The Crucial Role of Just Process for Equitable Industrial Decarbonization:
An Action Research Agenda for Carbon Management and Other Emerging Technologies

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I. INTRODUCTION

Significant transformations are underway in the U.S. to achieve net-zero carbon emission goals. Fossil-fuel energy generation from coal and oil is in decline, while renewable energy technologies are becoming less expensive and easier to deploy at scale. However, even with rapid reductions in fossil-fuel-based carbon emissions, significant accumulations of anthropogenic greenhouse gasses in the atmosphere will undermine efforts to combat the worst impacts of climate change successfully. The U.S. Department of Environment (DOE) has identified carbon management technologies, such as carbon capture and sequestration (CCS), as key to achieving industrial decarbonization, particularly in offsetting difficult-to-decarbonize sectors such as steel manufacturing, cement production, shipping, and aviation, where fossil-fuel alternatives are in development (Cresko et al., 2022). Large federal investments in these technologies offer a unique opportunity for the U.S. to rapidly decarbonize in pursuing climate goals.

However, CCS presents new technical and social challenges in its current path to rapid adoption. This is particularly the case with Department of Energy (DOE) incentives for deploying CCS as "hubs" – large-scale networks linking carbon emitters to carbon sequestration and utilization sites or regionally coordinated direct air capture (DAC) hubs. CCS hubs will require substantial infrastructure, new regional economies, and a skilled workforce to span broad geographic regions. Hubs also implicate accounting for the needs and concerns of a diverse and distributed public. Many communities targeted for CCS have disparate winners and losers in the benefits/impacts tradeoffs brought by prior energy and industrial development waves. Recognizing this, the White House whole-of-government Justice40 initiative requires that 40% of benefits from CCS and other projects receiving Justice40 funding flow to what they refer to as "disadvantaged communities" (see Section II. below for problems with this term). In these communities, marginalized groups bear the brunt of multiple injustices, such as systematic exclusion from decision-making, disproportionate exposure to environmental hazards, economic

hardship, limited access to environmental resources, and heightened vulnerability to climate change driven by CO2 emissions.

Research and experiences to date related to community engagement in, and public response to, carbon management are instructive. While there is broad agreement among technologists and government agencies that CCS is a crucial piece of industrial decarbonization, CCS is largely opposed within the environmental justice (EJ) community (Committee on Accelerating Decarbonization in the United States: Technology, Policy, and Societal Dimensions et al., 2023). Several high-profile EJ organizations fought unsuccessfully to keep CCS from being funded under the J40 program (Chemnick, 2023; Clean Air Now et al., 2022; Data for Progress et al., 2023; Wright et al., 2023), and some municipalities have already enacted legislation blocking CCS projects (Alliance for Affordable Energy 2022). Some social scientists studying community engagement related to CCS projects have called the private-developer-led engagement model that predominates "misguided" (Nawaz et al., 2024) and have argued for "more coordinated public and community engagement around carbon management" (US DOE, 2023, p. 1).

There is a clear need to rethink community benefits of CCS, including how they are determined and by whom, to ensure that communities hosting CCS can thrive in the just energy transition. Companies in the mining and oil and gas sectors, as well as major infrastructure projects, have been experimenting with various types of community benefit agreements as a way of ensuring a project "invests" in local communities, businesses, and government (e.g., Eisenson & Webb, 2023; O'Faircheallaigh, 2010; Zilliox & Smith, 2017). In this vein, recent DOE funding has required applicants to propose community benefit plans (CBPs). However, Justice40 focuses primarily on the "technical" benefits of funded projects related to climate, energy, and decarbonization, largely ignoring potential community benefits (Dutta et al., 2023), which can include community benefit agreements, cultural preservation, affordable and healthy housing, job creation and training opportunities, improved infrastructure, and environmental remediation, among others. Additionally – and this is the primary focus of this paper – scant attention has been paid to the engagement *process.* For example, while one of the eight policy priorities guiding DOE's Justice40 implementation is "Increases in energy democracy in DACs [disadvantaged communities]" (Office of Energy Justice and Equity, n.d.), current DOE CBP guidelines mention community ownership of project assets (i.e., outcomes) as a potential benefit to be tracked, but nothing about collaborative process or shared decision-making. This lack of attention to process ignores an aspect of this work that is foundational to its success and that, if done wrong, can derail industrial decarbonization efforts in both the short- and long-run. Process is critical given that so little guidance about CBPs is provided by DOE, which means that benefits are largely left to project teams to determine.

By focusing on distributive benefits versus harms, CBPs neglect to address the underlying structures that exclude diverse voices from defining what counts as benefits and harms in the first place. As Justice40 has rolled out, an unprecedented amount of funding has been allocated for community benefits planning at all levels – national, regional, state, local, and community-based – that, in turn, will require unprecedented collaboration. Funding opportunity announcements (FOAs) and CBP guidelines issued by the federal government include a variety of requirements for community "engagement" and/or consultation, as well as diversity, equity, inclusion, and accessibility (DEIA). However, CBPs must be grounded in procedural justice (just process) and recognition justice (cultural recognition and respect) in order to achieve distributive justice (equitable outcomes) (Jenkins et al., 2016). Foundational concerns include due process, transparency, intra- and inter-generational equity, and accountability (Sovacool et al., 2016). More recent scholarship calls for greater epistemic justice (justice in knowledge creation and expertise recognition), a greater emphasis on achieving distributed and community ownership, and dialogical space to question growth models (Ottinger, 2023; Sovacool et al., 2023). Fundamentally, this

scholarship suggests the need to develop and enact community engagement processes that move away from developer-led models of industrial development to ones that establish clear goals, mechanisms, metrics, and chains of accountability for inclusive collaboration and, ultimately, decision-making.

This paper proposes a social science research agenda for better understanding and improving community engagement for carbon management and other emerging technologies. We emphasize issues relevant to the social science research community that will assist in examining the development and implementation of CBPs. Furthermore, we suggest best practices for analyzing the factors, processes, and institutions that may affect desired outcomes of community engagement in CBPs through the lens of achieving procedural justice.

Developing strong frameworks for community engagement that draw from scholarship and practice will be crucial for industrial decarbonization efforts to succeed. This is quite a challenge given that the history of collaboration between historically disadvantaged communities and industry, universities, policy organizations, national labs, think tanks, etc. has been largely fraught and inequitable (e.g., Baldwin, 2015; Etienne, 2012; Markowitz & Rosner, 2013; Rudd et al., 2021; Taylor & Blondell, 2023). The agenda and research questions offered in this paper intend to help cultivate more just collaboration between project leads and historically marginalized communities and establish principles, guidelines, and frameworks for enacting "meaningful engagement, as described in FECM's engagement framework (U.S. Department of Energy, 2022), [which] involves building relationships and having a two-way dialogue with mutual learning that shapes how projects are developed" (US DOE, 2023, p. 1). More specifically, we share examples of projects, processes, and tools that aim to facilitate the inclusion of community knowledge and perspectives into all project stages, from planning through implementation, establishing a solid foundation for long-term, locally and globally advantageous collaborations that contribute to more equitable – and thus more successful – industrial decarbonization outcomes.

Three overall questions frame this paper. The first question is: *What does social science research to date tell us about the successes and pitfalls of community engagement, overall and particularly in infrastructure projects or projects led by powerful actors?* The second and related question is: *How is or might this research be applicable to carbon management?* These two questions are explored in Sections II and III. The third question is: *What social science research needs to be conducted to develop more inclusive and just processes for community engagement in carbon management planning and implementation that are most likely to result in equitable decarbonization?* This question is explored in Section IV – the longest section of the paper – which lays out five primary research questions, providing context and including secondary questions as well as examples of innovative community engagement practices that point out issues needing further study by scholars.

