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Political power and renewable energy futures: A critical review

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ABSTRACT

Inspired by the energy democracy movement, this conceptual review critically explores relationships between concentrated or distributed renewable energy and political power. Advocates assert that because the renewable energy transition is fundamentally a political struggle, efforts to shift from fossil fuels and decarbonize societies will not prove effective without confronting and destabilizing dominant systems of energy power. The objectives of this paper include: 1) theorizing and exploring the relationships between renewable energy and political power, 2) critically assessing tensions associated with an energy democracy agenda, and 3) drawing out the implications for democratizing renewable energy development in practice. Distributed energy-politics posits that distributed energy sources and technologies enable and organize distributed political power and vice versa. Efforts are underway to find ways to re-organize distributed energy flows into aggregated and concentrated stocks of energy and other forms of political power. More democratic renewable energy futures may benefit from strengthening democratic practices and outcomes, extending democratization of energy systems across all components, stages and end uses, and sharpening positions relative to dominant pressures of capitalism and market ideology, the ideology of unlimited growth, and the modernist/industrialist agenda. Renewable energy systems offer a possibility but not a certainty for more democratic energy futures.

1. Introduction

Our present era of fossil-fueled economies, societies and civilizations [1–3] has given rise to an anomalous and dangerous moment for contemporary humanity and our shared biosphere [4]. The accelerating trends of planetary warming evidenced through storms and ice melts, droughts and hunger, unrest and migration, increasingly compel a heightened sense of urgency regarding the need to rapidly end the age of fossil fuels. A growing consensus now views the transition to renewable energy systems, frequently understood as a process of fuel substitution, as a key strategy to address the climate crisis.

Despite a growing sense of urgency, the deployment of renewable energy technologies has been frustrated, it would seem, by democratic procedures. In many cases, local conflicts around renewables energy installations, especially wind power but also solar facilities, have delayed or even halted the uptake of renewables [5], mirroring the many worldwide historical conflicts around the development of technologies such as hydroelectric [6] and nuclear power [7,8]. It would thus appear an unlikely and even poorly considered time to call for greater democratic engagement with the renewable energy transition.

Within the past decade, however, renewable energy advocates and social and environmental justice activists have been organizing around a call for *energy democracy*. Energy democracy can be understood as a contemporary expression of decentralized grassroots movements of the 1970s, the 1980s and before. These earlier movements frequently sought to connect antinuclear activism and concerns about the geopolitical instability of fossil fuels with calls for local direct action and visions of “technological democracy” [9–11]. The origins of the present discourse around energy democracy can be traced to various activist communities within Europe and the United States who have been developing an explicit energy democracy agenda for nearly ten years. The term and notion of ‘energy democracy’ has since been taken up among climate justice activists, some trade unions and academics, and political parties, and put into practice through project-level, municipal, regional and national experiments¹ [12].

Compared to fossil fuels, renewable energy offers many perceived advantages in addition to fuel switching, including the relative availability of distributed renewable resources, the access to and modularity of their enabling technologies, and the potential for new forms of ownership [13] (in this issue). These advantages have inspired a

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¹ The authors note a limited set of empirical research and case studies on specific examples or initiatives of energy democracy particularly within the academic literature. From academic and non-academic sources, see for example [10,17,30,31,35,41,42,99].

movement committed to advancing social and environmental justice through a transition toward renewable energy technologies. These efforts are seen as an extension of various, widespread social movements working to address climate and economic crisis by not only resisting fossil fuel use and a market-driven green economy agenda but also by advocating for decentralized, democratized, and community-based renewable energy futures. This approach calls for reclaiming the energy sector and shifting political power to workers, households, communities, and the public, in opposition to a centralized, corporate, utility-scale renewable energy model [12,13 (in this issue),14,15–18]. Some leading organizations explicitly promoting energy democracy include the Local Clean Energy Alliance, Trade Unions for Energy Democracy, the Institute for Local Self Reliance, the Center for Social Inclusion, Transnational Institute, and the Rosa Luxemburg Foundation [12,17,19]. Energy democracy also connects with related terms such as energy justice, energy sovereignty, energy citizenship, and energy decolonization that similarly integrate political claims within agendas for energy transitions [12,13 (in this issue),14,20,21].

Energy democracy as yet defies specific definition [22]; while a multitude of priorities are embraced within the movement, several commonalities hold the energy democracy agenda together. Energy democracy is a part of the process of ongoing struggles for economic and political democratization as expressed through the practical project of energy transitions [17,22,23]. Seeing opportunity in renewable energy technologies, especially solar and wind technologies, energy democracy targets energy systems as key sites of political-economic contests, shifting power over diverse aspects of these sectors, including generation, distribution, finance, technology and knowledge [22], and pursuing a goal of high levels of deployment of renewable energy [19]. In particular, energy democracy seeks to empower low-income communities and communities of color [18,19,24,25], embracing the idea that those most marginalized are well-positioned to envision and lead toward different energy futures [19].

The energy democracy agenda seeks to advance democratization and participation through democratically-planned and public- and community-owned and -operated renewable energy systems that serve the public interest and deliver tangible community benefits, such as decent and stable employment, public space and transportation, and new public institutions. Energy democracy eschews not only centralized commodity-based energy models based on fossil fuels and nuclear energy but also historical inequalities, neoliberal ideologies, alliances with large corporate profit interests, privatization, market-driven and growth-based approaches and concentrations of economic and political power [14,15,18,22,26–31]. Energy democracy also means ensuring fair access to energy, taking responsibility for the quality of ecological systems, and changing attitudes about energy consumption toward conservation and sufficiency [10,15,18,29,30]. Ultimately, energy democracy redefines individual consumers as citizens, energy commodities and provisions as public goods, and infrastructure as public works or common resources [16,23,32,33].

Advocates are not blind to the significant barriers confronting this agenda. Community ownership may be constrained by persistent structural exclusions such as unfavorable systems of tax incentives [28,34] and lack of investment in marginalized communities [35]; historical rules and governing institutions favoring centralized electricity infrastructures and utilities [33,36]; inadequate and deeply undemocratic systems of financing involving fund managers concentrated in the global north who make key decisions about energy futures for the benefit of impatient investors with expectations of high rates of return [37]; and resistance from the incumbent interests, including the fossil fuel industry [38], nuclear and large-scale hydroelectric [37], and globally mobile capital [12].

Nevertheless, energy democracy advocates point to a variety of approaches² that can help to overcome these obstacles and advance an

energy democracy agenda. Most broadly, energy democracy would ensure public and community control and ownership of the energy sector, while policies and programs would seek to build capacity for communities to inclusively and effectively exercise this control for purposes identified by and accountable to the communities themselves [18,26]. Re-establishing this control is viewed as an essential first step [31]. Democratic ownership and control can take many forms, and creating diverse and flexible ownership structures of generation resources is central to the energy democracy agenda [18,26,27]. The need for large-scale coordination, re-distribution and investment requires that governments occupy a key role for facilitating, planning and owning energy systems, although the public sector itself requires a re-democratization following widespread corporate capture [12,14,17,22,39]. The state, municipalities, trade unions, and co-operatives are all recognized as critical arenas of contestation for energy democracy, offering no assurances of greater democracy but widely seen as promising approaches, particularly at the local and municipal level [12,23,31,39–43].

Finally, energy democracy advocates recognize that energy systems are inseparable from larger social and ecological patterns and relationships, and therefore energy democracy requires careful, inclusive and strategic construction of alliances [31,37]. Despite a sense of urgency around renewable energy transition, building collective political power and organization is viewed as a necessity, requiring short-, medium- and long-term goals and strategies [18]. Building alliances could begin by learning from other movements working toward a deeper transformation through energy transitions [22,37]; increasing collaboration among potential allies, for example, ecological and social movements, labor unions and energy sector workers, public managers and administrators, low-income communities and communities of color, and small businesses and research institutions [12,18,23,31,37,40,44]; and strengthening local institutions [23].

Energy democracy may provide a shared discourse and unifying vision for building alliances and institutions, and synthesizing values and struggles within a common agenda for reclaiming and restructuring energy systems as well as broader economic and political systems [15,22]. This call for energy democracy is strategic: democracy implies a broadly appealing agenda for greater inclusivity, equity, and influence among communities involved with renewable energy transitions. The call is also pragmatic: a massive shift of technologies within the modern energy sector presents innumerable challenges as well as potential benefits. Greater democratic engagement would offer communities a means to steer energy transitions and shape the development of renewable energy futures.

Energy democracy and energy transitions are also fundamentally political [45,46]. Given the seemingly pervasive grip that fossil fuel industries and their financial and political allies command over contemporary political life, energy democracy activists seek to make visible within the public sphere the hidden infrastructures, privatized decisions and distant consequences of modern energy systems. The instinct to politicize renewable energy transition reflects an implicit understanding that the transition from fossil-fuel dominant systems to those based on renewables offers an unprecedented yet potentially unrepeatable opportunity. As with new forms of media communications, new energy technologies present an opportunity to more deeply engage with questions of technological determinism [47]. Through selection and construction of these large-scale infrastructural technologies, the world will again be re-ordered: decisions and investments will be made, groups of actors will be politically re-positioned, and material structures as well as social and ecological patterns will be established that may endure for generations [48]. The form of politics used to steer renewable energy transitions will greatly influence the possibility for more democratic futures [49].

