



What is energy literacy? Responding to vulnerability in Philadelphia's energy ecologies

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ABSTRACT

Energy literacy scholarship has taken on the notable challenge of understanding and influencing the way people think about and consume energy to develop more sustainable energy systems. The idea is that information and understanding are the primary missing links between our current society and a future, more sustainable populace. Recent work in this field, however, has presented evidence to the contrary, throwing the value of current frames and programs of energy literacy into question. In this paper, we identify productive tensions and conceptual affinities between energy literacy and energy vulnerability and suggest, as a way forward, their exploration through the use and development of an energy ecology framework. The energy ecology framework focuses ethnographic and analytical attention to the place specific dynamics of energy infrastructures, access, and use that shape people's relationships to themselves, to other humans and non-human life, to materials and objects, and to their environment. This paper focuses on the energy literacy of more vulnerable energy users who experience inadequate access to affordable and reliable energy services, and also may have less financial and material resources to buffer harm. We use this data to argue that pinning energy literacy to energy vulnerability foregrounds how the knowledge, skills, and practices of relevance to energy literacy change over time and over the course of life, based upon one's changing position within different energy ecologies and also based upon changes in the relations within and across the open systems of which each energy ecology is composed.

1. Introduction

For decades environmental and climate scientists have warned us that climate change is an existential threat, that the global economy will need to both quickly and dramatically reduce (or even sequester) carbon emissions to avoid its more detrimental societal and ecological impacts. What this means on the ground is that people, industries, even whole societies will have to make significant changes to the way they relate to and consume energy.

Most scholars of energy agree that *culture* is the primary domain in which environmental sustainability efforts are attempting to intervene [1–7], but the mechanisms by which cultures change are as many as they are complex. Furthermore, unrecognized cultural assumptions often characterize and misguide efforts to understand and make use of these dynamics in any sort of pragmatic fashion.

One of the more prominent strains of intervention into energy

practices has been framed in terms of developing or improving energy literacy. A core assumption about energy literacy is that people's complacency about domestic carbon emissions lies in their superficial understandings of energy systems, including their own forms of participation in their reproduction [3]. Numerous social scientists have sought to test this basic hypothesis through empirical investigation [9–13]. Surprisingly, however, some scholars conclude from these investigations that the data does not necessarily support a correlation between increased energy literacy and increased sustainability [5,14].

Such conclusions beg important questions, including how the concept of “energy literacy” should be conceived and qualified. In a recent review of the current literature, behavioral psychologist Karlijn van den Broek suggests that an “energy literate person can be someone who knows the energy consumption of their domestic appliances, knows with what actions they can save energy in their home, knows how to make economic energy efficient decisions or knows about the relation

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between energy use and climate change” [6]. Van den Broek then develops a typology of literacies that includes device efficiency, financial impacts, and broader environmental dynamics between energy production and consumption; indexing a diversity of energy literacies in this fashion makes headway towards expanding the types of knowledge that may fall under the energy literacy concept. In this article, we build on what van den Broek [6] has called multifaceted energy literacy by taking an empirical approach that analyzes the diverse forms of literacy developed in the context of (and in response to) the ever-emergent vulnerabilities of dynamic energy ecologies. We continue to expand the range of relationships that matter for energy literacy by describing how energy systems are entangled with other interdependent and localized systems that implicate a broader range of relationships beyond the home.

We use data from our research on energy vulnerability in Philadelphia to develop *energy ecology* as a theory/method package [15]¹ that shifts how energy literacy is defined in research. By highlighting how energy vulnerability both frames and shapes multiple scales of relationality and positionality while also emphasizing the capacity for systems to intersect and shift, the approach is both descriptive enough to allow for critical analysis of configurations of real-world processes and flexible enough to attend to difference in terms of their more emergent or unstable qualities. In this case, we take an energy ecology approach to frame energy literacy as a form of systems awareness that calls for a simultaneous pluralization and politicization of energy expertise.

Using an energy ecologies framework we discuss an experimental project undertaken during the COVID-19 pandemic in the US Mid-Atlantic region.² Critically, the project focused on perspectives and experiences that have been less visible in energy literacy research, including transitional living and working conditions, threats of utility shutoffs, and preparation for service disruptions. This comes from our pinning energy literacy to energy vulnerability [16–19], which Day and Walker describe as “the variability of circumstances and processes through which problems of access to sufficient and affordable energy are manifest,” a term that “has the potential to work across many different national and regional settings” [17]. In other words, we look beyond the domestic appliances, conservation strategies, and financial considerations that dominate energy literacy research to show how these material artifacts, household practices, and understandings of energy within the home can be connected to state assistance programs, utility company policies, infrastructural insecurity, and the work of community organizations. These relationships, we argue – between domestic practices in the home and energy suppliers, social service organizations, and community educators – require a broader yet more nuanced understanding of relations to and within energy systems than has been considered in more conventional definitions of energy literacy.

2. An ecology of energy literacies

2.1. Resituating energy literacy research

One way of critically engaging our current conception of energy literacy is to resituate it within the history of shifting models, motivations, and rationales of energy education programming. Tracing these developments, we discern how concerns for and about energy literacy have consistently derived from energy vulnerabilities but, conventionally, only as these vulnerabilities have emerged at macro, geopolitical,

¹ “Such packages include a set of epistemological and ontological assumptions, along with concrete practices through which social scientists go about their work, including relating to/with one another and with the various nonhuman entities involved in the situation” [15].

² The US MidAtlantic region includes Pennsylvania, Delaware, New Jersey, and Maryland, which was the focus in our project. In some contexts, New York, Virginia, and West Virginia may be included in this regional designation.

and eco-environmental scales, rather than the household as Day and Walker and others use the terms. This focus on macrological vulnerabilities influenced the cultivation and deployment of energy literacy as a normative disciplinary technique of environmental and energy governance.³ We close this section by arguing for a reversal in this directionality, where energy literacy is cultivated from the ground up, taking shape around the particular vulnerabilities of households, uniquely situated in particular energy ecologies.

Growing concern with energy literacy can be traced back to the 1970s oil crisis, when energy conservation programming became public policy in K-12 schools in the United States, and experts from a range of sectors began advocating for a more energy knowledgeable public [20–23]. This marked a shift from previous forms of energy literacy programming, found in the home economics movement [24], as well as in efforts to modernize rural communities [25], both of which reflect state concern over educating publics about energy and the use of emerging technologies. As energy users became more removed from working with the fuel used to heat and light the home, new mechanisms were needed to bridge the sizable gap between the numbers on residential utility bills and energy use in the home. This was seen as an urgent national concern amid international energy insecurity related to fuel cost and reliability, a concern that has persisted amid shifting crisis frameworks.

The most common “hook” for compelling consumers to conserve energy was presented as financial savings and/or environmental benefits. To this day, studies of energy conservation often assess motivation for energy savings efforts – whether conservation or, in recent decades, efficiency through domestic technologies such as LEDs, Energy Star appliances, and solar – in terms of these two conditions of acceptability. As Karlijn van den Broek suggests in an analysis of research on energy literacy [6], financial and technological (relating to appliances or devices) knowledge has often been the focus of research and intervention. Researchers – at first behavioral economists and sometimes psychologists – developed frameworks to measure energy literacy in relation to residential conservation practices through engagement with and understanding of material artifacts such as appliances and light bulbs, a focus that persists today in human-computer interaction research that uses smart meters, community dashboards, and “nudge techniques” [26–28].

