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REPORT OF THE WORKING GROUPS - NSF 2026: Priorities and Research Needs for an Equitable Energy Transition

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REPORT OF THE WORKING GROUPS

NSF 2026 Workshops to Identify Priorities and Research Needs for an Equitable Energy Transition

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The working groups used the opinions and suggestions from the workshop participants. A full list of workshop participants is available at the end of this document.

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Working Group 1: Develop Research Topics and Open Questions

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Introduction

The topic of an equitable and just energy transition (ET) strives for the implementation of renewable, zero-carbon energy sources that benefit all people equitably. To achieve this requires collaborative partnerships between communities (who use the energy or host the infrastructure), businesses (who provide the equipment and energy), governments (who establish policy, regulations, permitting, and incentives at the federal, state, and local levels), and the scientific community (to help improve technologies, accessibility, analyses, impacts, and best practices). Each stakeholder group has a distinct agenda. We see a strong need for effective coordination between the stakeholder groups in developing and disseminating knowledge and information that can benefit all. As new programs and projects are implemented, it is of vital importance to measure, document, and openly disseminate impacts, successes, and shortcomings so that the aspirations as a whole can continue to advance. This report highlights compelling topics in need of research and key open questions that would serve to advance the U.S. in an equitable energy transition.

Models of equity

How do we define equity and how do we measure it? What is the role of communities in defining and pursuing equity, generally and regarding their own energy futures? How would we know we're making progress, and whose perspectives need to be factored into that evaluation? Could there be a useful index, or a multivariable radar chart? What does the radar or star chart look like? What are the key variables on such a radar chart, including (for example) cost to consumer, local economic benefit, new jobs, accessibility, and environmental impact?

Effective distributional equity

What does distributional equity mean, and how can we assess and ultimately create it in the services that energy systems provide, the costs that different groups pay for services, and in the outcomes that diverse households, groups, and communities are able to derive from those services? In what innovative ways can we help enable low-income communities to secure the benefits of new energy technologies (e.g., high-efficiency equipment, distributed renewables and storage, electric vehicles, etc.)? Suggestions include:

- Mapping past and current inequalities in services and outcomes
- Mapping inequalities in incentive structures

- Understanding principles of electricity rate design and how they distribute costs and benefits, and do the same for other types of energy.

Balancing equity, cost, and other factors in a system approach

Often the best long-term solution is not the cheapest. And costs at the systems level are not always the same as costs for various decision-makers located in different places within the system. How can we map and evaluate the distribution of benefits, costs, harms, and risks for an energy system (supply chains, waste streams, infrastructures), and how can we leverage that understanding to reasonably assess equity and justice in relation to changes to that energy system?

Design of equitable energy systems

How do the socio-technical designs of energy systems (e.g., financial architectures, governance arrangements) contribute to creating, perpetuating, and exacerbating inequalities in communities and societies, and what kinds of design changes could be introduced to produce better equity impacts going forward? How might co-design or community-owned models lead to better overall solutions? How to provide effective pathways for jobs and industries when phasing out old energy technologies for new? What governmental policies and incentives are effective? At what stage of technological development is it appropriate and practical to consider equity? How do we incorporate equity as an intrinsic design of emerging energy systems?

Community engagement and leadership

How does access to participation in energy systems design and governance play out presently, and how might it be done more equitably in the future? What are the best ways to foster community engagement or self-leadership? What are some examples of progress in this area, and how can they be disseminated broadly and further improved? For example, the DOE Office of Indian Energy projects. Build on participatory action research.

What are the implicit assumptions about community engagement? What are the appropriate activities that encourage community engagement?

It is important to consider what motivates a community to engage. This will vary for each community. Thus, any implicit assumptions of why a community can or may not engage need to be discerned from data and identify appropriate activities that encourage community engagement.

Related to community engagement, what are the tools and best practices for community thought processes that enable the community to reflect on their values, short term and long-term priorities and benefits?

Equity in technology and energy system development

How might programs (e.g., research, industry, policy) which incentivize diversity, equity, and inclusion help to advance the larger goals of a just and equitable energy

transition? How does one build equity into technology? What are examples from the public, private, or governmental sectors where this is already producing beneficial impacts?

Scale and ownership

What do ownership patterns in energy systems (e.g., of resources, generation and distribution assets, end use equipment, firms, etc.) look like? How do they distribute costs, benefits, risks, and opportunities? To what extent do ownership patterns increase or decrease inequalities—and for whom? Are there models that would leverage more equitable ownership patterns in energy systems to enhance equity more broadly in society? If so, what changes would be required to facilitate adoption of those models? What is the best scale for solutions—local, regional, state, national? Which ownership models work well (for example, regional co-op versus national corporation)?

Affordability

For some renewable energy technologies, cost is a prohibitive barrier that makes them inequitable. How can costs of renewable technologies be further reduced to the individual consumer so they can serve as the best solutions for all?

Justice

Environmental justice advocates have long highlighted the historical practices of redlining and siting of infrastructures (including energy infrastructures) in disadvantaged communities as unjust. Similarly, energy justice advocates have highlighted unjust treatment of disadvantaged communities in certain aspects of energy design (e.g., energy and fuel poverty, sacrifice zones in energy supply chains, etc.). How can a clean energy transition avoid similar challenges in the future, recognize past injustices, and provide redress to communities that have suffered past mistreatment?

Broad dissemination

As projects advance and progress is made, it is vital to provide clear information to all stakeholders in an open-source information portal and other means of dissemination.

Science and Technology

How do we incorporate equity as an intrinsic design of emerging energy systems? What is the appropriate stage for incorporation? How to facilitate (strategic vs. sustainable) deeply engaged collaboration between STEM and social sciences? How do we develop energy technologies that can be locally produced?

Broad Orientations

- Map and redress past and present inequalities, anticipate and redress harms of the transition, anticipate and avoid future inequalities in the design of future systems.

- Apply questions across all variants of energy systems (e.g., fuel systems, electricity systems, distributional grids, wholesale power markets, transmission systems, etc.).
- Apply questions across technologies.
- Apply questions across the different parts of the country (and the different utilities and energy systems that serve them).
- Apply questions to all participants in energy systems, including energy users/consumers, energy workers, and energy communities.
- Governance.

Working Group 2: Metrics for an Equitable Energy Transition

Members: Denia Djokić, Destenie Nock, Sergio Castellanos,* J. Chris Ford*

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1. Background

The year 2020 precipitated, in the context of multiple global and national crises, a heightened awareness of the deep fissures of inequities and injustices in our social fabric. One area in which these have manifested, historically and presently, is the energy sector. Questions such as the following arise: How much is consumed by what part of the population and what does it cost? What kind of energy sources are distributed where, how the costs and benefits of the material infrastructure and environmental impacts of each energy source is socially and geographically distributed? What are the context-specific histories of different communities with regards to energy access and how do these affect decisions around energy technology research in the present and future? To begin to understand the answer to these questions, more focused research is needed to make visible the equity and justice dimensions of the energy sector and study the sociocultural particularities of the technologies developed, the institutions that govern them, and the populations that consume said energy.

To put that energy consumption into context, in 2020 the energy consumed by the U.S. was more than 80 quadrillion British thermal units (QBTU), with the largest share attributed to the electric power sector (37%), followed by the transportation (26%), the industrial (24%), the residential (6%) and the commercial sectors (4%).[1] In terms of fuels, 78% of the nation's energy was provided by fossil-based resources (petroleum and other liquids (35%), natural gas (34%), coal (9%)), with the remaining 22% provided by nuclear, hydro, biofuels, and renewable energy resources.

Both the breadth and the large number of steps and process required to transform energy to its end-use (e.g., material extraction, processing into fuels, transportation, transformation, and final delivery for consumption), highlight the multiple dimensions in which people interface with these energy-consuming sectors.

The historical infrastructure deployment that brought us our current energy system has been associated with inequitable processes that have led to similarly inequitable outcomes. Taking coal as a fuel source example, studies have illustrated inequities derived from coal extraction, processing, and end use. In terms of extraction, coal mining has been documented to dismantle mountains, pollute rivers, and endanger wildlife[2]and increase morbidities.[3] In its end use, coal power plants are disproportionately located near minority communities, exacerbating negative health effects from smokestack plume exposure, and associated higher incidences of heart diseases and morbidities. Similar impacts can be tracked across the value chain and end use of other technologies, which also demand a technical and social-oriented focus.

