STATE OF ILLINOIS
ILLINOIS COMMERCE COMMISSION

Illinois Commerce Commission On Its Own Motion vs Ameren Illinois Company d/b/a Ameren Illinois Order Requiring Ameren Illinois Company to file an Initial Multi-Year Integrated Grid Plan and Initiating Proceeding to Determine Whether the Plan is Reasonable and Complies with the Public Utilities Act.	)))))))))))))))	Docket No. 22-0487

DIRECT TESTIMONY OF

DR. DESTENIE NOCK

ON BEHALF OF
ENVIRONMENTAL LAW & POLICY CENTER, NATURAL RESOURCES DEFENSE COUNCIL, UNION OF CONCERNED SCIENTISTS, AND VOTE SOLAR
(“JOINT NGO”)

AND

ENVIRONMENTAL DEFENSE FUND

MAY 11, 2023

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I. BACKGROUND AND SUMMARY

Q: Please state your name and business address.

A: My name is Destenie Nock. My preferred pronouns are she, her, hers. My business address is 119 Porter Hall - Carnegie Mellon University, 5000 Forbes Ave., Pittsburgh, Pennsylvania, 15213.

Q: By whom are you employed and in what capacity?

A: I am an Assistant Professor of Engineering & Public Policy and Civil & Environmental Engineering at Carnegie Mellon University. My work involves researching energy policy and energy poverty in the U.S. and Africa. I am also employed in part-time roles as Chief Sustainability Officer of DevvStream Inc., and as an independent consultant. My focus in these roles is on sustainability, carbon accounting, and energy equity analysis.

Q: On whose behalf are you submitting this testimony?

A: I appear here not on behalf of my employers, Carnegie Mellon University nor DevvStream Inc., but in my personal capacity as an expert witness on behalf of the Environmental Law & Policy Center, Natural Resources Defense Council, Union of Concerned Scientists, and Vote Solar, as well as the Environmental Defense Fund. Any statements shared by me are solely representative of myself, and do not represent the positions of Carnegie Mellon University nor DevvStream Inc.

Q: Please summarize your qualifications, experience, and education.

A: I am an academic researcher and analyst in electricity systems and energy transitions. I received my PhD in Industrial Engineering and Operations Research from the University of Massachusetts Amherst in energy systems modeling, energy policy, optimization, and sustainability analysis. Since finishing my PhD, I was a postdoctoral fellow for one year at

Carnegie Mellon University and have been a professor since then. In my capacity as a professor at Carnegie Mellon University, I have led energy justice and energy poverty research and have published 14 peer-reviewed publications related to energy policy and energy transitions, including on issues related to system design, using large data to identify energy poverty in households, and energy consumption analysis. In over ten years of working in the energy sector, I have held positions at the Utility Regulator for Northern Ireland, ExxonMobil, and Argonne National Laboratory. Additionally, I am involved with multiple data-based start-ups and early-stage companies (see JNGO/EDF Ex. 6.01). In my role of Chief Executive Officer of Peoples Energy Analytics, I direct analysis of energy usage data to detect abnormalities in energy usage for electric and gas utilities. In my role as Chief Sustainability Officer for DevvStream Inc., I am responsible for developing carbon offset standards and methodologies.

In addition to my PhD in Industrial Engineering, I hold a Master's of Science degree in Leadership for Sustainable Development from Queen's University of Belfast. I also earned two B.S. degrees from North Carolina A&T State University in Electrical Engineering and in Applied Mathematics. A detailed CV is attached as JNGO/EDF Exhibit 6.01.

Q: Have you testified before the Illinois Commerce Commission previously?

A: No.

Q: Please describe the research context for your testimony.

A: My testimony draws from research I have completed and forthcoming articles entitled "Inequalities Across Cooling and Heating in Households: Energy Equity Gaps," and "Quantifying Forgone Summertime Comfort as a Function of Avoided Electricity Use."

Both articles have been submitted to technical energy journals, and I have included working paper drafts as JNGO/EDF Exhibits 6.02 and 6.03. My testimony does not necessarily represent the views of my co-authors and their employers. Additionally, while my research is part of my professional responsibilities at Carnegie Mellon University, my testimony in this proceeding was developed outside of my role as a Carnegie Mellon University employee and does not represent the views of the university.

Q: Are you sponsoring any exhibits?

A: Yes, I am sponsoring the following exhibits:

- JNGO/EDF Exhibit 6.01: Curriculum Vitae of Destenie Nock.
- JNGO/EDF Exhibit 6.02: A draft of the forthcoming article "Inequalities Across Cooling and Heating in Households: Energy Equity Gaps."
- JNGO/EDF Exhibit 6.03: A draft of the forthcoming article "Quantifying Forgone Summertime Comfort as a Function of Avoided Electricity Use."
- JNGO/EDF Exhibit 6.04: A research article "Unveiling hidden energy poverty using the energy equity gap."

Q: What is the purpose of your testimony?

A: The purpose of my testimony is to provide recommendations and best practices for Ameren to consider to improve its assessment of energy poverty in their region and associated mitigation strategies. I focus my testimony on the use of smart meter data and energy usage assessments.

Through my testimony, I will: (1) describe my professional interpretation of energy poverty and smart meters, (2) explain methods to assess and mitigate energy poverty based on my research and experience in the energy industry, and (3) share recommendations on how

Ameren can improve its energy poverty identification methods to ensure the Company, the Commission, and all community members are able to understand and track progress on how benefits from the proposed grid plan are distributed across communities over time.

Q: Please summarize your conclusions and recommendations.

A: I conclude that Ameren should use its smart meter data to identify multiple forms of energy poverty (e.g., energy limiting behavior, energy burden, energy deficits, and distribution of outages and disconnections). As I explain in more detail in my testimony, one method of doing this would be to collect smart meter data at the daily level and evaluate household energy consumption of vulnerable and non-vulnerable groups. Non-vulnerable groups should be used as a baseline to identify energy consumption of non-financially constrained households. Ameren should also consider mechanisms to incentivize households to adopt energy efficient appliances without having to pay the upfront cost (i.e., connecting the infrastructure payments back to the meter). My specific recommendations are as follows:

1) Ameren should use smart meter energy consumption data at the daily level to track energy consumption abnormalities, energy burden, and energy limiting behavior over time. Then, the Company should include both high energy burden and households that limit energy consumption in their targets for energy efficiency upgrades.
2) Ameren should consider implementing steps to promote greater data transparency and the use of independent third parties to evaluate energy usage abnormalities.
3) Ameren should evaluate the success of energy poverty alleviation and investments based on a standard for how much energy households should be

using to maintain safe indoor temperatures (avoiding heat illness in the summer, and avoiding pipes freezing in the winter), as opposed to solely the percent of income they are spending on their bills.