All of this is to say, historically, energy literacy programs helped frame both environmental problems and energy access problems in terms of individual responsibility, insinuating a national concern over global energy insecurity into the domestic sphere. Some energy literacy research today continues to focus on what happens inside the home exclusively [6], to the exclusion of how energy systems, organizations, and policies shape how energy is conceptualized and used by households. While this frame continues to individualize knowledge and reify individual agency, this research has also revealed much about how households interact (or not) with domestic energy systems, including how people think about conservation [29], the costs of energy, and how those costs may be related to the use of devices [30–32]. Analysis of how people's actions are motivated by financial savings and environmental benefits is typically central to this research, although how these dynamics are measured varies across studies.

Parallel to and sometimes in conversation with energy literacy research are studies that investigate how knowledge of energy systems relate to support for environmental and economic policies including renewable energy production, transitions, and technology development [5,33,34]. This literature tends to use the term “literacy” less often, and “attitudes”, “knowledge” and “perceptions” instead. These studies are often less about the relationship between household energy use and

³ What follows is an incipient take at what can and should be developed into a more nuanced and thoroughgoing genealogy of energy literacy. Such an endeavor is, however, beyond the scope of this paper.

energy systems than about knowledge of energy production, technologies, and policies.

Unfortunately, the environmental bent of this research has often correlated with the exclusion of low-income households or earners, as well as historically marginalized communities [35]. The assumption here is that these groups are often structurally precluded from devoting the time or resources necessary to learning about or participating in energy or environmental politics. Such beliefs have proven unfounded. As Judith Schwartz argues, low-income communities show the same amount of diversity of energy worldviews as more affluent communities [36].

We thus take this methodological marginalization of low-income communities to be symptomatic of a normative approach to energy literacy, where treating marginalized and/or vulnerable communities as a monolithic bloc helps establish a universal and thereby apolitical conception and criteria of energy literacy. Part of what we argue for in this paper is that there should be more linkage between the domestic and systems spheres of energy literacy research, which would have the effect of pluralizing and politicizing energy expertise by pointedly making connections across an unwieldy landscape. Or as we refer to it here, an energy ecology.

While maintaining a narrowed environmental focus, a more critical and pedagogical approach to energy literacy can be found at institutions of education. Schools and other institutional settings have long served as a launch point for energy literacy programming, and thus research. School settings have the advantage of making connections between household energy use and energy systems at large [37,38] and have been used to assess the role that socialization plays in energy behavior [39]. In institutional settings, the scope of “energy” is generally more expansive and systems-based than on the household alone. Students are more likely to learn about energy sources, renewable energy, and relationships between energy and environment through science curriculum, for example. This may even develop into what Lowan-Trudeau and Fowler refer to as critical energy literacy [40], based on their study of the Youth Strike for Climate in Canada. Institutional settings, such as college campuses, have also been used to test how visualization technologies that are connected to smart energy systems can bolster energy literacy and conservation [36,41,42].

Our subsequent analysis builds from these areas of energy literacy research—which of course are not mutually exclusive and sometimes overlap—while also pluralizing and politicizing their otherwise universalist and normative assumptions. In our project we focus on how individuals think about, understand, and engage with energy systems through the home environment but shift the emphasis from conventional indicators of literacy—such as conservation practices and comprehension of utility bills—to how different communities understand, avoid, alleviate, or cope with energy vulnerability. Pinning energy literacy to energy vulnerability in this way gives the concept a useful level of precision and consistency without reducing its capacity to shift and flex as it is taken up in new contexts, all the while resisting the universalisms and normativity of conventional approaches. This analytical move was motivated by an appreciation of the place-specific energy issues of our research site, garnered through years of embedded engagement and community partnerships, and reflects part of what we

refer to as an energy ecology approach.

2.2. Pinning vulnerability to energy literacy

Energy literacy scholarship has been limited by the assumption that people have equally reliable and consistent access to affordable energy. Yet more than ever, energy vulnerability – also referred to as energy poverty, fuel poverty, and energy insecurity⁴ – poses a growing threat to households, communities, and states around the world. In this paper we use Rosie Day and Gordon Walker's [17] definition of energy vulnerability as,

A situation in which a person or household is unable to achieve sufficient access to affordable and reliable energy services, and as a consequence are in danger of harm to health and/or well-being. This open definition makes no specific judgment about which energy services are significant, what constitutes sufficient access, how harm may be involved or how substantial that harm needs to be. The notion of vulnerability also conveys a sense of potentiality or precariousness rather than necessarily a situation of demonstrable and existing harm.

Energy vulnerability is multifaceted and locally contingent, produced by configurations of infrastructural, environmental, economic, and social dynamics. It's also temporally variable, sometimes cyclical, sometimes enduring, and sometimes unpredictable. In the United States, many households experienced energy vulnerability for the first time during the pandemic, as unemployment skyrocketed and many daily activities were conducted at home only. For those already living in a state of energy vulnerability, utility shutoff moratoriums may have provided relief – but again, this varied from one state to another depending on the moratorium's duration and subsequent return to normal operations. Neither did pandemic moratoriums prevent the accumulation of utility debt.

In U.S. contexts, researchers have shown that energy insecurity (the term most often used by U.S.-based researchers) is predominantly associated with socioeconomic status [43–46], but that there are also sharp racial and ethnic disparities among U.S. households experiencing energy insecurity [44,47]. Similar to the conditions of fuel poverty [48–50], energy poverty [51], and energy vulnerability [16,52] in other places, the inability to access energy reliably and affordably is imbricated with countless socio-material dimensions. These include physical infrastructure such as inefficient housing stock and outdated thermal technologies [49,53–55], behavioral strategies such as conservation practices [16,56], assistance seeking, and decision-making around survival trade-offs [57,58], and associated financial hardships [53,59]; all dimensions we have observed in our own research as well.

Although energy literacy research and energy educational programs often focus on many of the same domestic artifacts and conditions that exacerbate energy insecurity, research and education have not come at energy literacy from a position concerned with the kinds of vulnerability that have become more common across the United States. Where energy vulnerability and energy literacy do intersect, it is often in cases where social justice organizations engage in advocacy work. One such example is described by Yoon and Sauri's [60] study of the Alliance against Energy Poverty in Barcelona, where the Alliance has used an array of

⁴ There are a number of terms used to describe what Day and Walker describe as energy vulnerability [17], each of which have emerged out of particular place and historical contexts, including fuel poverty, energy poverty, and energy insecurity. In this paper and our project overall, we use Day and Walker's definition of energy vulnerability because of its emphasis on the temporal dynamics, which have helped us keep an eye on the specific historical conditions that make energy vulnerability a political problem of structural violence, as well as on the potential harm posed by climate change, and other global or species-level events – like the COVID-19 pandemic. See Middlemiss's discussion of how these terms have developed in different contexts.

strategies to raise awareness about the structural dimensions of water-energy vulnerability's impacts on households.