In other words, if governed largely to preserve existing power relations, the renewable energy political economy may replicate existing dynamics of power, continuing to strengthen the powerful and weaken

² Various policy instruments have been proposed in support of an energy democracy agenda. See for example [17,18,27,28,31,35,39,42,44,54].

the marginalized [40]. Energy democracy sees renewable energy transitions as unavoidably political processes as well as key opportunities for advancing renewable energy and democracy together. This framing rejects the view of energy transition as simple technological substitution; rather renewable energy transitions cannot avoid the re-ordering of social and political relations. Energy democracy urges us to consider how, by whom and for whom renewable energy transitions proceed. In this way, energy democracy stands in sharp opposition to the strategy of “renewable energy by any means necessary” ([16], p. 2), and instead embraces energy as politics by other means [3].

This paper is motivated in part by the recognition of the significant challenges of this approach to renewable energy transitions, as an effort to sharpen the view of the task at hand. Energy democracy proposes a deep structural shift in energy systems as well as socioeconomic and political systems, and therefore requires critical reflection and open dialogue. As noted, advocates of energy democracy recognize these barriers and further realize that new strategies still must be developed. Nevertheless, energy democracy advocates argue that because the renewable energy transition is fundamentally a political struggle, efforts to shift from fossil fuels and decarbonize societies will not prove effective without confronting and destabilizing dominant systems of energy power.

With energy democracy as a point of entry, this review has three primary objectives:

- 1) to theorize and explore the relationships between renewable energy and (democratic) political power.
- 2) to critically assess tensions associated with an agenda to democratize renewable energy systems.
- 3) to draw out the implications for democratizing renewable energy development in practice.

The following section of the paper describes the methods used for this review, drawing from an energy-political lens. Addressing the first objective, Section 3 synthesizes various perspectives drawn from the literature on the relationships between energy technologies and democratic politics. In recognition that theoretical development of the politics of renewable energy systems remains limited [50], this synthesis of perspectives then enables the proposal of a theory of democratic energy politics for the renewable era. Section 4 then addresses the second objective by identifying and assessing potential limitations within energy democracy, acknowledging the challenges of an energy democracy agenda. This section critically engages with the theory of renewable democratic politics to strengthen the energy democracy agenda and suggest new approaches for supporting more democratic renewable energy futures.

Section 5 addresses the third objective related to practice. Here it is proposed that the democratic possibilities of renewable energy transitions and the possibilities for deeper sociotechnical transformation through these transitions, as sought by energy democracy, require that renewable energy technologies be deployed through strongly democratic models of energy development. Renewable energy systems offer a possibility but not a certainty for more democratic energy futures. Both concentrated energy politics and weak energy democracy may delay renewable energy transitions or facilitate a shift to more concentrated energy development strategies. Such strategies work to re-organize distributed energy flows into aggregated and concentrated stocks of energy, investment instruments, technological research, ownership patterns, etc. This section further calls into question the underlying political dynamics that frame renewable energy transition, suggesting that democratic governance may be entirely appropriate and potentially necessary despite the context of climate emergency. Renewable systems and democratic politics can be mutually supporting, and therefore it is proposed that renewable energy transitions be approached as means for democratic development. Finally, Section 6 concludes by asserting that despite limitations the move toward

renewable energy can be strengthened not weakened by an energy democracy agenda. By allowing an opportunity to carefully consider the assumptions driving renewable energy transition, energy democracy may allow a renewal of energy systems as well as democratic politics.

2. Methods

This review proceeded in two broad stages. We began by conducting a conceptual review of the term energy democracy drawing from non-academic and academic literature explicitly employing the term. Several peer-reviewed articles were included, representing a growing body of scholarly work that engages directly with activist and community-based renewable energy initiatives (e.g., [51]). Beginning in October 2015, online searches were conducted through various search engines publicly available in Canada and the United States, using search terms “energy democracy” and “energy and democracy” which yielded roughly two dozen reports, articles, websites and videos. Over the next 12 months, additional sources were added through searches of activist group websites, commonly cited references, notifications from relevant list serves, and participation in webinars.

Through this engagement with the perspectives of the energy democracy movement, and inspired by Mitchell’s provocative questions regarding the political possibilities for the end of the oil age [49], it became clear that the review deserved to be broadened to consider theoretical foundations of the relationships between renewable energy and political power. For this second stage, extending June through October 2016, the search terms were expanded to include “energy political power”, “renewable energy democracy”, “renewable energy political power” and related terms, avoiding only nominally similar terms (e.g. “democratic party”, “democratic republic”). Searches were performed through academic libraries, Web of Science, Scopus, and popular search engines to select English-language peer-reviewed academic literature and published books related to these objectives.

The review of sources proceeded in four iterative steps. First, the set of sources were coded to identify definitions, findings and conclusions, and calls for research. Additional sources were added based on references cited within the initial collection, especially historically significant works (e.g., [52]), resulting in approximately 100 sources reviewed in total. Processing then involved repeated topical sorting of coded materials, identifying patterns and relationships, writing analytic memos and noting reflections [53]. Topics that emerged iteratively for the conceptual review on energy democracy broadly included origins and advocates, definitions, purpose, barriers, principles and policies. Topics for the theoretical development broadly included energy and democracy, renewable energy and political power, and tensions, gaps and ambiguities. The breadth of work reviewed and topical categories that emerged then inspired the decision to approach the coded material through two distinct lines of inquiry to more deeply engage with the emergent themes, namely, the emerging concept of energy democracy and its uptake, and the relationships between renewable energy systems and political power. The review of the concept of energy democracy and of the energy democracy movement is summarized here in Section 1 and considered more fully in Burke and Stephens [54].

Identified through the process of review of existing literature, the concepts of *energopower* and *energopolitics* [55–57] were together employed as an analytical lens to guide and focus the examination of the relationships between political power and energetic power. *Energopower* and *energopolitics* extend to energy Foucault’s notions of biopower, meaning governance over life and populations, and biopolitics, meaning the processes through which life and populations have become objects of (state) political strategy [57,58]. *Energopower* is understood as the dynamics of power over modern life organized and enabled through energy, and conversely, the forms of energy organized and enabled through dynamics of power. *Energopolitics* are further understood as the operations of power in effort to leverage the

transformational capacity of modern energy sources [55–57]. These concepts support an understanding of political and energetic change and stability as dimensions of broader cultural dynamics, which holds open the possibility of further inquiry from diverse points of entry. As such, the concepts are adapted here for a broader audience as *energy-politics*. In addition to its relevance to the energy democracy movement, this analytical lens of energy-politics was selected to help emphasize the relational dimensions between systems of energy and political power [59] rather than strictly on the energy technologies themselves, while taking seriously the unique role that fossil-based energy systems play in the governance of modern life and the shaping of modern cultures [3].

The third step involved organizing the sorted materials within a conceptual outline used to guide the initial drafting of the review sections. Finally, once drafted, analytical memos and reflections noted through the course of this process were revisited, further sorted and used to synthesize and critically assess the reviews, confirm or modify topics and organization, and draw out key implications and gaps to support theoretical development.

3. Theory and potential for renewable energy politics

This section first synthesizes various perspectives from the literature on the relationships between energy sources and technologies and democratic politics to propose a theory of energy-politics (3.1), and then explores the political possibilities for renewable energy futures (3.2).

3.1. Relating energy and democracy through energy-politics

The claims of the energy democracy movement urge close consideration of the relationships between modern energy and political power.³ Understanding these relationships first requires some clarification regarding what is meant by power, politics and democracy in this context as all carry varied meanings. The idea of power involves both physical power as a measure of the rate of doing work or making transformations, commonly expressed in units of energy, as well as political and economic power commonly considered as a form of social control, authority or influence [100]. Emphasizing its relational quality, power involves the relative ability of an actor or group of actors to change the behavior of others [101]. Some groups hold greater capacity for shaping social action as compared to others [62], as in “power over” others [63]. This understanding of power reflects that of Max Weber who viewed power in terms of the possibility for an actor to assert their will in the face of resistance, through whatever means available [64]. Sources or measures of power as understood in social sciences take many forms including monetary wealth, access to natural biophysical materials, muscle exertion, civil authority, social connections, reputation, belief systems and artifacts such as weapons and technology [63,65]. Politics can refer to the processes of distributing resources and the power that explains their distribution [101]. Politics can also involve processes of using and controlling energy resources for purposes not necessarily related to energy. Energy becomes the mechanism through which other agendas are achieved [66]. Energy sources and their technologies are both a source and a result of power dynamics among opposing actors [67,68].

The meaning of democracy for sociotechnical systems is far from obvious [69]. For scholars, democracy typically can be understood as a participatory model of politics where governance is accountable to citizens, the most distinctive element of democracies [70]. Greater levels of citizen participation, such as direct citizen control [71], offer stronger models of democracy [72]. For purposes here, democracy is understood as not simply present or absent, but rather as existing on a

continuum of more or less democratic forms [32,73,74], a view that allows for a sophisticated set of standards for critically examining democratic systems rather than relying on any specific necessary condition [75]. Like governance, sociotechnical systems can be understood as strongly or weakly democratic depending on, for example, the values attached to the technologies or the forms of political organization and citizen control that these technologies enable. Such democratic elements do not arise on their own, rather they are designed into the sociotechnical system, intentionally or not [76]. For activists, democracy refers not only to a mode of governance, but also to a rhetorical claim for social and environmental justice [49]. It is the dual meaning of democracy, as both a form of sociotechnical governance and a visionary political claim, that informs the concept of energy democracy and its constituting element of energy citizenship.

