13

RENEWABLES GRABBING

Land and Resource Appropriations in the Global Energy Transition

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Introduction

A global transition from fossil fuels to renewable energies is urgently needed to mitigate climate change and to reduce the conflictive and contaminating extraction and consumption of coal, oil, and gas resources globally (IPCC, 2018). However, the onset of this transition has come along with the emergence of new geographical and technological frontiers of energy carrier production that are associated with new injustices experienced by local and customary groups (Sovacool, 2021). Vast amounts of land and other resources are required to develop renewable energy infrastructures, which has provoked new processes of land and resource acquisitions globally (Scheidel & Sorman, 2012). Well-known examples are land grabs associated with agro-industrial plantations producing crops for a growing global biofuels market (Borras et al., 2015, 2010), or land dispossessions for hydropower dams flooding vast areas and changing the river ecology on which customary livelihoods depend (McCully, 2001; Del Bene, Scheidel, & Temper, 2018). Justice concerns are also emerging over wind power plants (Avila, 2018; Franquesa, 2018) and the rapid expansion of large-scale solar power (Stock & Birkenholtz, 2019; Yenneti et al., 2016), where conflicts have sparked over the dispossession of local users from land and other environmental resources, lack of procedural justice in the decision-making processes, and questions over who will benefit from these green development projects and in which ways.

Energy systems can be characterized as an objective, a means, or a cause of conflict (Månsson, 2014). Renewable energy projects can be as conflictive as fossil fuel extraction projects, according to an analysis of 649 conflicts over diverse energy projects (Temper et al., 2020). The processes through which injustices emerge are diverse but recurrent. In a review of 20 years of related literature, Sovacool (2021) describes the persistent presence of four general processes characterizing low-carbon transitions across regions, actors, and mitigation options: enclosure (privatization of land and other resources), exclusion (marginalization of actors in the planning process), encroachment (environmental destruction), and entrenchment (increased vulnerability, disempowerment and wealth concentration). This observation poses significant questions of how to move toward more just energy transitions, while avoiding instances of what we call ‘renewables grabbing’: the grabbing of land and other environmental resources for the development of renewable energy infrastructure at the expense of local and

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customary users. Renewables grabbing can be understood as a form of green grabbing, where land and resources are appropriated for environmental ends (Fairhead et al., 2012). The concept of green grabbing draws specifically attention to the significant role 'green' factors play in shaping and restricting access to land. The concept has been useful to discuss declining access of customary users to land through climate change politics (Franco & Borras, 2019), tree plantations for forest recovery (Scheidel & Work, 2018), or the establishment of conservation areas (Benjaminsen & Bryceson, 2012). In this chapter, we specifically discuss processes of green resource grabbing linked to the expansion of renewable energy generation worldwide.

We first provide an overview of the general drivers of renewables grabbing and outline the growing demand for specific resources required in the energy transition. We then take a sectoral perspective and describe some of the emerging justice concerns associated with the main renewable energy frontiers of today: (i) large-scale biofuels, (ii) dams, (iii) wind power, and (iv) large-scale solar power projects. Following key questions in environmental justice scholarship (Schlosberg, 2004), we ask: what are the implications of the expansion of these renewables frontiers for distributional concerns, particularly regarding access to land and resources; for procedural justice in renewable energy planning; and for the recognition of different values and worldviews in shaping the forms of the renewable energy frontiers? While by no means all renewable energy projects are conflictive per se, within the scope of this chapter, we look specifically at those where conflicts over access to resources and their governance have emerged to better understand where pathways toward a more socially and environmentally just and democratic energy transition are needed, and how they may look like.

Changing Energy Frontiers

As global trends strive toward the decarbonization of energy systems, arguably better for people and the environment, this manifests in terms of a shift in socio-metabolic regimes toward a spatial extension and expansion of land required to provide energy carriers. A multitude of underlying drivers, stemming from different biophysical, socio-political, economic, cultural and technological processes, shape these changing energy frontiers (Figure 13.1). These underlying drivers are not isolated processes but are rather interrelated and embedded within the larger economic and political system (Muradian et al., 2012), led by forces of globalization (Lambin et al., 2001).

The end of abundant cheap fossil energy sources represents perhaps the most relevant biophysical condition shaping a transition from fossil fuels to land-based alternative energy sources, creating new spatial arrangements and horizontal energy regimes (Huber & McCarthy, 2017). While this shift has 'powered down' the energy output per unit of land, requiring more land to compensate for societal energy needs; it has also been pressured by the overall expansion of global societal metabolisms, that is, societies' current demands for materials and energy to sustain and grow (Muradian et al., 2012). This has resulted in the appropriation of ecological space (Hermele, 2014); a phenomenon experienced locally, nationally, and globally with crop fuels and renewable energy alternatives gaining momentum. The rising demand for alternative energy has been manifested on the ground in terms of large-scale land acquisitions for energy systems (Scheidel & Sorman, 2012), or small-scale appropriation and dispossession of land experienced in a systematic vein (Avila, 2018).