II. SOME NOTES ON FOCUS AND LANGUAGE

This paper intentionally focuses on community engagement rather than public engagement, and more specifically, on engaging *historically marginalized* communities in carbon management projects. This brief section explains these choices, as well as our decision to use the term "historically marginalized communities" rather than "disadvantaged communities."

Introducing emerging technologies and new industrial infrastructures can meet public skepticism and resistance. Nielsen et al. (2022) highlight the challenges in garnering public support for initiatives like CCS, renewable energy infrastructure, and other decarbonization technologies. Environmental justice communities have voiced specific concerns about the deployment of carbon management technologies (Anchondo, 2022), often stemming from fears of perpetuating local pollution, the risk of exacerbating

existing social and economic inequalities, and the potential for diverting attention and resources away from sustainable community development and renewable energy solutions. Trust shapes public perceptions and attitudes toward emerging technologies and industrial infrastructure. Historical environmental mismanagement, lack of transparency, and failure to deliver promised benefits have contributed to a trust deficit in the energy sector (Lynn, 2021). This mistrust complicates efforts to engage communities and gain support for new initiatives. Addressing trust issues is largely (though not fully) about improving communication and ensuring community engagement, leading to fundamental policy and practice changes.

Focusing on Community Rather Than Public Engagement: Community engagement is necessary to transition towards sustainable industrial practices and deploy emerging technologies in the energy sector. The active participation of communities, mainly those directly impacted by industrial activities, is crucial in shaping an inclusive and equitable path toward decarbonization (Mourik et al., 2021). As more policy actions and funding opportunities arise to mitigate climate change impacts, integrating local perspectives, assets, and needs into the planning and implementation of carbon management strategies ensures that these initiatives are both environmentally viable and socially just (McCauley et al., 2019). Equitable industrial decarbonization hinges on fairness, inclusivity, and shared benefits, and by prioritizing community engagement, projects can at least partly address socioeconomic disparities often exacerbated by environmental policies and industrial activities (Davis & Ramírez-Andreotta, 2021).

When discussing engagement in the context of CBPs, it is essential to distinguish between "community engagement" and "public engagement." In this paper, we focus specifically on community engagement. While "community" and "public" are often used interchangeably, each term has distinct connotations and implications. Community engagement implies a more focused approach in which engagement strategies are tailored to the needs, concerns, and aspirations of the people directly impacted by projects. It involves building trust, acknowledging past neglect or harm, and collaborating with local groups to co-create solutions. In contrast, public engagement refers to a broader, more general interaction with the wider public (Rowe & Frewer, 2005). Public engagement might not adequately address the unique needs of specific populations, as it tends to encompass a wide range of stakeholders with varying levels of influence and interest. In CBPs, emphasizing community engagement over public engagement is a strategic choice.

Social science research provides invaluable insights into the dynamics of community engagement, particularly in the context of environmental policymaking and industrial activities. Studies have underscored the importance of understanding local socio-cultural norms, power structures, and historical inequities to ensure effective and inclusive engagement (Martin et al., 2016). Environmental justice advocates and community organizers are pivotal in addressing communities' specific needs and challenges, particularly those disproportionately affected by industrial pollution and the impacts of climate change. They stress the necessity of recognizing and addressing the historical and ongoing injustices these communities face, advocating for engagement processes that are both consultative but also reparative and transformative (Martin et al., 2020). Strategies for effective and inclusive engagement include leveraging local knowledge systems, ensuring transparency in decision-making processes, and providing adequate resources and capacity-building opportunities for community members to engage deeply and effectively in dialogue and activities.

Enhancing frontline communities' power and decision-making authority, especially during a project's planning and implementation phases, is critical to effective community engagement (Scott-Buechler et al., 2023; Walker & Devine-Wright, 2008). Initiating dialogue with communities at the onset of the project lifecycle is not merely a procedural step; it is a strategic move that can significantly steer the

project toward beneficial outcomes for all stakeholders involved (Chilvers & Longhurst, 2016). Proactive engagement opens the door to an in-depth discovery of the surrounding communities' needs, concerns, and anticipations, laying the groundwork for a project that is both environmentally compliant and integrated within the social and economic landscapes of the impacted communities. Early involvement often leads to smoother implementation, as it builds trust and a sense of ownership among local stakeholders, resulting in stronger local support and reducing the likelihood of opposition or conflict during the later stages of the CCS project. This process of capacity building and stakeholder engagement not only empowers communities but also creates positive path dependencies by establishing a framework where adopting and scaling low-carbon technologies are increasingly seen as beneficial and necessary steps towards sustainable industrial practices, thereby fostering a reinforcing loop of commitment to decarbonization efforts.

In contrast, when communities are brought into the conversation after key decisions are already made, projects often face resistance. This resistance can stem from a sense of exclusion or the feeling that the project does not adequately address local concerns (Owens, 2004). As a result, projects might face demands for significant modifications, leading to increased costs and project delays. In some cases, this even results in the complete halting of projects due to strong community opposition. A critical aspect of meaningful community engagement is supporting communities in managing their affairs and making decisions that affect their future without undue external influence (Fung, 2066), including respecting the community's right to refuse projects. This right is fundamental to ensuring that community engagement is not just a token gesture but a genuine process of seeking consent and building collaborative relationships (Williams et al., 2022). This approach necessitates flexible project planning and a willingness to adapt to local needs and preferences. Establishing equitable governance structures is essential for creating a just and inclusive decision-making process (Sovacool et al., 2016). Empowering communities to have a say in projects that affect their lives and livelihoods reinforces the principle that community engagement is not just a formality but a crucial aspect of project planning and implementation. This shift from viewing communities as passive recipients of decisions to active participants in shaping projects is a matter of ethical responsibility as well as a strategic approach.

Engaging Historically Marginalized Communities: This paper focuses on projects and processes that specifically engage historically marginalized communities. We do this for two reasons. The first is that Justice40 specifically prioritizes these communities as recipients of benefits. Justice40 does this because it is well-established that industrial facilities are more likely to be situated within marginalized communities (Mohai et al., 2009) as both a result of discriminatory facility siting and racialized land use patterns (Pulido, 2000). Additionally, this focus is intended to address the resulting legacy pollution and negative health and community impacts from this practice. Despite using significantly less CO2 than middle and high-income individuals (Galvin, 2019), these communities will bear the greatest impacts of climate change (Bullard & Wright, 2012; Hallegatte & Rozenberg, 2017). Working in partnership with historically marginalized communities ensures that residents receive the co-benefits associated with decarbonization and better understand and actively participate in implementing these solutions, fostering a sense of ownership and empowerment. Acknowledging and building from the historical context of communities is essential for understanding the root causes of disparities and designing interventions that address these issues effectively (Fraser, 2014). The second reason we focus on engaging historically marginalized communities is to ensure that any social science research agenda related to carbon management prioritizes the voices of historically underrepresented or ignored populations in planning and development processes (Lucas-Darby, 2012).

Finally, we end this section with a comment on language. In community engagement, the importance of language in describing and interacting with communities cannot be overstated. The choice of words can

shape perceptions, influence the dynamics of relationships, and either support communities or contribute to further marginalization. It is imperative to avoid language that may inadvertently perpetuate stigma within communities (Massachusetts Medical Society, n.d.). This is particularly relevant in the context of terms such as "disadvantaged communities," which is the term used by the Justice40 initiative to describe communities that have been “marginalized, underserved, and overburdened by pollution” and are the intended beneficiaries of Justice40 work (U.S. White House, 2022). The term “disadvantaged” has been critiqued by several EJ and community groups that see it as implying a shortfall within these communities rather than acknowledging that community deficits result from systemic barriers. In response to this critique, various alternative terminologies have been adopted. For instance, one DAC hub uses the term “disinvested” to signify areas without adequate economic support. Similarly, Colorado's official EJ language has shifted to “disproportionately impacted,” which recognizes the uneven burdens these communities face due to their location and socioeconomic status. These terms are part of a broader movement to reframe the narrative in a way that highlights structural inequalities without assigning blame to the communities affected.

