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Authors	Ash, Michael;Baker, Erin;Tuominen, Mark;Venkataraman, Dhandapani;Burke, Matthew;Castellanos, S.;Cha, M.;Chan, Gabe;Djokić, D.;Ford, J. C.;Goldstien, Anna P.;Hsu, David;Lackner, Matt;Miller, C.;Nock, D.;Ravikumar, A. P.;Bates, Alison;Stefanopoulou, Anna;Grubert, E.;Kammen, D. M.;Pastor, M.;Attari, S. Z.;Carley, S.;Clark, D. L.;Deane-Ryan, D.;Kosar, U.;Bowie, Kerry;Johnson, Tina
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White paper: Research Challenges at the Intersection of Energy and Equity in the Energy Transition

Summary report from NSF2026: Conference Workshops to Identify Research Challenges at the Intersection of Energy and Equity in the Energy Transition

Michael Ash, *University of Massachusetts Amherst*; **Erin Baker**, *University of Massachusetts Amherst*; **Mark Tuominen**, *University of Massachusetts Amherst*; **Dhandapani Venkataraman**, *University of Massachusetts Amherst*; **Matthew Burke**, *University of Vermont*; **S. Castellanos**, *University of Texas at Austin*; **M. Cha**, *University of California, Santa Cruz*; **Gabe Chan**, *University of Minnesota*; **D. Djokić**, *University of Michigan - Ann Arbor*; **J.C. Ford**, *Florida International University*; **Anna P. Goldstein**, *University of Massachusetts Amherst*; **David Hsu**, *Massachusetts Institute of Technology*; **Matt Lackner**, *University of Massachusetts Amherst*; **C. Miller**, *Arizona State University*; **D. Nock**, *Carnegie Mellon University*; **A.P. Ravikumar**, *University of Texas at Austin*; **Alison Bates**, *Colby College*; **Anna Stefanopoulou**, *University of Michigan*; **E Grubert**, *University of Notre Dame*; **D.M Kammen**, *University of California at Berkeley*; **M. Pastor**, *University of Southern California, Los Angeles*; **S.Z, Attari**, *Indiana University Bloomington*; **S. Carley**, *Indiana University - Bloomington*; **D.L Clark**, *University of Wisconsin Madison*; **D. Deane-Ryan**, *The Bezos Earth Fund; The Greenling Institute*; **U. Kosar**, *Carbon180*; **Kerry Bowie**, *Browning The Green Space*; and **Tina Johnson** *Strategy & Development Consultants*

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I. Introduction

Energy systems fuel complex global socio-technical systems. The conversion and distribution of energy through the provision of electricity, transportation, and heating can generate profound economic inequities which can exacerbate existing social inequalities including race, gender, and socio-economic status across communities at local, regional, national, and global scales. These compounded inequalities are characterized by an intensifying unequal distribution of wealth, unequal access to energy resources, clean energy technologies, and clean environments. A transition toward a global net-zero carbon emission energy system is beginning in the United States and other industrialized nations, replacing aging and polluting energy technologies and infrastructure. This presents a challenge—and an opportunity—to reimagine equitable energy systems strengthening the fabric of society.

In this paper we summarize the conclusions of a series of workshops and related transdisciplinary discussions conducted during a two-year NSF 2026 Workshop Project on Research Challenges at the Intersection of Energy and Equity in the Energy Transition.

The research agenda recommendations concluded by workshop participants include needs for interdisciplinary research in:

- Methods for defining, characterizing, and measuring the dimension of equity in use-inspired research, including research on energy.
- The socio-economics of increasing distributional equity in the development of energy science and technology and in the delivery of energy services.
- Decision-making approaches capable of balancing equity, cost, and other factors at system-scale.
- Methods for incorporating equity into the design of socio-technical systems such as emerging energy systems.
- Building the evidence base in best practices for Community Engaged Research.
- Models of embedded equity in technologies and their socio-economic incentives.
- Approaches for treating equity as a component of research ethics in R&D projects.
- Modeling equity and beneficence within a Life Cycle Analysis paradigm.

The workshop also considered ways in which research funders, including federal agencies such as the DOE, the NSF, and EPA, as well as foundations, could incorporate an emphasis on equity in their grant-making processes, not only with regard to energy-related research but across a wide array of topics where societal impact is expected. The recommendations here include the following:

- Explicitly designating equity-related activities and research as an avenue for achieving broader impacts, thus bringing equity into merit review criteria.

