Towards Energy Justice: A Multidimensional Analysis of Energy Poverty Recognition and Responses in the United States

by

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Dedication

To my grandmother, Louise—my academic angel.

To my mother, Carol—my number one fan.

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Table of Contents

List of Tables

List of Figures

List of Appendices

Abstract

Energy justice frameworks and approaches build upon the foundation developed by environmental justice scholarship and activism to combat energy-related disparities. Disparities in access to modern energy services and technologies across nations have motivated contemporary approaches towards achieving the United Nations' Sustainable Development Goals and effectuating a just energy transition. Energy poverty, an oft-deployed characterization of these energy-related disparities, reflects a state or condition where households do not have access to sustainable, reliable, and affordable energy. However, current problem characterization and solution interventions for energy poverty in the United States lack a holistic framework that honors the multidimensional nature of household energy deprivation. Limited research explores the relationship between energy deprivation outcomes and spatially varying characteristics such as residential energy affordability, energy efficiency, and race/ethnicity, gender, and socioeconomic status of household occupants.

Accordingly, the crux of this dissertation lies in understanding how institutional barriers—across federal, state, and local levels—enable the persistence of household energy inequities. This dissertation therefore examines the multidimensional nature of energy poverty and the varied recognition of and responses to this phenomenon in the U.S. I use energy vulnerability as a lens to investigate this gap, including the technical, socioeconomic, and environmental-political dimensions that influence household levels of energy poverty. This dissertation employs a multi-method approach including a critical integrative literature review,

international and subnational policy comparative analysis, content analysis, and generalized logistic regression techniques. These analyses are situated within the context of historical and contemporary recognition of and responses to the 1973 oil crisis and the 2020 coronavirus (COVID-19) pandemic, respectively. By drawing parallels to formal recognition and responses in the United Kingdom, I promote a more expansive understanding of the current and future landscape of American energy poverty.

In Chapter two, I argue that the failure to formally recognize energy poverty at the federal level limits our understanding of its circumstances and hinders systematic approaches to reduce it. Findings suggest that current measurements and evaluative metrics hinge on the distribution of government resources and the number of ‘vulnerable’ households assisted, rather than the impact federal programs have had on improving household well-being and reducing overall energy poverty. In centering programmatic impact, I offer a more expansive definition and framework for comprehending and responding to energy poverty in the U.S.

The next two chapters explore the multiple dimensions of energy poverty and the varied responses to the COVID-19 pandemic. Chapter three asks, what factors are associated with the propensity to experience varying levels of energy poverty? I find that several technical, socioeconomic, and environmental factors influence the likelihood of experiencing higher levels of energy poverty. In response to the COVID-19 pandemic, Chapter four characterizes residential energy protection measures through a suite of resiliency responses deployed in 25 U.S. metropolitan regions. I examine the urgency and binding level of COVID-era protections and demarcate them as either mandatory or voluntary measures, finding that metropolitan regions with lower protections tend to have low-income energy burdens and that energy policy responses are unevenly distributed across the country.

This dissertation advances energy and environmental justice scholarship and clarifies the necessary policy interventions for improving energy access for energy-vulnerable households. Collectively, this analysis and examination of energy poverty recognition and responses provides an evidence base for recognizing energy access as a human right.

Chapter 1 Introduction

The impacts of climate change will transform the world as we know it. This basic understanding charges the global community with *managing the unavoidable and avoiding the unmanageable* impacts of climate change. The varied impacts of climate change are a direct consequence of the industrialization of our energy system. Nonetheless, access to energy remains essential for cultivating a life full of love, liberty, and justice. Energy shapes all aspects of life. Access to electricity is a "prerequisite for satisfying basic human needs, improving living standards, maintaining good human health, alleviating poverty, and facilitating sustainable development" (Tully, 2006). The International Energy Agency (IEA) defines energy access as "a household having 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 to reach the regional average" (IEA, 2020).

The United Nations' (UN) seventh Sustainable Development Goal (SDG) to "ensure access to affordable, reliable, and sustainable modern energy for all" (UN, 2015) uses this definition to benchmark its progress. Despite international recognition of the vitality of energy access, it is not explicitly codified as a human right (UN, 1948). However, access to electricity is still debated as a mechanism to achieve basic human rights (Löfquist, 2020) despite its central role in advancing societal development. Contemporary and earlier environmental injustices across nations (Bullard and Johnson, 2000; Bullard et al, 2008) have empowered calls for energy justice (Hernandez, 2015). Honoring the Principles of Environmental Justice (Delegates, 1991), Hernandez (2015) delineates four rights that establish the basis for demands along the energy continuum:

1. Right to healthy, sustainable energy production;
2. Right to best available energy infrastructure;
3. Right to affordable energy; and
4. Right to uninterrupted energy service.

Any violation of these rights jeopardizes energy access and decarbonization goals in support of the UN SDGs. Painfully, millions across the globe are afflicted by a lack of access to energy (IEA, 2020).

In the United States, 25 million households reported forgoing basic necessities to pay energy bills in the year 2015; and among them, seven million faced that decision each month (EIA, 2015). Further, 17 million households reported receiving a disconnection notice, and two million of them experienced such notice nearly every month (EIA, 2015). Low-income households spend nearly 14 percent of their income on energy costs compared to 3.6 percent for non-low-income households (U.S. HHS, 2011). Moreover, Black, Latinx, and renter-occupied households pay more for utilities per square foot than the average household (Drehobl and Ross, 2016; Drehobol et al, 2020). These household energy situations give rise to unsafe coping mechanisms such as dangerous heating methods and unhealthy temperatures in the home. Households that struggle with energy affordability and access and/or experience unsafe coping mechanisms are energy insecure or energy poor. Energy insecurity and energy poverty are terms often used to describe the inability of a household to meet its energy needs (Hernandez, 2016). In extreme hot and cold climates and during global crises, energy poverty exacerbates health-related risks. For example, 2.4 million U.S. households were unable to meet their energy payments and 1.7 million households received an energy disconnect notice in the early months of the coronavirus (COVID-19) pandemic (Memmott et. al, 2021).

Despite data that characterizes household experiences of energy poverty, there is no formal recognition of energy poverty nationally. To help mitigate energy poverty, programs exist at the national, state, and utility level. While current energy efficiency and bill payment programs have proven instrumental in reducing energy costs, retaining household warmth, and reducing greenhouse gas emissions, few interventions have developed systematic approaches to identifying energy inefficient homes and the specific factors that contribute to a householder's state of energy poverty. Current measures in the United States used to assess the state of energy poverty are incomplete and often exclude energy vulnerability factors—elements that would more accurately characterize a household's likelihood to experience an energy service disconnection or to have high energy burdens. Energy burdens describe household energy expenditure as percentage of its annual income. Moreover, limited research exists on the spatial correlations between residential energy affordability, energy efficiency, race/ethnicity, gender, and socioeconomic status (Bednar et al, 2017; Reames, 2016). Limited information centered on the interaction of these complex problems may contribute to the current state in which many households remain mired in energy poverty.

1.1 Value of Research

Accordingly, this dissertation fills this knowledge gap by examining the institutional barriers of energy poverty recognition and responses in the United States. These analyses are situated within the context of historical and contemporary recognition of and responses to the 1973 oil crisis and the 2020 coronavirus (COVID-19) pandemic, respectively.

The body of scholarship presented in this dissertation, to my knowledge, is the first to critically interrogate, evaluate, and demonstrate if energy poverty is formally recognized and explores what responses are deployed to mitigate its effect on U.S. households. Foundationally, my work reveals the absence of national energy poverty recognition by examining the fiscal imbalances of two federally-funded energy assistance programs. I argue that the absence of formal recognition of energy poverty at the federal level limits a more comprehensive understanding of its circumstances (e.g., impacts on public health) as well as more systematic approaches to reduce it. I draw parallels to formal recognition of and responses to energy poverty in the United Kingdom to promote a more expansive understanding of the current and future landscape of American energy poverty. In this way, my research casts U.S. policy in an international context, juxtaposing corollary policies advanced elsewhere. I develop a research agenda toward energy poverty reduction that encourages data driven evaluation, measurement, and verification of energy poverty alongside health-related outcomes at local, state, and national levels.

This dissertation advances knowledge by identifying factors associated with experiencing varying levels of energy poverty and characterizing subnational energy protections deployed in response to the COVID-19 pandemic. I use energy vulnerability to provide a novel and more expansive framework for understanding the multiple dimensions of energy poverty and to view the pursuit of energy justice in a way that encapsulates the variability of processes and circumstances that manifest from lack of access to adequate, affordable, and reliable energy in the United States. Moreover, I contribute to existing energy, environmental, and climate justice scholarship by promoting ongoing policy analysis and program evaluations to improve community health and to effectuate a just energy transition.

1.2 Research Aims and Questions

The overarching aim of this dissertation is to examine the multidimensional nature of energy poverty and the varied recognition of and responses to this phenomenon in the United States. This dissertation asks three questions:

1. Do the existing terms, measures, and metrics used to describe household energy poverty provide an adequate and comprehensive framework to characterize and quantify the amount, extent, and causes of energy poverty in the United States?
2. What factors are associated with the propensity to experience varying levels of energy poverty?
3. What type of energy protections are deployed in response to the COVID-19 pandemic? And what is the urgency and binding level of existing and COVID-19 era energy protections?

To address these questions, I employ a multi-method approach, threading a critical integrative literature review, international and subnational policy comparative analysis, content analysis, and a proportional odds/ordinal logistical regression. This dissertation finds that no formal recognition of energy poverty exists in the U.S. Moreover, I find that various technical socioeconomic, and environmental factors influence the likelihood of experiencing higher levels of energy poverty. Finally, I find that energy policy responses to COVID-19 are unevenly distributed across the country.

1.3 Theoretical Framework

My research sits at the interface of energy and environmental justice scholarship. This dissertation draws on several bodies of academic research to inform the framework for my analysis of household energy vulnerability in the United States. It incorporates ideas from the field of energy justice, concepts of spatial justice and vulnerability thinking. I evoke problem framing and policy process, including agenda setting, policy formation, policy adoption, policy implementation, and policy evaluation to understand their role in creating and sustaining disparities.

In order to situate myself as a scholar, it is useful to present a brief background and literature review that further motivates this work. First, I provide an overview of energy justice and describe the various scholarly communities within this burgeoning field. In concert with energy justice, the subsequent sections describe spatial justice and vulnerability thinking as a theoretical foundation for my examination of energy poverty recognition and responses in the U.S.

<u>1.3.1 Energy Justice</u>

Energy justice provides all individuals, across all areas, with safe, affordable, and sustainable energy (McCauley et al., 2013). Sovacool and colleagues (2017) define "energy justice" as a global energy system that fairly distributes both the benefits and burdens of energy services, and one that contributes to more representative and inclusive energy decision-making. Energy justice comprises three tenets of justice: distributional, recognition, and procedural (McCauley et al., 2013). Distributional justice, most closely related to early environmental justice scholarship and activism, acknowledges the inherent spatial inequality in the physical allocation of environmental benefits and ills and the uneven distribution of their associated responsibilities and impacts (Walker, 2009), including but not limited to the effects of environmental policy. Fraser (1997) and Schlosberg (2007) conceptualize the second tenet, recognition injustice, as (1) practices of cultural domination, (2) patterns of non-recognition (not considering people and their concerns) and (3) disrespect through stereotyping and disparaging language. They write: "Thus, recognition justice is more than tolerance, and requires that individuals must be fairly represented, that they must be free from physical threats and that they must be offered complete and equal political rights." (Walker, 2009). The final tenet of energy justice, procedural justice, is concerned with process and inclusion, crucially of those processes through which unequal distributional outcomes are produced or sustained (Young, 1990). Equitable procedures should engage all groups in decision-making, weigh their considerations seriously throughout, and provide access to information and legal processes for achieving redress or challenging decision-making processes. Procedural justice also requires participation, impartiality, and full information disclosure by government and industry coupled with appropriate and sympathetic engagement mechanisms. These elements are recognized as key interacting elements of justice in procedural terms (Walker and Day, 2012; Hunold and Young 1998; Young 1990). Appendix A displays each of the three forms of injustice and their component parts in fuel [energy] poverty. Schlosberg states: "These notions and experiences of injustice are not competing notions, nor are they contradictory or antithetical. Inequitable distribution, a lack of recognition and limited participation all work to produce injustice and claims for injustice" (Schlosberg, 2004, p. 529).

Thus, the concept of "energy justice" emerged to bring greater attention to energy policy (McCauley et al., 2013). McCauley et al. (2013) propose a new "energy justice" research agenda founded in the literature of environmental justice (Schlosberg, 2004) to address justice concerns within energy systems, from production to consumption—centered on the triumvirate of tenets: distribution, recognition, and procedural justice. However, the authors argue that the scope of environmental justice has substantively grown to encapsulate global concerns over climate and social justice (McCauley et al., 2013). Meanwhile, several authors have latched onto the call for research, deepening the stakes of what energy justice sought out to do—examine global energy systems with justice as the linchpin (Heffron and McCauley, 2014). This materialized as a deluge of conceptual frameworks to envision what an "energy-just world" could look like, including an analytical and decision-making tool alongside eight principles (Sovacool and Dworkin, 2015). The eight core principles proposed: availability, affordability, due process, transparency and accountability, sustainability, intra-generational equity, intergenerational equity, and responsibility serve as a practical, and principled approach to energy justice (Sovacool and Dworkin, 2015). Later, the authors accentuate energy decisions as justice and ethical concerns (Sovacool et al., 2016) and promote the three tenets as a three-pronged approach across the global energy system of production and consumption (Jenkins et al., 2016).

The emergence of energy justice as a concept—and later as an analytical and decision-making tool—has incited scholarly debate regarding its positioning relative to the environmental justice concept/paradigm. Scholars rally amongst three main camps in which energy justice should either be: (1) distinguished from, (2) viewed as separate but complementary to, or (3) as an extension of environmental justice. To situate myself as a scholar, I consider these viewpoints of the budding debate and conclude by providing a discussion that positions my research as an extension of environmental justice and embedded within the concept and framework of energy justice.

To this end, the camp of scholars that espouses energy justice as distinct from environmental justice lies along a spectrum. For instance, Heffron and McCauley (2017) postulate that “the application of justice in environmental and climate change decision making are not being effective” on the basis that (1) university-wide energy research centers “seem to have decreased and/or disappeared over the last two decades” and (2) there are increased climate emergency events and carbon dioxide emissions despite the success of environmental and climate justice concepts (Heffron and McCauley, 2017). They also state, “these issues highlight that society’s laws and application of justice in environmental and climate change decision-making are not being effective” (Heffron and McCauley, 2017). Here, in response, it is important to note the shortcomings of the authors’ lofty claims of the ineptness of environmental justice.

First, the authors use the ranking of energy research centers from the 2017 Times Higher Education World University Rankings as an evaluative metric to describe the success of environmental justice. This approach spotlights elite institutions and research productivity as the arbiters of justice deployment and ignores larger political and structural issues that interfere with the achievement of environmental justice’s aims and goals. Next, increased climate events and atmospheric carbon dioxide pollution have continued to increase annually. Nonetheless, these metrics, too, reflect the function of structural and systemic issues that have brought about climate change and cannot be blamed by the concept of environmental justice alone.

Further, Heffron and McCauley (2017) description and understanding of the aims of environmental justice law reads, “[environmental justice] is not about the elimination of environmental risks but the distribution of them. This claim displays a blatant misunderstanding of environmental justice, ignoring the sixth principle of environmental justice that states, “Environmental Justice demands the cessation of the production of all toxins, hazardous wastes, and radioactive materials, and that all past and current producers be held strictly accountable to the people for detoxification and the containment at the point of production". Though, not all law and policy reflect these principles, the concept and movement for environmental justice promotes equity and justice across the environmental continuum. To this end, I argue that environmental justice is and has been concerned about both the distribution and elimination of environmental burdens. Moreover, energy justice allows us to focus on energy whilst having environmental and climate justice implications.

Scholars in the energy justice is distinct from environmental justice camp state claims of its ineffectiveness. For instance, Jenkins' (2018) does not suggest an abandonment of environmental justice work; but rather, argues that its scope expansion and recognition in international scholarship "limits the material impact of environmental justice claims", further, stating that "it lacks defined and recognized content — a structure or approach that can be readily applied" systematically across scales. Notwithstanding its merits, Jenkins censures environmental justice as achieving limited gains in environmental protection or conservation and regards the core motivation of the movement as concerns for people in less affluent areas and not their environment. Jenkins concludes her critique stating "[environmental justice] is a floundering concept, with little benefit beyond the grassroots level" (Jenkins, 2018). As an alternative, she posits energy justice as "a more strategically impactful [concept]" that "is a rapidly applicable approach that can make more meaningful progress" (Jenkins, 2018).

As energy justice may provide a more strategic framing for responding to justice concerns that many recognize in familiar energy configurations; in this view, scholars understand energy justice as complementary to environmental justice. Agyeman et al., (2016) provide a comprehensive review and synthesis of the expansion and globalization of environmental justice as “practices of everyday life, illustrated by food and energy movements” to include “the ongoing community work and the importance of identity and attachment, informed by urban planning, food and climate concerns”. Equally important, Finley-Brook and Holloman, (2016) “empower energy justice” by highlighting how energy transitions in the U.S. build from and contribute to environmental injustices. The authors bring forth concerns of conflict between “green” and “just” as demonstrative of inequities in clean energy initiatives (Finley-Brook and Holloman, 2016). Hess and Ribeiro (2016) attempt to close the energy and environmental gap by suggesting a qualitative method based on environmental justice protocols to evaluate environmental justice in energy projects. The authors echo Schlosberg and Collins’ (2014) review of the embedded notions of sustainability in the environmental justice movement.

Honoring the environmental justice tradition, scholars view energy justice as a logical extension. In a seminal paper, Walker and Day (2012) reimagine fuel poverty to be understood as “an expression of injustice, involving the compromised ability to access energy services and thereby to secure a healthful living environment”. The authors build the case for aligning fuel poverty with concepts of social and environmental justice by recognizing that “other understandings of injustice [recognition and procedural in addition to distributional] are also implicated and play important roles in producing and sustaining inequities in access to affordable warmth” (Walker and Day, 2012). This direct link between environmental justice and fuel poverty extended the environmental justice literature more pointedly to household energy issues. Walker and Day (2012) continue, noting that fuel poverty interventions may largely be within the national scale; however, they extend beyond national boundaries as they are linked to global resource flows—directly modifying the atmosphere (Walker and Day, 2012). Baker (2019) builds on environmental and energy justice scholarship by uplifting an ‘anti-oppression’ principle that centers equity and justice in energy policy—considering the historical injustices perpetuated within system structures. This is in line with environmental justice analyses that consider cumulative impacts. Moreover, Baker (2019) notes that fair outcomes and procedural justice for impacted communities as a requirement within an 'anti-oppression' approach to energy justice. Energy justice, in this way, presents itself as a decision-making tool that could assist energy professionals, consumers and policy makers in making more informed energy choices. In a shift towards a more united front, and away from their earlier conceptual thought (McCauley et al., 2013; Heffron and McCauley, 2017), McCauley and Heffron, (2018) cast "just transition" as a framework of analysis that weds climate, energy, and environmental justice to assess where injustices will merge and how they should be tackled.

