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Communities in energy transition: exploring best practices and decision support tools to provide equitable outcomes

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Abstract
The U.S. coal industry has been in a state of decline for the past decade, a trend ushered by flat electricity demand, increased regulatory pressure, and market competition from cost-competitive clean energy sources. The receding economic viability of the coal industry has been acutely felt by the communities with immediate economic ties to coal-fired generation. With the energy transition underway, the question of how to engage communities as stakeholders in the decision-making process and address their needs through an equitable and just transition remains unresolved. To that end, this paper explores the economic, environmental, and social challenges presented by the energy transition at the community level, highlighting four case studies from transitioning coal-dependent communities across the United States to ultimately identify best practices in coal plant decommissioning processes. This paper weaves these community-identified best practices into two support tools—a decommissioning checklist and a redevelopment decision-making framework—that can be used to engage communities in the power plant retirement decision, the site reclamation phase, and eventual redevelopment of the site and revitalization of the surrounding community.

Keywords Energy transition · Energy justice · Decarbonization · Coal-dependence · Just transition · Decommissioning

1 Introduction

The latter half of the twentieth century witnessed the coal industry expand dramatically while the last decade saw the opposite [1]. Between 2010 and 2019, a total of roughly 102 gigawatts (GW) of coal-fired generating capacity—or more than 546 coal-fired units—were announced for retirement, with another 17 GW of retirements planned by 2025 [2]. Technological and economic advances in alternative energy sources, such as cleaner natural gas and renewable energy, and environmental regulatory pressure led to the decline of the U.S. coal industry, resulting in an increased number of retired and/or decommissioned plants across the country [3]. As the means of energy production continues to change, community engagement is critical to ensure that all stakeholders are included and community needs are met equitably in the transition to the new energy economy [4]. Pursuing a community-focused approach in the energy transition is vital for a number of reasons. First, the coal industry is forecasted to continue declining and this demands attentiveness to the frontline energy communities that have historically supported the industry. Second, the United States does not have a standard framework to guide an equitable energy transition process [5]. Currently, coal power plant retirements are addressed on a plant-by-plant basis and this leaves the decommissioning process to the discretion of the plant owner, making the role of the community in the decision-making process ambiguous at best [6].

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Coal-dependent communities are disproportionately poor, including those in rural areas, communities of color, and indigenous populations [7, 8]. In this paper, energy communities are understood to be social groups with identities rooted in their geographic proximity and economic dependency to the supply chain processes involved in coal production and plant operation; energy communities may exist within larger communities—that is, municipalities, tribes, or regions. The need to acknowledge community members as stakeholders in the energy transition process is critical, not only because there is no existing framework that identifies a public participation role for affected communities, but also because these communities have been historically denied the right to oversee how energy decisions affect them [9, 10].

This paper applies the lens of energy justice and equity in the context of a just transition to explore the economic, environmental, and social challenges presented by the United States' evolving energy landscape. It offers best practices in coal plant decommissioning processes, and proposes two support tools—a decommissioning checklist and redevelopment decision-making framework—that can be used to navigate the dimensions of a community-driven energy transition. Section 2 provides a background on the current status of the coal industry, the relationship coal plants have to the communities in which they are located, and the role of communities in the coal plant decommissioning process. Section 3 covers research methodology, including the community engagement process and conceptual framework used to analyze the community case studies and the support tools developed from this analysis. Section 4 discusses the case study results and applicability of the support tools to transitioning coal-dependent communities. Section 5 synthesizes key takeaways in community-identified best practices for equitable coal plant decommissioning processes and opportunities to expand this work in the future.

2 Background

Coal power plants have provided vital services in power generation, job creation, and incentivizing local economic activity. Longstanding plants (in operation for decades) are often regarded as generational employers, with their established presence playing a vital role in shaping community identity [11, 12]. However, fossil-fuel dependence has resulted in increased carbon dioxide emissions, exacerbating the pace of global climate change [13]. In addition, fossil-fuel power generation has impacted local communities through several criteria air pollutants and coal waste that are harmful to human health and the environment [5, 14]. The challenge of maintaining local economic security, retaining the community sociocultural fabric, and mitigating environmental consequences from power generation is particularly palpable for the communities facing the ongoing energy transition.

The energy transition is a global process happening right now, entailing the widespread transformation of the energy sector in order to curb greenhouse gas emissions and limit adverse climate change impacts by the second half of the century [15]. For energy companies, this process includes decarbonizing energy sources, as fossil-based systems of energy production and consumption shift to renewable systems, as well as deploying new technologies, enhancing sector energy efficiency, and responding to environmental, social, and political governance factors [16]. However, the energy transition is not just an effort to improve the wellbeing of the planet, but also its people. For energy communities affected by the transition away from fossil fuel dependency, the transition process is also a question of empowerment: *how can the shaping of the energy future be made into a participatory enterprise?* The UN's report on energy transition suggests that in order to ensure a just and equitable process, the transition must be implemented in such a way that both benefits and avoids dislocations for individuals, communities, countries, and regions [17].

Energy justice and equity in the context of the U.S. energy transition has particularly focused on the negative externalities imposed on communities that host fossil-fuel-based infrastructure. Executive Order 14,008, issued in early January 2021 by the Biden administration, established two initiatives to assist energy communities through the domestic energy transition: the Interagency Working Group on Coal and Power Plant Communities and Economic Revitalization (IWG) and the Justice40 Initiative [18]. As one of its first steps, the IWG identified 25 of the "most-impacted" regions for coal-related declines to prioritize for investments in the near term [19]. The IWG report also identified $38 billion in existing federal funding that could be accessed by coal communities to address infrastructure, environmental remediation, union job creation, and community revitalization [19].

The second initiative established by EO 14008 is the Justice40 Initiative, which directs 40% of the overall benefits of climate investments to disadvantaged communities [18]. However, the initiative is still in its initial stage, so it is still unclear how such investments will translate into meaningful outcomes for energy communities across the United States. Independent of the Biden administration's order, states have already begun addressing the clean energy transition and the equity implications of fossil fuel production declines, including the need for workforce training and transitioning for affected communities and financial assistance to support transition strategies [20, 21]. However, this piecemeal approach to energy justice and equity heightens the need to better understand what an equitable energy transition should look like and how communities at the forefront of this transition should be included in the process.