- Affirmatively including persons identified with communities that are typically underrepresented in early phases of projects, including the solicitation creation and proposal review process.
- Including funding for equity and beneficence in proposals for at least those programs that are use-inspired
- Providing guidance for proposers and reviewers on equity and beneficence under Solicitation Specific Review Criteria on certain use-inspired programs.
- Bringing equity and beneficence into guidance for Data Management Plans and plans for dissemination of research results.
- Encouraging Community Engaged Research by creating a class of special “Equity Insight” grant supplements to pay necessary costs for stakeholder engagement activities.
- Incorporating equity and beneficence considerations into the analysis of Project Risk in selected projects.

II. Equity and Beneficence in Scientific Research

The NSF 2026 workshop series on Research Challenges at the Intersection of Energy and Equity in the Energy Transition juxtaposed two societal projects of great importance to the 21st century scientific community: satisfying global needs for energy in ways that do not create global harm and making decisions on technological development in ways that go beyond efficiency and cost-benefit analysis to encompass fairness and distributional concerns. The intersection of these two movements occurs at an historic point of global transition from carbon-based energy to more sustainable and approaches, bringing an added urgency to address equity issues while templates for societal energy futures are still being cast. If a new route is not taken at this critical juncture, we can only imagine the future will mimic the past inequities.

In examining “energy equity” we are highlighting but one segment of a broader cross-cutting plane of inquiry dealing with concepts of equity and beneficence at the intersection of society and technology. Equity concerns arise in many facets of today’s techno-economic world, from biomedicine and healthcare to robotics, computers, materials, and agricultural technology. Indeed, the lineage of our NSF 2026 workshop project connects to an NSF 2026 Idea Machine finalist topic, “Equity and Beneficence in Sociotechnical System,” which focused in part on embedding notions of equity in the next generation of large-scale computer systems.

We begin by looking broadly at *equity in the processes and outcomes of research* as an understudied aspect of the scientific enterprise. For many funding agencies, we note that attention to equity is largely placed on equity of participation and processes relating to the funders’ programs and the national STEM workforce. For example, only a small portion of NSF awards containing the keyword “equity,” are funded by units other than those in the Education and Human Resources Directorate. Thus, it is a worthwhile first step to view equity and beneficence specifically in the

context of research activities and outcomes before turning to how equity concerns intersect with the energy transition.

Precisely defining “equity” is not an easy task. This project’s workshop process demonstrated the polyvalent meanings of “equity” across and within disciplines. The project developed consensus on the notion that *“advancing equity in scientific research” should entail scientists and research performers robustly engaging with stakeholders, the many parties who may ultimately be affected by the research, to strengthen the process of discovery.* Some of these parties can be viewed as invisible, marginalized, and unrepresented “communities” that are typically not consulted or included in any aspect of the work. Sometimes the “community” is an actual inhabited community where someday the results of the research and development efforts will be sited and where impacts will be experienced by residents, while in other cases the term “community” is taken more loosely, for example with regard to the impacts of energy technologies on a community that is closer to the energy production, or stakeholder groups in transmission and consumption (i.e., businesses or workers in a supply chain, regulators, etc.).

Workshop participants agreed that the notion of equity, under any definition, must embrace the ethics of respect for persons, beneficence, and justice for all communities throughout the process of exploring, developing, and deploying new technologies, as well as in the distribution of outcomes flowing from these technologies. To address historical patterns of marginalization, the primary attention of the workshop was on notions of equity involving disadvantaged communities not typically represented in scientific work and technological development.

The life cycle of new scientific and technological projects is long. Fundamental discovery research typically begins a lengthy process of development, which, if successful, culminates in eventual deployment and use. Scientific and technological lock-in can occur. By the time disadvantaged or excluded communities experience the impacts of new technological developments—for instance, the deployment of new energy innovations—it can be too late to adjust course technically, leaving recourse only to politics and the legal system. *If equity is systematically integrated both at the outset and iteratively during development stages, then steps can be taken early and frequently to incorporate the needs and ideas of affected stakeholders and communities into setting priorities and constraints for new technologies.* This basic idea forms the core of the work undertaken by the workshop participants during this project, with a particular focus on applications in the renewable energy area. The energy transition, which is now establishing technologies and uses that will last for decades or more, provides an essential and crucial site for developing this new relationship between science and communities.

Related to these core premises are three arguments in favor of applying the moral imperatives of societal equity and beneficence to the outcomes of research endeavors: the mission to benefit

society; research ethics; and the need to fund the underserved institutions that often have the closest connections to disadvantaged communities.

1. Societal Benefits as Core Mission

When the government sponsors scientific research, its work embodies a public purpose to serve the needs of its citizens. For example, NSF’s statutory mission “To promote the progress of science; to advance the national health, prosperity, and welfare; and to secure the national defense...” defines this public purpose. Similarly, DOE’s mission is “to ensure America's security and prosperity...” Affirmative attention to the equity and beneficence dimensions of proposed research endeavors is consistent with the public mission of Federal granting agencies. It would be in the nation’s public interest for federal funders to direct an equity focus on activities at early stages in the research-to-product life cycle, so as to avoid downstream conflicts with the agencies’ imperatives of health, prosperity, welfare, and security.