2. Definitions and Objectives

As noted in a recent NREL report,[4] there are differences in the terms related to equality, equity, and justice that ought to be clarified. *Equality* refers to sameness or having equal access or opportunities; *equity* refers to "the state, quality, or ideal of being just, impartial and fair";[5] and *justice* focuses on eliminating hurdles preventing equity, which "entails constructing a system that offers individuals and groups equal access to assets, options, and opportunities to pursue their life goals".[4]

To impart justice and correct the systematic inequalities in the energy sector, there needs to be progression towards equality of access and equality of capability. In a general sense, equality of access means that there are no laws or systemic barriers preventing the person from receiving the benefit. On the other hand, equality of capability implies that should a person have access to some opportunity they have the means to receive all of the benefits. The capability approach is concerned specifically with a person's actual ability to achieve various outcomes.[6]

These objectives are supported by addressing three different tenets of justice:

- **Procedural justice** – the idea of fairness and transparency of the processes that allocate resources and resolve disputes. This tenet is connected to the desire for equal rights and a due process to participate in societal decision-making processes. In a similar sense, this tenet encompasses inclusive and authentic engagement in efforts to develop, implement, and adjudicate programs or policies. Within a just energy transition, economically disadvantaged communities are able to express their concerns, desires, and needs as key energy system decisions are made. For example, California Assembly Bill 2419 establishes a Strategic Growth Council that includes members from the public to recommend polices and investment strategies and priorities for the state officials and appropriators. The Strategic Growth Council will implement a plan that a minimum 40% of Federal funds received would benefit disadvantaged communities. Similar examples were found in Illinois and Pennsylvania. In Illinois, the Future Energy Jobs Act (FEJA) was an output of a coalition of interest groups that resulted in increased investment in energy efficiency and targeting economically disadvantaged communities.[7] Similarly in Pennsylvania, various advocacy groups collaborated to improve to low-income energy-efficiency policy across the commonwealth.[8]

- **Distributive justice** – the principle of fairness in the allocation of rights or resources, arguing that one's place of birth, social status, and family influences are matters of luck that should not unduly influence the benefits we receive in life.[9] One of the key challenges facing the energy sector is that most renewable and energy efficiency polices fail the distributive justice test. Underserved communities rarely receive the benefits of energy efficiency and renewable energy polices, and oftentimes are paid for in part by low-income ratepayers.[10, 11] Recent policy changes in Florida (House Bill 741, 2022) have been designed to offset

the potential economic burden of residential rooftop solar on low-income households by phasing out the incentives of net-metering.

- **Intergenerational justice** – this tenet adds a time dimension to the justice discussion by considering community obligations to future generations. Efforts that increase development options of future generations improve intergenerational equity.[12] Intergenerational justice in clean energy requires a unique evaluation of which aspects of the present should be modified or unchanged for subsequent generations.[13] While decarbonization efforts of clean energy programs contribute positively to intergenerational justice, less emphasis and analysis of the efficacies of these programs on social and economic outcomes across generations has occurred.

3. Measuring Equity in our Energy System

To correct systematic inequalities in the energy space, justice must be imparted in an effort to progress towards equality. It is important to mention that efforts to measure equity have grown in interest in recent years, especially as resources are being funneled towards ensuring the procedures and outcomes in the energy space are equitable.

A framework on ways to evaluate progress in energy equity, specifically in storage technologies for social equity was provided by Michener et al.,[14] where differences in definitions between metrics, indicators, and indexes are identified. While often used interchangeably in literature, each is distinct in its functionality.

- **Metrics** are a quantitative measurement for a qualitative phenomenon that can help measure a specific equity outcome. Metrics are likely to become key for tracking equity-related efforts and ensuring goals are met.
- **Indicators** are a representation of relevant equity outcomes that can be used to establish the state of equity at a given point in time. Indicators are useful in collecting baseline equity measurements.[15]
- **Indexes** are multiple indicators that can be aggregated into a single measure.

There are also things that are difficult to measure and capture in a purely numerical sense. Examples of these situations can be feelings of poverty, lived experiences, feelings of belonging in a given group or environment, among others. Capturing both quantitative and qualitative metrics over time is vital to ensuring progress towards an equitable energy future is being made.

It is clear that advancing an equitable energy future requires understanding, accounting, and tracking the justice and equity implications of current and future energy projects, and their outcomes as they translate to end-uses (*e.g.,* energy poverty, energy burden, energy insecurity, and energy vulnerability).

Three categories central to the equity metrics, indicators, and indices development process have been adapted from the equity metric dimensions developed in the literature.[16] These categories, covering both quantitative and qualitative aspects, can be summarized as:

- Target population identification,
- Investment decision-making, and
- Program impact assessment.

The interaction of all the processes that comprise the energy transformation process, from a (raw) source to its final end-use, as well as the three categories central to the equity measurement development process, are depicted in Figure 1. This image embodies the need to capture the broad energy system spectrum, and to identify the population (underrepresented people and places) impacted by processes in the life cycle of the energy system in question, the investments that can enhance socio-institutional capabilities, and the co-development of programs and solutions. This process, guided by the tenets of justice, would provide the basis for constant evaluation, both qualitative and quantitative, of the programs and their impacts.

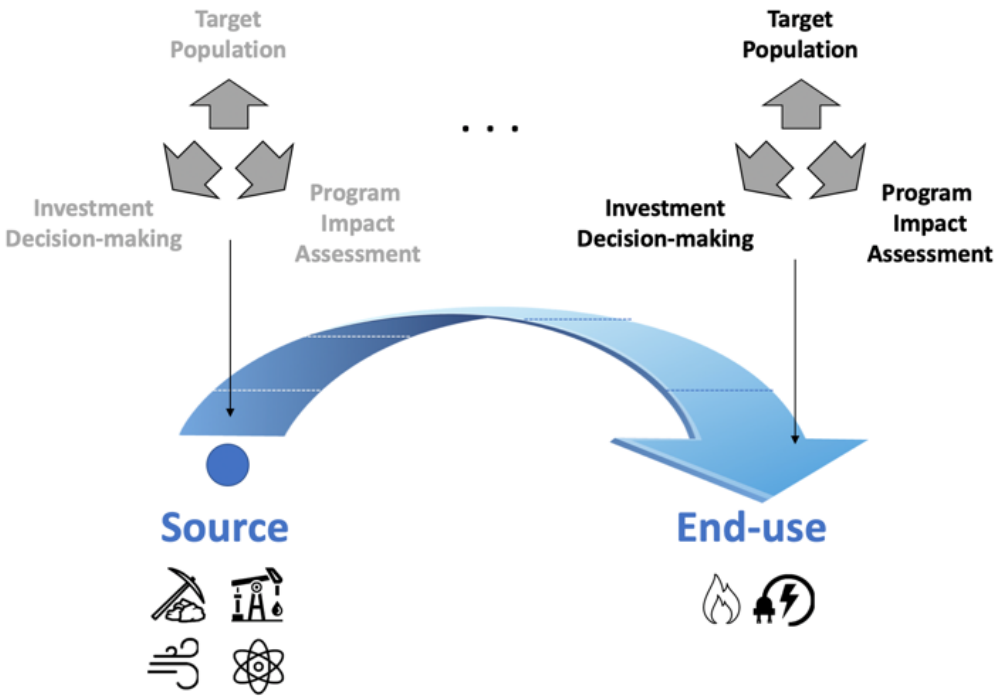

Fig. 1. The energy spectrum must be evaluated from source to end-use, probing for equity advancement across the thrusts of impacted populations, investments and their decision-making processes, and assessment of the impact of a given intervention.

4. Tracking Equity Measurements

Tracking efforts require flexibility to provide a benchmark for measuring and reevaluating progress over time. There might be associated risks in the process of tracking measurements. For example, one risk is the tendency to lump everyone together. This obscures the reality that impacts and implications of barriers to access occur at varying levels of severity. For example, in the northern part of the U.S. lack of access to low-cost natural gas or heat might affect health by causing hypothermia, while in the south lack of access to air conditioning could lead to heat stroke or heat illness.

5. Where to Start

We must first acknowledge structural and socially propagated inequities. In seeking to provide metrology for a more equitable energy system (and transition to such a system from the status quo), we develop a multi-dimensional framework of equity that accounts for dimensions of historical legacy, capacity, and potential. Historically, we have a current political, educational, and economic system marred with socially normalized inequities. Because of the historical legacy and local differences, these tracking efforts should be broadly defined at an agency level, but with a repertoire of options that can be adapted at a community level.

Examples might include metrics/indicators/indices that, for each stage (Fig. 1), seek to evaluate:

- Research expenditures with underrepresented researchers and minority-serving institutions;
- Risk capital investments and technology transfer activities with women- and minority-owned or -led businesses in the energy sector; or
- Community impacts inclusive of supplier and workforce diversity. For example, the solar photovoltaics industry has historically had poor penetration into underserved communities and has not tracked or prioritized minority-owned business suppliers.[17]

While we can address equity in access and opportunities, we cannot control equity in outcomes as they are dependent on free will and markets. Metrics and indicators can be used to bring awareness and influence markets and individuals. In deconstructing the economic model within the energy sector, we see indicators and metrics that can be developed around research, technology transfer, entrepreneurship, workforce.

6. Open Research Questions

There are multiple questions that we ought to address in the process of measuring inequity in the energy space and that require further work to be reflected in the research and development process. For example:

- **Injustices**
    - How can we mitigate and correct historical injustices, while mitigating the future risk of worsening inequality?
    - The model for restorative justice does not account for the complexities of the free markets, global supply chain dynamics, and economic liberties. What changes, refinements, or new models are needed for an equitable energy system?
    - How can metrics help avoid an adaptive framework, and aim for preventative action and addressing deeper systemic issues instead?[15]
- **Measurements**
    - Measures: Defining and understanding the types of measures and what's measurable is critical.
    - Indicators: Are there existing economic, social, and innovation factors that articulate the condition and quality of the energy system?
    - How do metrics help us understand power and how it is distributed (rather than "actually" measuring something)?
    - How can metrics (both measurable numbers or indicative attempts at capturing hard- or impossible-to-measure conditions) reveal hidden patterns or behaviors that expose inequalities in societies, especially among racialized and otherwise minoritized communities?
    - How do certain metrics help or hurt in the process of dismantling social, environmental, racial, etc. injustices?
- **Aspirational**
    - What does an equitable energy transition look like, how do we know how to best measure it, and what are the appropriate indicators?
    - At what speed, effectiveness, and degree of equity is epistemic justice being incorporated into institutions such as universities, the energy industry, or the government?
- **Intersectional**
    - What might be some economic-related metrics that can help us track equity in businesses, technology transfer processes, technology diffusion, and wealth creation and participation?
    - How rapidly is climate and energy justice being addressed without bypassing or ignoring other pillars of justice (restorative, distributive, procedural)?
    - How can metrics be incorporated into legal contexts? What justice is needed and/or expected in a legal process, and how will this justice be

enforced or applied? How can the success of a legal process seeking justice be measured? Was there a result of the application of justice through a legal process? How complete and equitable (in terms of serving all parts of society equally) is a legal and policy framework in a nation/globally?[15]

7. Challenges with Framing and Measuring Equity

When researchers, especially from the STEM fields, engage with metrics in their research, it is usually (though not always) with a connotation of objectivity, of absoluteness, of measurability that conveys a precision or degree of certainty that would otherwise not exist if that metric did not exist. In this research agenda recommendation framework, we suggest that the development of, or research on, metrics for a just and equitable energy transition must foreground the goal of reaching a more just and equitable society. To this end, the metrics in question can (should?) be first and foremost: a) tools to make injustices visible and legible, b) accountability mechanisms, and c) mobilizers toward changing an inequitable and unjust status quo.