In like manner, I believe my research is uniquely positioned at the interface of energy and environmental justice with notions of climate justice to elucidate the global implications of household energy vulnerabilities. The impetus for this reasoning with a particular emphasis on environmental justice are its roots in advocating and centering people of color in the movement and research. Presently, energy justice research is limited in its empirical accounts of energy disparities across race and ethnicity. Although energy justice scholarship encompasses research regarding whole systems approaches (Heffron and McCauley, 2014; Jenkins et al., 2014, 2016a), ethical behavior (Hall et al., 2013), climate change (Bickerstaff et al., 2013; McCauley et al., 2013), household energy consumption (Bednar et al., 2017; Walker et al., 2016; Reames, 2016), energy policy-making (Heffron et al., 2015; Sovacool et al., 2016), energy consumption and mobility (Simcock and Mullen, 2016), and theorization and methods (Sovacool and Dworkin, 2014; Sovacool, 2015; Jenkins et al., 2016b), current methods of assessing vulnerability in the energy justice field remain limited in terms of their ability to yield findings that can inform effective policy intervention and decision-making. Moreover, there is room for more integrated and intersectional approaches to energy justice scholarship (Jenkins et al, 2021).

Of particular importance to this dissertation, energy and climate justice are, in my view, central pillars that aid in efforts to mitigate environmental injustices. Rooted in the environmental justice tradition, energy justice and its three tenets provide the foundation that underpins the analysis of this dissertation.

1.3.2 Spatial Justice

The spatial justice framework advances our understanding of the causes and experiences of household energy deprivation by highlighting the spatial embeddedness of "inequities and flows that are engrained in the economic, infrastructural and cultural make-up of society" (Bouzarovski and Simcock 2017; Bouzarovski, 2014). Spatial justice emphasizes the geographic dimensions of inequality and inequity (Soja, 2010; Yenneti et al., 2016). Geographical patterns of inequality and inequity are influentially associated with household energy deprivation and the causes of energy poverty. Therefore, spatial justice provides a terrain for exploring the relationship between spatial, racial/ethnic, socioeconomic disparities and household energy vulnerability.

1.3.3 Vulnerability Thinking

Energy vulnerability thinking identifies fuel or energy poverty as a descriptor of a "state" within a certain temporal frame and identifies vulnerability as a set of conditions leading to the circumstances in that state (Bouzarovski et al., 2013; Hall, Hards, & Bulkeley, 2013). Thus, energy vulnerability thinking can be seen as probabilistic, highlighting the factors that influence the likelihood of becoming energy insecure (Bouzarovski, 2018). A departing point of this approach described by Middlemiss and Gillard, (2015) is the ability of an 'energy service poor' household to exit the condition or state in the future by changing some of their circumstances. In particular, Middlemiss and Gillard (2015) draw on the notion of 'emic' vulnerability, or the "description of phenomena understood by the person" (Spier, 2000) and its applications to energy vulnerability (See Appendix B). In this way, Middlemiss and Gillard explore subjective measures of how vulnerability is perceived by the household.

Except for a few studies, vulnerability thinking is limited in relation to energy justice. Harrison and Popke (2011) use the notion of 'assemblage' to analyze and situate household energy problems in rural North Carolina. Day and Walker (2013) build on the notion of assemblage, viewing energy poverty as "a particular kind of techno-social assemblage, made up of an array of networked actors and materialities that focus on the networked nature of energy poverty to help highlight its historical foundations and multidimensional character". Through this lens of assemblages, the array of actors and materialities that serve as factors that drive the emergence of the state of energy poverty are accounted for using a systems approach. Specifically, the assemblage lens highlights systemic pathways and conditions that compel household energy deprivation in homes (Bickerstaff et al., 2013; Bouzarovski et al., 2013; Hodbod and Adger, 2014).

This dissertation posits vulnerability thinking as a central web that informs the framework for my analysis of energy vulnerability inequities. It integrates theories of energy justice and spatial justice with vulnerability thinking (Bouzarovski and Simcock, 2017) by bringing forward the spatial and temporal variation of vulnerability factors that influence the rise of energy injustices.

Combined, theories of energy justice, spatial justice, vulnerability thinking provide an opportunity to assess household energy vulnerabilities in the U.S. while offering a framework and assessment tool to characterize household energy deprivation and to structure decision-making processes to mitigate energy poverty.

1.4 Recognizing Energy Poverty

In this section, I provide a literature review that illuminates the history of energy poverty recognition. Since Boardman's (1991) seminal work on fuel poverty, additional terminology and methodological approaches have surfaced to broadly capture the notions of energy access, affordability, and household energy deprivation across the globe. These attempts to characterize household energy injustices have been conceptualized similarly as fuel poverty, energy poverty, energy insecurity, energy vulnerability and energy precarity/precariousness, with some distinctions that vary by the respective authors/institutions. However, all forms of domestic, or household energy deprivation "share the same consequence: a lack of adequate energy services in the home, with its associated discomfort and difficulty" (Bouzarovski and Petrova, 2015). Bouzar (2007:1908) examines household energy deprivation as an 'innately relational phenomenon', stringing theories of infrastructure, poverty and everyday life to inform his analysis of the 'socio-spacial arrangements' of energy poverty in post-socialist Europe. Bouzar (ibid) continues to say, "when cross referenced with the most widely acceptable definition of relative income poverty, fuel and energy poverty alike can be considered under the same umbrella: as a set of domestic energy circumstances that do not allow for participating in the lifestyles, customs and activities that define membership of society". Nonetheless, terminology used to describe household energy deprivation among scholars, policy makers, and program managers is inconsistent — often muddling the objective, approaches, and metrics required to effectively characterize and reduce the number of households deprived of modern energy services, both regionally and globally. Few scholars have attempted to disentangle the dichotomy of the earlier used terms, fuel poverty and energy poverty (Bouzarovski, 2018; Li et al., 2014; Bouzarovski, 2014; Bouzarovski and Petrova, 2015; Thomson et al., 2016). Limited studies have reviewed the host of available metrics, indicators, and instruments used to measure and assess household energy injustices (Heindl, 2015; Hills, 2012; Herrero, 2017; Thomson et al., 2017; Culver, 2017).

Of the available terminology/concepts used to describe household energy deprivation, energy vulnerability shows promise in its ability to extend beyond the physical and economic determinants of energy poverty, capturing the multiple factors that can contribute to a household falling into a state of energy poverty. However, the published literature on energy vulnerability is scant. Although energy vulnerability lacks a formalized definition, Day and Walker (2013) theorize (energy) vulnerability as a "dynamic process, a coming together, or assemblage, of human and non-human presences and absences, alongside practices, norms and possibilities". This understanding of energy vulnerability goes beyond simply combining factors related to buildings, occupants, and climate, by addressing, in addition, how many of these factors interact with one another. Day and Walker (2013) explain that "[e]nergy vulnerability is a term that for us better captures the variability of circumstances and processes through which problems of access to sufficient and affordable energy are manifested, and one that has the potential to work across many different national and regional settings". Day and Walker understand energy vulnerability to have three general characteristics:

1. “Multidimensionality and produced through the union of social, technological and natural process.
2. Exact nature of this coming together for any particular person or household is locally contingent. Hence, energy vulnerability is variable in its production and character over space and time.
3. Energy vulnerability as experienced exhibits different temporal qualities, sometimes constant and unyielding, sometimes far more dynamic and shifting in cyclical or more unpredictable patterns.”

Middlemiss and Gillard (2015) build on existing vulnerability theory (Adger, 2006; Hinkel, 2011) and research (Spiers, 2000) to translate the concept of energy vulnerability to “the likelihood of a household being subject to fuel poverty, the sensitivity of that household to fuel poverty and the capacity that household has to adapt to changes in fuel poverty”. They note that the changing nature of all three concepts makes it likely that the energy vulnerability of a given household/individual/community is subject to change over time, asserting that “an analysis of energy vulnerability suggests that different households will hold different degrees of vulnerability, according to their exposure, sensitivity and adaptive capacity.” (Middlemiss and Gillard, 2015). In their analysis, they identify the lived experience of the fuel poor/energy vulnerable and find that households have limited agency through which they can reduce their vulnerability status. Although this study offers a starting point for characterizing energy vulnerability from the bottom up, it omits a characterization of the degree to which householders are in fuel poverty. Finally, Bouzarovski and Petrova (2015) emphasize energy services and vulnerability approaches to highlight the specific geographical dimensions of household energy deprivation through a typology of six energy vulnerability factors: access, affordability, efficiency, flexibility, needs and practices.

1.5 Dissertation Outline

This dissertation is divided into five chapters. Chapters 2-4 are structured as independent academic papers, one of which has already been published as a coauthored article in Nature Energy. Nonetheless, the chapters do build off and complement one another.

Chapter 2: Recognition of and Response to Energy Poverty in the United States presents an in-depth, integrative review of the academic literature from 1970-2018 of relevant energy justice scholarship, books, United States' statues, policy documents, and professional reports. I synthesized definitions, metrics, measures, and approaches of household energy deprivation and described departure points in how the United Kingdom and United States have characterized, addressed, and responded to similar household energy affordability issues because of the 1973-1974 oil crisis. In doing so, I find that there is no formal national recognition of energy poverty in the United States. I argue that the absence of this recognition misguides how we measure energy poverty; and consequently, how we evaluate solutions to energy poverty. These observations lead me to propose a new definition and conceptual framework for energy poverty and energy vulnerability, respectively.

I bolster this framework in *Chapter 3: Factors associated with experiences of energy poverty in the United States: An analysis through ordered logistic regression*. In this study I focus on understanding the factors associated with experiences of varying levels of energy poverty using an ordinal logistical regression methodology. I demonstrate that energy poverty experiences are multidimensional in nature and highlight the importance of data, measurement, and evaluation. I find that various technical, socio-economic, and environmental factors influence the likelihood of experiencing levels of energy poverty.

In *Chapter 4: Towards energy as a human right: State and utility level disconnect policies in the United States before and during the COVID-19 pandemic*, I magnify the importance of energy poverty recognition and response through a sub-national comparative energy burden, policy, and emergency response analysis. I characterize residential energy protection measures through a suite of resiliency responses deployed in 25 U.S. metropolitan regions in response to the COVID-19 pandemic. Additionally, I examine the urgency and binding level of COVID-19 era protections and demarcate them as either mandatory or voluntary measures. I find that metropolitan regions with lower protections tend to have low-income energy burdens. Further, I find that energy policy responses are unevenly distributed across the country and motivate contemporary recognition of energy as a human right.

In *Chapter 5: Conclusion*, I summarize key findings and the theoretical and practical implications of each of the three preceding studies. I argue that the most significant contributions of my dissertation research reveal varying degrees of recognition of and responses to energy poverty at the national and subnational levels whilst advancing energy poverty as a distinct and multidimensional issue. I connect these instances of recognition of and responses to multidimensional energy poverty to the imperative of a just energy transition through the concept of and movement for energy democracy. I conclude by identifying several pathways for future research that build on the foundation advanced in this dissertation.

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Chapter 2 Recognition of and Response to Energy Poverty in the United States[1]

Abstract

A household is energy poor when they cannot meet energy needs. Despite its prevalence, the US has not formally recognized energy poverty as a problem distinct from general poverty at the federal level, which limits effective responses. In this Review, we examine the measurement and evaluative metrics used by the two federally-funded energy programs focused on reducing high energy bills to understand how program eligibility requirements and congressional funding appropriations have shaped the national understanding and implementation of energy poverty assistance. We find that current measurement and evaluative metrics hinge on the distribution of government resources and the number of vulnerable households assisted, rather than improving household well-being and reducing overall energy poverty. We suggest that comparisons to formal food insecurity and fuel poverty recognition and national responses in the US and UK, respectively, can help inform the development of more comprehensive US responses to energy poverty going forward.

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2.1 Introduction

Stark disparities exist in US energy burdens, the percentage of household income spent on energy bills. Urban and rural low-income households (defined as 80% area median income or 150% Federal Poverty Level) spend roughly three times as much of their income on energy cost as compared to non-low-income households (7.2% and 9% vs. 2.3% and 3.1%, respectively)[1,2]. Moreover, low-income, African-American, Latinx, multifamily, and renter households are disproportionately impacted by high energy burdens[1]. Out of a total of 118.2 million US households, in 2015, the US Energy Information Administration (EIA) estimated that 17 million households received an energy disconnect/delivery stop notice and 25 million households had to forgo food and medicine to pay energy bills[3]. These household experiences have been described as indicators of energy insecurity or energy poverty – the inability of a household to meet their energy needs[4]. Yet, for the United States Government, energy insecurity and energy poverty are nebulous terms that do not exist in any statutory capacity. In other words, the federal government has not formally recognized energy poverty as a distinct problem.

In the absence of federal energy poverty recognition, states have implemented low-income energy assistance programs. Consequently, 51% of all funding to address high energy burdens is from utility ratepayer funded bill and energy efficiency assistance[1]. Despite the absence of federal statutes to characterize, measure, and evaluate the landscape of and responses to energy poverty, the essence of this phenomenon has generally been recognized in the US as evidenced by two federally-funded energy assistance programs: the Low-income Home Energy Assistance Program (LIHEAP) and the Weatherization Assistance Program (WAP). LIHEAP and WAP are administered by two different federal agencies, the Department of Health and Human Services (DHHS) and the Department of Energy (DOE), respectively. These programs were created to combat rising energy costs and promote household energy sufficiency in response to the 1973 oil crisis[5]. However, after nearly fifty years of federal energy assistance, one in three US households (37 million), still experience energy poverty[3].

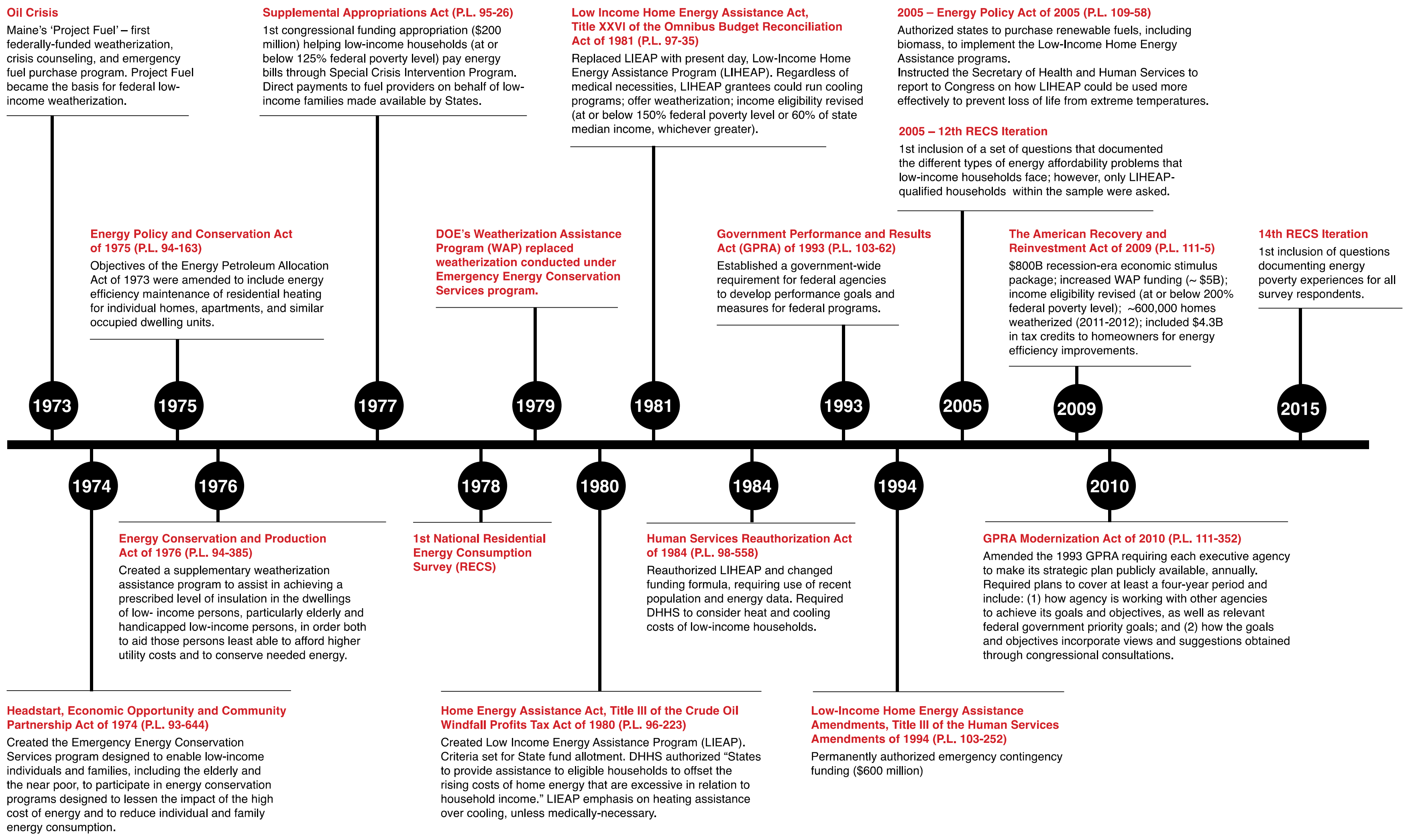
While the United Kingdom (UK) and US have had similar responses to energy poverty reduction, one key area of divergence lays in their formal recognition. Notably, the UK's fuel poverty strategy formally recognizes households as fuel poor when incomes are lower than average and fuel costs are higher than average[6]. Despite a lack of data supporting precipitous reductions in fuel poverty, the UK is armed with pivotal information to aid a more rapid and adaptive response to fuel poverty exacerbated by the climate crisis[7]. Moreover, the requirements to systematically advance household energy efficiency by specific dates signals a united and national priority for overall household wellness and access achieved through the multiple benefits of energy efficiency[8]. Unlike the devolved UK nations[8], the United States lacks federal energy poverty recognition and strategy that encompasses definitions, reduction targets/objectives, and periodic evaluation.