2.1 Socioeconomic context

Most coal power plants in the United States are located in rural and isolated regions with high rates of unemployment and poverty (Fig. 1) [22, 23]. Wilson et al. [24] offered an assessment on the socioeconomic and demographic differences for those living within three miles of a major U.S. coal-fired power plant and the findings showed that fenceline communities had a lower average income compared to the national average and were more likely to be people of color [5]. Haggerty et al. [25] also shows the social and economic vulnerabilities of rural communities and those living in remote locations due to the transition from coal power. The development path for rural communities is often different from urban areas, not only due to their geographic isolation, but also due to limited economic diversity, relatively lower population and development density, and high rates of vulnerable populations [26]. Infrastructure and public services, including tax revenue funds for schools, are especially dependent on local power plants, meaning closure of the plants will affect a significant portion of the regional economy [7]. For example, in Boone County, West Virginia, a $2.5 million budget deficit resulted from the loss of the statewide coal severance tax [27].

Coal-dependent communities have specific needs from the energy transition away from coal, including providing jobs for workers affected by plant shutdowns, funding public schools and other social services, supplying clean energy for local use, and maintaining a sense of community identity [11, 28]. Carley et al. [3] looked at the cultural and community adaptive capacity of coal communities and found that it is significantly difficult for the communities to accept the changes of the energy transition. Coal power plants have served as generational employers offering good paying

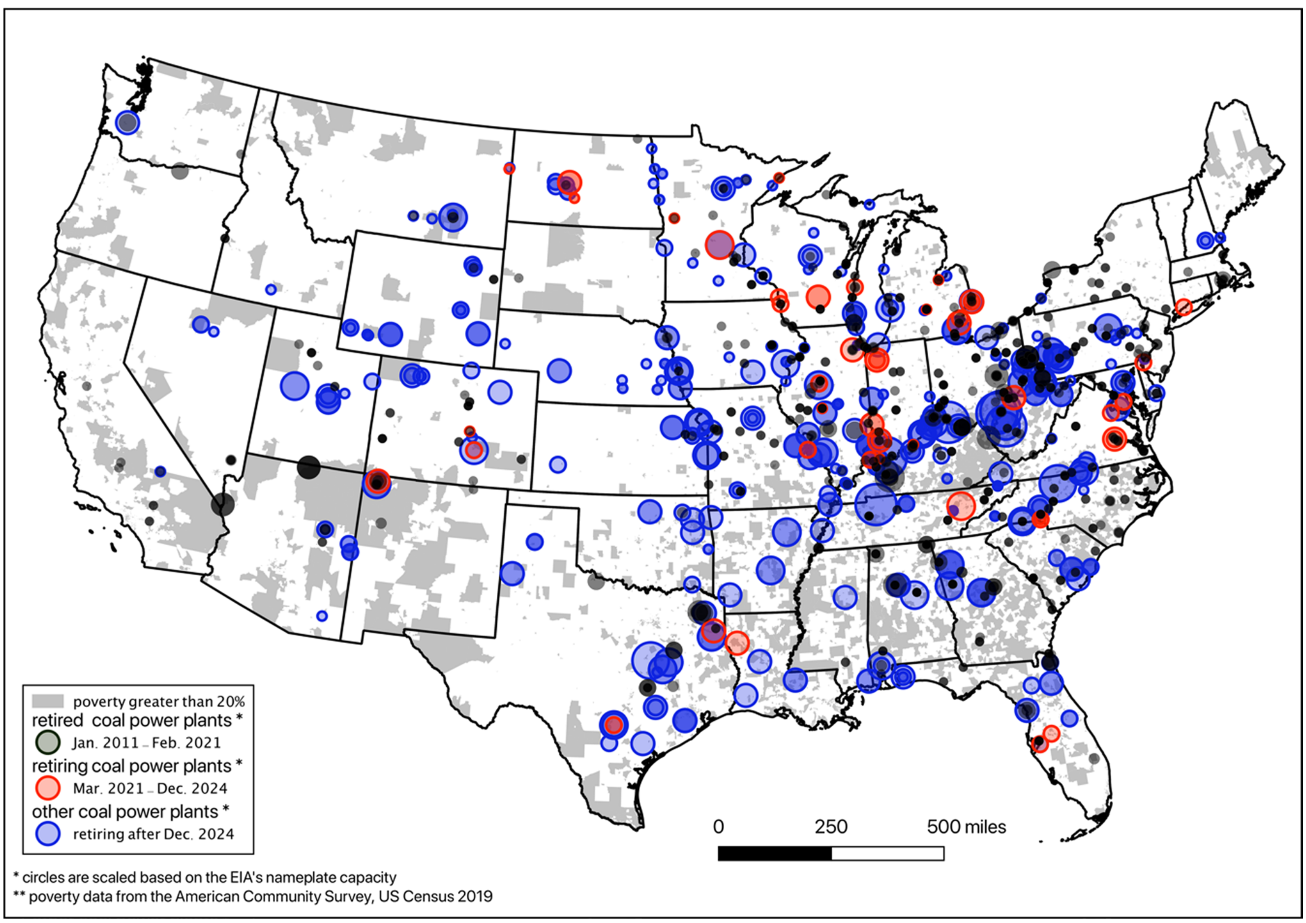


Fig. 1 Coal power plant retirement status [5]

Table 1 Nine largest coal-fired operating capacity by state, July 2021

State	Coal-fired operating capacity (MW)
Texas	18,276
Indiana	16,936
West Virginia	13,003
Pennsylvania	11,177
Kentucky	11,099
Missouri	10,821
Illinois	10,816
Ohio	10,480
North Carolina	10,136

Table 2 Nine largest coal-fired capacity retirements by state, 2000–2021

State	Coal-fired capacity (MW) Retired, 2000–2021
Ohio	13,581
Pennsylvania	9618
Illinois	8170
Alabama	7698
Texas	7483
Kentucky	6849
Florida	6106
Indiana	5688
Georgia	5669

jobs, weaving a fabric of community identity that is closely tied to coal as a culture. The study participants framed coal as the "common bond or identity" that held the community together. These deep cultural losses along with the loss of jobs and economic revenue must be addressed in planning for the energy transition [12, 25].

2.2 Status of coal power plants

Most coal power plants in the United States are at least 30 years old and have an average life of 40 years [29]. Since 2010, the electric power sector has retired around 30% of its coal power generating capacity as new and economically advantaged generating facilities take over the role of producing energy [30]. According to data from the Global Energy Monitor [31], there was a total of ~ 233 GW of coal-fired operating capacity in the United States as of July 2021—the states with the largest capacity (> 10 GW) are shown in Table 1. In addition, there was a total of 627 MW of mothballed coal-fired capacity. Between 2000 and 2021, approximately 127 GW of coal-fired power plants were retired (see Table 2 for the states with the largest capacity retirements), and an additional 17 GW are slated to be retired by 2025 (see Fig. 1). As shown in Tables 1 and 2, the regions hard-hit by the transition away from coal power in the past decades will continue to suffer losses and will need targeted support to efficiently and equitably manage the transition process.