Focusing specifically on NSF, one of the foundation’s three merit review principles governing its two-criteria (Intellectual Merit and Broader Impacts) merit review process reads: *“NSF projects, in the aggregate, should contribute more broadly to achieving societal goals. These ‘Broader Impacts’ may be accomplished through the research itself, through activities that are directly related to specific research projects, or through activities that are directly supported by, but are complementary to, the project.”* In work that considers the equity aspects of inputs to or outcomes from the development of technology, there is no question that efforts intended to positively address equity and open the research to a broader range of interests and voices do in fact contribute “broadly to achieving societal goals.” Because this criterion is a central tenet in NSF’s research efforts, attention to equity in the research process should be welcomed as an enabling factor for achieving broader impacts. Similar concepts hold with other federal or public interest agencies and foundations.

2. Research Ethics

The current boundaries for Research Ethics training and enforcement should extend the ethical “do no harm” imperative of beneficence toward those who are not formal research subjects but are instead communities that must live with the consequences of designs and decisions initiated during the research process. We urge funders to re-examine how they interpret Research Ethics in light of evolving ethical attitudes about equity for stakeholders at the intersection of scientific research.

3. MSIs, HBCUs, PUIs, and Equity Research

Some funders promote research at minority-serving institutions, HBCUs, and primarily undergraduate institutions, but more can be done to enable and incentivize their researchers to engage in equity-focused research. As members of a group of external stakeholders commented upon reviewing a draft of this report, such institutions are ideally situated to interact with communities through their location and cultural affinities. Teaching-focused, or less research-intensive HBCUs, while lacking the resources to produce as much peer-reviewed research, would

have greater capacity in achieving high degrees of trust and affiliation with their adjacent communities if these resources were provided. Smaller colleges want to solve problems in and around their community and may be able to do what larger institutions cannot because they are well connected to the community and understand the constraints. Funders should consider dedicating support to this sector for equity-focused research and especially towards fostering partnerships between research-intensive institutions and institutions with high capacity for equity-focused research.

III. Building Equity and Beneficence into Energy Transition Research Funding

The workshop examined challenges and research priorities at the intersection of two moving forces: 1) progressive and deliberate efforts to advance societal equity in designing, developing, and deploying new technological approaches, and 2) the ongoing transition away from unsustainable carbon-intensive energy sources and toward widespread development and use of sustainable renewable energy.

Compared to other socio-technical and R&D settings where equity concerns intersect with technical progress, the energy transition presents major exigencies. Technological infrastructure in the energy sector is typically very expensive, long-lived, physically embedded, geographically sited, and systemically complicated. Systems are often developed and owned by large institutional players whose power and remoteness from marginalized communities may work to the disadvantage of those communities. In addition, the anticipated pace of this energy transition over the near- and medium-term risks abandoning deliberative and equitable decision making behind in an understandable rush to “solve the carbon problem.” Many Environmental Justice communities have adopted a position that says “nothing about us without us.” If this is disregarded by researchers, it may delay the energy transition. With these considerations in mind, the workshop focused on approaches for deliberately building equity, beneficence, and community involvement into early and later stages of design and development of future energy technologies and systems.

Grant-making institutions can be linchpins in the effort to build equity and beneficence into energy-related R&D. One output of the project’s extended workshop process was the conception of an **“Equity in Energy Research”** framework for how such institutions can consciously pursue the role of change agents. This proposed framework consists of five areas for recommended change in the research funding process for energy-related support:

1. Integrating Equity into Solicitations

Sponsors and the scientific community should reframe equity as being integral to energy technology research. Doing this at the level of the research funding source would impact the formulation of funding solicitations and the allocation of funding levels for equity research. In integrating equity into funding calls, sponsors should go beyond asking for equity analyses in proposals and actually **fund equity-related research components associated with the programs**. Expanded funding support for equity-related research within program funding calls should be multi-dimensional and address energy equity from varied perspectives, including technology transfer and small business innovation research related to equity, and support for the development of networks and communities of institutions in this area.

2. Actively Soliciting Input

Funding solicitations should emphasize direct engagement for obtaining community input throughout the grant cycle that use inclusive approaches such as listening workshops, advisory boards, and review panels. Directly soliciting community input throughout the grant cycle requires more strenuous efforts by granting agencies at outreach to include perspectives from outside academia and from diverse backgrounds. The point is to bring these perspectives in at the earliest stage—during the agency’s formulation of calls for proposals and agenda setting for new initiatives. Ad hoc as well as formalized approaches (e.g., statutory advisory boards) utilizing the input of adequately compensated participants can be used to inform and advise at various stages of the research funding process including funding calls, proposal reviews, and grant awards.

