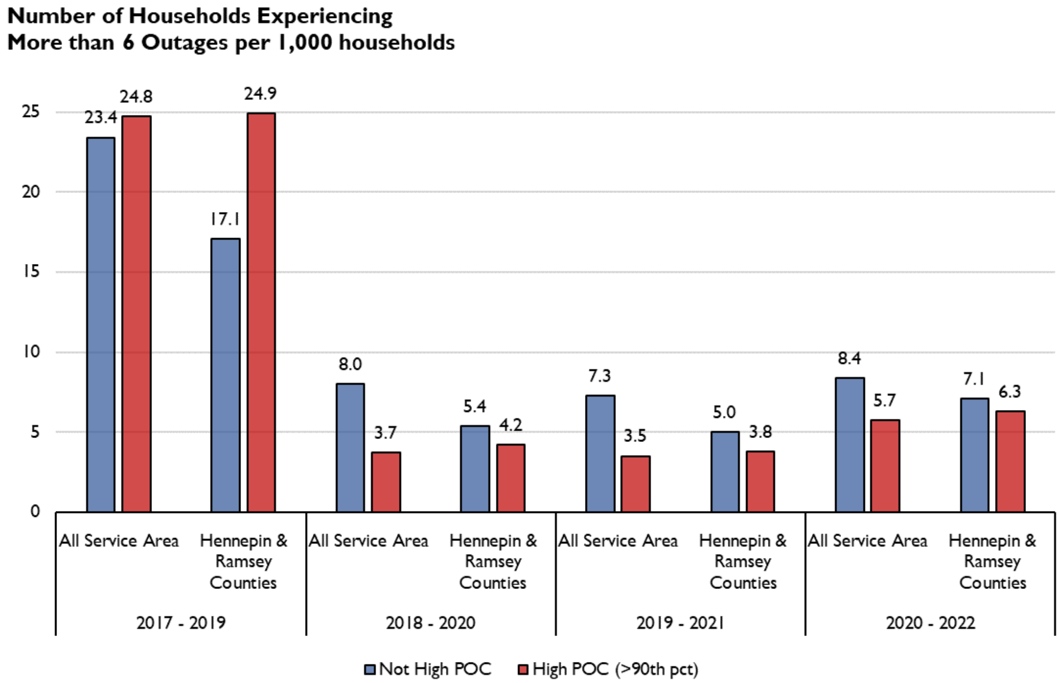

Figure 9. Households experiencing six or more sustained outages per year (CEMI-6), comparing CBGs with high percentage of people of color (POC) with other CBGs in Xcel Energy's Service Area and in Hennepin and Ramsey Counties from 2017-2022.

2.4.3. Descriptive Analysis of Hosting Capacity

Figure 10 compares hosting capacity metrics across CEJST-designated disadvantaged communities to other communities. The results show that hosting capacity is significantly higher in disadvantaged communities than other communities based both on the average area maximum hosting capacity and the average maximum hosting capacity per household.

Similarly, Figure 11 shows that hosting capacity is also higher on an area-average and per-household basis in communities in the top 10 percent of population of people of color.

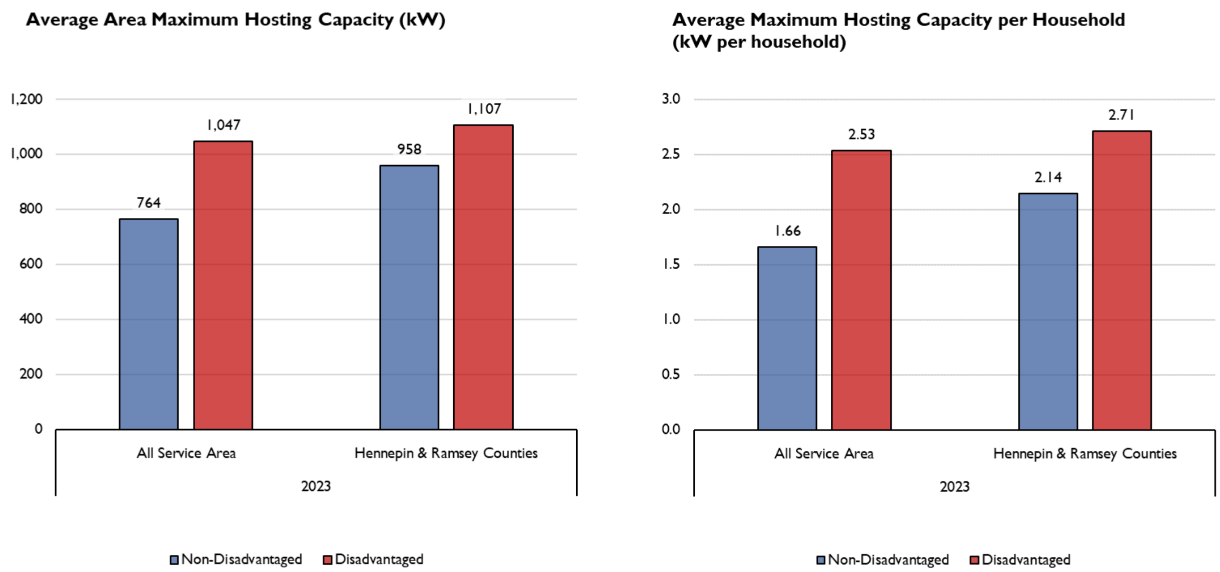

Figure 10. Average area maximum hosting capacity (left) and per household hosting capacity (right) comparing non-disadvantaged versus disadvantaged CBGs in Xcel Energy's service area and in Hennepin & Ramsey Counties from 2017-2021. Hosting capacity estimates shown for 2023.

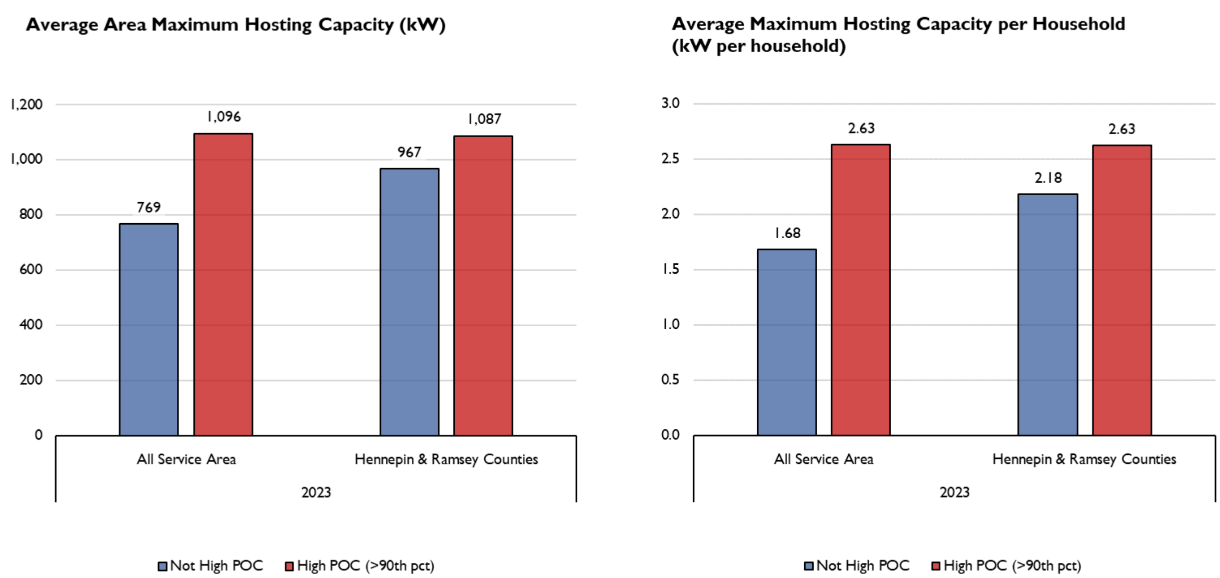

Figure 11. Average area maximum hosting capacity (left) and per household hosting capacity (right) comparing CBGs with high percentage of people of color (POC) with other CBGs in Xcel Energy's Service Area and in Hennepin and Ramsey Counties. Hosting capacity estimates shown for 2023.

2.4.4. Difference-in-Means Hypothesis Tests

In this section, we present results of difference-in-means hypothesis tests for each of the key outcome variables (long-term outages, multiple outages, involuntary disconnections, and hosting capacity) across each of the years of data. In Table 3, we conduct difference-in-means hypothesis tests comparing CEJST-designated disadvantaged communities to other communities. In Table 4, we conduct difference-in-means hypothesis tests comparing CBGs in the top 10% of population of people of color to other CBGs.

Table 3. Difference-in-means hypothesis tests comparing CEJST-designated disadvantaged communities to other communities across the rate of long-term outages, multiple outages, involuntary disconnections, and measures of hosting capacity.

		Non-Disadvantaged Communities (Non-DAC)	Disadvantaged Communities (DAC)	Difference (Non-DAC - DAC)	p-value	Statistically Significant?
Long-Term Outages: Customers Experiencing an Outage > 12 hours in a Year, per 1,000 households (CELI-12 x 1,000)						
2017-2019	All Service Area	6.90	3.12	3.77	0.0472	Yes
	Hennepin & Ramsey Counties	3.56	3.44	0.12	0.9037	No
2018-2020	All Service Area	23.89	27.60	-3.71	0.3803	No
	Hennepin & Ramsey Counties	20.98	29.51	-8.53	0.0414	Yes
2019-2021	All Service Area	24.01	26.54	-2.53	0.4905	No
	Hennepin & Ramsey Counties	20.02	27.91	-7.89	0.0247	Yes
Multiple Outages: Customers Experiencing > 6 Outages in a Year, per 1,000 households (CEMI-6 x 1,000)						
2017-2019	All Service Area	23.61	23.24	0.37	0.9231	No
	Hennepin & Ramsey Counties	16.48	23.23	-6.75	0.0312	Yes
2018-2020	All Service Area	8.16	3.69	4.47	0.0518	No
	Hennepin & Ramsey Counties	5.54	4.04	1.50	0.3946	No
2019-2021	All Service Area	7.41	3.74	3.67	0.0479	Yes
	Hennepin & Ramsey Counties	5.08	4.05	1.03	0.4767	No
Involuntary Disconnections, per 1,000 households						
2017-2019	All Service Area	9.17	28.19	-19.02	0.0000	Yes
	Hennepin & Ramsey Counties	7.76	28.95	-21.18	0.0000	Yes
2018-2020	All Service Area	3.30	8.92	-5.61	0.0000	Yes
	Hennepin & Ramsey Counties	3.08	9.54	-6.46	0.0000	Yes
2019-2021	All Service Area	3.42	9.43	-6.01	0.0000	Yes
	Hennepin & Ramsey Counties	3.25	10.07	-6.82	0.0000	Yes
Hosting Capacity (Maximum Area Hosting Capacity, kW)						
2023	All Service Area	763.90	1047.45	-283.55	0.0000	Yes
	Hennepin & Ramsey Counties	957.89	1106.81	-148.92	0.0000	Yes
Hosting Capacity per Households (Maximum Area Hosting Capacity per Household, kW/household)						
2023	All Service Area	1.66	2.53	-0.87	0.0000	Yes
	Hennepin & Ramsey Counties	2.14	2.71	-0.57	0.0000	Yes

Table 4. Difference-in-means hypothesis tests comparing communities with in the top 10% of populations of people of color to other communities across the rate of long-term outages, multiple outages, involuntary disconnections, and measures of hosting capacity.

		Not High People of Color Population (Bottom 90%)	High People of Color Population (Top 10%)	Difference (Not High POC - High POC)	p-value	Statistically Significant?
Long-Term Outages: Customers Experiencing an Outage > 12 hours in a Year, per 1,000 households (CELI-12 x 1,000)						
2017-2019	All Service Area	6.77	2.69	4.08	0.0655	No
	Hennepin & Ramsey Counties	3.61	2.90	0.71	0.5820	No
2018-2020	All Service Area	23.43	32.98	-9.55	0.0469	Yes
	Hennepin & Ramsey Counties	21.20	35.62	-14.43	0.0089	Yes
2019-2021	All Service Area	23.48	32.33	-8.85	0.0375	Yes
	Hennepin & Ramsey Counties	20.53	31.71	-11.18	0.0183	Yes
2020-2022	All Service Area	31.56	46.37	-14.81	0.0012	Yes
	Hennepin & Ramsey Counties	37.41	47.77	-10.36	0.0941	No
Multiple Outages: Customers Experiencing > 6 Outages in a Year, per 1,000 households (CEMI-6 x 1,000)						
2017-2019	All Service Area	23.42	24.77	-1.34	0.7635	No
	Hennepin & Ramsey Counties	17.09	24.92	-7.83	0.0641	No
2018-2020	All Service Area	7.99	3.69	4.29	0.1006	No
	Hennepin & Ramsey Counties	5.37	4.20	1.16	0.6172	No
2019-2021	All Service Area	7.27	3.50	3.76	0.0804	No
	Hennepin & Ramsey Counties	4.99	3.81	1.18	0.5449	No
2020-2022	All Service Area	8.39	5.74	2.65	0.1887	No
	Hennepin & Ramsey Counties	7.10	6.29	0.81	0.7087	No
Involuntary Disconnections, per 1,000 households						
2017-2019	All Service Area	9.52	33.15	-23.63	0.0000	Yes
	Hennepin & Ramsey Counties	9.58	35.03	-25.45	0.0000	Yes
2018-2020	All Service Area	3.25	11.29	-8.03	0.0000	Yes
	Hennepin & Ramsey Counties	3.47	12.15	-8.68	0.0000	Yes
2019-2021	All Service Area	3.42	11.98	-8.57	0.0000	Yes
	Hennepin & Ramsey Counties	3.76	12.68	-8.91	0.0000	Yes
2020-2022	All Service Area	5.25	19.01	-13.76	0.0000	Yes
	Hennepin & Ramsey Counties	5.67	19.56	-13.89	0.0000	Yes
Hosting Capacity (Maximum Area Hosting Capacity, kW)						
2023	All Service Area	768.82	1095.63	-326.81	0.0000	Yes
	Hennepin & Ramsey Counties	966.99	1087.00	-120.01	0.0027	Yes
Hosting Capacity per Households (Maximum Area Hosting Capacity per Household, kW/household)						
2023	All Service Area	1.68	2.63	-0.95	0.0000	Yes
	Hennepin & Ramsey Counties	2.18	2.63	-0.45	0.0002	Yes

3. Methods

In the three major analyses we conduct for disconnection rates, service quality, and DER hosting capacity analysis, we compute the conditional and unconditional annual rates (disconnections, CELI-12, and DER hosting capacity) using Ordinary Least Squares (OLS) regression models by regressing these rates on an indicator of the percent of households that identify as people of color, poverty rates, and median household income at the CBG level. We also use year and county fixed effects and an additional set of CBG-level controls. In equation (1), we show the basic model for our regression models.

$$y_{it} = \alpha_c + \lambda_t + \delta POC_{it} + \beta X_{it} + \varepsilon_{it} \quad (1)$$

where, y_{it} is the annual block group (i) dependent variable: disconnected homes (per 1,000 homes), CELI-12 (per 1,000 homes), and hosting capacity (kW per household), **δ** represent the variables of interest- representing the impact of POC on the dependent variable, α_c are county-level fixed effects, λ_t are year fixed effects, and X_{it} includes block group characteristics: median household income, poverty rate, unemployment rate, population density, renters, multifamily housing, newly built buildings, and households with no access to the internet.