4) Ameren should analyze its smart meter data to detect abnormalities in energy usage, and track energy poverty through the region, as well as report these metrics at the census block level. This could then be used for better targeting of poverty alleviation efforts. Specific abnormality detection should include the following:

   a. The use of smart meter data to identify who is limiting energy consumption at the beginning and across the duration of cooling and heating seasons.
   b. The use of smart meter data to identify spikes in energy burden over the months, as opposed to yearly, to identify sudden dips in energy affordability. I also suggest reporting this at the census block group level.
   c. The reporting of data at the census block group level to identify distribution of disconnections and outages across vulnerable populations and evaluate how infrastructure upgrades affect the disparities of disconnections and outage experiences.

I invite Ameren to discuss these important concepts in more detail in its rebuttal testimony and would appreciate the Company's thoughts for developing a roadmap for implementing this analysis through its Grid Plan. The remainder of my testimony describes recent academic and practical scholarship related to the concept of energy justice, including my research on energy poverty, and provides support for my recommendations above.

II. THE NEED FOR ENERGY POVERTY METRICS BROADER THAN ENERGY BURDEN

Q: What is your understanding of the term "energy justice"?

A: Energy justice is a broad term that involves "evaluating (a) where injustices emerge, (b) which affected sections of society are ignored, (c) which processes exist for their remediation in order to (i) reveal, and (ii) reduce such injustices."[1,2] While there are many facets to energy justice I will focus my definitions on three lenses: procedural, recognition-based, and distributional.

Procedural justice refers to a fair process in which diverse stakeholders are included in the decision-making process. Recognition-based justice refers to which communities have been ignored, harmed, or misrepresented (e.g., siting of toxic plants and disproportionate environmental burden on minority communities).[3] Achieving recognition-based justice means ensuring that communities who have historically been harmed by the energy system (e.g., high levels of pollution in their environment leading to higher health burden, or historically more outages and disconnections in their communities), receive a higher proportion of the benefits to compensate for historical burden.

Lastly, distributional energy justice refers to the distribution of costs and benefits of the energy system. A system is distributionally just if communities share the benefits and burdens equally. Some examples of a distributionally just system are ones where A) every household has an air conditioning unit and functional heating system, B) no one is at

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[1] Jenkins, K., McCauley, D., Heffron, R., Stephan, H., & Rehner, R. (2016). Energy Justice: A Conceptual Review. Energy Research & Social Science, 11, 174-182.
[2] Walker, G. (2009). Beyond Distribution and Proximity: Exploring the Multiple Spatialities of Environmental Justice. Antipode, 41(4), 614-636.
[3] Pastor, M., Sadd, J., & Hipp, J. (2001). Which Came First? Toxic Facilities, Minority Move-in, and Environmental Justice. Journal of Urban Affairs, 23(1), 1-21.

risk of heat stroke in their homes because they can substantively cool their homes, and C) everyone spends less than 6% of their income on their energy bills.

In this testimony, when referring to energy justice as it pertains to data, I will primarily be focused on distributional energy justice.

Q: What is your understanding of the term "energy inequities"?

A: Energy inequities refers to a household lacking reliable and affordable access to both clean cooking facilities and to electricity, which is enough to supply a basic bundle of energy services initially, and then an increasing level of electricity over time as more energy infrastructure is deployed within the household (e.g., adopting home air conditioners, electric stoves, and electric vehicles). This definition has been adapted from the International Energy Agency.[4]

Q: What is your understanding of the term "energy burden"?

A: Energy burden refers to the percent of income a household spends on their energy bills. High energy burdens are a national challenge that has persisted over the years. A recent study found that across all U.S. households, 25% (30.6 million households) face a high energy burden (i.e., spending more than 6% of household income on energy bills) and 13% (15.9 million households) face a severe energy burden (i.e., spending more than 10% of household income on energy bills).[5]

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[4] IEA. (2020). Defining Energy Access: 2020 Methodology. Energy Access. Achiev. Mod., 16, 260-271.

[5] Drehobl, A., Ross, L., & Ayala, R. (2020). How High are Household Energy Burdens? An Assessment of National and Metropolitan Energy Burdens Across the US. https://www.energy.gov/sites/default/files/2021-12/ACEEE%2C%20Household%20Enegy%20Burdens.pdf

While energy burden is one common bivariate measurement showing the percentage of household income that is spent on energy bills, it by itself is not an energy poverty measure but rather an indication of expenditure on energy bills. Once a threshold is set (i.e., 10% or 6%) then falling above or below that line can indicate who may be experiencing energy poverty.[6] It should be noted that while national energy burden thresholds are often recommended between 6-10%, the regional cost of living should be used to inform an acceptable level of spending on energy bills, and it would be more valuable to calculate energy burden based on net income as opposed to gross. Net income would account for things that households must pay for before they can spend money on their energy bills (e.g., rent, taxes).

Q: What is your understanding of the term "energy limiting behavior"?

A: Energy limiting behavior refers to a household's inability or unwillingness to consume enough energy to reach a desired level of comfort.[7] A household is said to be displaying energy limiting behavior when they reduce their energy consumption significantly below another household within the same region that does not have financial constraints on their energy spending. Take, for example, two households—A and B—that live in the same region and have similar preferences for their indoor temperature (i.e., setting their thermostat to around 70 °F in the summer). Household A is a low-income household (i.e., a large financial constraint on energy spending), and Household B is a high-income household (i.e., no financial constraints). If Household B starts using their air conditioning

[6] Brown, M. A., Soni, A., Lapsa, M. V., Southworth, K., & Cox, M. (2020). High energy burden and low-income energy affordability: Conclusions from a literature review. Progress in Energy, 2(4), 042003.
[7] Cong, S., Nock, D., Qiu, Y. L., & Xing, B. (2022). Unveiling Hidden Energy Poverty Using the Energy Equity Gap. Nature communications, 13(1), 2456.

unit when it is 70 °F outside, but Household A waits until it is 77 °F outside, then household A is displaying 7 °F of energy limiting behavior compared to Household B.

Q: What is your understanding of the term "disconnections"?

A: Disconnection refers to a deactivation of connection assets that results in cessation of distribution services to a consumer. In the case of electricity disconnection, this means that the customer is no longer able to receive electricity into their household and would not be able to operate their electricity appliances. Members of a household may struggle to pay energy bills and if they default on their bills, they face the potential of service disconnection.[8]

Q: What is your understanding of the term "energy insecurity"?

