frontiers | Frontiers in Sustainable Energy Policy

TYPE Specialty Grand Challenge
PUBLISHED 01 December 2022
DOI 10.3389/fsuep.2022.1063207

OPEN ACCESS

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SPECIALTY SECTION
This article was submitted to Energy and Society, a section of the journal Frontiers in Sustainable Energy Policy

RECEIVED 06 October 2022
ACCEPTED 10 November 2022
PUBLISHED 01 December 2022

CITATION
Carley S (2022) Specialty grand challenge: Energy transitions, human dimensions, and society.
Front. Sustain. Energy Policy 1:1063207.
doi: 10.3389/fsuep.2022.1063207

Specialty grand challenge: Energy transitions, human dimensions, and society

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KEYWORDS

energy justice, just transition, energy policy, human behavior, human dimensions, energy institutions, energy metrics

To achieve the goal of limiting global temperature rise to 1.5°C compared to pre-industrial levels, the International Energy Agency (IEA) predicts that it will be necessary to double the share of low-emissions energy technologies across the world between 2020 and 2050 (International Energy Agency, 2021). Changing the share requires both an immense reduction in carbon-intensive energy resources and a similarly immense increase in low- and no-carbon resources. These requirements—or, alternatively phrased, this energy transition—will obviously have significant implications for technology development and deployment, but it will also have implications for social, cultural, and human development. The need for research into these societal developments is of the utmost importance. The energy transition and its related scholarship hinge on four key elements: (1) the energy transition scholarship must include human dimensions; (2) notions of a just transition must be inclusive of other vulnerable and traditionally disadvantaged populations; (3) institutions, and the proliferation thereof, will be important to the evolution of the energy transition; and (4) it will be essential to continue to develop metrics and methodological approaches that account for the human- and equity-dimensions of energy systems.

Energy transition scholarship must include human dimensions

Discussions about and planning for the energy transition tend to focus most intensively on technological feasibility, often at the exclusion of social, cultural, political, and behavioral factors. Similarly, in the carbon mitigation scholarship, studies most often focus on either technological feasibility and portfolio development, or on economic efficiency—again, at the neglect of actual human experiences.

There are countless topics related to society and the energy transition that are primed for exploration, but here I offer just two as examples. As a first example, and one that is most often discussed in the evolving just transitions literature, is the topic of legacy fossil fuel communities that will lose their employment opportunities, economic livelihood, and tax base for social and public services as a result of a decline in the demand for fossil fuels. According to the announced pledges that countries have made as part of the Paris Agreement, the IEA predicts a loss of 2 million coal jobs across the world, the majority of which are in the Asia Pacific and Eurasia, and a loss of 0.5 million oil and gas jobs predominantly across the Asia Pacific, Europe, and North America (International Energy Agency, 2021). Although the energy transition may evolve slowly, as such transitions tend to do, the impacts on local communities are much faster and, in many of these regions of the world, are already fully evident (Sovacool et al., 2022).

The literature to date has documented some of the challenges faced by legacy communities within these regions of the world, including challenges associated with a loss of economic opportunity (Lobao et al., 2016; Roemer and Haggerty, 2021) and culture and identity within these communities (Carley et al., 2018). Scholars have also identified a lack of preparedness or resilience for these impacts as led by all levels of government (see, e.g., Haggerty et al., 2018; Roemer and Haggerty, 2021; Helmke-Long et al., 2022). Where the literature could particularly grow from further investigation includes, but is certainly not limited to, studies of how government and other organizations can successfully help these communities transition; comparative analyses across different contexts (e.g., regions or fossil fuel industries); and inclusion of employees and communities across various supply chains related to fossil fuel industries.

As a second example, the transition to clean technologies requires behavioral changes, and scholarship within this domain must continue to grapple with the behavior-technology discontinuities that exist. Up to 72% of global greenhouse gas (GHG) emissions are attributable to household behavior and individual consumption (Hertwich and Peters, 2009). Thus, to ensure a successful transition and meet climate goals, it is essential that individuals and households adopt the more efficient and less carbon-intensive technologies that are available in the marketplace. Importantly, households must also modify their use of energy services since energy technologies may require different daily habits or lifestyles (see, e.g., Attari et al., 2010; Sovacool et al., 2022). Here, the literature will continue to benefit from studies on how to minimize the discontinuities that currently exist between technology requirements and behavioral responses, including a focus on human misperceptions, cognitive limitations, heuristics, mistrust, lifestyle mismatches, and a lack of resources, information, pre-conditions, and social acceptance.