To this end, we lay out the potential advantages as well as stumbling blocks of metrics development and measurement:

- Metrics, as we treat them in this framework, are not "objective" in the traditional Western scientific sense of the word, but a tool used to mobilize change--specifically, to do anti-racist, anti-sexist, and anti-colonial work. (Normative statement:) We aim to develop a research agenda that works towards improving and increasing access, opportunity, equity, and justice. We need to understand whether, which, and to what extent metrics may or may not be able to help with this.
- Metrics should not be developed or researched for metrics' sake because humans love to put things in boxes, especially things they can't measure. Should the word "metric" be contested? *Indicators* or *guide* or *justice level check* is probably more appropriate for realities that are difficult to put into boxes.
- The development of a metric/indicator in and of itself should be an act of justice. How do you capture the realities of a marginalized group or vulnerable sector of the population in such a metric? The *process* of research and capturing/modeling realities is important and needs to be participatory.
- The unification of scholarly communities and research that all engage with concepts of justice and equity (e.g., climate, environmental, and energy) is important,[18] but not at the expense of nuance. We need a complex, flexible framework that allows for all forms of justice to be laid out and contested, and the dismantling of injustices (through, among others, metrics in existing tools and frameworks) in an inclusive/holistic way that does not simplify or flatten certain realities or give preferential treatment of some realities over others. Important elements include: fora for democratic deliberation, contestation of policy and

'justness' of it, research that is in conversation with each other, and metrics that are not just checkboxes.

8. (Tentative/Initial) Recommendations

- Develop a more comprehensive Energy Equity Metrology Framework as highlighted in Fig. 2. Previous efforts by many researchers highlight the need and basis for equity measurement. [15, 19, 20]
    - Add to energy equity framework for social impact[14]to be more precise around economics inclusive of workforce, business ownership, intellectual property, investment capital, SBIR/STTR awards, leadership, grants, and contracts.
    - Add political investment and policy indices
    - Include data owners (federal agencies and trade groups)
    - Develop industrial and market indices
    - What other metrics and indices may be offered to a?
- Energy burden and energy justice research is siloed. Incentivize to create a multidimensional analysis that includes economic measures. Fig. 2. shows an Energy Equity Metrology Framework that includes workforce, business activities, technology transfer, and capital equity dimensions. It is modeled after the framework for energy injustice and proposes process for a just energy transition metrology.[20]

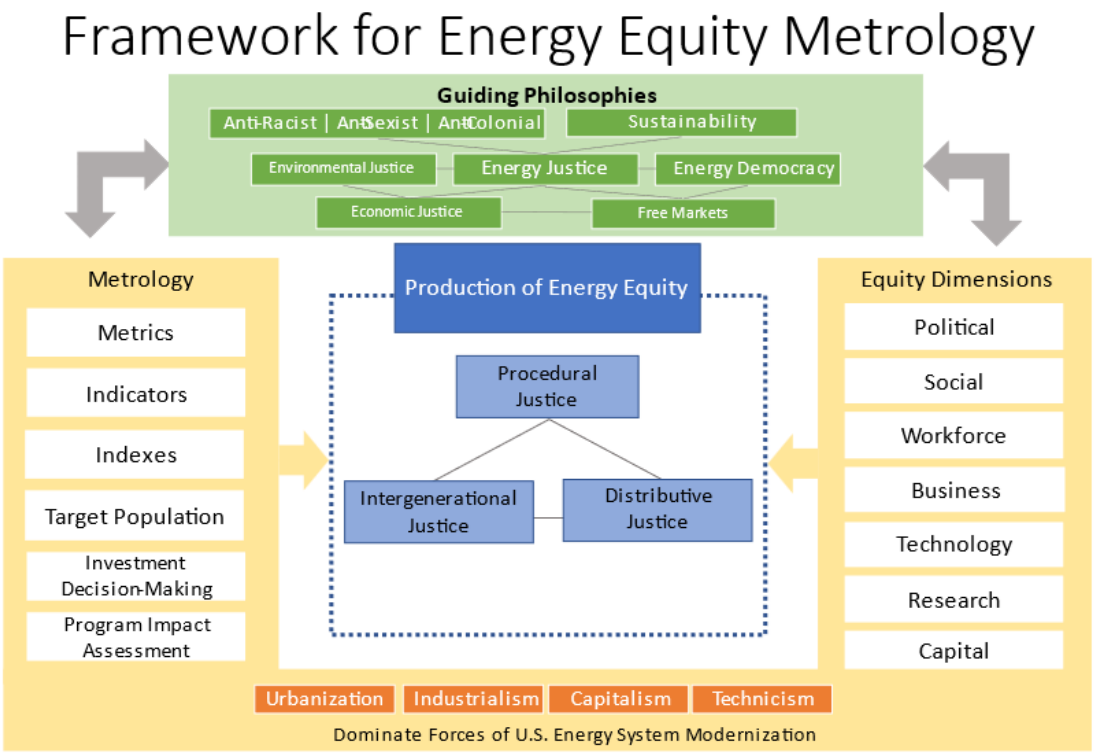

Fig. 2. The process to achieving energy equity requires a multi-dimensional analytical basis inclusive of economic measures such as impacts on workforce, business activities, technology transfer, and capital.

- While planning for some national transition, policy makers must remember that injustices look different across communities that have been on the receiving end of different burdens. Fund research to examine historical injustices and add funding mechanisms to assess community impact. Include community impact as part of the environmental impact for energy projects. Examine policy levers for community impact assessment.

Working Group 3: Community Engaged Research for Energy Justice

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Introduction

Community engaged research provides an opportunity for communities, workers, and other stakeholders to inform and impact research outcomes.[1] This research method can ground theoretical work in empirical realities, develop new grounded theory, and provide communities with much needed research capacity. However, how to successfully conduct community engaged research, particularly for researchers new to the method, raised many questions and concerns in the initial NSF workshop. Moreover, the specific challenges of the energy transition and the goal of energy justice require researchers to understand how to apply community engaged research to advance a just energy transition.

Even though there was uncertainty around how to conduct Community Engaged Research (CER), there was a clear sense of the desired goals. Workshop participants identified that CER should: 1) ensure that communities participants, at any level, are adequately compensated and protected from "extractive" research that only benefits the researcher, 2) provide for appropriate time scales to allow for "meaningful" participation, which can take more time to build trust and authentic relationships, 3) align with the actual needs of the communities to address their concerns and challenges, 4) co-create solutions so that communities are equal partners.

Among the questions raised on how to conduct CER, several addressed fundamental and foundational issues: When is community-engaged research appropriate? Relatedly, how can researchers self-assess the importance of partnering, how can communities evaluate the value of partnership, and how can funders gauge the authenticity of researcher-community partnership? What does "meaningful" engagement mean and what are the accountability mechanisms around it? What methods of engagement should be used–should it be an advisory board or more than advisory? How can communities control and direct research? Who is considered as part of "community" and how can Labor and other stakeholders not typically engaged be included? What happens when community self-assertion does not align with the research agenda? These questions are not necessarily answered in this brief, but we raise them as outstanding questions among our colleagues and as potential discussion questions for our next workshop.

Below, we highlight the unique aspects of community engaged research specific to energy justice, principles of community engaged research, best practices, and

[1] A key distinction that arose from the workshop is the differentiation of Community Engaged Research where research is conducted in alignment with communities and community values versus Community-based Participatory Research where community members are direct participants in data collection.

opportunities for innovations to support community engaged research for funders, researchers, and others.

Acronyms and Definitions

- Public Scholarship: scholarship with a public purpose or value, which may be complemented with public outreach.
- Engaged Research or Community-Engaged Research (CER): public scholarship rooted in collaboration between scholars and community-based partners. Community-Engaged Research draws on multiple types of knowledge when defining research questions, developing research design, gathering and analyzing data, and applying findings.[21]

  Andrew Furco, Professor of Higher Education and Associate Vice President for Public Engagement at the University of Minnesota, developed this table to differentiate traditional scholarship and engaged scholarship:[22]

Traditional Research	**Engaged Research**
Breaks new ground in the discipline.	Breaks new ground in the discipline *and has direct application to broader public issues.*
Answers significant questions in the discipline.	Answers significant questions in the discipline *that have relevance to public or community issues.*
Is reviewed and validated by qualified peers in the discipline.	Is reviewed and validated by qualified peers in the discipline *and by members of the community.*
Is based on solid theoretical basis.	Is based on solid theoretical *and practical* bases.
Applies appropriate investigative methods.	Applies appropriate investigative methods.
Is disseminated to appropriate audiences.	Is disseminated to appropriate *academic and community* audiences.
Makes significant advances in knowledge and understanding of the discipline.	Makes significant advances in knowledge and understanding of the discipline *and public social issues.*
	Applies the knowledge to address issues in the community.