A: Energy insecurity has been defined as a "multi-dimensional construct that describes the interplay between physical conditions of housing, household energy expenditures and energy-related coping strategies."[9] In a recent study, researchers found that energy insecurity was significantly associated with poor respiratory, mental health, and negative sleep outcomes, and that energy insecurity explains some existing respiratory and mental health-related disparities in vulnerable populations.[10] Energy insecurity is also heavily tied with food insecurity,[11] since households may forgo purchasing health food options to put

[8] Flaherty, M., Carley, S., & Konisky, D. M. (2020). Electric Utility Disconnection Policy and Vulnerable Populations. The Electricity Journal, 33(10), 106859.
[9] Hernández, D. (2016). Understanding 'Energy Insecurity' and Why It Matters to Health. Social Science & Medicine, 167, 1-10.
[10] 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.
[11] Cook, J. T., Frank, D. A., Casey, P. H., Rose-Jacobs, R., Black, M. M., Chilton, M., ... & Cutts, D. B. (2008). A brief indicator of household energy security: associations with food security, child health, and child development in US infants and toddlers. Pediatrics, 122(4), e867-e875.

money towards energy bills, or disconnections and outages can cause food to spoil. Sometimes energy insecurity and energy poverty definitions overlap because both refer to a household's inability to adequately meet basic household energy needs.

Q: What is your understanding of the term "energy poverty"?

A: Energy poverty is a broad term defined as having inadequate energy services within the household, or an inability to consume energy at a desired level.[12,13,14,15] A holistic definition of energy poverty would include people who limit their energy consumption (i.e., display energy limiting behavior), lack energy infrastructure (i.e., broken air conditioning or heating system), and spend a large portion of their income on their energy bills (i.e., high energy burden).

Q: How do the terms described above relate to energy poverty metrics?

A: Metrics, generally understood, are ways of tracking the status of whatever is being measured and evaluated. The terms described above can be included as categories of metrics to provide a more complete understanding of energy poverty, where it may be occurring, and the multiple forms people may be experiencing. These metrics should be used to evaluate the equity implications of grid modernization.

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[12] Doukas, H. & Marinakis, V. Energy poverty alleviation: effective policies, best practices and innovative schemes. https://doi.org/10.1080/15567249.2020.1756689 15, 45–48 (2020).
[13] Romero, J. C., Linares, P. & López, X. The policy implications of energy poverty indicators. Energy Policy 115, 98– 108 (2018).
[14] Sovacool, B. K. Fuel poverty, affordability, and energy justice in England: Policy insights from the Warm Front Program. Energy 93, 361–371 (2015).
[15] Piachaud, D. Problems in the Definition and Measurement of Poverty*. Journal of Social Policy 16, 147–164 (1987).

Q: Why is it important to have energy poverty metrics that are broader than energy burden?

A: It is important because only looking at spending habits will not illuminate whether a household is using energy in their home to create a safe indoor temperature. For example, in my research I have shown that households that spend more than 6% of their income on their energy bills may not turn their air conditioners on until it is above 90 °F outside. This is a widespread problem. The Energy Information Administration (EIA) recently published a survey that showed 27% (34 million) of US households had difficulty meeting their energy needs, and over 10% kept their homes at unsafe and unhealthy temperatures.[16] According to the EIA, 24% of households in the Midwest reported experiencing some form of energy insecurity.

There have been recent reports showing that people have died of heat related causes even though they all had air conditioners in their homes. In a study of New York City heatwaves from 2000–2011, the authors found that of people who died in their homes, 88% did not have an air conditioner, and 12% had air conditioners that were broken or not in use.[17] In Maricopa County in Arizona, between the years 2006-2016, 347 people died indoors from heat despite all of the households having air conditioning units. 82.7% of these heat-deaths occurred in a space that was inadequately cooled. Of the people that died, an air conditioning system was present in 228 households (79.4% of people), yet in 34.2%

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[16] Energy Information Administration.
https://www.eia.gov/todayinenergy/detail.php?id=51979&src=%E2%80%B9%20Consumption%20%20%20%20%20%20Residential%20Energy%20Consumption%20Survey%20(RECS)-b6
[17] Wheeler, K., Lane, K., Walters, S., & Matte, T. (2013). Heat Illness and Deaths—New York City, 2000–2011. Morbidity and Mortality Weekly Report, 62(31), 617.

of these households the air conditioner was turned off (most likely due to financial constraints), and in 52.6% of the households the air conditioner was broken, lastly 13.2% deaths occurred in households that were disconnected from electricity service.[18]

In all of the deaths related to overheating, the air conditioner was not present or not in use (for various reasons), which would lead all of these households to have low energy burden because they were not using energy and therefore not paying for it. However, this lack of energy use came at the expense of their lives. These two examples from New York City and Arizona highlight the life and death consequences of lack of energy use, which energy burden cannot capture. Hence, energy poverty metrics and analysis need to be larger than energy burden analysis and be based on multiple metrics.

III. Prevalence of Energy Inequities in Vulnerable Communities

Q: How do you define "vulnerable communities" and "vulnerable customers"?

A: I consider communities to be vulnerable when certain populations of people are at a higher risk for poor health or experiencing energy inequities because of the barriers they experience to social, economic, political, and environmental resources, as well as limitations due to a disability or illness.[19,20] Customers can also be considered vulnerable when they have difficulties affording a sufficient level of energy in their home.

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[18] Iverson, S. A., Gettel, A., Bezold, C. P., Goodin, K., McKinney, B., Sunenshine, R., & Berisha, V. (2020). Heat-associated mortality in a hot climate: Maricopa County, Arizona, 2006-2016. Public Health Reports, 135(5), 631-639.

[19] Clarke, P., & Nieuwenhuijsen, E. R. (2009). Environments for healthy ageing: A critical review. Maturitas, 64(1), 14-19.

[20] Rahman, M., Ahmed, R., Moitra, M., Damschroder, L., Brownson, R., Chorpita, B., ... & Kumar, M. (2021). Mental distress and human rights violations during COVID-19: a rapid review of the evidence informing rights, mental health needs, and public policy around vulnerable populations. Frontiers in psychiatry, 11, 603875.

Q: What do you consider to be a "low income" customer?

A: Generally, if a customer has an annual income of less than $15,000, I will consider them to be low income. This distinction will vary by region, as living in downtown Chicago will require a different cost of living than a rural region. However, for the case of this testimony I focus on an annual income of $15,000 because this is the lowest reported income range in census block groups. (As a note, the federal minimum wage of $7.25 per hour[21] would lead to an annual income of $15,080 for a household that worked a full-time 40-hour per week job). In this testimony, if the papers or analysis I reference diverge from these definitions, I will define the income groups used in those papers or analysis.

Q: Does energy poverty have multiple facets?