2.3. Ecological paradigms and energy systems

Combining STS and practice theory, recent studies have used the energy ecology concept to analyze the way that the material (technologies and infrastructures) and social (uses and practices) elements of energy projects hang together, inform, and influence each other [61,62]. We draw on Aritzia and colleagues' description of heating ecologies in particular, which points to relationships between in-home and out-of-home infrastructures and practices that constitute heating [61]. They use an ecological framework to look at enactments that follow and fall outside of normative rubrics, which guide heating policy. We attempt the same work using an energy ecology framework to zoom out to a systems view and also into specific enactments of energy literacy that don't count in normative rubrics.

Though energy ecologies are always "open" in the sense of being composed of and exposed to processes of differentiation, they are also shot through with the sort of techniques, strategies, and apparatuses of productive power [63], which engender relatively stable energy infrastructures, cultures, practices, and regimes of truth, about which one can become *literate*. Taking a normative approach to "energy literacy"—focused on assessing or correcting domestic practices, political attitudes, educational settings, and information systems—represents one such technique of power, dedicated to the production of a thrifty and environmentally conscious subjectivity.

Given the urgent need to limit climate change, it's tempting to be swayed by such an approach. But there are other ways to conceptualize energy literacy, and top-down definitions and approaches risk missing lived experiences that may be related to overlooked issues like energy vulnerability, which, as Middlemiss and Gillard argue [18], needs to be situated locally and understood from the bottom-up. What one needs, desires, or is even enabled to become literate about, in terms of energy, looks different based upon one's position at a specific nexus of systems of energy, knowledge, and power, a perspective we derive from Patricia Hill Collins [64]. As our discussion below will show, conventional approaches to energy literacy neglect the diversity of ways in which people understand and navigate energy ecologies. Tying the energy literacy concept to vulnerability, by contrast, renders the concept more ecological, and therefore more capable of keeping up with people's continuous adaptation to a changing climate and with their creative appropriations of an ever-shifting ecology of energy regulations, technologies, and services. Paying attention and giving credence to these forms of literacy is not only ethical, it's also strategically advantageous, as we gain access to forms of knowledge that are situated differently than our own [65].

We consider energy literacy in terms of political consciousness, or a critical awareness of the structural yet dynamic nature of energy vulnerability. It is therefore our contention that what it means to be energy literate looks different at different times, in different places, and from different positionalities.⁵ In certain regions, energy literacy might include knowing what times of year you are at risk for service disruptions – such as during the height of summer when there might be brownouts, or during hurricane or tornado season. It might also include knowing the kinds of assistance programs that are offered by local utility companies, to help with bill payment and also to upgrade outdated appliances or help with weatherization. Energy literacy, understood ecologically, would include knowledge of alternative energy suppliers and consumer rights.

Studying energy literacy through an energy ecology framework

⁵ This is similar to the assemblages approach that Day and Walker use to conceptualize energy vulnerability [17]. See also Howe and Boyer for a collaborative [66,67], multi-scalar ethnography of renewable energy politics that is deeply informed by the power dynamics of discrete locales.

represents a shift in the intended purpose of energy literacy studies. Rather than looking to test the accuracy of people's everyday energy beliefs, or to develop criteria for assessing the degree to which people know what they *should* know about energy, we treat fieldwork as an opportunity to encounter unexpected knowledges (or knowledge gaps), strategies, and insights into the role of energy in the lives of our interlocutors and in the wider society. This is not to naively suggest that everyone already knows what they need to know about energy—which would be to deny the validity of the whole energy literacy project. Rather, there are as many ways to be energy literate or illiterate as there are positions within energy ecologies.⁶ Through our fieldwork in energy conservation workshops and conducting interviews with everyday energy users, we discovered new axes of literacy needed to address household-scale energy vulnerability.

3. Methods

3.1. An ethnography of energy vulnerability in Philadelphia

The project described in this paper – The Energy Rights Project – is designed in the tradition of experimental ethnography [66–68], where methods of data collection and writing are responsive to the emergent and ever-shifting dynamics of a changing world. This sometimes means pivoting research design mid-fieldwork, or adopting techniques of engagement that were not planned for at the project's outset. At other times, listening to interlocutors may cause a change of focus and inquiry; intervention may be required, in collaboration with communities. The Energy Rights Project began as an investigation of how energy systems (re)produce and exacerbate different kinds of vulnerability in the US MidAtlantic region. This research stemmed from a prior ethnographic project based in the city of Philadelphia, conducted through a community-based climate education project [69].

Over a five year period, community-based workshop participants repeatedly directed conversation about the impacts of climate change towards concern over energy bills, weatherization, and needed home repairs. Participants knew well how extreme weather could impact their homes, but what could they do about their energy bills? At the climate education workshops, attendees sometimes reported that they had been threatened with utility shutoffs, and described domestic hacks to keep energy costs low. Participants explained that programs to help with energy use, such as the Low-Income Household Energy Assistance Program (LIHEAP), were inadequate or hard to qualify for. In response to these observations, The Energy Rights Project was designed to investigate how energy assistance programs were failing households in the US MidAtlantic region, as well as the heterogeneous strategies used by energy users, energy service organizations (ESOs), and civic agents to make energy both accessible and affordable.

Energy vulnerability is a major issue in Philadelphia; aged housing stock, high poverty rates and housing burdens, as well as tangled titles make accessing affordable energy consistently a challenge for many households. Within this context, there is also a robust network of ESOs, which provide education and support to residents seeking utility assistance, weatherization, and budget counseling. ESOs are myriad in form: small community-level organizations, nonprofits with more than 100 staff members, and governmental agencies. Some neighborhood ESOs have been in existence for more than forty years while city-wide agencies have been in existence much longer.

⁶ The approach we take in this paper has also been influenced by the Multi-Level Perspective's appreciation of different scales of action that correlate with different levels of structuration and stability [68], by practice oriented approaches for their emphasis on temporality, performance, and reproduction [69,70] and by the energy cultures framework for their integrative approach to energy knowledge, belief, behavior, and material culture [1].

3.2. Pivoting with the pandemic

What began as participant observation in Philadelphia's ESOs was upended nine months into fieldwork when the COVID-19 pandemic forced agencies to close or go remote in March 2020. The conditions of stay-at-home orders, job loss, and emergent health risks instigated new research questions and demanded a revised approach to data collection. How did the sudden rupture reconstitute relationships to energy? The ethnography had to shift in response to the broad instability brought about in March 2020 [70]. Part of this shift involved a field school on energy vulnerability, scheduled to run at Drexel University between April–June 2020. Lacking the ability to conduct participant observation in-person, other modes of investigation had to suffice for the field school, one of which was remote interviews.

The interview instrument⁷ was designed during the field school, with students, the Energy Rights Project team, and with feedback from other researchers studying the impacts of the pandemic in those early months. The instrument combined open-ended and structured questions, some of which were taken from an instrument used at community-based workshops run by ESOs; other questions were specific to the conditions of the pandemic. Interview questions asked about the impacts of COVID-19 on the household, including employment, the conditions of work and school, energy use, expenses, income, and conservation strategies. There were also questions about emergency preparedness and energy service disruptions, both before and during the pandemic, as well as questions that queried respondents' knowledge of energy and energy systems, utility assistance, and weatherization. The first set of interviews was conducted between May and June 2020; a total of 86 interviews were completed with respondents recruited using the snowball method through the university-based field school. Interviews were conducted over the phone or Zoom and took an average of 45-min to complete.