In this Review, we suggest that the absence of formal energy poverty recognition at the federal level limits a more comprehensive understanding of and effective response to energy poverty as a distinct problem, and not simply a manifestation of more general problems of poverty. To this end, we describe energy poverty as the distinct notion of household energy deprivation that limits social and material necessities for participation in society[9]. We first review federal responses to energy poverty in the US as pseudo recognition. The energy poverty responses deployed by LIHEAP and WAP are used as case studies to describe how program eligibility requirements and congressional funding appropriations shape our understanding and targeting of which households require energy assistance. Then, we examine the performance measurements embedded within evaluative standards that indicate the program's success to demonstrate the misunderstanding of each program's effectiveness in reducing energy poverty. Next, we draw parallels to formal recognition and responses to food insecurity in the US, and to fuel poverty in England, as a way to promote a more expansive understanding of the current and future landscape of energy poverty and pathways to effectively responding in the US[10]. We conclude with recommendations to advance national energy poverty reduction in the US, and in particular encourage the development and reassessment of an expansive energy poverty definition, reduction objectives, integrated strategies, and comprehensive measurement and evaluation.

2.2 US response to energy poverty as pseudo recognition

Notwithstanding recognition short of a formal energy poverty definition, LIHEAP and WAP, alongside state level affordability targets and energy efficiency objectives serve as national responses to the issue. Government action at the intersection of energy and equity has been driven by either geopolitical or economic crises that affect energy prices, rather than by a comprehensive, long-term approach to address disparities in energy affordability. Energy poverty response as pseudo recognition has a nearly fifty-year history in the US beginning with the state of Maine's Office of Economic Opportunity initial recognition of the impact that the 1973 oil crisis had on low-income and elderly households' ability to meet their energy needs. In response, they applied for federal funds to implement "Project Fuel". Project Fuel's main focus was to weatherize homes; however, funds were also used for crisis counseling and purchasing fuel in emergency situations. Project Fuel inspired weatherization at the national level with a focus on household weatherization and energy conservation; however, funds were allowed for fuel voucher programs. The oil crisis catalyzed a series of US government reorganizations and the creation of new energy-related departments and programs, by which weatherization and household energy assistance became responses, or pseudo acknowledgements, of the issue of energy poverty. Figure 2-1 presents a timeline highlighting relevant policies associated with energy poverty responses, including the economic crisis of the late 2000s which heightened government attention to low-income energy assistance programs and increased funding appropriations.

Figure 2-1: Timeline of US energy poverty response-as-recognition. Key developments in Public Law (P.L.) and data acquisition between the years 1973 and 2015



LIHEAP, authorized in 1981, provides home energy bill assistance to help subsidize high energy expenditures for low-income households. The WAP, authorized in 1976, is the largest and longest running federally-funded residential energy efficiency program. WAP provides eligible low-income families with the opportunity to permanently reduce onerous energy bills through cost-effective, energy efficiency upgrades. As a requirement, whole-house retrofit approaches are used to ensure the cost-effectiveness of energy efficiency measures. The whole-house approach guides energy efficiency measures by looking at the synergy of the building's envelope, appliances, and heating and cooling systems. Private contractors and in-house employees deliver weatherization services to WAP participating homes each year.

Program eligibility requirements, defined by statute and embedded within the purpose of both LIHEAP and WAP, identify which households are eligible for energy assistance and govern program targeting and implementation. Table 2-1 presents language of LIHEAP and WAP program purpose, eligibility requirements, and performance measures. Targeting approaches for WAP and LIHEAP are centered on income eligibility, a high energy burden, and demographic characteristics of a 'vulnerable household'. The statutes define vulnerable households as those with young children below five and elderly members above 65 years old, and individuals with disabilities. Eligibility based on household income maintains energy burden as the dominant metric to understand the prevalence and severity of US energy poverty.

Table 2-1: Comparison of LIHEAP and WAP purpose, eligibility requirements, and performance measures

Program	**LIHEAP**		**WAP**
Year created	1981		1976
Administering agency	US Department of Health and Human Services, Administration for Children and Families, Office of Community Services, Division of Energy Assistance		US Department of Energy, Office of Energy Efficiency and Renewable Energy, Weatherization and Intergovernmental Programs Office
Agency mission	To enhance the health and well-being of Americans by providing effective health and human services and by fostering medicine, public health and social services		To ensure America's security and prosperity by addressing its energy, environmental and nuclear challenges through transformative science and technology solutions
Purpose	"to assist low-income households, particularly those with the lowest incomes, that pay a high proportion of household income for home energy, primarily in meeting their immediate home energy needs"		"…to increase the energy efficiency of dwellings owned or occupied by low-income persons, reduce their total residential energy expenditures, and improve their health and safety, especially low-income persons who are particularly vulnerable such as the elderly, persons with disabilities, families with children, high residential energy users and households with high energy burden"
Eligibility	Highest value between a household: ●being at or below 150% of the federal poverty level (FPL) income guidelines; or ●60 percent of the state median income		●200% FPL ●Recipient of Supplemental Security Income or Aid to Families with Dependent Children and less than 200% FPL (US DOE, 2017)
Performance measures	Recipiency targeting index	Scores are the national percentage of LIHEAP-eligible households that receive services and have either a senior citizen or a young child (under the age of five) in the household, compared to the percentage of households estimated by the Census Bureau as being LIHEAP-income eligible and having a senior citizen or young child in the household	Number of homes weatherized
	Energy burden measures		
	Benefit target index	Does LIHEAP furnish higher benefits to higher burden households?	
	Burden reduction target index	Does LIHEAP pay a larger share of the home energy bill for high burden households?	
	Prevention and restoration measures		
	Service loss prevention	How many times did a LIHEAP benefit prevent loss of home energy services for households at imminent risk?	
	Service restoration	How many times did a LIHEAP benefit restore home energy service for households who were disconnected, out of fuel or who had inoperable equipment?	

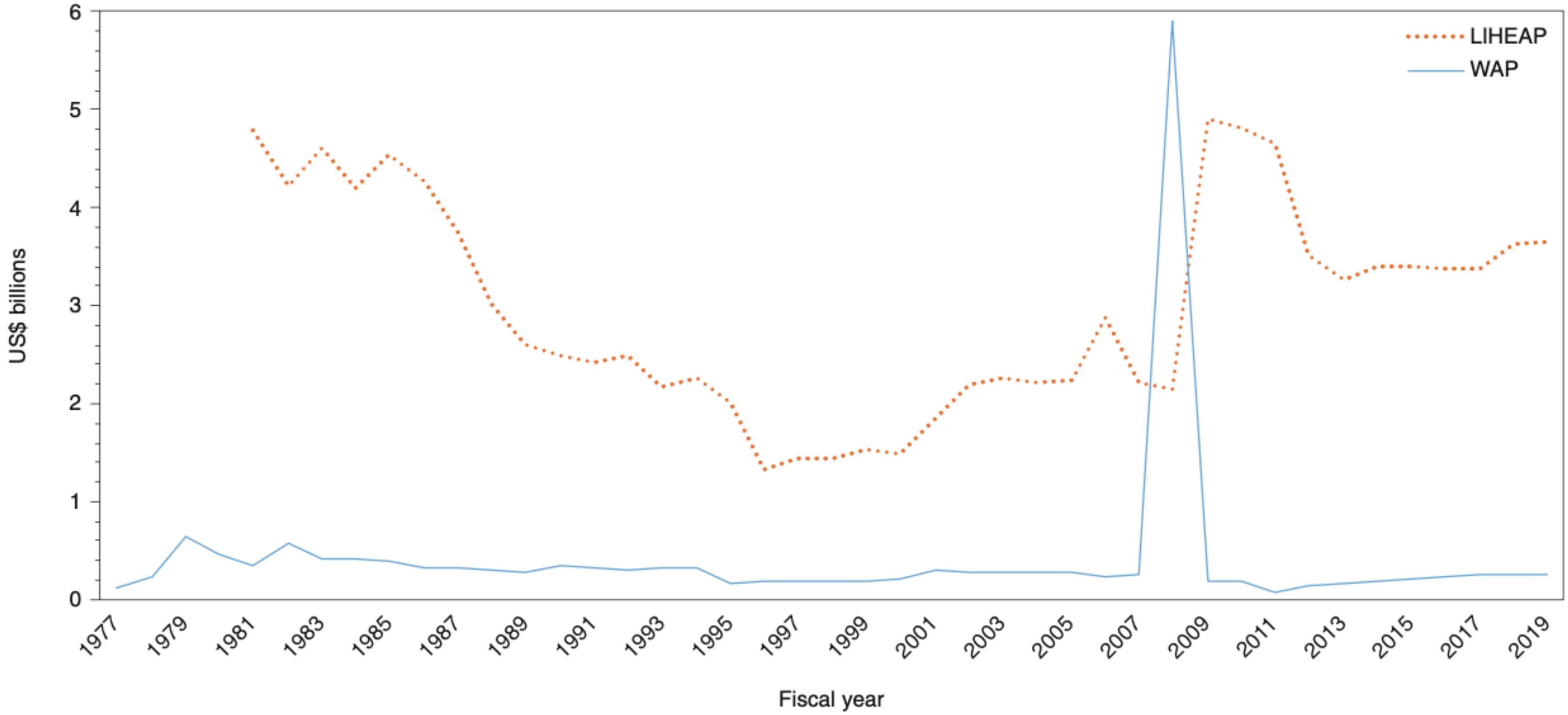
LIHEAP and WAP are administered as block-grants by DHHS and DOE, respectively. Combined, the Federal Government has spent $134.6 billion on low-income household energy assistance since the late 1970s. LIHEAP is a revenue support system provided to eligible households each year, whereas WAP is often a one-off, non-recurring capital investment in energy efficiency measures. LIHEAP benefits roughly 25 percent of eligible households each year and WAP has weatherized seven million households; however, nearly 40 million households remain income-eligible for energy efficiency assistance[11]. Federal block-grants are provided to states, the District of Columbia, territories and Indian tribal organizations and are implemented at times, alongside utility ratepayer dollars at the household level by local governments or nonprofit agencies, most often Community Action Agencies.

Program implementation is also shaped by annual congressional funding appropriations. For WAP, formula allocations for each state are based on three factors: low-income population as a share of the nation's total low-income population expressed as a percentage; climatic conditions obtained through heating and cooling degree days for each state; and, residential energy expenditures by low-income households in each state[12]. For LIHEAP, the funding formula is a bit more complicated and was updated in 1984[13,14]. Appropriations are released each year contingent on the formula and congressional Continuing Appropriation Resolutions. The previous formula of 1981 determined allocation percentages based on antiquated data, political compromise and accommodation[13]. The 1984 "New" formula represents a percentage of US low-income energy expenditure by state. To capture state level low-income energy expenditure, the following values are used for household-level calculations: total residential energy consumed as measured by total British Thermal Units (Btu); temperature variation as 30 year average heating and cooling degree days; heating and cooling consumption for total US and low-income households; average fuel price per fuel source.

Appropriations for these two programs have fluctuated over time, each receiving large boosts during the recession-era American Recovery and Reinvestment Act of 2009. It is important to note the historical disparity in their funding appropriations as shown in Figure 2-2. LIHEAP funding averages nearly $3 billion annually since its inception. WAP funding pales in comparison to LIHEAP appropriations, averaging nearly $0.4 billion annually[15]. Comparatively, LIHEAP allows states to transfer up to 25% of its funds to WAP, making LIHEAP one of the largest additional potential funding sources for WAP. Even with greater funding, a majority of income-eligible households (84%) do not receive LIHEAP assistance[11]. Naturally, the immediate need of bill-assistance is greater than the speed at which households can be weatherized warrants greater funds to LIHEAP. Nevertheless, the persistence of greater appropriations to LIHEAP over WAP appears to reflect a policy approach based on a notion that energy poverty is a temporary misfortune to be remedied primarily by some form of debt recovery, despite evidence demonstrating WAP as an effective and sustainable solution towards household energy affordability with multiple benefits[16], including those to public health

Figure 2-2: Historic LIHEAP and WAP funding appropriations by fiscal year.

Values not adjusted for inflation. Shown in current US dollars. Figure data from LIHEAP Clearinghouse (https://liheapch.acf.hhs.gov/Funding/funding.htm).



States have regulatory authority over LIHEAP and WAP implementation, and there are trends toward recognizing energy affordability as a policy priority at the state-level. For instance, certain states have specific target dates to achieve energy efficiency objectives, such as Connecticut which aims to weatherize 80% of homes by 2030 (Public Act No. 11-80). Other states and municipalities have energy affordability goals. For example, the Governor of New York created an energy affordability policy in 2016 with a six percent energy burden goal and Portland, Oregon has a 10-year plan to reduce energy burdens in Oregon affordable housing. Moreover, several state-level energy regulatory requirements ensure low-income energy assistance is provided in the form of energy efficiency and bill payment assistance to achieve energy affordability. State energy efficiency resource standards by law require utilities to pursue energy efficiency as a cost-effective energy resource[17]. Although eligibility requirements vary, utility ratepayer-funded programs often complement LIHEAP assistance and are funded through charges assessed on all or some commercial, industrial, and residential customers. The assessed charges are often referred as public goods surcharges, system benefits charges, public benefits, universal service fees, universal energy charges, meter charges. State and local funds administered as supplements to LIHEAP funding garners eligibility for incentives from the federal government, thus increasing available resources to distribute. Additionally, on-bill financing programs are loans made to utility customers to pay for energy efficiency improvements.

2.3 Evaluation of US Responses to Energy Poverty

Performance measures and program evaluations are the lynchpins of federally funded energy assistance. They inform both the executive branch's and congressional committees' decision making about the programs they oversee[18]. The Government Performance and Results Act (GPRA) of 1993 emerged out of the "frustration" that decision making was hindered by the shortage of good information on the results of federal program efforts[18]. Its update, the GPRA Modernization Act of 2010 reinforced key elements to improving the effectiveness and efficiency of government. This Act emphasized the use of goals and measures to improve outcomes and requires quarterly review of progress achieved towards goals.

Performance goals/objectives are important because they guide performance measures that inform evaluations of program performance. Performance measures aim to provide quantifiable information on the effectiveness of meeting program performance goals/objectives. In other words, they help evaluate the success of programs. Two organizations, APPRISE, Inc. (Applied Public Policy Research Institute for Study and Evaluation) and Oak Ridge National Lab, are commissioned to serve as performance review committees/workgroups to conduct program evaluations for both LIHEAP and WAP, respectively.

The DHHS annual performance goals/objective focus on targeting LIHEAP heating assistance to vulnerable, low-income households that have the highest energy burdens. However, individuals with disabilities are not included in this assessment of vulnerable households.

The recipiency targeting index is currently the only evaluative LIHEAP performance measure that quantifies the targeting performance objective and describes the national percentage of eligible households that receive services and have either a young child or senior citizen in the household[19, 20]. In 2014, four new 'developmental' performance measures were approved to quantify LIHEAP's impact on household energy burdens, prevention of energy loss, and restoration of energy services to allow State grantees building capacity for necessary data collection (See Table 1 for details).

Although the current LIHEAP performance measures satisfy the statutory requirements for monitoring and reporting, less is known about the program's effectiveness in reducing the actual problem of energy poverty. The performance measures maintain and emphasize a 'distributive' goal which focuses on inputs—how government resources are distributed—and outputs—the number of vulnerable beneficiaries assisted—rather than impact or outcomes, such as how the program has influenced the lives of all households experiencing energy poverty. According to DHHS, performance measures were not met in some years[21], formally signaling program failures to the federal government despite having assisted over 6.3 million households with heating[11], and more recently cooling, costs. The approved performance measures provide useful information from an operational standpoint on whether LIHEAP assistance is working. However, each of these measures lack strategic and long-term understanding of the extent to which LIHEAP reduces negative consequences to the health and well-being of households living in energy poverty. Moreover, no comprehensive national program evaluations have been conducted for LIHEAP despite mandates[18] that call for evaluative information to understand whether and why a program is working well or not.

Conversely, WAP has undergone several comprehensive national and local program evaluations since 1993 that assess the operations, cost-effectiveness, and non-energy benefits of the implementation and benefits of WAP[16]. The peer-reviewed and statistically robust national evaluations have demonstrated that weatherization provides cost-effective energy savings, health and safety benefits, support for job creation, and a stable platform for continued investment in energy efficiency[16, 22]. Specifically, WAP saves households an estimated average $283 annually alongside many other non-energy benefits[22]. Non-energy benefits garner $2.78 for every $1.00 invested into the program, providing more livable homes, fewer missed days of work and decreased out-of-pocket medical expenses by an average of $514 annually[22]. Although these evaluations expand our understanding of the benefits of WAP**,** the primary performance measure that was used to demonstrate program success, similar to LIHEAP, can be classified as distributive or production-based; specifically, the number of retrofits or low-income homes weatherized. Thus, performance measures have not appropriately assessed the effectiveness of energy efficiency improvements in solving the problem as outlined in the purpose of the established statute.

Although each program seeks to address the symptoms of energy poverty, the legislation creating each program did not formally recognize this problem. Consequently, reduction focused strategies or metrics embedded within a national energy poverty policy to understand the effectiveness of each program's response were not established. Nonetheless, each program has a list of successes, namely, reducing energy costs[23, 24], improving children's growth and health[24], retaining household warmth, and reducing greenhouse gas emissions[16, 26]. Despite measurable successes, without formal and comprehensive recognition of energy poverty, the effectiveness of current responses continue to be masked by poor performance measures not aligned with national energy poverty reduction.

This review of the LIHEAP and WAP program objectives and relevant policy documents juxtaposed to their fiscal imbalances reveals a dearth of definitions, measures, and program evaluations that limit a more accurate characterization of the prevalence, severity, and causes of energy poverty experienced in the United States.

2.4 US Recognition of and Response to Food Insecurity

In contrast to energy poverty, the prevalence and severity of other issues in the US have been recognized and understood more formally, namely, food insecurity. In 1990, the United States Department of Agriculture (USDA) formally established and endorsed a definition for food insecurity. The need for better monitoring and assessment of the nutritional state in the US led to the enactment of the National Nutrition Monitoring and Related Research (NNMRR) Act of 1990. Embedded within a 10-year comprehensive plan, the Act outlined a task to "recommend a standardized mechanism and instrument(s) for defining and obtaining data on the prevalence of 'food insecurity' or 'food insufficiency' in the United States and methodologies that can be used across the NNMRR program and at State and local levels"[27].

To develop the needed measure, the federal interagency working group, "the Food Security Measurement Project" was founded in 1992 and built on existing research, collaborating with the US Census Bureau and private-sector experts. The group ensured the final measure was appropriate and feasible for standard and consistent use across the country. Annual measurement began in 1995 by administering the food security questionnaire as a supplement to the current population survey. Initial analysis estimated the prevalence rates of food insecurity and produced a scale that measures the severity of deprivation in basic food needs as experienced across various household types. An assessment of the stability and robustness of the measurement model across years, major population groups, and household types established the stability of the food security measure[28]. This type of federal recognition demonstrates the measurement capacity required to respond and reduce energy poverty in the US.