A: Yes. Energy poverty and a household's ability to afford energy can depend on a number of factors such as electricity price, prices of other goods, and heating or cooling needs.[22] I will provide two examples:

1) Assume Household A (single parent with 2 children) lives near a polluting coal-fired power plant, makes $25,000 a year in annual income and has an inefficient heating and air conditioning unit which leads to the household spending $3,000 a year on energy bills. In this case, the two facets of energy poverty they are facing are environmental and affordability-based energy poverty. The environmental facet of energy poverty results from the emissions coming from the power plant which affects their health (i.e., asthma and respiratory illness stemming from particulate matter emissions). The affordability facet of

[21] https://www.paycor.com/resource-center/articles/minimum-wage-by-state/
[22] Sovacool, B. K. (2015). Fuel poverty, affordability, and energy justice in England: Policy insights from the Warm Front Program. Energy, 93, 361-371.

energy poverty results from Household A spending 12% of their income on their energy bills (severe energy burden).

2) Assume Household B (single parent with 3 children) makes $25,000 a year in annual income but does not have an air conditioning unit because the upfront cost was too high. Household B spends $1,000 per year on their energy bills, but keeps their thermostat set to fifty degrees in the winter and uses their stove (gas or electric) to heat their home in order to keep their household energy bills low for fear of disconnection. Household B only spends 4% of their income on their energy bills, so they would not be considered energy poor from an energy burden standpoint, but they are exhibiting energy limiting behavior (keeping thermostats low in the winter), and an affordability facet of energy poverty (cannot afford an air conditioner). The household is also facing the risk of disconnection (if their bills spike too high in the winter).

In summary, the two examples of Households A and B highlight the multiple facets of energy poverty, and different coping mechanisms of household occupants. In the Household A example, there was a high energy burden and the family faced environmental concerns from living near a polluting power plant. In the Household B example, the family had a low energy burden, but they did not have an air conditioning system (meaning they are at risk during heat waves), and they are at risk of a disconnection so they are using their stove to heat their home. These two examples highlight how energy burden alone cannot capture all instances of energy poverty and energy insecurity.

Q: In which ways can inequities in the energy system impact low income and vulnerable customers?

A: There are several ways. For purposes of this testimony, I would like to highlight four ways: (1) disconnections, (2) energy usage and affordability challenges, (3) energy usage and deficit challenges, and (4) energy usage and infrastructure barriers.

Q: Please explain how disconnections can impact low income and vulnerable customers.

A: Disconnections can impact low income and vulnerable customers when the households are unable to use electricity in both extreme and normal weather conditions. In extreme cases, such as heat waves or deep freezes, a disconnection could expose household occupants to death or frozen pipes.[23] Alternatively, in normal conditions there are many factors that can result from a disconnection. Food may spoil due to lack of refrigeration. There is the possibility that other health impacts may ensure such as mold, allergens, and lack of proper water facilities. Lastly there is greater mental stress due to inability to pay bills, potential ramifications from landlords, and the inability to satisfy basic needs.

Q: Please explain how energy usage and affordability challenges can impact low income and vulnerable customers.

A: Energy usage and affordability challenges can impact low income and vulnerable customers when the indoor temperatures create unsafe indoor environments that pose health risks. Energy-limiting households (i.e., those with unhealthy and unsafe indoor

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[23] O'Sullivan, K. C., Howden-Chapman, P. L., & Fougere, G. (2011). Making the connection: The relationship between fuel poverty, electricity disconnection, and prepayment metering. Energy Policy, 39(2), 733-741.

temperatures) may put themselves at risk of cold- or heat-related illness,[24] excess indoor moisture, mold growth, and other adverse health effects (e.g., respiratory illness and asthma).[25,26,27]

Q: Please explain how energy usage and deficit challenges can impact low income and vulnerable customers.

A: Deficit challenges refers to situations when people cannot consume enough energy to maintain a sufficient level of basic services. In other words, as a household's energy services are electrified (e.g., refrigeration, cooling and indoor temperature regulation, transportation), inability to afford to pay electricity bills and resulting avoidance of energy usage (severe energy limiting behavior which causes an energy deficit), could put low-income customers at serious health risks.

Energy deficit challenges can impact low income and vulnerable customers when they forgo using their air conditioning and heating systems and this results in mold growth, higher instances of respiratory illness and asthma,[28,29] as well as death.[30] It could also affect

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[24] O'Sullivan, K. C., Howden-Chapman, P. L., & Fougere, G. (2011). Making the connection: The relationship between fuel poverty, electricity disconnection, and prepayment metering. Energy Policy, 39(2), 733-741.
[25] Hernández, D. & Siegel, E. Energy insecurity and its ill health effects: a community perspective on the energy-health nexus in New York City. Energy Res. Soc. Sci. 47, 78–83 (2019).
[26] Damp Indoor Spaces and Health. Damp Indoor Spaces and Health, https://doi.org/10.17226/11011 (National Academies Press, 2004).
[27] Evans, J., Hyndman, S., Stewart-Brown, S., Smith, D. & Petersen, S. An epidemiological study of the relative importance of damp housing in relation to adult health on JSTOR. J. Epidemiol. Community Health 54, 677–686 (2000).
[28] Hernández, D. & Siegel, E. Energy insecurity and its ill health effects: a community perspective on the energy-health nexus in New York City. Energy Res. Soc. Sci. 47, 78–83 (2019).
[29] Evans, J., Hyndman, S., Stewart-Brown, S., Smith, D. & Petersen, S. An epidemiological study of the relative importance of damp housing in relation to adult health on JSTOR. J. Epidemiol. Community Health 54, 677–686 (2000).
[30] Wheeler, K., Lane, K., Walters, S., & Matte, T. (2013). Heat Illness and Deaths—New York City, 2000–2011. Morbidity and Mortality Weekly Report, 62(31), 617.

them when they are in an outage or a disconnection (the most extreme form of energy deficit) because this would cause the majority of appliances to become unusable. Food will spoil due to lack of refrigeration,[31] the heating system (even if unelectrified gas or oil fuel tank) will cease to operate due to lack of communication with the thermostat, and communication services (i.e., cell phones) to request help in case of dire need of emergency assistance will cease to operate.

Q: Please explain how energy usage and infrastructure barriers can impact low income and vulnerable customers.

A: Infrastructure inequities, such as the inability to acquire or fix an air conditioning unit in the home, can create high heat indoor environments that can pose a heat stroke or heat illness risk.[32,33]

Sometimes customers may struggle to adopt electrification technologies, such as electric vehicles, air conditioning, etc., because the upfront cost is high. But when they are able to adopt, it can lead to increased consumption of electricity. That means that over the duration of the cooling and heating period they will have higher bills. Thus, energy usage and infrastructure barriers can impact low income and vulnerable customers when it prevents the adoption of climate adaptation technologies, or changes spending habits in the household.

