Energy Justice – Measuring Impacts in Energy Communities: A Synthesis of the Literature

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Abstract

The benefits and costs of deploying technologies to meet decarbonization targets are not likely to be evenly distributed, and energy communities will face both risks and opportunities in response. This paper identifies metrics available to support energy justice impacts assessments in these communities based on a review of the literature.

1. ENERGY JUSTICE IN ENERGY COMMUNITIES

The assurance of energy justice has become a priority consideration for practitioners, scholars, and policy makers, alike (Baker, et al., 2023; Carley & Konisky, 2020). Referring to equitable social and economic participation in the energy system by all persons and the remediation of existing social, economic, and health burdens, energy justice is an essential component to successfully restructuring existing systems of energy production and consumption to meet current decarbonization goals (Initiative for Energy Justice, 2023; Berkely Lab, 2023; U.S. Department of Energy, 2023; McCauley, Heffron, Stephan, & Jenkins, 2013). Those likely to be most impacted by the restructuring are energy communities, whose interests have historically not been at the forefront of such decisions.

Passed in August of 2022, the Inflation Reduction Act (IRA) uses three different indicators to identify energy communities. These include 1) census tracts (and those directly adjoining) where a coal mine closed after 1999, or a coal-fired power plant retired after 2009, 2) metropolitan or non-metropolitan statistical areas where at any time after 2009 at least 0.17 percent of the direct employment or at least 25 percent of the local tax revenue was from the extraction, processing, transport, or storage of fossil fuels, and whose unemployment rate was at or above the prior year's national average rate, and 3) brownfield sites as defined by the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (Interagency Working Group on Coal & Power Plant Communities & Economic Revitalization, 2024; Rami & Pesek, 2024). [1]

The U.S. Department of Energy (DOE) has developed a tool to spatially locate areas classifiable as energy communities based on the proceeding criteria (U.S. Department of Energy, 2023). Questions remain to be answered about if and how the energy justice impacts of clean energy projects sited within these energy communities and supported by the IRA or other similar policies can be measured. In particular, these questions pertain to projects wherein technologies designed to aid in decarbonization efforts are being designed, developed, or deployed. The purpose of this paper is to develop a shared and comprehensive understanding of what metrics are available and appropriate for evaluating the energy justice impacts of such projects by synthesizing the results of a scientific literature review conducted on energy justice impacts measurements.

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Similar to Baker et al. (2023) we use the term metrics to refer to measures, tools, and frameworks. These include both qualitative and quantitative measures of individual well-being, mapping tools, and evaluation frameworks. We review the literature for each as a means to provide an overview of the ways in which progress toward decarbonization goals through implementation of energy technologies can be evaluated from the perspective of their influence on justice. As most energy justice metrics are built around assessing energy injustices (and similarly inequities), such as the percentage of the population that is energy poor or energy insecure, these types of metrics are listed where appropriate throughout the paper (Preziuso, Tarekegne, & Pennell, 2021).

2. MEASURES OF INDIVIDUAL WELL-BEING

Individual well-being is a broad construct encompassing multiple dimensions often assessed using qualitative and quantitative analysis methods. Qualitatively evaluating the well-being of an energy community requires gaining awareness of justice concerns from the perspective of those directly impacted (i.e., members of the community) and is achieved through the organization, synthesization, and interpretation of responses from focus groups, interviews, and other similar activities (Carley, Evans, & Konisky, 2018; Hammarberg, Kirkman, & de Lacey, 2016). Several studies have taken this approach to evaluate the energy justice impacts of the low-carbon transition – see Fuller and McCauley (2016), Carley, Evans and Konisky (2018), Sovacool, Martiskainwn, Hook, & Baker (2019), McCauley et al. (2019) and Axon and Morrissey (2020) for recent examples.

These approaches often involve micro-scale, human-centered investigations of the opinions, attitudes, values, beliefs, and preferences of community members. Data from such evaluations, however, are not amenable to counting or measuring, and can be time consuming, expensive, and difficult to both collect and replicate (Hammarberg, Kirkman, & de Lacey, 2016; Baker, et al., 2023). As such, traditional approaches to measurement do not apply. Instead, responses from individuals are presented to showcase analytical points

(Hammarberg, Kirkman, & de Lacey, 2016). In the case of energy justice impacts assessments, such approaches can be used to pinpoint whether and what types of injustices are present within communities, as well as the community's preferred approach for remediation.