- Community-Based Participatory Research (CBPR): "Community-based participatory research is a collaborative research approach that is designed to ensure and establish structures for participation by communities affected by the issue being studied, representatives of organizations, and researchers in all aspects of the research process to improve health and well-being through taking action, including social change."[23]

- Participatory Action Research (PAR): "Participatory action research seeks to understand and improve the world by changing it. At its heart is collective, self-reflective inquiry that researchers and participants undertake, so they can understand and improve upon the practices in which they participate and the situations in which they find themselves. The reflective process is directly linked to action, influenced by understanding of history, culture, and local context and embedded in social relationships. The process of PAR should be empowering and lead to people having increased control over their lives."[24]
- Co-Production and Co-Creation: Co-production and co-creation connote a "joint effort of citizens and public sector professionals in the initiation, planning, design, and implementation of public services."[25] While there is some definitional ambiguity to these terms,[25] the concept of co-production and co-creation has been used to describe collaborative research between researchers, practitioners, and members of the public in ways where "everyone works together in more equal partnerships and shares responsibility and power throughout the research project."[26]
- Community: Many different definitions of "community" have been advanced by scholars. One particularly resonant definition of community is "a group of people with diverse characteristics who are linked by social ties, share common perspectives, and engage in joint action in geographical locations or settings."[27]
- Institutional Review Board (IRB): "The purpose of IRB review is to assure, both in advance and by periodic review, that appropriate steps are taken to protect the rights and welfare of humans participating as subjects in the research."[28]

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1. What Is Distinct about Community Engaged Research in Energy Justice?

There is well-developed research with translational implications in community-engaged research in general as well as in particular fields, such as public health and environmental justice. We focus here on the specific and distinct challenges of developing community-engaged research in the domain of energy, which we consider essential for a just energy transition.

How and why is community-based research different *with energy* than with other sectors?

Because of the importance of high-cost, long-lived, highly-networked capital and infrastructure, energy systems must necessarily operate on long time scales. Decisions made now may have decades or centuries (or in the case of nuclear power, millennia) of implications for energy systems themselves and for a host of interacting socio-technical systems. Fast reversals or retrofits may not be possible, and there are substantial advantages to getting the high-cost investment right in the first place rather than attempting to retrofit unjust and inegalitarian systems later, after their contours have solidified.

Research, development, and implementation do not appear on a clean slate. There is already much capital installed and many systems and processes (some unjust and dysfunctional, some functional) already in progress.

Energy is fundamentally intertwined with many other systems that bear on justice and equity, including food and water, air, housing and shelter, and transportation and mobility. With respect to intertwined systems, we underline the importance of two-way connections between the social and technical domains. A technical aspect of energy — for example, a limitation on long-distance transmission — can bear on the regulation of land use. A social aspect of mobility — for example, the need for large-scale, rapid, around-the-clock intra-urban commutes — can dictate the need for technical aspects of energy.

Earlier large-scale investments in energy were highly centralized and often designed to meet the needs of dominant industrial actors. Energy planning has often, although not always, been designated as a largely technical matter with the expectation of user acceptance of and adaptation to the large-scale energy systems offered by governments or large private utilities. The specification of parameters for systems was defined by reference to the scientific and technical with no need for community engagement. That system of planning has left multiple troubling legacies.

The complex world of energy science, engineering, planning, and implementation implicates different or additional sets of actors than community engaged research in general. Examples of additional, energy-specific actors whose input is essential may include citizen utilities boards, utilities and generators themselves, energy intermediaries such as independent service operators, labor unions, environmental-advocacy organizations, tenants' unions, and consumer cooperatives. Hence, community-based research on energy faces an initial specific challenge of defining communities for energy systems[29]

- Energy is a ubiquitous infrastructure. Sometimes the infrastructure is literally buried; in other cases, it is so universal and familiar as to be invisible in plain sight; and in still more cases, the life cycle of energy from extraction to disposal may involve effects on some participants that are hidden from other participants. Affected communities — even those that experience powerful direct effects of the complete set of flows — may have a limited base of individual knowledge experience. Research can make these hidden flows and effects visible.
- Energy is one of the most complex and technocratic systems in modern life. The interplay of technology, markets and private interests, and public regulation with high-cost capital and infrastructure has necessitated enormous technocratic control. This industrial organization creates significant concerns about procedural injustice and representation as well as longstanding concerns about regulatory capture (regulatory capture refers to the situation when regulated interests (e.g., utilities) influence regulators or rules to the advantage and profit of the regulated interest).

  - In the United States, energy regulation has a complex federated structure with distinct, important, and interacting jurisdiction for federal, state, and local governments and courts. Multi-layer regulation necessitates enormous regulatory expertise. Lawsuits involving tension between layers of jurisdiction are common.
  - Small local movements for energy democracy operate within a system that is much larger than the local community itself. Energy research on the technical and social potential for local power could build the potential to amplify local community action through the larger energy system.
- Even defining community is a challenge in the domain of energy. Production and consumption are often geographically and economically separated, with multiple overlaid structures (local, national).
- As a complex cybernetic system, energy is a likely site of widespread deployment of artificial intelligence, for example, for demand-side management as an energy-efficiency solution. This likelihood presents the domain of energy with a host of concerns about justice in artificial intelligence and in information technology (e.g., algorithmic decisions and surveillance). There are likely emergent and under-explored considerations bearing on justice in complex, technocratic systems that combine market and regulatory mechanisms for administration. For example, the implications or impact of intermittent or differentially priced energy may vary substantially depending on community capacity.
- Energy has additional salience because of the enormous amount of public and private investment at stake – certainly in the trillions of $US – during the energy transition.
  - The stakes in terms of an equitable and just transition have been partially and initially recognized, for example, in the Justice40 initiative that specifies having the federal government commit to "delivering 40 percent of the overall benefits of federal climate, clean energy, affordable and sustainable housing, clean water, and other investments to disadvantaged communities that have been historically marginalized, underserved, and overburdened by pollution."[30] Specifying, operationalizing, implementing, and measuring the terms of this commitment is an enormous and specific challenge, and research is needed. Justice40 represents a great opportunity but also carries risks of inadequate conceptualization and implementation. Research can both draw from and contribute to the momentum for justice in energy transition planning.
  - As a social and technical transition, the Energy Transition faces a nearly certain socioeconomic and spatial mismatch between potential beneficiaries and potential losers.
    - For example, there are clear and disturbing mismatches between job loss in sunset industries and job growth in sunrise industries. Many

sunset industry jobs are high quality employment (with higher pay, more unionization, and career ladders), which makes the decline of these sectors deeply troubling for affected communities, which are often in areas that have already felt the effects of deindustrialization. Clean energy is the fastest growing job sector, but the organization and quality of the attached jobs are still emerging. The quality of jobs in an industry reflects a wide set of technical, social, economic, and political decisions, involving skills and training, unionization, taxes and subsidies, and technological choices. Research can both interpret and guide a just transition, including both the phase-down of sunset industries and the ramping-up of sunrise industries in ways that are protective and supportive of affected communities.

- The capital and infrastructure (and associated jobs) create challenging dilemmas for communities. Once placed, capital and infrastructure (for example, mines, electrical generation units, transmission systems) can be simultaneously important to incomes yet threatening to health – a "can't live with them, can't live without them" relationship for communities.
- In every transition, the energy system has provided enormous opportunities for building wealth. The equity of that opportunity depends on the interplay of technical and social and policy considerations.
- The sunsetting electrical utility system is a mixed bag; we can replicate successful elements and learn from the mistakes.
  - The electrical utility system has tended to offer high-quality, unionized employment.
  - Employment opportunities have not always been allocated fairly by sex and race.
  - The monopoly structure of electric utilities has been prone to regulatory capture and unaffordable high monopoly pricing. Affordable electricity and access to energy are (non-exhaustive) elements of "energy democracy" which has become a key focus of energy justice activists and scholars, e.g., https://nonprofitquarterly.org/power-to-the-people-why-we-need-energy-justice/.

2. What Makes Community Engaged Research Successful?

Community Engaged Research is one approach to achieve a just energy transition, which can occur along a spectrum of involving affected communities into the design, implementation, evaluation, and dissemination of research. The CDC defines community engaged research broadly as "the process of working collaboratively with groups of people who are affiliated by geographic proximity, special interests, or similar situations with respect to issues affecting their well-being".[31] Community Engaged scholarship can be:

- Basic science with stakeholder advice to better describe/explain;
- Co-produced knowledge to describe/explain;
- Evaluation research that informs practice;
- Action research that co-produces intervention.

The theoretical framework for community engagement originates from principles established in the public health field, although is practiced in other sectors, such as community-based NGOs. A widely cited theoretical framework for community engaged research outlines the following conditions for success (adapted from NIH, 2011):[31]

1. Before starting, the researcher should be clear about the purposes or goals of the engagement effort and the populations and/or communities they want to engage.
2. Before starting, the researcher should become knowledgeable about the community's culture, economic conditions, social networks, political and power structures, norms and values, demographic trends, history, and experience with efforts by outside groups to engage it in various programs. The researcher should learn about the community's perceptions of those initiating the engagement activities.
3. The researcher should first go into the community, establish relationships, build trust, work with formal and informal leadership, and seek commitment from community organizations and leaders to create processes for mobilizing the community.
4. The researcher should accept that collective self-determination is the responsibility and right of all people in a community. No external entity should assume it can bestow on a community the power to act in its own self-interest.
5. Success requires partnering with the community is necessary to create change and improve health.
6. All aspects of community engagement must recognize and respect the diversity of the community. Awareness of the various cultures of a community and other factors affecting diversity must be paramount in planning, designing, and implementing approaches to engaging a community.
7. Community engagement can only be sustained by identifying and mobilizing community assets and strengths and by developing the community's capacity and resources to make decisions and take action.
8. Organizations that wish to engage a community as well as individuals seeking to effect change must be prepared to release control of actions or interventions to the community and be flexible enough to meet its changing needs.
9. Community collaboration requires long-term commitment by the engaging organization and its partners, such as the research team and other partners.