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[31] USDA. Food Safety During Power Outage: Refrigerated Food and Power Outages: When to Save It and When to Throw It Out. https://www.foodsafety.gov/food-safety-charts/food-safety-during-power-outage#:~:text=As%20the%20USDA%20notes%20in,after%204%20hours%20without%20power.

[32] Iverson, S. A., Gettel, A., Bezold, C. P., Goodin, K., McKinney, B., Sunenshine, R., & Berisha, V. (2020). Heat-associated mortality in a hot climate: Maricopa County, Arizona, 2006-2016. Public Health Reports, 135(5), 631-639.

[33] Wheeler, K., Lane, K., Walters, S., & Matte, T. (2013). Heat Illness and Deaths—New York City, 2000–2011. Morbidity and Mortality Weekly Report, 62(31), 617.

IV. THE ROLE OF SMART METER DATA IN ADDRESSING ENERGY POVERTY AND ENERGY INEQUITIES

Q: What are "smart meters"?

A: Smart meters, or advanced metering infrastructure, refers to digital meters that collect energy usage information in increments of fifteen minutes and hourly. According to Ameren's website, "the smart meter and the network system work together to allow for two-way communication – the meter sends signals to Ameren Illinois and Ameren Illinois can communicate directly with the meter."[34] Smart meters measure how much energy a household uses based on the time of the day, but do not record the individual appliances energy consumption patterns.

Q: What is your understanding of Ameren's smart meter deployment?

A: In 2016, the Illinois Commerce Commission approved Ameren Illinois' plan to accelerate the rollout of smart meters to all of its customers, an effort that is underway and that the utility says saves customers $46 million annually. Ameren Illinois had been ramping up its smart meter deployment. In 2016, more than 345,000 households had received new two-way meters.[35] According to the company, Ameren Illinois has deployed 1.2 million smart meters as of 2020.[36] And it is my understanding that the company is close to completing its roll out of smart meters. [37]

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[34] https://www.ameren.com/illinois/company/reliability/grid-of-the-future/smart-meters
[35] https://www.utilitydive.com/news/illinois-regulators-approve-amerens-accelerated-smart-meter-rollout/427053/
[36] https://ameren.mediaroom.com/2020-12-10-Ameren-Illinois-electric-rates-to-decrease-in-2021
[37] https://www.edisonfoundation.net/-/media/Files/IEI/publications/IEI_Smart_Meter_Report_April_2021.ashx

Q: How can smart meter data be used to quantify the experience of low-income and vulnerable customers?

A: Smart meter data can be used to quantify the experience of low-income customers by collecting information on energy consumption profiles by temperature fluctuations and comparing that against the high income and non-financially constrained counterparts.[38] Abnormalities in customer's energy usage has been used to show that low-income groups wait until longer into the summer to start using cooling infrastructure, and more recent research suggests that low-income groups start using heating infrastructure earlier in the winter, most likely due to lack of insulation and recommended guidelines from landlords to set thermostats high to prevent pipes from freezing. The summer months do not have a standard guideline for thermostat setting for safety.

This information about abnormalities in customer energy usage can be used to identify weatherization needs, when air conditioning and air-cooling systems are not functioning properly, and which households are not able to adapt as the outdoor temperature changes. This lack of adaptability can be used to identify health risks in households that may spawn from lack of energy use. Additionally, the smart meter data and abnormal behavior assessments can be used to identify which vulnerable households may need or benefit from energy assistance and weatherization programs, which would reduce targeting costs, and aid in more efficiently deploying assistance.

[38] Cong, S., Nock, D., Qiu, Y. L., & Xing, B. (2022). Unveiling hidden energy poverty using the energy equity gap. Nature communications, 13(1), 2456.

My specific recommendations for how Ameren can use smart meter data to identify abnormal usage patterns that may indicate the need for assistance are as follows:

1) Collect household energy usage data (both electricity and gas) at the daily level and identify how household energy usage changes with the daily outdoor temperature. Ameren should identify changes at the beginning of the cooling and heating seasons and compare low-income groups with high-income groups to identify who is exhibiting energy limiting behavior early on (see JNGO/EDF Exhibit 6.02).
2) Using the daily energy consumption and outdoor temperatures Ameren should also identify energy limiting behavior throughout the cooling and heating seasons by calculating household slopes and comparing vulnerable groups to their non-vulnerable counterparts (see JNGO/EDF Exhibit 6.03).
3) Ameren should use smart meter data at the sub-daily level (i.e., 30 or 15-minute intervals) to detect sudden drops in energy usage, despite rises or dips in the outdoor temperature. This would allow Ameren to identify if infrastructure has broken and would aid in energy efficiency roll out. For example, if an air conditioner is broken, this would present a prime opportunity for upgrading to an energy efficient heat pump, and mitigate energy poverty in the region.

Q: What has research shown about energy usage challenges?

A: Research has shown that low-income groups can experience poverty in multiple ways and that forgoing energy usage can lead to dire consequences.[39]

In a study in Arizona (see JNGO/EDF Exhibit 6.04) my colleagues and I highlighted that households which experienced high energy burden were more likely to limit their energy consumption. There were over eighty households in the study which limited their energy consumption to potentially unsafe levels that wouldn't have been considered energy poor solely under the energy burden measure [40] (above 78° F in the summer). In the Arizona study my co-authors and I showed that low-income groups (less than $15,000 in annual income) waited 4-8° F longer than high income groups ($150,000 or more in annual income) to start using their air conditioning units in the summer.

This trend of households limiting their energy consumption also holds for Illinois. In my preliminary analysis of ComEd's electricity usage data, I have found that low-income groups wait 3° F longer in the summer to start using their cooling systems, while in the winter, electric based heating households start heating their homes 6° F earlier than high income groups, mostly likely due to insulation differences in homes (See JNGO/EDF Exhibit 6.02 which uses ComEd's smart meter data). Note: there was no smart meter data on natural gas-based heating homes available for study.

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[39] Hernández, D. (2016). Understanding 'energy insecurity'and why it matters to health. Social science & medicine, 167, 1-10.
[40] Cong, S., Nock, D., Qiu, Y. L., & Xing, B. (2022). Unveiling hidden energy poverty using the energy equity gap. Nature communications, 13(1), 2456.