In this paper, we have chosen to use the term “historically marginalized” rather than disadvantaged. This term acknowledges that certain groups have been systematically excluded and underserved over extended periods. Furthermore, it shifts the focus from current disadvantages to a broader historical context, underlining the need for rectifying long-standing injustices – for striving for reparative justice. It implies a responsibility not just to assist but to actively work towards reversing the impacts of historical marginalization. Using language that highlights inequity rather than disadvantage also sets the stage for emphasizing the strength and resilience of these communities, recognizing their agency and self-determination despite the systemic barriers they have faced and continue to encounter, including in carbon management and other emerging energy technologies.

III. LESSONS FROM RESEARCH TO DATE

Formulating a research agenda for community engagement in decarbonization initiatives, specifically in carbon management, should leverage social science studies related to community engagement and public participation in infrastructure development. The agenda must also address the specific complexities and prospects unique to the decarbonization process. Major bodies of literature emphasize how differences in influence and expertise can inequitably distribute the risks, harms, and benefits of infrastructure projects (e.g., Anand et al., 2018; Curley, 2023; Folch, 2019; Harvey & Knox, 2015; Phadke, 2018). This literature includes research on energy and natural resource production framed with the lens of extraction or extractivism (D’Angelo & Pijpers, 2022; Gómez-Barris, 2017; Jacka, 2018; Jalbert et al., 2017). Renewable energy development is not immune from these concerns, leading to the term “green extractivism” (Tornel, 2023; see also Alonso-Fradejas, 2021; Howe, 2019; Hu, 2023). These studies often call for greater distributional, procedural, and recognition justice, though sometimes without explicitly using those terms.

The question of procedural justice is especially salient for engagement. Research often highlights how governance structures favor industry (Jalbert et al., 2019; Kroepsch, 2018; Ottinger, 2013). In instances where engagement is made superficial, such as providing input on decision-making around the location of oil and gas pipelines with little effect on outcomes, experiences of “performative” participation can tangibly harm communities (Bell et al., 2024). A large body of literature also explores the potential for community-led engagement projects to hold industry more accountable (e.g., Jalbert and Kinchy, 2016; Jalbert et al., 2023). Examples are seen in the use of fenceline air monitoring data, collected by residents and used to counter industry arguments of pollution (Ottinger, 2010), or forced transparency projects aimed at oil and gas operators to reveal the industry’s externalities, such as the impacts of waste streams

(Kinchy & Schaffer, 2018). Some studies examine novel governance structures that may enhance procedural justice (e.g., Marlin-Tackie et al. 2020) or public involvement in hazard mitigation planning (Osland, 2015). The wind sector has been a particularly fertile area of research, highlighting both the opportunities and limitations of integrating principles of procedural justice into the design of wind infrastructures (Elkjær & Horst, 2023; Elmallah & Rand, 2022; Firestone et al., 2018; Gross, 2007; Levenda et al., 2021; Ottinger et al., 2014; Walker & Baxter, 2017). These projects run the full spectrum of "engagement," from token inclusion to community ownership (Gonzalez, 2019), highlighting the need to be specific when using the term. Other large bodies of literature make more instrumental cases for engagement, positioning engagement within a business case for social acceptance (see Smith 2021 for a summary). Studies of the coercive nature of "participation" – and how it can narrow ethical frames – caution against "engagement" as an uncomplicated ethical good (Harvey & Knox, 2015; Kelty, 2020; Li, 2015). It is essential to point out that calls for "engagement" can also stem from very different motivations. Most of the above research grounds the need for engagement in an ethical case: engagement is the right thing to do to ensure equitable participation and (hopefully) more equitable distribution of benefits and harms. However, the links between procedural and distributional justice are more often proposed than empirically documented (Suboticki et al., 2023).

While social science research on carbon management has not reached the volume of research on mining, oil and gas, or renewable energy, two decades' worth of social science research dedicated to carbon management exists. Buck (2021) summarizes significant trends in this literature and points to future directions. Initial research efforts employed survey methodologies to explore variables influencing public perceptions and acceptance. This approach aligns with a substantial volume of research focused on these themes within energy production and natural resource management. There are some consistencies, such as storage being the most controversial component of carbon management, but also some mixed findings, such as the varying degrees of public acceptance of CCS influenced by factors like personal beliefs about climate change, perceived proximity to its impacts, and demographic variables like political affiliation, urban versus rural residency, and income levels. Buck proposes four future research directions: 1) understanding carbon capture and storage in the context of just transitions and tradeoffs; 2) exploring the benefits and environmental justice dimensions of deployment; 3) examining approaches to and outcomes of engagement; and 4) understanding how information landscapes shape views of CCS. She concludes by calling for a "new kind of mission-driven social science research agenda for decarbonization" that integrates the future users of the research from the early stages of proposal and design (2021: 5). She also helpfully lays out how climate scientists and the public differently evaluate and deliberate carbon management and calls for research that facilitates community deliberation.

Incorporating existing social science research findings into carbon management practices demands a careful examination of how aspects such as scale, materiality, and socio-political context influence the application of various research approaches and conceptual frameworks to specific projects. This process entails understanding the significance of project scale and how it affects community engagement and perception. Materiality, or the physical and practical aspects of carbon management projects, shapes public opinion and acceptance. Furthermore, the socio-political context, encompassing policies, cultural norms, and societal values, significantly impacts the implementation and reception of these projects. For example, in Louisiana, carbon management projects are entangled with concerns over racial injustice and environmental risks from oil and gas pollution, leading to public outcry and fear among lower-income and majority-minority communities that their concerns will be marginalized in project decisions (Jones, 2024). In contrast, discussions in Illinois and Nebraska about CCS projects center on their impact on rural livelihoods and landowner rights, with debates focusing on using eminent domain for pipeline construction and the need to balance economic interests, environmental protection, and

individual property rights (Center for Rural Affairs, 2022; Nardi, 2023). Researchers must adapt and tailor their methodologies and theoretical models to effectively address these diverse and complex factors. The form and role of corporations also matter. While large oil and gas companies lead many carbon management projects – Oxy's effort to rebrand itself as the leading carbon management company is just one example (Occidental Petroleum Corporation, n.d.) – others are led by climate start-ups, which complicates the rather monolithic treatment of corporations in the "extractivism" literature. The term "carbon management" itself encompasses different technologies that involve different kinds of "communities" and require different kinds of engagement: a hub structure involves dispersed locations, whereas a CO2 injection site is a fixed location with a timeframe that is imagined to be permanent, long after pipelines and other infrastructure are gone. It is also unclear whether CO2 pipelines will become as politicized as those carrying petroleum products, though CO2 pipeline protests in the Midwest suggest they could.

Carbon management – especially in the context of DOE-funded projects requiring CBPs – also requires reconsideration of how the existing social science literature has framed the researcher's position in relation to the projects they are studying. The intense politicization of mining and oil and gas projects has led to deep divides in the academic community between researchers who align with activists and other industry critics and those who work in closer, though not always collaborative, relationships with industry projects (see Smith 2021 for a summary). This has not occurred with the same force or magnitude for social science on renewable energy projects, perhaps suggesting that judgments of the role of the researcher may be strongly linked to ethical judgments of the industry itself. This role is further intensified as social scientists, like most of the authors of this paper, assume the role of CBP lead. This opens up another area for research and reflection that involves assessing their (our) influence on project design, implementation, and evaluation and their (our) interaction with stakeholders, including policymakers, community members, industry players, and other researchers, including researchers at our own institutions.

