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Commentary

Enabling and centering equity and justice in clean energy transition research

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Energy researchers have historically studied how power systems can provide cheap, clean, and reliable energy. While these three attributes are critical for clean energy transitions, the energy justice movement supports an equally necessary focus on equity and justice. In recent years, research has sought to understand how decision-making and infrastructure design can enable fair socio-technical changes in energy systems, from production to consumption to retirement.

Stemming from the environmental justice and fuel poverty scholarship and advocacy that emerged in the 1970s in the United States and the United Kingdom, the energy justice research

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space has consolidated and evolved since the 2010s. Over the past decade, the energy justice literature has highlighted how the design and operation of energy systems can have unequal socio-spatial impacts and has illuminated opportunities toward more inclusive energy services.

A critical review is required to map out the obstacles and opportunities in this field at a time when a confluence of economic, social, and political trends have brought issues of equity and justice to the fore (e.g., US Executive Order 14008). In this article, we explore three challenges the energy justice field faces as it engages with research on clean energy transitions in the US: setting boundaries for its research agenda; developing generalizable metrics to assess energy justice claims; and implementing those metrics to inform policy. We identify promising developments in these areas and make suggestions for future work.

The situation today

Energy justice research has evolved to become a "crosscutting social science research agenda which seeks to apply justice principles to energy policy, energy production and systems, energy consumption, energy activism, energy security and climate change".[1] Past work has proposed frameworks to develop the scope and consolidate the theoretical underpinnings of the field. Although such conceptualizations vary, most researchers have coalesced around three tenets of energy justice: the distribution of (dis)benefits of energy systems (distributional justice); the inclusivity and representativeness of decision-making practices in energy policy (procedural justice); and what sectors of society are ignored in such processes (recognition justice).[2]

Beyond these shared precepts, questions remain on how to use theoretical understandings of energy inequity in energy decision making. Some of this uncertainty stems from the unique challenges of studying the nuanced concepts of equity and justice in the context of an interdisciplinary field with an expanding scope and a significant number of stakeholders with different perspectives (see Figure 1). The energy research community has an opportunity to develop a common set of justice principles to operationalize metrics and methodologies for evaluating energy policies, programs, and projects. A shared and practical approach to analyzing energy systems through energy justice lenses could facilitate knowledge transfer between peers operating under distinct intellectual frameworks and prevent perceived contradictions within this research space.

Setting boundaries

The majority of energy justice researchers' focus on how injustices can originate and be resolved uniquely within energy systems stands in stark contrast with the far-reaching and structural nature of the conditions that give rise to these problems. For instance, energy poverty can be traced to broader structural and social issues such as wealth inequality, segregation, and unequal home ownership rates. Because these issues are not strictly energy system challenges, potential solutions will lie at the intersection of multiple sectors (e.g., housing, energy, transportation). An exclusive focus on identifying issues and solutions within energy systems may lead researchers to (1) miss opportunities to generate fruitful links between energy policy and other social policy[3]; and (2) make certain controversial topics ripe for bad faith arguments to oppose clean energy deployment.

Energy poverty research could benefit from work that examines policy tools that can mitigate all root causes of energy poverty. Previous work has explored whether responses to food insecurity can be used to model a strategy to combat energy insecurity and recognized the inadequacy of the historically low levels of federal funding for long-term solutions, such as home weatherization programs, in comparison to more short-term responses such as bill assistance programs.[4] A similar comparative approach could be undertaken to analyze funding appropriations for other housing programs, or to evaluate the energy efficiency of affordable housing, as well as projecting impacts of increases in social assistance and minimum wage on energy poverty indicators.

We acknowledge that tradeoffs exist between targeted energy policy responses and the types of comprehensive solutions discussed above, and specific compromises depend on location, political constituencies, and desired policy timelines. Yet, constraining energy justice research within energy systems boundaries could backfire by providing fodder for bad faith arguments. For example, utilities have cited research demonstrating inequitable residential solar adoption across race and income[5] to promote policies that significantly curb rooftop solar deployment.[6] Similar concerns can be raised to halt the decommissioning of natural gas networks—a topic that has received scant attention in the energy justice literature—since high electrification costs could leave low-income households paying for expensive fossil fuel infrastructure maintenance. Indeed, inequitable adoption is not unique to rooftop solar and stems from structural and societal problems (e.g., wealth and homeownership inequality). Energy policy tools are likely an inefficient way to redress the influence of these broader social barriers to technology adoption. As a way forward, decision makers could explore alternatives to rate increases to finance solar incentives, including raising revenue from more progressive tax structures, such as sales or income taxes.[7]