Unlike qualitative evaluations, quantitative approaches to assessing energy justice impacts rely on numerical (i.e., quantifiable) metrics and utilize spatial, statistical, and regression analysis techniques. Quantitative energy justice assessments help identify who is experiencing energy injustices, the degree to which they are experiencing them, and what their underlying causes are or might be (Carley, Evans, & Konisky, 2018). Oftentimes, this requires combining different data points ranging from the sociodemographic characteristics (e.g., age, race, gender, education) of community members to economic and other well-being indicators.[2] Table 1 provides a list of indicators used to support quantitative energy justice impacts assessments identified from the literature review.

3. MAPPING TOOLS

Multiple mapping tools are available to identify energy communities and illustrate, as well as evaluate questions, policies, and practices with respect to their influence on energy justice (DOE Office of Energy Justice and Equity, 2024). These include the Energy Justice Dashboard (BETA), the Energy Justice Mapping Tools for Schools and Disadvantaged Communities, and the Low-Income Energy Affordability Tool. The Energy Justice Dashboard is a pilot data visualization tool displaying DOE-specific investments in communities experiencing disproportionately high and adverse economic, human health, climate-related, environmental, and other cumulative impacts. The Energy Justice Dashboard relies on data from different DOE offices, including the U.S. Environmental Protection Agency (EPA), which supplies the dashboard with data on communities experiencing air pollution or public health risks based on reports from their EJScreen tool (Office of Economic Impact and Diversity, 2023).[3]

The Energy Justice Mapping Tools for Schools and Disadvantaged Communities are visualization tools for exploring and producing reports for specific school facilities and communities classifiable as disadvantaged, respectively. The Energy Justice Mapping Tool for schools can be used to determine whether the school is located in a disadvantaged community, rural area, designated as a community shelter, or what percentage of the school's students qualify for free or reduced lunch. Similar to the Energy Justice Mapping Tool for Schools, the Energy Justice Mapping Tool for Disadvantaged Communities can be used to explore and produce reports on census tracts categorizable as disadvantaged communities, or DACs, pursuant to Executive Order (EO) 14008.[4]

The Low-Income Energy Affordability Data (LEAD) tool was created to help stakeholders understand housing and energy characteristics for low- and moderate-income households in the United Stated. As such, the tool maps household energy burdens to other socio-economic variables such as their income, age of the dwelling in which they reside, primary fuel used to heat their home, type of housing (e.g., single family home vs. apartment) and whether the household rents or owns (Office of State and Community Energy Programs, 2023). Each of the aforementioned tools can be used to geographically locate energy communities and analyze underlying data, such as what percentage of the schools within the community are Title 1.[5] Such tools are valuable for practitioners seeking to understand energy justice within these communities.

4. FRAMEWORKS

Large-scale, deep decarbonization models are frequently used to assess the emissions reduction potential and monetary impacts of deploying competing technology pathways to decarbonization (Spurlock, Elmallah, & Reames, 2022; NASEM, 2021). Noting the need to be able to assess these technology pathways from the perspective of their impacts to justice and equity, Spurlock et al. (2022) developed the Equitable Deep Decarbonization Framework. Cemented by the four tenants of energy justice – restorative justice, recognition justice, procedural justice, and distributional justice – the framework operationalizes the identification of just technology pathways to decarbonization through a series of steps.

Restorative justice, which calls for the repairment of prior harms to communities and the environment, informs each of the steps and serves as an *ex-ante* rather than *ex-post* evaluation criterion (Spurlock, Elmallah, & Reames, 2022).[6] Guiding the reader through each of the framework's steps, Spurlock et al. (2022) calls for the identification of different metrics to characterize outcomes of deploying one technology pathway over another. Suggested metrics are both quantitative and qualitative, focused on accountability, transparency, and inclusivity of energy communities in the decision-making process to address unequal and inequitable distribution of resources, risks, and responsibilities across both physical and spatial dimensions (Sullivan, 2006; Spurlock, Elmallah, & Reames, 2022).