2.5 UK Recognition of and Response to Fuel Poverty

2.5.1 Recognition

The UK became the first country in the world to formally recognize and strategically respond to fuel poverty[29]. The Warm Homes and Energy Conservation Act of 2000 established a target for ending fuel poverty 'as far as reasonably practicable' for all households within 15 years. This recognition prompted a legal commitment to produce a Fuel Poverty Strategy; thus, elevating the urgency of the problem. Formal recognition provided an ambitious policy objective with outcomes that mattered at the household level. The strategy initially defined a fuel poor household as "…one which needs to spend more than 10% of its income on all fuel use and to heat its home to an adequate standard of warmth"[30]. Despite insufficient follow-through in practical policies, formal recognition embedded within the UK strategy provided the impetus for understanding the prevalence and severity of fuel poverty through measurement.

The established fuel poverty definition was complemented with an associated metric/measure that benefited the UK nations in quantifying household energy requirements against the strategy. The "ten-percent indicator" catalyzed national fuel poverty measurement. However, the fixed threshold made this definition hypersensitive to changes in domestic energy costs and difficult to track the impact of implemented response measures that improved energy efficiency[31], thus concealing the impact experienced at the household level rendered this metric invalid.

The critiques of this definition and metric led to the English adoption of the Low-income High-cost (LIHC) metric in the updated 2015 Fuel Poverty Strategy[7]. The LIHC measure identifies fuel-poor households if incomes are lower than average and fuel costs are higher than average. This updated metric enabled better targeting and prioritization of English households living in the most severe cases of fuel poverty. However, the devolved nations retain the ten-percent indicator. Notwithstanding the capacity of the LIHC metric to identify fuel poor households, its relative nature is critiqued because it allows households to move in and out of fuel poverty[32] and obscuring the role energy markets have in producing fuel poverty[33].

Subsequently, the proposed Low-Income Low Energy Efficiency (LILEE) metric aims to broaden and update the current measure to an absolute measure – capturing all low-income households with high costs that live in inefficient homes[32]. The proposed measure identifies households as fuel poor if they live in property with an energy efficiency rating below Band C per the Fuel Poverty Energy Efficiency Rating (FPEER) system and if after housing costs and energy needs, their income would be below the poverty line[32]. Based on the government's Standard Assessment Procedure, FPEER assesses the energy performance of domestic properties whilst accounting for the direct impact policy interventions affect household energy costs[34]. The current high cost threshold would change to an absolute one while the income threshold remains unchanged per existing LIHC methodology. This metric is better aligned with the statutory fuel poverty targets described in the next section[32]. The formal recognition of fuel poverty in the UK as a distinct problem, separate from general poverty has allowed for an adaptive understanding of the problem's manifestation over time.

2.5.2 Response

Throughout the history of fuel poverty responses in the UK, household energy efficiency improvements were maintained as the primary and most cost-effective vehicle to address the negative impacts on health and well-being associated with living in a cold home. For example, from 2000 to 2013, England's Warm Front Home Energy Efficiency Scheme (WF) lessened the prevalence of fuel poverty whilst cutting greenhouse gas emissions and increasing annual incomes of households[35].

Key fuel poverty policies center on the implementation of energy efficiency for households. Expressively, this technical conception has been critiqued as potentially damaging, marginalizing other solutions towards income and living cost equality[33]. Even so, the 2014 statutory fuel poverty target for England echoes energy efficiency as the primary method and commits to ensuring that as many fuel poor households as reasonably practicable achieve a minimum FPEER rating by 2030 with interim targets by 2020 and 2025[36]. The 2015 strategy[6] in England emphasized more effective policy-making and delivery to address the structural problems of fuel poverty and to meet decarbonization goals. To tackle the least energy-efficient private rental properties in England and Wales, the Minimum Energy Efficiency Standards established a baseline efficiency for new and renewal tenancies based on FPEER. Coordination efforts between relevant health and housing policies with other departments initially hampered the implementation of energy efficiency assistance (WF) to households suffering the most. Since the demise of WF, no government funding is provided for energy efficiency. However, similar to on-bill financing schemes, the Green Deal supports energy efficiency through a pay-as-you-save private loan scheme for household energy efficiency upgrades[35]. The Energy Company Obligation (ECO) is an energy efficiency scheme in the UK aimed to tackle fuel poverty. The ECO levies money from each customer as a proportion of their bill, so all income groups contribute payments. The fund is then spent on energy efficiency improvements in people's homes. ECO is meant to be focused primarily on the fuel poor; however, the poor definition of eligibility limits effective targeting.

2.5.3 Evaluation

The Annual Fuel Poverty Statistics monitor progress against the 2015 statutory target and track (1) the proportion of households in fuel poverty using the LIHC indicator and (2) their fuel poverty gap, the reduction in fuel bill that the average fuel poor household needs in order to not be classified as fuel poor. These headline statistics are based on data collected by the English Housing Survey, a continuous national survey commissioned by the Ministry of Housing, Communities and Local Government and provides information about the housing circumstances, condition, and energy efficiency of English homes. These data are vital elements that support England's Department for Business, Energy, and Industrial Standard (BEIS) to develop, monitor, and evaluate the key fuel poverty policies[6]. To measure progress against the 2014 fuel poverty targets, BEIS is legally bound to use FPEER[33]. The Committee on Fuel Poverty (formally the Fuel Poverty Advisory Group) is a Non-Departmental Public Body sponsored by BEIS established to monitor the English Government's progress on the 2015 fuel poverty strategy and to provide independent, expert guidance on meeting milestones and targets[37]. The UK's fuel poverty evaluation approach provides the mechanisms to track policy goals with embedded public oversight to ensure the government is meeting those goals.

2.6 Moving Forward

There is an opportunity to explore the benefits demonstrated by UK fuel poverty and US food insecurity recognition, responses, and evaluation. Notably, formal recognition of US energy poverty would catalyze rapid energy efficiency investments, develop universal metrics to understand the landscape of US energy poverty, and align LIHEAP and WAP statutes with associated health outcome/impact performance measures.

To move towards a more nuanced understanding of and efficient response to energy poverty reduction, we suggest a more inclusive and efficient inquiry to energy poverty engagement that establishes the prevalence and severity of energy poverty experienced across the US, explores its drivers, determines reasonable energy poverty reduction objectives, investigates how existing policy and programs compliment and coordinate innovative solutions to achieve set objectives, evaluates the effectiveness of deployed solutions, and assesses how such solutions may be optimized for climate adaptation. Ultimately, we hope that this leads to the establishment of a statutory amendment that tasks the development of an independent interagency working group and a national energy poverty strategy including a definition and comprehensive measurement and evaluation of local, state, and national progress towards set reduction objectives in the United States.

The development of an energy poverty strategy, including definition, metrics, and solutions must be reflected in principles of risk assessment. Failing to acknowledge the risk, or potential harm that may occur with living in sub-standard housing, or lack of household energy should be regarded as a threat to national well-being and potential to rival other nations and spur economic growth. In recognizing the risks to public health vis-à-vis household energy poverty[4, 41], risk characterization provides a lens that encourages problem formulation of energy poverty. Risk characterization accurately describes hazardous situations in a way that reflects the significant concerns of the interested and affected parties[42]. This decision-relevant description should be understood and accessible to the parties and pubic officials[42]. The usefulness of risk characterization and subsequent risk analysis will fail if the perspectives and knowledge of the interested and affected parties are absent[42,43]. Applying the techniques of risk analysis and characterization are essential in making informed decisions on human health, welfare, and the environment as linked to energy poverty. Problem characterization and solution interventions should employ an energy vulnerability perspective. Energy vulnerability recognizes the multidimensionality of household energy poverty and offers a new lens to characterize the problem spatially and temporally whilst seeking understanding of the dynamics that influence a household's energy poverty risk. Through this lens, energy poverty is recognized as a 'state' within a certain temporal frame and identifies vulnerability as a set of conditions leading to such circumstances in that state[41,44]. Thus, energy vulnerability thinking can be seen as probabilistic, highlighting the factors that influence the likelihood of becoming energy poor[41]. Correspondingly, a consistent, comprehensive definition of energy poverty centered on the notion of energy vulnerability is vital to formally recognizing energy poverty and bridging the assessment gap between scholars, policymakers, and program managers. Thus, we propose to define US energy poverty as a state where households are challenged by everyday situations in meeting basic energy needs because of an assemblage of socio-economic, technical and environmental-political factors[4, 45, 46]. Factors known to be associated with energy poverty include gender, age, housing age, tenure type, energy inefficiency, education, employment, geography, socioeconomic status, and race/ethnicity[39,47,48].

Given the multidimensionality and variation of energy poverty across the diverse climate zones, the production of data that characterizes this problem for the US should be intentional in its exploration. Thus, the development of quality indicators and data sets would aid capturing the essence of this problem beyond existing energy affordability measures. A standardized national instrument developed in concert with the independent, interagency working group is critical to understanding the landscapes of energy poverty temporally.

Equipped with the capability to measure different dimensions of energy poverty, reasonable reduction-based objectives surface as an opportunity for local development and national coordination. Objectives establish baseline goals through which energy poverty reduction can be assessed and achieved. Formal energy poverty recognition alongside reduction-based objectives and performance measures would better align LIHEAP and WAP as an official energy poverty strategy that encourages longitudinal data collection and innovative solutions.

The separate federal channels for LIHEAP and WAP limit opportunities for coordination, promote redundant administrative and reporting duties for states and local agencies, and maintain incompatible eligibility requirements. We envision a restructuring that collapses the processes and procedures of LIHEAP and WAP under the DOE given their demonstrated measurement and evaluative efforts and WAP's more expansive statutory purpose. Such restructuring would require a good data base and would promote alignment of broader public health[4] and carbon mitigation goals[15] with interim targets for energy poverty elimination by 2030 and 2050.

Energy efficiency evaluation, measurement, and verification are vital in demonstrating the financial benefits of bill assistance and the multiple benefits of energy efficiency[49]. Reduction focused performance measures and program evaluations offer a means to incorporate existing WAP evaluation components aimed at minimizing environmental and health risks whilst maximizing energy and cost savings. Periodic evaluation would maintain a record of the effectiveness of deployed responses. Energy poverty and its responses can then be reassessed to understanding how the landscape has changed and how the problem of energy poverty has evolved.

2.7 Conclusion

We contend that the absence of formal energy poverty recognition at the federal level has limited a more precise response and more inclusive understanding of the prevalence, severity, and causes of energy poverty in the US. Issues of energy poverty remain omnipresent across the US despite the presence of local, state, and federally-funded energy assistance programs for energy burden reduction. Historically, the US has entrenched its assessment and response to energy poverty through national programs based on low household incomes and relative energy burdens, which has constrained the understanding and targeting potential of energy poverty exclusively towards affordability and away from related health outcomes as a result of household inefficiencies.

Congressional funding appropriations showcase the primary response and disproportionate support that LIHEAP historically receives compared to WAP and elucidate the disparity in investments of federal resources aimed at responding to energy poverty, despite LIHEAP's design as a short-term solution. We do not highlight the disparities in congressional funding as a means to bolster support for its discontinuation or disinvestment. Rather, these disparities magnify the need for purposeful performance measures and systematic program evaluations that underpin the process in funding federal energy assistance programs.

Current performance measures and program evaluations hinge on distributive targets—focusing on the number of households assisted. The consequences of distributive focused performance measures are a product of mischaracterizing US energy poverty and a quotient of its evaluation history that all suggest the inadequacies of LIHEAP to holistically ensure the reliability of adequate household energy services alone. The lack of energy poverty reduction targets and health improvement targets within performance measures that are critical in examining near and far term understanding of energy poverty reduction and responses.

Moving forward, a statutory amendment is needed that defines energy poverty, promotes its reduction, and develops performance measures to more inclusively understand and evaluate the impact of all energy poverty responses. Energy vulnerability thinking can connect the analysis of inequities in vulnerability to household energy poverty. This perspective maintains the significant role data driven evaluation, measurement, and verification of outcomes have on minimizing environmental and health risks whilst maximizing energy and cost savings. Energy vulnerability framing in concert with energy and environmental justice principles[38, 39] amplify the need for adequate access to affordable household energy and recognizes its importance as a national policy issue. This reframing prompts a research agenda and policy action to ameliorate US energy poverty.

To solve the multidimensional issues of energy poverty, the US must develop an expansive framework and respond with clarity. Fortunately, there is an opportunity to tackle energy poverty, which is being exacerbated by climate change and unjust energy transitions, by leveraging the history, shortfalls, and innovation of formal fuel poverty recognition and responses in the UK. The preponderance of household energy inequities that plague low-income and households of color will intensify without first acknowledging the realities of energy poverty in the US.

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Chapter 3 A Multidimensional Understanding of Factors Associated with Energy Poverty Vulnerability in the United States

Abstract

Energy poverty plagues millions of American households annually, jeopardizing their access to modern energy services. Without formal recognition of energy poverty nationally, much of the current discourse in the United States centers the energy burden metric, or the amount of a household's income spent on energy costs. Consequently, more nuanced understandings of factors that influence the causes, severity, and prevalence of energy poverty are shielded. This paper asks: What factors are associated with the propensity to experience varying levels of energy poverty? To help answer this question, I employ a proportional odds logistic regression model across 16 technical, socio-economic, and environmental factors. Additionally, I develop an energy poverty severity scale based on life threatening conditions and experiences. I explore descriptive statistics of energy poverty severity across various socio-spatial dimensions. I find that varying factors influence the likelihood of experiencing higher levels of energy poverty. This paper demonstrates the vitality of a multi-dimensional approach to energy poverty characterization, measurement, and evaluation. Moreover, this work encourages more nuanced approaches to understanding and alleviating energy poverty in the United States.

3.1 Introduction

Energy poverty afflicts millions of American households annually, compromising their access to reliable, affordable, and sustainable energy required to fully embrace a healthy and thriving life. In 2015, the Energy Information Administration found that one out of every three American households experience some form of energy poverty annually (EIA, 2015). Despite data that support and describe energy poverty experiences as a distinct issue–it is not formally recognized nationally (Bednar and Reames, 2020). Programs at the federal, state, and utility level seek to mitigate instances of energy poverty through bill payment relief and household weatherization. These programs recognize elderly people and households with children as vulnerable populations. However, actual vulnerability to energy poverty and those classified as most vulnerable to experiencing it are often incongruent with policy understanding and programmatic solution implementation (Raissi and Reames, 2020).

Much of the current energy poverty debate focuses exclusively on residential energy burdens, or the percent of income spent on energy costs. This focus prevents more nuanced understandings of the factors that influence the likelihood of experiencing energy poverty. Moreover, this approach often hampers efforts to effectively target the most vulnerable populations when other socio-spatial demographics are not considered (Reames, 2016). To address these drawbacks, energy vulnerability has surfaced as a more expansive framework for recognizing energy poverty as a multidimensional issue (Bouzarovski and Petrova, 2015).

Responses to energy poverty experiences signal the importance of energy services. For example, date and temperature-based protections shield household energy shut-offs at specific times and temperature thresholds during the year (Franklin et al, 2017). Yet still, we know little about the causes, severity, and prevalence of energy poverty across the United States.

Accordingly, this paper asks: What factors are associated with the propensity to experience varying levels of energy poverty? This paper seeks to understand these energy vulnerability factors to encourage a more expansive characterization, measurement, and evaluation of energy poverty.

First, the paper provides a brief literature review of relevant factors associated with energy poverty and its related consumption and efficiency indicators. Next, data and methods used for this study are described alongside the development of the novel energy poverty severity scale. Then, results are presented. Finally, the paper concludes by reiterating the importance of data, measurement, and evaluation in energy poverty recognition and response.

3.2 Background

U.S. energy poverty is "a state where households are challenged by everyday situations in meeting basic energy needs because of an assemblage of socioeconomic, technical and environmental–political factors" (Bednar and Reames 2020). Socioeconomic factors include household income, race/ethnicity, gender, and number of household members. Technical factors involve age of housing structure and appliances, levels of insulation, and frequency of drafts. Environmental-political factors detail spatial dynamics such as varying heating and cooling degree days as well as relevant energy policy and programs that impact households.

3.2.1 Socioeconomic Factors

Castaño-Rosa et al. (2018) demonstrate that an increase in the number of children in the household resulted in an increase in energy vulnerability level. Additionally, a reduction in income due to monthly medication expenses increased household energy vulnerability (Castaño-Rosa et al., 2018). Tonn and Eisenberg (2007) note that elderly households consume more energy per capita than other households because they spend more time in their homes and tend to be more sensitive to cold conditions, which makes prospective increases in energy prices particularly problematic. In their examination of lifestyle and home energy conservation in the U.S., Dillman et al. (1983) find that low-income households accept lifestyle cutbacks while the wealthy invest in conservation. Further, Cutter and Finch (2008) note that race/ethnicity, socioeconomic position, and gender are among the most common characteristics that define vulnerable populations, along with migration and housing tenure (renter or owner). Along these lines, Bednar et al. (2017) find that underrepresented racial/ethnic residents are more likely to live in energy inefficient homes.

3.2.2 Technical Factors

In the technical domain, the main drivers behind residential energy consumption have been found to be the floor area, dwelling efficiency, household heating patterns, and living room temperature (Kelly, 2011). Castaño-Rosa et al. (2018) show that an increase in energy vulnerability can result from increased energy consumption due to the damage of insulation in the dwelling. As a function of consumption, energy insecurity can also be influenced by household inefficiencies (Healy and Clinch, 2004). Energy-efficient improvements in heating and water-heating installations can decrease household energy vulnerability (Castaño-Rosa et al., 2018).

3.2.3 Environmental – Political Factors

State policies and programs can extend and strengthen energy efficiency efforts and advance building energy codes to alleviate high energy burdens while providing households with more choices in how they use energy (Berg et al., 2017). Federal budget appropriations for energy assistance programs can also alter a household's energy vulnerability level, considering that funding is not a part of an entitlement (mandatory) grant. Extreme weather events such as lower-than-average winter temperatures can increase heating degree days (HDD) and consequently increase household energy costs. Conversely, higher-than-average summer temperatures can increase the number of cooling degree days (CDD) and associated increases in energy costs.

3.3 Data and Methods

3.3.1 Data Source

This paper uses data from the 2015 Residential Energy Consumption Survey (RECS). The 2015 RECS is a nationally representative sample of housing units administered by the U.S. Energy Information Administration (EIA). The dataset captures useful information on characteristics of the housing unit, energy usage patterns, and household demographics. Data are also available regarding the frequency of energy poverty experiences. The 2015 RECS used a multistage area probability sample design, dividing the population from designated Census Public Use Microdata Areas (PUMAs) into Census block groups and ultimately, into individual housing units. In total, the 2015 RECS sampled 5,686 housing units representing 118.2 million occupied households nationally. Sampling weights from the 2015 RECS were used to produce a representative population estimate of all households. The weights were post-stratified to the

2015 American Community Survey, estimating a total of 118.2 million occupied housing units in the United States.

3.3.2 Development of Energy Poverty Severity Scale

To explore the multidimensional nature of energy poverty, this paper characterizes an energy poverty severity scale that delineates varied levels of energy poverty experiences. The scale is developed as a response variable that collapses 11 variables from the 2015 RECS dataset. Measures were selected of household-level energy poverty that describe the amount and per month frequency of: reporting any energy insecurity, reducing or forgoing basic necessities to pay home energy bill, leaving home at unhealthy temperatures, receiving a disconnect or delivery stop notice, and heating and cooling equipment are unusable . The response variable, energy poverty, is comprised of three ordered levels: no energy poverty, moderate energy poverty, and severe energy poverty, with assigned values zero, one, and two, respectively. Table 3-1 displays the developed energy poverty severity levels with its corresponding variables.