The way that Xcel Energy reports the disconnection and CELI-12 data (by average disconnection rates over 3 years) biases the actual rates due to multiple overlaps between different periods. For example, the 2020 rates (the average of 2018, 2019, and 2020) and the 2021 rates (the average of 2019, 2020, 2021) biases the actual rates which can lead to underestimation of the variability in the dataset and overstate the significance of the findings. To account for this possible violation, we create a panel using rates from two reporting periods: 2019 and 2022 to eliminate any overlapping years.

4. Regression Results

In this section we present the results of our analysis of disconnection rates (Section 4.1), rates of extended outages (Section 4.2), and hosting capacity (Section 4.3) against demographic indicators. For each outcome variable, we implement nearly identical regression model specifications.

4.1. Electric Service Disconnection

Table 5 presents the outcomes of a fixed effects model employed to examine the correlation between utility disconnection rates and various variables, with a focus on the percentage of people of color (POC) within a CBG. Model (1) only regresses the POC percent value with disconnection rates. The result of Model (1) shows that increasing a CBG's POC population by 10 percentage points is associated with an increase of 2.93 disconnections per 1,000 households, controlling for year and county-fixed effects. This is a practically significant finding when compared to the average disconnection rate of 6.82 disconnections per 1,000 households shown in Table 1. The estimate for POC across all models is statistically significant at the 0.01 level when controlled for the economic and structural characteristics of the block group (separately and together.

In Model (5), we control for the CBG's median household income ($100,000), poverty (%), population density (1,000 homes per sq. miles), unemployment rate (%), renters (%), and the proportion of homes built after 1990 (%). The linear regression model suggests significant correlations between a CBG's POC and the rate of electric utility disconnection. Model (5) reports that after controlling for a number of variables, a 10 percentage point increase in the POC share of the population is associated with the number of disconnected homes per 1,000 increasing by 2.24.

Table 5. OLS Regression Model of Electric Utility Disconnections for the panel of 2017-2019 average and 2020-2022 average disconnections

Dependent Variable:	Disconnected homes (per 1,000 households)				
Model:	(1)	(2)	(3)	(4)	(5)
POC (0-100%)	0.2927*** (0.0116)	0.2271*** (0.0132)	0.2645*** (0.0118)	0.2940*** (0.0118)	0.2236*** (0.0133)
Poverty (0-100%)		0.1201*** (0.0171)			0.0777*** (0.0210)
Med. HH Inc. ($100,000)			-3.492*** (0.3699)		-1.296** (0.5153)
Population Density (1,000 households per sq. mile)				-0.0147 (0.0307)	-0.0925*** (0.0321)
Unemp. Rate (0-100%)					0.1633*** (0.0528)
Renters (0-100%)					0.0184 (0.0112)
Built after 90s (0-100%)					-0.0379*** (0.0066)
Year FE	✓	✓	✓	✓	✓
County FE	✓	✓	✓	✓	✓
Observations	4,511	4,511	4,511	4,511	4,451
R^2	0.3638	0.3776	0.3737	0.3639	0.3852

Significance Codes: *** p < 0.01, ** p < 0.05, * p < 0.1

4.2. Service Reliability

In the following analysis, the focus shifts to long-duration outages as captured by the CELI-12 metric, which likely has a more pronounced impact on under-resourced communities compared to multiple short-duration outages, as gauged by the CEMI-6 metric.

Table 6. Regression Model of Long Duration Service Disruption in Minnesota for the panel of 2017-2019 average and 2020-2022 average service disruptions.

Dependent Variable:	CELI-12: Homes Experiencing Outages >12 hrs (per 1,000 households)				
Model:	(1)	(2)	(3)	(4)	(5)
POC (%)	0.0652 (0.0441)	0.1992*** (0.0563)	0.1009** (0.0452)	0.1089** (0.0042)	0.2078*** (0.0561)
Poverty (%)		-0.2455*** (0.0630)			-0.0770 (0.0790)
Med. HH Inc. ($100,000)			4.424** (1.814)		-7.307** (2.876)
Population Density (1,000 households per sq. mile)				-0.4941*** (0.1001)	-0.2258** (0.0989)
Unemp. Rate (%)					0.0177 (0.2021)
Renters (%)					-0.3180*** (0.042)
Built after 90s (%)					-0.3027*** (0.0275)
Year FE	✓	✓	✓	✓	✓
County FE	✓	✓	✓	✓	✓
Observations	4,511	4,511	4,511	4,511	4,451
R^2	0.1187	0.1213	0.1194	0.1211	0.1493

Significance Codes: *** p < 0.01, ** p < 0.05, * p < 0.1

The outcomes of the regressions are shown in Table 6. Model (1) estimates the association between a CBG's percent POC and CELI-12 rates, accounting for year and county fixed effects. Models (2-5) estimate multivariate regressions with multiple controls. For Models (2-5), the percent POC in a CBG is statistically significant, indicating the robustness of the estimated value. Model (5) estimates a coefficient of 0.2078 for POC. The interpretation of the estimate is that, after controlling for different neighborhood characteristics, a 10 percentage point rise in the POC population is associated with 2.078 additional homes experiencing long-duration outages, controlling for multiple socioeconomic factors. The estimates in Model (2-5) are statistically significant at the 0.01 level.

4.3. DER Hosting Capacity

Table 7 shows the effect of a CBG's demographics on the average maximum hosting capacity per household. Hosting capacity is measured in kilowatts (kW) per household. Model (1) estimates the impact of a CBG's POC concentration on the grid's available hosting capacity. The model's estimate shows that a 10 percentage point increase in the POC population increases the per household hosting capacity by 0.107 kW. However, this estimate is only robust when controlling with control (Model 1), and when controlling for Median Household Income (Model 3) and Population Density (Model 4), at the 0.001 level.

Table 7. Regression model of per household hosting capacity in 2023.

Dependent Variable:	Average Maximum Hosting Capacity per Household (kW per household)				
Model:	(1)	(2)	(3)	(4)	(5)
POC (%)	0.0107*** (0.0018)	0.0036 (0.0025)	0.0085*** (0.0021)	0.0112*** (0.0019)	0.0036 (0.0026)
Poverty (%)		0.0141*** (0.0039)			0.0111** (0.0047)
Med. HH Inc. ($100,000)			-0.1769* (0.1007)		0.1836 (0.1254)
Population Density (1,000 households per sq. mile)				-0.0059 (0.0046)	-0.0173*** (0.006)
Unemp. Rate (%)					0.0264*** (0.0088)
Renters (%)					0.0038 (0.0024)
Built after 90s (%)					-0.0041** (0.0016)
County FE	✓	✓	✓	✓	✓
Observations	2,028	2,028	2,028	2,028	1,985
R^2	0.213	0.225	0.213	0.213	0.232

Significance Codes: *** p < 0.01, ** p < 0.05, * p < 0.1

Model (3) includes the POC and median household income, excluding the poverty percentage. The coefficient for the median household income (-0.1769) is statistically significant at the 0.1 level, indicating that neighborhoods with higher median income are associated with a lower available hosting capacity.

From Model (5), the per household hosting capacity is not associated with the POC, as indicated by the estimate that is not statistically significant. However, Model (5) shows that the per household hosting capacity decreases in denser neighborhoods. The relationship shows that, controlling for various neighborhood characteristics, a 10 percentage point increase in the population density (1,000 households per sq. mile) of a neighborhood decreases the per household hosting capacity by 0.173 kW.

5. Conclusion

The findings of this paper reveal strong associations between socioeconomic variables, including race and income, with utility disconnections and reliability metrics. Although the findings do not make causal claims, we believe that these statistically significant associations demand attention from energy system planners and policymakers. While we do not believe that our findings necessarily imply deliberate racial bias on the energy system planners' part, this does not negate the potential for utilities and policymakers to take proactive steps toward fostering equity in the electric system through the principles of energy justice. Some measures to address these issues include protecting low-income customers from disconnections, investing in marginalized communities to improve utility service quality, and equitably expanding distributed energy resources capacity.

This paper highlights the urgent need for policy interventions to rectify these deep-seated disparities, ensuring access to reliable, high-quality utility services for all people, irrespective of their socioeconomic or racial backgrounds. Moving forward, the goal should not merely be to avoid deliberate injustices but to create systems that ensure fairness and equity, particularly as the energy system is poised to see once-in-a-generation infusions of capital to decarbonize the economy. While this research focused on Minnesota, the findings and proposed interventions have broader implications, offering valuable insights for other states grappling with similar disparities. We hope this study stimulates and encourages further research and dialogue toward policy changes prioritizing energy equity and justice.

Acknowledgments

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References

Baker, S.H., Carley, S., Konisky, D.M., 2021. Energy insecurity and the urgent need for utility disconnection protections. Energy Policy 159, 112663. https://doi.org/10.1016/j.enpol.2021.112663

Brockway, A.M., Conde, J., Callaway, D., 2021. Inequitable access to distributed energy resources due to grid infrastructure limits in California. Nat Energy 6, 892–903. https://doi.org/10/gnbjn8

Bureau of the Census, 1994. Census Blocks and Block Groups, in: Geographic Areas Reference Manual. U.S. Department of Commerce.

Carley, S., Graff, M., Konisky, D.M., Memmott, T., 2022. Behavioral and financial coping strategies among energy-insecure households. Proceedings of the National Academy of Sciences 119, e2205356119. https://doi.org/10.1073/pnas.2205356119

Carley, S., Konisky, D.M., 2020. The justice and equity implications of the clean energy transition. Nat Energy 5, 569–577. https://doi.org/10.1038/s41560-020-0641-6

Chan, G., Klass, A.B., 2022. Regulating for Energy Justice. New York University Law Review 97, 1426–1506.

Cong, S., Nock, D., Qiu, Y.L., Xing, B., 2022. Unveiling hidden energy poverty using the energy equity gap. Nat Commun 13, 2456. https://doi.org/10.1038/s41467-022-30146-5

Elmallah, S., Reames, T.G., Spurlock, C.A., 2022. Frontlining energy justice: Visioning principles for energy transitions from community-based organizations in the United States. Energy Research & Social Science 94, 102855. https://doi.org/10.1016/j.erss.2022.102855

Flaherty, M., Carley, S., Konisky, D.M., 2020. Electric utility disconnection policy and vulnerable populations. The Electricity Journal 33, 106859. https://doi.org/10.1016/j.tej.2020.106859

Graetz, N., Boen, C.E., Esposito, M.H., 2022. Structural Racism and Quantitative Causal Inference: A Life Course Mediation Framework for Decomposing Racial Health Disparities. J Health Soc Behav 63, 232–249. https://doi.org/10.1177/00221465211066108

Graff, M., Carley, S., 2020. COVID-19 assistance needs to target energy insecurity. Nat Energy 5, 352–354. https://doi.org/10.1038/s41560-020-0620-y

Harker Steele, A.J., Bergstrom, J.C., 2021. "Brr! It's cold in here" measures of household energy insecurity for the United States. Energy Research & Social Science 72, 101863. https://doi.org/10.1016/j.erss.2020.101863

Hernández, D., 2016. Understanding 'energy insecurity' and why it matters to health. Social Science & Medicine 167, 1–10. https://doi.org/10.1016/j.socscimed.2016.08.029

Hernández, D., Aratani, Y., Jiang, Y., 2014. Energy Insecurity among Families with Children. National Center for Children in Poverty, Columbia University Mailman School of Public Health, New York.