Six months later, Philadelphia's ESO network began hosting weatherization workshops again, mostly over Zoom. Our team began conducting participant observation at the workshops and recruited participants for interviews, which were also conducted over the phone or Zoom. Between December 2020 and February 2021, we interviewed 83 participants recruited from these weatherization workshops.

Against the backdrop of the field school and the weatherization workshops, as ESOs and other energy networks were learning how to conduct business virtually during the first year of the pandemic, we began to participate in and observe the work happening in these organizations, including attending administrative meetings, staff trainings, public webinars, and eventually in-person events by summer 2021. This fieldwork was supplemented by analysis of reports emerging about household energy vulnerability, shifts in domestic energy use, utility shutoff moratoriums, and other changes taking place in different sectors of the energy industry.

3.3. Comparative analysis of interview groups

In addition to field observations from the weatherization workshops, our analysis derives from comparative analysis of interview data collected from the field school and the weatherization workshops. There were significant demographic differences between the two interview groups – the field school group ($N = 86$) and the weatherization workshop group ($N = 83$) – in addition to the contextual differences in how respondents were recruited, as well as what our research team was able to observe in the weatherization workshops.

In the weatherization workshop group, an overwhelming majority of respondents were women, more than two-thirds were Black or African American, and most were over the age of 35. In the field school group,

⁷ The interview instrument developed during the 2020 field school is available here: <https://energyrights.info/content/spring-2020-shifting-energy-demands-during-covid-19-survey-instrument>

nearly half of respondents were college-aged, and undergraduate or graduate students or recently graduated from college. Slightly more respondents were men than women, and more than 60 % of respondents were white (Tables 1 to 3).

Since respondents from the field school were recruited within a university context – through students in the field school, which included graduate students and advanced undergraduate students – there was a higher percentage of respondents that had completed graduate school than in the weatherization workshop group. Neither completed level of education or income level were associated with specific forms of energy literacy in our study (Tables 4 and 5).

More weatherization workshop participants owned a home than those recruited through the field school, but the percentage of renters (both house and apartment) were similar between the two groups (Table 6). Nonetheless there are differences between renting a house and renting an apartment, particularly when this difference is combined with the student status of many of the field school respondents. Moreover, significantly more respondents in the weatherization workshop group lived in a house, rather than an apartment. Living arrangements and type of dwelling undoubtedly play a role in what inhabitants know about their energy systems, and how they interact with energy infrastructure, but other factors played a role as well, such as proximity to a Neighborhood Energy Center, growing up in a household that utilized energy assistance programs, and living with someone with a medical vulnerability, for example.

By contrasting these two interview groups – the weatherization workshop group and the field school group – we aim to highlight forms of energy literacy that not only represent but engage local energy ecologies. In some cases (Section 5) this literacy stems from previous experience of household energy vulnerability; at other times, this literacy is cultivated by sharing ways of addressing energy vulnerability, as within the context of community-based workshops. In several cases, literacy was built through the interview process itself, as interviewers made vulnerabilities more legible, shared energy assistance information with respondents, or described pandemic-related moratoriums.

In the following section, we draw on participant observation and interviews with weatherization workshop respondents to describe how the workshop format and information presented cultivate locally, situated energy literacy. Next, we contrast knowledge and experience of utility shutoffs and energy assistance to highlight how energy literacy may derive from vulnerability.

4. Community-based energy education

The small participant windows of Zoom came back into view as the workshop facilitator stopped sharing her screen. She had been demonstrating how to apply tube caulk around the large bay windows in her home. This was one of the benefits of having the workshop held in a remote setting: the facilitator could show participants how to use the

Table 1

Interview data comparing self-reported respondent gender between the field school group ($N = 86$; data collected between May–June 2020) and the weatherization workshop group ($N = 83$; data collected between December 2020–February 2021).

Gender	Field school ($n = 85$)	Workshop ($n = 83$)	Cumulative ($n = 167$)
Women	34.12 %	79.52 %	56.56 %
Women; cisgender	9.41 %	4.82 %	7.14 %
Men	30.59 %	13.25 %	21.89 %
Men; cisgender	23.5 %	0 %	11.91 %
Cisgender	1.18 %	0 %	0.6 %
Prefer not to say	1.18 %	1.21 %	1.19 %
Transgender	0 %	1.21 %	0.59 %
Any identity not listed	0 %	1.21 %	0.59 %

Table 2

Interview data comparing self-reported respondent age between the field school group (N = 86; data collected between May–June 2020) and the weatherization workshop group (N = 83; data collected between December 2020–February 2021).

Age	Field school (n = 86)	Workshop (n = 83)	Cumulative (n = 169)
18–24	43.02 %	2.41 %	23.08 %
25–34	17.44 %	15.66 %	16.57 %
34–44	20.93 %	28.92 %	24.85 %
45–54	5.81 %	13.25 %	8.88 %
55–64	5.81 %	28.92 %	17.16 %
65–74	5.81 %	9.64 %	7.96 %
75–84	1.16 %	0 %	0.59 %
85–94	0 %	1.21 %	0.59 %

Table 3

Interview data comparing self-reported respondent race/ethnicity between the field school group (N = 86; data collected between May–June 2020) and the weatherization workshop group (N = 83; data collected between December 2020–February 2021). Categories were taken from the U.S. census.

Race/Ethnicity	Field school (n = 86)	Workshop (n = 82)	Cumulative (n = 168)
Asian	24.42 %	6.1 %	15.48 %
Black or African American	8.14 %	67.07 %	36.91 %
Middle Eastern or Northern Africa	2.33 %	1.22 %	1.79 %
Native Hawaiian or Other Pacific Islander	2.33 %	1.22 %	1.79 %
White	61.63 %	12.20 %	37.5 %
Hispanic, Latino, or Spanish origin	3.49 %	12.20 %	7.74 %
Any identity not listed above	3.49 %	1.21 %	2.38 %
Prefer not to say	0 %	3.66 %	1.79 %

Table 4

Interview data comparing self-reported respondent highest level of education completed between the field school group (N = 86; data collected between May–June 2020) and the weatherization workshop group (N = 83; data collected between December 2020–February 2021).

Highest level of education	Field school (n = 86)	Workshop (n = 82)	Cumulative (n = 168)
Some high school	2.33 %	3.66 %	2.98 %
Completed high school	11.63 %	24.39 %	17.86 %
Some college	20.93 %	23.17 %	21.89 %
Completed college	30.32 %	31.71 %	30.95 %
Some grad school	5.81 %	1.23 %	3.57 %
Completed grad school	31.4 %	7.32 %	19.64 %
Technical or trade school	1.16 %	1.23 %	1.19 %
Prefer not to say	1.16 %	7.32 %	4.17 %

materials they received in the participant kits in an actual domestic setting. Held in person, the facilitator would typically use a demo window brought to the workshop location, usually a community center. Yet in December 2020, few people were interested in attending in-person events, months before COVID-19 vaccines would be widely available. This meant that community members who had trouble getting out during winter (or otherwise) *could* attend; this was a huge benefit, we found in post-workshop interviews, for older and disabled attendees. Remote workshops also made it easier for participants to ask questions about their specific home setting by showing the facilitator their windows, heating units, or faucets over Zoom – all domestic materials which could be used to conserve energy. The facilitator wasn't always the one answering questions either; sometimes participants would offer advice,

Table 5

Interview data comparing self-reported respondent income between the field school group (N = 86; data collected between May–June 2020) and the weatherization workshop group (N = 83; data collected between December 2020–February 2021). Categories included those given by participants.