IV. PROPOSAL FOR A SOCIAL SCIENCE RESEARCH AGENDA

What social science research needs to be conducted to develop more inclusive and just processes for community engagement in carbon management planning and implementation that will most likely result in equitable decarbonization? The social science research agenda we propose includes five research questions addressing various issues related to this umbrella question. The first three questions each focus on a different population to engage: 1) historically marginalized communities, as populations that leaders of carbon management projects wish and/or are required to engage; 2) developers. technologists, and government actors, as groups often situated as project leads but rarely discussed in terms of their engagement preparation and capabilities; and 3) social scientists who – like four of the six co-authors of this paper – are being engaged as CBP leads in carbon management projects. The fourth question focuses on developing productive project teams that unite all these groups. The fifth and final question asks about tracking and measuring engagement and collaboration, both within the project team and between the team and historically marginalized communities.

1. ENGAGING AND BUILDING TRUST WITH HISTORICALLY MARGINALIZED COMMUNITIES

Primary Research Question: **What are the benefits, limitations, outcomes, and lessons learned from the varied approaches that have been or are being used to engage historically marginalized communities in projects that are led by more powerful partners, industries, and institutions?**

Engagement strategies are not universal but rather are shaped by various factors. The scale of the project dictates the depth of engagement required, with larger projects necessitating a more robust and encompassing approach. The materiality of a project, or its direct impact on local communities, cannot be overstated, as it shapes the community's perception and involvement in the project. Moreover, the socio-political environment in which a project operates profoundly influences engagement strategies, demanding adaptability and sensitivity to local dynamics.

At a basic level, community engagement is important just for projects to be able to proceed at all. The importance of taking community engagement in carbon management seriously is illustrated by examples such as the Barendrecht CCUS project, where insufficient community engagement led to project abandonment. This highlights the need for more effective partnerships and a comprehensive approach to represent all community segments. Additionally, the dynamic relationship between social, political, technological, and economic factors underscores the importance of a comprehensive and inclusive engagement strategy (Nielsen et al., 2022).

However, more importantly, effective and genuine community engagement in projects largely led by powerful groups outside communities, such as carbon removal, is not merely about securing "buy-in" or conducting public relations but rather centers on building trust. This is important in any project that brings together groups that have historically had – and not had – power. However, it is especially challenging with projects that center on industries like carbon management, which face significant opposition. As explained in *Accelerating Decarbonization,* "there is a pressing need to accelerate and expand social science research about how to build trust in the context of contentious decisions" (Committee on Accelerating Decarbonization in the United States: Technology, Policy, and Societal Dimensions et al., 2023, p. 214).

Authentic community engagement needs to focus on involving historically marginalized communities in decision-making. This includes recognizing the breadth of "community" to encompass frontline (immediate) populations as well as those indirectly affected. Engagement should be two-way, continuous, and adaptable, allowing community perspectives and expertise to influence project trajectories significantly. Such engagement is not a one-off event but an ongoing process, necessitating transparency, collaborative leadership, and inclusivity at every stage. The community's decisions must be taken seriously and respected, even if they mean rejecting a project. Community engagement will be a cornerstone of ethical carbon management practices only by following best practices in decision-making (Ziegler & Forbes, 2010).

Applied policy reports, as well as community-authored and activist-informed materials such as memoranda, emphasize the importance of establishing – as foundations for community engagement – equitable governance structures and well-defined guardrails that facilitate community co-creation and community ownership and result in enhancing communities' power, not just over the project but over their communities overall, by nurturing self-governance and self-determination. Even more foundational is practicing epistemic justice by recognizing the importance of local historical and contemporary context to the project at hand and acknowledging and valuing community knowledge as expertise (Callahan et al., 2021; Energy Equity Project, 2022; Scott-Buechler et al., 2023) – and compensating communities for their epistemic contributions (Georgia Tech Serve-Learn-Sustain, 2022).

To flesh out the primary research question – **What are the benefits, limitations, outcomes, and lessons learned from the varied approaches that have been or are being used to engage historically marginalized communities in projects that are led by more powerful partners, industries, and institutions?** – we propose the following secondary research questions: *What is the range of ways in which carbon management projects try to build trust between project teams – which are generally developer-led – and communities? What assumptions of scale, participation, knowledge, and power are*

embedded in different engagement techniques? What are the educational, training, and life experience backgrounds of the people developing and leading engagement strategies, and how do they impact process and project outcomes? What are the stakes of applying techniques developed in one context (i.e., community-driven projects) to very different ones involving different actors, constraints, and accountabilities, such as for-profit corporations, large-scale utilities, federal environmental permitting, etc.? How does the privacy of processes such as DOE negotiations impact key aspects of trust-building, such as engaging from early stages and being transparent? How do spectrums of engagement apply – or not – to carbon management projects? What does moving to the right on the spectrum, towards stakeholder action (EPA Spectrum of Public Involvement) or community ownership (Gonzalez, 2019), look like in the context of these projects?

Maintaining transparency fosters trust and ensures informed participation. Transparency, including increased access to information, is vital for marginalized communities, given their long-standing experiences with deceit, notably in matters of industrial siting (Markowitz & Rosner, 2013). This history highlights the importance of adopting transparent practices to rebuild trust and ensure equitable access to accurate information. For example, Louisiana's Decision Support Tool facilitates informed community dialogue on carbon management development in the state. The tool features interactive maps integrating social, environmental, and comprehensive factors, providing communities, regulators, and project developers with critical information to assess project suitability based on local factors (Bita, 2024). This initiative demonstrates a proactive approach to transparency and collaborative decision-making in aligning community values with project goals. However, social science research also cautions that transparency does not guarantee acceptance but can generate new forms of dispute, concerns, sites, problems, and subject positions (Barry, 2013; Harvey & Knox, 2015).

Another important aspect of formulating engagement strategies that are both informed and contextually relevant entails integrating knowledge systems by blending academic theories with local, experiential knowledge. For example, the Tribal Adaptation Menu integrates indigenous knowledge, culture, language, and history into climate adaptation planning to bridge communication gaps between tribal and non-tribal entities. Not only does this example act as a model of the collaborative process, but it also retools our mindset to recognize the critical importance of the bidirectional relationship between humans and the natural environment, which is crucial for successful climate adaptation (A Tribal Climate Adaptation Menu Team, 2019). Ultimately, successfully translating theoretical considerations into practical engagement practices hinges on continuous learning, adaptability, and a commitment to fostering authentic collaboration.

2. ENGAGING DEVELOPERS, TECHNOLOGISTS, AND GOVERNMENT ACTORS IN COMMUNITY COLLABORATIONS

Primary Research Question: **What is needed to ensure that technologists and industry practitioners, as well as government actors, have the competency and literacy to be effective partners with communities – especially historically marginalized communities – in deep decarbonization?**

Most carbon management projects are led by companies whose core competencies are grounded in applied science and engineering and whose leaders are trained in those fields. In companies, community engagement professionals – when these positions exist – often experience marginalization in terms of resources and having to report to managers and executives whose dominant expertise is STEM-focused (Kemp & Owen, 2013; Smith, 2021). Making engagement more just requires intervening in how developers and technologists understand and practice "community engagement" and how community engagement activities are integrated into projects.