Hernández, D., Siegel, E., 2019. Energy insecurity and its ill health effects: A community perspective on the energy-health nexus in New York City. Energy Research & Social Science 47, 78–83. https://doi.org/10.1016/j.erss.2018.08.011

Konisky, D.M., Carley, S., Graff, M., Memmott, T., 2022. The persistence of household energy insecurity during the COVID-19 pandemic. Environ. Res. Lett. 17, 104017. https://doi.org/10.1088/1748-9326/ac90d7

Liddell, C., Guiney, C., 2015. Living in a cold and damp home: frameworks for understanding impacts on mental well-being. Public Health 129, 191–199. https://doi.org/10.1016/j.puhe.2014.11.007

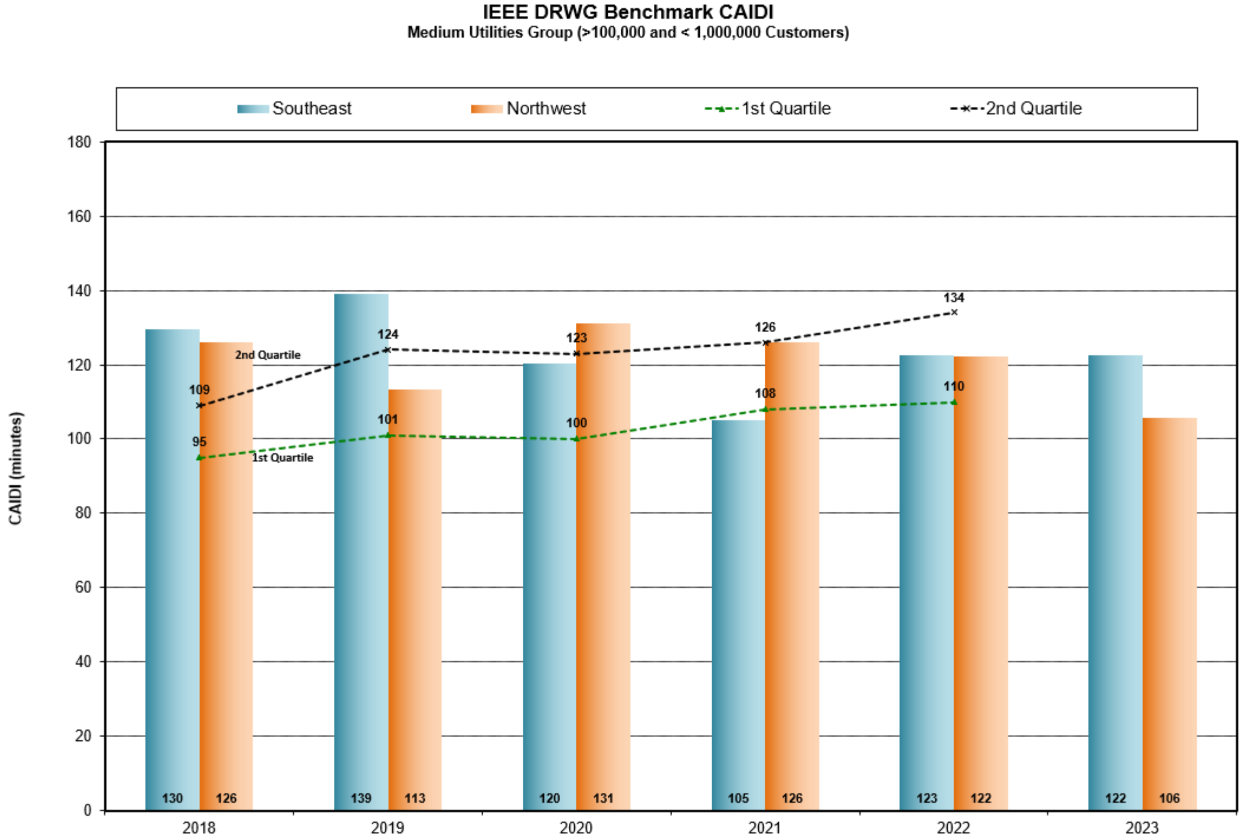
Memmott, T., Carley, S., Graff, M., Konisky, D.M., 2021. Sociodemographic disparities in energy insecurity among low-income households before and during the COVID-19 pandemic. Nat Energy 6, 186–193. https://doi.org/10.1038/s41560-020-00763-9

Schott, J., Whyte, K., 2023. Setting Justice40 in Motion: The Hourglass Problem of Infrastructure Justice. Environmental Justice 16, 329–339. https://doi.org/10.1089/env.2022.0046

Swope, C.B., Hernández, D., Cushing, L.J., 2022. The Relationship of Historical Redlining with Present-Day Neighborhood Environmental and Health Outcomes: A Scoping Review and Conceptual Model. J Urban Health 99, 959–983. https://doi.org/10.1007/s11524-022-00665-z

Welton, S., Eisen, J.B., 2019. Clean Energy Justice: Charting an Emerging Agenda. Harvard Environmental Law Review 43, 307–371.

Graph 29



VI. EQUITY ANALYSIS RESULTS

Order Point 3 of the Commission's March 22, 2023 Order, required the Company to:

> *conduct an analysis that examines whether there is a relationship between poor performance on the five identified metrics displayed on the interactive map and equity indicators. Required Xcel to file this analysis with its next service quality report due April 1, 2024.*

Order Point 4 further required:

> *If Xcel's analysis determines there are disparities in any of the five metrics displayed on the map, required Xcel to identify preliminary steps it could take to rectify the disparities and if Commission approval is required, where and when it would expect to file solutions. This should include an analysis of whether modifications to Xcel's Quality of Service Plan are necessary to address any identified disparities. Required*

Xcel to file this preliminary plan with its next service quality report due April 1, 2024.

These requirements are addressed below.

A. TRC Study Background

In compliance with this Order, Xcel Energy contracted with TRC Companies[4] (TRC) to provide an analysis of the five metrics listed on our interactive map -- Customers Experiencing Lengthy Interruptions of 12 hours or more (CELI-12), Customers Experiencing Multiple Interruptions of six or more (CEMI-6), Disconnections, CIP Low Income Participation (CIP LI), and Low Income Energy Affordability Program Participation (LI EAP or Affordability Program) -- to identify if there are any disparities in performance on these five indicators that can be correlated to equity indicators such as income level, percent of people in poverty, or percent people of color. The TRC analysis expands on analysis performed by Dr. Gabriel Chan on behalf of the Just Solar Coalition as part of our last Electric Rate Case.[5] We provide a brief background and summary of the TRC's report below, a copy of which is included here as Attachment Q.

The analysis in Dr. Chan's testimony focused on the correlation between race and utility disconnection; it did not include an analysis of all five metrics required in the Commission's March 2023 Order. In his testimony, Dr. Chan provided analysis that showed, using a linear regression methodology, and after controlling for income and poverty, that disconnections were higher in census block groups with a larger proportion of People of Color (POC). As TRC describes in further detail in their report, their analysis extends the linear regression modeling used by Dr. Chan by 1) including additional information relevant to a customer's ability to pay their bills and disconnections; 2) adding flexibility to the explanatory variables, allowing identification of the ranges of values that different characteristics are associated with in the variables they studied; 3) extending the analysis [as required] to the five metrics reported in our Interactive Map, including outage duration at 12 hours or more, outage frequency at six or more, participation in the CIP Low Income programs, and participation in Low Income Energy Affordability Programs.

TRC utilized data from the American Community Survey provided by the U.S. Census Bureau to extend beyond the key variables in our Interactive Map. They note

[4]Seattle, WA | TRC (trccompanies.com)
[5] Surrebuttal Testimony of Gabriel Chan on Behalf of Just Solar Coalition in Docket No E002/GR-21-630, Dated December 6, 2022.

that some variables are likely to contribute to disconnections such as:

- Home ownership rates along with housing vintage information, used by TRC as proxies for wealth.
- Limited English proficiency, home computer access, and home internet access, used by TRC as proxies for ease of communication.
- Home computer access, home internet access, and distance to the nearest payment center that accepts payments for Xcel Energy, used as proxies for access to payment options.

TRC indicates in their report that leaving out key variables such as those listed above "leads to a bias in modeling known as omitted variable bias, where the estimated impact of included variables is biased due to their correlation with important variables that are left out. In this case, the extent to which percent POC is correlated with other relevant factors will bias the results regarding the impact of percent POC on disconnections and other key metrics." Further, "inclusion of these additional variables significantly reduces omitted variable bias, as well as increasing model fit. These variables similarly provide relevant explanatory power for the other key metrics investigated."

TRC explains how their nonparametric kernel smoothing modeling approach allows for additional insights provided by the key and explanatory variables they incorporated, expanding beyond Dr. Chan's linear regression method that assumes the relationship between variables is a straight line.

B. TRC Study Findings

The TRC analysis indicates that, "in general, Xcel Energy performs well on key electric reliability and service quality metrics, and low-income program participation metrics."[6] The analysis did not identify poor utility performance in any of the five metrics presented on our Interactive Map. However, by including additional variables, TRC was able to identify three metrics where there may be opportunities for improvement and to provide potential recommendations to assess further.

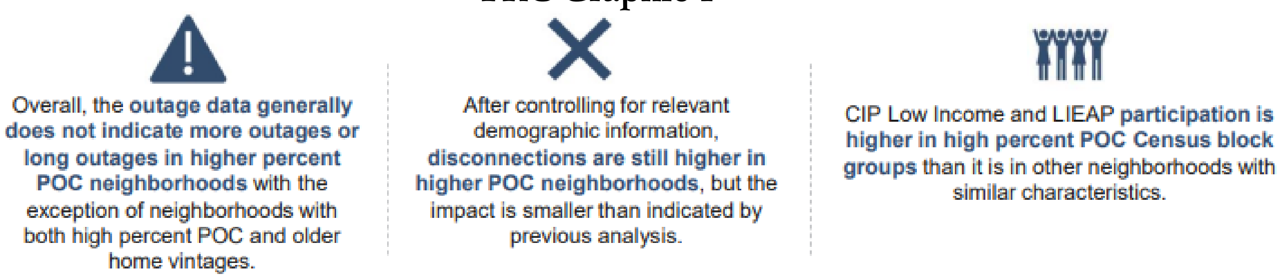
Ultimately, the TRC Study concluded:

> This analysis indicates that in general, Xcel Energy performs well on key electric reliability and service quality metrics, and low-income program participation metrics. The analysis identified three places where there are opportunities for improvement. First, there have been more long-

[6] Attachment Q at 17.

duration outages in high percent POC communities that also have older housing vintage. There may be an opportunity to assess vegetation management practices in those neighborhoods or assess distribution equipment vintage that could lead to longer outages. Second, disconnections are higher in high percent POC neighborhoods even after controlling for other relevant explanatory variables; we cannot determine from the data if this is due to higher non-payment rates or differential application of disconnection policy. Given the success of enrollment in the LI EAP and CIP LI programs in high percent POC neighborhoods, there may be opportunities to leverage those relationships to identify a path to address the disparity in disconnections. Finally, CIP LI participation may be lower in very-low-income communities. This may present an opportunity to conduct additional outreach or assess program barriers to participation in those communities.[7]

TRC Graphic 1[8]



C. Opportunities for Improvement Identified in the TRC Analysis

Below we address outage duration, disconnections, and CIP LI programs and the opportunities for improvement for these metrics identified by TRC's analysis.

1. CELI-12 (Outage Duration)

TRC's analysis shows that a "comparison across most neighborhoods shows no overall trend in CELI-12 with rising percent POC."[9] However, "among neighborhoods with older homes, CELI rises rapidly with percent POC."[10] In other words, "the outage data generally does not indicate more outages or long outages in higher percent POC neighborhoods, with the exception of neighborhoods with both

[7] Attachment Q at 17.
[8] Attachment Q at ES-1.
[9] Attachment Q at ES-1.
[10] Attachment Q at ES-1.

high percent POC and older vintage homes."[11]The TRC analysis identified this outage duration effect occurred primarily in three areas: North Minneapolis, South Minneapolis, and surrounding downtown St. Paul.[12] TRC indicates there may be opportunity in assessing our vegetation management practices or our distribution equipment vintage to improve this segment of our customer base, particularly in those identified areas.

In order to help understand the challenges in these locations and the opportunities for improvement, we took a deeper look at the outage durations in these areas in the recent past. For example, we know that events that result in 12-hour duration or longer outages are typically significant and occur infrequently. A majority (54 percent) of metro area outages of 12-hour duration or more in the 2019 to 2021 time period resulted from two large storm events on August 14, 2020, and September 17, 2021. Both of those days were classified as major event days and together resulted in over 32,000 customer interruptions of 12 hours or more. The locations most impacted by these two storm events substantially overlap with the three primarily affected areas identify by TRC.

In addition, despite the inclusion of three years of data in the TRC analysis, there is an influence on the data that results from the distinct locations where each major storm's most damaging impacts occurred. The locations most impacted by these two events were therefore not necessarily representative of the full set of the company's system and customer characteristics. As a result, some area's characteristics may be over-represented in the CELI data.

In terms of preliminary steps, the Company could take to address the long-duration outages in the identified communities, as the TRC analysis pointed out, there may be an opportunity to assess vegetation management practices in those neighborhoods or assess distribution equipment vintage that could lead to longer outages. In terms of vegetation management, the Company could evaluate enhanced vegetation management in these areas of concern. Hazard trees located outside the standard clearances are an opportunity to address. Emerald ash borer infestations have generated a higher risk for overhead line impacts in recent years. Homeowners in lower income neighborhoods may be less able to afford insecticide treatment or address dying ash trees on their property. Enhanced vegetation management could work to mitigate these heightened risks to overhead distribution lines.

[11] Attachment Q at ES-1.
[12] Attachment Q at 7.

In terms of distribution equipment vintage, targeted undergrounding may be a solution to bring stronger reliability to older vintage homes served by an older vintage of our distribution network. TRC's analysis found a correlation between income level, POC, and older housing vintage. As part of Order Point 5 of the Commission's December 5, 2023 Order in Docket No. E002/M-23-73, the Company was directed *to provide an analysis of the incremental costs associated with achieving IEEE first quartile performance that includes a discussion of timeframes, costs, and benefits in their SRSQ 2024 filing*. In that discussion, we provide a preliminary analysis of incremental costs associated with achieving IEEE first quartile results in this report (beginning on page 94). This analysis can act as a guidepost to consider distribution equipment upgrades like undergrounding wires, including in these specific communities. The distribution lines identified for undergrounding in our Order Point 5 analysis also serve the same areas identified by in the TRC analysis as having longer outer durations in areas of higher POC (North Minneapolis, South Minneapolis, and surrounding downtown St. Paul). If the Commission is interested in pursuing a targeted undergrounding plan, the Company would require time to fully scope and pilot this project but is open to filing a plan.

Disconnections

Despite recognizing "the success of enrollment in the LI EAP and CIP LI programs in high percent POC neighborhoods," the TRC analysis indicates that after "controlling for relevant demographic information [e.g., income, poverty, and home ownership] disconnections are still higher in higher POC neighborhoods, but the impact is smaller than indicated by previous analysis."[13] The study identifies three potential reasons for these results: 1) a higher rate of non-payment in higher percent POC neighborhoods; 2) potential disparities in disconnection policy; or, 3) disparities in how people in different communities access elements of the disconnect policy—like payment plans.[14]

To try and reach low-income communities with a self-identified higher proportion POC, the Company can utilize current algorithms that identify customers who have not received assistance, are carrying past due balances, and also reside within the identified communities. Targeted outreach about our energy assistance and payment options to these identified areas could include a variety of contact methods that can be tracked for effectiveness. This activity does not require Commission approval. Results of these activities could be tracked and filed in either the next Annual Electric Service Quality Report or added to our Annual Low Income Discount Report.

[13] Attachment Q at ES-1-2.
[14] Attachment Q at 11.

Another upcoming action by the Company that may reduce disconnections and increase participation in low-income affordability programs is an Automatic Bill Credit Pilot program, developed with the Equity Stakeholder Advisory Group (ESAG) convened under Docket E002/M-22-266, and soon to be filed as a proposed pilot. This pilot aims to reduce energy burden – the share of household income spent on energy. Households with high energy burden are more likely to fall behind on energy bills and be disconnected. This pilot would focus on geographic areas of high electric energy burden and lowering barriers to receiving assistance. In brief, the pilot proposes to provide an automatic bill credit to all households in U.S. Census Block Groups where electric energy burden exceeds four percent, and is designed to reduce electric energy burden to four percent for the median-income household in each Census Block Group, without imposing any of the income qualification or program enrollment requirements that anecdotally discourage low-income households from applying for assistance. If approved, the pilot would run for two years and be evaluated by a third-party evaluator for its success on (among other metrics) reducing disconnection rates.