Income	Field school (n = 59)	Workshop (n = 63)	Cumulative (n = 122)
\$0	11.86 %	15.87 %	13.93 %
Under \$20,000	13.56 %	17.46 %	15.57 %
\$20,000–\$30,000	20.34 %	33.33 %	27.05 %
\$40,000–\$64,999	18.64 %	34.92 %	27.05 %
\$65,000–\$89,999	10.17 %	3.18 %	6.56 %
> \$90,000	11.86 %	4.76 %	8.20 %
Unsure	0 %	1.59 %	0.82 %
On disability/SSI	0.82 %	1.59 %	0.82 %
Food stamps	0.82 %	1.59 %	0.82 %
Varies	10.17 %	1.59 %	5.74 %

Table 6

Interview data comparing self-reported respondent housing status between the field school group (N = 86; data collected between May–June 2020) and the weatherization workshop group (N = 83; data collected between December 2020–February 2021). Categories included those given by participants.

Housing	Field school (n = 85)	Workshop (n = 83)
I rented an apartment	36.47 %	19.82 %
I rented a house	8.24 %	27.71 %
I lived in a house or building that I own	35.29 %	45.78 %
I lived with a family member or friend	11.77 %	3.62 %
I lived in a dorm	4.71 %	0 %
I rented a room	2.35 %	2.41 %
Priest residence	1.18 %	0 %
I lived in a home my father rented for me	1.18 %	0 %

or the group together would troubleshoot an issue, offering suggestions on how best to apply caulk or make sheets of plastic last through the winter.

In this section, we describe community-based weatherization workshops as dynamic spaces that cultivate energy literacies from the ground up. While workshop facilitators brought in their own expertise, their objective was not to impart universally-applicable knowledge in a unidirectional manner, but rather to pull the community's own experiences and knowledges of Philadelphia's energy ecology into the room, in ways that were fine-tuned to participant vulnerabilities. This included how to use locally available weatherization products on aged housing stock, discussing assistance programs that were available to medically vulnerable households, and pointing to neighborhood resources that could supplement grant programs. The workshop's design and function exemplify a more ecological approach to energy education, in other words, attending to forms of energy literacy that better reflect and respond to the complexity and situatedness of energy vulnerability.

Some workshop participants were attending the Philadelphia Gas Works (PGW) weatherization workshop for the first time, but others attended annually so they could refresh their skills and learn about updates to energy assistance programs. "Things always change," Jamella, an elderly woman said in a post-workshop interview. Although she had direct experience with energy assistance because of her previous employment, she noted that there were often changes to program requirements or application forms, even if minor. Sometimes new products are distributed at the workshops – new styles of light bulbs, caulk, or window kits. Attending the workshops was the best way to stay updated, Jamella explained.

"I learn something new every year," Kamille, an elderly homeowner,

reported when asked during our interview what was most useful about the workshop, “even if most of the information I know.” Kamille has attended many weatherization workshops over the years, and has applied for energy assistance through her local NEC. Each time, however, she’s been rejected from programs like LIHEAP because of her fixed income and the program’s rigid eligibility requirements.

“It’s good to “refresh on the education,” Marquis, a teacher and homeowner, told us. Marquis was currently struggling to pay his utility bills. In the past, he had received energy assistance such as LIHEAP and WAP. He’s also attended multiple weatherization workshops over the years to learn conservation strategies that can help him make ends meet. The participatory style of the workshops meant that different questions came up at each workshop, with participants sharing their specific, situated experiences.

PGW is the largest municipally-owned natural gas company in the U. S., with approximately 500,000 customers. Any PGW customer can attend the weatherization workshops, which are held annually beginning in the fall and ending in April, once the weather warms up and the heating season ends. The utility company contracts with community-based energy assistance organizations, Neighborhood Energy Centers (NECs), who facilitate the utility’s weatherization workshop in locations across the city. The participant kits included handouts and DIY weatherization materials, which could be used to reduce drafts during the winter months. NEC facilitators often spent at least 20 min of the hour-long presentation on the window kits, which could be difficult to install the first few times or if the windows were oddly sized and shaped, such as bay windows.

This particular workshop was hosted by an NEC located in an area of the city where bay windows were very common. Several participants had questions about how to use DIY weatherization products with these kinds of windows, which were larger than standard windows and also closer together. Before the facilitator could respond, another workshop participant chimed in to explain how she secured several pieces of plastic together. The kits given out by PGW would only go so far; you had to buy more at Home Depot, she explained. Another woman added that you didn’t even need to buy the window kits; you could just buy the type of plastic used in the window kits in larger pieces to save money.

The conversation turned from DIY weatherization practices to energy assistance. One woman explained that she was living paycheck to paycheck and struggling to afford her utility bills, especially during the winter months. She was interested in learning more about the customer assistance programs that the workshop facilitator had described at the beginning of the presentation. She explained that she felt guilty about applying for grants because she didn’t want to take the money from families who needed it more. This was a common worry expressed by folks who attended the conservation workshops – the fear that if they applied for and received energy assistance there would be less money for people in their community in a similar or worse situation than them. The facilitator responded with a refrain that had been repeated at nearly every such event our research team members attended:

There is so much money left on the table at the end of each year. But even if you don’t qualify or want to apply for assistance, we can still help with budget billing, and we can still help you make a plan for yourself. There is a huge pie, and every quarter and every year pieces of assistance funding get sent back to the government because people aren’t taking advantage of it. Don’t reject yourself, let us work with you and see where you land. Maybe all you qualify for are the weatherization kits, but we can still help you with a budget.

Budgeting is a foundational skill used by energy counselors to help households pay their utility bills. As a strategy, it can’t address all dimensions of energy vulnerability, but it is a starting place since many who seek energy counseling are struggling to make ends meet. Budgeting, of course, is a form of financial literacy, but different from the financial literacy often described in the energy literacy literature, which

tends to focus on energy-efficient appliances and how the savings these products enable offset bills in the long term. The budgeting activities undertaken in Philadelphia’s NECs focus on monthly expenses and income, which help to determine if there are expenses that households could cut out. Budgeting is also used to determine if a household qualifies for customer assistance programs through the utilities, or grants such as LIHEAP or the Utility Emergency Services Fund (a program local to Philadelphia), or other forms of social services such as food stamps and rental assistance. Household budgeting leads to applications for different forms of assistance, which NEC counselors help utility customers navigate. The myriad activities undertaken by NEC counselors is a comprehensive design used to address energy vulnerability in the city, helping to prevent households from taking on utility debt, receiving shutoff notices, or making trade-offs between basic necessities.