3. Increasing Likelihood of Success

Grant-making agencies can make a difference in the success of community-involved research processes in several ways. First, they can identify research areas that would benefit from direct community input. Second, they can sponsor and develop training programs to improve the ability of researchers and communities to successfully collaborate. Developing community capacity for meaningful dialog with scientific researchers, for example, with science shops, can advance STEM education goals and support for scientific research as well as enhancing fruitful communication about the research goals at hand. Third, formal mechanisms should be developed to resolve challenges that arise from community engagement, including the potential for competing equity claims. In contemplation that conflicts will at times arise between benefits of energy technologies competing against potential harms foreseen by community members, funders could invest in research and training in resolution of such conflicts.

4. Bringing Equity into the Review Process

Review and award criteria should be expanded to include assessments of community involvement, equity analysis, and multidisciplinary engagement. In the review stage of grant proposals, the incorporation of community input on broad-based review criteria could be a major factor in how responsive the eventual awards are to community needs and preferences.

The inclusion of case studies and qualitative research, in complement with or in place of high-quality quantitative data, can be helpful in developing good research questions and their appropriate use should be welcomed in evaluating proposals for funding. Proposal review considerations should also include plans for and history of effective community engagement, as well as participation of scholars with broad expertise and capacity for public communication of risks and of science.

5. Adjusting Funding Streams for Equity

Sponsors should expand and modify existing funding streams to better fit the needs of interdisciplinary research at all levels: individuals, community groups, and universities. To engender trust with community participants, research that engages a community should be supported over longer periods of time and have mechanisms for flexibility. Funding agency investments could ensure that graduate student researchers who are members of underrepresented communities have the opportunity to receive longer periods of funding support, to mitigate against short-term and insecure academic appointments and to build the pipeline of trained, interdisciplinary scholars ready to lead tomorrow's research teams. Funding agencies should also work with academic institutions to create broadened types of fellowship support for applicants who may be outside of the Ph.D. track but clearly capable of contributing to energy equity research, including community leaders and practitioners. Finally, support for interdisciplinary investigators in equity-related topics should be supported and championed by funding agencies.

We appreciated gaining additional non-academic insight on funding issues through comments made by external stakeholders on this report's draft. The need for further education of program officers related to equity was mentioned. It was noted that it is not enough to have equitable and inclusive language in the proposal; the program officers must manage in a way that reflects the proposal. Similarly, cultural competency training for reviewers was urged. One project management suggestion was early and pervasive feedback and/or review from persons representing constituencies. Another commenter urged funding agencies to use their influence on proposers to encourage research universities to support and collaborate with faculty at smaller institutions. Recognizing the potential of HBCUs to contribute more in research designed with equity in mind, one commenter lamented that in their opinion, lower- and middle-tier HBCUs don't apply to NSF because they have been so "shut down" in the past, and when they do so they are discouraged by the amount of resources required for them to submit and manage awards. Another external commenter suggested that funding agencies should solicit and fund "Stage Zero" ideas and projects to seed equity-driven concepts and innovative approaches, not only in basic STEM research topics but also in applied technical areas where community-based incubators and small business-academic collaborations can be brought more directly into the equity-driven research arena. Finally, one stakeholder suggested that the impetus for incorporating more equity considerations into federal research funding should perhaps come via a policy lever, using a high-level, all-of-government approach similar to Justice 40.

IV. Processes for Community Engagement in Research

Pervading the workshop series and associated project efforts was the idea of inclusive research involving community engagement as an enabling condition for greater equity. A working group devoted to Community Engaged Research (CER) impaneled as part of this project worked on questions related to modes of research conducted in alignment with communities and community values.

CER promotes equity by providing an opportunity for communities, workers, and other stakeholders to inform and impact research outcomes. CER can ground theoretical work in empirical realities, develop new grounded theory, and provide communities with much needed research capacity.

Community Engaged scholarship can be:

- Basic science with stakeholder advice to better describe and explain
- Co-produced knowledge that describes and explains
- Evaluation research that informs practice
- Action research that co-produces intervention

Workshop participants agreed that CER should:

- Ensure that community participants, at any level, are adequately compensated and protected from “extractive” research that only benefits the researcher.
- Provide appropriate time scales to allow for “meaningful” participation, which can take more time to build trust and authentic relationships.
- Align with the actual needs of the communities to address their concerns and challenges.
- Co-create solutions so that communities are equal partners.