Winner [48] offered a theory of technological politics, asserting that “within a particular complex of technology...some aspects may be flexible in their possibilities for society, while other aspects may be (for better or for worse) completely intractable” (p. 135). This theory rejects the view that technology is infinitely flexible, drawing attention to the way human ends are made to adapt to technical means and how choices of technologies may require or strongly enable certain political relationships [48]. Different technologies form relationships with different groups of social actors [68]. Modern large-scale energy technologies are understood not as determinant of human societal relationships and political systems, but as co-evolving with them, as integrated sociotechnical systems [33]. A theory of technological politics would require an examination of the degree to which certain technologies may embody or strongly enable democratic values and the flexibility of their constituting elements. Those who wish to see democratic institutions persist must give attention to the choice of energy systems [69], and inversely those who favor certain energy technologies must consider whether they can support or even survive democratic governance [77].

The diverse and at times contradictory findings of academic research suggest a highly complex and uncertain relationship between energy and democracy in general. Smil [78] finds little relationship between political freedoms and energy use. Calling to question a simplistic view that principles of freedom and democracy progressed in large measure due to increased energy supply, Smil notes that such principles originated and were more recently advanced within relatively low energy societies while numerous examples exist of high energy oil states suppressing their populations [78]. Although choices of energy systems do powerfully influence social outcomes, an effect described as a *soft determinism* [47,79], very different social systems can arise from the similar material bases and the path of social change following technological change is difficult to predict [45]. Likewise, despite sharing similar technical components, the specific configuration of electric power systems made in different societies have shown considerable variation, reflecting differences in local traditions, societal aspirations, political arrangements and principles underlying economic practices [79].

Various observers of technology and society have long recognized this co-evolutionary dynamic, often with a concern for the potentially deleterious influences of modern technologies upon people and society. Mumford [69] famously argued that modern Western society faces a choice between democratic and authoritarian technics. Similarly, the recognition of promising social and political change, particularly through renewable energy technologies, has been linked to Lovins’ argument for the adoption of “soft” energy technologies and the soft energy path [80]. Lovins saw in diverse, accessible and appropriate applications of renewable energy technologies the opportunity for new sociopolitical arrangements, while recognizing that the hard path, that of not only nonrenewable energy sources but also highly complex and large-scale sociotechnical arrangements, remains dominant. Technologies are viewed as representative of the values of the society for which they are invented, and these values can be transported and expanded

³ For an accessible yet critical compilation of historical essays and perspectives on social, political and cultural dimensions of modern energy systems see Nader [60]. For an international perspective on the political economy of energy systems see Van de Graaf et al. [61].

across time and space [69,81].

Hall and Klitgaard [100] articulate a relevant theory of energy technological politics: “When the physical power to run an economy was solar, the economic and political power tended to be more widely distributed. The increased use of fossil fuels, which are concentrated energy, tends to concentrate both economic and political power” (p. 145). This basic theory underlies the energy democracy movement’s approach to renewable energy activism. Energy technologies based on concentrated energy sources, such as fossilized stocks of sunshine stored as hydrocarbons, ultimately and over time organize and enable more concentrated forms of power and centralized or authoritarian political relationships, and vice versa. This relationship refers to a *concentrated energy-politics*, characterized as weakly democratic. Decentralized energy technologies, such as those drawing directly from renewable and primary sources produced from continuous flows of solar energy on Earth, offer greater inherent flexibility and can more readily organize and enable distributed political and economic power, and vice versa. This relationship is described as *distributed energy-politics*, and conversely characterized as strongly democratic. These theoretical relationships allow for the examination of specific forms of energy and energy technologies.

Before turning to renewables, the relationships involved with non-renewables are briefly reviewed. That technological artifacts embody political qualities has always been a controversial claim, yet the claim continues to be made by both critics and boosters alike [48,82]. For nuclear energy, the fuel for conventional nuclear fission requires finite stores of uranium. Exploiting these fuels requires accumulated investments and centrally-operated technologies. Henderson [83] argued that energy technologies such as nuclear power, are “*inherently* totalitarian” (emphasis in original) and “incompatible with democratic forms of government” due to their complexity, tendency for centralized authority, high levels of social and capital investment, risk and vulnerability, and the way these technologies systematically disenfranchise the public from decisions as evidenced by widespread public opposition (see also [84]). Weinberg [77] conversely saw nuclear power as the highest achievement of democratic societies, asserting that nuclear energy and the atomic bomb would help transition authoritarian systems into democracies and bring in a lasting period of peace. Indeed, in the United States, nuclear electricity had been promoted historically and politically as a necessary means for protecting democracy against communism [85].

According to Weinberg [77], there exists no irreconcilable tension between these concentrated energy technologies and democracy. However, Weinberg also suggested that a basic tradeoff may exist between democratic pluralism and technological efficiency, by which he meant centralization and the perceived economies of scale as associated with nuclear energy technologies. Deepened forms of democracy could restrain the adoption of centralized technologies.

Empirically, the relationship of nuclear energy and democracy appears consistent with the proposition of concentrated energy-politics. Although nuclear energy has endured under democratic regimes, this technology has co-evolved based upon narrow (and political) calculations of costs and benefits and highly centralized administration. Observations of nuclear programs across numerous countries suggest that overly optimistic visions of the future benefits of the technology by planners and promoters has served to override public concerns about present costs [85]. Additionally, because of the risks of both immediate and long-term catastrophes associated respectively with nuclear reactors and radioactive waste, strict and precise protocol must govern nuclear energy presently and far into the future. Despite half a century of tremendous, deliberate political and economic backing, nuclear energy has so far failed to live up to its promise as the energy source of peaceful modernity [62]. Both grassroots, democratic resistance as well as unsustainable financial requirements, meaning an inability to sustain accumulation, suggest tensions between nuclear energy and democratic politics.

For fossil fuels, Ross [86] finds a tendency for reliance on oil (and non-fuel mineral) wealth to have antidemocratic effects, particularly in poor countries. The link between oil and authoritarianism may be due to a combination of social and political factors that work to demobilize the public. Hall and Klitgaard [100] see a historical connection between the access to petroleum and the concentration of economic and political power as noted, evidenced for example by the consolidation of the oil industry. This energy source and its associated accumulations of wealth and power are co-evolutionary historical anomalies. Lohmann and Hildyard [37] similarly argue that the combination of fossil fuels with heat engines and commodified labor in the context of capitalist political economies has enabled processes of extraordinary accumulation. Earlier societies had discovered and used steam engines and fossil fuels, but not in a way directed entirely for processes of accumulation. In this sense, modern energy companies are financial as well as technical firms, pursuing consolidation of both energy and capital [37]. Likewise, Malm [1] proposes that fossil fuels provide the requisite infrastructure, sustained through public institutions, that allows transnational energy firms to exploit the inexpensive labor needed for the accumulation of globally mobile capital.

Mitchell [49,87] uncovers important differences between forms of fossil fuels and the ways they are co-produced with modern democracy. Unprecedented access to concentrations of non-renewable stocks of hydrocarbons in the form of coal contributed to the rise of mass democracy in the late nineteenth and early twentieth centuries, due in large part to the need for labor to extract and transport coal through relatively narrow, dispersed and interconnected channels. These conditions gave workers in mines, railyards, and docks new and unprecedented political power, exercised especially through general strikes that would slow, disrupt or shut off entirely the access of increasingly urbanized and industrialized societies to these sources of energy. In response and in effort to weaken working-class mobilization, the industry and its political allies yielded to pressure for welfare democracy and universal suffrage. Oil, on the other hand, could be moved more readily from one region to another with less need for clusters of workers. The desire to control labor as well as to protect profits from transnational competition elicited first the shift from coal to oil and then the consolidation of the oil industry within a handful of transnational companies. These shifts served to limit democratic politics through the latter half of the twentieth century [49].

Although there may be no inherent quality of fossil fuel sources that demands concentrated political power, or vice versa, it appears that some forms of fossil fuels, petroleum sources in particular, are especially compatible with concentrated political and economic power due to the ways that they are made to be concentrated and their effects to demobilize populations. There appears to be some consensus supporting the possibility that concentrated forms of energy and energy technology tend to enable and be enabled by concentrations of political power, although the relationship varies across sources and technologies.

3.2. Political possibilities for renewable energy futures

Turning next to renewables, this section considers the possibilities of energy-politics associated with renewable energy sources, meaning forms of power over modern life that enable and are enabled by renewable energy systems, to understand the potential compatibility of renewable energy sources and technologies with distributed and democratic patterns of political and economic power.⁴ Because energy democracy advocates overwhelmingly favor wind and solar electricity [36], we limit our discussion here to the consideration of grid interconnected wind-water-solar (WWS) energy, namely wind and

⁴ For an empirical study on the mechanisms through which politics influences renewable energy development across U.S. states see Yi and Feiock [50].

hydroelectric energy and concentrated solar and solar photovoltaics. In accordance with the broader focus of this special issue on energy futures, these generating technologies are widely considered as among the most promising energy systems for supporting a global renewable energy future [88]. We also acknowledge, however, the possibility or even necessity for energy futures based on heterogeneous locally appropriate combinations of renewable energy sources including tidal, wave, and geothermal energy.