In relation to workforce impacts, between 1985 and 2001, coal industry employment fell by 59% even with a 28% increase in coal production [5, 32]. In 2019, U.S. coal production hit its lowest level and the number of coal mining employees decreased significantly [32–35]. Employment in coal power plant generation facilities also fell by 7700 people in 2020 [36]. Demand for coal-fired power generation is forecasted to continue declining as decarbonization of the electricity sector becomes more prevalent and other, more economic, technologies such as natural gas, wind, and solar take over the role of power production (Fig. 2) [37].

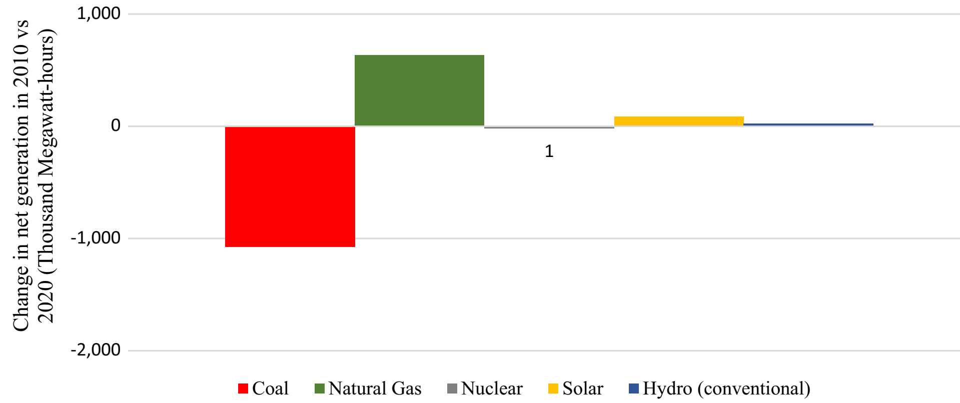


Fig. 2 Change in net electricity generation by source (2010 vs. 2020)

2.3 Coal power plant decommissioning process

The U.S. coal transition and power plant decommissioning process is not structured toward community engagement in plant owner/operator planning and decision-making [25]. Lange et al. [38] discuss the notion of transition management, a governance approach aimed at facilitating multi-actor participation to account for multiple societal viewpoints and expectations. The status quo coal transition process is complex with conflicting values and interests existing in an unstructured governance realm. U.S. coal facilities are typically authorized by state permits, and plant retirement decisions are addressed on a plant-by-plant basis [6, 39]. This leaves the decommissioning process to the discretion of the plant owner, not only resulting in a nonstandard process, but also often leaving facilities mothballed rather than fully decommissioned [5]. During the retirement decision stage, plant owners usually have to decide whether to continue operation through the end of a plant's expected life; leave the plant idle until it is economically feasible to reactivate production; or announce retirement and cease power production [5, 39].

Affected communities often do not have a say in the decision to retire a coal plant, although they face the economic spillover effects of power plant closure. Once plant retirements are announced, the plant may be left idle, be repurposed with a fuel switch, be redeveloped to serve other electric grid needs, or be redeveloped and repurposed with alternative commercial activities [5, 40] (see examples of potential repurposing options in Table 3). The future of the plant after retirement depends on the economics of decommissioning and the potential redevelopment options of the retired plant [40]. The needs of the community, including workforce services and skills training for displaced workers, and the availability of state-funded environmental clean-up programs could also influence the outcomes of the decommissioning process. To align the different needs of stakeholders affected by power plant decommissioning, coordination and multi-actor approaches are key to the transition process [41].

Table 3 Repurposed coal power plant sites

Plant name	Plant owner	Location	End use
Beckjord	Duke Energy	New Richmond, Ohio	Battery storage
Eastlake	FirstEnergy	Eastlake, Ohio	Synchronous condenser
Widows Creek	Tennessee Valley Authority	Jackson County, Alabama	Data center
Mount Tom	FirstLight Power	Holyoke, Massachusetts	Solar and battery storage
Brayton Point	Dynegy	Somerset, Massachusetts	Offshore wind and transmission infrastructure

3 Methodology

3.1 Conceptual framework

Energy justice is defined as an approach that explores the distribution of costs and benefits of modern energy systems and investigates whether energy decision-making procedures are fair and if stakeholders have access to information and participation in the decision-making process [42, 43]. Energy justice seeks to unveil vulnerabilities in energy transitions [44] and find a voice for the excluded [45, 46].

This paper employs energy justice as a conceptual framework with which to integrate the dimensions of recognition, distributive, procedural, and restorative justice for equitable decision-making in the energy transition. By this, we mean that different types of vulnerabilities and needs of community groups are *recognized;* energy injustices and the *distribution* of those injustices are identified; stakeholders are *procedurally* engaged in decision-making; and past energy injustices are *mitigated* in the context of transitioning from conventional modes of operation (i.e., fossil fuels) to a modernized energy system. This requires the hazards, externalities, and benefits of the energy system and its associated services to be distributed in such a way that access to these outcomes is not disproportionately shouldered by any one community group [47]. In other words, equity in the energy system is about the sharing of environmental benefits and burdens across society.

Energy justice is a principal tenet of the just transition process, which considers where injustices emerge, who is affected by such injustices, and which processes exist for their remediation [46]. In this paper, we consider energy equity within the context of a "just transition" to mean that workers in the coal industry should not have to carry the economic burden of a low-carbon transition, which would force the eventual replacement of their traditional mode of economy (i.e., fossil fuel dependency) by low-carbon sectors [48].

We use Sovacool and Dworkin's [42] model for energy justice as a conceptual, analytical, and decision-making tool that can (1) help distinguish the recognition, distributive, procedural, and restorative constituents of an equitable energy transition; (2) evaluate solutions for community-specific energy transition challenges; and (3) assist utilities, communities, and local governments in making more informed energy choices. Energy justice is key to ensuring that access to energy systems and services is equitable and that energy decision-making procedures are fair. Because an equitable transition is underscored by the fair treatment and meaningful involvement of affected stakeholders, it must involve an inclusive approach by which community members' needs are voiced, meaningfully recognized, and treated with fair consideration throughout the process.