Other frameworks developed to support energy justice impacts assessments include the Justice Underpinning Science and Technology Research (JUST-R) metrics framework (Arkhurst, et al., 2023), the Energy Justice Decision Making Framework (Sovacool, Heffron, McCauley, & Goldthau, 2016), and the Energy Justice Scorecard (Baker, DeVar, & Prakash, 2019). The JUST- R framework was developed to enable early-stage energy researchers to assess and address justice considerations associated with their research (Arkhurst, et al., 2023; Dutta, et al., 2023). It consists of thirty metrics from the energy justice literature and an additional twenty metrics proposed to fill gaps in the literature around applying energy justice to early-stage research (Arkhurst, et al., 2023; Dutta, et al., 2023).

The Energy Justice Decision Making Framework operationalizes eight different principles of energy justice – availability, affordability, due process, transparency and accountability, sustainability, intra and intergener-

Table 1. Indicators Used to Support Quantitative Energy Justice Impacts Assessments

Category	Indicator	Sources
Demographic	Race/Ethnicity	(Hernandez, Jiang, Carrion, Phillips, & Aratani, 2016)
	Age	(Hernandez, Jiang, Carrion, Phillips, & Aratani, 2016); (Pellegrini-Masini, Egner, Klockner, & Lofstrom, 2021)
	Gender	(Damgaard, McCauley, & Long, 2017); (Pellegrini-Masini, Egner, Klockner, & Lofstrom, 2021)
	Education	(Hernandez, Jiang, Carrion, Phillips, & Aratani, 2016); (Pellegrini-Masini, Egner, Klockner, & Lofstrom, 2021)
	% of Population Marginalized by Caste/ Ethnicity	(Damgaard, McCauley, & Long, 2017)
	Social Status	(Pellegrini-Masini, Egner, Klockner, & Lofstrom, 2021)
	Social Outlook	(Pellegrini-Masini, Egner, Klockner, & Lofstrom, 2021)
	% of Population with No Household Facilities	(Damgaard, McCauley, & Long, 2017)
	Housing Type	(Pellegrini-Masini, Egner, Klockner, & Lofstrom, 2021); (Hernandez, Jiang, Carrion, Phillips, & Aratani, 2016)
Geographic	Immigration Status	(Hernandez, Jiang, Carrion, Phillips, & Aratani, 2016)
	Region	(Hernandez, Jiang, Carrion, Phillips, & Aratani, 2016)
	Geographical Area Type	(Hernandez, Jiang, Carrion, Phillips, & Aratani, 2016); (Pellegrini-Masini, Egner, Klockner, & Lofstrom, 2021)
	Distance From Energy Source	(Damgaard, McCauley, & Long, 2017)
	Elevation	(Damgaard, McCauley, & Long, 2017)
	Loss of Amenity to Local Communities Due to Energy Source	(Heffron, McCauley, & Sovacool, 2015)
Economic	Rent Burden	(Hernandez, Jiang, Carrion, Phillips, & Aratani, 2016)
	Personal Income	(Pellegrini-Masini, Egner, Klockner, & Lofstrom, 2021)
	Economic Outlook	(Pellegrini-Masini, Egner, Klockner, & Lofstrom, 2021)
	Economic Energy Insecurity	(Hernandez, Jiang, Carrion, Phillips, & Aratani, 2016)
	Family Income Level	(Hernandez, Jiang, Carrion, Phillips, & Aratani, 2016)
	Gini Coefficient of Equivalized Disposable Income	(Pellegrini-Masini, Egner, Klockner, & Lofstrom, 2021)
	Gini Coefficient of Wealth Distribution	(Pellegrini-Masini, Egner, Klockner, & Lofstrom, 2021)
	Gross Domestic Product Purchasing Power Standards (GDP PPS) Per Capita	(Pellegrini-Masini, Egner, Klockner, & Lofstrom, 2021)
	Median Income	(Pellegrini-Masini, Egner, Klockner, & Lofstrom, 2021)
	Cost of Energy	(Heffron, McCauley, & Sovacool, 2015)
	Income	(Napton & Day, 1992)
	Energy to Disposable Income Ratio	(Heffron, McCauley, & Sovacool, 2015)
	CO2 Tax	(Heffron, McCauley, & Sovacool, 2015)
	Cost/Benefit to Public Health Services from Energy Source	(Heffron, McCauley, & Sovacool, 2015)
	Cost of Energy Related Accidents	(Heffron, McCauley, & Sovacool, 2015)
	Environmental Pollutants from Energy Sources	(Heffron, McCauley, & Sovacool, 2015)
Energy Infrastructure	Subsidies for Energy Source Extraction	(Heffron, McCauley, & Sovacool, 2015)
	Fluctuation and Price Instability in Energy Supplies	(Heffron, McCauley, & Sovacool, 2015)
	Employment Created from Energy Infrastructure Development	(Heffron, McCauley, & Sovacool, 2015)
	Costs and Benefits of New Energy Infrastructure	(Heffron, McCauley, & Sovacool, 2015)
	Cost of Fluctuation and Instability in Energy Supplies	(Heffron, McCauley, & Sovacool, 2015)
	Cost and Benefit of Importing/Exporting Energy Supplies	(Heffron, McCauley, & Sovacool, 2015)
	% of Population with Access to Specific Energy Type	(Damgaard, McCauley, & Long, 2017)