Stakeholder comments cautioned that CER must be tailored to the community, and that every community is both culturally unique and internally layered. In addition, they also recommended that the cost of changes to a newer technology and their affordability are carefully considered when solutions are before implementation. An example that they provided was the prevalent use of older cars with poorer mileage in communities with fewer gas stations that are farther apart. Many members of these communities may not be able afford an electric vehicle and thus placing charging stations may not be a viable solution. Thus, research partners need to discern and incorporate the range of voices and experiences in culturally diverse or layered communities. Interests may diverge for example between younger renters, semi- or fully retired senior citizens dependent on fixed incomes, and those in the middle likely building families and seeking to purchase homes. Stakeholders asserted the need in CER practice for community immersion of

the research team, and for identifying and working with local champions who hold “cultural capital” – persons known, trusted, and respected in the community. A suggestion was made to rethink rewards and benefits, and to think beyond monetary awards, in CER projects.

Workshop participants recognized a risk in CER in situations that can be considered extractive in nature. Extractive, or transactional, research may occur when a researcher brings together community members for the sake of winning a competitive research award or in a manner to inform or consult, yet fails to provide either tangible benefits or decision-making power to the affected community. Extractive research sometimes manifests itself in poor neighborhoods where research sites are framed as a “laboratory,” and is particularly problematic when the community in question is a community of color or otherwise marginalized, and of which the researcher is not a member. Extractive research runs a high risk of engendering community mistrust that can be long-lived, consequential, and unethical. Conversely, developing and maintaining reciprocal and respectful research relationships increases the challenge of meaningful engagement.

Workshop participants noted several principles of community engaged research to which the research community should strive to adhere. These are situated within theoretical principles that have been articulated among the CER community and have sometimes been implemented in partnership agreements (which could be systematically assessed and improved). 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 were 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 through 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.

Community Engaged Research tailored to local communities begins with identifying and understanding “community.” To understand specific communities, it is important for researchers to first build authentic relationships within them 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 research. Doing so also requires making commitments to partnership that can extend well beyond the project timelines of typical funding cycles. The CER working group posits that 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. With regard to technical aspects, stakeholders suggested emphasizing the time component of the R&D life cycle, including the longevity and viability of solutions. Solutions with multiple improved version cycles whose adoption curves “trickle down” to low-income users over time (due to affordability dynamics or infrastructural obstacles) often mean that those most in need benefit less from innovations, while newer, more effective technologies are deployed elsewhere. Stakeholders also urged sharing a timeframe for action, and designing sustainable outcomes. As progress occurs, additional participation and engagement can be built upon that.

Researchers and communities may have legitimate differences in definitions of the situation and in goals, given differing personal and organizational backgrounds of researchers and communities, but boundaries can be bridged by deliberately building trust and respect between researchers, community organizations, and individuals in communities. Good CER practice includes cultivating a common language, developing a sense of mutual benefit from collaboration, and creating a clear set of expectations of contributions toward the collaborative effort. For engaged research on energy, CER practitioners should establish shared understanding for the different forms of “expertise” applied to energy work: from the physical and technical challenges of energy engineering to the lived experience of energy insecurity. Stakeholders urged awareness of how a community labels itself, and cautioned researchers not to apply their own label or to use labels that are destructive or stigmatizing to a community.

Intermediary organizations can facilitate building bridges and trust across researchers and communities. Examples of such organizations include community-based organizations with experience working with researchers, national or regional umbrella organizations that have both capacity for working with researchers and legitimacy with member organizations, university extension service units that are experienced in working with communities, such as the University of Massachusetts Amherst Clean Energy Extension, grant-making organizations with roots in both communities and research organizations, and K-12 and higher education institutions in the community.

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

To support CER funding and institutionalization, the working group suggested that universities could leverage their positions within communities on a nationwide basis to form consortia of local organizations developing ecosystems or “learning communities.” These groups could be

oriented toward advancing a community's interest in energy transition, bolstered by university research capacity, in service of community goals and in the definition of research needs.

Universities and other research organizations seeking to develop institutional support for Community Engaged Research must appropriately align their organizational incentives and structures. 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 CER can also entail changing graduate curricula to include research ethics, methodological training on CER, and more rigorous and differentiated processes for institutional review of research design. Institutional review boards (IRBs) could “open themselves to the possibility of accepting communities as not only sites of research but also as viable researchers”¹ which could increase community involvement in an expanded definition of ‘human subjects’ protection.

V. Toward a Research Agenda

In this section, we lay out a set of research areas or topics that workshop participants consider to be worthy of consideration for both future funding investments and the attention of the interdisciplinary research community in general. Section IV covers workshop participants' recommendations to funders on operational or policy recommendations concerning ways that they could integrate equity practices into its research grant making activities (on a broad basis, not solely with respect to energy equity).