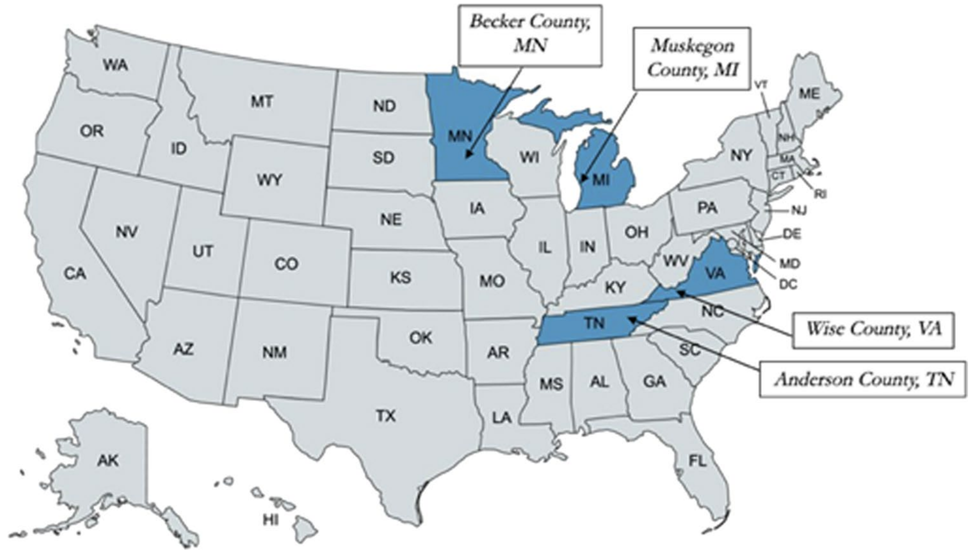
3.2 Case studies

This research draws from the experiences of transitioning communities in a range of U.S. geographical settings—from the Midwest to the South—to help identify the best practices in coal plant decommissioning processes. The study identified case study participants through online searches of community-based organizations experienced in local advocacy for communities affected by the energy transition. Of the five organizations initially contacted, two of whom—Appalachian Voices (AV) and the Just Transition Fund (JTF)—ultimately provided the four cases studies for this study [49, 50]. Between March and July 2021, AV and the JTF garnered community experience and sentiment surrounding the local coal plant retirement decision and decommissioning process in four representative communities—Wise, Muskegon, Anderson, and Becker counties, shown in Fig. 3. These community engagements were guided by an outline questionnaire developed by the authors.

Given these organizations' established presence and general trust with the localities they are engaged with, AV and JTF served as intermediaries between the affected communities and the authors of this paper. Two representatives from each organization communicated with their respective community members and representatives to provide an overall historical context to the coal plant, its relationship to the community, and the community background, as well as information on the motivations for plant retirements, the community's perspective on the plant decommissioning process, and the community's needs, wants, and vision for a post-transition society. A series of virtual meetings averaging about 30–60 min were conducted with these grassroots organizations to develop the case studies, which were then analyzed to identify the best practices for equitable community energy transitions.

The meetings focused on defining the questions needed to gauge the community's overall experience and concerns across three general buckets: economic impacts, environmental impacts, and broader sociocultural community impacts. In particular, the study aimed to understand each community's concerns related to economic revenue

Fig. 3 Case study locations



(e.g., replacing lost tax revenue and jobs), environmental ramifications (e.g., land use impacts and exposure to remaining coal waste, such as on-site coal ash or gob piles), and societal implications (e.g., public health hazards and cultural losses stemming from the closure of an intergenerational employer). The study also engaged the communities to understand their vision for the future: *What should happen to the site after decommissioning, and how can future site alternatives support and/or mitigate community needs and concerns?* The authors of this paper iterated with the organization partners to develop questions for case study evaluation, but ultimately leveraged AV and JTF as the "go -between" liaisons to the sample communities due to their reputation in enhancing the agency of local communities and knowledge of local outreach channels. AV and JTF engaged with the members of the Becker, Wise, Muskegon, and Anderson County communities to collect their responses to the aforementioned questions and their reactions to the retirement announcement and plant decommissioning process.

Subsequent meetings with AV and JTF were used to iterate on the development of a comprehensive summary that highlighted each of the community's backgrounds, concerns with the decommissioning process, and ideas for site alternatives. A high-level overview of key plant and community characteristics, such as location, facility ownership, county population demographics and poverty levels, and baseline economic impacts of plant operation at the county level, is provided in Table 4.

This paper builds on the output summary from each of these case studies and offers two transition support tools, a decommissioning checklist—based on community-identified best practices for supporting an equitable transition—and a redevelopment decision-making framework for guiding the site redevelopment process, which are explained in further detail later in the paper.

3.3 Methodological limitations

Before providing the results of the study, it is important to discuss the nature of this paper's community engagement methodology, as it is one step removed from the communities that serve as the focus of the study, and ultimately obfuscates the ability to provide granularity in community politics. The use of community organizations as intermediaries between the authors and the communities themselves means it was not possible to capture the nuance in community perspectives, as residents may express drastically different sentiments over the plant closure itself and therefore have varied visions for what a coal-free future should look like—as well as the priority actions that should be taken to get there. How agency is distributed amongst community members in shaping the trajectory of the decommissioning process is also a question of equity and justice, since unequal power dynamics can give certain individuals more credibility or influence in the community. While this study looks at equity and justice in the context of external stakeholder collaboration (namely between communities, local governments, and plant owners), it does not consider community politics—Who has the authority to make decisions in a community? What gives these individuals this authority? Who is not part of the internal decision-making process?—and therefore fails to provide insight into intra-group dynamics that can affect the

Table 4 Case study overview

Plant name and location	Plant owner	Community background	Economic impacts of plant*
Virginia City Hybrid Energy Center (VCHEC), Wise County, VA	Virginia Electric & Power Co (Subsidiary of Dominion)	County pop. = 38,000 Pop. below poverty level = 22.1% (2019 Census)[1] Demographic breakdown: 92.1% White, 5.5% Black	No. of jobs supported: 153 Revenue generation: $6–8.5 million in local taxes; $25–40 million in local economic activity
Bull Run Fossil Plant, Anderson County, TN	Tennessee Valley Authority	County pop. = 75,000 Pop. below poverty level = 15.3% (2019 Census) Demographic breakdown: 89.3% White, 3.26% Black, 2.54% Multiracial	No. of jobs supported: 125 Revenue generation: $450,000 annual payment (in lieu of taxes)
Cobb Power Plant, Muskegon County, MI	Consumers Energy (Subsidiary of CMS Energy)	County pop. = 173,000 Pop. below poverty level = 13.5% (2019 Census) Demographic breakdown: 81.2% White, 14% Black, 1% Native American or Alaskan Native descent	No. of jobs supported: 100 Revenue generation: $70 million in local taxes; $4 million in property taxes
Sherburne Generating Station (Sherco Plant), Becker County, MN	Xcel Energy	County pop. = 95,000 Pop. below poverty level = 11.4% (2019 Census) Demographic breakdown: 89.35% White, 0.19% Black, 7.52% Native American	No. of jobs supported: 300 (up to 800 employees on site when plant is undergoing maintenance) Revenue generation: $6.5 million in property taxes

[1] In 2019, the national poverty rate was 10.5%

pace and outcome of plant decommissioning. This is a key knowledge gap that should be addressed in future research: how to balance intra-community and extra-stakeholder politics to ensure that all affected voices are heard equitably.