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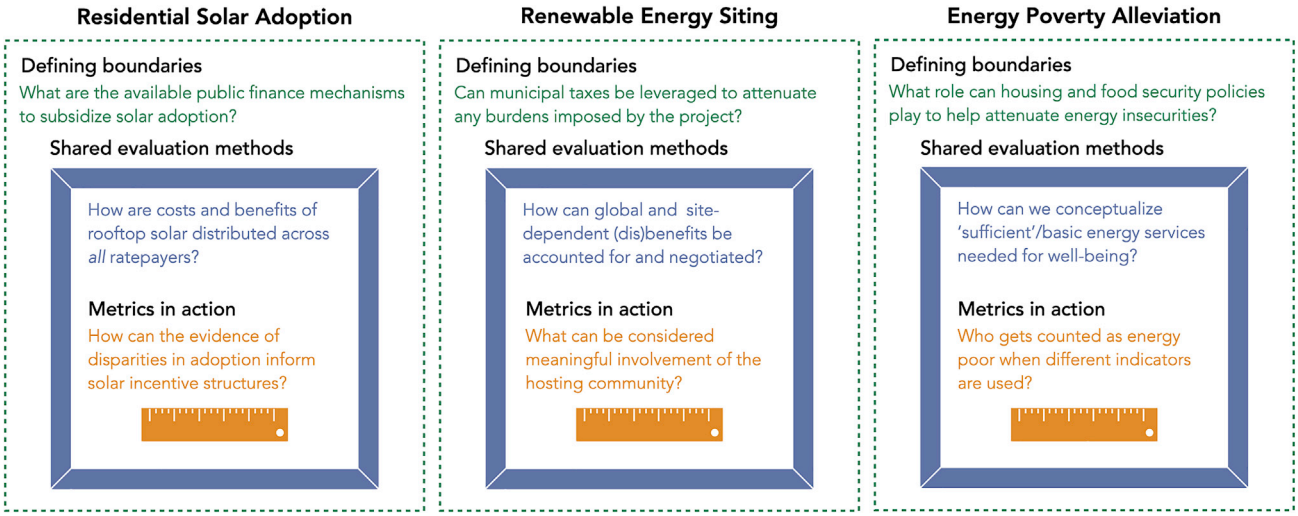

Figure 1. An example of relevant questions that can be formulated to illustrate the challenges outlined in the paper, applied to key issue areas in energy justice research

Developing methods to assess energy justice claims

Energy justice researchers, emerging from a broader community of clean energy and just transition researchers, are actively working toward a common set of methodologies and metrics they can use when examining the justice and equity implications of decision making in energy systems. Though there is a shared understanding of some of the *characteristics* that are required for projects to be considered just—such as community participation in decision making—seldom is there any guidance on how to *evaluate* concepts such as engagement or empowerment in these processes. In part, it is evident that there is a need for subjective assessments to translate what these terms mean to local stakeholders and to ultimately make claims on procedural energy justice. Yet the value of consolidating a structured approach to analyze energy justice claims cannot be overstated. The imperative to mitigate climate change imposes ever closer deadlines for significant amounts of clean energy capacity to be installed in the coming years. Compiling an agreed set of scale- and industry-specific metrics[8] to systematically analyze future investment, innovation, and siting decisions can help respond to this urgency and center energy justice concerns. Specifically, operationalizing holistic "equity screenings" accounting for socially regressive effects of rapid decarbonization would contribute to socially responsible energy transitions. Ideally these metrics would also be compatible with widely used analytical methods (e.g., cost-benefit analysis).