Table 3-1:Energy poverty severity development

Energy Poverty Severity Level	RECS(2015) Variables used to develop energy poverty levels
None (0)	
Moderate (1)	Forgo basic necessities due to home energy bill
	Received a disconnect notice
	Keeps home at unhealthy temperatures
Severe (2)	Required medical attention - home too hot
	Required medical attention - home too cold
	Unable to use heating equipment because it was broken and could not afford repair/replacement
	Unable to use cooling equipment because it was broken and could not afford repair/replacement
	Unable to use heating equipment because could not afford and were disconnected(or not delivered for bulk fuel)
	Unable to use cooling equipment because could not afford electricity and it was disconnected

To initialize the variable, households that do not report any experiences of energy poverty are assigned a value of zero. Households that reported at least one non-life-threatening experience of energy poverty; namely, forgoing basic necessities due to home energy bill; receiving a disconnect notice; or keeping their home at unhealthy temperatures, were characterized as moderate level of energy poverty.

Finally, households that reported at least one of the following life-threatening experiences were characterized as severe energy poverty: medical attention needed because home was too hot or too cold; unable to use heating or cooling equipment in the last year because it was broken and they could not afford repair/replacement; unable to use heating equipment in the last year because they could not afford it and were disconnected (or not delivered for bulk fuel); and unable to use cooling equipment in the last year because could not afford electricity and it was disconnected.

3.3.3 Ordered Logistic Regression

Under the traditional approach, an ordered logistic or proportional odds model (McCullagh, 1980) is a tool used to examine the determinants of ordinal-level outcomes. Ordinal logistic regression is most suitable when the dependent or outcome variable has more than two categories and each of the values have a meaningful and sequential order. The utility of this regression model is that as one independent (predictor) variable increases it results in a shift to either end of the spectrum of the ordinal response. Said another way, this type of logistic regression models the relationship between predictor variables and the propensity to be in each higher ordered category.

An important assumption underlying ordinal logistic regression is the proportional odds assumption or parallel regression assumption, which states that coefficients that describe the relationship between the lowest outcome versus all higher categories of the response variable are the same as those that describe the relationship between the next lowest category and all higher categories. In other words, the relationship between each pair of outcome groups is the same. The distance between categories is assumed to be unknown and that a latent variable underlies the response categories (Harrell, 2001). The proportional odds model, for a response variable Y having levels 0, 1, 2, . . . , k is as follows:

$$\Pr\,[Y \geq j \mid X] = \frac{1}{1 + exp\left[-\left(\alpha_j + X\beta\right)\right]'} \qquad \text{eqn (1)}$$

where j =1, 2, … , k. There are k intercepts (alphas). Using a common vector of coefficients, β connects probabilities for varying j. The proportional odds model enables parsimonious modeling of the distribution of Y. The independent variables are represented by X.

The ‘svyolr’ function from the R package, SURVEY (Lumley, 2020; 2010; 2004) was used to compute the log-odds ratios and confidence intervals. Each were then exponentiated to determine the relevant odds-ratios that describe the likelihood of each factor increasing a household from one level of energy poverty to the next.

3.3.4 Model Inputs

The rationale for choosing energy poverty vulnerability factors is based on the published literature. These measures were segmented into three categories of energy vulnerability, namely, technical, socio-economic, and environment-policy, which help identify and describe energy poverty experiences. Sixteen measures were selected from the 2015 RECS iteration to explore associations that influence vulnerability to household energy poverty in the United States. The technical energy vulnerability variables included in the model are: Housing construction year, adequate insulation, and presence of draft. The socio-economic energy vulnerability variables included in the model are: Housing tenure (renter occupied vs owner occupied vs no rent[2]) household income, total dollar spent on energy, householder race (and Hispanic descent), householder sex, presence of elderly, children, or greater than four household members. The environment-policy variables included in the model are: Census division, census urban type, heating and cooling degree days, and energy assistance. The aforementioned dimensions and variables reflecting them each are depicted in Table 3-2.

[2] Occupied without payment of cash rent

Table 3-2: Variables used in proportional odds model

Energy Vulnerability Category	RECS (2015) Variable
Technical	Adequate Insulation
	Presence of Draft
	Structure Year Built
Socio-economic	Income
	Total dollar spent on energy
	Housing Tenure
	Race/Ethnicity
	Sex
	Household w/ Child
	Household w/ Elder
	Household w/ 4 + members
Environment-Policy	Census division
	Census 2010 Urban Type
	Cooling Degree Days
	Heating Degree Days
	Received Energy Assistance

3.4 Results

3.4.1 Descriptive Statistics

This section presents descriptive statistics results for the energy poverty severity scale developed herein.

3.4.1.1 Energy Poverty by Race/Ethnicity

Figure 3-1 displays the percentage of households by race/ethnicity that experience some level of energy poverty (moderate and/or severe). Indigenous households experience levels of energy poverty two times greater than white households (52% vs. 26%) and 2.4 times greater than Asian households (52% vs. 22%). Additionally, Black households experience levels of energy poverty nearly twice that of white households (51% vs 26%). Latinx households experience levels of energy poverty more than twice that of Asian households (46% vs. 22%) and nearly twice that of white households (46% vs. 26%).

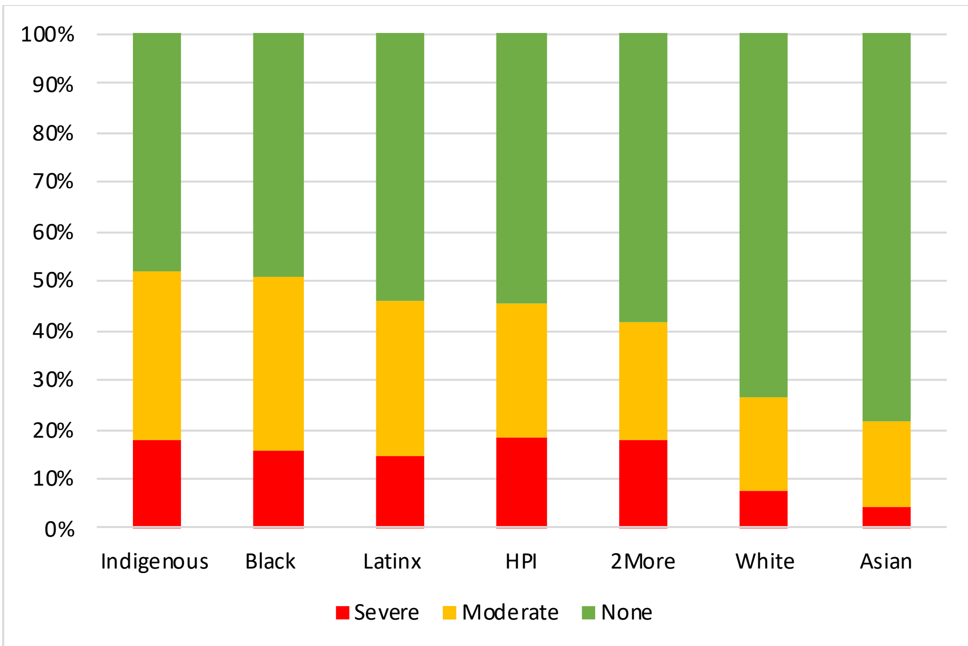

Figure 3-1: Energy poverty severity by household race/ethnicity

3.4.1.2 Energy Poverty by Housing Tenure

Figure 3-2 displays energy poverty severity by housing tenure. Renters experience energy poverty 1.8 times greater than homeowners (43% vs. 24%). No-rent households experience energy poverty 1.4 times greater than homeowners (34% vs. 24%). Even among homeowners, 24 percent of these households experience some level of energy poverty.

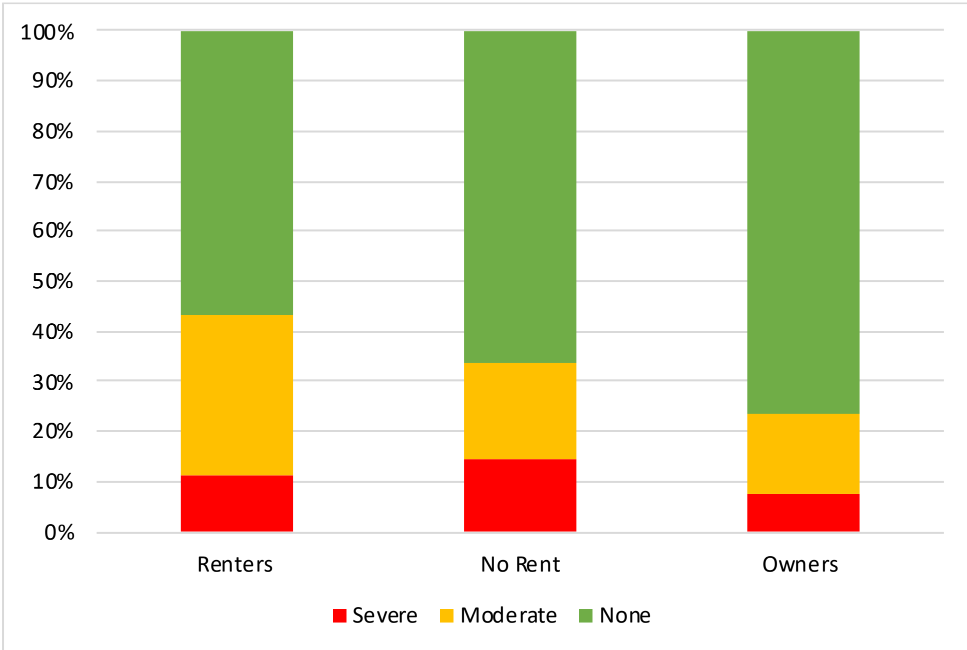

Figure 3-2: Energy poverty severity by housing tenure/ownership status

3.4.1.3 Energy Poverty by Income

When looking at energy poverty severity across household income, all groups experience some level of energy poverty (See Figure 3-3). Fifty percent of households making less than $20,000 annually experience moderate and severe levels of energy poverty. As expected, energy poverty experiences dwindle as household income increases.

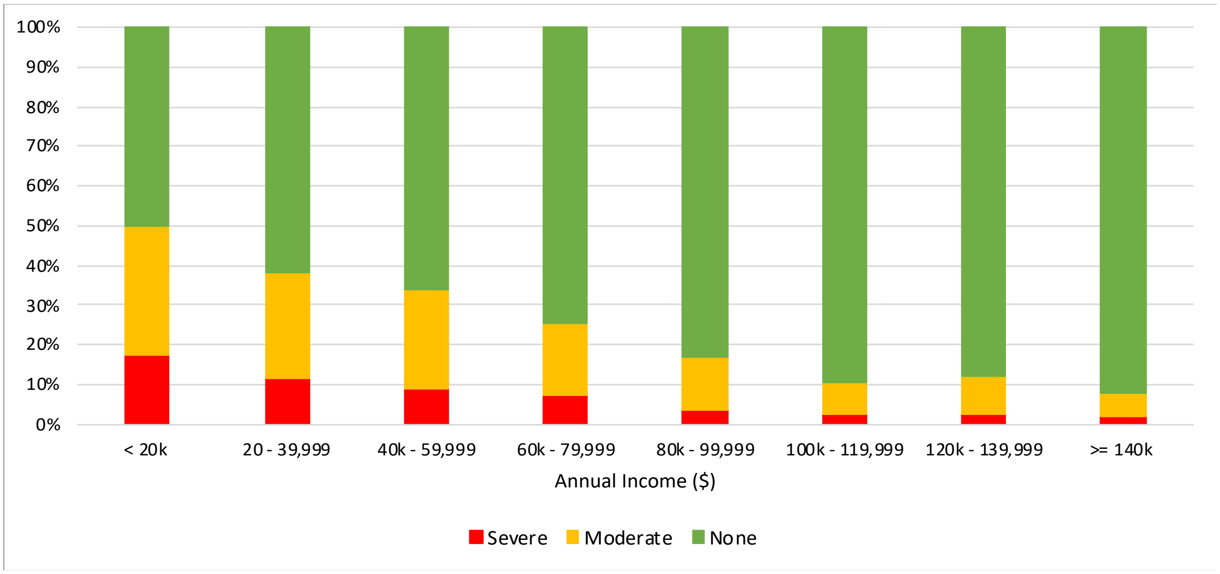

Figure 3-3: Energy poverty severity by annual household income (year 2015)

3.4.1.4 Energy Poverty by Census Division

The distribution of energy poverty experiences varies across all census divisions in the United States. East south central and New England divisions have the greatest percentage of households experiencing energy poverty.

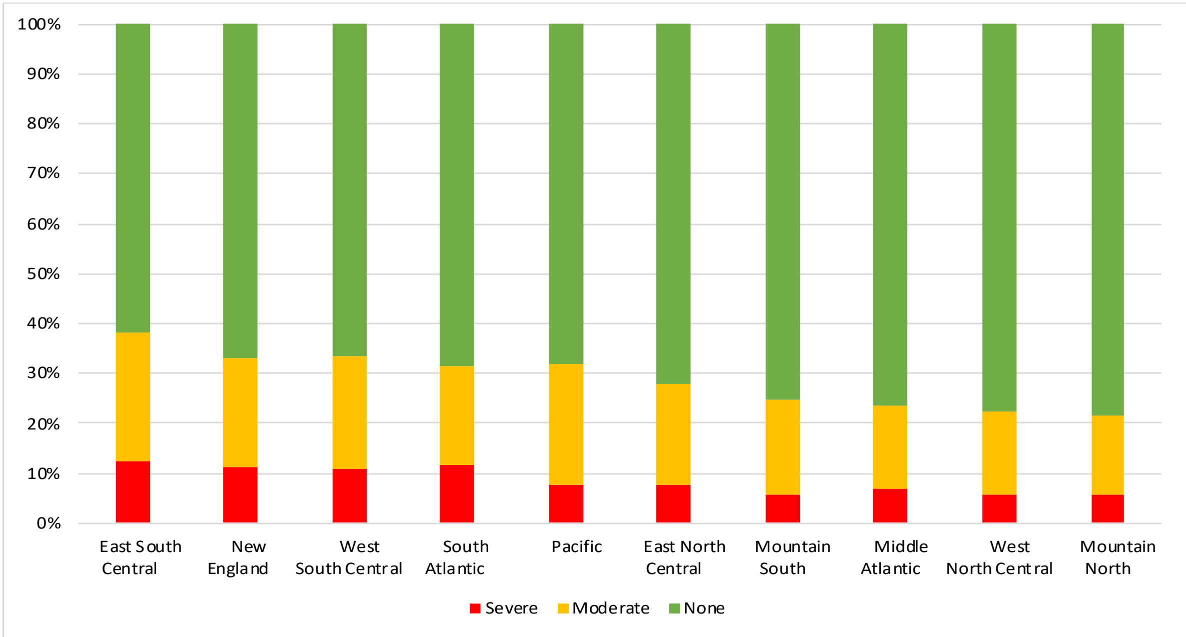

Figure 3-4: Energy poverty severity by US census division

<u>3.4.2 Ordinal Logistic Regression Model</u>

Table 3-3 shows the results of the ordinal logistic regression displaying the odds ratios (OR) and 95% confidence intervals (CI).

Table 3-3: Multivariate ordered logistic regression for energy poverty severity

	Dependent Variable = Energy Poverty	
	Odds Ratio	(95% Confidence Interval)
Less than $20k	2.54***	(1.96, 3.30)
$20k - $39,999	1.88***	(1.48, 2.40)
$40k - $59,999	1.57***	(1.22, 2.02)
$60k - $79,999	**Ref**	
$80k - $99,999	0.65**	(0.47, 0.90)
$100k - $119,999	0.33	(0.22, 0.50)
$120k - $139,999	0.36	(0.23, 0.56)
$140K or >	0.21	(0.13, 0.35)
Total Annual Energy Costs($)	1.00***	(1.00, 1.00)
Homeowner	**Ref**	
Renter	1.19***	(1.00, 1.43)
No Rent Pay	1.16	(0.52, 2.58)
Well Insulated	**Ref**	
Adequately Insulated	1.13	(0.94, 1.35)
Poorly Insulated	1.39***	(1.09, 1.629)
Not Insulated	1.38	(1.460, 1.78)
No Draft	**Ref**	
Drafty Always	3.86***	(2.73, 5.45)
Drafty Most Times	2.98***	(2.26, 3.94)
Drafty Sometimes	1.56***	(1.31, 1.85)

	Dependent Variable = Energy Poverty	
	Odds Ratio	(95% Confidence Interval)
Before 1950s	**Ref**	
1950-1959	1.15	(0.86, 1.52)
1960-1969	1.04	(0.80, 1.36)
1970-1979	1.03	(0.81, 1.30)
1980-1989	1.080	(0.83, 1.40)
1990-1999	0.97	(0.72, 1.30)
2000-2009	0.84	(0.64, 1.09)
2010-2015	0.94	(0.61, 1.45)
white	**Ref**	
Black	1.55***	(1.24, 1.93)
Indigenous	2.53***	(1.36, 4.70)
Asian	0.73	(0.47, 1.12)
Hawaiian/Pacific Islander	1.55	(0.32, 7.58)
Two or more Race/ethnicity	1.48	(0.92, 2.37)
LatinX	1.57***	(1.26, 1.95)
No Child in Household	**Ref**	
Child in Household	1.18*	(0.97, 1.43)
No Elderly household member	**Ref**	
Elderly household present	0.52***	(0.44, 0.63)
Less than 4 household members	**Ref**	
Four or more household members	1.39***	(1.13, 1.73)

	Dependent Variable = Energy Poverty	
	Odds Ratio	(95% Confidence Interval)
Male	**Ref**	
Female	1.31***	(1.13, 1.51)
East-North Central	**Ref**	
New England	1.24	(0.85, 1.81)
Mid-Atlantic	0.80	(0.60, 1.07)
West-North Central	0.82	(0.62, 1.09)
North-South Atlantic	0.88	(0.62, 1.09)
East-South Central	1.06	(0.73, 1.54)
West-South Central	0.84	(0.58, 1.24)
Mountain North	0.71*	(0.47, 1.07)
Mountain South	0.56**	(0.33, 0.95)
Pacific	0.87	(0.62, 1.20)
Urban Cluster (Population 2.5k - 50k)	**Ref**	
Urban Area (Population >50)	1.02	(0.77, 1.34)
Rural	0.93	(0.76, 1.14)
CDD65	0.99	(0.99, 1.00)
HDD65	0.99**	(0.99, 1.00)
No Energy Assistance	**Ref**	
Received Energy Assistance	2.73***	(2.18, 3.43)
Observations	5,686	
Note:	*p<0.1; **p<0.05; ***p<0.01	

Technical/physical structure variables

Residents with worse insulation levels compared to well insulated homes have higher odds of experiencing higher levels of energy poverty. For example, households that reported poorly insulated or not insulated are 39 and 38 percent more likely to experience higher levels of energy poverty than households reporting well insulated. Not insulated housing units were not statistically significant. Relatedly, households that reported a frequency of always experiencing a draft in the home and most of the time are 286 and 198 percent, respectively, more likely to experience higher levels of energy poverty than households that report never having a draft. The age of housing stock was not statistically significant for any year.