A variety of approaches exist to engage with communities, but not all result in meaningful community engagement and, ultimately, empowerment. Articulated in Arnstein's *A Ladder of Citizen Participation* (1969)[32] and refined among scholars in recent years, engaging with communities can fall along a spectrum of performative *consultation*, which is typically one-way and often occurs after critical research decisions have been made, to *empowerment,* in which the community is responsible for identifying the questions, methodology, and implementation of research. As identified in Figure 2, in employing these various phases of participation – and by extension, participatory research – the *impact* of the research increases along the spectrum.

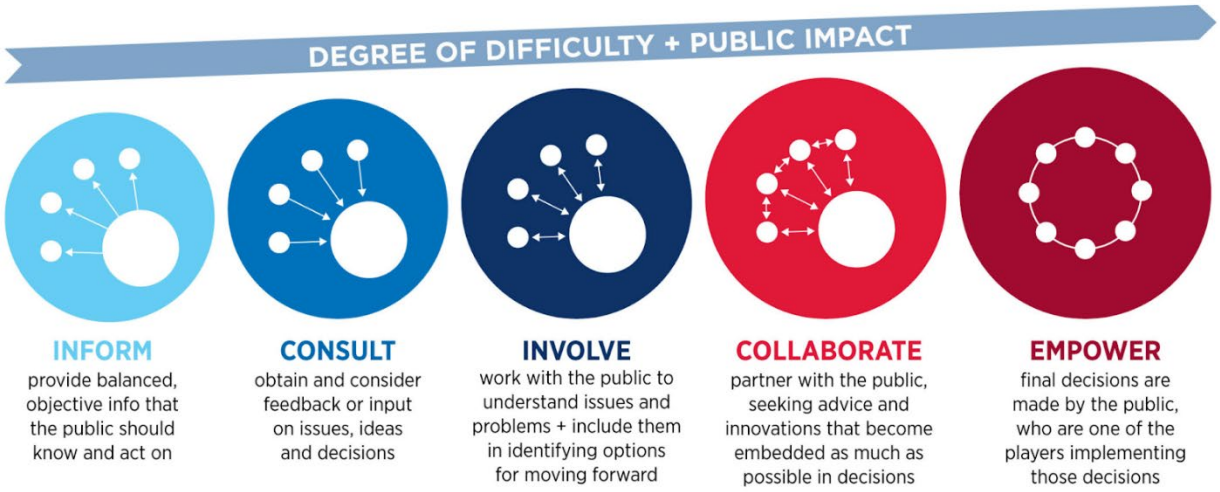

Figure 2: Spectrum of Participation in increasing level of community impact. Figure from KU Office of Research, Adapted from International Association for Public Participation (IAP2) Spectrum of Public Participation (2023). https://research.ku.edu/community-engagement

Along the spectrum of community engagement, different approaches to community engaged research can be appropriate in different circumstances. It is important to provide funding opportunities that are differentiated not just on topical scope but also on the modes of engagement (e.g., funding projects that create a community advisory panel to oversee project design, and funding collaborative efforts that build community empowerment through co-created research projects). And across different modes of engagement, it is valuable that research efforts build on the experience of other researchers that have developed approaches to different forms of community engagement (see for example, Newman, et al. on best processes for establishing community advisory boards in the context of medical research;[33] as another example, is the work of Szanton on the difficulties in matching university research priorities with that of disadvantaged communities;[34] see also Strand, et al. for principles of community-based research generally).[35]

While a worthy goal of the research community may be to move towards empowerment by engaging in CER, we caution that community engaged research may not always be appropriate. For example, researchers engaging in fundamental science need

not design a CER project for the sake of meeting a "one-size-fits-all" requirement that researchers of the energy transition must engage with a community. Workshop participants note a considerable risk in more performative CER is the extractive nature of research. Extractive, or transactional, research can occur when a researcher brings together community members for the sake of winning a research proposal or in a manner to inform or consult but fails to deliver any tangible benefits back to that community or fails to offer decision-making power to the affected community. This sometimes materializes in poor neighborhoods, where research is framed as a "laboratory." This is particularly problematic when the community in question is a community of color, or otherwise marginalized, and of which the researcher is not an in-member. There is an especially high danger of extractive or transactional research in the context of high funding and rapid change. Extractive research runs a high risk of engendering community mistrust, and such mistrust can be long-lived and consequential – as well as unethical. The importance of developing and maintaining reciprocal and respectful research relationships increases the challenge of meaningful engagement.

Workshop participants noted several principles of community engaged research that the research community should strive to achieve. These are situated within theoretical principles that have been articulated among the CER community. Workshop participants overwhelmingly identified the importance of the *co-creation* of solutions such that they meet the "real" needs of the affected community. For example, research that creates local value or community benefits was highlighted as critical to the success of CER. Within the context of the energy transition, co-creation of solutions with local value should be implemented in a way that is technology-agnostic. It was strongly noted that researchers that are reliant on finding solutions to a preferred technology may fail to recognize resulting harms, effects on local communities, or preferred solutions that could create co-benefits or value in other sectors.

3. What Are Approaches to Community Engaged Research?

Community engaged research tailored to local communities begins with identifying and understanding "community." To advance understanding of specific communities, it is important for researchers to first build authentic relationships within communities before and during the research process. This can pose a challenge for academic researchers who come from backgrounds not typically shared by the communities they engage with in their research. Particularly for more "external" researchers, it is important to invest time and resources in building authentic relationships, which involves both introspection of a researcher's own identity and power and building empathy and understanding of the history and positionality of communities. Building authentic relationships can take time and resources well in exceedance of less engaged energy research. Doing so also requires making commitments to partnership that can extend well beyond the project timelines of typical funding cycles. But universities and many other research organizations are positioned as durable institutions and should, in principle, be capable of making decade-long commitments in their communities to allow

for meaningful engagement (rather than building more superficial partnerships through short-term funding cycles).

The different personal and organizational backgrounds of researchers and communities often creates a situation of working across boundaries, which highlights the need to build trust and respect between researchers, community organizations, and individuals in communities. It is also important to cultivate a common language, develop a sense of mutual benefit from collaboration, and create a clear set of expectations of contributions toward the collaborative effort. For community engaged research in energy in particular, it can be important to establish shared understanding for the different forms of "expertise" that are applied to energy work: from the highly rarefied and jargon-laden world of energy engineering to the lived experience of energy insecurity.

The need to work across boundaries highlights the important role of intermediary organizations that can facilitate building bridges and trust across researchers and communities. Examples of intermediary organizations that can facilitate trust building between academic researchers and communities include:

- Community-based organizations with experience working with researchers
- University extension services with experience working with communities
- Grant-making organizations that have roots in both communities and research organizations

Working across boundaries can also involve breaking down boundaries or building mutual embeddedness of researchers and communities. For example, researchers could work from within community organizations as formal affiliates or supervisors of student interns. And community members could serve as scholars in residence in universities.

3.1 Funding and Institutionalizing Community Engaged Research

One approach can be to leverage the positionality of universities within communities across the country to form consortia of local organizations that can develop an ecosystem or "learning community" oriented toward advancing a community's interest in energy transition, bolstered by university research capacity, in service of community goals and research needs.

Institutional support for community engaged research requires aligning the organizational incentives and structures of universities and other research organizations toward community engaged research. This involves expanding tenure expectations and faculty hiring decisions to recognize, reward, and incentivize community engaged research in line with university missions, and directing internal university funds toward engaged research. Institutional support for community engaged research can also involve changes to the curriculum of PhD students to involve research ethics, methodological training on community engaged research, and more rigorous and differentiated processes for institutional review of research design. As Brown, et al. note,[36] once institutional review boards (IRBs) "open themselves to the possibility of accepting communities as not only sites of research but also as viable researchers, they can alter procedures in order to increase community involvement in human subjects protection."

It is also important to routinize the compensation of non-researchers who devote time, effort, and expertise that add value to the overall engaged research effort. Financial compensation is the first step in the recognition of non-academic expertise that adds essential value to engaged research efforts.

Finally, it is important that relationships between researchers and communities do not end with the completion of the formal academic deliverables of a project. Instead, it is important for relationships to extend through the context-specific goals of the collaboration to avoid extractive relationships that meet only the researchers' needs. In this way, engaged research can also serve to build capacity in communities.

4. Outstanding Questions, Concerns, and Opportunities for Supporting Community Engaged Research

This section focuses on opportunities, questions, and concerns for researchers to support community engaged research on energy justice. Issues related to funders supporting community engaged research are covered in the Working Group 4 report.

Below are questions and statements that workshop participants raised around community-engaged research and the energy transition:

- What is the role of universities in supporting a just transition? What is the power that universities and research apparatus more generally hold? How can the research enterprise's power be deployed for a just transition?