When a household faces energy usage challenges, there can be fatal consequences. Heat waves kill more persons, on average, than any other extreme weather event in the United States, and the primary adaptation measure for increasing heat waves instances is air conditioning (and associated increases in electricity use). For example, in Illinois the July 1995 Chicago heat wave is estimated to have caused around 700 deaths.[41] In Europe, a 2003 heatwave caused thousands of deaths, including an estimated 14,800 in France alone.[42] To protect against heatwaves, air conditioners present a life saving measure but difficulty paying bills, disconnections, and inability to adopt or afford adequate energy consumption can negate the ability of households to maintain indoor safety. Moreover, recent studies have indicated that urban heat island effects can vary widely across cities, with low-income and minority neighborhoods experiencing the worst of extreme temperatures.[43] As referenced earlier, in an Arizona study,[44]

> "of 347 heat-associated injuries leading to deaths that occurred indoors, the presence or absence of air conditioning was documented for 287 (82.7%) deaths, all of which occurred in an indoor space that was inadequately cooled. An air-conditioning unit was absent in 59 (20.6%) deaths and present in 228 (79.4%) deaths. Of these 228 deaths, the air-conditioning unit was turned off (but documented to be functional) for 78 (34.2%) deaths and nonfunctioning for 120 (52.6%) deaths; the electricity in the residence was turned off for 30 (13.2%) deaths."[45]

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[41] Klinenberg, E. (2015). Heat wave: A social autopsy of disaster in Chicago. University of Chicago press.
[42] Bouchama, A. (2004). The 2003 European heat wave. Intensive care medicine, 30, 1-3.
[43] Popovich, N., & Flavelle, C. (2019). Summer in the city is hot, but some neighborhoods suffer more. The New York Times.
[44] Iverson, S. A., Gettel, A., Bezold, C. P., Goodin, K., McKinney, B., Sunenshine, R., & Berisha, V. (2020). Heat-associated mortality in a hot climate: Maricopa County, Arizona, 2006-2016. Public Health Reports, 135(5), 631-639.
[45] Iverson, S. A., Gettel, A., Bezold, C. P., Goodin, K., McKinney, B., Sunenshine, R., & Berisha, V. (2020). Heat-associated mortality in a hot climate: Maricopa County, Arizona, 2006-2016. Public Health Reports, 135(5), 631-639.

These concerns are not limited to traditionally "hot" climates. In an analysis of heatwaves in New York City (years 2000 – 2011), annually on average 447 residents were treated at the emergency center for heat illness, 152 were hospitalized, and 13 people died. While there was little information on which households in the study had air conditioners, "of the 48 decedents, 41 (85%) were overcome by heat in their own home. Of 26 deaths with information available on the presence or absence of air conditioning, 23 (88%) did not have any air conditioner, and the remaining three (12%) had an air conditioner that was broken or not in use."[46]

While the above examples are related to heat waves, there is evidence that despite a warming climate there is greater climate variability in winter due to a weakening jet stream, which could increase exposure to extreme temperatures in colder months, especially in the Midwest and Northeast.[47]

Q: Can you provide any examples of how smart meter data can be applied in this context?

A: As mentioned above, my research focuses on ways that utilities can analyze smart meter data to detect energy abnormalities that may indicate a need for assistance (see JNGO/EDF Exhibits 6.02 and 6.03). For example, in the article provided as JNGO/EDF Exhibit 6.02, my co-authors and I focus on abnormality detection at the beginning of the cooling and heating periods and use the high-income households to identify the average outdoor

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[46] Wheeler, K., Lane, K., Walters, S., & Matte, T. (2013). Heat Illness and Deaths—New York City, 2000–2011. Morbidity and Mortality Weekly Report, 62(31), 617.

[47] Romanowsky, Erik, Dörthe Handorf, Ralf Jaiser, Ingo Wohltmann, Wolfgang Dorn, Jinro Ukita, Judah Cohen, Klaus Dethloff, and Markus Rex. "The role of stratospheric ozone for Arctic-midlatitude linkages." Scientific Reports 9, no. 1 (2019): 7962.

temperature at which households would turn on their electric-based heating and cooling systems. We find that the cooling gap (average outdoor turn on points for low- and high-income groups) between low- and high-income groups is 3° F, while the electric based heating energy equity gap is twice as large at 6° F. In the cooling season, low-income households consume less overall energy for a shorter period than high-income households; in the heating season, low-income households also consume less but for a longer period than high-income households. Among low-to-middle-income households, our metric identifies 19,001 households (20%) in the cooling sector and 1,290 households (24%) in the heating sector who may be neglected by the traditional energy burden measure.

In the article provided as JNGO/EDF Exhibit 6.03 my co-authors and I use smart meter data from Arizona to identify abnormalities in electricity usage over the entire cooling season in Arizona.

V. IMPLICATIONS FOR REGULATORY NEEDS

Q: Based on your testimony, what implications do you see for regulatory needs?

A: Broadly, as more essential services become electrified, there needs to be more of a focus on ensuring that households are able to use enough energy to be healthy and safe in their homes. There are three focus areas that I would like to highlight here: (1) data transparency needs and sharing of data, (2) needs for equity analysis, and (3) implications for grid modernization.

Q: Please explain the need for data transparency and sharing.

A: Data transparency and sharing is important to create a baseline standard and more accurate metrics for assessing energy poverty. Data transparency and greater availability could be used to focus regulatory decisions on ensuring everyone has enough energy in their homes to be healthy and safe, yet there is limited information on actual household energy usage over the cooling and heating seasons. Data transparency would allow more efficient evaluation of energy consumption abnormalities, energy limiting behavior in households, and provide an avenue for energy equity evaluation. The current energy transition discussion in the United States has been primarily focused on reducing overall energy consumption through energy efficiency measures and tackling energy burden by reducing the amount of income a household spends on their utility bills. But these narrow foci miss the health implications of consuming too little energy (i.e., mortality risk of disconnections, and long-term impacts of forgoing energy usage).

Q: Please explain the need for equity analyses.

A: In general, equity analyses can be used in utility planning to inform demand side investments, energy gaps in households, and community investment needs. Equity analyses are important because they provide information on the energy usage abnormalities, service gaps in vulnerable communities, and how rate changes will impact the ability of vulnerable households to keep their homes at a safe and comfortable temperature.

In my research on traditionally "colder" climates, we have found some households set their thermostats to forty degrees or less (i.e., turning heating system off), when it is less than thirty degrees outside. This puts the household at risk of having their pipes freeze. When pipes freeze in a house there is also water poverty and food poverty, which can lead to a bigger heath crisis, pipes bursting, damage to unit and belongings, and possible housing dislocation.