1. Research is needed on **methods for defining, characterizing, and measuring the dimension of equity in use-inspired research**, including research on energy. It became clear during this project's workshop activities that developing such models and metrics is both highly desirable and difficult to achieve, given the variability in settings to be encountered and methods to be employed. As one statement by the project's Metrics Working Group put it, *“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.”*
2. Research is needed in the **socio-economics of increasing distributional equity in the development of energy science and technology and in the delivery of energy services**. As articulated by the workshop's Research Topics Working Group: *“What does*

¹ Brown, P.; Morello-Frosch, R.; Brody, J.; Altman, R.; Rudel, R.; Senier, L.; Pérez, C. *“IRB Challenges in Multi-Partner Community-Based Participatory Research”* | Collaborative Initiative for Research Ethics. <https://www.brown.edu/research/research-ethics/irb-challenges-multi-partner-community-based-participatory-research> (accessed September 26, 2022).

distributional equity mean, and how can we assess and ultimately create distributional equity in the services that energy systems provide, the costs that different groups pay for services, and the outcomes that diverse households, groups, and communities are able to derive from those services?” Important questions for scientists, economists, operations researchers, and engineers relate to optimizing electricity markets and other processes, as well as incentive structures to achieve equity outcomes, and formulating innovative methods for maximizing access to and benefits of new energy technologies for low-income communities.

3. Research is needed in **decision-making approaches capable of incorporating equity, cost, and other factors at system-scale**. In particular, how can we map and evaluate the distribution of benefits, costs, harms, and risks associated with an energy system in ways that enable intelligent system-scale changes to be made that result in greater equity?
4. Research is needed in **methods for incorporating equity into the design of socio-technical systems** such as emerging energy systems. The study of systems design approaches that could yield less systemic inequality as old energy technologies are phased out for new ones would be worthwhile and beneficial to both industry and to society. The workshop phrased this question: *“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?”*
5. Research is needed to build the evidence base in **best practices for Community Engaged Research**. These methods could bring equity and beneficence considerations into the work of: (a) identifying research needs and formulating research questions, (b) designing and executing research projects, and (c) evaluating the outcomes and impacts of research efforts. The workshop identified questions such as: *“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 implicit assumptions about community engagement? What are the tools and best practices for community thought processes that enable community members to reflect on their values, short-term and long-term priorities, and benefits?”*
6. Research is needed on **models of embedded equity in technologies and their socio-economic incentives**. How does one build equity into the technology that appears in the marketplace? How does one incorporate equity in technology designs that may appear in the marketplace after a period of time?
7. Research is needed on approaches for **treating equity as a component of research ethics in R&D projects**. This would involve widening the Research Ethics focus beyond research subjects and direct participants in research, to include identified and not-yet identified communities and other stakeholders whose benefit or detriment may accrue from the

conduct of the research. In this context, curricular and training efforts conducive to bringing equity into the Research Ethics body of practice, including the development and incorporation of case studies, would be important to develop.

8. Research is needed on the challenge of modeling equity and beneficence within a Life Cycle Analysis (LCA) paradigm. Just as LCA can be used to quantify relative advantages and disadvantages of different technological options across the total life cycle of a product (e.g., environmental indicators to compare materials, methods, etc.), perhaps this tool can also account for societal benefits and detriments of using one or another technological development or approach.
9. Research is needed on the best practices and strategies that will enable convergent science for addressing cross-disciplinary research questions. Answering research questions that will enable equitable energy transition requires a diverse team of researchers to work together to build their integrative capacity. For such a team to work together congruently and effectively, it is essential that all the participants step outside their expertise siloes to hear, discuss, and incorporate views from other stakeholders and disciplines. This requires identifying effective methods for forming these teams and a commitment to the time required and the strategies to integrate the diverse expertise that is traditionally siloed throughout the process from conception to completion.

VI. Operational Recommendations for Funders

Workshop participants placed substantial emphasis on the role of research funding agencies such as the Department of Energy and the National Science Foundation in fostering greater equity and beneficence in socio-technical systems, such as those involved in the energy transition. In Section III we outlined justifications for taking up the advancement of societal equity as explored in this theme (i.e., going beyond equity of participation in the STEM research and education ecosystem). Here, we provide a set of recommendations that relate to agency and foundation funding processes and ways in which they might be changed to support greater equity and beneficence, not only with respect to the energy transition but for all aspects of research. (For more discussion see reference [73] below).