- What if we thought of a broader question first before assuming that engaged scholarship is the answer? Engaged scholarship is only part of the answer of a much wider set of activities that the research enterprise/universities can deploy given its power and positionality.
- Not all research need be community engaged research; not all public engagement need be engaged research.
- When are the different models of C.E.R. appropriate and effective?
- How can the full lifecycle of research funding be opened to community engagement, from setting priorities for research areas, to developing RFPs, to selecting projects for the research itself, to reporting, publication, and providing accountability in R&D, investment, and capturing benefits for communities?
- When and how is it possible for communities to veto what they perceive as dead-end or harmful directions of research? Is it possible to develop criteria and what are they? Public support for research might require evidence of substantial likelihood of widely shared community benefits and low likelihood of dangerous or disequalizing outcomes.
- How can we provide for longevity of institutions for community control of research. (Can we develop an analogy to overhead (indirect costs) for academic research funding to enable institutions to survive and flourish?)
- Labor has a unique relationship to the application of research and should have a seat at the table. For example, the Climate Jobs National Resource Center engages labor unions to produce climate policy proposals.
- Introduce a broad array of strategies to capture the benefits of publicly funded research for the broad public good, from community-engaged research to intellectual property to purchasing agreements.

Working Group 4: Funding Processes to Enable Interdisciplinary Research at the Intersection of Energy Technology and Social Justice

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* Chair

Summary

This section discusses processes for funders to enable interdisciplinary research at the intersection of energy technology and social justice. There is a need for equity thinking to permeate all levels of the science and technology research enterprise as it relates to energy transition. Here we discuss how funders, such as federal agencies and foundations, can be active partners in expanding the role of equity in energy research and development.

First, we discuss the need for an interdisciplinary approach to research at the intersection of energy technology and equity. Then we discuss the literature and resulting recommendations on processes for equity-centered research assessment, and processes to enable community-engaged research. We highlight two NSF programs with promising elements. Among our recommendations is that NSF explicitly review and evaluate these programs so that the most impactful elements can be adopted more widely.

Two key elements were highlighted in terms of needs: 1) the importance of truly interdisciplinary approaches; and 2) the importance of integrating both the technical and technological elements of the energy system with social justice and equity. These connected themes were highlighted over and over in the workshop discussions, noting that current processes tend to lean on disciplinary silos and so do not enable this. The literature emphasizes the need for bringing social sciences in more fully to research on the energy transition, in particular the need to fund it alongside the more technical aspects. Examples of programs that have been successful in inducing interdisciplinary research are NSF's IGERT and NRT programs. On the other hand, most of the regular programs in NSF directorates are highly siloed, with extremely narrow conceptions of what makes a particular proposal acceptable in that program. Similarly, most DOE programs are focused on natural sciences and technology and do not prioritize having social scientists as part of the team. This includes a recent call on CCS that asks for an energy justice evaluation in the proposal but does not encourage social science as part of the funded project. We provide examples of international programs from Canada, Netherlands, and Norway that have produced highly interdisciplinary research on the energy transition. This topic is closely related to Working Group 1 on research questions.

Ensuring that equity is a priority requires building it into all stages of decision-making. We focus on the selection of funded projects among proposals. Crucial, but challenging, is the selection of evaluation criteria. Workshop participants and the literature note that peer review reinforces the conservative nature of academia. The NSF proposal

evaluation process is known for a strict focus on methodology. More weight should be placed on research that asks important questions. On the other hand, when citizens are involved in research assessment, they focus on the importance of the problem and pay less attention to whether or not any one project is able to deliver a solution. One recommendation to combat the biases of the peer review process while maintaining scientific integrity is to establish an inclusive evaluation process and adopt equity-centered metrics, including rigorous qualitative metrics. In addition, funders must pay attention to how calls for proposals are framed. This topic is closely related to Working Group 2 on metrics.

Community engagement in the research enterprise includes community participation in the *selection* of projects, and community participation in the *design of processes and calls for proposals* aimed at providing opportunities for communities to be engaged with research that is relevant to them. Both aspects are related to decolonizing research. As one participant from the workshop commented, "Solutions are often brought to or provided for vulnerable communities vs. co-created with them." This suggests communities and other stakeholders should be involved in shaping research questions from the outset. Taking a step back, this means that communities should also shape calls for proposals. A common theme in the workshops was that communities must be provided with the resources to participate in the formation and evaluation of research programs, as well as the resources to actively participate in research projects. One key idea is to put communities in the driver's seat, allowing them to identify collaborators from academia, rather than the other way around. For example, provide small resources to community groups that are interested, and allow them to develop capacity and to reach out to principal investigators (PIs).

Both ARPA-E and NSF have existing model structures that could enable this. In ARPA-E, the program director hosts workshops with stakeholders to shape the entire program. In this case the stakeholders tend to be from industry and academia, but a process like this could include community groups. We note, however, that such community groups may require upfront resources to develop the capacity and carve out the time to participate in such workshops. There is anecdotal evidence that the ARPA-E process is effective, in the sense that the program director will pivot a program based on feedback and ideas from the stakeholder workshops. This model differs from the current NSF model, in which communities are encouraged to get involved in research projects after a call for proposals has been issued. Another option is for NSF to provide resources to community groups, similar to existing competitive research planning grants, allowing them to set the agenda and invite PIs to listen. Below, we note several challenges and open questions around such community engagement models. We emphasize that any plan to engage communities must involve representatives of frontline communities from the beginning. This is related to Working Group 3 on community engagement.

We look at two NSF programs in the light of the above: the Smart and Connected Communities (SCC) program, and the Civic Innovation Challenge (CIVIC). SCC specifically

addresses research at the intersection of technology and society, and is therefore one of the few programs that bring together engineering and social science. Nevertheless, it follows the traditional funding process in which university teams lead proposals and include project partners from non-academic organizations. Along with standard criteria they address integrative research and community engagement. CIVIC, which grew out of SCC, is intended to build a more cohesive research-to-innovation pipeline, and foster collaborative spirit across communities. CIVIC flips the community-university dynamic, asking communities to identify civic priorities ripe for innovation and then partner with researchers to address those priorities, focusing on research where real-world impact can be evaluated within 12 months. It is intended to foster "communities of practice" around high-need problem areas that allow for meaningful knowledge sharing and cross-site collaboration during both pre-development and piloting. This program allows for, and even requires, that civic organizations be compensated for their role.

While these two programs are promising, it would be extremely valuable to evaluate the outcomes of these programs using a broad range of metrics and methods to determine which aspects have been successful and may be extended to other programs.

Here we outline suggestions for topics for the second workshop.

- A session to collaboratively come up with examples of what equity-focused integrated engineering-social science research would look like. The goal is to go beyond broad goals of including equity that nobody would disagree with. Key question is how do we translate it into actual funding calls and research? Providing examples would be extremely helpful.
- A session on how to effectively encourage community engagement through calls for proposals. Working collaboratively with communities (as opposed to other researchers) is a skill that not all academics have or are taught. Thus, requiring direct engagement might result in unintended consequences where neither party is satisfied with the arrangement. Probing questions regarding community engagement include: 1) What projects need direct engagement with the research enterprise and how can NSF or other agencies decide that? (e.g., communities might want to have input into research on siting or disposal but not necessarily on other topics, etc.). 2) Related to 1), has any agency asked communities when/where/how they would get involved? While the recommendation from us as scientists to include community organizations in the research process is well-meaning, it falls into the trap of removing agency from said communities by speaking for them. 3) How can NSF and other agencies provide training to academics and universities on effective community engagement? 4) What mechanisms should be in place when there is a conflict? NSF and other agencies sponsor research that cater to U.S. national interests but also routinely include global benefits. If there is a conflict between local and global impacts, how will it be resolved?

- Develop a set of specific questions that NSF should ask of their internal data on SCC and CIVIC (or other programs)? Some key questions to focus on include:
    - Based on NSF's metrics for success of its grant programs, were there any observed differences in the success or effectiveness of the SCC and SCC-CIVIC programs?
    - Were community members that were part of these programs surveyed to learn about their experience with different aspects of this program including grant writing, engagement with universities, benefits to their community, and award process?
    - Did the outcomes correlate with community satisfaction/engagement?
    - What lessons on community engagement can we learn from NSF's experience with the CIVIC program?

1. Introduction

There is a need for equity thinking to permeate all levels of the science and technology research enterprise as it relates to energy transition. In this section we focus on the role of funders. Funding processes need to be equity-centered, inclusive, and interdisciplinary. This section is organized as follows. First, we discuss the need for an interdisciplinary approach to research at the intersection of energy technology and equity. Then we discuss the literature and resulting recommendations on processes for equity-centered research assessment, and processes to enable community-engaged research. We highlight two NSF programs with promising elements. We end with recommendations for further discussion and research.

2. Need for Interdisciplinary Research at the Intersection of Energy Technology and Equity

2.1. Introduction

The topic in this subsection has two pieces: the importance of interdisciplinary research, and the importance of research at the intersection of energy and equity. In 2.1 we provide motivation based on the discussions that took place during Workshop 1. In 2.3 we briefly review the literature supporting the need for these research intersections. In 2.4 we provide both examples and counter examples of best practices.