Demographics

Underrepresented racial/ethnic residents have increased odds of being in energy poverty compared to white residents. Indigenous, LatinX, and Black households are 153, 57, and 55 percent, respectively, more likely to experience higher levels of energy poverty compared to white households. Households with an elderly member present are 48 percent less likely to experience higher levels of energy poverty as compared to homes without an elderly resident. Households with children are 18 percent more likely to experience higher levels of energy poverty than homes without children. Households with four or more persons in the home are 39 percent more likely to experience higher levels of energy poverty than homes with less than four members. Respondents that identify as female head of household are 31 percent more likely to experience higher levels of energy poverty than their male counterparts.

Income

Having annual household incomes $80,000 or more is associated with reduced odds of being in higher levels of energy poverty compared to incomes in the $60,000–$79,999 range. For example, households making less than $20,000 annually, between $20,000 and $39,999, and between $40,000 and $59,999 are 154, 88, and 57 percent more likely to experience higher levels of energy poverty as compared to the $60k–$79k range. Exploring housing tenure status, renters are nearly 19 percent more likely to experience higher levels of energy poverty as compared to owners. Occupied households who do not pay cash rent were not statistically significant.

Environment

When exploring census divisions, residents living in the Mountain North and South divisions are 29 and 44 percent, respectively less likely to experience higher levels of energy poverty as compared to the East North Central census division. Residents living in all other census divisions were not statistically significant.

Households living in an Urban Area, defined as having a population greater than 50 thousand people, and households living in Rural Areas (outside an Urban Area) were not statistically significant as compared to Urban Cluster households. Cooling degree days did not have a significant effect on increasing the odds of experiencing energy poverty. However, heating degree days did have a statistically significant effect, marginally increasing the odds of elevated energy poverty severity levels.

Households that reported receiving energy assistance are 173 percent more likely to experience higher levels of energy poverty than those that do not receive assistance.

3.5 Discussion

This study illuminates our understanding of U.S. energy poverty severity and finds that various technical, socio-economic, and environmental factors influence the odds of a household to experience higher levels of energy poverty. Poor insulation and more frequent draftiness had a significant effect on increasing a household's odds of experiencing higher levels of energy poverty. These findings support existing research claims that energy efficiency and weatherization upgrades have health and financial benefits for low-income homes, as households experience unhealthy temperatures and draftiness much less post-weatherization (Tonn et al, 2021). However, weatherization alone is insufficient in addressing the totality of issues faced by low-income households (Hernandez and Phillips, 2015). Age of housing stock, however, did not have a significant effect on energy poverty severity. Though, poor insulation and draftiness could be used as a proxy to better understand efficiency in older housing. Despite older homes traditionally being more energy inefficient, future work should explore cultural understandings of thermal comfort and older housing dwellings (Roberts and Henwood, 2019).

Low annual household incomes, as expected, increase the odds of experiencing higher levels of energy poverty. Often marginalized Black, Brown, and indigenous households have increased odds of experiencing higher levels of energy poverty. These results corroborate existing research that demonstrates racial disparities in energy poverty (Tong et al, 2021; Wang et al, 2021; Reames, 2016; Bednar et al, 2017) and energy burden (Drehobol et al, 2020). Moreover, female identified households are also more vulnerable to increased levels of energy poverty (Robinson, 2019). Future research should continue to explore the interrelated effect of race and gender in energy poverty vulnerability.

Census divisions were not significant in demonstrating increased odds of experiencing higher levels of energy poverty beyond the mountainous regions of the U.S. This might indicate that energy poverty experienced is not constrained to a particular region of the country. However, although not significant, Urban Areas showed marginally higher odds of being in energy poverty as compared to rural areas, which were 7 percent less likely to experience energy poverty. Notwithstanding the aforementioned findings, a 2018 report by the American Council for an Energy Efficient Economy (ACEEE) and the Energy Efficiency for All (EEFA) coalition demonstrated the importance of spatiality, particularly considering that a high concentration of low-income households reside in rural areas (41 percent of households) (Ross and Drehobol, 2019).

Heating degree days showed a significant effect on marginally decreasing the odds of experiencing energy poverty. Cooling degree days, on the other hand, did not have a significant effect. However, energy poverty literature tends to focus on cold homes and space heating, often excluding warmer homes and space cooling (Thomson et al, 2019). Future research should take a longitudinal approach to investigating the multiple dimensions that influence energy poverty severity across various climates, particularly given rising temperatures.

3.6 Conclusion

In this paper, I have defined energy poverty severity using the EIA 2015 RECS data. I applied an ordinal logistic regression model to better understand the factors that influence the severity of energy poverty in the U.S. In addition to formal recognition of energy poverty, annual and longitudinal survey instruments would provide a vehicle to understanding the nuances embedded within the multidimensionality of U.S. energy vulnerability. Ultimately, this work provides policy makers with an understanding of the multiple dimensions of energy poverty vulnerability and may inspire more targeted and holistic responses to this issue in the U.S.

To complement and further this study, future research could explore energy vulnerability factors at a more granular level and evaluate trends over time. For example, understanding how (i) energy vulnerability fluctuates across municipal and state boundaries and (ii) divergent policy approaches to energy efficiency and bill payment assistance are applied in these jurisdictions would lead to more targeted approaches toward energy assistance. I propose that eligibility requirements that consider the physical structure of the home and the ability of a household to regulate thermal comfort should be included in energy poverty assessments. Moreover, to better target the most vulnerable households, special attention should be paid to households with women, children, and multiple household members.

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Chapter 4 Towards Energy as a Human Right: State and Utility Level Disconnect Policies in the United States During COVID-19

Abstract

The United Nations' Sustainable Development Goals promote access to affordable, reliable, sustainable and modern energy for all, yet millions of American households suffer from energy poverty, threatening their continued access to electricity. Disparities in access to affordable and sustainable household energy have been documented spatially, racially, and economically. While policies supporting energy protections have been in place for years, they vary spatially. The COVID-19 pandemic of 2020 unveiled the entrenched environmental and energy injustices that threaten public health at the household level and inspired energy protection responses to address pandemic-caused economic hardship. This paper explores the responses implemented in 25 major metropolitan areas in the United States. We employ a content analysis of policy language to examine the urgency and binding level of COVID-19 era protections, demarcating them as either mandatory or voluntary measures. We characterize a suite of residential energy protections as 'energy resiliency responses' required to reduce vulnerability to energy poverty and build resilience during the pandemic. We examine the total number and type of responses relative to household energy burden. We find differences in consumer energy protections among low-income and highly energy burdened households and conclude that protections are unevenly deployed across the country. Our findings motivate contemporary

national, state, and local energy poverty recognition and responses that center personal and economic wellbeing during and after crises.

4.1 Introduction

The United Nations' seventh Sustainable Development Goal aims to "[e]nsure access to affordable, reliable, sustainable and modern energy for all". While many may consider inconsistent access to electricity a problem unique to less industrialized nations, the U.S. Energy Information Administration reports that one third of American households suffer from energy poverty, threatening their access to uninterrupted electricity (EIA, 2015). Energy poverty is "a state where households are challenged by everyday situations in meeting basic energy needs because of an assemblage of socio-economic, technical and environmental–political factors." (Bednar and Reames, 2020). Energy burdens describe a percentage of income spent on home energy cost. Nationally, nearly 31 million households experience high energy burdens[3] with nearly 16 million of these households facing severe energy burdens[4] (Drehobl et al, 2020).

The 2020 pandemic caused by a novel coronavirus and disease resulting from infection (COVID-19) and subsequent economic fallout exacerbated existing energy poverty and introduced new experiences of it. On March 11, 2020, the World Health Organization (WHO) declared COVID-19 a pandemic and many jurisdictions imposed shelter-in-place orders that shifted energy consumption levels from schools and workplaces to households. In the early months of the pandemic, 2.4 million U.S. households could not pay their energy bills and 1.7 million households received an energy disconnect notice (Memmott et al, 2021). Combined,

[3] High energy burdens are defined as energy expenditures greater than 6% of annual household incomes.
[4] Severe energy burdens are defined as spending greater than 10% of annual household incomes on energy expenditure.

energy burden and energy poverty threaten access to the affordable and reliable energy required for safety and welfare, especially during a pandemic.

For most households, energy consumption is a non-discretionary portion of their budget, enabling basic living needs to be met, such as food storage, cooking, lighting, heating, and cooling. In the case of highly energy burdened households, Bohr and McCreery (2020) demonstrated that high energy burdens can imperil household members' future economic wellbeing, presenting challenges for upward economic mobility (Bohr and McCreery, 2020). Moreover, highly energy burdened households are often simultaneously challenged by, "physical and mental health, education, nutrition, job performance, and community development" (Drehobl et al, 2020). As a result of these intersecting social burden, high energy burdened households are more vulnerable to utility debt and succumbing to energy poverty. Similarly, low-income and people of color households are more likely to have higher energy burdens and occupy energy inefficient homes (Bednar et al, 2017). Poor housing characteristics have been shown to increase psychological distress (Evans, 2003) and increased air pollutant exposure for lower socioeconomic households (Adamkiewicz et al, 2011). Correspondingly, households comprised of members of historically underserved racial groups face disparities in air conditioning access, likely contributing to higher heat-related mortality in these populations (O'Neill et al, 2005). Energy poverty is a public health issue (Jessel et al, 2019; Hernandez, 2016) that is not formally recognized nationally despite state and local responses (Bednar and Reames, 2020).

Unemployment, combined with increased time spent at home, has impaired several households' ability to pay for basic energy services. Together, the intersection of the COVID-19 pandemic and the concomitant social, economic, and environmental health issues characterizes a much larger and more complex problem—a syndemic. A syndemic, or synergized pandemic, "is characterized by biological and social interactions between conditions and states, interactions that increase a person's susceptibility to harm or worsen their health outcomes" (Horton, 2020). A syndemic approach characterizes the complexity of these intersections and helps illuminate synergistic failures stemming from systemic racism and troubled political leadership (Mendenhall, 2020). Framing in this way enables a more expansive understanding of factors that influence a households' ability to secure energy access and respond to disruptive events.

Principally, energy access is important to building overall resilience. Resilience has been described by the Intergovernmental Panel on Climate Change (IPCC) as "the ability of a system and its component parts to anticipate, absorb, accommodate, or recover from the effects of a potentially hazardous event in a timely and efficient manner" (Lavell et al, 2012). However, resilience within the energy landscape often encapsulates both positive and negative attributes, including reliability and inequality, respectively (Baker, 2019). Liévanos and Horne (2017) describe unequal resilience as "the extent to which the return to system equilibrium is unevenly experienced throughout the system". In this paper, we build on the aforementioned IPCC definition and frame resilience within the broader understanding of energy vulnerability (Bouzarovski and Petrova, 2015) as a probabilistic approach that illuminates elements that shape the possibility of experiencing energy poverty.

Exactly a year after the WHO pandemic declaration, the American Rescue Plan Act (ARPA) of 2021 was signed into law. The ARPA included $4.5 billion in supplemental Low-Income Home Energy Assistance Program (LIHEAP) funds and $19 billion for the rental and utility assistance program. Early in the pandemic, the Coronavirus Aid, Relief, and Economic Security (CARES) Act[5] was signed into law on March 27, 2020, which appropriated $900

[5] Public Law 116-136

million in supplemental funding for LIHEAP to help “prevent, prepare for, or respond to” home energy needs surrounding the national emergency (HHS, 2020).

However, despite existing federal programs to support household energy needs, no nationwide moratorium—a prohibition of energy utility shut-offs—were included within the ARPA 2021 or CARES Act. Between the end of July and the end of October 2020, the percentage of U.S. households covered by COVID energy protections fell nearly 30 percent (from 56 to 40 percent) (NEADA, 2021). State and local responses exist to support income-qualifying households; however, program managers often experience challenges with implementation (Raissi and Reames, 2020). Energy disconnection policies and consumer protections aim to mitigate adverse effects resulting from the lack of energy; however, state and local responses to energy poverty vary across the country (Franklin et al, 2017). Even so, the scholarly literature that explores state and utility energy protections (Flaherty et al, 2020) is limited. To understand how subnational responses across the country are associated with energy access vulnerability and resilience, we explore the varying energy protection actions in response to the COVID-19 pandemic.

This study involves 25 metropolitan areas that have been systematically evaluated by the American Council for an Energy Efficient Economy (ACEEE) to assess the socioeconomic and demographic dimensions of residential energy burden. We characterize energy protection measures through a suite of resiliency responses deployed in these metropolitan areas in response to the COVID-19 pandemic. Our analysis centers low-income and highly energy-burdened households given their increased vulnerability to energy poverty. This paper asks: What type of energy protections are deployed in response to the COVID-19 pandemic? And what is the urgency and binding level of existing and COVID-19 era energy protections? Thus, the objectives of this paper are threefold. First, to examine the urgency and binding level of COVID-19 era residential energy protection responses, we chronicle each metropolitan area's initial energy protection responses in reference to the WHO pandemic declaration date. Initial actions are demarcated as either mandatory or voluntary responses. Next, we characterize a suite of resiliency responses necessary to reduce vulnerability to energy poverty and build overall household resilience during the pandemic. We denote the type and total number of protections deployed in each metropolitan area. Finally, we examine the total number of energy resiliency responses relative to household energy burden. In doing so, our examination highlights disparities in energy protections across the country, particularly for lower-income households. The paper concludes with a discussion of the importance that data, measurement, and evaluation have on energy protection responses during the pandemic and pathways forward. We illuminate the imperative to align energy poverty responses with energy vulnerability metrics—echoing calls for energy justice (Hernandez, 2015) and formal recognition of uninterrupted access to energy services as a human right (Franklin et al, 2017).

4.2 Methods

The framework of this analysis centers vulnerable, highly energy burdened low-income populations[6] within 25 metropolitan areas (see table 4-1) across the U.S. These areas were chosen based on data availability in the 2017 American Housing Survey that formed the basis for the 2020 ACEEE residential energy burden evaluation report.

This study employs a qualitative content analysis to better understand the urgency and binding level of residential energy protections and to chronicle initial responses regarding

[6] Low-income is defined as at or below 150% federal poverty line.

uninterrupted access to energy services. Content analyses enable “subjective interpretation of the content of text data through the systematic classification process of coding and identifying themes or patterns” (Hsieh and Shannon, 2005). We analyze policy language and actions taken in response to the COVID-19 pandemic from publicly available data, including individual regulatory and government orders, emergency resolutions, directives, press releases, dockets, and legislation. We primarily examine major Investor-Owned Utilities (IOU) because they typically fall under a statewide regulatory body that governs rate structures and energy protections for a sizable amount of the population. However, three of the examined metropolitan areas (Riverside, CA, San Antonio, TX, and Seattle, WA) are served by municipal-owned utilities. Our analysis covers the pandemic response period between March 2020 and February 2021. We recognize that as the pandemic lingers, responses continue to evolve, with some expanding, contracting, or expiring.

Table 4-1: Utility and Regulatory Structure by Metropolitan Area

Metropolitan Area	State	Major Utility	Ownership	Regulatory Body
Atlanta	Georgia	Georgia Power	Investor Owned	State of Georgia Public Service Commission
Birmingham	Alabama	Alabama Power	Investor Owned	Alabama Public Service Commission
Detroit	Michigan	DTE	Investor Owned	Michigan Public Service Commission
Las Vegas	Nevada	NV Energy	Investor Owned	Nevada Public Utilities Commission
Miami	Florida	Florida Power & Light	Investor Owned	Florida Public Service Commission
Oklahoma City	Oklahoma	Oklahoma Gas & Electric Co	Investor Owned	Oklahoma Corporation Commission
Phoenix	Arizona	Arizona Public Service	Investor Owned	Arizona Corporate Commission: Utilities Division
Tampa	Florida	Tampa Electric Company	Investor Owned	Florida Public Service Commission
Baltimore	Maryland	BGE	Investor Owned	Maryland Public Service Commission
Boston	Massachussets	Eversource	Investor Owned	Massachusetts Department of Public Utilities (DPU)
Chicago	Illinois	Commonwealth Edison (ComEd)	Investor Owned	Illinois Commerce Commission
Dallas	Texas	TXU Energy Retail Co	Investor Owned	Public Utility Commission of Texas
Houston	Texas	Entergy Texas, Inc	Investor Owned	Public Utility Commission of Texas
Los Angeles	California	Southern California Edison	Investor Owned	California Public Utility Commission
Minneapolis	Minnesota	Nothern States Power Company (Xcel Energy)	Investor Owned	Minnesota Public Utilities Commission
New York City	New York	ConEdison	Investor Owned	New York Department of Public Service
Philadelphia	Pennsylvania	PECO Energy Co	Investor Owned	Pennsylvania Public Utility Commission
Richmond	Virginia	Virginia Electric & Power Co	Investor Owned	Virginia Division of Public Utility Regulation
Riverside	California	City of Riverside	Municipal	Riverside, CA Board of Public Utilities appointed by the City Council
Rochester	New York	Rochester Gas & Electric Corp	Investor Owned	New York Department of Public Service
San Antonio	Texas	CPS Energy	Municipal	Board of Trustees
San Francisco	California	PG&E	Investor Owned	California Public Utility Commission
San Jose	California	PG&E	Investor Owned	California Public Utility Commission
Seattle	Washington	Seattle City & Light	Municipal	Seattle City City Council Transportation & Utilities Committee
Washington	DC	Potomac Electric Power Co	Investor Owned	District of Columbia Public Service Commission

We take a directed approach to content analysis, where existing theory on energy poverty guides key concepts as initial coding categories (Potter & Levine-Donnerstein, 1999). Accordingly, we delineate and characterize a suite of resiliency responses to serve as coding categories. Our suite of resiliency responses is comprised of seven categories of energy protection responses aimed at reducing vulnerability (increasing resilience) to energy poverty in light of the pandemic (See Table 4-2). These responses include: (1) suspend energy service disconnections for delayed or missed payments; (2) reinstate service for customers currently disconnected for non-payment of arrearages; (3) suspend accrual of late payment fees; (4) waive all reconnection fees; (5) offer low-income payment assistance programs; (6) offer flexible payment assistance; and (7) have a medical exemption policy to prohibit disconnections. Next, policy and action language were binary coded across all seven categories.