The PGW workshops, in other words, were not just about energy conservation or DIY weatherization, which was how the utility often marketed the events. NEC counselors created a space to talk about strategies for tackling energy vulnerability – which meant sharing information and practices that were culturally and locally relevant to community members, *and* information about state energy policy and local programming that was both governmental and nongovernmental. This included, for example, sharing information about Pennsylvania’s medical stays, which can prevent shutoffs in households where a person’s health depends on an electrically-powered device. It meant talking about the requirements for the federal Weatherization Assistance Program (WAP), which could help update aged housing stock. In turn, workshop participants would describe the barriers they faced when applying for assistance, such as determining whether their house met the basic requirements for WAP. But sometimes conversation also focused on how the temperature of the home impacts how air moves, or which neighborhood stores sold the weatherization products needed to make the home more efficient.

The NEC-led workshops created a space for information exchange about energy systems specific to Philadelphia utility customers, local housing stock, and seasonal change – all of which impact how assistance programs are administered. Unlike other U.S. states, for example, Pennsylvania does not allow for LIHEAP grants during the summer months. Similarly, the state’s annual shutoff moratorium is only in place from November 1st to March 31st. In short, the weatherization workshops cultivated energy literacy that was situational, local, and that made connections between in-home and out-of-home energy systems. It’s a bottom-up approach to energy literacy, centered on the particular vulnerabilities of the participants in a way that resists universalist or normative models of energy literacy. The goal of these workshops was to turn the implicit, situated knowledges of the participants into a collective resource, a store of knowledge and strategies with which to begin crafting one’s own literacy based on the unique vulnerabilities of each household.

In the next section, we look at how knowledge of utility shutoffs and responses to threats of shutoffs differ between interview respondents who attend the PGW workshops and those who did not (the field school group). As previously stated, there are significant differences between the two interview groups, in terms of age, gender, and race and ethnicity, which directly stem from how each group of respondents was recruited for the interviews. However, the aim of the following comparison is to show, first, how households with connections to NECs have a more robust understanding of energy systems, including an awareness of utility company policies, federal energy assistance programs, and the ability to conceptualize responses to energy vulnerability. The second aim is to show how energy literacy exceeds the household context and the energy costs that a utility customer bears, such as the utility company, federal policy, and local resources such as NECs.

5. Responding to utility shutoffs

During COVID-19, knowing where to go for social services and other

forms of economic assistance has become paramount. In the United States, as of March 2021, up to 37 million households had overdue utility bills, about a third of the country's households, with arrears totaling more than \$27 billion [71]. That's an increase from \$11 billion in household arrears in 2019. One study found that, on average, household utility debt had reached \$850. But in the MidAtlantic region, energy assistance organizations in New Jersey and Pennsylvania are seeing overdue bills as high as \$2000-4000. With loss of income and higher costs of living, more households have to make choices between buying food, making rent or mortgage payments, and keeping up on utility bills, among other expenses – conditions that have been robustly documented in the energy vulnerability and energy insecurity literatures. Prior to the pandemic, many people had never before needed to seek assistance – unemployment, rent relief, food stamps, and grants or payment programs for utility bills – and were unfamiliar with long-standing federal programs, such as the Low Income Household Energy Assistance Program (LIHEAP).

A subtle way to collect, provoke, or share situated knowledges of energy assistance is to ask what strategies might be used to prevent a utility shut-off. In the United States, a household is threatened with a utility shut-off when they fall behind on bill payment. In Philadelphia, each of the three main utility companies (gas, electric, and water) has different policies regarding shut-offs, as well as distinct “customer assistance programs” which provide payment agreements to customers who are struggling to afford their utility bills. There are also local and federal grant programs that help prevent households from having their utilities shut off. When respondents were asked how they would address a utility shutoff notice if they themselves did not have the money to prevent the shutoff, interview participants responded to the open-ended question in a range of categories, including calling the utility company to see if a payment arrangement could be made, borrowing from friends or family members, taking out loans, and seeking government assistance (Table 7).

While about a quarter of respondents would try to negotiate with their utility company and almost as many would reach out to their social networks, nearly one in five participants stated that they had no idea how to address a utility shut-off, having never been in the situation before. Furthermore, 17 out of 167 respondents said they would let the shutoff happen and “deal with it”, meaning they would try to live around a lack of electricity, heat, or water. A handful of participants stated that they would “move away”, sometimes specifying that they would move in with friends or family members. More than a fifth of respondents said they would take out a loan, and one person said they would go into their 403b, an employer-offered retirement account. The limited imagination

Table 7

This table shows coded responses to an open-ended interview question that asked interviewees what they would do if they received a utility shutoff notice and they did not have the money to pay the bill.

Response to utility shutoff	Field school (n = 84)	Workshop (n = 83)	Cumulative (n = 167)
Take out a loan	14.29 %	16.87 %	14.37 %
Go to family or friends	23.81 %	16.87 %	20.36 %
Call provider	16.67 %	32.53 %	24.55 %
Government assistance	8.33 %	10.84 %	9.58 %
Deal with it	11.91 %	3.62 %	7.78 %
Seek (unspecified) help	1.19 %	7.14 %	4.19 %
Save up money	4.76 %	3.62 %	4.79 %
Relocate	5.96 %	1.21 %	3.59 %
Contact landlord	0 %	1.21 %	0.60 %
Go to a community agency	0 %	10.84 %	5.39 %
I don't know	26.19 %	9.5 %	17.95 %
Just pay it	0 %	1.21 %	0.60 %
Go into 403	0 %	1.21 %	0.60 %

for how to handle the threat of a utility shutoff can be characterized as a form of literacy shaped by a less vulnerable position within the broader energy ecology.

For instance, there were some significant differences between the weatherization workshop and field school respondent groups. While 22 respondents from the field school group stated that they did not know what they would do in such a situation, only eight respondents from the weatherization workshop group were unsure how to respond (Table 7). Terry, a maintenance worker who rents in Philadelphia, was one of those eight respondents. Throughout the interview it became apparent that Terry's energy literacy was obtained through lived experiences - they did not seek out information if it wasn't necessary for their household at a given time.

Interviewer: Hypothetically, if you received a shutoff notice in the mail from one of your utility companies, for example PECO or PGW, and you didn't have the money at the time to pay the bill and avoid the shutoff, how would you address the situation?

Interviewee: Wow. If I didn't have the money, and they were going to shut me off... I don't know. I've never been in that situation. I mean, is there anything you can do? You don't have the money. Would you borrow money?

Interviewer: There's assistance programs, neighborhood energy centers, bill payment programs. There is financial aid and assistance that they can offer.

Respondent: See, I don't know anything about this stuff.

Terry had never experienced a shut-off, nor been threatened with a shutoff, so when prompted about how they would respond in such a situation, their knowledge of available assistance was nonexistent. This was the case for many respondents who had never been in such a situation: they did not know what they would do and had never considered being in such a situation.

Sydney, a college student from the field school group who works as a research assistant, stated after a long pause,

I don't know how to answer this. I really don't know what I'd do...I think it would depend on the whole situation. Like... because I don't see that happening to my household, I feel like there would be other things that would have to be going on that would influence what my options would be.

In this case, Sydney was referring to her parents' household, where she had been staying since the beginning of the pandemic. She was unable to imagine being in a situation where a utility company would shut off services. Many of her responses to our interview questions showed that she lives in a household that is relatively secure in terms of energy access and affordability- Sydney's household was never threatened with a shut-off, she was unfamiliar with energy assistance programs, and reported that she never looks at her household's utility bills. In her case, although her household was using significantly more energy (electricity, gas, water) since the beginning of the pandemic, everyone had been able to transition their work to a remote setting; no one had become unemployed and the balance between using more energy was offset by driving less, staying home, and cooking more. Nonetheless, during the interview, Sydney stated that she was worried her household would have to start making difficult decisions between what bills to pay.