Engineering and other STEM disciplines have a particular and problematic history of engaging with communities that is vital to understand and address. Engineering curricula have privileged preparing students for corporate careers since the Progressive Era in the United States (Layton, 1986; Noble, 1977; Smith & Lucena, 2021). Engineering students and novice professionals are often socialized into a technical/social dualism (Faulkner, 2007) that defines "social" skills related to areas such as community, engagement, justice, and ethics as "soft skills" rather than core competencies (Cech, 2013; Leydens & Lucena, 2017). As a result, a longitudinal, multi-institutional study found that engineering students' concern for public welfare actually dropped as they pursued their degrees, leaving them to graduate with less concern than when they entered college (Cech, 2014). Even engineers who express strong desires to learn about the people impacted by their work and to minimize harm and maximize benefit find it challenging to do so, given workplace divisions of labor (Smith, 2021). Finally, most natural resource companies frame the question of ethics as one of *how* to do development responsibly, not *whether* to do development at all (Smith, 2021) – a clear violation of procedural justice.

The primary research question – **What is needed to ensure that technologists and industry practitioners, as well as government actors, have the competency and literacy to be effective partners with communities – especially historically marginalized communities – in deep decarbonization?** – was developed in response to the tendency to ask this same question about whether the *public* has the competency and literacy to engage in decarbonization partnerships with the project leads (NASEM 2024:198). Our question seeks to turn this original question on its head. To flesh out this question, we propose the following secondary research questions: *How are STEM-trained industry leaders and practitioners – who generally have very little knowledge of perspectives of historically marginalized communities or issues and no or minimal experience engaging with these communities – being prepared to consider societal implications of carbon management projects? How are developers and technologists being prepared to engage with these communities, in specific locales? Given that developers and technologists have limited time – and the fact that their institutions or businesses generally do not reward them for deepening their understanding of these aspects of the project – what are effective ways to prepare them to engage in congenial, productive, and successful interactions and collaborations? How can STEM-trained industry leaders and practitioners learn from and support community engagement experts inside and outside of their organizations, companies, agencies, and institutions?*

Creative efforts to intervene in engineering education and to cultivate sociotechnical habits of mind abound, including integrating social justice into curricula, projects, and research (Hirsch et al., 2023; Hoople & Choi-Fitzpatrick, 2020; Leydens et al., 2021; Smith et al., 2021); nurturing activist engineers (Karwat, 2020); contextualizing engineering (Kleine et al., 2023); and integrating ethnographic methods into more traditional stakeholder assessment (Gibson et al., 2023). For example, Leydens and Lucena (2017) synthesize efforts to make the inherent social justice dimensions of engineering visible in assignments, courses, programs, student activities, and campus initiatives. One example is a multi-year study integrating social justice into an electrical engineering feedback control systems course (Leydens et al., 2021). The interdisciplinary group of researchers – including the instructor of record – found variations in how students identified as problem solvers and valued different forms of knowledge and factors that (de)motivated learners. They found that students who offered the most robust descriptions of social justice also questioned the technical/social dualism into which they had been socialized. Another example is a multi-year study that integrated a critical approach to corporate social responsibility inside required courses in petroleum engineering (Smith, 2021). Students ended their courses being able to identify more stakeholders and offer more nuanced analyses of the social responsibilities of practicing engineers.

3. ENGAGING SOCIAL SCIENTISTS AND HUMANISTS AS CBP LEADS

Primary Research Question: **How can social scientists and humanists shape community benefits planning as action-oriented researchers embedded in carbon management and other industrial decarbonization projects?**

This overarching question is motivated by the ongoing experiment in community benefits planning, with Department of Energy projects mandating such plans and the Justice40 requirements placed on large-scale decarbonization projects receiving federal funding. Social scientists and humanists are performing essential work related to key aspects of community benefits, Justice40, workforce development, and DEIA. There is unprecedented encouragement for social scientists to collaborate on significant infrastructure projects, yet this is fraught as participation is formatted in particular ways. There is a need to better understand the emergence of this "scholar-as-community benefits practitioner" role and how it fits into the evolving social science-humanities-decarbonization research nexus. The reflexive literature on the scholar-practitioner offers insights into the nuances and distinctions among individuals engaging in this work, elaborating, for example, how identifying more as a practitioner or more as a scholar shapes outcomes for research and communities (Wasserman & Kram, 2009). Methods and disciplinary roots matter as well. Many literatures on engagement and education suggest innovative approaches to community engagement as action research "that considers the complexity of human dimensions of energy systems and their intersection with lives and livelihoods of people" (NASEM 2023:198). Realizing the promise of community benefits requires careful attention to the people, approaches, and ideas shaping these plans and where they are situated in industrial decarbonization projects.

The primary research question – **How can social scientists and humanists shape community benefits planning as action-oriented researchers embedded in carbon management and other industrial decarbonization projects?** – is further elaborated through secondary research questions intended to understand the role and influence of social scientists and humanists in this new paradigm. These additional questions include: *In what ways have social scientists been enrolled into DOE carbon management projects? (As implementers of outreach? As trackers of benefits? As researchers in their own right?) How are community expertise and social science/humanities knowledge integrated (or not) into overall project activities? What different opportunities and barriers do we experience based on our institutional location, our role on the grant, project participants, the organization of our grants, etc.? What skills and limitations do we bring to the CBP lead role and how can we increase our knowledge and abilities to lead this work? How is our knowledge integrated (or not) into overall project activities? How are we and our expertise perceived by our collaborators on the "development" or commercialization side? How do we each experience being interpellated as "part" of projects at the same time as we are internally critical of them? How does this role both depend on and jeopardize the trust that we have built with communities to date? Ultimately, what are the long-term advantages and disadvantages of occupying these roles, for the projects, our partners, and our careers?*

The opportunity to have social scientists and humanists embedded in and empowered to shape such projects is not without precedent. For example, when Congress authorized the National Nanotechnology Initiative in 2000, the language of the legislation drew attention to the critical role of the social sciences in creating and delivering on a "long-term vision for addressing societal, ethical, environmental and educational concerns" of nanoscale science and engineering (Guston, 2014, p. 222). One outcome of this emphasis was two centers, at Arizona State University and the University of California Santa Barbara,

charged with investigating and designing the anticipatory governance of nanotechnology innovations. Researchers at the two institutes, in collaboration with networks of social scientists and historians of science and technology in the U.S. and Europe, developed methods for working with scientists and engineers, communities, and publics, to think through the consequences of innovations in science and technology and their transfer and scaling beyond the lab. Guston and Sarewitz (2020) called it "real-time technology assessment" and laid a framework for engaging scientists and the public in anticipation, reflexivity, and engagement processes.

The Justice40 mandate is far more ambitious and demanding of those charged with delivering and demonstrating community benefits. Engagement is a prerequisite, but the deliverable is measurable improvement in people's lives, especially among historically and deliberately marginalized communities. Jones, Abrams, and Lahiri (2020), writing for The British Academy, elaborate the essential role of the social sciences, arts, and humanities in creating positive futures for people and the planet post-COVID-19. A key takeaway is that building and rebuilding are acts of policy and imagination (Yusuff & Gabrys, 2011). For industrial decarbonization, industries are being reassembled or constructed anew, and the question, "What can they deliver to people and communities?," is mostly not of a technical nature. Indeed, humanist scholars argue that answering such questions presents an opportunity to unpack, examine, and recast complex relationships between diverse peoples and technologies (Yaszek, 2006; Johns-Putra, 2016). A number of scholars and activists are turning to Afrofuturism to imagine futures that radically redefine the relationship between Black people and technology. Coined in 1994 by Mark Dery in his essay, "Black to the Future," Afrofuturism "explores the intersection of African diaspora culture with technology" and focuses on "Black people imagining and creating futures of their own design" (Groundswell, 2020). Afrofuturists draw on African and African diaspora culture and traditions to turn technology from something that has largely caused harm – Dery writes, "technology is too often brought to bear on black bodies (branding, forced sterilization, the Tuskegee experiment, and tasers come readily to mind)" (1994, p. 180) – to something that they direct themselves to the benefit and empowerment of Black people. Winchester III (2018) states, "Afrofuturism can plug the imagination gap, offering a better and potentially more inclusive imagining of future possibilities in technological design." Examples of putting Afrofuturist principles into action to work towards sustainable futures include the urbanist collective BlackSpace, which "center[s] Blackness in architecture, design, and urban planning" (Blackspace, 2024), and the Emergent Strategy Ideation Institute, which developed and teaches a strategy for change that is grounded partially in the work of science fiction writer Octavia Butler and that seeks to mimic the constant change of the natural world (Emergent Strategy Ideation Institute, 2024).