2.2. Motivation: Community Concerns

The most common theme in the discussions around this area was the need for "Spaces/forums to engage with different stakeholders and interdisciplinary research," to bring "technical folks into the same room as people working in social equity, e.g. resource planning that utilities do." They note that there is a need "for different skill sets to address equity in our energy transition. Yet, many NSF program directors often lean on disciplinary silos to decide whether a project is in scope. Help NSF understand unique needs of this topic." Many noted that interdisciplinarity in academia may not be

enough, there is a need to "Create, fund, support research spaces, such as collaborations between academia and local communities, that are transdisciplinary in nature and makeup. This could be done through academic consortia or individual grants that award funds to projects centering equity and justice around energy issues in local communities. It is in these local spaces that the most effective research questions and approaches for that particular space get shaped, which can then be systematically shared (through, e.g., consortia networks) with communities doing the same kind of research elsewhere." A related suggestion is "Expanding research teams to include different disciplines and researchers outside of the academy, and establishing the expectation that those people need to be paid out of grant funds."

One particular reason for encouraging interdisciplinarity is that "Researchers hold especially high standards for what counts as 'data' regarding equity problems. Interdisciplinary research spaces are better about this."

Other comments were: "More researchers and practitioners are focusing on topics at the intersection of energy technology and equity, and funders are putting money behind it" and "Discussions are often unidimensional, focused on one particular aspect of inequity without considering the intersection of other forms of inequity."

2.3. Literature Review and Findings

McCauley et al.[37] find that "The spectrum of research offers critical perspectives on the energy transition as well as tools for decision-making and policy processes. Quantitative, qualitative, and mixed methods all contribute to our understanding of the problems and the success of responses." They suggest there is a need to focus on "The importance of introducing the interdisciplinary approach between social sciences and natural sciences as well engineering implementation supported by scientific data and experiments" and suggest that this is an area for future studies.

Overland and Sovacool argue that there is too little money going to social sciences in climate research, including research into the energy transition.[38]

In a relevant paper focused on research at NIH, Scheider et al.[39]argue that in order to provide fundamental societal transformation, research programs must "broaden type and scope of funding." Other relevant literature includes the work of the importance of social relations and energy justice research.[40, 41]

2.4. Best Practices and Counter Examples

A key idea from the workshop and literature is that interdisciplinary research can support problem-centered, equity-first thinking. One positive example of this is the Urban Energy Justice Lab at the University of Michigan (https://urbanenergyjusticelab.com/). This lab employs students with a wide range of backgrounds, including public policy, human ecology, geomicrobiology, soil science, geospatial analysis, computer science, and engineering. The research coming out of this lab includes equity-centered research on renewable energy,[42] energy efficiency[43], energy poverty,[44]and sustainability education.[45]

This lab has been funded by a number of programs. At the federal level it has been funded by NSF's Smart and Connected Communities, DOE's Solar Energy Evolution and Diffusion Studies (SEEDS) program, and the NIH's National Institute of Environmental Health Sciences (NIEHS). In addition, the lab has been funded by foundations including The Energy Foundation and The Joyce Foundation. It is a positive sign that this external support has funded interdisciplinary equity-centered energy research.

Another idea is the need to include social science in particular, and multiple disciplines more generally. Some programs that have been successful at inspiring interdisciplinary research are the NSF IGERTs and NRTs. In some cases, this includes combining social sciences with STEM. They are able to do this by focusing on topic areas of broad social interest, by focusing on graduate students, who have not been inculcated as strongly into disciplinary silos, by providing funding for large teams (20-30 grad students) and by having a slightly longer time period of 5 years, which allows innovative collaborations time to flower. For example, in a recent paper[46], a collaboration between economists and computer scientists, showed how algorithms intended to evaluate energy efficiency were biased, falsely indicating that higher-income households were more in need of energy efficiency upgrades than lower-income households. This work was funded by an NRT focused on energy and equity.

On the other hand, most of the regular programs in NSF directorates are highly siloed, with extremely narrow conceptions of what makes a particular proposal acceptable in that program. Similarly, most DOE programs are very science-focused and don't leave room for social scientists to be part of the team.

NEED: Examples of programs that have been good at funding qualitative research, in particular combinations of qualitative and quantitative, and especially combinations of qualitative social science with STEM.

One particular point is the need for funding that brings disparate people together in a way that helps establish new language and norms. One example may be the newly launched NSF program Growing Convergence Research, which explicitly discusses the need to develop a common language.

Finally, we look for programs that have funded research at the intersection of energy technology and social equity. To do this, we searched Applied Energy, a journal that typically publishes engineering and natural science papers, to identify papers at the intersection. The examples were all from outside the U.S., and all included some partners from industry. A paper on smart grid and energy justice[47] was funded by The Netherlands Organization for Scientific Research (NWO) under the Responsible Innovation Program, the Amsterdam Institute for Advanced Metropolitan Solutions (AMS), and TFECo B.V, the last partner being a consultancy. A paper on bridging socio-technical and justice aspects[48] was funded by the Bergen Research Foundation and the Akademia Agreement between Statoil and the University of Bergen (Statoil is Norway's state-owned energy company). A paper applying sophisticated modeling to energy access[49] was funded by a Four-Year Doctoral Fellowship at the University of British Columbia and the Mitacs Globalink Research Award. Mitacs is a not-for-profit supporting industrial and social innovation.

On the other hand, many U.S. federal funding agencies and programs, especially those intended to push forward STEM, are often siloed in a way that makes it hard to bring social scientists into the program in a meaningful way. For example, consider a recent DOE call on CCS. On the one hand, this call explicitly included a consideration of equity and justice issues for the first time in a DOE program. However, there are some weaknesses in how the call for proposals was designed that impact the likelihood of real collaboration on equity and science. First, the equity considerations were only attached to the implementation part of the program. At this point, the science is well-determined, meaning that equity is an add-on rather than fundamental. The program did include funding for more fundamental research in CCS, but this part did not include any incentives for considering equity. Second, the call for proposals asked the PIs to do equity analysis before being funded and did not explicitly encourage equity research as part of the project. This significantly devalues equity research and leaves little room for sophisticated social science research to play a role.

3. Equity-Centered Research Assessment Processes

3.1. Introduction

- Energy equity and climate justice are increasingly popular as talking points, but the language of equity must be backed by a substantively modified approach to research funding.
- The strategic priorities of all funded research programs related to energy transition must include equity from the start, rather than equity-related research being siloed into a single program.
- To ensure that equity is a priority requires building it into all stages of decision-making.
    - Ex Post: Measuring and evaluating equity outcomes alongside other priority metrics. Selecting appropriate metrics is not trivial and may involve

non-quantitative assessments; see the Working Group 1 report for more discussion.

- Ex Ante: Equity must also be prioritized in the selection of funded projects. Again, selection of metrics is difficult, perhaps even more so in the case where the research has not yet taken place.

3.2. Rethinking Research Assessment

- New technologies are built to market or regulatory specifications. For a technology innovation to appropriately address equity challenges the developers should center equity "specifications" equally to others (e.g., new grid solutions built with community ownership in mind).
    - DOE is starting to require equity analyses. . In spring of 2021 the DOE had a call for proposals on CCS that required an equity analysis for later stage projects, as part of the proposal DOE should require equity impact assessment a la broader impacts at NSF, to be conducted by experts on four dimensions: Design equity, Distributional and siting equity, Procedural equity, and Historical legacy (Parthasarathy, Shobita. Testimony Before House Science Subcommittee on Energy. July 16, 2021).
- Peer review reinforces the conservative nature of academia. NSF's evaluation process in particular is known for a strict focus on methodology. More weight should be placed on research that asks important questions over problematic notions of "objectivity" and "rigor."
    - Reviewers discount novel ideas[50]
    - Consensus decisions result in a failure to fund "high-risk/high-return research"[51]
    - Lee et al. reviews commonly cited sources of bias in peer review including, but not limited to, nationality, language, gender, and prestige.[52]
    - Insular "old boy" networks contaminate peer review systems[53]
- In evaluations of research proposals by members of the general public, support differs by income and education if supporting a project imposes a personal cost upon evaluators. Evaluators' personal experience with a particular problem is associated with greater support. Citizens focus on the importance of the problem and pay less attention to whether or not the project is able to deliver a solution.[54, 55]
- Public value mapping is a method of assessing whether there is coherence among the public values of the research program stakeholders.[56-58]
- Track research outputs, and consider equity by asking whether the output leads to outcomes or impacts that accomplish a specific goal or reached specific beneficiaries.[59]

4. Community-Engaged Research Funding Processes

In this section we start with a discussion of the importance of engaging communities in research. We then focus on ways in which communities can be engaged in the research enterprise, and end with a discussion on the importance of providing resources to community organizations for their work in the research enterprise.

4.1. Engaging Communities in Research Is Important

One strain in the academic literature on community engagement in research emphasizes ways that community viewpoints add to energy research and innovation. The following two testimonies to Congress by two scholars of energy innovation emphasize the role of community engagement in relieving inequitable impacts proactively, encouraging grassroots and user-informed perspectives, consultation, and suggest ways that citizens can be drawn into existing processes.

- Parthasarathy, Shobita. Testimony Before House Science Subcommittee on Energy. July 16, 2021[60]
    - DOE should consult communities on projects, meaning sponsor deliberative democratic engagement (aka participatory technology assessment), and using community advisors in grantmaking.
- Farooque, Mahmud. Testimony Before the House Science Subcommittee on Research and Technology, May 6, 2021.[58]
    - The Center for Nanotechnology and Society at ASU helped develop a Participatory Technology Assessment, which engages informed citizens through dialogue to improve outcomes for science and technology decisions.
    - Expert and Citizen Assessment of Science and Technology (ECAST) network launched to build a participatory engagement capacity in the United States. Portfolio includes nuclear waste disposal, climate intervention, and automated vehicles.