Key physical properties are understood to influence the politics of WWS renewable energy sources and technologies. Compared to concentrated stores of hydrocarbons, renewables sources are generally weaker yet more widely distributed forms of energy [87]. This possibility for distributed and decentralized energy is seen among advocates as the best opportunity to reassert democratic control of energy sources and renewable energy development [17]. Distributed generation technologies range in size, from very small 1 kW generators up to between 5 and 30 MW facilities. Distributed generation typically connects to the distribution or sub-transmission sections of the electric grid, reducing distance between generation and load [36,89]. Decentralization also increases the political salience of renewables relative to their output. Whereas the processes of extraction of fossil and nuclear fuels historically have remained largely out of public view in many industrialized nations heavily reliant on these sources, distributed renewables increase the visibility and in some cases the relative visual and local environmental impact per unit of output [90]. Additionally, due to the frequently smaller size of renewable facilities, more of them are to be built, which increases the number of siting decisions to be made [90].

As with nonrenewable concentrated energy sources and technologies, the forms of energy-politics of renewables cannot be easily generalized across all renewable sources and technologies. Distributed renewable energy systems do not necessarily imply a distinct social or political order [72]. However, in the case of interconnected WWS energy for a 100 percent renewable future, a few commonalities appear relevant for their possible political implications. Solar and wind energy introduce greater variability to the grid, requiring both new approaches to grid operations as well as re-organization of physical infrastructure. By interconnecting geographically dispersed and technologically diverse WWS generators to a common transmission grid, the short-term and seasonal intermittency of sunshine and wind across the grid can be smoothed to reliably match supply and demand. Connecting solar and wind to hydropower across a broad region, for example, can support reliable grid operations and may require extra-long-distance transmission. Variability can also be reduced by “smart” demand-response management, such as adding loads including smart appliances or electric vehicle charging stations to support flexible supply. Better weather forecasting and analysis and excess energy storage, either decentralized or centralized, are also recognized necessities for scaling up interconnected renewables [91].

Turning to specific WWS technologies, the politics of large-scale hydroelectricity are notoriously contentious. Large-scale hydroelectric dams generate electricity by concentrating large flows of falling water. Like nonrenewable systems discussed previously, hydroelectric dams typically involve centralized management and consolidation of capital investments [82]. These so-called megaprojects often have been viewed as resounding technical successes even as their construction has resulted in massive displacements, alterations of entire river basins, and loss of human and nonhuman life. Hydroelectric dams at once provide flood control while also contributing to significant evaporation and generation of greenhouse gas emissions [92]. Again, like nuclear, hydroelectricity has been deliberately promoted as a supporting infrastructure for modernity, democracy and new social orders, by taming natural forces and supplying continuous, low-cost and renewable electricity even to underserved regions. In the US, for example, promotion of international development of hydroelectric dams was linked to efforts to expand business interests and oppose communism [82]. Yet empirically the relationship is more complex. Relatively poorer,

populous and less democratic countries have developed greater levels of hydroelectricity than wealthier, more democratic countries [38], while democratic regions that have developed significant hydroelectricity have done so through weakly democratic political processes that initially failed to meaningfully include marginalized groups [93].

Due to the decreasing availability of sites and potential for increasing costs and conflict of hydroelectricity, a broad group of actors are turning away from hydroelectric power in favor of renewable energy sources and technologies viewed as more accessible and democratic [94]. This move is supported by advancements in storage technologies that may allow batteries to serve the function of stable base supply [94]. The view of energy democracy advocates is that there is an opportunity to broadly share the ownership and benefits of solar and wind generation and democratize the electric grid due to the widespread availability of solar and wind sources [18], the modularity of the technologies, and the potential to rapidly install these systems [36] even in locations with relatively poor resource potential [10].

Although both solar and wind technologies support relatively small-scale, distributed deployment [36], both also face limitations for community-based ownership [27]. Wind energy technologies are often constructed at large scales and great expense, involving large financial investments made by a small number of investors [95]. These factors may contribute to reported conflicts among perceived supporters and opponents of wind energy facilities [95]. Wind is frequently deployed in relatively remote locations, which increases the distance to users and reduces the potential for community ownership or shared output. Solar has seen tremendous growth in distributed generation, but here collective ownership has been limited because most installations are built to serve single residential or commercial property owners [27]. Nevertheless, distributed photovoltaic solar technology is often viewed as the preferred technology for energy democracy [36] due to the possibilities for including communities and broadly sharing benefits. For example, although modules and invertors may not be produced locally, solar photovoltaic is seen as an opportunity to support local employment and involvement of labor by stimulating demand for local installations, locally-manufactured components, and local planning [31]. Other renewable systems are seen as potentially compatible with an energy democracy agenda depending on local resource availability, including geothermal, small hydro, combined heat and power, or biomass/biogas [18], although these have received much less attention. Solar and wind technologies therefore offer flexibility rather than certainty, meaning that these technologies do not necessitate but may facilitate more democratic societies [48].

Renewable systems open the grid to political contest in ways not seen since the grid's early development, and therefore energy democracy seeks to reclaim control of the electricity grid. As compared to existing fossil fuel-based systems, renewable energy futures require sharply increasing electrification of end uses such as transportation and heating, potentially increasing the political salience of grid technologies. Additionally, distributed generation with two-way flows calls into question the need for the historic contract granting utilities monopoly power over the grid. The microgrid is viewed as a key technological innovation that may facilitate distributed control of the electric grid. Microgrids are a collection of interconnected loads and distributed generation and storage resources within a clearly defined boundary that can be managed as a unit within the larger grid, allowing connection and disconnection under either grid-connected or island mode operations [96]. Open grid management would allow any user to also connect as a producer, or prosumer [26].

Beyond the physical technologies, community control also requires building capacity for financial investment and technical and managerial capacity. Policies are therefore required that allow people to participate collectively and not only as individuals [26], channeling existing energy expenditures and shifting public resources and institutional investments toward new investment models for community ownership [18]. Technical capacity includes manufacture, installation and

Table 1
Two strategic frameworks for advancing renewable energy futures.
(Adapted from Weinrub and Giancattarino [18]).

Topic	Centralized model of renewable energy	Decentralized model of renewable energy
Analysis of the crisis	The climate crisis is separate from the economic crisis. This implies that the climate crisis can be resolved without addressing the economic crisis, and vice versa.	The economic and climate crises are inextricably linked—an integrated crisis reflecting the collision of globalized capitalism with the Earth's ecological limits.
Solution to the Crisis	The solution to the climate crisis is to replace fossil fuel energy with renewable energy in order to transition to a de-carbonized capitalism. The solution to the economic crisis is seen as a separate matter.	Replace the globalized capitalist system and its inherent growth dynamic with sustainable economic development based on renewable energy to meet the needs of human beings, rather than the needs of capital accumulation.
Structural aim	De-carbonize the current economic system without fundamentally changing it.	Transition to a new, de-carbonized, ecologically-sound, life-sustaining economic system that can serve the needs of the world's peoples.
Programmatic approach	Reduce greenhouse gas emissions—mainly through market mechanisms and new technology, but within the current structure of corporate economic and political power.	Create an alternative, equitable, social and economic order based on democratic principles and an energy platform that seeks to replace the corporate energy establishment with alternative institutions.
Socio-economic change agents	Those who have benefitted most from the current globalized capitalist system: corporations and supporting states.	Those most impacted by globalized capitalism: workers, low-income communities, and communities of color.
View of energy	Energy is a commodity, the basic enabler of capital accumulation and an expanding growth economy, all of which increases the contradictions of the existing economic and political system.	Energy is a resource, a basic enabler of economic life—to be democratized and harnessed to meet human needs and transition the world to an ecologically sustainable economic future.

maintenance of electricity systems, as well as development of new systems of public management that allow democratic community control, requiring new training programs at all levels [12,16].

A critical factor for energy democracy is the development model through which these technologies are deployed. The energy democracy movement recognizes that the choice of different scales of deployment, from the largest megaprojects to the smallest community solar project, potentially lead to very different renewable energy futures [18]. The development of the transmission grid is further viewed as sufficiently flexible to support divergent renewable energy futures [36]. Echoing Lovins and others, energy democracy sees two opposing models or visions of renewable energy development pathways [18,97,98], a centralized model and a decentralized model (Table 1).

Both approaches are deemed technically possible under certain conditions [97]. Yet despite the potential desirability of pursuing multiple development pathways simultaneously [102], competition for limited resources may make these options mutually exclusive [36,80,98]. Energy megaprojects involve the construction of large capital intensive and transnational technological systems, often requiring billions of dollars of investment and spanning over large geographical areas and multiple political jurisdictions. As with any sociotechnical system, they include not only physical elements but also financing agreements, regulatory systems, skills, knowledge, maintenance and so on [92], which shape and enable social and political relationships. The flexibility of solar and wind may therefore involve either concentrated or distributed energy-politics.