CIP Low Income Programs

Finally, the TRC analysis indicated the CIP LI program "does not appear to be underserving communities with high percent POC. It may be underserving very low-income communities, which is not unexpected" given other known challenges.[15] Thus, the Company has "an opportunity to improve performance among the lowest-income neighborhoods."[16] The Company is already taking action to try and reach more of our low-income customers. Our CIP LI programs in 2024 include the Low-Income Home Energy Squad, the Home Energy Savings Program, and the Low-Income Multi-Family Building Efficiency Program. In recent years the Company has made changes to our programs to expand participation. These changes focus on reducing landlord/tenant barriers by increasing the percentage of equipment costs covered by rebates for low-income rentals, simplifying the qualification of tenants as low-income, and expanding outreach efforts to better reach building owners.

We will continue to work with stakeholders to expand access to our programs not only through the formal reviews and workshops supported by the Department and Commission, but also through informal channels as we develop relationships and more established communication channels with the entities engaged in providing both energy and non-energy related services to the low-income communities we serve.

[15] Attachment Q at 14.
[16] Attachment Q at 15.

Modifications to the Energy Conservation & Optimization (ECO) triennial plans are approved through the Department of Commerce. No action is required by the Commission at this time.

VII. CONCLUSION

Xcel Energy is committed to providing our customers with quality, reliable service. We appreciate this opportunity to report our performance to the Commission, and respectfully request that the Commission accept our annual report on safety, reliability, and service quality.

The Company requests a renewal of the temporary variance to Minn. Rule 7820.2500 under the revised timeframe proposed in this filing to account for regulatory review.

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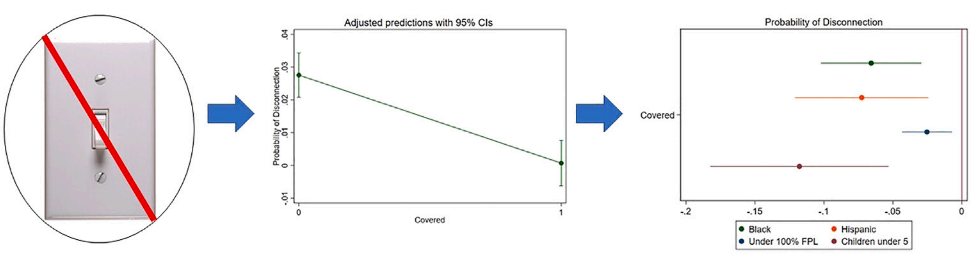
Utility disconnection protections and the incidence of energy insecurity in the United States



Trevor Memmott,
Sanya Carley,
Michelle Graff,
David M. Konisky

tmemmott@iu.edu

Highlights

COVID-19 disconnection moratoria significantly reduced rates of disconnection

Protected households are less likely to have to forego basic household expenses

Protections are most beneficial for households of color and those with young children

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Article

Utility disconnection protections and the incidence of energy insecurity in the United States

Trevor Memmott,[1,3,*] Sanya Carley,[1] Michelle Graff,[2] and David M. Konisky[1]

SUMMARY

Energy insecurity—the inability to secure one's energy needs—impacts millions of Americans each year. A particularly severe instance of energy insecurity is when a utility disconnects a household from service, affecting its ability to refrigerate perishable food, purchase medicine, or maintain adequate temperatures. Governments can protect vulnerable populations from disconnections through policies, such as shutoff moratoria or seasonal protections that limit disconnections during extreme weather months. We take advantage of the temporary disconnection moratoria that states implemented during the COVID-19 pandemic to assess the efficacy of state protections on rates of disconnection, spending across other essential needs, and uptake of bill payment assistance. We find that protections reduce disconnections and the need for households to forgo other expenses. We further find that protections are most beneficial to people of color and households with young children. We conclude with a discussion of the policy implications for energy-insecure populations.

INTRODUCTION

Most U.S. states and territories implemented public health mitigation policies, such as stay-at-home orders, in March 2020 to control the spread of COVID-19. These mandates severely limited domestic population movement[1] by closing businesses, schools, and other gathering places. The stay-at-home orders provided public health benefits, including reductions in COVID-19 infections and fatalities,[2] but they also contributed to reduced economic activity, a spike in unemployment,[3] increased financial worries,[4] and adversely affected the ability of many households to pay their monthly bills.[5]

In response to the economic disruption caused by stay-at-home orders and the possibility that millions of Americans would be unable to pay their energy bills, many U.S. states enacted temporary measures to prevent regulated electric utilities from disconnecting residential customers for nonpayment. Specifically, 34 states and the District of Columbia implemented moratoria to protect their residents from utility disconnections. These measures gradually expired throughout the latter months of 2020, even as the pandemic persisted. While these moratoria were temporary, most states have regular—often seasonal—limits on when, and under what circumstances, a regulated utility can shut off service to its customers. The degree and timing of these policies, however, vary, and there is little empirical analysis of whether these policies substantially reduce disconnections or provide households meaningful relief from energy-related material hardship, a phenomenon often referred to as energy insecurity.

One reason for the paucity of disconnection protection policies analysis is data limitations. Historically, few utilities have released disconnection information and, even when publicly available, the data are not granular enough to link them to household-level characteristics. Two recent analyses, however, have taken advantage of variations in COVID-era, emergency, state-level utility protections as well as disconnection data disclosed by utilities during the COVID-19 pandemic that makes some progress on related questions. Jowers et al.[6] explored housing precarity across the United States during the pandemic, analyzing eviction and utility disconnection moratoria and their impacts on COVID-19 infections and related deaths. The authors found that moratoria on utility disconnections reduced infections by 4.4% and mortality rates by 7.4%. In another study, Cicala[7] analyzed the data reported by utilities in the state of Illinois to evaluate

[1]O'Neill School of Public and Environmental Affairs, Indiana University, Bloomington, IN, USA

[2]Maxine Goodman Levin School of Urban Affairs, Cleveland State University, Cleveland, OH, USA

[3]Lead contact

*Correspondence: tmemmott@iu.edu

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Table 1. Dates that each survey wave was administered, along with survey sample size and the number of months covered by each wave.

	Wave 1	Wave 2	Wave 3	Wave 4
Survey Administration Date	4/30/2020–5/25/2020	8/4/2020–8/20/2020	1/15/2021–1/22/2021	5/24/2021–6/5/2021
Sample Size	2,831	2,247	1,670	1,378
Months Covered	April/May 2020	June-August 2020	September 2020-January 2021	February-May 2021

patterns of disconnections at the zip-code level and found that residents in Black and Hispanic zip codes were four times more likely than White households to be disconnected.

In this analysis, we similarly evaluate the impact of the state-level COVID-specific disconnection protections on household well-being. We capture additional granularity by studying household-level data from a nationally-representative survey of low-income households at or below 200% of the federal poverty line (FPL), which, unlike past work, enables us to control for important household-level characteristics. Moreover, because this study is national in scale, we can leverage the heterogeneity in the scope and duration of the temporary pandemic moratoria orders, creating an opportunity to use spatial and temporal variation to estimate the policies' effects on various household-level indicators of energy insecurity.

We address two primary research questions. First, to what extent do utility disconnection protections result in fewer disconnections? Second, what are the socio-economic consequences of these protections and, specifically, do the protections curtail households' need to forgo other expenses or reduce their need to rely on financial assistance to pay their energy bills?

To study these questions, we merge monthly state-level utility disconnection protections with original survey data designed and collected by the authors. The survey is a nationally representative sample of households with incomes at or below 200 percent of the FPL. We collect data from the same respondents at four points in time between April/May 2020 and May 2021, approximately the first year of the pandemic. The timing and sample size of our survey is displayed in Table 1, Table 2 compares means of respondents who were and were not covered under a moratorium, and Table 3 presents all variable definitions. The survey measures the household-level composition and monthly indicators of whether a respondent reported being able to pay their energy bills and if their utility disconnected them from their electricity service for nonpayment. Due to the timeline of the study, we have the unique opportunity to consider the impact of both the state-level, emergency disconnection moratoria as well as regular, seasonal protections. Through a series of regressions, we estimate the effect of these policies on low-income households. Results from our empirical analysis suggest that, on average, when protections were in place, households were less likely to be disconnected from their electricity service and forgo basic food and healthcare expenses to pay an energy bill. We also find some suggestive evidence that disconnection protections reduced a respondent's reliance on social networks and government agencies for assistance to pay an energy bill.

This paper makes several important contributions. First, our findings provide the first estimates of the effects of disconnection protection policies on household-level socio-economic outcomes. Second, these findings complement recent work[8–10] that reveals disparities in residential energy insecurity by demonstrating that disconnection policies specifically benefit socially vulnerable populations. Finally, our analysis offers insights for policymakers on how disconnection protections can serve as a policy instrument to address material hardship among low-income households both during crisis situations, such as the COVID-19 pandemic, as well as under more typical circumstances.

Disconnection protection policies

To address concerns about energy insecurity at the beginning of the pandemic, many states implemented emergency shutoff moratoria that prohibited regulated utilities from disconnecting customers from their energy services. Such implementation took different forms, in which some state governors declared emergency orders that suspended shutoffs while other states' public utility commissions issued orders for utilities to discontinue disconnections. Under these protections, ostensibly, residents receiving service from a regulated utility could not be disconnected by their utility provider for nonpayment.

Table 2. Distribution of pre-treatment control variables among respondents who were covered or not covered under state disconnection protection in May 2020

	Not Covered			Covered			
	Count	Mean	Std. Dev.	Count	Mean	Std. Dev.	Diff. in Means
Black	958	0.17	0.38	1047	0.17	0.38	0.00
Hispanic	958	0.15	0.36	1047	0.13	0.34	0.04
Unemployed	958	0.20	0.40	1047	0.20	0.40	0.00
Education	958	2.81	1.24	1047	2.88	1.32	0.07
Under_100%_FPL	958	0.36	0.48	1047	0.37	0.48	0.01
Household member under 5	958	0.17	0.37	1047	0.15	0.36	0.02
Household size	958	2.86	1.70	1047	2.73	1.83	0.16
Own home	958	1.66	0.60	1047	1.62	0.60	0.04
Household member over 65	958	0.35	0.48	1047	0.43	0.50	0.08
Cooperative	958	0.26	0.44	1047	0.08	0.27	0.18
Muni	958	0.32	0.47	1047	0.07	0.27	0.25
IOU	958	0.42	0.49	1047	0.86	0.37	0.44

Additionally, there was heterogeneity in both the start and end dates of the moratoria. Some states (e.g., Colorado) only implemented protections in the early months of the pandemic, while other states extended protections into 2021 (e.g., California). Moreover, utilities subject to disconnection limitations also varied across states, since only those utilities regulated by state public utility commissions (PUC) were required to abide by the emergency orders. For example, in the state of Arkansas, both investor-owned utilities (IOUs) and cooperatives are regulated by the state commission, whereas, in the state of Maryland all three utility types—IOUs, cooperatives, and municipal utilities—fall under state regulation. Thus, if residents living in Arkansas get their energy service via a municipal utility, they were not protected through the state disconnection protection order. In addition to mandatory moratoria, five states implemented voluntary moratoria in which regulated utilities agreed but were not legally prohibited from shutting off customers in cases of nonpayment.

Figure 1 shows a map of the emergency utility disconnection orders implemented through January 2021, including whether a state had a mandatory utility disconnection order, voluntary agreement, or no protection in place. Thirty-four states had a mandatory protection in place for at least one month. The map reveals protections were more likely to be voluntary or nonexistent in the Southern and Plain states. Additionally, protections with the longest duration were generally enacted in the Northeast, upper Midwest, and West Coast.

In addition to the COVID-19 emergency disconnection orders, over 40 states have statutory-based utility disconnection protections that aim to limit shutoffs during specific times of the year and/or for vulnerable populations. There are three general categories of state-level protections: (1) seasonal protections (i.e., states prohibit regulated utilities from disconnecting electric service to residents in certain months of the year); (2) temperature protections (i.e., states prohibit regulated utilities from disconnecting electric service to residents if the temperature is above or below a certain threshold); and (3) population-based protections (i.e., states prohibit regulated utilities from disconnecting electric service to specific members of the population, including but not limited to senior citizens and those with specific medical conditions).[11] As of 2021, 29 states implemented some form of seasonal protections and 23 have temperature-based protections, some of which overlap.[12]

Often, these policies do not fully prohibit disconnections. Rather, they require customers to demonstrate eligibility for an exemption.[12] For example, four states have no disconnection protections unless a household member has a physician or public health official certify, through documentation, that they would be adversely affected by a shutoff. And, again, it is important to emphasize that protections only apply to utilities under state jurisdiction. In all but one state, Nebraska, investor-owned utilities fall under state regulation, whereas only 11 states regulate municipal providers, and 16 states regulate cooperatives. Finally, 46 states and the District of Columbia allow customers to set up a payment plan as an alternative to

Table 3. Descriptive statistics and variable definitions for all the variables used in the regression models, using survey weights