The energy poverty concerns are not limited to the winter. In the summer, I have found that some households wait until it is ninety degrees outside to start using their air conditioning units (assuming they have them). In Arizona, my research has shown that low- income households, and particularly those making less than the national minimum wage ($15,000), wait 4-8° F longer than high income households ($150,000 or more) to start using their air conditioning units. In my analysis in Illinois, we see similar trends in the summer with low-income groups waiting on average 3° F longer into the summer than high income households to start using their air conditioning systems (see JNGO/EDF Exhibit 6.02). Given that landlords are not required to provide air conditioning units, even though air conditioning systems are the main adaptation strategy for climate change, this will be a large barrier to solving energy poverty. On the other hand, in Illinois we see that in the winter low-income groups start heating their homes on average 6° F earlier than high income groups (See JNGO/EDF Exhibit 6.02). This indicates that in the Midwest region households are less cold tolerant early in the heating season and could be indicative of lack of insulation in their homes.

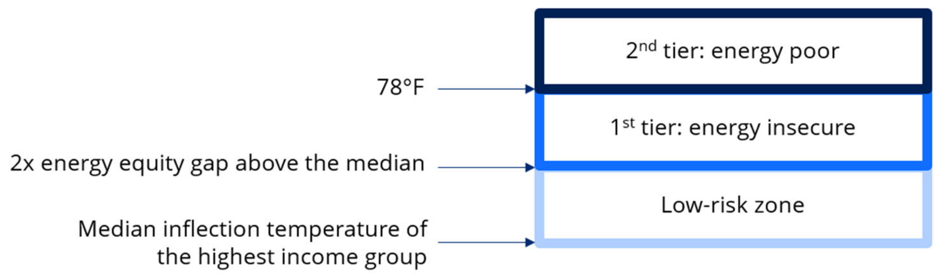
There are regulatory needs for ensuring households can use a basic amount of energy in their homes and identifying energy deficits through comparing low-income and vulnerable households to their nonvulnerable counterparts. Here I introduce a tiered system (first presented in Cong et al 2022 (see JNGO/EDF Exhibit 6.04)) to identify the households with the highest risk of heat-related illness and death.

In Cong et al[48], we describe the tiered method as follows (see JNGO/EDF Exhibit 6.04):

[48] Cong, S., Nock, D., Qiu, Y. L., & Xing, B. (2022). Unveiling Hidden Energy Poverty Using the Energy Equity Gap. Nature communications, 13(1), 2456.

"First, we assume the median inflection temperature of the highest income group is the ideal inflection temperature for this region. This assumption stems from the belief that the highest income groups are the least likely to constrain their budget and thus would initiate cooling systems earliest in the year. We acknowledge that there are multiple factors that can influence the risk of occupants in high heat temperatures.

The inflection temperature and the threshold temperature we choose to be the energy poverty cutoff serves as a first screening for identifying households that are at higher risk of putting themselves in danger of overheating. Then, similar to using a standard deviation, we define people with inflection temperatures between one and two energy equity gaps above



the ideal inflection temperature to be in the low-risk zone. Next, we define households with inflection temperatures between two energy equity gaps and 78°F to be energy insecure. Within government buildings, it is recommended that 78°F degrees be the indoor set point[49], meaning this temperature setting may limit the risk for mold and allergen build-up, as well as heat-related illness and death. Finally, households with inflection temperatures higher than 78°F are defined as energy poor. We use the indoor 78°F comfort set point as our energy poverty threshold because households would need some degree of cooling above this average outdoor temperature. We acknowledge that heat-mortality risk occurs when outdoor temperature rises above 90°F, as seen in Díaz et al[50] (note their study of mortality risk used daily maximum temperatures). Our goal is to identify households at risk for both health-related illness and death, which can result from a lower temperature threshold. We derive this lower threshold (78°F) from recommended indoor AC setting for government buildings[51], as well as from recommendations of utility companies[52]."

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[49] Energy Tips for Institutional and Government Buildings | ddoe. https://doee.dc.gov/service/energy-tips-institutional-and-government-buildings.

[50] Díaz, J. *et al.* Heat waves in Madrid 1986-1997: Effects on the health of the elderly. *International Archives of Occupational and Environmental Health* **75**, 163–170 (2002).

[51] Energy Tips for Institutional and Government Buildings | ddoe. https://doee.dc.gov/service/energy-tips-institutional-and-government-buildings.

[52] Thermostat Settings: The Ideal Settings for Summer & Winter. https://valleyservice.net/blogs/thermostat-settings.

In addition to the need for energy usage analysis there needs to be multiple methods for facilitating energy efficiency investments in vulnerable households. Policymakers, regulators, and Ameren could consider tying household investments to the meter. This would provide revenue recovery through the long-term payback of the meter, while reducing the financial burden of upfront cost investment on vulnerable households. This would provide an equity-focused strategy for grid modernization. For example, the Pay As You Save (PAYS®)[53] program makes it easier for households to reduce their utility bills and make their homes more comfortable, while creating long-term energy savings. The PAYS investment strategy gets around a customer's inability or unwillingness to take on debt by tying the payback to the meter. Under PAYS, utilities cover all or most of the upfront costs needed to install energy-efficient equipment in a home. Utility regulators in Missouri, Georgia, and Arkansas have already approved tariffs based on the PAYS® system. Other areas where PAYS® based programs are up and running include North Carolina, New Hampshire, California and Tennessee. Some of the utility branded names for those programs are: How$mart (KY), Upgrade To Save (NC), HELP PAYS® (AR), Water Upgrade $ave (CA), U-Save Advantage (TN) and Lagrange SOUL (GA).[54] For a variety of reasons, most of the activity surrounding the PAYS model has thus-far been centered on smaller, rural cooperatives, but this type of program has been active in the power sector for nine years.[55]

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[53] https://spireenergy.com/pay-as-you-save#:~:text=What%20is%20PAYS%3F&text=Spire's%20Pay%20As%20You%20Save,efficient%20equipment%20in%20your%20home.
[54] https://www.eetility.com/pays
[55] https://www.utilitydive.com/news/pay-as-you-save-co-ops-are-reaching-new-customers-with-a-novel-way-to-pay/424234/

It's my understanding that Ameren administers a comprehensive energy efficiency program has been an active participant in the Illinois Energy Efficiency Stakeholder Advisory Group (SAG) for many years, and the Company is therefore likely familiar with the PAYS model I describe above. It would be helpful for Ameren to elaborate on the topic of using PAYS or a similar program model to reach vulnerable and at-risk customers in its rebuttal testimony.

Q: Please explain the grid modernization implications you see.