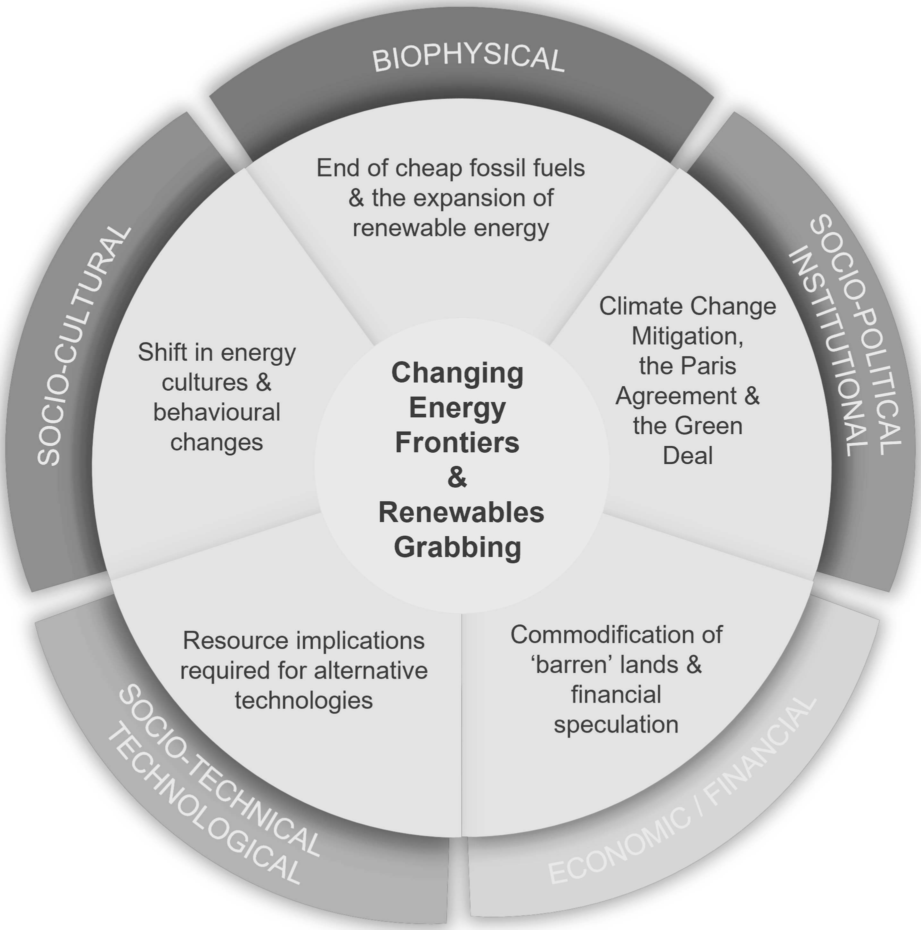

Figure 13.1 Underlying drivers of changing energy frontiers.
Source: The authors.

The biophysical changes in energy supply systems and their implications for land requirements in the energy transition have been profoundly shaped by institutional and socio-political processes. The 'extractivism of renewable energies' (Del Bene, Scheidel, & Temper, 2018) to scale up to increasing energy demands have been extensively promoted under the ecological modernization paradigm (Scoones et al., 2015) for achieving win-win solutions for all; a notional failing to grasp the complexities and socially differentiated injustices of renewable energy rollouts. Furthermore, institutional arrangements in line with the Paris Agreement, the Green New Deal, notably in the EU and in the US, and increasing ambitions amid the COVID-19 pandemic to green the global economy have been steering the politics of energy transitions. Yet, green alternatives to fossil fuels are championed without much questioning of underlying justice implications and shifting costs (Zografos & Robbins, 2020), for example, on Indigenous and marginalized populations and lands in the name of the energy transition (Temper et al., 2020).