Afrofuturism is not representative of the social sciences and humanities' contribution to community benefits planning; rather, it exemplifies essential, unexpected, and diverse considerations that surface when these perspectives are centered. The structure and power of the social sciences and humanities in these projects offer an important opportunity for experimenting with action research that can have immediate and long-term impact. Understanding how the social sciences and humanities are involved in community benefits work and how much influence their ideas and scholars have in these projects is essential to understanding and shaping just and equitable industrial decarbonization.

4. DEVELOPING PRODUCTIVE PROJECT TEAMS

Primary Research Question: **How can project teams develop dynamics that respect and incorporate the diverse range of knowledge and expertise of all team members, especially given the techno-centric nature of the projects (and of the FOAs)?**

As noted in prior sections of this paper, equitable decarbonization requires attention to procedural justice—sustained and effective engagements with communities that afford opportunities for people to shape project designs to advance community visions, voice concerns, minimize adverse impacts, and ensure the delivery of benefits. Engagement in these contexts, however, is not just a face-forward effort. For the labor of engagement to bear fruit, robust internal project coordination must occur across many stakeholder groups with competing interests in CCS projects, from corporations to educational institutions, local governments, public interest groups, landowners, and more. However, in many areas where CCS is being deployed, project developers may have little experience working across sectors and may even have contentious relationships with the public stemming from historical projects (Bolsen et al., 2022; Buck, 2022; Moon et al., 2020).

Echoing how regulatory agencies often think about "safety culture" as a cornerstone of responsible operation of energy systems (e.g., USDOT 2021), we suggest that CCS developer teams similarly adopt an "equity culture" in their day-to-day thinking about how projects move from the conceptual to the concrete. In imagining equity culture, we consider DOE FOA stipulations that CCS project teams address community benefits through community and labor engagement, workforce development, DEIA, and Justice40. Community benefits programming might easily be delegated to the public relationship office or, in the evolving state of CCS, to social scientists on project teams. However, this approach maintains that only some team members must be conversant in the mechanisms of engagement or trained to utilize insights gained from engagement to maximize procedural justice. Instead, an equity culture approach sees the imperatives of procedural justice integrated across team interactions and throughout the lifecycle of a project. The following questions may offer insights into how equity culture might manifest in more productive project teams.

The primary research question – **How can project teams develop dynamics that respect and incorporate the diverse range of knowledge and expertise of all team members, especially given the techno-centric nature of the projects (and of the FOAs)?** – is further elaborated through foundational research questions related to building capacity to establish an equitable team culture: *How are power imbalances between different stakeholders, such as project developers, CBP leads, and community groups, being addressed? And how are those imbalances accounted for in context with potential historical harms experienced by some participating parties? Are there robust training programs in place for project teams to build cultural competency and to ensure respectful relationships are maintained in team dynamics?As part of cultural competency, how might training programs extend to epistemic competency – encouraging stakeholders from different backgrounds, disciplines, and sectors to share knowledge, expertise, and experiences? What mechanisms are in place to address conflicts when differing perspectives and competing interests within project teams emerge?*

The primary research question is also elaborated through secondary research questions related to establishing an equitable governance structure within the project team: *Is project planning centralized, or does decision-making occur at different scales and across stakeholder groups? For instance, does the project provide resources to support regional and community-level working groups? Are these planning groups provided mechanisms to communicate with the core developer team? Does this core team include direct and formal representation of historically marginalized communities? How are project decisions and information communicated to stakeholders, and are there accessible mechanisms in place for providing feedback and input back to project teams? Have the core team and ancillary groups established agreed-upon standards for project-level engagement methods, timelines, communication strategies, and best practices for negotiating community benefits? And, importantly, is the project's performance monitored against those standards? Finally, what processes are in place to ensure that the*

project's equity culture evolves and adapts to participants' changing understandings, new technological demands, and other factors inherent in the deployment of complex, large-scale development projects?

The above questions form a loose agenda for researchers thinking about how to build and evaluate equity culture in carbon management projects, particularly with an eye toward engaging with, and providing benefits to, historically marginalized communities. Ultimately, developer-led teams must rethink historical project management designs that center technical expertise and corporate culture, which includes greater transparency and accessibility of information. This logic not only diminishes the transformative potential of dialogue across communities of practice but also inhibits epistemic justice, where multiple forms of expertise, experience, and knowledge can come together to build more sustainable and more resilient projects.

There are several emerging examples of how project teams proactively develop structures for long-term community relationships. In California, the Community Alliance for Direct Air Capture (CALDAC) is a coalition of researchers, nonprofits, and industry partners exploring DAC in the San Joaquin Valley. Beyond seeking to deploy technological innovations in carbon sequestration, the Center for Law, Energy and the Environment (CLEE) at the University of California, Berkeley's law school, which leads CALDAC, argues that it is pioneering "a new style of project governance and ownership" for large-scale industrial facilities that include co-developed "go/no go" decision points, community ownership models, and a suit of community oversight panels for technical assessment, operations and management, community benefit negotiations, and risk mitigation (Berkeley Lab, 2023; Chemnick, 2023). In the Southwest Regional DAC Hub, project planners are implementing a team management infrastructure for maximizing equity culture at different scales (Southwest Regional Direct Air Capture Hub, n.d.). Consisting of compensated community representatives from across its Hub sites, a Workforce and Labor Advisory Board will oversee industry training, ensure worksites prioritize workers' rights, offer workforce development opportunities for traditionally marginalized groups, and maintain healthy workplaces. Similarly, the project's Community Advisory Board will coordinate engagement efforts across the Hub—working between the core project team and communities to co-design criteria and metrics for maximizing community benefits and minimizing impacts. Alongside these, the Hub's DEIA and J40 committees will ensure the project maintains best practices for equity in its decision-making spaces and outputs. Similar structures can be found in other DAC Hub team structures, including in Louisiana and Texas (DOE Office of Clean Energy Demonstrations, n.d.).

5. TRACKING AND MEASURING ENGAGEMENT AND COLLABORATION:

Primary Research Question: **How does the "metrification" of engagement, justice, and DEIA shape how carbon management projects are designed, implemented, and evaluated?**

Metrics play a large role in decarbonization efforts being tracked and evaluated. In part, this is because the federal infrastructure funding supporting many of these projects is required to track community benefits. Many FOAs, including those for carbon management, require awardees to track the flows of benefits and harms to historically marginalized communities or – if the project is still in early research and development – to anticipate the flows of benefits and harms, and all applicants are tasked with creating and tracking progress toward SMART (specific, measurable, assignable, realistic and time-related) milestones. In public presentations, DOE personnel trace this impetus to both the need to demonstrate accountability to the Justice40 initiative and to demonstrate accountability to American taxpayers. It is also important to underline that metrics are also embedded in the environmental justice movement itself, including foundational demonstrations that industrial facilities were disproportionately located by marginalized communities (Mohai et al., 2009).