The centralized renewable energy model uses extended high-voltage transmission networks, super-grids, to connect renewable megaprojects [97] including remotely-sited large solar photovoltaic arrays and wind projects to populous load centers [36]. A variety of factors appear to be driving the growth in both size and number of energy megaprojects, including perceived economies of scale (i.e. lower per unit costs associated with larger size facilities), localized accumulation of expertise, increasing regulation that disproportionately affects smaller projects, competition with national energy companies, as well as a belief that such projects represent modernity and high cultural achievement [92]. Hydroelectric dams and wind power projects have been increasing in size, while large-scale solar projects have been proposed for many of the Earth's solar resource-rich deserts and equatorial regions [92].

Energy democracy advocates view this centralized renewable energy model as a product of concentrated financial and economic power as well as institutional inertia following a century of centralization, and rarely resulting from democratic community-level action [18,36]. The centralized renewables strategy seeks to decarbonize the existing economy rather than transform it [18]. With few exceptions, these

centralized projects serve the interests of the politically and economically powerful, empowering corporations rather than communities while overriding democratic restraints [18]. Ratepayers pay for these large-scale projects and associated transmission for many years and land is often acquired through use of eminent domain [36]. Energy democracy advocates argue that the so-called “NIMBY” (i.e., not-in-my-backyard) response to large-scale renewable projects is more constructively viewed as an appropriate response by citizens who recognize democratic potential in solar and wind energy yet find these technologies developed under a centralized model. In many cases this model appears to deliver lucrative profits to absentee owners who already possess significant economic and political power [36]. Failing to share benefits of new energy infrastructure may inspire ongoing resistance and slow or prevent the deployment of renewable energy systems [36]. Even remotely-sited large-scale projects meet public resistance [36] by a globally mobilized citizenry.

By contrast, a decentralized model of renewable energy development is seen to enable development of renewables at the community level, allowing for new economic and ecological relationships [18]. This approach largely depends on distributed generation technologies, meaning smaller more geographically dispersed power generation units situated closer to end users [98] and connected through microgrids [103]. For decades observers have declared a variety of benefits of the decentralized renewable energy model beyond electricity output [36]. Small- and medium-scale renewable systems, deployed at the scale of urban neighborhoods or rural villages, are expected to reduce overhead including capital and administrative costs, reduce energy costs, reduce transmission and distribution losses, increase grid reliability [80], and reduce incidence of blackouts [36]. Smaller operations reduce the distance between generation and point of use, and allow users to generate and sell energy [24]. Community-scale projects require smaller land areas, minimizing the need for costly transmission and distribution lines and use of eminent domain [36,44]. Optimal economies of scale are realized at relatively modest sizes for wind and solar facilities, making mid-size projects more cost effective than larger projects [36]. Distributed generation is also expected to significantly reduce financial risk and allow deployment of renewables at a faster pace [104].

According to energy democracy advocates, decentralized energy supports decentralization of authority, favoring community control and ownership of renewable energy resources rather than extending the legacy of corporate ownership [104,18]. Decentralized authority means greater self-reliance, local approval and planning, as well as greater local accountability and responsibility for social and environmental impacts of electricity use [11,24,104,105]. Community-based renewable energy models could increase public participation, particularly in

rural areas [106]. Community-scale projects could support local economic circulation (i.e. the multiplier effect [107]) and local income via sales and returns on investments and create more local jobs than large-scale projects, while creating opportunities for residents to be owners and decision makers [44,105].

By retaining economic benefits locally and sharing benefits more broadly, the distributed renewable energy model is expected to build a stronger political constituency that will support the expansion of renewable energy and oppose fossil fuel systems [36]. Local energy solutions are seen to offer the potential to build relationships among neighbors and capacity for self-reliance among communities, allowing people and communities greater autonomy from currently dominant institutions [11]. Energy democracy advocates point to these effects to make the case that decentralized renewable energy technologies are more strongly compatible with democracy and more likely to co-evolve with distributed political and economic power. Through these processes, the grip of concentrated energy-politics is loosened, and new relations of distributed energy-politics take hold.

4. Tensions in an energy democracy agenda

This section examines the tensions and gaps for energy democracy, broadly related to three themes: limits of democracy (4.1), qualities of energy technologies (4.2), and the breadth of competing agendas for which future renewable energy systems may be made to serve (4.3).

4.1. Limits of democracy

Concerning democracy, energy democracy ultimately involves not only a political claim but also a mode of governance. However, there are recognized limits of democratic governance that deserve greater attention among advocates and practitioners. These limits generally relate to democratic procedures and democratic outcomes.

Procedurally, greater democratization of energy systems may be limited in several ways. Deepened forms of energy democracy require the emergence of an engaged energy citizenry, yet there is evidence that for a variety of reasons citizens may not have sufficient willingness or motivation to increase their long-term participation with technically complex systems and decision making, even given financial incentives [49,72,106,108,109]. Many participants, including those in government and business, may not view decentralization, participation or community-ownership as highly relevant, necessary or pragmatic [45,105,106,109,110], thus limiting the prospect for a new form of energy citizenship.

Similarly, modern forms of democracy, even under higher levels of participation, do not necessarily lead to the models of strong democracy envisioned by the energy democracy movement, such as community ownership [9,70,72,111]. Energy democracy clearly involves collective action, yet distributed renewables systems at the residential and commercial level may not provide sufficient opportunities to organize collective self-governance [70,112]. Democracy also involves a potentially agonistic pluralism requiring engagement across diverse and even irreconcilable perspectives while increasing the number of actors and decision points, which can limit the prospect for radical change [113–115].

Advocates of energy democracy have engaged minimally with questions of effective outcomes of democratized energy systems. While there may be good reason to distribute concentrated political power, decentralized energy-politics must also deliver desirable outcomes. Maintaining accountability and responsibility for effectiveness is needed to sustain political support [116–118]. Local energy may be conducive to more conservative politics [10] that reinforce existing local power dynamics [119], or democratically prioritize short-term economic benefit over other social and environmental concerns. It remains unclear how these possibilities relate to the energy democracy agenda.

Energy democracy also needs to consciously and effectively extend democratic practice to broader levels to overturn the energy status quo [11,33,97,108,120]. Typically, energy democracy in practice has focused on the local level, although it may be that entirely decentralized renewable energy systems are technically feasible only under a limited set of conditions, for example, in communities with low demand and little industry [97]. Within the energy democracy movement, there is an emerging interest in finding ways to democratize energy systems on a broader scale while retaining the core commitment to the vision of distributed energy-politics [12]. Two potentially complementary proposals, drawing primarily from academic communities, for scaling up decentralized renewable energy systems include a regional model and a polycentric model. Regional models typically require the development of new institutions operating across a geographic area larger than a municipality or state/province and smaller than a large nation state. Energy regions may be organized around a set of existing projects such as local cooperatives, geographic renewable resource zones, or by connecting transmission systems [95,97,121,122].

Polycentric or networked renewable energy governance functions by connecting and blending existing stakeholders at multiple scales and across social sectors, reshuffling their authority away from more hierarchical modes of governance toward a model of power sharing [116,123]. Nested institutions are organized functionally rather than geographically, while regulatory units may retain some autonomy over geographical areas [33,123]. Multiple authorities may overlap political jurisdictions, resulting in redundancy where different actors or levels can ensure that services are provided [123]. Despite various potential advantages, decentralized, networked or polycentric models of governance and local control have not always performed well [15,33,116,122], may suffer from issues of fragmentation, institutional illegitimacy and lack of authority [124] and may not ensure social justice [11].

Two additional issues of outcomes appear especially relevant to the energy democracy movement: the pace of transition from fossil fuels to renewable energy, and the potential for conflicts with ecologically beneficial outcomes. Pragmatists argue that responding to climate change requires that large-scale wind and solar and long-distance transmission be built as quickly as possible [125]. Therefore, opening up to alternative interests is considered much too impractical [62]. Energy democracy may look to the possibility for hybrid energy systems of both large- and small-scale, maintained under democratic control, as a way of addressing this tension [31].

Additionally, scholarship on green democracy recognizes a tension between democratic procedures and substantive ecological outcomes [82,126,127]. Like energy democracy, green democracy rejects authoritarianism and instead seeks to address environmental problems through democratization [127], yet others argue that in advanced modern consumer societies, more democracy leads to less ecological sustainability [128]. In practice, local actors have been found to underrate global environmental issues [129]. Resolving this ends-means dilemma would require additional policies and reforms that can safeguard ecological outcomes, such as environmental rights [127].

4.2. Political ambiguities of renewable energy technologies

Another set of key tensions for energy democracy relates to the specific qualities or features of renewable energy technologies that may or may not enable distributed energy-politics. While sunshine and wind are widely and freely available, the supporting technologies and infrastructures are not [98,122]. Therefore, democratizing energy systems requires social or public engagement along the entire global energy supply chain [15], including technological life cycles and system-wide energy flows. This implies that democratization of energy systems does not simply mean localizing energy, because the points of generation and end use, even if closely connected, represent only a fraction of the larger industrial system supporting renewable energy technologies.

An energy-political analysis of the strength of democratic compatibility for decentralized renewable energy technologies would thus consider the technological system as a whole, including both the temporal life cycles of each constituting technological element as well as the spatial networks of energy flows.