Variable	Description	Observations	Min	Max	Mean	Std Dev
Disconnected	A binary variable set to 1 if the respondent was disconnected in the previous month	21,837	0	1	0.02	0.13
Forgo expenses	A binary variable to set to 1 if the respondent indicated that they had to forgo basic household expenses to pay for an energy bill in the previous month	21,837	0	1	0.10	0.30
Financial Assistance	A binary variable set to if the respondent indicated that they received assistance paying their energy bill from a government agency, energy provider, a friend or family member, a faith-based organization, a nonprofit, a payday lender, or a loan from a banking institution	21,837	0	1	0.10	0.30
Mandatory	A binary variable set to 1 if the respondent was covered by a mandatory disconnection moratorium for at least 15 days in a given month	21,837	0	1	0.39	0.49
Mandatory + Voluntary	A binary variable set to 1 if the respondent was covered by a mandatory or voluntary disconnection moratorium for at least 15 days in a given month	21,837	0	1	0.41	0.49
Mandatory + Seasonal + Voluntary	A binary variable set to 1 if the respondent was covered by a mandatory, voluntary, or seasonal disconnection moratorium for at least 15 days in a given month	21,837	0	1	0.42	0.50
WAP/LIHEAP (lagged one month)	A binary variable indicating whether a respondent received WAP or LIHEAP in the previous month	21,824	0	1	0.05	0.21
Other Government Assistance (lagged one month)	A binary variable indicating whether a respondent received SNAP, TANF, SSI, SSDI, Medicaid or Medicare, Veterans Benefits, or unemployment insurance in the previous month	21,824	0	1	0.37	0.48
Black	A binary variable set to 1 if the respondent indicated that they identify as Black	21,837	0	1	0.17	0.38
Hispanic	A binary variable set to 1 if the respondent indicated that they identify as Hispanic	21,837	0	1	0.20	0.40
Unemployed	A binary variable set to 1 if the respondent indicated that they were unemployed in the given month	21,837	0	1	0.17	0.37
Education	The level of education a respondent has obtained, ranging from no high school through a postgraduate education	21,837	1	6	2.70	1.35
Under 100% FPL	A binary variable set to 1 if a respondent is under 100% of the Federal Poverty Line.	21,837	0	1	0.40	0.49
Household size	The number of individuals residing in an individual's household, ranging from 1 through 20	21,837	1	20	2.76	1.78
Children under 5	A binary variable set to 1 if the household has at least 1 child under 5 living in the household	21,837	0	1	0.15	0.36

(*Continued on next page*)

Table 3. *Continued*

Variable	Description	Observations	Min	Max	Mean	Std Dev
Own Home	A binary variable set to 1 if respondent owns their home	21,837	0	1	0.42	0.49
Household member over 65	A binary variable set to 1 if the household has at least 1 member over 65 living in the household	21,837	0	1	0.44	0.70
Cooperative	A binary variable set to 1 if the respondent gets their utility services provided by a Cooperative	21,837	0	1	0.15	0.36
IOU	A binary variable set to 1 if the respondent gets their utility services provided by an Investor-Owned Utility	21,837	0	1	0.66	0.47

disconnection,[12] though these plans neither include long-term debt relief on the interest accrued for not paying in full nor are they adjusted based on the resident's income or ability to pay.[13]

In the present analysis, we consider the individual and aggregate effects of the COVID-specific mandatory and voluntary moratoria on several outcome measures. Our study additionally couples the temporary moratoria with the pre-existing seasonal protections. Specifically, we include seasonal policies—defined at the monthly level—if the law protects all regulated customers, regardless of the amount they owe on their utility bills, if they are facing financial hardship, or are qualified low-income customers. During our study period, eleven states had a seasonal protection in place for at least one month, though seven of these states had a disconnection moratorium that extended through the entirety of their seasonal protection period—Arkansas, Massachusetts, New York, Pennsylvania, Washington, Wisconsin, and Wyoming. We are not able to incorporate all seasonal disconnection protections. We exclude those that rely on household characteristics or payment requirements, and we do not include daily temperature-based protections because of the monthly structure of our survey data. Thus, over the duration of the study period, an individual may have been protected by a temporary emergency order or through a seasonal disconnection protection, which will likely bias our estimates in a conservative direction. Figure 2 displays the timing of the emergency protections as well as the regular seasonal protections during our study's time period, for each state and Washington, D.C. (May 2020 to May 2021), and Figure 3 graphs our three primary outcomes in these months.

Empirical expectations

We exploit variations in COVID-19 pandemic disconnection policies as well as state-level seasonal protections to quantify the effect of utility shutoff protections. We expect these state-level utility protections to have three potential implications. First, we expect shutoff moratoria to significantly reduce disconnections. In addition, we expect that populations who tend to suffer from higher rates of energy insecurity will have benefitted the most from these protections and thus experience the largest decreases in their probability of having their service disconnected by their utility.

Second, disconnection moratoria should allow households to shift their spending from their energy bill to other essential goods, like food and medicine. Past research shows that low-income households are more sensitive to disruptive economic events[14] and those facing utility insecurity are more likely to engage in bill juggling—including strategic non- or partial-payment of other bills—to keep their electric service from being disconnected.[15] Because disconnection moratoria explicitly remove the risk that a household loses electricity service, low-income households could potentially redirect their spending to other household necessities.[16] This is especially salient for individuals and families who lost income or employment because of the economic fallout of the COVID-19 pandemic.

Third, we expect people covered by disconnection protections to have reduced their reliance on financial assistance to help pay off their energy bills. Under "normal" circumstances, energy-insecure households often receive financial help from friends, family members, churches, or local nonprofits to avoid disconnections.[17] Additionally, households sometimes seek assistance from more formal entities, including local government

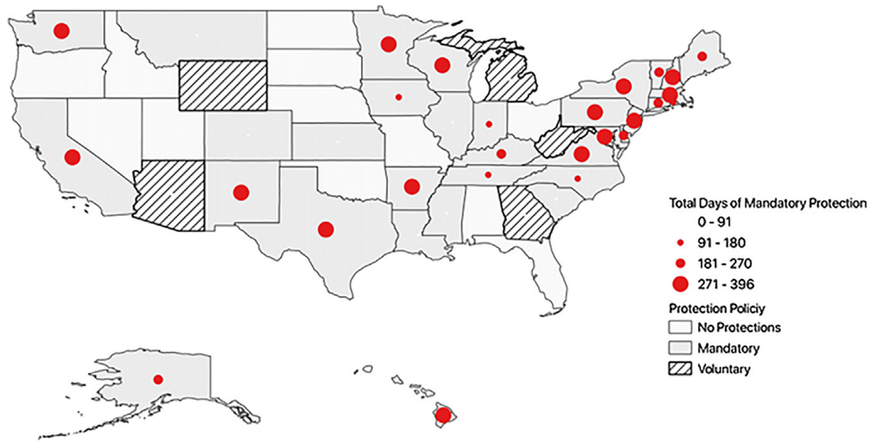

Figure 1. Map of mandatory and voluntary disconnection moratoria from May 2020 through May 2021

assistance programs, but these programs vary in their generosity, eligibility requirements, and availability.[18] However, those with limited social networks are less likely to receive assistance during times of need[19]; therefore, without an immediate threat of disconnection, we hypothesize that households are less likely to reach out to informal social networks or apply to more formal government programs to pay their energy bills.

To summarize, we expect that the disconnection protection policies implemented in many states reduced the prevalence of disconnections among households that are served by a regulated utility when compared to similar households in states without such protections. Moreover, we posit that these households are less likely to have forgone other important household necessities or to have solicited financial assistance to pay an energy bill.

RESULTS

To test our empirical expectations, we estimate a series of two-way fixed effects regression models, which are described in further detail in the STAR Methods section. Table 4 presents the results with our first dependent variable: whether a household was disconnected from its utility service in any given month. For each dependent variable, we measure the impact of utility protection as the temporary, mandatory COVID-19 moratoria first, then add the voluntary protections second, followed by the seasonal protections last.

The model estimates show that respondents covered by disconnection protections were less likely to report being disconnected from their service, with minor variation in the effect sizes across the three models. To estimate the magnitude of the effects, we additionally estimate average marginal effects (AME) for several of our models. The results shown in Table 4 suggest that being protected by a mandatory moratorium reduced the likelihood of a household having their energy shut off, controlling for other factors. The coefficient of 2.7 ($p = 0.000$) implies that respondents who were not covered by a disconnection moratorium were disconnected at a rate of about 2.8% while those who were covered got disconnected at a rate of around 0.01%. For context, extrapolating from 2020 estimates of households at or below 200% of the FPL,[20] this suggests that approximately 69,144 low-income households (179,744 individuals) avoided disconnections during the first year of the pandemic.

The results in Table 4 additionally reveal that race and other vulnerable household characteristics are correlated with higher rates of disconnections. Specifically, we find that Black households, Hispanic households, households with children under 5 years old, larger households, and those that are served by cooperative (relative to municipal) utilities were all more likely to be disconnected from their electricity service. We do not find that households with an unemployed respondent were more likely to be disconnected, which might reflect that many laid-off individuals received enhanced unemployment benefits during the pandemic, enabling them to avoid some expected material hardship.[21]

In Table 5, we display the results of our estimation of the effect of disconnection protections on the likelihood that a household forgoes other basic household expenses (Models 1–3) and receives financial

Figure 2. Mandatory (green), voluntary (red), and standard seasonal (blue) disconnection protections from May 2020 through May 2021, by state

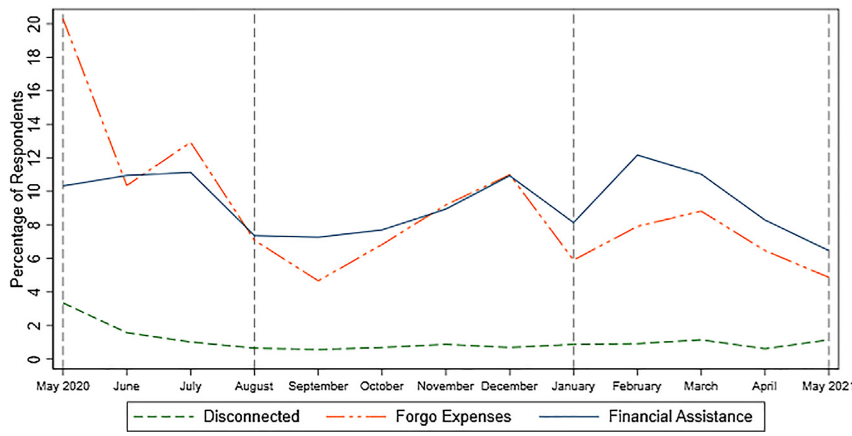

Figure 3. Distribution of survey respondents being disconnected (green, dashed), having to forgo basic household expenses (red, alternating solid and dash), and receiving energy assistance from informal social networks (blue, solid), monthly from May 2020 to May 2021

assistance to pay an energy bill (Models 4–6). These results indicate that disconnection protections decreased the probability that a household reported having to forgo other basic expenses, which suggests that when people are less concerned about being disconnected, they can allocate their resources toward other household necessities such as medical care and food. AME estimates suggest that being protected by a mandatory moratorium reduced the likelihood of a household forgoing basic household expenses, controlling for other factors. The 2.5 ($p = 0.000$) coefficient implies that respondents not covered by a moratorium reported forgoing expenses at a rate of approximately 10.6% while respondents who were covered reported a rate of approximately 8.1%. With respect to receiving financial assistance to help pay an energy bill, the coefficients in Models 4 through 6 are negative but none reach a standard level of statistical significance. These estimates suggest that there may be an effect consistent with our expectations, but it is not definitive.

Regarding the estimates for control variables, we find that Black households, households that are under 100 percent FPL, and those that have children under 5 years old were more likely to seek financial assistance to pay their energy bills; whereas those that were served by an IOU were less likely to seek financial assistance. We additionally find that larger households, Hispanic households, those who experienced unemployment during the first year of the pandemic, those with incomes that are at or below 100 percent FPL, and households with children under 5 were all more likely to have to forgo expenses even when disconnection protections were in place. Surprisingly, we find that receipt of government assistance is positively associated with forgoing expenses, which may reflect the correlation between a low-income family needing to simultaneously participate in government assistance and forgo expenses, rather than suggesting that receipt of assistance necessitates that a family forgoes expenses.

Contrary to our expectations, we find that adding voluntary and seasonal protections had little impact on the estimated coefficients of disconnection protections across all models. Therefore, the results may suggest that mandatory moratoria were the most binding of the three types of policies during this time.

DISCUSSION

This study finds that the utility disconnection moratoria that states implemented during the COVID-19 pandemic had a substantial impact on disconnections. People in states without such protections, or who were not covered by their state moratorium in a given month, faced a greater likelihood of being disconnected than those who were covered by a moratorium. Based on our models, mandatory moratoria decreased the likelihood of a respondent being disconnected from an estimated rate of 2.8%–0.01%. Additionally, it is likely that some utility companies were more forgiving to customers in arrears during the pandemic, irrespective of an implemented moratorium, meaning our estimates are likely conservative. Our primary model suggests, however, that even when controlling for key economic indicators, vulnerable households—specifically Black households, Hispanic households, and households with children under 5 years old—were more likely to have their electricity disconnected by their utility for nonpayment. These

Table 4. Linear probability model predicting whether a respondent reported having their utility service disconnected

	Model 1: Disconnected	Model 2: Disconnected	Model 3: Disconnected
Mandatory	−0.027*** (0.007)		
Mandatory + Voluntary		−0.025*** (0.006)	
Mandatory + Voluntary + Seasonal			−0.025*** (0.006)
WAP/LIHEAP lag	0.002 (0.006)	0.002 (0.006)	0.002 (0.006)
Other Government Assistance Lag	−0.002 (0.003)	−0.002 (0.003)	−0.002 (0.003)
Black	0.010*** (0.004)	0.021*** (0.004)	0.021*** (0.004)
Hispanic	0.012** (0.005)	0.012** (0.005)	0.012** (0.005)
Unemployed	0.003 (0.004)	0.003 (0.004)	0.003 (0.004)
Education	0.000 (0.001)	0.000 (0.001)	0.000 (0.001)
Under 100% FPL	−0.001 (0.003)	−0.001 (0.003)	−0.001 (0.003)
Children under 5	0.045*** (0.008)	0.045*** (0.008)	0.045*** (0.008)
Household size	0.002* (0.001)	0.002* (0.001)	0.002* (0.001)
Own home	−0.003 (0.002)	−0.003 (0.002)	−0.003 (0.002)
Household member over 65	0.002 (0.002)	0.002 (0.002)	0.002 (0.002)
IOU	0.005 (0.004)	0.005 (0.004)	0.005 (0.004)
Cooperative	0.024*** (0.007)	0.024*** (0.007)	0.024*** (0.007)
State FE?	Yes	Yes	Yes
Month FE?	Yes	Yes	Yes
Observations	21,824	21,824	21,824

Cells contain OLS regression coefficients, with robust standard errors in parentheses. Levels of statistical significance: *p < 0.1, **p < 0.05 ***p < 0.01.

results suggest that utility protections help, but disparities in rates of disconnections for vulnerable families continue to persist.

We also find that utility disconnection moratoria decreased the likelihood that a household had to forgo basic household expenses, such as food or medical care, to pay an energy bill and avoid the threat of utility disconnection. Evidence shows that when attempting to avoid utility disconnection, households often engage in a set of economically harmful coping strategies, such as accruing credit card debt or strategically skipping bill payments.[22] In this context, our findings suggest that disconnection moratoria have an economic impact beyond utility service shutoffs by allowing families to avoid tradeoffs between keeping the power on and carrying debt, having enough to eat, or seeking medical assistance.