To illustrate the need for coherent methodologies and metrics, consider the scenario of renewable energy plant siting. Such projects can yield positive and negative impacts for host communities, in contrast to the overwhelmingly negative health impacts of fossil fuel plant siting. The literature is split on whether project siting could be a vector for achieving energy justice (e.g., bringing economic benefits through local tax revenues, jobs, and low-cost electricity) or a burden for under-resourced communities (e.g., through land dispossession and local environmental or aesthetic impacts). Objective, quantitative metrics could help stakeholders understand the energy justice implications of specific project proposals. These metrics could help determine whether projects pose a net justice boon or burden to host communities and how to balance (dis) benefits accruing at a local and global scale, without systematically creating "energy sacrifice zones". In addition, a consolidated review of work in this area could assemble the reasonings and learnings from different case studies to derive a guiding set of metrics that can serve as a more nuanced—even if incomplete—way of discerning whether projects follow energy justice principles. Existing methods to create environmental justice indicators—where pollution and social vulnerability indexes are combined to compute cumulative levels of burden—can provide a foundation for energy justice metrics.

In the interim, quantitative researchers who are not working on small-N case studies could take a positivist stance, evaluating their conclusions through multiple lenses, instead of deciding within their own intellectual framework whether results signal net (dis)benefits. A recent paper exploring drivers of renewable plant siting decisions followed this approach, analyzing results along a "continuum of perspectives from the literature framing

project hosting as mostly negative to hosting as mostly positive".[9] In doing so, the authors provide alternative interpretations of the effects of siting patterns according to the various perspectives that could arise in different contexts.

Putting metrics to work

With the development of specific metrics, it is necessary to contextualize their validity as proxies for energy justice and to identify their limitations. To date, most quantitative efforts in the energy justice literature have centered on either *descriptive* energy insecurity measurements or the unequal distribution of resources, particularly rooftop solar,[5] but also electric vehicles, energy efficiency, and power plant siting. However, there is little discussion on how metrics (1) should be used in conjunction with one another to recognize different capabilities and lived experiences across socio-demographics; and (2) can be used to *design* and *target* future resource allocation in an equitable manner.

An illustrative example of the need for multiple indicators is the measurement of household energy poverty. The quantification of energy poverty in the Global North has mostly compared the levels of household energy expenditures relative to income, using the "energy burden" indicator. In this way, energy insecurities are reduced to an affordability issue, disregarding important systemic inequities in housing energy efficiency, climate-risk exposure, and coping strategies such as the "heat or eat" dilemma. Energy burden is an attractive metric because it is easily calculated. On its own, however, it does not fully capture the true lived experiences of the energy-poor, mediated by cultural, behavioral, and structural factors. For instance, a household that resorts to unsafe coping strategies (e.g., maintaining unhealthy indoor temperatures during the winter) can reduce their energy expenditures in ways that remove them from expenditure-based definitions of energy poverty. Although European researchers and institutions such as the EU Energy Poverty Observatory (EPOV) have addressed these issues by proposing complementary indicators to account for different manifestations of energy poverty,[10] these limitations are still prevalent in recent US-focused research.[11] Future work could apply the metrics put forward by EPOV to a US context, to understand how different measures of energy poverty can impact the underlying demographics of who gets counted as energy poor. In this line of research, a recent article proposed the "energy equity gap" indicator, which looks at disparities in energy usage across income groups, to complement energy burden measurements for low-income households that under-consume electricity. These homes would not otherwise be captured through the energy burden indicator.[12] A variety of energy poverty indicators can help inform and expand energy poverty alleviation programs' targeting and eligibility criteria, which are currently based on income thresholds and household size.

Metrics such as the ones discussed above can reveal the patterns of inequality in the use of energy services. Future work in this area should go beyond measurements of disproportionality to geographically targeted intervention recommendations. Past research has proposed prioritization strategies for equitable investments in energy conservation and efficiency based on quantifying distributional inequalities in energy use intensity and program participation at the neighborhood scale.[13] Although work in this vein provides valuable insights at a high spatial resolution to guide future investments, restrictions (e.g., proprietary, budgetary) to accessing the data required for these nuanced analyses persist.

Energy justice research, concerned with identifying challenges and opportunities for vulnerable communities to meaningfully participate in energy transitions, has gained traction in recent years. However, it is still in the early phases of developing comprehensive metrics to evaluate the equity and justice implications of decision making in energy systems. Future research in this space could propose generalizable approaches which use a shared set of metrics to inform the design of policies in the energy sphere and beyond. If it succeeds in navigating the complexities embedded in this process, energy justice research could help chart the path toward cheap, clean, reliable, and *just* energy systems.

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C.C.M. and E.O. declare a professional affiliation with the Lawrence Berkeley National Laboratory, which does not pose a competing interest.

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