Taking a solar photovoltaic generating facility as an example, the life cycle of this technology involves multiple phases including resource extraction, manufacture, transport, installation, operations, maintenance, decommissioning, materials reuse and recycling, disposal, and site restoration [130]. Each of these life cycle phases involves energy and material inputs, waste outputs, human labor, and so on, and each phase requires an understanding of its compatibility with distributed energy-politics. The greatest social and environmental impacts of these technologies typically occur at points of extraction [125]. A strongly democratized solar facility would thus need to prioritize the democratization of the sites of extraction of the constituting inputs, for example, silver for solar photovoltaics or aluminum and steel for mounting structures. So-called rare earth minerals such as those used in manufacturing of photovoltaic modules (as well wind turbines, efficient lighting, electric vehicles, etc.), despite not always being rare, are nevertheless generally found in concentrated locations [131]. The number of companies that process and trade these materials are few and their extraction involves high capital investment as well as high risks and impacts to environment and workers [131]. Democratizing renewable energy may involve the use of more abundant and less concentrated inputs and suitable substitutes, while expanding resource recycling [97,131].

For the manufacturing phase, patterns of power relations used “within the factory gates” are often extended throughout society [48]. A democratized energy system would require democratization of all major industries and firms contributing technological components to energy systems [22], for example, by restructuring as democratically-managed worker-owned cooperatives. Likewise, the life cycle phases of installation, operations and maintenance, and decommissioning would require democratic governance through the duration of the project, perhaps 30–50 years. An advantage for renewables, these phases create the opportunity for a larger number of higher quality employment than in conventional energy sectors, which may increase the interests and strategic importance of labor [111]. New forms of employment emerging within the renewable energy field offers the potential to diversify the energy sector to include more women and under-represented minorities [132]. On the other hand, jobs in the renewables sector currently tend to be nonunionized while more highly distributed generation may prevent the opportunity for workers to organize [22].

Spatially, renewable energy generally “flows” from resource collection, electricity generation, transmission, distribution, storage and end use. Land is obviously needed to collect wind and solar energy, but the implications of renewable energy transitions for spatial reconfiguration of social, economic and political patterns remains underappreciated [133]. For example, the legacy of private property ownership as well as the land areas required for siting mid-scale wind and solar facilities remains highly exclusionary, particularly for low income people and people of color [24,98]. The need for more land for renewable energy systems (i.e. energy sprawl [103]) could fuel further land speculation and concentration of ownership. The energy generated by renewable energy facilities also flows and blends within larger networks that include baseload, intermediate and fast peaking facilities as well as storage [36]. Multiple types of generating facilities will therefore require scrutiny even under an energy future supplied predominantly by solar and wind.

Regarding transmission and distribution, the grid is clearly contested space for energy democracy. Some argue that large grids can be democratically controlled [97], yet the experience of other mega-projects warrants skepticism regarding governance of a future super-grid. Large-scale, complex transmission systems tend toward centralization of ownership and management [125]. Technical elites

generally operate with significant autonomy from democratic oversight save for stakeholder advisory functions [72,104]. Historically, grid access and ownership has been exclusionary and has not sufficiently ensured grid parity [24]. Transmission also suffers similar land access constraints as that of generating facilities [98]. The grid also raises questions around the political power of labor. As noted, workers have occupied a politically strategic position under coal-based energy systems, yet in a highly interconnected renewable grid network, it is not clear whether labor (or a community) could effectively constrain energy supplies for political influence [22,87].

A smart grid also presents ambiguities and does not necessarily alter the political flexibility of the grid [36]. In a distributed smart grid or “energy internet” scenario, much of the decision making and operations could remain within the scope of technical operators. Demand side management conventionally views end users as on-demand receivers of electricity, and risks extending regulatory relations to the level of individual consumers and end use devices. On the other hand, with supporting policy, the smart grid may make it possible for consumers to use, store and supply energy to the grid as prosumers [94,98]. Smart grids involve networks of information and data, raising the question of democratization of these data systems [98]. Transmission systems could be extended to access diverse users or alternatively to reach the largest markets and commercial and industrial loads [125]. Microgrids may enable local renewable generation, storage and exchange [96], yet moving to community-owned microgrids also requires restructuring grid operations and management systems, including new governing actors [98], new legal institutions [103], greater policy support [96], and an active energy citizenry working to reclaim the grid [10].

Storage has not received the same scrutiny as the grid, yet it will likely become increasingly important for an energy democracy agenda. Storage can be managed like an energy source and is thus also politically flexible. Energy storage made attractive to big investors may enable concentrated renewable electricity among a smaller number of large-scale storage facilities (e.g., “giant batteries” [134]) or alternatively facilitate distributed storage among marginalized communities [135]. Similarly, the infrastructure for recharging electric vehicles may be developed as distributed systems across homes and work places or as centralized fueling stations resembling conventional gasoline stations [98]. An energy-politics lens allows careful consideration of the political possibilities of all these technological elements constituting a renewable energy system.

Perhaps most critically, the end uses of the energy flows require a consideration of their implications for democracy. What purposes would or should a decentralized renewable energy system serve within a democratized energy system? Who benefits, and who decides? The social, political, economic and cultural context [3] that energy systems are made to serve will largely determine the degree to which distributed renewable energy systems can be made democratic. Energy democracy advocates and scholars have not yet closely engaged with the question of the democratic potential of specific end uses and technologies. However, the movement has been increasingly clear that the purpose of democratized energy systems is not to advance capital accumulation and an expanding growth economy but rather to meet human needs and create an ecologically sustainable economy [18,22]. This view sets the energy democracy movement apart from many if not most contemporary advocates of renewable energy transition pushing for a “big green” energy development approach. This perspective also positions energy democracy in opposition to the defining ideological agendas of our time.

4.3. Competing agendas

An additional set of tensions in the energy democracy agenda relates to broader contextual influences, landscape pressures or dominant agendas of societies. While clearly a variety of such competing agendas will shape and possibly limit the processes and outcomes of energy

democracy, it is worth considering more directly how these dynamics could play out. The key competing agendas identified include capitalism and market ideology, the ideology of unlimited growth, and the modernist/industrialist agenda. The energy democracy movement, as well as academic and critical scholarship, recognize that these issues deserve heightened attention [12,18]. These agendas provide the ideological fuel for the organization and concentration of power over modern life through energy systems. Essentially these issues point to tensions involved with a strategy of specifically targeting the energy sector for reform and transformation within a broader, globalized political economy [23,136].

Energy democracy seeks to build on and extend various oppositional movements resisting the corporate fossil fuel agenda by providing a broadly-inspiring political vision that can confront the capitalist growth imperative through transformation of the energy sector [10,18,31]. In this way, the energy democracy movement clearly rejects the transnational corporate project of privatization and capital accumulation and instead aligns with citizens, workers and communities. How to break and replace existing dependencies remains less clear [12]. Strong resistance and staunch opposition to a renewable future from those currently benefiting from the fossil fuel legacy system have proven to have powerful influence on societal priorities in energy [67,137]. This legacy of alliances with concentrated power appears quite apparent in the debate over the appropriate role of the state [12,138] but also over the role of markets and investments for energy democracy. Financing a potentially large-scale and rapid renewable energy transition while reducing dependence on alliances with globally mobile fossil capital poses obvious challenges [1,12,37]. The dependencies of labor in particular are viewed as a potential impediment to the energy democracy agenda [12,18].

Distributed renewable energy systems display flexibility with respect to either concentrated or distributed financial alliances. This flexibility is demonstrated by seemingly contrary ideologies within the renewable energy industry, at once viewed as an opportunity for large financial gain and aggregation of investment capital using logics of the investor class [37,139] while also celebrating the democratization of finance through small-scale loans and the expansion of small, local installers [140]. Similarly, energy democracy advocates have variously argued for this new agenda using liberal economic logic (e.g., market-based incentives, personal electric vehicles) as well as more transformational or critical social perspectives (e.g., energy as a public good; post-extractivism) [141]. Energy democracy requires a more certain position regarding this agenda to avoid uncritically advancing dominant economic logics.

To some degree, energy democracy advocates have also recognized the need to question the assumption of ever-increasing growth in energy consumption, thus considering the needs served by energy systems and how and by whom these needs are defined [16,22]. However, there remains ambiguity as to whether energy democracy includes a degrowth strategy [51] or emphasizes the potential for renewables to fuel new economic growth [28]. The assumption of need for increasing levels of energy has received sharp criticism. Illich [81] notably argued that beyond a certain threshold, increasing levels of per capita energy use create power imbalances and social inequity. Low energy use allows for a diversity of forms of social life while high energy use requires technocracy, regardless of political economic model. Smil [78] finds no measurable benefit to quality of life above average annual energy consumption rates of 110 GJ per capita, but rather high energy consumption does correlate with high environmental impact and greater global inequity. If renewable energy systems are built to support infinite economic and energetic growth and consumption, the financial costs may require many trillions of dollars, increasing the reliance on fossil fuels and concentrated economic power to make the transition [37]. Energy democracy may begin to coalesce around a notion of selective growth based on genuine human needs, within a broader commitment to degrowth and decreased total energy use [51].