The results presented here have several implications for policymakers. First, disconnection moratoria are effective in reducing the incidence of utility disconnections and other energy-related material hardship. Protections are particularly helpful for vulnerable populations, yet more and better-targeted government and

Table 5. Linear probability model predicting whether a respondent had to forgo a basic household expense, or received financial assistance to pay an energy bill each month

	Model 1: Forgo expenses	Model 2: Forgo expenses	Model 3: Forgo expenses	Model 4: Social assistance	Model 5: Social assistance	Model 6: Social assistance
Mandatory	−0.025*** (0.010)			−0.014 (0.010)		
Mandatory + Voluntary		−0.024** (0.009)			−0.012 (0.006)	
Mandatory + Voluntary + Seasonal			−0.023** (0.009)			−0.010 (0.010)
WAP/LIHEAP lag	−0.009 (0.012)	−0.009 (0.012)	−0.009 (0.012)	0.011 (0.014)	0.011 (0.014)	0.011 (0.014)
Other Government Assistance Lag	0.013** (0.006)	0.014** (0.006)	0.014** (0.006)	−0.000 (0.006)	−0.000 (0.006)	−0.000 (0.006)
Black	0.014* (0.007)	0.014** (0.007)	0.014** (0.007)	0.022*** (0.008)	0.022*** (0.008)	0.022*** (0.008)
Hispanic	0.031*** (0.010)	0.030*** (0.010)	0.030*** (0.010)	−0.015 (0.009)	−0.015 (0.009)	−0.015* (0.009)
Unemployed	0.024*** (0.009)	0.024*** (0.009)	0.024*** (0.009)	0.011 (0.009)	0.011 (0.009)	0.011 (0.009)
Education	0.001 (0.002)	0.001 (0.002)	0.001 (0.002)	0.004** (0.002)	0.004** (0.002)	0.004** (0.002)
Under 100% FPL	0.039*** (0.006)	0.039*** (0.006)	0.039*** (0.006)	0.037*** (0.006)	0.037*** (0.006)	0.037*** (0.006)
Children under 5	0.035*** (0.011)	0.035*** (0.011)	0.035*** (0.011)	0.071*** (0.012)	0.071*** (0.012)	0.071*** (0.012)
Household size	0.015*** (0.002)	0.015*** (0.002)	0.015*** (0.002)	0.000 (0.002)	0.000 (0.002)	0.000 (0.002)
Own home	−0.003 (0.005)	−0.003 (0.005)	−0.003 (0.005)	0.013*** (0.005)	0.013*** (0.005)	0.013*** (0.005)
Household member over 65	−012*** (0.004)	−012*** (0.004)	−012*** (0.004)	0.005 (0.005)	0.005 (0.005)	0.005 (0.005)
IOU	−0.009 (0.008)	−0.009 (0.008)	−0.009 (0.008)	−0.014* (0.008)	−0.014* (0.008)	−0.015* (0.008)
Cooperative	0.007 (0.010)	0.007 (0.010)	0.007 (0.010)	0.002 (0.011)	0.002 (0.011)	0.002 (0.011)
State FE?	Yes	Yes	Yes	Yes	Yes	Yes
Month FE?	Yes	Yes	Yes	Yes	Yes	Yes
Observations	21,824	21,824	21,824	21,824	21,824	21,824

Cells contain OLS regression coefficients, with robust standard errors in parentheses. Levels of statistical significance: *p < 0.1, **p < 0.05 ***p < 0.01.

utility assistance might be required to overcome the current racial disparities that have been documented by previous energy insecure literature. This finding is especially important as rates of energy insecurity are likely to rise in the future as climate change increases average temperatures and extreme weather events.[23]

Second, we find that the effects of moratoria on energy insecurity are largely driven by mandatory protections, as opposed to voluntary or seasonal protections. This finding provides important insight for lawmakers and regulators who wish to reduce energy insecurity because it suggests voluntary and seasonal protections are not preventing disconnections, nor do they appear to significantly reduce the likelihood that a household will forgo other expenses. Unlike mandatory disconnection protections, voluntary policies yield the decision about household disconnection to the utilities, who are primarily concerned with recovering their costs. In addition, ongoing seasonal protections are complicated and often do not offer full protection to vulnerable populations. Further, it is likely that effect sizes were at least partially driven by the fact that these mandatory moratoria were not burdensome to customers—e.g., they did not require documentation or require a household to show that its family's economic circumstances had deteriorated—which is not true of many of the seasonal protections.[11] Past research has shown that detailed eligibility requirements reduce program take-up.[24]

Another critical point to consider is that millions of Americans are served by unregulated utility providers. Therefore, especially in times of crisis, policymakers should consider expanding disconnection protections to all customers, including municipal and cooperative utility customers. However, when designing and implementing disconnection moratoria, policymakers must consider that utilities will need to recoup arrears, meaning the companies may pass costs on to other customers through higher electricity rates.

Finally, our findings show that our current stable of welfare programs, including standard programs, like Medicaid, as well as energy-specific programs, like LIHEAP, do not statistically reduce one's likelihood of being disconnected or a household's need to forgo medical and food expenditures. This finding stresses the importance of funding and expanding energy assistance programs that are accessible and available to low-income populations to avoid the most deleterious impacts of energy insecurity. Additional support for these programs may also help relieve some households in the U.S. of the chronic cycle of energy insecurity. Further, while utility disconnections both prevented utility shutoffs and the likelihood that a household had to forgo expenses, state moratoria were not paired with utility debt relief—with the exception of the California Arrearage Payment Program (CAPP) which provided over $1.5 billion in relief for delinquent customers.[25] A 2020 report from National Energy Assistance Directors Association (NEADA) estimated that customer utility debt increased from $12 billion pre-pandemic to $32 billion at the end of 2020.[26] Thus, disconnection moratoria may provide substantial benefits in the short term but, if not combined with debt relief, do little to prevent energy insecurity in the long term.

Our analysis provides important new information on the impact of state-level disconnection protections on the energy security and financial stability of low-income populations. These results have important implications for both advocates and government officials. Our study shows the importance of designing utility disconnection policies to protect the most vulnerable populations and reduce energy insecurity, especially during periods of economic crisis.

Limitations of study

This study is not without limitations. First, our survey does not allow for an analysis of differential utility behavior at the state level, as our sample is only representative at the national level for households at or below 200% FPL. Second, while we account for heterogeneity in disconnection policies by state, we cannot account for discretionary utility behavior in response to the pandemic. Some utilities, even without state regulation, may have opted to be more lenient on customers who were experiencing hardship. Third, some states protect residents from disconnection under special circumstances, such as documented proof of a medical condition. We are unable to verify respondents in our dataset who are covered by such protections. Finally, the temporal constraints of our survey do not allow us to accurately estimate disconnection rates prior to the beginning of the COVID-19 pandemic.

STAR★METHODS

Detailed methods are provided in the online version of this paper and include the following:

- KEY RESOURCES TABLE
- RESOURCE AVAILABILITY
  - Lead contact
  - Materials availability
  - Data and code availability
- METHOD DETAILS
  - Outcome variables
  - Primary independent variable
  - Control variables
  - Model

SUPPLEMENTAL INFORMATION

Supplemental information can be found online at https://doi.org/10.1016/j.isci.2023.106244.

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AUTHOR CONTRIBUTIONS

All authors contributed equally to this manuscript.

DECLARATION OF INTERESTS

The authors declare no competing interests.

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REFERENCES

1. Lasry, A., Kidder, D., Hast, M., Poovey, J., Sunshine, G., Winglee, K., and Ethier, K.A. (2020). Timing of community mitigation and changes in reported COVID-19 and community mobility - four US metropolitan areas, February 26-April 1, 2020. Morbidity and Mortality Weekly Report *69*, 451.
2. Fowler, J.H., Hill, S.J., Levin, R., and Obradovich, N. (2020). The effect of stay-at-home orders on COVID-19 infections in the United States. Preprint at arXiv. https://doi.org/10.1101/2020.04.13.20063628.
3. Baek, C., McCrory, P.B., Messer, T., and Mui, P. (2020). Unemployment effects of stay-at-home orders: evidence from high frequency claims data. Rev. Econ. Stat. *120*, 1–72.
4. Tull, M.T., Edmonds, K.A., Scamaldo, K.M., Richmond, J.R., Rose, J.P., and Gratz, K.L. (2020). Psychological outcomes associated with stay-at-home orders and the perceived impact of COVID-19 on daily life. Psychiatry Res. *289*, 113098.
5. Garner, T.I., Safir, A., and Schild, J. (2020). Changes in consumer behaviors and financial well-being during the coronavirus pandemic: results from the US Household Pulse Survey. Monthly Lab. Rev. *143*, 1.
6. Jowers, K., Timmins, C., Bhavsar, N., Hu, Q., and Marshall, J. (2021). Housing Precarity & the COVID-19 Pandemic: Impacts of Utility Disconnection and Eviction Moratoria on Infections and Deaths across US Counties (No. w28394) (National Bureau of Economic Research).
7. Cicala, S. (2021). The Incidence of Extreme Economic Stress: Evidence from Utility Disconnections (No. w28422) (National Bureau of Economic Research).
8. Graff, M., Carley, S., Konisky, D.M., and Memmott, T. (2021). Which households are energy insecure? An empirical analysis of race, housing conditions, and energy burdens in the United States. Energy Res. Social Sci. *79*, 102144.
9. Memmott, T., Carley, S., Graff, M., and Konisky, D.M. (2021). Sociodemographic disparities in energy insecurity among low-income households before and during the COVID-19 pandemic. Nat. Energy *6*, 186–193.
10. Hernández, D., and Laird, J. (2021). Surviving a shut-off: US households at greatest risk of utility disconnections and how they cope. Am. Behav. Sci. *66*, 856–880.
11. LIHEAP (2020). State disconnection policies. https://liheapch.acf.hhs.gov/Disconnect/disconnect.htm.
12. Flaherty, M., Carley, S., and Konisky, D.M. (2020). Electric utility disconnection policy and vulnerable populations. Electr. J. *33*, 106859.
13. Verclas, K., and Hsieh, E. (2018). From utility disconnection to universal access. Electr. J. *31*, 1–8.
14. Rodems, R., and Pfeffer, F.T. (2021). Avoiding material hardship: the buffer function of wealth. J. Eur. Soc. Policy *31*, 517–532.
15. Heflin, C., London, A.S., and Scott, E.K. (2011). Mitigating material hardship: the strategies low-income families employ to reduce the consequences of poverty. Sociol. Inq. *81*, 223–246.
16. Ganong, P., Jones, D., Noel, P., Greig, F., Farrell, D., and Wheat, C. (2020). Wealth, Race, and Consumption Smoothing of Typical Income Shocks (NBER). Working Paper, (w27552).
17. Middlemiss, L., Ambrosio-Albalá, P., Emmel, N., Gillard, R., Gilbertson, J., Hargreaves, T., Mullen, C., Ryan, T., Snell, C., and Tod, A. (2019). Energy poverty and social relations: a capabilities approach. Energy Res. Soc. Sci. *55*, 227–235.
18. Murray, A.G., and Mills, B.F. (2014). The impact of low-income home energy assistance program participation on household energy insecurity. Contemp. Econ. Policy *32*, 811–825.
19. Middlemiss, L., and Gillard, R. (2015). Fuel poverty from the bottom-up: characterising household energy vulnerability through the lived experience of the fuel poor. Energy Res. Soc. Sci. *6*, 146–154.
20. Kaiser Family Foundation (2021). Distribution of total population by federal poverty level. https://www.kff.org/other/state-indicator/distribution-by-fpl.
21. Farrell, D., Ganong, P., Greig, F., Liebeskind, M., Noel, P., & Vavra, J. (2020). Consumption effects of unemployment insurance during the covid-19 pandemic. Available at SSRN 3654274.
22. Carley, S., Graff, M., Konisky, D.M., and Memmott, T. (2022). Behavioral and financial coping strategies among energy-insecure households. Proc. Natl. Acad. Sci. USA *119*. e2205356119.
23. Graff, M., Konisky, D.M., Carley, S., and Memmott, T. (2021). Climate Change and Energy Insecurity: A Growing Need for Policy Intervention (Environmental Justice).
24. Graff, M., and Pirog, M. (2019). Red tape is not so hot: asset tests impact participation in the Low-Income Home Energy Assistance Program. Energy Pol. *129*, 749–764.
25. Palm, I. (2022). California to Pay Millions in Overdue Utility Bills for Struggling Families (KTLA).
26. Wolfe, M. (2020). Press Release: Electric Gas and Residential Arrearages Are Growing Rapidly (NEADA).
27. Vavreck, L., and Rivers, D. (2008). The 2006 cooperative congressional election study. J. Elect. Public Opin. Parties *18* (4), 355–366.

28. Ansolabehere, S., and Rivers, D. (2013). Cooperative survey research. Ann. Rev. Pol. Sci. *16*, 307–329.

29. Ansolabehere, S., and Schaffner, B.F. (2014). Does survey mode still matter? Findings from a 2010 multi-mode comparison. Polit. anal. *22*, 285–303.

30. Liu, H., Cella, D., Gershon, R., Shen, J., Morales, L.S., Riley, W., and Hays, R.D. (2010). Representativeness of the patient-reported outcomes measurement information system internet panel. J. Clin. Epidemiol. *63*, 1169–1178.

31. Ross, L., Drehobl, A., and Stickles, B. (2018). The High Cost of Energy in Rural America: Household Energy Burdens and Opportunities for Energy Efficiency (American Council for an Energy Efficient Economy).

32. She, P., and Livermore, G.A. (2007). Material hardship, poverty, and disability among working-age adults. Soc. Sci. Q. *88*, 970–989.

33. Cheng, T.C., and Trivedi, P.K. (2015). Attrition bias in panel data: a sheep in wolf's clothing? A case study based on the Mabel Survey. Health Econ. *24*, 1101–1117.

34. Drehobl, A., and Ross, L. (2016). Lifting the High Energy Burden in America's Largest Cities: How Energy Efficiency Can Improve Low Income and Underserved Communities (American Council for an Energy Efficient Economy).