Quantifiable metrics can help make patterns visible and set the stage for improvement. Yet, while metrics facilitate making certain kinds of strong claims, they also risk "informating" justice (Fortun, 2004) or rendering justice issues into problems that can be understood and manipulated through information systems. This risks narrowing the kinds of ethical questions that can be asked and answered: not all justice issues can be turned into a metric. For example, Max Liboiron's (2023) conception of anti-colonial science centers on good relations with Land, understood as physical territory and the ecological, ethical, and spiritual relationships held together in particular places. They show how most scientific practice is grounded in the assumption of settler access to Indigenous Land. In their work, metrics can estimate the ingestion of plastic by species of fish, but would fail to measure the more-than-numeric loss of the relationships surrounding that species: its spiritual significance, its place in food cultures, etc. To return to carbon management, metrics could track the impacts of new infrastructure on particular species or track human health indicators. But which would track whether and how that infrastructure and its attendant social systems affect spiritual relationships among species, environments, and other people? Most metrics are a poor proxy for fundamental questions of what it means to live a good life, as people and communities define it; and metrics run the risk of reducing life to numbers. Philosopher Achille Mbembe asks, "What remains of the human subject in an age when instrumental reason is carried out by and through information machines and technologies of calculation?" and then, "What will it take to turn instruments of calculation into instruments of liberation?" (2021, p. 11).

Epistemic justice compels us to consider how community knowledge and concerns are integrated – or not – into the design, collection, and analysis of metrics, most of which currently stem from the DOE's policy priority areas. The primary research question – **How does the "metrification" of engagement, justice, and DEIA shape how carbon management projects are designed, implemented, and evaluated?** – is further elaborated through secondary research questions related to tracking and measuring community engagement: *What are the most appropriate and meaningful ways to gather diverse community input on the CBP tracking tables themselves? Beyond the benefits and harms laid out in the DOE CBP template, what more community-centric benefits and harms ought we be tracking for carbon management projects? What other kinds of strategies are there for tracking justice outcomes, outside of quantitative tables? What kinds of justice concerns (e.g., those related to process/procedural justice, or knowledge/epistemic justice) are not legible, or are less legible, as metrics? What are key patterns in the community-driven benefits and harms generated in our projects, and what do these suggest about different framings of Justice40? How does the inclusion of other benefits and harms change how we and others understand and implement Justice40? In what ways does opening up the identification of benefits and harms move toward epistemic justice? What kinds of metrics and data sources are most helpful for tracking community engagement processes and the impacts of processes on project outcomes? What assumptions are embedded into the federal screening tools, built from metrics, that forestall more robust understandings of justice, especially as related to internal and external processes?*

Additional questions can be elaborated related to tracking and measuring internal team collaboration and dynamics. For instance, building on the observations above about how to build equity culture in project teams, one might ask: *How do you measure the power and collaboration dynamics within a project team (e.g., the relationship between the technical, industry, and CBP sub-teams) to better understand their influence on the types and depths of community engagement and ultimately the project outcomes? What are the best ways to measure and track community leadership and influence within a project team? What kinds of metrics and data sources will be helpful for tracking team dynamics? What kinds of important considerations about team dynamics are not amenable to being turned into metrics?* To approach these questions, researchers might examine the frequency and quality of communications

between core project teams and ancillary planning and advisory groups; analyze the number of team members from historically marginalized groups and the frequency of their decision-making opportunities; track the number and types of capacity-building and training programs offered to project management teams related to cultural sensitivity, knowledge sharing, and community and public engagement; and measure the accessibility of project-related information and communication materials, and the extent to which these are disseminated with transparency.

To provide a more comprehensive evaluation process, the assessment of CBPs should be enhanced by incorporating qualitative metrics alongside the traditional quantitative metrics. Quantitative metrics, frequently misinterpreted as inherently objective, can yield measurable data on the effects of a CBP on aspects such as economic growth, educational advancement, environmental, and health improvements. These can include, but are not limited to, metrics such as air quality improvement, energy savings, carbon footprint reduction, job creation rates, economic impacts on local businesses, and diversity in procurement processes. However, it is crucial to recognize that biases can influence quantitative metrics in their design, interpretation, and implementation. Thus, suggesting that quantitative measures are purely objective while qualitative measures are inherently subjective oversimplifies the complexity of data analysis and interpretation in CBPs. For example, in the initial phase of implementing evaluations within two domestic CCUS projects, the introduction of qualitative metrics is designed to complement traditional quantitative assessments. These qualitative measures focus on broader stakeholder feedback, capturing the community's long-term perceptions of the project's benefits. This includes evaluating stakeholder engagement effectiveness, community support and concerns, perceived environmental and social impacts, and the project's alignment with community values and sustainability goals. By embedding these qualitative insights into the evaluation framework, project developers and stakeholders can better understand the projects' roles within the broader context of community well-being, environmental sustainability, and economic resilience, facilitating informed decision-making and fostering a more inclusive and participatory project development process.

The JUST-R framework proposes a novel approach to metrics (Dutta et al., 2023). It combines energy justice (e.g., Sovacool et al. 2016) with key principles of Responsible Innovation (RI), such as anticipation, reflexivity, inclusion, and adaptiveness (Owen et al., 2013). The JUST-R framework was designed to assess early-stage energy research and development, but we see value in using it to assess projects closer to commercialization. Beyond the metrics already proposed in the literature cited, JUST-R proposes new metrics, including hidden process costs, breadth of pre-existing knowledge review, distribution of research results, distribution of hazard exposure during the research life cycle, and identification of set versus flexible parameters.

Evaluation can also apply to the relationships formed to deliver community benefits. Caughman and colleagues (2020, 2023) have written on formative evaluation of partnerships among universities, cities, and communities, which observes and intervenes in the course of a project's implementation to improve the relationship between project partners and promote long-term relationship development in service of larger goals such as economic transformation or industrial decarbonization. They note the importance of attending to the relationships across organizations in these projects and evaluating and sharing feedback and insights while the project is ongoing in an effort to hopefully improve project outcomes.

V. CONCLUSION

This paper has presented an agenda for conducting social science research that aims to help develop more community-centric processes for engaging historically marginalized populations in carbon management projects, with the ultimate goal of advancing equitable decarbonization. The background,

analysis, and research questions above suggest some helpful scaffolding for this agenda, which we share here as concluding food for thought.

Scaffolding #1: Action Research – The agenda presented here calls for action research that blurs distinctions between studying and doing work, whether carbon management or otherwise. An action research approach is key if we want our research to make an immediate difference, for example, by employing methodologies such as formative evaluation (Caughman et al., 2020), which uses interim analysis to revise research and action design at multiple stages throughout the project. Participatory Action Research (PAR) is a community-driven research methodology that is one model that we suggest employing. PAR focuses on collaborations with historically marginalized communities and centers community partners' voices and desired outcomes. It is a research orientation that engages residents and community leaders as experts who generate valid and crucial knowledge about their communities and experiences. This contrasts with traditional approaches in which academics, municipalities, think tanks, and corporations lead the research as PIs. As such, PAR pays attention to power dynamics within the research and often seeks to change inequitable systems, policies, and practices (Fine, 2008). PAR trains residents, from youth to adults. to be researchers to study equity issues that they want to influence and work for changes based on their findings to ensure benefits to the community. PAR has been shown to have numerous positive outcomes, such as empowering marginalized groups to create change, improving individual and collective efficacy, and bolstering academic engagement and achievement (Ozer et al., 2020). Employing an action research approach can also be helpful in re-centering communities, thus ensuring that our research methodologies practice what we preach, which is especially important given that carbon management projects are largely industry-driven, emphasizing stakeholder rather than participatory models of engagement. Action research will also be helpful in learning more about the carbon management ecosystem and how funding opportunities, institutional arrangements, and other aspects of the system shape opportunities for social science and community participation. In other words, we need to study both actual projects (and consider ways to make them more just and equitable) and the institutional processes and structures through which projects are made possible, created, and refused.