Finally, energy systems and energy use are intimately tied up with visions of modernism, industrialism and human progress [3,4,82,85]. However, the energy democracy movement has yet to address these issues directly. Solar and wind renewable sources are found in highly concentrated areas such as the world's deserts [92] or polar arctic regions, which can support consolidation of the industry. Meanwhile, globally interconnected super-grids have been proposed to connect solar and wind megaprojects using long-distance, high-voltage transmission lines [142,143]. Given this possibility, democratizing renewable energy may demand a more clearly articulated stance on the modernist/industrial agenda. For example, democratic energy systems may require higher levels of mature technologies, meaning optimal for a human scale, and a rollback to over-industrialization [81]. Likewise, energy democracy may require greater emphasis on technically diverse, locally appropriate, non-electric, "low" renewable technologies [80]. Together, the competing agendas of capital accumulation, endless growth, and modernist industrialism may continue to marginalize or limit the more radical opportunities for energy democracy and constrain the possibility for distributed renewable energy systems to co-evolve with democratic politics [3].

5. Discussion: renewable energy as democratic development

Given the possibility for an unprecedented energy transition and the plurality of energy futures envisioned [144] (in this issue), energy democracy arrives at a critical time for the future of energy, inspiring many timely and politically important questions regarding renewable energy futures: How can energy systems be built to advance democratic development independently of economic development? How will public works be rebuilt and by whom? How would different groups of people in specific contexts choose to build energy systems differently? Who among developers, financiers, governments, communities, workers, etc. are best positioned to drive the deployment of renewables and why? Should systems of knowledge, finance, and electricity transmission extend out primarily toward wealth and power or toward more diverse and less powerful groups? Who will have control over the flows of energy in the renewable future and what are the political consequences of constraining these flows? If the energy democracy agenda is not embraced, will energy futures perpetuate social and ecological injustices? More fundamentally, how is it that people around the globe have committed themselves to a potentially unrepeatable project of planning and constructing an entirely new modern energy system with little serious public discussion about what purpose it should serve, how big it should be, who should own it, and how and by whom all this should be decided? Energy democracy challenges us to place the political questions of energy technologies and systems at the center of efforts and inquiry regarding renewable energy futures.

Yet democratizing energy systems also requires confronting some basic tensions. Beyond the rhetorical claims, energy democracy requires good democratic governance. There is a need for improved models of democratic governance within the energy sector. Democratic procedures need to be improved at all levels and local community capacities and capabilities [145] (in this issue) need to be supported, especially related to the technical aspects of energy systems. How can energy democracy in practice ensure meaningful participation, for example, over highly technical matters? Locally and regionally? How can a broader sense of energy citizenship be developed, forms of citizenship that involve more thorough engagements than conventional processes of voting [146] (in this issue) while overcoming citizens' reluctance to engage [13] (in this issue)? The question of democratic outcomes also deserves attention, especially related to the issues of environmental protections and the concerns over pace of transition. How does energy democracy ensure a sufficiently rapid energy transition while protecting local and global ecosystems? What new ecological practices are required for managing renewable energy systems?

The democratic potential of the entirety of renewable energy

systems over time also requires a careful appraisal. Land use and resource extraction present unique challenges for democratization given presently concentrated ownership patterns. Globalized industrial systems will require greater attention to the choice of technologies and the ways that different technologies may empower different communities of place as well as communities of interest. What role will non-electric and less industrialized technologies play in advancing democratized energy futures? What level of prominence will private electric vehicles take in relation to public transport systems? How can energy systems in their entirety, including non-renewables as well as renewables, be democratized and not simply localized? What strategies are needed to redistribute political power across all stages of globalized technological life cycles and energy supply chains? Ultimately this line of questioning leads to a re-assessment of the purpose of modern energy systems, whatever the source or technology. How can the agenda of modern energy be restructured to support democratization of finance? How can labor re-align with an energy democracy agenda? Can energy democracy support strategic growth for communities in need and degrowth for overdeveloped areas?

The energy democracy movement advances a potentially transformative vision and agenda for renewable energy futures, yet the history of unfulfilled energy imaginaries should serve as a reminder of the need for critical reflection. Voices from within the movement have already pointed to some of these tensions [22]. Further inquiry from scholars and advocates including those reviewed here may serve to support democratic energy futures. Based on this review, a research agenda for energy democracy would prioritize: inquiry on models of strongly democratic energy governance at all levels; community capacity-building targeting especially technical and financial capacities; policies to complement democratic reforms; systematic democratic assessments of life cycles and supply chains of renewable energy technologies and development of explicitly democratic, small-scale, low technologies; better understanding of strategic alliances particularly with labor and local environmentalists; and a deeper examination of the relationships between energy democracy and post-capitalist, post-growth, and post-industrial agendas. Additionally, the present work would benefit from further empirical research and inquiry through specific contexts and cases, employing participatory and normatively reflective methods where possible (e.g., [147 (in this issue), 148 (in this issue)]). Addressing these concerns and approaches may expand the opportunity for energy democracy to support the democratic development of renewable energy.

Lessons learned in this special issue may provide insight regarding how and why decentralized or distributed energy technologies tend to enable distributed political and economic power and vice versa. For example, the ease of access to ownership of the modular end-use technologies allows more participants into the decision-making space regarding the production of energy systems [149 (in this issue)]. The new roles that renewables allow of energy citizens as producers and owners inspire new patterns of thinking among individuals, which serves to increase interest in policy and decision-making [146 (in this issue)]. Similarly, the new roles inspire an increase in the quantity of available discourses and imaginaries available, which then influences policy shifts, technological changes and experimentation ([150] (in this issue)). Renewables increase competitiveness in electricity markets, which undermines traditional monopolistic and oligopolistic regimes and creates space for new constituencies and alliances [151 (in this issue)]. Renewables enable a greater diversity of local practices, increasing learning processes that extend the range of development of renewables [152 (in this issue)]. Spatial remoteness of communities has historically facilitated decentralized political and economic organization while making infrastructural development less attractive, yet remote areas may hold abundant renewable resource potential [149 (in this issue)]. The complexity and coordination involved in diverse renewable energy infrastructures requires governance structures that engage with a wide spectrum of stakeholders and interests [149 (in

this issue)]. Social movements can mobilize diverse communities around normative objectives and shared identities to implement and sustain renewable energy initiatives [153 (in this issue)]. Additional research could serve to unpack these and other specific factors and processes through which communities, political economies and renewable energy technologies co-evolve. Also, given the push for increasing renewables within the context of existing dominant regimes, further work is needed for understanding how and why more concentrated forms of technologies may enable distributed technologies and vice versa [149 (in this issue), 152 (in this issue)].

Two points, the issues of *pace* and *compatibility*, stand out as particularly relevant for understanding renewable energy transitions as democratic development opportunities. Regarding pace, energy democracy calls into question not only the democratic possibility but also the necessity for rapid renewable energy transitions. Emerging under the pressures of the oil age, contemporary renewable energy systems are likely to develop in particular ways. Although renewable energy offers tremendous social and environmental advantage over fossil fuels, renewable systems reduce the possibility for concentrated power (centralized decision making, high rates of return, control over labor, etc.). Concentrated power thus delays renewable energy transitions until mechanisms can be put in place to sustain existing power relations.

Since the oil crises of the 1970s, the historically slow progress to renewables in many parts of the world reflects the difficulty of dramatically upscaling decentralized technical systems while retaining and extending consolidated political power and accumulation. Rather than laying the groundwork for democratizing energy (e.g., building new institutions for community control), the dominant efforts for renewable energy transition prioritize development of mechanisms for the politically and economically powerful to reap their expected benefit from new energy systems, such as by aggregating distributed projects to attract larger investors. Renewable energy transitions proceed slowly so as not to disrupt capitalism (as in meeting projected demand) and according to the logic of the market (as in an economic opportunity). Research and development is now underway to overcome these challenges, investigating long-distance high-voltage transmission, large-scale storage, and mapping and acquisition of renewable resource zones. In effect, this work involves finding ways to concentrate relatively distributed energy sources. Increasing the capacities to concentrate renewable energy enables new opportunities for concentrating political and economic power.

Under these pressures, democratic energy-politics may ultimately delay or modify renewable energy transitions. Weak energy democracy, characterized by participation in siting procedures, may impede renewable energy deployment and/or elicit more remote siting and long-distance transmission under centralized operations, and thus drive a more centralized or hybrid renewable-conventional energy transition. Siting decisions are a way to extend some local control without allowing more fundamental issues to be publicly debated or ownership to be shifted. Strong energy democracy, on the other hand, may drive a more distributed energy system, redistribute and strengthen democratic political power, and ultimately result in an accelerated energy transitions guided primarily at the community level. The renewable energy transition as such can be viewed as more a *democratic opportunity* than an economic opportunity. The evolution of democracy has been stalled by the era of concentrated energy-politics enabling and enabled by petroleum. An energy democracy agenda may renew democratic politics through energy transitions, and a broad set of policies are available to empower communities and regions for this effort. From an energy democracy perspective, the challenge of transition is not so much about creating more ideal economic conditions for renewables or deploying renewables as an economic development strategy. Rather, the urgent need is to create better democratic governance to enable distributed renewables, and likewise to deploy renewables as a democratic development strategy. These dynamics add complexity to the prospect for rapid and democratic energy transitions.

Yet energy-politics also raises the question of the desirability of rapid energy transitions. The renewable energy transition is not simply a race against climate change nor primarily about substitution of fuel sources. The burning of fossil fuels must rapidly be put to an end, both to reduce the damages of the climate emergency and to reduce the power of incumbent energy interests. Climate change and climate justice require rapid decarbonization, and energy democracy justifiably places resistance to fossil fuels and decarbonization at the top of a short-term agenda [67,154], which itself raises a host of issues of how to equitably and democratically end fossil fuel production and use [155] (in this issue). However, climate mitigation requires a broad set of strategies including reducing fossil fuel investments and subsidies [156], lowering of aggregate consumption levels, and changing land use practices [157], strategies that may yield greater short-term social and environmental benefit than rapidly deploying renewables.