1. **Bring equity into agency- or foundation-wide merit review criteria** by explicitly including work that addresses equity, respect for persons, beneficence, and justice. When proposers thus choose to include equity and beneficence within their project's planned efforts, they would consequently be expected to explain their evidence-based strategies for achieving greater equity and distributed beneficence and to defend the quality of their proposed approaches.
2. **Bring equity into the solicitation creation and proposal review process** by welcoming, seeking out, and inviting persons identified with communities that are typically unrepresented or underrepresented to actively participate in and provide substantive input on review panels. In addition, funders should develop capacity for these communities to understand and to

contribute meaningfully to these reviews.

3. In selected solicitations, especially where use-inspired research is expected, **require funding for equity and beneficence in the budget**. As a second-best action, an equity and beneficence **“Plan” or “Statement”** could be required as part of the Project Description or as a Supplemental Document. This would be a section of the proposal where the significance, innovation, and impact of any proposed efforts to integrate equity into the research effort would be described in some detail, requiring proposers to communicate directly about this aspect of their proposal and enable reviewers to more readily assess its quality and appropriateness. This runs the risk, however, of being a box-checking exercise that takes researchers away from meaningful equity-focused research, and so should only be used with caution and care. Project-funded work that integrates equity into the research effort would of course also be described in the Project Description, but this special section would mandate a described strategy for equity and beneficence, *per se*.
4. In selected solicitations as appropriate, include **proposer/reviewer guidance on equity and beneficence under Solicitation Specific Review Criteria** (for example, *“How well does the proposal reflect incorporation of stakeholder or community ideas into the project plan as a conscious, demonstrated effort to examine and address societal equity and distributed beneficence of the proposed project?”*)
5. **Bring equity and beneficence into guidance for Data Management Plans and plans for dissemination of research results**, encouraging proposers to provide broad transparent access for all potential users, including populations not typically considered as recipients of research data and results.
6. Encourage Community Engaged Research by **creating a class of special “Equity Insight” grant supplements** for up to six months of early-stage, evidence-based stakeholder engagement activities, as well as for ongoing stakeholder participation in the project’s execution. This support could be designed as optional top-off funding included in a full proposal budget, documented by a separate plan within the proposal that is evaluated by all reviewers. Budgets for these activities would be expected to pay for not only social sciences related expertise but also compensation for outside individuals devoting their effort to planned Equity Insight activities.
7. Consider **incorporating equity and beneficence as part of Project Risk** in selected projects. All projects carry some degree of risk of not achieving their goals. Research projects are often subjected to some form of risk analysis during the review process, and certain proposals are expected to present a discussion of risk and a management plan for its minimization. If the goals or objectives of a project define an end condition to be achieved, in principle the performer should plan for and manage the risk of not attaining it. We suggest that one way to think about the intersection of equity considerations with technological development is to envision a progressive chain of R&D work projects that ultimately delivers a package of

intended benefits along a time scale, where one of the benefits could be the minimization of harmful consequences to affected communities. In this model, the total project risk of not realizing this particular equity benefit would need to be monitored and managed along the chain of R&D activities, starting from the earliest point. This would provide a mechanism for examining and addressing equity matters regularly through the project cycle, thus making successful equity outcomes more likely.

VII. Process and Workshop Participants

This workshop project was awarded in response to a January 2020 call for workshops and EAGER projects that could build on the NSF 2026 finalist topics by developing research agendas that NSF could consider for future investments. This Summary of Project Conclusions is therefore intended as a brief set of recommendations for action not only by the research community but by NSF as well. Here we recap and discuss key topics that motivated and animated this convening of scholars and practitioners, and we provide two sets of recommendations: one on areas for future research at the intersection of energy and equity, and the other on ways for NSF to advance equity in its research grant-making activities. The NSF 2026 Idea Machine theme “Equity and Beneficence In Sociotech System” that inspired our workshop focused on integrating equity and beneficence in development of next-generation large-scale computing systems, while our project focused on priorities and research needs at the intersection of social justice and the Energy Transition, today’s grand challenge to phase out carbon-intensive energy systems in favor of renewable and sustainable ones. Both share the vision of advancing equity for those impacted by the implementation of new technological developments.

In April 2021 we held four half-day virtual workshop sessions that attracted a total of 52 participants. Each workshop session included a distinguished keynote speaker, lightning talks by participants on relevant topics, and breakout discussions facilitated by members of the Organizing Committee with ideas captured through collaboration tools (Padlet). Following this stage, four Working Groups met during the fall and winter of 2021 to examine particular aspects of the topic more deeply. The four teams were:

- WG1: Research Topics and Open Questions
- WG2: Defining and Measuring Equity in the Energy Sector
- WG3: Community Engaged Research
- WG4: Funder and Institutional Processes

During two half-day virtual workshop sessions in March 2022, we heard and discussed reports from the Working Groups and made plans to obtain input from stakeholders. Subsequently, we

met with a set of external non-academic stakeholders for their input and moved toward finalizing the conclusions of the project.