A just transition must include other vulnerable populations as well

A truly "just transition" must include those who work in legacy fossil fuel industries *as well as* the many other historically marginalized communities who have borne the brunt of negative energy system externalities, such as through localized air or water pollution, land degradation, and toxic chemical exposure. Often, these are the same communities that either will not receive the benefits of the energy transition or will be further burdened (Carley and Konisky, 2020). In the case of the energy transition, it is typically the same socio-demographic groups who face the largest burdens, including burdens related to energy production (e.g., extraction, refinement, production, and waste) (Sovacool, 2021) and consumption (Brown et al., 2020). Although the transition has the potential to benefit these communities by removing localized sources of fossil fuel production or extending access to clean energy technologies, it is a mistake to believe that these benefits will be automatic. Rather, the extension of these benefits will require deliberate, coordinated efforts.

Consider the case of energy poverty as an example, which has long been a pernicious problem across the world. More than one billion households still lack electricity, and this number has not changed dramatically over time despite significant international attention focused on energy poverty mitigation. In the United States, about one in three households struggle to pay their energy bills (U. S. Energy Information Administration, 2015), and more than half of all low-income households engage in risky coping strategies to pay their bills (Carley et al., 2022). Studies from across the world find that households of color, those with young children and the elderly, and those who are lower-income are most likely to face conditions of energy poverty (Brown et al., 2020). The energy transition has the potential to extend access to modern electricity to these energy-poor communities and households through micro-grids, distributed generation, and low-carbon and centralized electricity, but it also can exacerbate energy poverty. If the energy transition raises the cost of energy due to new infrastructure investments and stranded assets, then energy-poor households, and, more generally, households that are severely budget constrained, will be more likely to suffer from adverse outcomes such as forgoing expenses on food or being shut-off from power.

Access to clean energy technologies, such as residential solar photovoltaics, may help these households, yet plenty of empirical evidence shows that low-income and other disadvantaged populations are less likely to access these technologies or their associated tax benefits (see, e.g., Borenstein and Davis, 2016; Reames et al., 2018). Lacking access may also eventually mean higher energy prices for these populations (Davis and Hausman, 2021) since utility companies need to spread the fixed costs of services among a declining sub-set of the population that still purchases full electricity services off the grid (those with residential solar, for example, no longer pay as much for these services). To ensure that these disadvantaged households can (1) avoid energy poverty and (2) access clean energy technologies, targeted policy and other solutions are required, including energy policies as well as policies and efforts that span across housing, health, and other domains. Here, the literature will benefit immensely from more development.

Institutions matter

A transition to low-carbon, efficient, and advanced energy resources to meet decarbonization goals will require that electricity markets deploy more distributed energy resources, develop better demand-side management and response, expand their capacity markets, refine their integrated planning processes, and build out new infrastructure. This transition will require similarly epic changes for transportation markets, including expanded infrastructure and modified supply chains. All of these developments will occur simultaneous to, and must be integrated with, both carbon mitigation and adaption policy developments. With all of these changes come new business opportunities and market arrangements, respectively, all of which is set within a constantly evolving milieu of institutional rules.

These institutional arrangements, and the implications thereof for society, are ripe areas of research inquiry. For instance, one may ask how different types of utilities make different decarbonization investment decisions, how these decisions integrate equity criteria, and why? What are the opportunities for new market players, and how do current institutional structures limit or enhance their roles? How are decisions made within various institutional structures, and who is provided a voice in those decisions? How do new institutional arrangements affect politics, and vice versa?

Metrics and methodologies are needed

An understanding of the need for more research and action related to the energy transition and a just transition outpaces our understanding of metrics and methodological tools that can be used in this space. Metrics are essential for population identification, such as to identify frontline communities and traditionally underserved and disadvantaged communities, as well as the overlapping layers thereof. Metrics are also essential for quantifying exposure or deprivation, for example, and monitoring these conditions before and after targeted policy or other interventions. Although the increasing access to online and user-friendly screening and mapping tools produced by the U.S. government and research centers is highly promising, as are many recent studies on measuring energy transition vulnerability, the literature will continue to benefit from new advancements in both metrics and program evaluation techniques that account for all equity, justice, and human-dimensions of energy systems. Similarly, forecasting methodological techniques and ex ante impact assessments must evolve to be able to account for equity and human-dimensions of energy decision-making, so that planning for the future can be inclusive of all populations and fully account for the distribution of benefits and burdens across them.

Author contributions

The author confirms being the sole contributor of this work and has approved it for publication.

Conflict of interest

The author declares that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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