A: In 2016, Ameren launched a billion-dollar grid modernization program centered around smart meter deployment.[56] According to the company, as of 2020 under its "modernization action plan," "1.2 million smart meters have been installed, power poles and wires have been strengthened, and more delivery infrastructure is being placed underground."[57] It is my understanding that the Company is close to completing its smart meter rollout.[58] Before 2019, Ameren reported that the grid modernization efforts had already resulted in "235,300 fewer outages and saved customers an estimated $46 million each year."[59] While these system wide benefits are positive and necessary, it is important for Ameren's Grid Plan to include more detail about which customers are primarily receiving these benefits, and the distribution of outage reductions between vulnerable and non-vulnerable customers. There are multiple grid modernization implications for energy equity analyses that I see, and below I detail how demand response can be used to improve user experience, and how the PAYS program may be used to improve service in Ameren's area.

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[56] https://www.utilitydive.com/news/illinois-regulators-approve-amerens-accelerated-smart-meter-rollout/427053/
[57] https://ameren.mediaroom.com/2020-12-10-Ameren-Illinois-electric-rates-to-decrease-in-2021
[58] https://www.edisonfoundation.net/-/media/Files/IEI/publications/IEI_Smart_Meter_Report_April_2021.ashx
[59] https://ameren.mediaroom.com/news-releases?item=1491

(1) There is a possibility for improving the reliability of the grid through demand response programs that also have dual benefits for energy poverty reduction. There are many demand programs that focus on peak-shaving (reducing the amount of energy used at high demand times), but there is an opportunity to use demand response to do valley-filling (incentivizing energy usage during low demand times such as high solar output). Ameren is currently pursuing a version of peak-shaving demand response. In one example of a cost-savings program from the Ameren website, the company stated that "enabled by smart meters, more than 7,000 customers voluntarily used less electricity during two high-demand, or 'peak,' high-temperature days in August and September. These customers earned bill credits ranging from a few dollars up to $63."[60]

In some cases, specifically during non-heatwave and non-deep freeze times of peak demand, a certain level of energy-limiting behavior in the interest of demand response and peak load reduction may be valuable and acceptable in nonvulnerable households. This hinges on outdoor temperatures being in a moderate range as to not pose a health risk. Energy-limiting behavior of the kind observed in some energy burdened and energy deficit homes, to a degree that endangers the health of the people in those homes, should be avoided at all costs and is not a desirable or acceptable means of achieving peak reduction goals. There should be standards of minimum acceptable energy consumption in residential households to ensure safety in households. Additionally, peak reduction efforts should focus on nonvulnerable households and higher income groups.

[60] https://ameren.mediaroom.com/news-releases?item=1491

I would welcome further discussion from Ameren in its rebuttal testimony regarding the potential design and implementation of demand response programs aimed at the dual benefits of energy poverty reduction, valley filing during low demand times, and peak load reduction.

(2) With grid modernization there are opportunities for improving detection of energy limiting behavior and spikes in energy burden on the demand size. Smart meters can be used to identify abnormalities in energy consumption (e.g., energy limiting behavior, energy burden, energy poverty). I discuss specific recommendations in this category earlier in my testimony.

(3) Demand side management through programs like PAYS and weatherization can reduce overall energy usage while also improving affordability and reducing weather-related health risks for vulnerable customers. For example, research shows that weatherization could reduce low-income household energy burden by up to 25% in addition to making it easier for households to maintain a safe and comfortable temperature.[61] I welcome Ameren's further thoughts on leveraging demand-side programs to address its vulnerable customers in its rebuttal testimony and recommend that additional discussion be included in its Grid Plan.

[61] Drehobl, A., Ross, L., & Ayala, R. (2020). How High are Household Energy Burdens? An Assessment of National and Metropolitan Energy Burdens Across the US. https://www.energy.gov/sites/default/files/2021-12/ACEEE%2C%20Household%20Enegy%20Burdens.pdf

VI. CONCLUSION

Q: What should the Commission do in this case?

A: I recommend that Ameren should consider the following best practices to use its smart meter data to track energy deficits, energy limiting behavior, and energy burden in low-income households. I also recommend that Ameren consider adopting a Pay as You Save model for energy efficiency rollout in low-income and vulnerable households.

1) Ameren should use smart meter energy consumption data at the daily level to track energy consumption abnormalities, energy burden, and energy limiting behavior over time. Then they should include both high energy burden and households that limit energy consumption in their targets for energy efficiency upgrades.
2) Households should qualify for energy assistance and weatherization upgrades based on multiple energy poverty metrics. This could include energy burden, disconnection risk, energy use abnormalities, and amount of energy a household uses in the home.
3) Ameren should promote greater data transparency, and the use of independent third parties to evaluate energy usage abnormalities.
4) Ameren should evaluate the success of energy poverty alleviation and investments based on a standard for how much energy households should be using to be healthy (avoiding heat illness in the summer, and avoiding pipes freezing in the winter), as opposed to just the percent of income they are spending on their bills. There are households who are not using enough currently and pushing those households to use less (in the absence of energy

efficiency upgrades and weatherization) could put them at a greater risk or mortality or weather-related illness.

5) Ameren should use its smart meter data to detect abnormalities in energy usage, and track energy poverty through the region. This could then be used for better targeting of poverty alleviation efforts. Specific abnormality detection should include the following:

   a. Use smart meter data to identify who is limiting energy consumption at the beginning of cooling and heating seasons. This should be based on estimating the outdoor temperature at which households start using their heating and cooling infrastructure. The high income group (>150,000 annual income) should be used as a baseline to identify how households would consume energy without a budget constraint. Then the disparity between the average outdoor temperatures at which the high- and low-income groups should be compared, and any household waiting longer than the average of the high income groups plus one times the gap should be investigated for energy poverty instances in their home. See the tiered system presented above.

   b. Use smart meter data to identify who is limiting energy consumption throughout the cooling and heating seasons using the estimated slopes for cooling and heating systems as the outdoor temperature fluctuates. An example of this calculation method can be seen in JNGO/EDF Exhibit 6.03. By detecting changes in the energy consumption slopes Ameren can remotely detect gaps in energy infrastructure, and advocate for efficient deployment of climate adaptation technologies (e.g., air conditioners). In the future, I recommend including infrastructure upgrades to climate adaptation technologies in utility distribution investment plans. To recover the cost of household upgrades Ameren can tie the cost recovery to the meter at the location as opposed to individual occupants. This will provide a reduced risk pathway for cost recovery, and allow for efficient technology rollout.

c. Use smart meter data to identify distributions of disconnections and outages across vulnerable populations and evaluate how infrastructure upgrades effect the disparities of disconnections and outage experiences.

6) Policymakers, regulators, and Ameren could consider tying household investments to the meter. This would provide revenue recovery through the long-term payback of the meter, while reducing the financial burden on the household resident. For an example, see the PAYS program mentioned above.

Q: Does this conclude your testimony?

A: Yes.