Importantly, Sydney's response suggests that more context was needed to understand the factors that pushed her family into energy vulnerability-i.e., why is the household in the position, and what resources may still be available to draw on? We also found that, in the field school group, many respondents mentioned asking parents or grandparents for money, or using a credit card, which reflects a sense of a safety net tying their household to others, producing a level of financial security that was less common among the workshop participants. This

also reflected the proportion of field school group respondents who were college-age or college students at the time of the interview.

Lacking access to this safety net, the workshop group was more aware of the wider energy ecology in which their household was positioned. Many more respondents from the weatherization workshop group, for example, stated that they would call the utility company to make payment arrangements (27 of 83 respondents), an option that only 14 of 86 respondents from the field school group considered (Table 7). There was a greater awareness among weatherization workshop respondents, in other words, that the utility company would work with customers to find a resolution. Sharon, who attended a weatherization workshop and is a renter in Philadelphia, was furloughed at the beginning of the pandemic, and was only receiving 80 % of her salary between April–June of 2020. Though she had never enrolled in an energy assistance program, she reported that she was strained financially and had difficulty paying her bills during that time. This prompted Sharon to become familiar with available energy assistance options: “A lot of time you can call and get on a payment plan. They don't want to cut you off as much as you don't want to be cut off.”

There are also certain circumstances under which the utility companies cannot shut off service. When asked if she had ever received a shut-off notice, Teagan, another woman from the weatherization workshop group responded,

Oh, absolutely, in the past. Probably electricity. My gas was under my landlord, so, probably electric. It never would have got shut off. They both [her children] use nebulizers, so I would have gone to have them fill out a form to prevent shutoff. So I would have gotten a medical extension, if I needed that.

Teagan was the only respondent to mention that there are policies that prevent shutoffs for people with medical equipment needs during our interviews, although this information was brought up during a few of the workshops we observed. Again, this speaks to the organic discussions and information shared in community-based workshop settings, which derives as much from who is in the room as what material is contained in the slide deck.

In her interview, Teagan discussed an experience of energy vulnerability that is similar to many who are living in Philadelphia. Although Teagan completed graduate school and earns more than the median income in the city, she still struggles with her monthly utility bills. She lives in a home that needs basic systems repair and weatherization, yet her income makes her ineligible for available assistance programs. Everyday expenses are burdensome for Teagan as she faces multiple intersecting financial stresses: her low credit score has made it difficult for her to afford maintenance on her aged home energy infrastructure, she is saving for retirement as someone in her mid-50s, and she financially supports one of her sons who is in college. Her household's vulnerability to utility shut-offs combined with her son's vulnerability to temperature-related health emergencies led her to learn about lesser known utility company policies that will prevent a service shut-off in households with medically vulnerable family members.

Another woman from the weatherization workshop group shared her experience with a pre-pandemic shut-off notice, and then relayed that the utilities could not currently shut off service because of the pandemic. Marie is an unemployed single mother who rents in Philadelphia, and has been struggling with her utility bills, which have increased since the beginning of the pandemic. Although she receives monthly child support payments, this income stream has become insecure because the City's family courts closed during the pandemic. As an individual living in a household with two children who are schooling remotely, and with a member of the household needing to use a medical device that is solely powered by electricity, the thought of losing access to electricity is inconceivable.

I received a shut-off notice for gas, I forget, was either gas or electric. It was only for \$200, it was this guy who said he was gonna turn off my gas. He said he didn't want to turn it off because I only owe \$110 so I went and paid it. If I had a shut-off notice but did not have the money to prevent the shut-off, I would tell them they can't do that because we are in a pandemic then go apply for grants.

During the first year of the pandemic, many U.S. states had moratoriums on utility shut-offs. Pennsylvania also has an annual winter shutoff moratorium from December 1st to March 31st to prevent households at or below 250 % of the federal poverty line from losing heat during cold weather. This is knowledge of the local energy ecology that many low-income households have, based on our ethnographic research with energy assistance organizations in Philadelphia, but is not something that new utility customers (i.e. college students) and households above the poverty line are familiar with.

Another weatherization workshop respondent, Jimmy, reflected on a broader range of options available to address a shutoff, which included working with the utility company and also assessing thermal needs at the moment.

I would see if there is an agreement to come up with to take care of it... depending on which bill it is. I would see if they could give me an extension. Otherwise I would have to take that shut-off until I could pay it. But if it was cold outside, I would really try to explain my situation and see if I could work something out to get the heat on while I pay it off.

Jimmy noted that time of year and seasonal temperature would factor into his approach, as well as what utility was being shut off. A gas shutoff in summer would not be as impactful, for example, as a gas shutoff in winter. Jimmy rents a room in his friend's home and works multiple jobs. In his interview, Jimmy discussed how the pandemic resulted in him having to quit one of his jobs; in order to keep their utility bills affordable, he and his roommate began practicing energy conservation techniques more regularly. He has also attended multiple weatherization workshops to learn about his home energy system, and reported that he learns something new each time he goes. Though Jimmy has never dealt with a shut-off notice before, the financial burdens brought on by the pandemic forced him to think through how he would deal with this threat.

One means of preventing a utility shutoff or reinstating service is to seek energy assistance, which may be provided through government programs or utility companies. This option can be seen in some of the above quotes, such as when the woman mentioned she would apply for grants, and in the first quote where the interviewer mentioned the program to one of our respondents, Terry. While only a quarter of spring respondents reported knowing about such programs, nearly three-quarters of winter respondents could name energy assistance programs (Table 8).

Fonda used to work at an NEC and helped households apply for available energy assistance programs. When the pandemic struck, both

Table 8

This table shows the number of interviewees who were aware of the following assistance programs: Low-Income Household Energy Assistance Program; customer assistance programs; Weatherization Assistance Program; Earned Income Tax Credit; and Social Security Income.

Familiarity with assistance	Field school (n = 81)	Workshop (n = 83)	Cumulative (n = 164)
LIHEAP	14.81 %	92.77 %	52.27 %
CAP	7.41 %	68.68 %	38.41 %
WAP	7.41 %	67.47 %	37.81 %
EITC	37.04 %	60.24 %	48.78 %
SSI	29.63 %	56.63 %	40.85 %
All of the above	1.24 %	34.94 %	18.29 %
None of the above	50.62 %	1.21 %	26.61 %

Fonda and her husband ended their part-time employment, since her husband was in a high-risk group. The loss of both of their income streams created a strained financial situation for their household. Though she is familiar with available assistance and could benefit from the assistance, she reported that they are ineligible for these programs:

I have received a shut-off notice for water and electricity. I received the shut-off notices years ago. If I received a shut-off notice and did not have the money to prevent the shut-off, I would negotiate with the company, see if they could give me an extension or if I could get on budget billing. I could also use a LIHEAP or a crisis grant. Right now we are over income for these programs. We still apply to them every year.