35. Hernández, D., Jiang, Y., Carrión, D., Phillips, D., and Aratani, Y. (2016). Housing hardship and energy insecurity among native-born and immigrant low-income families with children in the United States. J. Child. Poverty *22*, 77–92.

36. Hernández, D., Aratani, Y., and Jiang, Y. (2014). Energy insecurity among families with children (National Center for Children in Poverty. Columbia University).

37. Hernández, D. (2016). Understanding 'energy insecurity' and why it matters to health. Soc. Sci. Med. *167*, 1–10.

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STAR★METHODS

KEY RESOURCES TABLE

REAGENT or RESOURCE	SOURCE	IDENTIFIER
Deposited data		
Raw and analyzed data	This paper	https://doi.org/10.7910/DVN/7WFYCT
Software and algorithms		
Stata	Stata	Stata 17

RESOURCE AVAILABILITY

Lead contact

Further information and requests for resources and reagents should be directed to Trevor Memmott: tmemmott@iu.edu.

Materials availability

This study did not generate new unique reagents.

Data and code availability

- All original code has been deposited at Harvard Dataverse (https://doi.org/10.7910/DVN/7WFYCT) and is publicly available as of the date of this publication.
- Any additionally information reported in this study is available from the lead contact upon request.

METHOD DETAILS

The data we analyze in this paper come from an original, four-wave, panel survey of low-income households that we designed to examine energy insecurity during the pandemic. During each wave, we asked respondents a range of questions about their household composition, economic circumstances, and energy (in) security. We also asked respondents to identify their utility provider to match utility data to state disconnection moratoria. Among those respondents for whom we did not have self-reported utility data, we assign their utility type using several approaches. First, using geospatial files in QGIS, we assign a respondent a utility type if the household's zip code is fully contained within the service territory of single IOU, municipal utility, or cooperative utility. In cases where multiple utilities operate in a zip code, we assign a utility type if more than half of the utilities in a single zip code are a single type (i.e., three utilities service a single zip code, and if two of three utilities in zip code are IOUs, we assign it as an IOU). We drop the remaining 352 observations – approximately 1.5 percent of the sample – for which we do not have utility data.

YouGov, a private polling and data analytics firm, administered the survey online. To create a nationally-representative sample from its standing panel, YouGov employs a two-stage process wherein the firm generates a target sample by drawing a random sample from a target population that is derived from the general population (for this case, using data from the 2017 American Community Survey). The firm then uses a matching algorithm to select potential respondents from its panel of approximately two million U.S. participants to generate a representative sample.[27] Scholars have validated extensively the underlying methodology that YouGov uses.[27–30]

Because energy insecurity is more prevalent among low-income families,[31] we designed the survey to focus on households with incomes at or below 200 percent of the FPL. Not only has past research used 200 percent of the FPL as an indicator of low-income U.S. households,[32] but this income threshold is particularly relevant for the present study because federal energy bill assistance programs, such as the Low Income Home Energy Assistance Program (LIHEAP), often set eligibility at 150 percent of the FPL, enabling us to consider households both above and below the threshold.

Table 1 summarizes the timing and sample size for each of the four waves of the panel survey. The first wave of the survey (n = 2,831 respondents) was between April 30 and May 25, 2020 and incorporates a second identical survey that we fielded simultaneously to Indiana residents, wherein we include those Indiana participants who also participated in the subsequent waves of the survey and weighted these responses to be nationally representative; the second wave of the survey between August 4 and August 20, 2020 (n = 2,247 respondents); the third wave of the survey between January 15 and January 22, 2021 (n = 1,670 respondents); and the fourth wave of the survey between May 24 and June 5, 2021 (n = 1,378 respondents). The reduction in sample size over the course of the survey was anticipated. We set approximate thresholds for our sample size to maintain a sufficiently large and nationally representative sample in each wave of the survey, and closed the survey after these thresholds were met to minimize the time duration of data collection. YouGov generates post-stratified weights using propensity scores based on gender, race and ethnicity, age, geographic region, and education levels; we employ these weights in our analysis. We used an unbalanced panel in our analysis to preserve the original sample population and avoid potential issues that can arise due to survey attrition.[33] We provide an alternative estimation using a balanced panel of respondents. Results are consistent with the unbalanced panel and can be found in Table S5 in the Supplemental Information Section. We also estimate survey attrition based on sociodemographic indicators in Table S13.

In each of the four survey waves, we asked respondents to reflect on the previous months and report in which months they experienced certain events, such as utility disconnection, making trade-offs across food and medical care versus paying energy bills, and uptake of financial assistance. While such recall questions may be prone to error, we believe that respondents are likely to remember the general timing of these conditions and circumstances. To address potential recall bias, we also provide an alternative estimation which aggregates our data to the level of a survey wave and regress our outcome variables on the number of days that a respondent was protected during that wave. These models, which are consistent with our primary model specifications, are further described in our supplemental information section.

Outcome variables

We employ three main outcome variables in the analysis. To address the first research question, we measure whether a survey respondent reported that their household was disconnected from its utility service in any month from May 2020 through May 2021. We use two other survey items to address the second research question of whether the presence of disconnection protections allowed residents to shift resources to other household needs and to reduce their reliance on financial assistance. The first variable captures whether respondents reported forgoing basic expenses, like food and medical care, to pay their energy bills in each month, and the second measures whether the respondent reported receiving financial assistance to pay their energy bill (e.g., from a government agency, their energy provider, a friend or family member, a faith-based organization, a nonprofit, a payday lender, or a loan from a banking institution) in each month. Survey questions are included in Table S11.

During our study period, about 1.7 percent of respondents reported that they had their electricity service disconnected by their utility, approximately 10 percent had to forgo basic household expenses to pay an energy bill, and about 10 percent received financial assistance to pay an energy bill. For all three outcome variables, rates were higher among respondents who were not protected by a disconnection moratorium. Figure 3 graphs the outcome variables over the study period and shows that all three measures were at their highest in the first month of the pandemic (e.g., when lock-down orders were first put into place), and then fluctuated thereafter with some evidence of seasonal effects.

Primary independent variable

The treatment variable measures whether a respondent was covered under a state disconnection protection in each month. We employ three iterations of treatment. The first measures whether a respondent was covered by a COVID-related temporary mandatory disconnection moratorium, which we expect will drive much of the variation in the effect of protections, as mandatory protections are designed to prohibit any disconnections among protected populations. The second measures whether a respondent was covered by a COVID-related temporary voluntary or mandatory disconnection moratorium. We expect that adding voluntary protections, wherein utility companies agree not to shutoff respondents, will account for additional variation in our outcome variables. Finally, our third measure includes whether a respondent was covered by a COVID-related temporary mandatory or voluntary protection or a regular seasonal protection. We think that including seasonal protections alongside the temporary COVID-related protections best captures the full effect of disconnection protections during the study period.

To measure protection, we code a respondent as a "1" if their state had a disconnection protection in place and their utility service fell under state regulation and a "0" if the respondent was not covered in that month. A state is coded as covered if a protection was in place for 15 or more days. We use 15 as a cut-off because it represents respondents being protected against utility disconnection for at least half the days in a month. In our sample, which ranges from May 2020 through May 2021, about 56% of respondents were protected under a moratorium in at least one month using this definition.

The nature of our survey data does not enable us to formally check for parallel trends before the imposition of policies, but we can evaluate whether household characteristics differ among those in our survey population who were and were not covered by a COVID-19 temporary, mandatory, or voluntary disconnection moratorium in each month. Because there is within-state variation in protection based on type of utility, we are not concerned with state-level dispersion of policies. Instead, we consider household-level characteristics in our analyses to ensure that the households covered and not covered by moratoria are comparable. Table 2 compares the means of respondents based on key underlying characteristics—race, employment status, education, whether a household's income was at or below 100% of the FPL, whether the household had children under 5 in the household, and household size—for those who were and were not covered by a moratorium in May of 2020. We also provide a balancing table of all observations in each month from May 2020 through May 2021 in Table S6 in the Supplemental Information section. We do not find substantial difference in means, except in the case of utility provider type. This is a function of state regulatory policies, wherein IOUs are far more likely to fall under state regulation, and cooperative and municipal utilities are less so. Importantly, the results of Table 2 show a similar, or relatively balanced, distribution in sociodemographic characteristics that have previously been associated with energy insecurity – race, income, and having young children in the household – between the two groups of households. Thus, we would not expect differential rates of utility disconnection or energy-related financial hardship among those who were covered by a disconnection moratorium and those who were not based on pre-coverage household characteristics.

Control variables

In addition to our main regressors, we control for several household characteristics that may otherwise confound the relationship between disconnection protection policies and the energy insecurity outcomes. Specifically, we use three variables to control for whether a respondent received government assistance in the previous month, all of which we think would make a household less likely to experience energy insecurity. The first variable measures whether a respondent noted having received funding from one of the two major federal energy assistance programs (i.e., the Weatherization Assistance Program (WAP) or LIHEAP); and the second variable indicates whether a respondent reported having received another form of government assistance (specifically, assistance from the Supplemental Nutrition Assistance Program (SNAP), Temporary Assistance for Needy Families (TANF), Supplementary Security Income (SSI) or Social Security Disability Income (SSDI), Medicaid or Medicare, Veterans Benefit, or unemployment insurance). We also include several variables measuring sociodemographic characteristics that past scholarship has indicated are associated with energy insecurity: the respondent's race,[34] employment status,[9] educational obtainment,[35] income,[36] household size (i.e., how many members are in the household),[18] and whether the household has children under the age of 5 years old.[37] Finally, we control for the utility type from which the respondent receives service. We present all variable definitions in Table 3.

Model

As noted, we estimate a series of two-way fixed effects regression models which exploit heterogeneity in protections across states and over time, and our main treatment variable is whether a respondent was covered by disconnection protection policies. Specifically, we estimate the following regression:

$$Y_{ist} = \alpha + \beta_1 Policy_{ist} + B_2 GA_{ist-1} + \beta_3 X'_{ist} + \gamma_s + \delta_t + \epsilon_{ist},$$

where Y_{ist} represents one of our three binary outcome variables for a respondent i in state s and in month t. *Policy* is a binary variable indicating if a respondent was covered by a disconnection protection. As described in the data and code availability section, we consider a respondent covered if a protection was in place for their utility for at least half a month (i.e., 15 days). *GA* represents whether a respondent received government assistance in the previous month, and X' is a vector of sociodemographic control variables. The model includes state and month fixed effects to control for unobserved variation across states (i.e., economic conditions) and over time (i.e., seasonal or temperature variation). In addition to the three primary models, we also assess the heterogeneity of our results along sociodemographic indicators, including households of color, households at or below 100% of the FPL, those who are unemployed, and households with children under the age of 5 years old. We use a linear probability model (LPM) to estimate the main models, but we also estimate logistic regression models as a robustness check. Results of both the LPM and logistic regression models, which can be found in Table S7 in the Supplemental Information section, yield consistent results.

In the Supplemental Information section, we also report the results of several additional robustness checks to further test for parallel trends and to address potential concerns that states adopted moratoria in response to prior rates of energy insecurity, differential within month coverage of protection policies, and recall bias in our self-reported outcome data. Specifically, we test whether utilities in states that adopted a mandatory moratorium had differential rates of connection prior to the pandemic (Table S8), use a continuous daily measure of protection to account for partial-month protections (Table S9), and aggregate our disconnection and protection data to the wave-level to account for potential recall bias (Table S10). These robustness checks, all of which are further explained in the supplemental information section, are consistent with the primary models presented in the paper and suggest that the two-way fixed effects approach provides unbiased estimates of the effect of utility disconnection protections on utility disconnections and energy-related material hardship.

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Commentary

It is time to modernize energy insecurity policies to account for extreme heat

Sanya Carley[1,*] and David M. Konisky[2]
[1]Kleinman Center for Energy Policy, Stuart Weitzman School of Design, University of Pennsylvania, Philadelphia, PA 19072, USA
[2]Paul H. O'Neill School of Public and Environmental Affairs, Indiana University, Bloomington, IN 47405, USA
*Correspondence: scarley@upenn.edu
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The increasing incidence of extreme heat events compromises the well-being of households who are energy insecure. To help households avoid catastrophic health outcomes, it is necessary to modernize energy insecurity policies and protections to ensure access to essential cooling services. Here, we discuss ways in which state governments can update their utility disconnection protections, the federal government can reform the Low Income Home Energy Assistance Program (LIHEAP), and other complementary policy efforts can help individuals stay cool while keeping their energy bills down.

Introduction

This past year, 2024, was the hottest on record, with temperatures surpassing 1.5°C of warming relative to pre-industrial levels for the first time.[1] The incidence of extreme heat and weather events is also increasing and at the cost of significant human lives. Studies link extreme heat exposure[2]—and even just hot days—to mortality. Although heat-related-illness fatalities are much more common in poorer, under-served countries, they also occur in the United States (U.S.); the Fifth National Climate Assessment reports that there were about 700 deaths due to heat each year in the U.S. between 2004 and 2018, with other estimates putting the number closer to 1,300 deaths per year.[3]

Exposure to extreme heat can also produce other health effects, as well, including dehydration, cardiovascular disease or complications,[4] respiratory disease, and mental health impacts,[5] which in some cases may be irreversible. Such conditions can also lead to death; a meta-analysis of the corresponding literature found a 1°C increase is associated with a 2.1% increase in mortality from disease and a 1.1% increase in morbidity.[5]

Maintaining safe and comfortable temperatures in the face of growing heat extremes requires access to reliable and affordable electricity. Yet, utility companies shut-off service to millions of Americans each year when they cannot afford their monthly electricity bills. Recent studies show that utility shut-offs correlate with extreme weather among low-income customers.[6] While air conditioning can prevent one from dying during heat events,[7] households experience a surge in utility disconnections following days of extreme heat due to an increase in their energy usage and the associated increase in their bills.[6] Other correlates of energy insecurity among low-income households include those with inefficient or old housing, households of color, and households with vulnerable populations such as young children or members who rely on electronic medical devices.[8]

The impacts of a potential or actual disconnection on a household can be severe. Households may keep their homes at uncomfortably hot temperatures to avoid turning down their thermostat,[9] use other strategies to stay cool such as sitting in a running car with the air conditioning turned up, strategically pay down one bill one month and another the next, or forgo expenses on food or healthcare.[10] These practices and conditions can lead to adverse mental and physical health outcomes, and in some circumstances, heat strokes and heat-related mortalities.