4 Results and discussion

4.1 Case study results and discussion

The four case studies of the coal-dependent communities presented in this paper are mainly alike by the lack of meaningful community involvement in determining the direction of the decommissioning process, but unique in regard to each communities' needs in the transition away from coal. These communities' experiences in the decommissioning process not only illuminate the above points, but also inform the best approaches for engaging communities throughout the decision-making process, identifying their needs, and supporting post-retirement plans best suited to the local community's environmental and economic profile. Table 5 summarizes the specific motivations behind each case study's plant closure, as well as the community's reaction to the retirement decision and concerns for the future.

An equitable transition includes the fair treatment and meaningful involvement of affected stakeholders [43]. For the energy transition to also be a just transition, it must address who gets what, how processes drive the distributive principles behind "who gets what," as well as who gets brought to the decision-making table and how participatory governance structures influence who gets heard [11]. That is to say, a just transition broadly consists of two core dimensions: distributive justice and procedural justice [51]. In Wise County, the lack of transparency in the decommissioning process pushed activists from the local area to fight for new legislation to prevent their experiences from being shared by other Virginia communities also facing power plant closures. The bill (VA Clean Economy Act 2020 [52]), successfully enacted into law in 2021, affords these communities the very principles of transparency that Wise County residents did not receive to be disclosed to the affected communities, including detailed retirement dates for the plants anticipating closure, utility-provided retirement studies, and a public notice and hearing requirement for plant closure.

In the Muskegon and Becker County case studies, there was yet again an imbalance in stakeholder representation. The lack of engagement in the retirement decision, and the lack of opportunity for negotiations, effectively stifled the communities' ability to bargain for the outcomes they wanted. It also sent a powerful message—that community voices do not hold as much weight as the stakeholders who have financial and political leverage, or in this case, the plant owners.

In all of the case study communities, we found reports of economic, environmental, health, and sociocultural concerns linked to the coal plant retirements and the toxic waste legacies left behind from years of operation. However, these concerns were unique to each community and therefore require solutions tailored to their distinct nature. For example, the clean-up of gob waste was identified as a major concern for the Wise County community, whereas coal ash storage and associated groundwater leakage were unique environmental challenges imposed on the Anderson County community.

In addition to economic concerns (that is, job losses, tax revenue losses, and the costs of environmental remediation), communities also dealt with the unquantifiable losses of cultural nostalgia and a sense of community pride. For example, residents in Wise County and Muskegon County considered the large power plant smokestack as a city monument. Although it is difficult to measure how a plant closure may disrupt the social fabric of a community [3]. It is nevertheless an important community concern that must be accounted for during the decommissioning process. Although the opportunity for a transparent negotiation process was not particularly evident in any of these case studies, early and continued community engagement throughout the decision-making process can help address these concerns. Understanding community perspectives early in the process also affords more thoughtful consideration of the post-decommissioning projects needed to replace jobs, revenue, and economic activity, as well as manage long-term environmental and health impacts. For each community affected by plant closures, the pace, direction, and desired outcomes of the decommissioning process will look different, and should look different, because they reflect individual community needs.

4.2 Decommissioning checklist and redevelopment decision-making framework

4.2.1 Decommissioning checklist

A central theme throughout the case studies that we explored is the complexity behind reaching mutual consensus. Community members, plant owners, and local town officials may have drastically different visions of what the future should look like. The stakeholders involved in the decision-making process may also have varying motivations behind

Table 5 Motivations for plant retirements and community responses and concerns

Plant name and location	Motivations for retirement	Community response	Community concerns
Virginia City Hybrid Energy Center (VCHEC), Wise County, VA	VA Clean Economy Act 2020 (HB 1526) requires Dominion to sell 100% clean energy to retail customers by 2045 and requires the retirement of the VCHEC by 2045. Plant runs at very low-capacity levels; Integrated Resource Plan (IRP) filing indicated 22% capacity in 2019, no power production May–June 2020. Expected capacity factor by 2035 = 3.2%	There was significant local opposition to the construction of the facility in 2012 by environmental groups and community activists, who stood against the plant for both environmental and economic reasons. The announced closure was therefore met with a "we told you so" sentiment	Impacts to local economy, including businesses, livelihoods, and the school district tax base; Clean-up of gob waste remaining on site
Bull Run Fossil Plant, Anderson County, TN	Rising economic cost of maintaining declining and environmentally taxing performance; Tennessee Valley Authority analysis showed that retirement of this unit (and its sister unit in KY) would result in an estimated $320 million in net present savings, amounting to $1.3 billion in avoided capital costs for Tennessee Valley Authority	There were mixed reactions to the retirement decision; some argued the plant provides critical fuel diversity and economic baseload power; others cited climate change and environmental and human health factors as key reasons for shuttering the facility	Clean-up and remediation of coal ash (stored on site) and associated challenges with fly ash and groundwater leakage
Cobb Power Plant, Muskegon County, MI	Investments in upgrading existing plants demonstrated to be economically unattractive due to: the utility's goal of decreasing greenhouse gas emissions across its electric-generating fleet; cost of upgrading the units to comply with the Environmental Protection Agency's Mercury and Air Toxics Standard rule; and cost-competitive natural gas and renewable energy sources	Considering the facility's old age, declining performance, and environmental footprint, the community did not fight to save the plant	Identification and selection of a site alternative aligned with community's needs and vision for the future
Sherburne Generating Station (Sherco Plant), Becker County, MN	Minnesota's carbon-reduction goal of 80% by 2050, as well as Xcel's own IRP decarbonization goals (2016–2030)	Initially, the community was in denial regarding the plant's fate and thought Sherco might be saved since it powered a quarter of the Twin Cities	Identification and selection of a site alternative aligned with community's needs and vision for the future

the decommissioning and subsequent redevelopment processes. For example, plant owners consider the different business models and financial structures available to them for covering expensive closures [53], while also weighing into account the need to replace lost capacity and meet regulatory requirements. In contrast, communities and local governments' proposed redevelopment pathways for the former plant site may be based on the need to replace lost revenue or mitigate environmental burdens.