While 77 out of 83 participants from the weatherization workshop interview group had heard of LIHEAP before, only 12 respondents from the field school group had heard of the program, despite the fact that LIHEAP has been available since 1980. Similarly, while 56 participants from the weatherization workshop group had heard of the Weatherization Assistance Program (WAP), another long-standing federal program, only seven respondents from the field school interview group were familiar. The numbers were the same for customer assistance programs (CAP) offered by the local utility companies: 57 respondents from the weatherization workshop group were familiar with CAP, the assistance program offered by the local electricity utility, versus merely six from the field school group.

There was also a dramatic difference in program use; while only one person from the field school group had been on an energy assistance program prior to the pandemic and only one person since the pandemic began, 43 participants from the weatherization workshop group had been enrolled in an energy assistance program prior to the pandemic (more than half the group), and 18 had enrolled during the pandemic (Table 9).

As previously noted, the huge difference between awareness of energy assistance programs can in part be explained by the fact that all weatherization group interviewees had been recruited from the PGW workshops hosted by Philadelphia's NECs. At these workshops, facilitators discuss local CAPs offered by the utility companies, and also federal programs such as LIHEAP and WAP. Respondents' relationship to NECs and workshop attendance, combined with previous or current enrollment in an energy assistance program, is part of what explains the difference between the two groups, given that respondents in the weatherization workshop group had attended the workshop – which included information about energy assistance – within a month prior to our interview.

It was striking to us as researchers how few respondents in the field school group had considered the threat of a utility shutoff, and by extension, the lack of knowledge and imagination for how to respond. By contrast, no respondent in the weatherization workshop group was unfamiliar with the threat of utility shutoffs. This, we believe, stems from how they were differently situated within the energy ecology. Many weatherization workshop respondents were homeowners and were decades older than the field school group respondents; all were

Table 9

This table shows how many respondents in each interview group had been enrolled in an energy assistance program to help pay for utility bills, including LIHEAP, CAPs, and other emergency funds local to Philadelphia.

Energy assistance enrollment	Field school (n = 84)	Workshop (n = 83)	Cumulative (n = 167)
Enrolled before COVID	1.19 %	52.44 %	25.51 %
Enrolled during COVID	1.19 %	21.95 %	11.45 %
Never	85.72 %	39.02 %	62.65 %
I don't know	1.19 %	1.22 %	1.12 %
I am unaware of such programs	11.91 %	0 %	6.02 %

Philadelphia residents and had lived most of their lives in the city, which is significant because energy vulnerability has been a widespread problem in Philadelphia since the 1970s. As a result, there is a robust network of ESOs, community-level energy workshops, and annual campaigns to promote awareness of assistance programs that can prevent shutoffs. Field school respondents, by contrast, were more likely to be new or newer to paying utility bills, and had much less cultural and institutional knowledge of Philadelphia than residents who had lived and owned homes in the city.

It's important to mention that while our conception of energy literacy still turns on the possibility of a “lack,” we resist both normativity and universalism by situating this lack in terms of an emergent ecology. That is, one's energy knowledge and strategies are at an ever-present risk of becoming inadequate, no matter who one is or what one already knows about energy and energy systems. Age, homeownership, community connections, and income, along with the onset of other, more unpredictable events, all shape energy literacy when understood ecologically.⁸ And while this may at first seem like a platitude, it marks a stark departure from more conventional strains of energy literacy research, which has typically adopted a more static and universal (even if multifaceted) criteria for energy literacy. Such conceptions not only miss the connection between energy literacy and energy vulnerability, they also increase the potential for discursive risks and gaps by unduly restricting the general purview of energy literacy research.

6. Conclusion

Energy literacy scholarship has taken on the notable challenge of understanding and influencing the way people think about and consume energy to develop more sustainable energy systems. The idea in that information and understanding are the primary missing links between our current society and a future, more sustainable populace. Recent work in this field, however, has presented evidence to the contrary, throwing the value of current frames and programs of energy literacy into question.

In this paper, we identify productive tensions and conceptual affinities between energy literacy and energy vulnerability and suggest, as a way forward, their exploration through the use and development of an energy ecology framework. We began by describing how energy literacy in the US developed its historically contingent criteria and rationality in and through strategically motivated responses to the forms of energy vulnerability emerging at the nexus of macro-scale geopolitical, economic, sociotechnical, and environmental events and processes. We also noted how the financial and environmental incentives of the majority of contemporary energy literacy programs, and the forms of energy literacy they foreground, have tended to reproduce individualizing knowledge regimes and exclude from consideration the energy issues and strategies of many marginalized communities. We argue that these discontents are rooted in conventional energy literacy studies' top-down, normative approach, against which we contrast our ecological approach.

The energy ecology framework is a theory/method package that can help focus ethnographic and analytical attention to the place-specific dynamics of energy infrastructures, access, and use that shape people's relationships to themselves, to other humans and non-human life, to materials and objects, and to their environment. Stepping away from middle-class parameters of energy literacy, which have historically focused on how to reduce energy consumption through conservation

⁸ The pandemic marked a shift in the energy ecology that both emphasized and expanded the diversity of households who are vulnerable to utility shutoffs, thus reconstituting, we argue, what “counts” as energy literacy. While service shutoffs have long been used by utility companies to compel bill payment, the number and diversity of households who are unable to afford utilities has dramatically increased since March 2020, leading more energy users to ask what can be done when lacking funds to pay for service.

and efficiency technologies, this paper focuses on the energy literacy of more vulnerable energy users – which existing research shows disproportionately impacts low-income households, older women, Black families, those living with disabilities, college students, and people with chronic disease conditions – which experience inadequate access to affordable and reliable energy services, and also may have less financial and material resources to buffer harm. We use this data to argue that pinning energy literacy to energy vulnerability foregrounds how the knowledge, skills, and practices of relevance to energy literacy change over time and over the course of life, based upon one's changing position within different energy ecologies and also based upon changes in the relations within and across the open systems of which each energy ecology is composed.

Those at risk for or living in a state of energy vulnerability often develop forms of energy literacy that are particular to their situation. This diversity is far wider than what has typically been focused on in the literature. The field of energy studies would benefit from further study of how vulnerable energy users meet their broader literacy needs. Important forms of knowledge about energy ecologies that have conventionally gone unaccounted for include knowledge of institutions and policy, such as utility company policies that may prevent a shutoff, government grants that provide financial assistance for energy bills, and awareness of audit systems that can lead to home weatherization. It also includes tacit knowledge, such as how to make choices about allocating resources in order to meet needs – around seasonal temperatures, for example, the needs of family members, or based on external resources such as social and local networks (i.e. cooling centers during heat waves). Looping these overlooked knowledge forms and knowledge gaps, encountered in the field, back into our conceptions of energy literacy both enriches the concept and helps produce the types of energy expertise that are needed to promote more sustainable and more just energy futures.

Although our definition of energy literacy continues to stem from household energy relations and even allows room for analysts to discern when people and institutions are *lacking* in the forms of literacy they may need to address emerging vulnerabilities, our emphasis on situating both these *knowledges* and *gaps in knowledge* in terms of vulnerability, an individuated and emergent criterion, sets our approach apart. As shown in this paper, the impacts of climate change and the current pandemic demand that household energy users understand *energy ecologies*, which include utility company policy, consumer rights, and financial assistance options, among other forms of energy ecology knowledge. This framework also allows for continued attentiveness to the ever-evolving dynamics of energy in transitional societies.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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