4.2. Engage Communities in Designing and Selecting Research Programs and Projects

Another strain of literature encourages participation by communities to determine the actual goals of research. A starting assumption here seems to be that communities and researchers are different but can still collaborate in complementary ways. However, this assumes that communities themselves don't do research, and that researchers themselves need to engage communities. Alternative models are of course citizen science, participatory research, and responsible research.

A number of Padlet comments emphasized that this difference is part of the problem:

- "Solutions are often brought to or provided for vulnerable communities vs. co-created with them."

- "NSF should explicitly give community groups the primary role when soliciting equity-focused grants."
- "Expanding research teams to include different disciplines and researchers outside of the academy."

However, "co-creation" requires initial capacity, willingness to collaborate, and trust. The idea of engagement between the government and non-government actors such as community groups is partially addressed by research on engagements between states and industries in setting industrial policy.[61, 62]

A decolonizing approach would be to break down walls and restructure power relations, but we did not find good examples of this in academic literature. A number of research justice reports emphasize the importance of basing research in personal and community goals and experiences.[63]

One emphasis is for research designs to include or consider many possible types of community knowledges, including community and cultural knowledge, experiential knowledge, and mainstream and institutionalized knowledge (often produced outside of the community).

Another crucial aspect of the research justice literature in public health is that research supports rather than determines community needs and goals. This comes from the observations that self-determination is a fundamental goal of social justice; communities are most aware of their needs; and to enact social change, communities need to remain engaged and invested with long-term campaigns and coalitions.

- Padlet comments: "Labor and EJ coalitions have to have voice early in the process," "starts with actual frontline community needs first," "communities/stakeholders have an opportunity to shape the research questions from the outset;" "Is LA 100 a robust example of equity in action? Were frontline communities meaningfully included?"

The research justice literature argues that research can play a key role in realizing community goals through organizing and campaigns (building understanding, coalitions, leaders, pressure on campaign targets).[64-68]

Finally, the responsible research literature emphasizes the responsibility of researchers as a group separate from communities.[69-72]Stilgoe et al.[72] note that "Responsible innovation means taking care of the future through collective stewardship of science and innovation in the present. Four dimensions: anticipation, reflexivity, inclusion, and responsiveness. Including the public in scientific governance can change outcomes. Example case study of geoengineering: a proposed test of particle delivery was postponed and then cancelled, as a result of the reflexiveness of a responsible innovation process."

Related to this comment is a comment from the Padlet in the workshop: "Researchers, scientists, engineers, all need to be aware of the importance of interacting with communities who will benefit or be harmed by their innovations. Not just superficial

consultation, but deep engagement;" "If people give input bottom-up style but it's not understood, or not taken seriously, it wastes their time and is a missed opportunity."

4.3. Pay People for their Participation and Reduce Administrative Barriers

This point was made repeatedly in the workshop that researchers who are doing engagement as part of their job should not be asking for volunteer time from people who are under-resourced. However, this results in challenges that academics are not necessarily currently trained for, as outlined here:

- Need to consider the community capacity, so some parts can be done with the whole community and other parts with leaders.
- Simply paying some community members could avoid harder thinking about what the whole community might want.
- Suggestions to overcome research fatigue include collaborating with community professionals and sharing work back with communities.[73]
- Mistrust of researchers, research institutions, and motivations.[74]
    - Padlet comments: "Put community groups in a primary role, coupled with enough resources and capacity building so it's not just the Big Greens that are able to apply."

In ARPA-E, the program director hosts workshops with stakeholders to shape the entire program. In this case the stakeholders tend to be from industry and academia, but a process like this could include community groups. We note, however, that such community groups may require upfront resources to develop the capacity and carve out the time to participate in such workshops. There is anecdotal evidence that the ARPA-E process is effective, in the sense that the program director will pivot a program based on feedback and ideas from the stakeholder workshops.

5. Case Studies of Funding Agencies Incorporating Energy in Equity

5.1. Case Study 1: NSF Smart and Connected Communities (SCC)

Mission: "Integrative research that addresses fundamental technological and social science dimensions of smart and connected communities and pilots solutions together with communities."

5.1.1. General Features

- This proposal specifically addresses research at the intersection of technology and society and is therefore one of the few programs that bring together engineering and social science.
    - Four different directorates jointly fund and review proposals: Computer and Information Science and Engineering; Education and Human Resources; Engineering; and Social, Behavioral and Economic Sciences.

- Several programs stem from the broader SCC domain with collaborations outside of NSF (key recommendation in our paper). One example is Civic Innovation Challenge, focusing on two broad categories of research: communities and mobility, and disaster resiliency (see below for more).
- But, still required to satisfy NSF's statutory mission: "high-risk, high-reward approaches or significantly advance theoretical foundations of S&CC sociotechnical research."
- Key focus on sustainability beyond NSF funding (similar to ERC proposals and several DOE/ARPA-E projects): "sustainability of the research outcomes beyond the life of the project, including the scalability and transferability of the proposed solutions."
- Traditional funding calls: University teams lead project proposal, and include project partners from non-academic organizations.
- Standard review criteria for intellectual merit and broader impacts, and includes additional criteria on how the proposal addresses integrative research and community engagement.

5.1.2. The Good

- Requires integrative research that addresses both technological and social science dimensions and must incorporate multidisciplinary perspectives of scientific areas from all participating NSF directorates.
- Broad array of application areas: agriculture, infrastructure, energy, health, inclusivity, workforce development, social services, safety, water, etc.
- Provides specific project examples of how technology and social sciences should be integrated.
- Meaningful community engagement activities should be an integral part of research.
- Community stakeholders are encouraged to have leadership roles within proposing teams (although this is not required for proposal submission).

5.1.3. The Bad

- Research ideas are expected to be initiated by academic personnel who then solicit community partners for collaboration.
- There is no requirement for inclusion of community members as co-PIs or senior personnel (although it is encouraged).
- Community members are not officially part of review panels.

5.2. Case Study #2: NSF Civic Innovation Challenge (special program from the SCC Domain)

Mission: Research and action competition to build a more cohesive research-to-innovation pipeline and foster collaborative spirit across communities. Collaboration with other agencies: DHS and DOE.

NSF is trying something like ARPA-E on a small scale by funding projects that are specifically designed for pilot demonstration and long-term deployment – very uncharacteristic of NSF. It is unclear if NSF is built to see projects through demonstration and deployment. Will have to wait for results on the CIVIC grants to assess effectiveness.

How does the Civic Innovation Challenge differ from the broader SCC domain? [This fixes some of the flaws with the original SCC track proposals]

- CIVIC flips the community-university dynamic, asking communities to identify civic priorities ripe for innovation and then to partner with researchers to address those priorities.
- CIVIC focuses on research that is ready for piloting in and with communities on a short timescale, where real-world impact can be evaluated within 12 months.
- CIVIC requires the inclusion of civic partners in the core project team to emphasize civic engagement.
- CIVIC organizes and fosters "communities of practice" around high-need problem areas that allow for meaningful knowledge sharing and cross-site collaboration during both pre-development and piloting.

5.2.1. New review criteria

How effectively does the collaborative approach described in the proposal break down barriers between academia, civic organizations, and local and state governments to achieve the desired impact?

5.2.2. The Good

- Civic partners should jointly develop proposals with universities based on community needs, not just scientific interests.
- Civic partners must be assigned co-PI roles on the proposal.
- Partner institutions in communities should be appropriately compensated (no 'free' collaboration).

We recommend that NSF study these programs. For example, NSF could use their internal data to investigate whether they survey community members of funded grants at the completion of the program? How did the outcomes correlate with community satisfaction/engagement, etc.?

6. Recommendations and Items for Discussion

Some recommendations include the following:

- Research institutions should evaluate tenure requirements, publishing expectations, department cultures, etc., and make needed adjustments such that incorporating equity into all types of energy research is actively encouraged and will become the norm. People doing science and engineering research will continue to see equity as an afterthought (a "nice to have" but not mandatory) if their incentives do not change.
- Establish an inclusive evaluation process.
- Use equity-centered metrics, being open to qualitative metrics as well.
- Use levers other than just formal evaluation metrics: framing of calls for proposals, training for program officers, etc.
- A key recommendation is that NSF explicitly review and evaluate the SCC and CIVIC programs so that the most impactful elements can be adopted more widely.

Here we outline suggestions of topics for the second workshop.

- A session to collaboratively come up with examples of how equity-focused integrated engineering-social science research would look like. The goal is to go beyond broad goals of including equity that nobody would disagree with. A key question is how do we translate it into actual funding calls and research? Providing examples would be extremely helpful.
- A session on how to effectively encourage community engagement through calls for proposals. Working collaboratively with communities (as opposed to other researchers) is a skill that not all academics have or are taught. Thus, requiring direct engagement might result in unintended consequences where neither party is satisfied with the arrangement. Probing questions regarding community engagement include: 1) what projects need direct engagement with the research enterprise and how can NSF or other agencies decide that? (e.g., communities might want to have input into research on siting or disposal but not necessarily on other topics, etc.). 2) Related to 1), has any agency asked communities when/where/how they would get involved? While the recommendation from us as scientists to include community organizations in the research process is well meaning, it falls into the trap of removing agency from said communities by speaking for them. 3) How can NSF and other agencies provide training to academics and universities on effective community engagement? 4) What mechanisms should be in place when there is a conflict? NSF and other agencies sponsor research that cater to U.S. national interests but also routinely include global benefits. If there is a conflict between local and global impacts, how will it be resolved?
- Develop a set of specific questions that NSF should ask of their internal data on SCC and CIVIC (or other programs)? For example, did they survey community

members of funded grants at the completion of the program? How did the outcomes correlate with community satisfaction/engagement, etc.?

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