Workshop participants are listed here, with members of the organizing committee noted with an asterick.

Michael Ash*	University of Massachusetts Amherst
Shazeen Attari	Indiana University
Shalanda Baker	US Department of Energy
Erin Baker*	University of Massachusetts Amherst
Alison Bates*	Colby College
Kerry Bowie	Msaada Partners
Matt Burke	University of Vermont
Sanya Carley	Indiana University
Sergio Castellanos	University of Texas Austin
Mijin Cha	University of California, Santa Cruz
Gabe Chan	University of Minnesota
Fahmida Chowdhury	National Science Foundation
Dessie Clark*	University of Massachusetts Amherst
Noel Crisostomo	California Energy Commission
Danielle Deane-Ryan	Libra Foundation
Denia Djokic	University of Michigan
Mary Fechner*	University of Massachusetts Amherst
Paul Fenn	Local Power
Chris Ford*	Florida International University
Anna Goldstein*	University of Massachusetts Amherst
Peter Green	US Dept. of Energy National Renewable Energy Laboratory
Ben Griffiths	Massachusetts Attorney General's Office
Emily Grubert	Georgia Institute of Technology
Amaani Hamid	Leapfrog Power Inc.
David Hart	George Mason University
Susannah Hatch	Environmental League of Massachusetts
Suzy Hobbs Baker	US Dept. of Energy
David Hsu	Massachusetts Institute of Technology
Lisa Hu	California Strategic Growth Council
Tina Johnson	Johnson Strategy and Development
Dan Kammen	University of California Berkeley
Ugbaad Kosar	Carbon180
Matt Lackner	University of Massachusetts Amherst
Kathy Fallon Lambert	Harvard University
Melissa Lott	Columbia University
Arshad Mansoor	Electric Power Research Institute
Joyce McLaren	US Dept. of Energy National Renewable Energy Laboratory
Clark Miller	Arizona State University
Seth Mullendore	Clean Energy Group
Destenie Nock	Carnegie Mellon University

Adaora Okoro*, ¹	Edison International
Bindu Panikkar	University of Vermont
Manuel Pastor*	University of Southern California
Nina Peluso	Form Energy Inc.
Arvind Ravikumar	Harrisburg University
Morgan Scott	Electric Power Research Institute
Suzanne Singer	Native Renewables
Mark Tuominen*	University of Massachusetts Amherst
D. Venkataraman*	University of Massachusetts Amherst
Venkat Viswanathan	Carnegie Mellon University
Karen Whelan-Berry*	University of Massachusetts Amherst
Kyle Whyte	University of Michigan

* indicates member of the organizing committee

¹ Although Adaora Okoro works at Southern California Edison (SCE), her participation in this project was neither sponsored by nor affiliated with SCE in any way. Any views expressed in this report are her own and are not made on behalf of SCE.

External Stakeholder Reviewers

Sumesh Arora	Entergy (formerly, Mississippi Development Authority)
Henry Golatt	HBCU Clean Energy Initiative
Bryan Patterson	Center for Renewable Energy & Sustainability, Johnson C. Smith University
Karen Soares	HBCU Clean Energy Initiative

Student Volunteers from Chemistry at UMass Amherst

Simon Harrity (Undergraduate)
Michael Lu-Díaz (Graduate Student)
Gaurav Mitra (Graduate Student)
Eric Ostrander (Graduate Student)
Emily Smith (Graduate Student)
Subhayan Samanta (Graduate Student)
Priya Srivastava (Visiting Scholar)
Zhaojie Zhang (Graduate Student)

About the Energy Transition Institute (ETI)

The mission of the Energy Transition Institute at the University of Massachusetts Amherst is to enable a fast and fair transition to a decarbonized energy system in the United States. We do stakeholder-engaged interdisciplinary research with a dual focus on technology systems and human systems to enable an equitable energy transition.

Our research advances a clean and just energy system throughout the lifecycle of its technologies and social processes. ETI brings together faculty, staff, students, and external partners to promote equity and effectiveness in scholarship on climate solutions. Our research, teaching, and engagement promote convergence across disciplines to develop new cohorts of diverse, innovative, interdisciplinary scholars and change-makers who will help to realize and maintain a more equitable energy system. We engage collaboratively with community partners to co-create knowledge that empowers marginalized groups, with particular attention to those vulnerable to harm from climate change or the energy transition. We communicate scientific research relevant to real-world technology and policy decisions in an accessible way. In these ways, we guide public and private decision-makers toward an equitable and rapid transition to a decarbonized energy system.

www.energytransitionumass.org

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