Our understanding of the human health risks of exposure to extreme heat is evolving significantly faster than our understanding of how to use policies and regulations to protect vulnerable households. Long-standing policies to address energy insecurity include utility disconnection protections and emergency bill assistance, yet each has significant shortcomings when it comes to protecting vulnerable populations. In the era of climate-change-induced heat events, it

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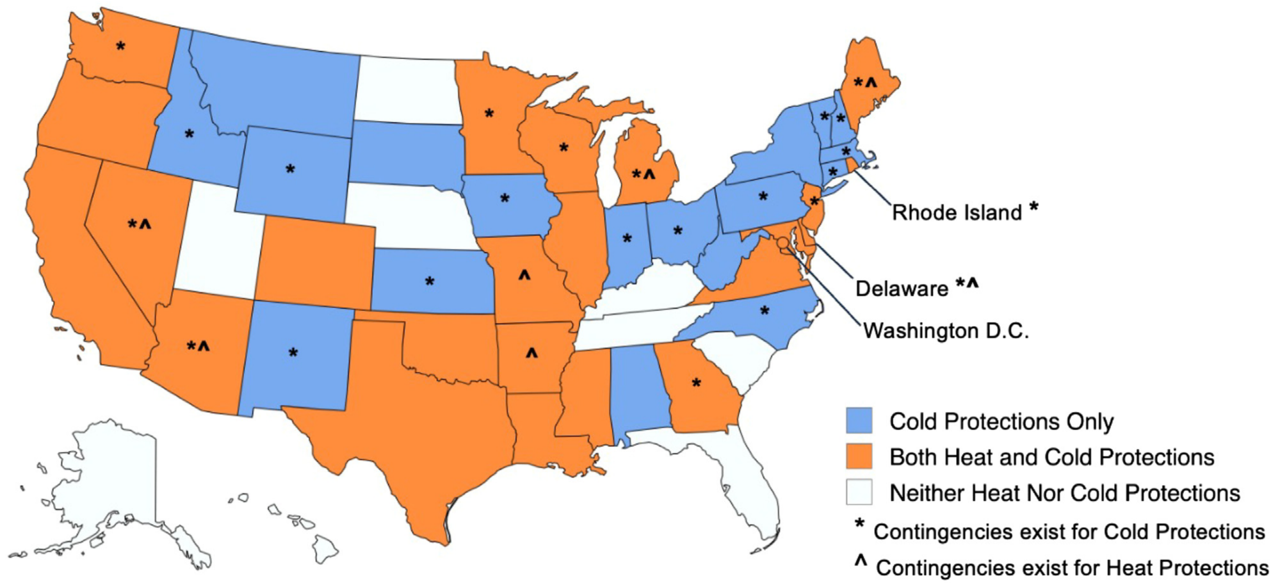

Figure 1. U.S. heat and cold disconnection protections
Blue represents those states with only cold protections, and orange represents those with both heat and cold protections. The symbols track those states with specific contingencies to their policies.

is time to transform these policies while also ensuring more universal access to cooling options.

In this commentary, we focus specifically on these energy-insecurity policies and offer suggestions for policy redesign under conditions of more prevalent heat exposure. Our discussion of policy approaches is not intended to be exhaustive, and the policies we note comprise just part of what is required to build heat resilience. However, the approaches we focus on represent efforts that policymakers can pursue in the short-term while considering longer-term and more structural interventions.

Results

Disconnection protections

In the U.S. context, states establish regulations for electricity market operations within their borders, including both utility disconnection protections and procedures that a utility must follow when a customer is at risk of a disconnection.[11] Protections are typically based on date, based on temperature, or identify specific vulnerable populations that are protected (e.g., those with documented medical conditions) with corresponding requirements for compliance.[12]

Most states—41 total plus Washington DC—offer protections during cold weather, most commonly through a partial or absolute moratorium on disconnections during specific winter months.[12] Yet, less than half of the states—23 total—and Washington DC have protections during periods of heat, most based on heat advisories or specific temperature thresholds (see Figure 1). Not all these policies are universal protections, though, and many have further eligibility contingencies (e.g., Delaware provides protection when the temperature falls below 32°F but only between November 15th and March 31st).

Modernizing utility disconnection protections requires more states to add heat-related protections. Effective approaches include a temperature-based moratorium or both a temperature- and date-based moratorium, so that households have full protection both during typical hot months *and* during non-seasonal, erratic heat events. These policies are necessary in all regions of the country, since even northern states with historically cooler climates are increasingly experiencing more days of extreme heat. Additional policy improvements include (1) protections for renters to guard against delinquent landlords and (2) national standards that apply across all states and utilities to overcome the problem that current state policies only apply to regulated utilities. States can also modernize their disconnection policies with explicit protections for households with young children—which is currently only policy in four states—or with older residents, two of the most vulnerable populations for energy insecurity.

Low Income Home Energy Assistance

Low Income Home Energy Assistance Program (LIHEAP) is a federally funded program that provides financial assistance to low-income households for home energy needs. In practice, LIHEAP focuses predominantly on heating because of policy design features that prioritize protections from cold weather: (1) a series of calculations using "old" and "new" formulas, the former of which skews funding toward cold weather states, and (2) congressional "hold harmless provisions," which curtail changes to historical funding levels.[13]

These combined allocation techniques lead to a disproportionate amount of the funds flowing to colder weather states year after year and a general lack of alignment with the distribution of all those at need for energy assistance. A recent study found that a more streamlined allocation process based on energy burden—the proportion of income spent on home energy needs—would yield a more even distribution across the states; specifically, it would shift a portion of the funding from cold weather states to those in southern and hotter regions.[14]

The administrative timing of LIHEAP fund disbursement introduces another challenge during times of heat. States receive LIHEAP resources at the beginning of the fiscal year and typically spend the majority of the funding before the start of summer. Moreover, because funding levels are insufficient to meet the needs of eligible households—LIHEAP serves an average of about 20% of eligible households[14]—most of the annual, block-grant funding is exhausted on heating needs in the winter months. A potential improvement in design could be one that allocates funds at multiple points throughout the year or requires states to reserve funds for hotter months, ideally in conjunction with an overall increase in appropriations to avoid shifting needed winter funds to the summer.

Additional cooling protections

Modernizing these state and federal initiatives to account for hot weather conditions has the potential to significantly improve energy security, but complementary protections are also needed.

A first category of protections involves efforts to either provide air conditioning or maximum indoor air temperature thresholds to those who face structural access or affordability barriers. There is sparse information on state and local policies, but recent media reports (see, e.g., Blumgart[15]) suggest landlords generally are not required to provide air conditioning to renters, regardless of their state's climate conditions. Several cities such as Dallas, Texas, and Phoenix, Arizona, mandate maximum temperature thresholds, which has implications for the provision of air conditioning. By contrast, requirements for functioning heating are nearly ubiquitous. Given the increasing prevalence of prolonged, extreme heat events, state and local governments could modify policies and ordinances such that cooling or habitable temperatures are guaranteed for renters. At the same time, such policy changes need to come with financial support for the bill payer (e.g., reduced rates, energy assistance), since the use of air conditioning—or energy efficient heat pumps—will increase energy consumption and their associated costs; tenant incentives or penalties to address standard split-incentive problems; anti-displacement provisions; alternative financing mechanisms such as upfront rebates; and education and financial incentives to ensure that the air conditioning units run at maximum efficiency.

Public cooling centers offer another way to provide relief to energy insecure individuals during heat events. Cooling centers are not a new idea, but their efficacy requires more concerted planning. One study in New York City, for example, revealed a mismatch between those communities most in need with those who had access to centers, as well as a mismatch between center hours (e.g., during the work week) and when one needs cooling assistance (e.g., during the weekend).[16] Other limitations of cooling centers include the transportation required to access them, a lack of capacity to handle specific medical needs of those who visit (e.g., immunocompromised individuals), and the inability to address other aspects of one's home that may also suffer from extreme heat such as mold growth or pet well-being.

A second category of protections are preventative solutions to energy insecurity, which can simultaneously reduce the ambient temperature or further lower bills. Three prominent examples are (1) planting trees to provide shading, (2) replacing surfaces such as roofs that have high thermal inertia (e.g., by painting them white or planting roof gardens), and (3) providing weatherization assistance, including through improvements to the building envelope (e.g., air sealing, insulation, ventilation, and passive thermal). Public policy can support these efforts through grants and public works projects, as well as through more structural reforms to reduce administrative burden, provide more financial stability, and extend outreach and education to local communities.[17]

Discussion

No single policy, or even suite of policies, is a silver bullet, and all the refinements presented in this article are accompanied by limitations and tradeoffs. Yet, a combination of energy access and preventative relief measures can help address some of the inherent tradeoffs associated with this suite of public policies. Specifically, providing disconnection protections or air conditioning access, respectively, will help keep vulnerable populations from experiencing dire health outcomes from heat exposure, but they may also have financial implications. For example, if one accumulates debt during a disconnection moratorium, they may face the immediate risk of a shut-off once the moratorium ends, or if one faces higher bills because of having a new air conditioning unit while budget constrained, they will similarly be at greater risk of a disconnection. Preventative policy interventions, however, can decrease the temperature within a home, or neighborhood, while simultaneously lowering energy bills. Additional coordination with utilities to extend their energy efficiency and bill assistance programs, such as discounted billing and percentage of income payment plans, can also help relieve the financial pressures on energy insecure households.[18]

Another important tradeoff is that expanding cooling (e.g., through air conditioning or cooling centers) may run counter to climate mitigation efforts, since more cooling—even if highly efficient—necessitates more energy consumption, which may result in higher greenhouse gas emissions. To address this tradeoff, shorter-term policy adjustments should accompany longer-term structural, infrastructural, and technological strategies such as building out the grid with more renewable and battery technologies, including decentralized energy resources, in a way that brings costs down while simultaneously addressing climate change and ensuring grid resilience. Another longer-term strategy is to improve the efficiency and performance of buildings so that overall consumption declines at the same time that individual households are able to afford to cool their homes to safe temperatures.

Efforts to modernize energy insecurity policies to account for rising incidence of heat are essential. This is a public health imperative that requires coordinated action at all levels of government, as well as partnerships with utilities and technology companies. Efforts also require closer attention to opaque areas of utility regulation such as disconnection protections and long-standing social assistance programs such as LIHEAP. Extreme heat is now a regular occurrence, and we are increasingly understanding its impacts; it is time for public policy to catch up.

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AUTHOR CONTRIBUTIONS

Conceptualization, S.C.; investigation, S.C. and D.M.K.; visualization, S.C. and D.M.K.; project administration, S.C.; writing, S.C. and D.M.K.

DECLARATION OF INTERESTS

The authors declare no competing interests.

REFERENCES

1. The Copernicus Programme (2025). Copernicus: 2024 is the first year to exceed 1.5°C above pre-industrial level. https://climate.copernicus.eu/copernicus-2024-first-year-exceed-15degc-above-pre-industrial-level.
2. Nori-Sarma, A., Anderson, G.B., Rajiva, A., ShahAzhar, G., Gupta, P., Pednekar, M.S., Son, J.Y., Peng, R.D., and Bell, M.L. (2019). The impact of heat waves on mortality in Northwest India. Environ. Res. *176*, 108546.
3. Marvel, K., Su, W., Delgado, R., Aarons, S., Chatterjee, A., Garcia, M.E., Hausfather, Z., Hayhoe, K., Hence, D.A., Jewett, E.B., et al. (2021). Chapter 2. Climate trends. In Fifth National Climate Assessment, C.P. Normile, ed. (U.S. Global Change Research Program).
4. Liu, J., Varghese, B.M., Hansen, A., Zhang, Y., Driscoll, T., Morgan, G., Dear, K., Gourley, M., Capon, A., and Bi, P. (2022). Heat exposure and cardiovascular health outcomes: a systematic review and meta-analysis. Lancet Planet. Health *6*, e484–e495.
5. Yang, X., Xu, X., Wang, Y., Yang, J., and Wu, X. (2024). Heat exposure impacts on urban health: A meta-analysis. Sci. Total Environ. *947*, 174650.
6. Barreca, A., Park, R.J., and Stainier, P. (2022). High temperatures and electricity disconnections for low-income homes in California. Nat. Energy *7*, 1052–1064.
7. Sera, F., Hashizume, M., Honda, Y., Lavigne, E., Schwartz, J., Zanobetti, A., Tobias, A., Iñiguez, C., Vicedo-Cabrera, A.M., Blangiardo, M., et al. (2020). Air Conditioning and Heat-related Mortality: A Multi-country Longitudinal Study. Epidemiology *31*, 779–787.
8. Memmott, T., Carley, S., Graff, M., and Konisky, D.M. (2021). Sociodemographic disparities in energy insecurity among low-income households before and during the COVID-19 pandemic. Nat. Energy *6*, 186–193.
9. Cong, S., Nock, D., Qiu, Y.L., and Xing, B. (2022). Unveiling hidden energy poverty using the energy equity gap. Nat. Commun. *13*, 2456.
10. Carley, S., Graff, M., Konisky, D.M., and Memmott, T. (2022). Behavioral and financial coping strategies among energy insecure households. Proc. Natl. Acad. Sci. USA *119*, e2205356119.
11. Flaherty, M., Carley, S., and Konisky, D.M. (2020). Electric utility disconnection policy and vulnerable populations. Electr. J. *33*, 106859.
12. S. Carley, D.M. Konisky, Utility disconnection. (2024). https://utilitydisconnections.org/index.html.
13. L. Perl, The LIHEAP Formula. (2019). https://crsreports.congress.gov/product/pdf/RL/RL33275/61.
14. Batlle, C., Heller, P., Knittel, C., and Schittekatte, T. (2024). US federal resource allocations are inconsistent with concentrations of energy poverty. Sci. Adv. *10*, eadp8183.
15. Blumgart, J. (2019). Should landlords be required to provide air conditioning? https://whyy.org/articles/should-landlords-be-required-to-provide-air-conditioning/.
16. B. Lander, Overheated, Underserved: Expanding Cooling Center Access. (2022). https://comptroller.nyc.gov/reports/overheated-underserved/.
17. Raissi, S., and Reames, T.G. (2020). "If we had a little more flexibility." Perceptions of programmatic challenges and opportunities implementing government-funded low-income energy efficiency programs. Energy Policy *147*, 111880.
18. Adams, J., Carley, S., and Konisky, D.M. (2024). Utility assistance and pricing structures for energy impoverished households: A review of the literature. Electr. J. *37*, 107368.