The decommissioning checklist offered in this paper is a tool for stakeholders involved in power plant decommissioning to assess whether the process is equitable. For example, a plant owner can follow the checklist to confirm it has equitably engaged affected communities before, during, and after the plant retirement decision and throughout the decommissioning process. This checklist was developed according to the commonalities between community-identified best practices for the plant decommissioning process in the case studies. Between the Wise, Muskegon, Anderson, and Becker communities, local residents identified the following thematic areas as critical to an equitable transition: early and continued engagement throughout the transition process; early planning of post-decommissioning activities; recognition and mitigation of economic, environmental, and social impacts on the community due to plant closure; identification of financial assistance resources; information transparency; and acknowledgment of communities as stakeholders who have a right to determine their futures [5].

These key areas were reconfigured into the following broader categories for the checklist—community engagement, community-driven decommissioning planning, community-driven redevelopment process, and community assistance (Table 6). Under each category are associated questions that direct the stakeholder (in this case, the plant owner) to identify whether or not they are meeting certain criteria representative of a community-driven transition process. For example, under the category of "Decommissioning Planning," an affirmative answer to the question *Was an economic remediation plan developed to address and alleviate economic impacts from plant closure (e.g., lost jobs, revenues,* etc.*)?* would mean that the plant owner has considered the importance of early planning to offset economic burdens on the community. The checklist then offers additional sub-questions to prompt more granular information from the plant owner. For example, if the plant owner developed an economic remediation plan, they are then prompted to answer the following question: *Does the plan consider workforce transition?* If the owner identifies they have not sufficiently met the criteria, they now have context with which to revise their work and reconsider their efforts in equitably engaging the community. As such, the checklist provides guidance for areas in which a plant owner can improve.

The decommissioning checklist (Table 7) can help plants owners ensure they are guiding a just transition away from coal power while also building greater understanding of community needs and wants—and how these needs and wants can be packaged into a redevelopment option that marries all the stakeholders' visions, including the plant owner. The premise behind the decommissioning checklist is that a plant owner can go through each of the categories—community engagement, community-driven decommissioning planning, community-driven redevelopment process, and community assistance—to make sure they are reaching the recognition, procedural, distributive, and restorative justice components of equitable decision-making.

By using the checklist, a plant owner not only learns about where they are falling short of engaging affected communities, but also about the community's sentiments regarding the future of the site. Knowing the latter, the redevelopment decision-making framework can then be employed by the plant owner to generate site redevelopment options that iterate between utility interests, such as cost-effective business models and financial structures, as well as the community's interests in mitigating economic, environmental, and social burdens. By guiding an equitable decommissioning process, a utility can then be prepared to participate in a community-driven redevelopment process, one that underpins the needs of the stakeholders but also recognizes the weight that community members themselves have as critical decision-makers in the energy future.

4.2.2 Redevelopment decision-making framework

In a just transition, the decommissioning considerations that are unique to the plant owner must also contend¦ with community and local government needs, as well as regulatory requirements, to weave a multi-stakeholder conversation about potential redevelopment pathways. Plant owners, utilities, communities, and local governments are the foundational stakeholders that hold weight in the determination of the future plant site. As such, the framework outlines an iterative process in which the stakeholders'"must-have" requirements for the future use of the site are identified as baseline inputs for the development of future site alternatives.

Table 6 Equitable decommissioning criteria

Category	Specification	Description
Community Engagement	Early Engagement	The community was informed about the retirement decision before public announcement and given opportunity to respond to the decision
	Information Transparency	The community was informed about the implications of the retirement decision, including the near-term economic impacts of plant closure on the community, as well as the timeline for the decommissioning process
	Community Feedback Opportunities	Listening sessions were provided to the community to hear the concerns and needs of affected residents
	Mechanisms/Mediums for Engagement	Feedback opportunities and methods for engaging the community in the decision-making process were offered through multiple mediums, such as virtual sessions, write-ins or surveys, and/or public forums
	Continued Engagement	The community was given updates on the progress of the decommissioning process and opportunities to provide input throughout various stages of the process, from beginning (i.e., retirement decision) to end (i.e., plant removal and site redevelopment)
Community-Driven Decommissioning Planning	Economic Remediation Plans	Strategic plans and/or a series of projects were designed to address and alleviate the economic impacts imposed on the community as a result of plant closure. These impacts include, but are not limited to, job losses, the need to re-train or transition the existing workforce, lost revenues, and declines in economic activity
	Environmental Remediation Plans	Strategic plans and/or a series of projects were designed to address the environmental impacts imposed on the community as a result of plant operation and to provide solutions for unique environmental burdens such as gob waste, coal ash and fly ash, and associated challenges with storage and groundwater leakage
	Public Health Remediation Plans	Strategic plans and/or a series of projects were designed to address and alleviate the public health burdens associated with exposure to coal plant operations and pollutant by-products, including groundwater contamination, respiratory illness, cardiovascular disease, lung cancer, and other health consequences
	Sociocultural Remediation Efforts	The social context and cultural value of the plant to the community was recognized, and specific efforts were conducted to address the potential cultural impacts of plant closure. Such efforts could include, but are not limited to, educational sessions about the history of the plant, final site tours, and other opportunities to commemorate the site and legacy of the plant
Community-Driven Redevelopment Process	Site Redevelopment Planning	The community was actively engaged about the timeline, direction, and progress of site redevelopment and given substantial consideration in the decision-making process behind the selection of site alternatives
Community Assistance	Financial and Technical Resources	The community was informed of and/or provided a variety of resources to assist with decision-making throughout the decommissioning process, including: federal, state, or local funding to assist with community revitalization efforts, environmental clean-up, and/or evaluation of site alternatives; technical expertise for addressing unique challenges to the community and/or assessing the feasibility of future use plans; and other financial and technical resources catered to community needs

Table 7 Decommissioning checklist

Stakeholder: Plant owner/utility

Category	Specification	Questions	Yes/No/Not applicable
Community Engagement	Early Engagement	1. Was the community notified about the plant closure before public announcement?	
		a) Was the notification given with considerable advance (i.e., weeks ahead of public announcement)?	
		2. Was the community given an opportunity to provide feedback on the retirement decision?	
		a) Was the community made aware of avenues for engagement (i.e., provided a repository or guidance on where and how to provide feedback? Shown where they could contact the utility for questions?)	
		b) Was the feedback period long enough to gauge community sentiment (i.e., enough time to collect a representative sample of residents' concerns)?	
	Information Transparency	3. Was the community made aware of the retirement timeline and proposed decommissioning schedule?	
		4. Was the community informed of decommissioning terminology and language (i.e., given opportunities to learn about the retirement decision and what it means?)	
		5. Was the community informed of the specific impacts that plant closure poses to its residents?	
	Community Feedback Opportunities	6. Were listening sessions provided throughout the retirement decision and decommissioning process to gauge community feedback?	
	Mechanisms/Mediums for Engagement	7. Was the community given more than one medium for which to provide feedback (e.g., in-person, virtual, written)?	
	Continued Engagement	8. Was the community given updates on the progress of the decommissioning process and opportunities to provide input throughout various stages of the process?	