Note: Indicators in this table include both quantitative and qualitative variables pertaining to energy justice within energy and other communities. Quantitative variable can be either continuous (i.e., can take any values within an interval) or discrete (i.e., can only take specific numerical values). Qualitative variables or categorical variables describe a feature of a community, or its members being studied (e.g., average income).

ational equity, and responsibility – that can be applied to real world problems of interest. Lastly, the Energy Justice Scorecard is a tool for evaluating an existing or proposed energy policy according to whether it 1) has participation in the policy making process by marginalized communities, 2) remedies prior or present harms faced by communities, 3) centers decision-making on the needs of marginalized communities, 4) offers social, economic, or health benefits, and 5) makes energy more accessible and affordable to these communities. Practitioners can use the scorecard to evaluate policies against a "perfectly" energy just policy.

5. CONCLUSIONS

Meeting current decarbonization goals will require demonstrating and deploying clean energy technologies. Of interest and particular importance are the energy justice impacts of such demonstrations and deployments for energy communities. This paper provides a synthesis of the quantitative and qualitative measurers, mapping tools, and frameworks, collectively referred to as metrics, available to support energy justice impacts assessments based on a review of the literature. While the results of the review suggest multiple metrics exist, ensuring a just energy transition, will require identifying how these metrics can be used together to collectively support analysis efforts related to energy justice impacts assessments. Specifically, the energy justice impacts related to designing, developing, and deploying energy technologies. Given their mission to drive innovation and deliver technology solutions to support affordable, abundant, and reliable energy, researchers at the DOE's National Energy Technology Laboratory are undertaking research to develop *EEJustTech* – a holistic procedure for conducting energy justice impacts assessments that will leverage the metrics described above.

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Footnotes

[1] While some energy communities are also disadvantaged communities, it is important to note that not all energy communities are also disadvantaged communities. The Department of Energy identifies disadvantaged communities as a group of individuals living in geographic proximity (such as census tract), or a geographically dispersed set of individuals who have something in common (e.g., their nationality) who are overburdened or underserved according to 36 indicators covering the topic areas of climate change, legacy pollution, energy, transportation, health, water and wastewater, housing, and workforce development (Office of Energy Justice and Equity, 2023).

[2] An example would be the number of persons in an energy community who are energy poor. Being able to quantify the rate of energy poverty requires gathering data on the income and fuel expenditures of households.

[3] EJScreen is an EPA's environmental justice mapping and screening tool that provides EPA with a nationally consistent dataset and approach for combining environmental and demographic socioeconomic indicators. EJScreen users choose a geographic area; the tool then provides demographic socioeconomic and environmental information for that area. All of the EJScreen indicators are publicly available data. EJScreen simply provides a way to display this information and includes a method for combining environmental and demographic indicators into EJ indexes (EPA, 2023).

[4] Disadvantaged communities are similar but different to energy communities. The DOE's working definition of disadvantage is based on the cumulative burden of a census tract. There are thirty-six (36) burden indicators that reflect fossil dependence, energy burden, environmental and climate hazards, and socio-economic vulnerabilities.

[5] Title I schools are schools that receive federal funding to support the hire of additional teachers and support staff, purchase computers or software, support after and summer school programs, and purchase additional materials. Eligibility is based on the number of students who qualify for free or reduced lunch (National Center for Education Statistics, 2024).

[6] Restorative justice as an *ex-post* criterion suggests compensating those harmed by a proposed policy.