Moreover, whether the pace of deployment of renewable energy systems improves the Earth's climate remains less certain. Less ambiguous improvements for the climate would require that each unit of renewable energy generated displace at least the equivalent unit output of fossil fuels, whereas renewables may prove largely additive to rather than substitutive of nonrenewables [158]. From a strictly biophysical perspective, renewables are likely better deployed at a pace no faster than global and local environments can safely accommodate, as measured not only by added greenhouse gas emissions but also using various other relevant indicators of ecological limits including aggregate biodiversity loss and land use change resulting from new infrastructural development [159]. Renewable energy futures as developed under the legacy of logics of the fossil fuel era thus risk inducing critical global social and environmental problems of the future [125].

In other words, although the present climate emergency requires a rapid response to decarbonize societies, this response does not necessarily require a simultaneous and rapid expansion of renewable energy systems. The renewable energy transition when unpacked appears more as a political calculation rather than a matter of science or climate justice. Undoubtedly the energy democracy movement takes seriously the threats of climate change, yet it also challenges us to understand the political reasons for rapid transitions. Whose interests will be most served through new energy infrastructures? Will a rapid energy transition seek to extend concentrated power into new energy regimes, or conversely build new political power among communities, energy citizens, unions and so on?

Supporting the latter case, energy democracy may still pursue rapid transition, but not solely to stabilize the climate. In this case a swift transition serves to accelerate the transfer of political power and possibly save democracy from the suffocating grip of concentrated energy-politics. Energy democracy is viewed as the best if not only means for achieving a timely, just and environmentally sustainable energy transition by giving genuine political voice, decision-making power, and economic benefit and opportunity to labor unions, communities and the public [15,27,29,30,154]. This shift in political power may then enable greater resistance to the fossil fuel agenda, and thus allow more meaningful climate responses. There may then be an urgency to the energy democracy agenda, but it is a qualified urgency. A democratic response to climate emergency requires immediate resistance to fossil fuels coupled with the deployment of renewable energy systems at a pace that sustains and can be sustained by democratic governance, lest projects of democratization collapse and renewable solutions rapidly transform into the next human catastrophe.

This development model likely would favor community-owned solar and wind, microgrids, small-scale storage before “big green” energy infrastructures, at least until such larger systems can be built up through democratic process and control. Yet it also implies a broader set of democratic strategies, including reducing the need for electricity and transportation, enlisting diverse appropriate “soft path” technologies, and prioritizing climate adaptation, food and water systems and restoration. In short, energy democracy presents an opportunity to ask

what the need is for energy systems, and for whom, before ramping up new industrial-scale (renewable) energy systems. Energy democracy helps reveal how the common meaning of the renewable energy transition neatly collapses within a single agenda what are in fact two distinct energy trends involving different timelines and different political consequences.

Turning to the issue of compatibility, renewable energy systems may offer a greater compatibility with democracy, but soft determinism implies that energy democracy is not a certainty even under a renewable future. Understanding the potential relationships between specific forms of concentrated energy and political power requires a careful examination of the distinct patterns enabled by specific energy sources and infrastructures. It may be too simplistic to say that a certain energy source or technology is or is not concentrated. Rather it is necessary to explore how and where energy sources are *made* to be concentrated and to which actors they most directly relate. As with our understanding of democracy, concentrated energy sources may involve democratic elements to greater or lesser degrees. The potential for concentrated power relations may then be characterized by degree rather than simply as either centralized or decentralized, concentrated or distributed, and so on [149] (in this issue). Different forms of concentrated or distributed energy are co-produced with different political economies and even different forms of democracy. This implies a need for greater attention among advocates to characteristics and differences across specific technologies rather than a blanket advocacy for “renewable energy” as an unspecified group.

Strong energy democracy is characterized by community-based control across *all* elements of renewable energy systems, from extraction to operations to disposal, and from resource collection and generation to transmission and distribution to storage and end use [20]. Each stage of the lifecycles and energy flows of renewable energy systems could be assessed for its political attributes and its compatibility for concentration or democratization. Solar panels, geothermal wells, wind farms, long-distance cables, monitoring stations, data and software systems, walls of batteries, smart meters, EV charging stations, the internet of things; each of these technological systems involve political dynamics. Analysis through energy-politics draws attention to the ways that energy and energy-related technologies enable distribution or concentration of power, and in turn, whether the politically powerful or politically powerless are enabling these technologies. Strongly democratic renewable energy transitions require loosening alliances with concentrated economic and political power and strengthening alliances with distributed economic and political power throughout all stages of energy systems.

Understood as such, the renewable energy transition is a long-term, ongoing political event involving very different renewable energy alliances. Societies will not so much as choose one renewable energy future or another nor intentionally re-order energy sociotechnical systems. Energy futures, whether renewable, democratized or otherwise, will emerge over time out of the dynamics among groups aligned around more concentrated or more distributed political and economic power [37]. Unavoidably entangled within this struggle are modern homeowners, landowners, ridgelines, diverse ecosystems, technicians, grid operators, system planners, electricity market analysts, installers, line workers, small business owners, renewable energy advocates, etc. Under current conditions of political fragmentation, energy democracy may be a means for building a coalition of energy democracy actors at local and regional levels. Despite this key political possibility, renewable energy systems remain largely out of view of local and regional politics save for weakly democratic procedural questions. This review seeks to position the issue of political power at the center of the debate around energy futures and to raise the profile of energy democracy. The possibilities for sociotechnical transformations require that renewable energy technologies be deployed through strongly democratic models of energy development.

6. Conclusions

The energy democracy movement represents a contemporary expression of ongoing struggles for social and environmental justice through engagement with technological systems. Energy democracy redefines individual energy consumers as energy citizens, energy commodities as public goods, and energy infrastructure not as a class of assets but rather as public works or common resources. Recognizing an opportunity in the renewable energy transition, the agenda for energy democracy calls for opposing fossil fuels and other centralized energy systems agenda, reclaiming the energy sector within the public sphere, and restructuring energy systems technologies and governance for greater democracy and inclusivity. Above all, energy democracy allows for a vision of renewable energy transitions as pathways for democratic development.

The energy democracy agenda draws from an implicit theory of technological politics for the renewable era, which considers the degree to which renewable energy sources and technologies enable and are enabled by democratic politics. These relationships between energy systems and political dynamics are softly deterministic, meaning there exists over time a tendency or compatibility between energy technologies and political power. Relative to more centralized energy systems such as petroleum, decentralized or distributed energy technologies such as solar and wind power offer greater flexibility and can therefore more readily organize and enable distributed political and economic power, and vice versa, a relationship described as distributed energy-politics.

The energy democracy vision may unify diverse perspective around a shared strategy for renewable energy futures. Strong energy democracy requires public and community-based empowerment and ownership of renewable energy systems, including land, renewable generation facilities, microgrids, and small- to medium-scale storage technologies in addition to a host of supporting policies and principles for building capacity at the community and regional levels. To achieve this vision, greater attention will need to be given to strengthening democratic practice and ensuring desirable outcomes. Efforts for democratizing energy systems will further need to extend through all stages of technological life cycles and across the entire chain of energy flows, from sun and wind and on to end use. Energy democracy offers an occasion for deeper engagement with the question around the end purpose and benefits that energy systems, renewable or otherwise, should be made to serve and provide. Energy democracy does not take for granted that renewable energy systems should be built to further capital accumulation, endless growth, or industrial expansion, and thus the discourse of energy democracy allows the prospect for more critical and inclusive consideration of the need and purpose for renewable energy futures.

In this present age of oil, decentralized politics and decentralized energy systems co-evolve within the existing context of centralized energy-politics. Renewable energy transitions, distributed generation and democratic politics all currently suffer under concentrated energy-politics. This point implies that stronger forms of democratic engagement with energy transitions are required to overcome the tendency for concentrated power to either delay the deployment of renewables so that existing power dynamics can be reliably sustained, or to extend present patterns into new energy regimes through a centralized model of renewable development. In a time of climate emergency, weak forms of democracy may also delay the transition or elicit centralization, and thus persistent local resistance to renewables may reflect a missed opportunity to redistribute political and economic power.

As a democratic development model, renewable energy transitions require an accelerated reduction in the use of fossil fuels for social, ecological and political reasons, but do not necessarily entail an immediate ramping of renewable energy infrastructures. The pace of renewable energy deployment is a political calculation and requires attention to the needs and interests served under different scenarios. As social transformations, just, democratic and ecological energy

transitions demand a commitment to building community capacity for democratic energy governance while avoiding a perpetuation of the many social and ecological injustices of existing dominant energy systems. Renewable energy transitions will likely emerge through ongoing and long-term dynamics of political power involving differences in visions, alliances and political consequences. Energy democracy opens the possibility for renewed and renewable forms of democracy, created through deepened and more inclusive engagements with the development of renewable energy futures. If distributed energy-politics reasonably expresses the possibilities for renewable energy and political power in a time of climate emergency, then energy democracy provides a hopeful and well-timed response.

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