Table 7 (continued)

Stakeholder: Plant owner/utility			
Category	Specification	Questions	Yes/No/Not applicable
Community-Driven Decommissioning Planning	Economic Remediation Plans	9. Was an economic remediation plan developed to address and alleviate economic impacts from plant closure (e.g., lost jobs, revenues, etc.)?	
		a) Does the plan consider tax base restoration/revitalization or revenue creation?	
		b) Does the plan consider workforce transition?	
		i) Does the workforce transition strategy offer former plant workers employment within a nearby vicinity?	
		ii) Does the workforce transition plan offer former workers employment that affords comparable quality of life?	
		c) Does the plan consider workforce training?	
		i) Does this plan offer training prior to plant retirement?	
		d) Does the economic remediation plan consider cascading economic impacts to the community, such as impacts on education services, social programs, and community services due to tax base reductions and overall loss of revenue to the community (both direct and indirect economic losses)?	
		e) Does the plan offer support for community improvement projects (e.g., updating lighting systems, fixing roads)?	
		f) Does the economic remediation plan specify how its action items will be funded?	
		i) Does the plan specify the utility's financial commitment?	
		10. Given the incurred costs for mitigation of economic burdens associated with plant closure, does the local economic plan avoid imposing an increased energy burden on the community?	
		11. Were economic remediation efforts conducted at the beginning of the decommissioning process?	
	Environmental Remediation Plans	12. Was a NEPA assessment or environmental compliance review conducted for the plant site?	
		13. Was an environmental remediation plan developed to address and alleviate environmental impacts from plant operations?	
		a) Does this plan provide solutions to alleviate environmental problems unique to the plant site and community (e.g., coal ash storage, gob piles, groundwater leakage, fly ash, etc.)?	
		b) Given the incurred costs for remediation of environmental burdens associated with plant operation, does the local environmental clean-up strategy avoid imposing an increased energy burden on the community?	
		c) Does the plan assure that no unjust burden is placed upon another community through the disposal of coal waste by-products?	
		d) If applicable, does the plan recognize the community's water rights?	

Table 7 (continued)

Stakeholder: Plant owner/utility

Category	Specification	Questions	Yes/No/Not applicable
	Public Health Remediation Plans	14. Was a public health plan developed to address and alleviate health impacts from plant operation?	
		a) Does this plan provide solutions to alleviate health hazards unique to the plant site and community?	
	Sociocultural Remediation Efforts	15. Were efforts made to acknowledge and address the sociocultural impacts of plant closure?	
		16. Were solutions provided for these unique impacts? (E.g., Were opportunities provided for the community to learn about or commemorate the plant site?)	
Community-Driven Redevelopment Process	Site Redevelopment Planning	17. Was the community actively engaged about the timeline and progress of site redevelopment?	
		18. Was the community given the opportunity to propose site redevelopment ideas?	
		19. Was the community encouraged to survey redevelopment options?	
		a) Was the community able to survey multiple redevelopment options to determine the best use scenario?	
		b) Was the community involved in selecting the redevelopment options best-suited to the community profile and needs?	
Community Assistance	Financial and Technical Resources	20. Was the community informed of all potential funding resources to support decommissioning and site redevelopment?	
		a) Were the costs of redevelopment distributed amongst stakeholders equitably (e.g., costs are not unjustifiably disproportionate to one stakeholder)?	
		21. Was technical assistance provided to support communities in assessing the feasibility of site alternatives?	
		22. Were additional partnerships/expertise leveraged to support the community through the decommissioning process?	