Dates of regulatory and state level policy responses were examined and categorized as either mandatory or voluntary actions. We demarcate urgency by the number of days elapsed from the WHO pandemic declaration (March 11, 2020) to the initial protection response for each metropolitan area, and binding level as either mandatory or voluntary.

Finally, total energy protections across the seven categories were tabulated into a summation scale. Total energy protections in all 25 metropolitan regions were compared to their respective low-income energy burdens to understand the suitability of energy poverty responses. Finally, total COVID-19 era energy protections were compared against the proportion of highly energy burdened households within each metropolitan area.

4.3 Results

4.3.1 Urgency and Binding Level

In reference to the WHO pandemic declaration date, Figure 1 highlights the number of days elapsed before energy protections were deployed. During the first week after declaration, the Oklahoma Corporation Commission and Georgia Power serving Atlanta and Oklahoma City, respectively, coordinated and implemented voluntary protections, and 12 metropolitan areas experienced deployment of mandatory protections. Over the next week, the percentage of metropolitan areas instituting voluntary protections increased to 37.5 percent (3/8) while the percentage of mandatory responding metros increased to 82.35 percent (14/17). At the 21st day, nearly all voluntarily responding metros had implemented energy protections, compared to 100 percent of mandatorily responding metropolitan areas.

We also chronicled residential energy protection responses by examining their binding level and urgency (Figure 4-1). We found that 17 metropolitan areas had mandatory energy protections in place compared to 7 metropolitan areas with voluntary energy protections in place. Of the metropolitan areas surveyed, only Birmingham had no pandemic-era energy protections in place to shield customers from losing access to energy services.

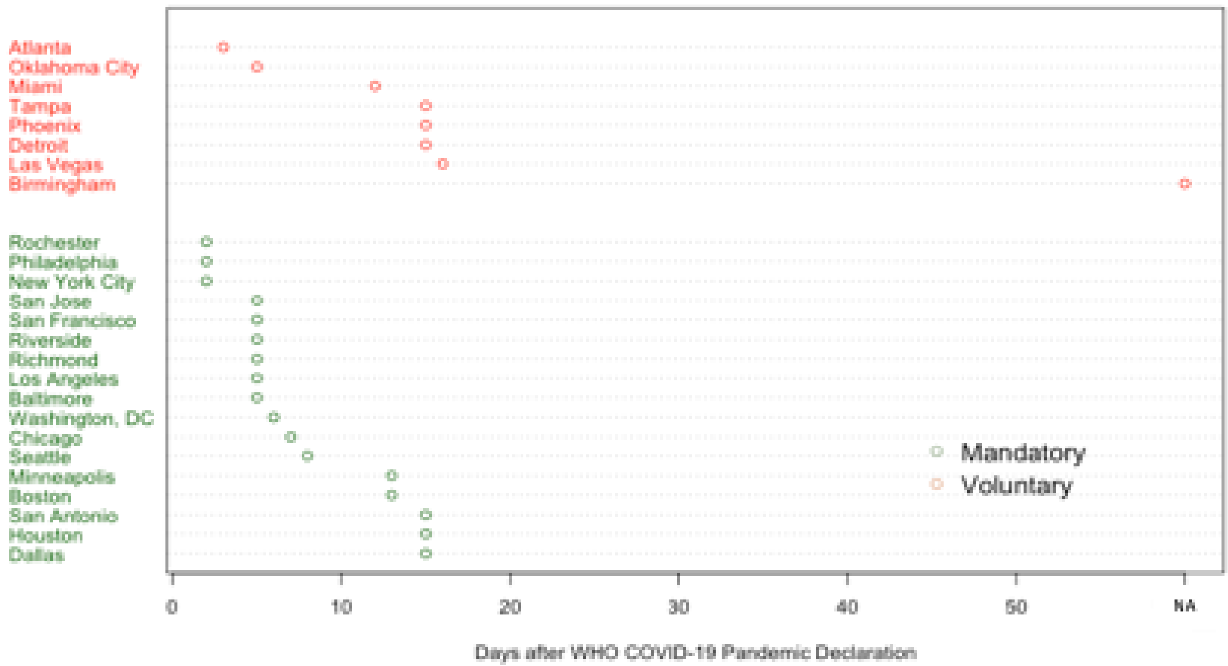

Figure 4-1: Urgency and Binding level of 25 Metropolitan Area's Energy Protection Response to COVID-19

Table 4-2: Suite of energy resiliency responses by metropolitan area

	Energy Protection							
Metropolitan Area	**Suspend Service Disconnects**	**Reinstate** Service for Customers currently disconnected for non-payment	Suspend accrual of **late payment fees**	**Waive all reconnect fee**	Offer **low-income** payment assistance program	Offer **flexible** payment assistance program	Have **medical exemption policy** to prohibit disconnections	Total
Birmingham	✗ 0	✗ 0	✗ 0	✗ 0	✓ 1	✗ 0	✓ 1	2
Atlanta	✓ 1	✗ 0	✗ 0	✗ 0	✓ 1	✗ 0	✓ 1	3
Minneapolis	✗ 0	✗ 0	✓ 1	✗ 0	✓ 1	✓ 1	✗ 0	3
Oklahoma City	✗ 0	✗ 0	✗ 0	✗ 0	✓ 1	✓ 1	✓ 1	3
Baltimore	✓ 1	✗ 0	✗ 0	✗ 0	✓ 1	✓ 1	✓ 1	4
Miami	✓ 1	✗ 0	✓ 1	✗ 0	✓ 1	✓ 1	✗ 0	4
Phoenix	✓ 1	✗ 0	✓ 1	✗ 0	✓ 1	✓ 1	✗ 0	4
San Francisco	✓ 1	✗ 0	✗ 0	✗ 0	✓ 1	✓ 1	✓ 1	4
San Jose	✓ 1	✗ 0	✗ 0	✗ 0	✓ 1	✓ 1	✓ 1	4
Seattle	✓ 1	✗ 0	✗ 0	✗ 0	✓ 1	✓ 1	✓ 1	4
Tampa	✓ 1	✗ 0	✓ 1	✗ 0	✓ 1	✓ 1	✗ 0	4
Washington, DC	✓ 1	✗ 0	✗ 0	✗ 0	✓ 1	✓ 1	✓ 1	4
Boston	✓ 1	✗ 0	✓ 1	✗ 0	✓ 1	✓ 1	✓ 1	5
Dallas	✓ 1	✗ 0	✓ 1	✗ 0	✓ 1	✓ 1	✓ 1	5
Houston	✓ 1	✗ 0	✓ 1	✗ 0	✓ 1	✓ 1	✓ 1	5
Las Vegas	✓ 1	✗ 0	✓ 1	✗ 0	✓ 1	✓ 1	✓ 1	5
New York City	✓ 1	✗ 0	✓ 1	✗ 0	✓ 1	✓ 1	✓ 1	5
Philadelphia	✓ 1	✗ 0	✓ 1	✗ 0	✓ 1	✓ 1	✓ 1	5
Rochester	✓ 1	✗ 0	✓ 1	✗ 0	✓ 1	✓ 1	✓ 1	5
Los Angeles	✓ 1	✗ 0	✓ 1	✓ 1	✓ 1	✓ 1	✓ 1	6
Richmond	✓ 1	✗ 0	✓ 1	✓ 1	✓ 1	✓ 1	✓ 1	6
Riverside	✓ 1	✗ 0	✓ 1	✓ 1	✓ 1	✓ 1	✓ 1	6
San Antonio	✓ 1	✗ 0	✓ 1	✓ 1	✓ 1	✓ 1	✓ 1	6
Chicago	✓ 1	✓ 1	✓ 1	✓ 1	✓ 1	✓ 1	✓ 1	7
Detroit	✓ 1	✓ 1	✓ 1	✓ 1	✓ 1	✓ 1	✓ 1	7

4.3.2 Suspend and Reinstate Service Disconnects (1&2)

To ensure the health and safety of residents in and outside of their homes during the pandemic, access to running water and adequate energy services is vital. Therefore, the fundamental response to guarantee wellness in the home is to prohibit interruption of energy and water services and reinstate services where previously disconnected. Protections that suspended service disconnections due to non-payment were enacted in nearly all metropolitan areas (n=22), except for Minneapolis, Oklahoma City, and Birmingham. However, actions to reinstate disconnected services were far less prevalent; as only Detroit and Chicago were covered by orders to reinstate services. The Michigan Public Service Commission encouraged DTE Energy to reinstate service for disconnected homes in Detroit (Case U-20757), while the Illinois Commerce Commission mandated ComEd to reinstate energy for Chicagoans (Docket No. 20-0309).

4.3.3 Suspend accrual of late payment fees & waive reconnect (3 &4)

The next response required to reduce energy poverty vulnerability is to lessen the psychological and economic burden that comes with being behind on a utility bill. To accomplish this, suspending and waiving the accrual of both late payment and reconnection fees is necessary. For metropolitan areas that addressed arrearages, *i.e.*, an amount of money that is owed and should have been paid earlier, 68 percent of metropolitan areas suspended late fees (17/25), excluding: Oklahoma City, Atlanta, Birmingham, Baltimore, San Francisco, San Jose, Seattle, and Washington, DC. For example, in addition to waiving late fees, interest, and penalties throughout the duration of the emergency, the Minnesota Public Utilities Commission also ordered regulated utilities to suspend negative reporting to credit agencies for residential customers through the end of 2020 (Docket 20-375).

Only 24 percent (6/25) of the metropolitan areas studied waived reconnection fees during the pandemic period. Areas that have not waived these fees include: Chicago, Detroit, Los Angeles, Richmond, Riverside, and San Antonio.

4.3.4 Offer low-income & Flexible payment assistance (5&6)

The federal LIHEAP program instructs all metropolitan areas to offer low-income payment assistance. However, Atlanta and Birmingham are the only two metropolitan areas studied that do not offer flexible payment assistance to customers impacted by the COVID-19 pandemic.

4.3.5 Medical Exemption Policy (7)

Although medical exemption policies that prevent energy disconnections for particular conditions are common across the country, they vary greatly. Eighty-four percent of analyzed metropolitan areas have medical exemption policies. Miami, Tampa, Phoenix, and Minneapolis are the only four metropolitan areas that do not have a medical policy that prevents disconnections. Many states allow disconnections to be postponed with a valid medical certificate for up to 21-30 days, although there are limits on how many extensions are possible. For example, New York may postpone a disconnection for 30 days with a medical certificate with the option to renew for an additional 30 or 60 days at the discretion of the commissioner. In Washington, a medical certificate can be used twice within a 120-day period and will allow postponement for the lesser of 60 days or the length of the certificate; however, customers must also enter a payment agreement.

4.3.6 Total Energy Protections and Low-Income Energy Burden

The total number of energy protections vary across the 25 metropolitan areas. Figure 4-2 displays total energy protections deployed in response to the COVID-19 pandemic alongside low and median household energy burden values for that metropolitan area. Utility customers in Birmingham, Alabama had the lowest total number of COVID-19 energy protection responses (two), despite having the highest energy burdens examined in this study and the greatest percentage of households with high energy burdens in the country (38 percent) (Drehobl et al, 2020). Conversely, Detroit and Chicago have the most comprehensive suite of energy protections out of all metropolitan areas analyzed, although Detroit has a large percent of households with high energy burdens (30 percent). Half (12) of metropolitan areas have below average energy protection responses. Thus, Figure 4-2 illustrates the gap in resiliency responses deployed, especially given that these energy burden figures are from 2015 and are likely to have increased due to the pandemic.

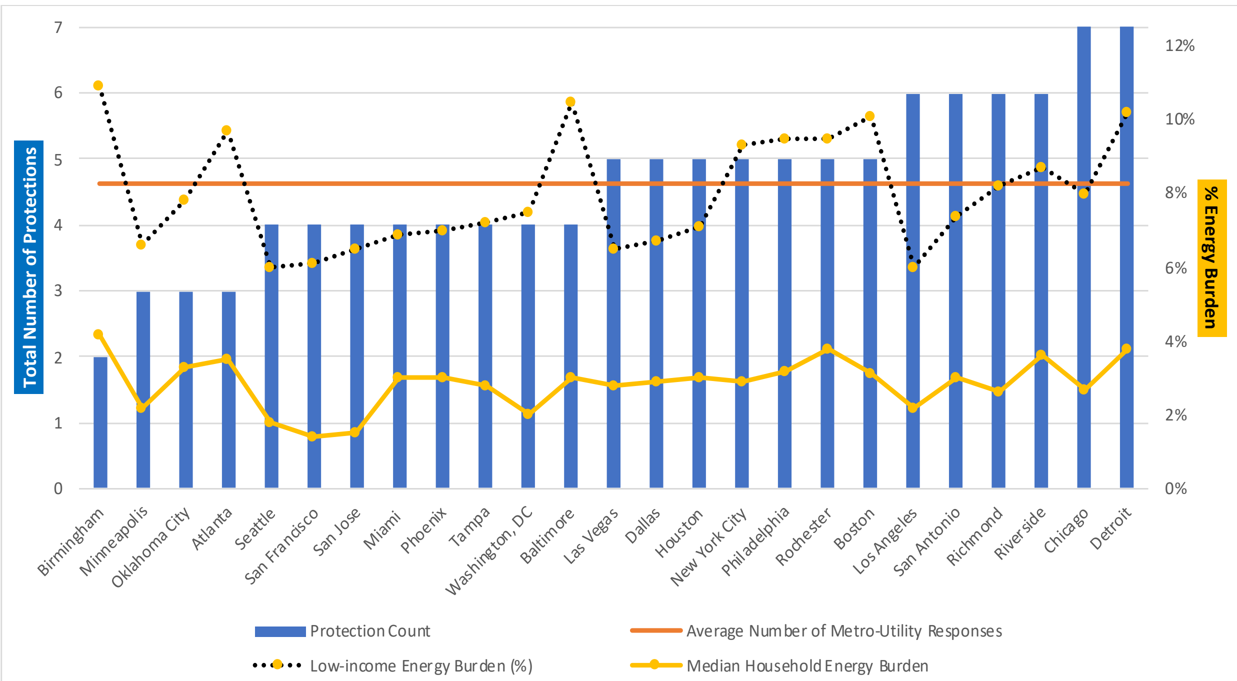

Figure 4-2: Total Metropolitan COVID-19 Energy Protections and Low-income Energy Burden

To explore the impact of resiliency responses to low-income and highly energy-burdened households, the tree map shown in Figure 4-3 displays three pieces of information: Metropolitan area label, its respective number of households with high energy burdens in proportion to its population size, and total COVID-19 responses depicted in graduated colors. Here we can see how resiliency responses vary across metropolitan areas with similar proportions high energy-burdened populations. For example, New York City has fewer protections than Los Angeles and

Chicago despite having a much larger proportion of the population with high energy burdens. Similarly, protections for highly energy-burdened households in Atlanta pale in comparison to Philadelphia and Detroit. Phoenix has fewer protections than Riverside despite the two metropolitan areas sharing similar proportions of highly energy-burdened populations. Similarly, Miami has fewer responses than Dallas, comparatively. Considering smaller cities, Richmond's protections are more numerous than those of San Jose given their similar proportions of populations of highly energy-burdened households. This suggests inequitable responses that hinge on where a household is located as well as regulatory, government, and/or utility leadership.

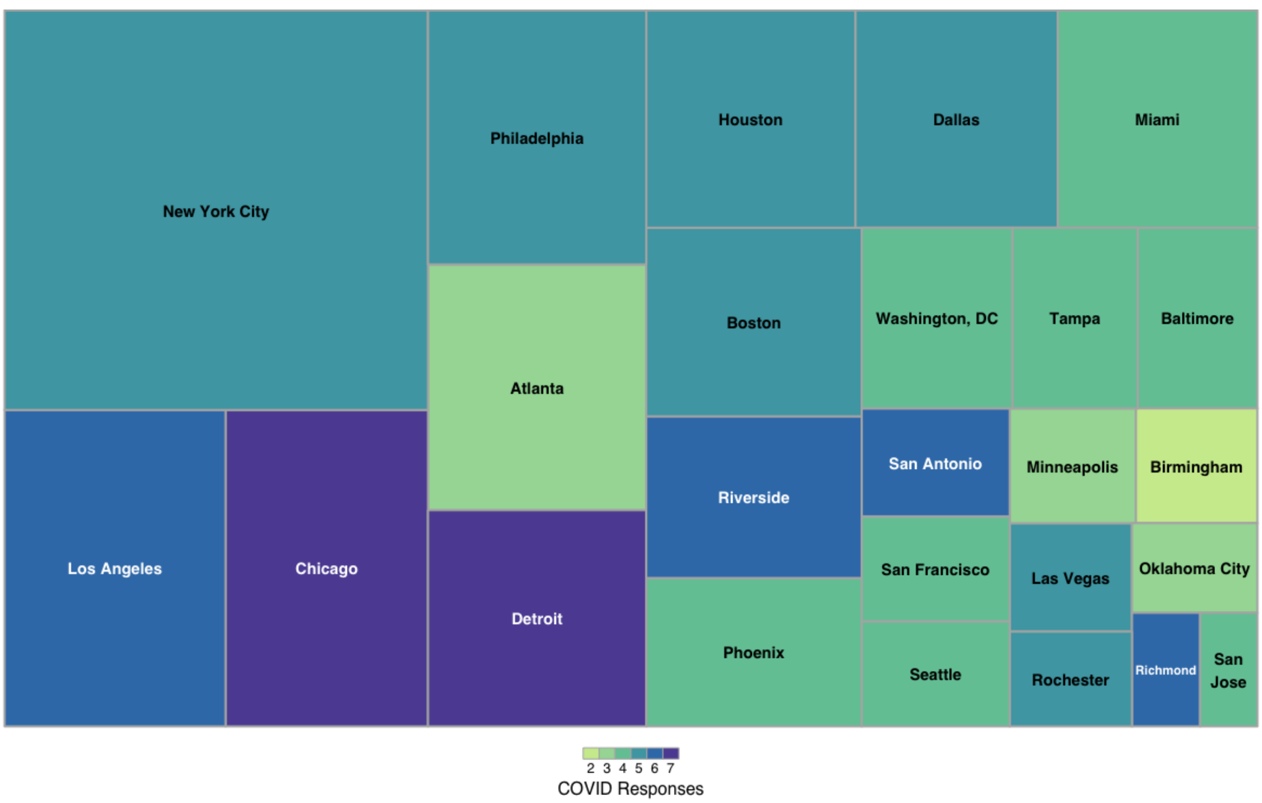

Figure 4-3: Treemap of 25 US Metropolitan area's Energy Protection Response to COVID-19 Pandemic by Proportion of Households with High Energy Burdens (>6%). Larger- size rectangle indicates higher proportion of energy-burdened households

4.4 Discussion

The analysis in this paper centers low-income and highly vulnerable populations and finds that residential energy protections are deployed unevenly across the country, despite responding to the same global issue. Energy protection responses of 25 U.S. metropolitan areas to the 2020 COVID-19 pandemic revealed great diversity in the number and type of responses, which can have important implications for the health and wellbeing of residents. The urgency (timing) and binding levels of energy protection responses are important to ensure equitable access to energy provisioning. However, responses to the pandemic varied based on mandatory or voluntary actions. More than double the number of metropolitan areas responded with mandatory versus voluntary actions within the first (65 percent vs. 25 percent) and second (82 percent vs. 37.5 percent) weeks since the WHO pandemic declaration. For many households, relegating the responsibility of energy protections to investor-owned utilities often prompts additional barriers and levels of communication to maintain energy services. Moreover, this distinction between mandatorily and voluntarily responding metropolitan areas shapes what types of energy protections are deployed.