Scaffolding #2: Community Expertise – Action research requires changing how we work with community partners. Rather than viewing partners as groups that we need to "engage" – or as groups that are simply trusted messengers who will help us engage their communities and the public – we need to see them as experts and innovators (Hirsch et al., 2023), with their own sophisticated knowledge systems that need to be integrated into projects to ensure both innovation and success (Executive Office of the President, 2022). From a research perspective, this entails taking community knowledge seriously throughout the technological research lifecycle, from low technology readiness level (TRL) research through project design, planning, negotiations, deployment, and evaluation. Recognizing, valuing, and building on community knowledge as expertise is the only way to achieve epistemic justice and is crucial to studying, developing, and implementing successful CBPs. We can put this foundational approach into action in several ways. One way already discussed in this paper is working with community partners as co-PIs, for example, using the abovementioned PAR framework. Relatedly, we can engage with community partner PIs – and with their communities – based on their principles for engagement. Community networks create many such principles to try to equalize power relations and prioritize community-created visions and goals. Examples include the CARE and FAIR Principles for Indigenous data futures (Carroll et al., 2021), The Principles of Environmental Justice (Delegates to the First National People of Color Environmental Leadership Summit, 1991), and the Jemez Principles for Democratic Organizing (Working Group on Globalization and Trade, 1996).

Another way to collaborate with communities as experts, also discussed above, entails diversifying our sources, as we have done in this paper, to include written and oral materials that are either generated by communities or center community voices. These materials can encompass various sources, from memoranda to newsletters, blog posts, and action plans, such as the 10-Year Strategic Action Plan recently drafted by The Southeast Region Environmental Justice Network (2023). Contrary to most thinking about when to start working with communities, Dutta et al. (2023) argue that including community knowledge "is particularly useful early in R&D, when the technological concept is highly general, and the specific end-user community is not yet known and lays a foundation for employing community-based participatory research at later stages" (p. 433). We can also take community knowledge and expertise as the object of study by researching projects that center this expertise, such as the Community Alliance for Direct Air Capture (mentioned above), and engagement efforts that use methods intended to identify and build on community assets and knowledge, such as popular education (Hirsch, 2010) and asset-based community development (Chupp et al., 2023; Hirsch et al., 2011). One example of the latter is the "Big Plans, Community Action" methodology developed by The Field Museum in Chicago, in which communities identify local assets that they can build on to address community challenges in ways that simultaneously advance broader efforts for social and environmental change. One project using this methodology is the Chicago Community Climate Action Toolkit (The Field Museum, 2023), in which different communities across the city developed unique approaches to advancing the Chicago Climate Action Plan in support of their own visions for their communities' futures. For example, partners in the historic black community of Bronzeville focused on integrating sustainable food practices into their efforts to become a destination for African and African-American cuisine, while partners in the Latino community of Pilsen focused on advancing native plant gardening by promoting its connection to Monarch butterflies, which are symbols of immigration rights and beloved by community members who hail from Michoacán, Mexico, where there is a well-known Monarch butterfly sanctuary (Hirsch, 2016).

Scaffolding #3: Reflexive Research – As increasing numbers of social scientists and humanists are recruited to lead or play roles in carbon management projects, we need tools to think critically about this participation. There is a long tradition of reflexivity among scholars who practice "engaged" research that supports communities and social movements. Such reflexivity becomes more complicated – and polarizing – when it involves collaboration with actors such as corporations, governments, and utilities. Here, the concept of critical participation, as theorized by Downey (2009), is helpful. Whereas traditional participant-observation positions the researcher as external to the field of practice being studied and "outreach" as distinct from scholarly practice, critical participation emphasizes that researchers are part of the continual unfolding of the fields they are studying. Rather than viewing "outreach" as a final, derivative step, critical participation foregrounds the eventual uptake of our research as shaping the research agenda itself. Scholars engaging in critical participation manage three risks: 1) *cooptation,* or the transformation of a project into "something indistinguishable from that which it studies"; 2) *social engineering*, or "presuming that one's expertise warrants the authority to legislate change through a research project"; and 3) *rejection* by the people with whom we seek to collaborate (Downey & Lucena, 1997, p. 120). These three considerations provide fertile areas for reflection by social scientists and humanists embedded within CCS projects that they themselves do not control.

Such reflection will likely raise the thorny issue of how questions of carbon management are framed, expanding from the central "how" question of most developer-led carbon management projects – as in, "how to do CCS responsibly" – to first ask "whether" carbon management should be implemented in a specific community, and then to ask, "if so, then how?" For social scientists and humanists who come to carbon management projects with critical lenses, such as the authors of this paper, starting with "how" can be profoundly uncomfortable if they sidestep community consent and procedural justice (Smith,

2021). The alignment between climate urgency and developer pressures has led to resistance to carbon management projects among environmental justice scholars and activists; they can feel like another round of unjust industrial development cloaked in green halos. At the same time, many of us recognize the importance of putting our knowledge and skills to work in the "how" space to achieve critical climate and equity goals (Buck, 2021).

Scaffolding #4: Social Science and Humanities Research Agenda – Our final scaffolding emphasizes the importance of including – indeed, *centering* – the humanities in any research agenda aimed at "developing and assessing ideas for social and behavioral research to speed efficient and equitable industrial decarbonization." The humanities are often engaged for education and communication purposes. For example, *Accelerating Decarbonization* (2023) references Richard Scarry's children's books as an example of how to help the public think about their relationships to energy; Boston University's Visualizing Energy project (Institute for Global Sustainability, 2022 turns data into stories that are intended to spur actions towards sustainability; and the Science History Institute uses the arts to help the public understand chemistry, engineering, and the life sciences (Science History Institute Museum and Library, 2024). But the humanities offer far more than communication and storytelling. Including literature, philosophy, history, communications, religion, and more (American Academy of Arts and Sciences, 2024), the humanities embed technological challenges, such as energy transitions, within cultural contexts. Sub-disciplines, such as environmental humanities and energy humanities, address social and behavioral change as core challenges related to what it means to be human and co-exist as multiple peoples with differing values and beliefs and as multiple species with diverse connections to and dependencies on natural systems (Energy Humanities, 2023; Holm et al., 2015). For example, the Center for Science and the Imagination at Arizona State University convenes scientists, engineers, science fiction writers, and artists to craft stories that reimagine human beings' relationship with technology and grapple with how new technologies reorder humanity. The mission is not to communicate science but rather to "reignite humanities' grand ambitions for innovation and discovery" (Center for Science and the Imagination, n.d.). This approach uses the humanities to drive innovation, not simply communicate it. Framing and tools from humanities disciplines can be used to develop research questions and methodologies that treat people and communities as full human beings rather than stakeholders and ask questions about how carbon management and similar projects make assumptions about – and aim to reconfigure – fundamental aspects of society and culture such as "space and belonging," "work and individual autonomy" (Szeman, 2021), and the need for what Mbembe calls "co-belonging" (Humanities Futures, 2017).

In conclusion, we recommend connecting this effort – aimed at developing a social science research agenda focused on team and engagement processes related to community benefits plans in initiatives such as carbon management projects – to another effort to develop a transdisciplinary research agenda on facilitating collective imagination processes to create transformative sustainable futures. In their important review of recent articles related to this topic, Moore and Milkoreit (2020) challenge us to consider concepts such as imagination and imagining alternative futures from the perspectives of history and power, noting that "participatory and coproduction processes of imagination can be thoughtfully designed in ways that address the power asymmetries that have historically dominated decision making for the future, or conversely, can be designed and used to resist changing power asymmetries, or even to imagine an enduring unsustainable or unjust path for the future," One of the central questions for their research agenda – "What is the relationship between imagination, power and governance[?]" (p. 7) – can serve as one important foundation for a combined social science/humanities research agenda that explores questions about just processes for collaboration and community engagement for a clean and equitable energy future.

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