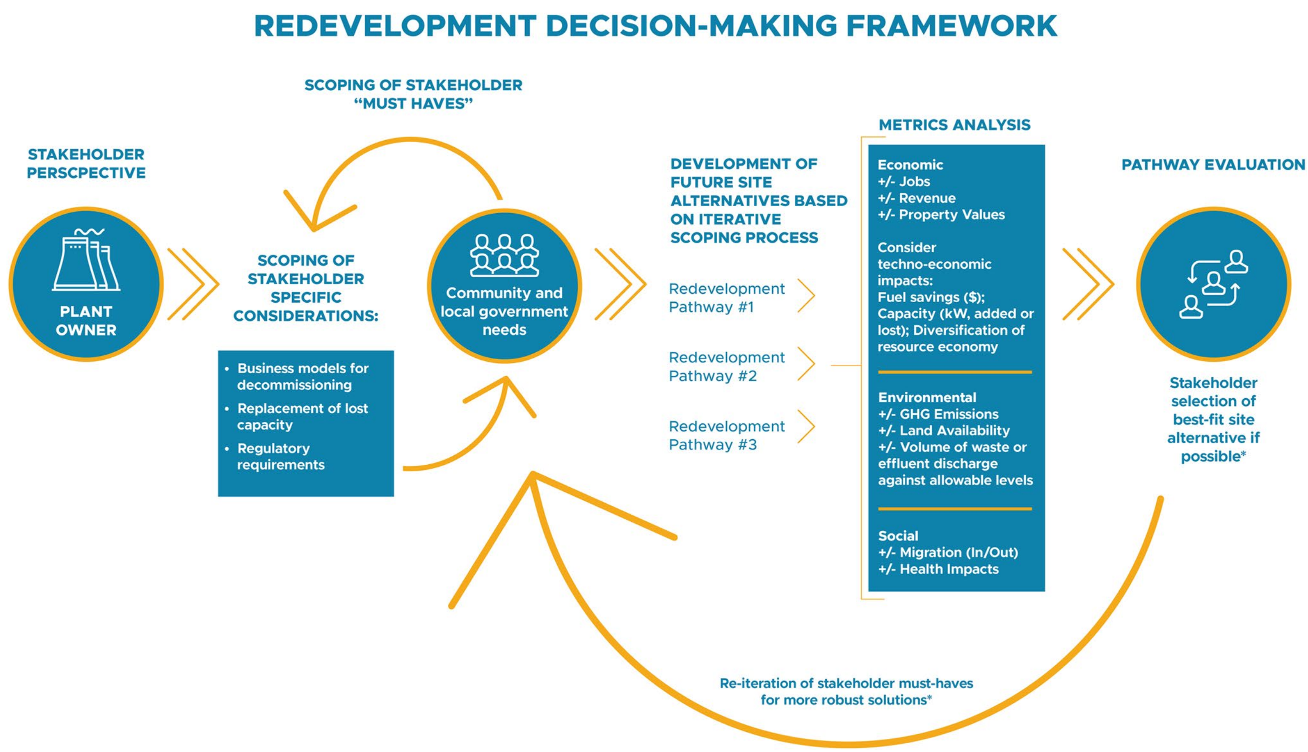


Fig. 4 Redevelopment decision-making framework

The redevelopment decision-making framework (Fig. 4) highlights this iterative process that encompasses the redevelopment stage, a process that must continually integrate the desired outcomes of stakeholders into site options that mutually serve their varied visions. The framework is intended to evaluate redevelopment pathway strategies against a business-as-usual scenario of continued coal plant operation to highlight the associated economic, environmental, and social benefits and burdens of the potential projects (compared to the business-as-usual scenario) to ultimately determine which redevelopment pathway best supports the community profile and the needs of stakeholders. Once a baseline has been developed for the stakeholders' desired outcomes for the future of the site, redevelopment pathways can be proposed. If the proposed pathways fall short of meeting stakeholders' "must-haves" for the future, the scoping process can be redone to reflect on new ways to marry the needs of each stakeholder. More robust site solutions can then be generated and further evaluated. The activities required at each stage of the decision-making framework are described in detail below.

Stage 1: Key stakeholders iterate between their needs and the needs of other affected stakeholders to craft an understanding of the "must-have" criteria for potential redevelopment pathways. In a just transition, the decommissioning considerations that are unique to the plant owner must also contend with community and local government needs, as well as regulatory requirements, to weave a multi-stakeholder conversation about potential redevelopment pathways. During the scoping of the redevelopment phase, a utility will need to iterate between the community and local government to capture the needs and wants of *all* affected stakeholders in the design of the future site. Community concerns could potentially encompass the need to replace lost revenue and/or mitigate environmental burdens, whereas local officials might envision community revitalization as a critically-desired outcome of the redevelopment process. For a just energy transition, the plant owner needs to understand stakeholders' "must-haves" for redevelopment, or baseline requirements the future site should meet, in order to develop future site ideas that meaningfully incorporate these assorted stakeholder needs.

Stage 2: The plant owner proposes redevelopment options that align with the pre-determined criteria (i.e., stakeholder "must-haves"). Once a baseline has been developed for the stakeholders' desired outcomes for the future of the site, redevelopment pathways can be proposed. Redevelopment options will vary depending on the "must-haves" of the plant owner, community, and local government, but can include the following [6, 39]:

- Fuel switch and/or new generation: redevelopment into alternative forms of energy generation.
- Transmission and distribution network support: repurposing to handle load pockets or remote transmission.

- Industrial activity: redevelopment of site to utilize locational benefits—such as access to railroads, waterways, ports, highways, utility grids, and existing industrial workforce—to support industrial activity.
- Commercial activity: redevelopment to support commercial use.
- Recreational repurpose: redevelopment of site to utilize locational benefits—such as proximity to water and geographical land features—to support recreational use and tourism.

Stage 3: Evaluate proposed potential pathways against a business-as-usual scenario to understand the economic, environmental, and social benefits and costs of the future alternatives, and use the evaluation results to reach a consensus with stakeholders on the most viable, or best-fit, future use of the site. Figure 4 shows example metrics for how such an analysis could be conducted—the outputs from these metrics could then be compared to the business-as-usual scenario for stakeholders to discuss the pros and cons of each potential option and iterate on the best course of action. Based on the results of the metric analysis, stakeholders can either reach a consensus on the best-fit site alternative or re-iterate the scoping process (to redefine stakeholder needs) and generate new solutions for evaluation.

Stage 4: Optional re-iteration of the scoping process in order to generate new site ideas should the proposed pathways fall short of reaching stakeholder must-haves.

As shown in Fig. 4, the redevelopment decision-making framework presented in this paper is in the conceptual stage, and future work is necessary to identify the metrics and analysis tools that could be used to gauge the economic, environmental, and social pros and cons of each redevelopment strategy.

4.3 Future work

Potential avenues for expanding this research are plentiful, but two particularly useful next steps for this study are to (1) refine and validate the decommissioning checklist against different communities undergoing the energy transition, and (2) develop the metrics and analytical methodology needed to understand the benefits and costs of potential redevelopment pathways (compared to a baseline or business-as-usual situation). The benefit of validating the decommissioning checklist is determining whether the categories and corresponding questions comprehensively cover the recognition, procedural, distributive, and restorative justice components in an equitable decommissioning process. By having more communities and plants owners review the checklist, the best practices can be refined to capture additional nuances, and a more detailed questionnaire can be developed.

Additional work could also be performed to translate the redevelopment decision-making framework into a usable tool. The framework currently proposes a number of example metrics that could be used to analyze the economic, environmental, and social footprint of different redevelopment options, but they are not comprehensive of all the benefits and burdens imposed by these different options. For example, one way the economic analysis could be expanded is by examining local economic value added by induced or indirect industries affected by the site's future use—such as retail and hospitality (which can boom during the construction phase of a project, when an influx of temporary workers spend on local restaurants and hotels, for example), legal services, real estate, and transportation—and compare this to a baseline scenario. However, the development of such an analytical tool would not only require determining *which* metrics to use, but also whether these metrics could be used agnostically or be universally applicable to all communities.

5 Conclusion

Now more than ever, coal-dependent communities across the nation are being faced with the economic, environmental, and social challenges of the energy transition. These frontline energy communities are not only affected by the economic challenges of plant closure (e.g., employment, tax revenue generation) and environmental health burdens of long-term plant operation (e.g., pollution, associated health effects), but have also been historically disenfranchised from the environmental decision-making process. Such burdens are especially compounded in these communities, as they tend to be disproportionately poor and minority, lacking resources and representation.

The case studies explored in this paper offer valuable insights into community-identified best practices for the coal plant decommissioning process and lessons on how to lead a more equitable and inclusive process. These case studies were used to inform the development of two transition support tools (i.e., a decommissioning checklist and a redevelopment decision-making framework) that can be used to uplift communities in the power plant retirement decision, the site reclamation phase, and eventual redevelopment of the site and revitalization of the surrounding community. However, further research is necessary to validate the decommissioning checklist's comprehensiveness and develop the metrics and analytical methodology for the redevelopment decision-making framework.

As the energy landscape in the United States continues to evolve, a community-driven transition approach is needed, especially given the historical neglect energy communities have faced and the long-term forecasted decline of the coal industry. Community engagement and participation is critical to the transition away from coal power because there is no one-size-fits-all solution—the decommissioning process must be unique and specific to the needs of each community.

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