In our resiliency response characterization, the suite of energy protections in metropolitan areas with lower protections seem to have higher proportions of low-income energy burdens; consequently, contributing to greater vulnerability. While it is important to investigate the total number and type of protections deployed in each metropolitan area, a question that begs to be answered is: Are the deployed protections sufficient given the current low-income population's energy burden? When comparing the total number of protections per metropolitan area to their low-income energy burden versus the energy burden of total households, a number of equity dimensions surface. For example, San Francisco has a below average total number of protections (four), despite their low-income population having more than four times the energy burden of all other households in the city (6.1 percent vs. 1.4 percent). This is also true for San Jose (4.3 times) (6.5 percent vs. 1.5 percent), Washington, D.C. (3.75 times) (7.5 percent vs. 2.0 percent), Baltimore (3.5 times) (10.5 percent vs. 3 percent), and Seattle (3.3 times) (6 percent vs. 1.8 percent). For each of these metropolitan areas, this signals the need for more intentional development of energy burden reduction interventions to narrow the gap between low-income households and total households. Walker and Day (2012) remind us that, "without recognition of difference, specific needs and vulnerabilities can remain hidden and neglected in the formation of policy interventions".

4.5 Limitations

This study could be strengthened by exploring other metropolitan areas that cover the remaining states in the country. Inclusion of rural areas would provide helpful insights into how cooperative energy utilities respond to shock events like the pandemic. Moreover, an exploration of the compounded effect of both energy and eviction moratoriums at the state and local level would be of paramount interest during this time. This study recognizes the impact that housing, and access to energy have on everyday living. A coordinated assessment of the aforementioned issues would enrich disaster response and energy and environmental justice scholarship.

4.6 Conclusion

This research sought out to understand national vulnerability to energy poverty within 25 major metropolitan areas in the U.S. by examining the urgency and binding level of COVID-19 era residential energy protections, characterized through a suite of resiliency responses required to reduce vulnerability. In this paper, we understand that higher energy burdens contribute to greater vulnerability for energy shut-offs and that vulnerability to energy poverty is not equally distributed across the country, disproportionately afflicting the most marginalized communities. We elucidate the varying actions taken by state regulators and utility companies and illustrate the uneven distribution of protections. Our subnational analysis of energy protections during a pandemic demonstrates varying levels of recognition of and responses to energy poverty in the United States and motivates the contemporary recognition of energy as a human right. Responses during the COVID-19 pandemic illustrate temporary action over sustained interventions compared to previous energy crises (Bednar and Reames, 2020). Utility polices that guarantee service connection at the household level would eliminate disparate experiences of energy poverty across the country. Appropriate and effective responses to the COVID-19 pandemic must include universal access to uninterrupted energy services. Policy and regulatory responses should aim to halt the adverse effects associated with inaccessible energy, thus building the resilience or capacity of residents to respond to disruptive events. Moreover, a data driven approach to define, diagnose, describe, and prescribe an appropriate characterization of energy poverty and associated responses would facilitate more a thorough evaluation of energy access in the U.S.

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Chapter 5 Conclusion

The goal of this dissertation was to examine the multidimensional nature of energy poverty and the varied recognition of and responses to this phenomenon in the United States. Each chapter enclosed built upon the others to provide an evidence-base that supports the recognition of energy access as a human right. Accordingly, this dissertation interrogated the characterization of energy poverty vulnerability by examining the historical and contemporary recognition of and responses to the 1973 oil crisis and the 2020 coronavirus pandemic. This dissertation also explored factors associated with vulnerability to energy poverty.

To achieve the UN SDG of ensuring access to affordable, reliable, and sustainable modern energy for all, an explicit recognition of energy access as a human right would motivate the deployment and development of policies and programs to encourage appropriate data, measurement, and evaluation of energy poverty vulnerability. In this concluding chapter, I first provide a summary of major findings and contributions of this dissertation. I then connect multidimensional energy poverty to the imperative of a just energy transition through the concept and movement for energy democracy. Finally, I conclude with an outline of my future research plans that would support the recognition of energy access as a human right.

5.1 Summary of major findings and contribution

In *Chapter 2: Recognition of and Response to Energy Poverty in the United States*, I reveal the absence of formal recognition of energy poverty at the national level. In light of this gap, I propose a definition for U.S. energy poverty that honors its multiple dimensions by using the notion of energy vulnerability to describe the spectrum of factors that influence the state of energy poverty experienced. This chapter takes a diagnostic approach and argues that without a formal definition of energy poverty, measurement is inadequately guided; and consequently, deployed solutions cannot be properly evaluated. In support of this foundational dissertation argument, I use two federally-funded energy assistance programs as case studies and examine their measurement and evaluative metrics. I illustrate disparities in each program's funding appropriations and eligibility requirements that guide the national understanding and implementation of energy assistance.

This chapter finds that current measurement and evaluative metrics focus on the distribution of government resources and the quantity of vulnerable households assisted, instead of focusing on improving household well-being and reducing overall energy poverty. I draw parallels to formal recognition of food insecurity and fuel poverty and national responses in the US and UK, respectively, to encourage a more expansive grasp of the current and future landscape of energy poverty. This chapter concludes with a discussion on national energy poverty reduction and pathways for effective responses by promoting the development and reassessment of definitions, reduction objectives, integrated strategies, and comprehensive measurement and evaluation.

In *Chapter 3: A multidimensional understanding of factors associated with energy poverty vulnerability in the United States*, I ask: What factors are associated with the propensity to experience varying levels of energy poverty? To answer this question, I developed an energy poverty severity scale that demarcates moderate and severe levels of energy poverty based on life threatening risk. I utilized an existing dataset (RECS 2015) administered by the Energy

Information Administration and built an ordinal logistic regression model. I draw on the extant literature to determine which factors to include in this exploratory analysis.

This chapter advances our understanding of the factors that influence the likelihood of experiencing higher levels of energy poverty—moving beyond traditional approaches that characterize energy burden as an exclusive metric. I find that, in addition to household energy burden and income, several technical, socioeconomic, and environmental factors such as poor insulation, increased draftiness, renter households, and census regions increase the odds of experiencing elevated levels of energy poverty.

Chapter 4: Towards energy as a human right: State and utility level disconnect policies in the United States before and during the COVID-19 pandemic examines a contemporary response to energy poverty—thereby establishing a further basis for household energy protection mechanisms. In this penultimate chapter, I echo the imperative of energy poverty recognition and response through a sub-national analysis and examination of energy protection responses to the 2020 coronavirus pandemic in 25 major U.S. metropolitan areas. This chapter investigates the urgency and binding level of COVID-19 era energy protection measures and delimits them as either mandatory or voluntary. I characterize residential energy protection measures in response to COVID-19 and develop a suite of seven resiliency responses required to reduce vulnerability to energy poverty. Moreover, I highlight existing state and utility level household energy protections. The analysis in this chapter finds that residential energy protections are deployed unevenly across the country. Furthermore, it finds that low income and highly energy burdened populations have fewer energy protections. This chapter advances knowledge by situating recognition of and responses to energy poverty as an integral mechanism for reducing energy vulnerability.

5.2 Connecting Energy Democracy

Operationalizing a just transition requires a radical imagination that is conducive to envisioning a future where our current extractive economy becomes a living and regenerative economy (see Appendix C). In this regard, Lanckton and DeVar (2021) describe the importance of equity-based metrics that center restorative justice, meaningful participation, adequate reporting, and accountability mechanisms. This dissertation has magnified the importance of data, measurement, and evaluation of the multiple dimensions of energy poverty—motivating contemporary responses to accelerate the energy transition.

The notion of energy democracy presents an entry point for civic and community engagement alongside a framework that centers just energy transitions and sensible decision-making. Energy democracy is a revolutionary movement in energy that encourages collective decision-making and participation that helps advance the environmental, economic, and social justice needs of communities (Fairchild and Weinrub, 2017). It recognizes the historical implications of industrialization through an energy lens and the unequal burden of energy and environmental inequities borne by low-income households, indigenous groups, and communities of color. Energy democracy promotes a shift in the energy, environmental, social justice, and economic paradigms to provide an equitable and inclusive path forward for each community. This framework embodies a central tenet of energy justice: procedural or process justice. Baker (2019) notes that, "procedural justice demands communities have access to decision-making processes concerning their land". Amplifying the energy democracy framework would encourage active participation in a more equitable, sustainable, and resilient society, particularly for oft overlooked and marginalized communities.

Procedural justice is concerned with process and inclusion, crucially of those processes through which unequal distributional outcomes are produced or sustained (Young, 1990). Equitable procedures should engage all groups in decision-making and weigh their considerations seriously throughout and also provide access to information and legal processes for achieving redress or challenging decision-making processes. Although these components are recognized as key interacting elements of justice in procedural terms (Walker and Day, 2012; Young 1990), calls for a just energy transition do not clearly indicate “who will develop and control that energy, to what end, or to whose benefit. The impetus is to decarbonize the economy, but otherwise leave the basic economic and social system—the institutional framework—intact.” (Fairchild and Weinrub, 2017). Violations of procedural justice, such as involuntary resettlements concerning hydroelectricity construction, expansion of oil tar sands, and mining (Sovacool et al., 2016), have been recognized in the energy justice literature; however, empirical accounts exploring household energy decision-making are limited.

To amplify calls for energy democracy and justice-based solutions at the household level, one must critically examine the link between insufficient public participation and deficiencies in the decision-making of program managers and policy makers. . Given our understanding that humans are often bad at making complex and unaided decisions (Slovic et al., 1977), the development of a decision support framework would provide a sensible, credible, and defensible mechanism for making a string of difficult and interrelated choices over time (Arvai et al., 2012). Gregory (2000) notes that “the goal of a structured decision approach to public involvement is proving policy makers with improved insight about the decision at hand”, not consensus. Instead, a value-focused approach that focuses on a given stakeholder’s primary interest and preferred alternatives have shown to lead to more thoughtful and better-informed risk management decisions. (Arvai et al, 2001). Arvai and colleagues (2012) note the importance of structured decision-making for developing energy strategies as a process that marries deliberation and analysis. The authors offer six basic elements to aid the decision support process. These are: clearly defining the decision problem; identifying objectives to guide the decision-making process; generating logical and creative alternatives that directly address the objectives; establishing the predicted consequences associated with alternative decisions; controlling inevitable tradeoffs when selecting among alternatives; and implementing decisions, monitoring outcomes measured against objective achievement, and adapting to changing conditions. Building on the scholarship and practice of decision support frameworks to extend the concept of energy justice as a decision-making tool would assist energy professionals, consumers, and policy makers in making more informed energy choices that promulgate energy access as a human right.

Operationalizing a decision support framework would provide a conduit to carefully structuring decision-making to improve insights about targeting household energy needs, populations requiring energy assistance, and upstream interventions at the local, state, and federal level. Additionally, such a framework would help us to better understand the specific consequences of alternative choices made by households that place them in energy vulnerable situations such as using unsafe methods for heating. Engaging in a structured decision-making process would enhance the effectiveness of alleviating household energy deprivation. The effectiveness of this alleviation method stems from a structured model aimed at clearly defining the decision problem and searching for preferred objectives and alternatives. This framework would provide a transparent mechanism that encourages policy makers and program managers to explicitly acknowledge household values and trade-offs. Baker (2019) reminds us that, "[e]nergy policy holds the potential to restructure society by redistributing power along lines of race and class". This process or restructuring recognizes the vitality of substantive residential involvement in energy decision-making, leading to better investments in time, money, and resources, which would ultimately lead to a more just and evaluative energy transition.

5.2 Future Research Agenda

5.2.1 Assessment of Residential Energy Vulnerability through a Multidimensional Index

My future work builds on the energy poverty severity scale by constructing a novel energy vulnerability index. This future research intends to characterize, quantify, and validate energy vulnerability nationally at the household level. Detroit, Michigan and Phoenix, Arizona are great candidates for case study comparison given their racial/ethnic demographics, housing stock, and energy efficiency policies. The research findings would provide a more comprehensive assessment of the upstream influential factors, leading to a state of energy poverty. Understanding the fluctuations of energy vulnerability across municipal and state boundaries would lead to more targeted approaches for deploying energy assistance. Moreover, this granular understanding would help interrupt the cycle of bill assistance policy prescriptions to better understand how interventions on upstream energy vulnerability factors can promote a more sustainable and systematic solution to ameliorate this problem. Machine learning methods would be appropriate to operationalize a scoring system based on inputs of energy vulnerability factors from local and state levels.

5.2.2 Modeling spatial disparities of residential efficiency, energy poverty, and firewood use in Santiago, Chile

Access to adequate, affordable, and reliable energy is an urgent issue faced by households globally. Indeed, this dissertation demonstrates that traditional measures used to describe energy poverty exclusively focus on household incomes and energy expenditures—foreclosing more nuanced understandings of the multiple dimensions of energy poverty. In Chile, energy poverty is a major health concern, exacerbated by dwelling inefficiencies and the use of firewood for cooking and warmth—each contributing to negative health consequences. Energy prices in Chile are the most expensive in Latin America and ranked as costly relative to other OECD nations. While discussions about mitigating inequality have been common in Chilean political discourse and practice since the resurgence of democracy in 1990, like many other countries, Chile has spatially segregated metropolises. As a Fulbright scholar, I will expand my energy justice research to Santiago, Chile to examine energy poverty policies, programs, and disparities affecting vulnerable Chilean populations. Spatial regression techniques and statistical outlier analyses would inform, map, and examine how physical and social energy poverty vulnerability elements are distributed across Santiago and Chile's climate regions. In doing so, my work on Chilean energy poverty will provide a comparative case study that complements and complicates my findings in Chapter 2 of this dissertation as published in *Nature Energy*, which illuminate energy poverty recognition and responses in the U.S. Equipped with these insights, we can then understand how economic and policy interventions can help to reduce this vulnerability in Santiago, the U.S., and cities across the globe.

The importance of energy poverty recognition showcased in this dissertation promotes equitable development of measurement, evaluation, and accountability metrics across the country. Recognition of energy injustices globally provides fertile ground to characterize, describe, and innovate appropriate measures and responses. Even so, this dissertation is limited by its reliance on empirical accounts that do not sufficiently reflect community perspectives and input. Next steps of this research need to expand the energy vulnerability framework, research, and practice to various educational, indigenous, and local community groups. Research and praxis of energy, environmental, and climate justice scholarship should center community perspectives and active engagement to ensure justice in the inevitable clean energy transition.

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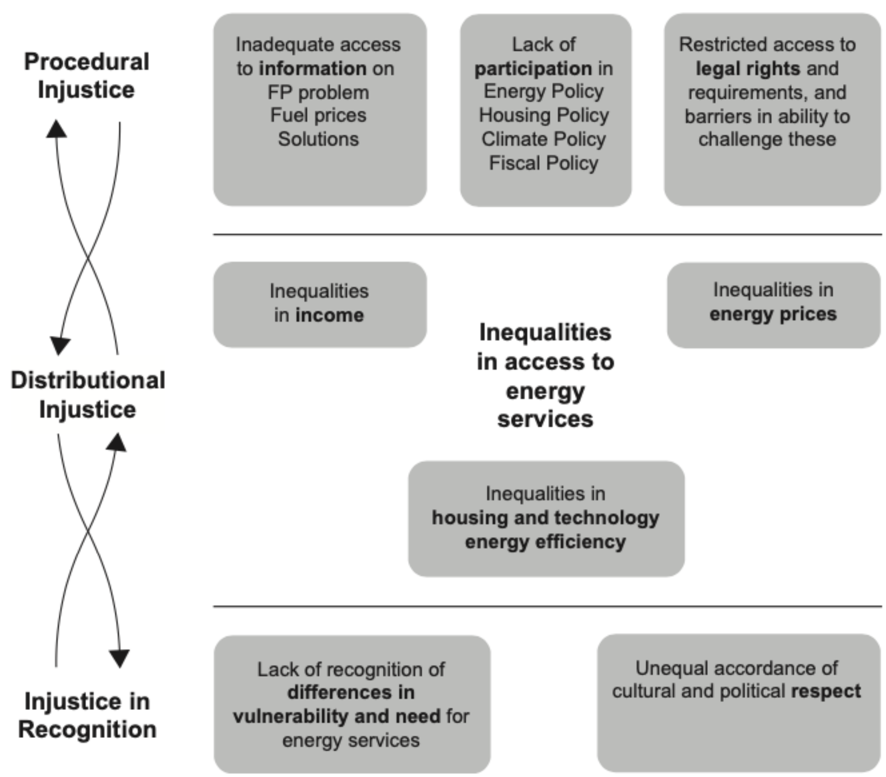
Appendices

Appendix A: Three forms of injustice and their component parts in fuel poverty (Walker and Day, 2012)



Appendix B: Attributes of emic vulnerability and their application in an energy vulnerability context (Middlemiss and Gillard, 2015) (Spiers' attributes of emic vulnerability and their application in an energy vulnerability context (Spier, 2000)

Spiers's attributes of emic vulnerability	Definitions	Application to energy vulnerability
Integrity	"the person's sense of soundness in the various dimensions of her or his life."	The ability to keep warm/cool and therefore live a decent life.
Challenge	"Vulnerability is experienced when there is a perceived challenge to integrity with a corresponding uncertainty about the ability to respond adequately."	Anything that challenges a household's ability to keep warm/cool.
Capacity for action	"Capacity for action refers to the individual's perceived ability to withstand, integrate or cope with the challenge."	How a household copes with (and perceives itself coping with) the challenges to its ability to keep warm/cool.
Multi-dimensionality	"the fact that vulnerability varies from one person to another and from one experience to another"	The fact that energy vulnerability is experienced differently by different people in different circumstances.
Power	"the extent to which a challenge directs or constrains action, and the extent to which the person perceives the potential for change"	The extent to which challenges allow a household to act to avoid energy vulnerability, and the household's perception of their own agency on energy matters.

Appendix C: **Just Transition Strategy Framework (Movement Generation and Our Power Campaign, 2016)**