The revaluation of land in the context of changing biophysical and institutional environments has come along with economic changes in land use, resulting in the commodification of so-called waste, barren, or unproductive lands to make them available for energy systems, as advocated by numerous actors such as pension and sovereign wealth funds, agro-businesses, energy conglomerates, finance firms, technology companies, states, and local or international speculators (Hermele, 2014; Sassen, 2013). This has led to land being grabbed in many parts of the world. New investment opportunities of commodifying 'under'-utilized land for energy carrier production, such as biofuels crops (Ariza-Montobbio et al., 2010) or solar power (Stock & Birkenholtz, 2019), have not only been fostered by states, developers, and financial institutions but have also been reinforced by asymmetrical power relations between institutions and governments embedded within unequal North-South dynamics, South-South relations, and rising agents in the East (Borras et al., 2011; Dauvergne & Neville, 2010). Financial speculation, moreover, is aggravated when acquired land is purposefully kept empty, to be sold once land prices gain higher value (Fairbairn, 2014).

Finally, socio-cultural transitions implying a shift in energy cultures (Stephenson et al., 2010), accompanied by socio-technological innovations, also have immediate and indirect consequences on global value chains, resource acquisition, and land use. As behavioral, cultural, and technological shifts materialize, resource implications required for alternative technologies shift the politics of land use globally. For instance, as electric vehicles are promoted further under climate neutrality pacts, land grabs for lithium deposits may increase, leading to mineral dependency and cost shifting. Many green technologies (e.g., wind turbines and electric vehicle batteries) that rely on rare earth elements (REEs) are currently supplied from China providing more than 99% of the supply. Solar photovoltaic technologies relying on semiconductor materials and battery factories have also resulted in waste implications due to toxic and hazardous chemicals, externalizing health implications while also outsourcing supply chains (Newell & Mulvaney, 2013). In an attempt to offset emissions, the promotion of renewable energies triggers mining expansions and a complex web of repercussions and tensions resulting from new mining frontiers that come about with such a transition (Phadke, 2018).

The new resource requirements provoked by the complex interplay of biophysical, socio-cultural, institutional, and technological changes alter not only the political ecology of land use but also of water, labor, and traditional energy sources such as biomass, closely interwoven in the global food-energy-water nexus (D'Odorico et al., 2018; Giampietro et al, 2014; Perrone & Hornberger, 2014). For example, energy pathways requiring intensive water use due to provision, extraction, generation, or cooling technologies have been shown to cause water injustices and 'water grabbing' (Dell'Angelo et al., 2018; Franco et al., 2013). Current trends in energy provision and consumption have the potential to increase the pressures on land use and users, and create new environmental injustices, while reinforcing existing vulnerabilities in terms of access to land and other nexus resources (Capellan-Perez et al., 2017). The next section details these implications for the four main renewable energy frontiers.

Resource Grabbing and Conflict at the Renewable Energy Frontiers

A diverse and growing body of research on resource grabbing and conflicts over renewable energies has emerged over the last decade. Within the limited scope of this chapter, we do not aim to provide an in-depth review of available literature for each renewable frontier. Instead, we aim to highlight some of the major concerns arising in the energy transition, based on a selection of articles that illustrate both empirical and conceptual concerns. In addition to academic articles, we also draw on the empirical wealth of information documented in the global Atlas of Environmental Justice (EJAtlas)[1], particularly for the discussion of the more recent rise of resource grabs related to solar power megaprojects.

Large-Scale Biofuels

Traditional and small-scale biomass uses such as wood for cooking and heating represent the oldest form of bioenergy use. The current trend toward large-scale biofuels, which has provoked vast land grabs, is based on an entirely different production and consumption model. Large-scale biofuels rely on industrialized land use and wage labor (Giampietro & Mayumi, 2009), are embedded in complex capitalist and globalized supply chains (Margulis et al. 2013), and produce uneven social and ecological consequences across and within regions of production and consumption (Dauvergne & Neville, 2010). Conflictive and environmentally devastative biofuels crop monocultures are expanding rapidly in (but not limited to) the Global South (e.g., Aha & Ayitey, 2017; Alonso-Fradejas, 2021), whereas their consumption as a clean replacement for dirty fossil fuels occurs increasingly (but not only) in the global North, driven by climate change mitigation policies and renewable energy mandates (e.g., Larsen et al., 2014). The global rise in demand for biofuels, and the envisioning of agriculture as the ‘oil wells of the 21st century’ (Borras et al., 2015), has significantly reshaped current processes of agrarian change, the politics of land use, and the rise of conflicts over land grabs. (Borras et al., 2011, 2010).

Land dispossession and conflicts over biofuel crop plantations are mainly associated with first-generation biofuels, that is, biofuels based on edible food crops such as sugarcane, corn, wheat, or cassava used for bioethanol production, or oil palm, soybean and rapeseed crops used for biodiesel production.[2] Land is the most central resource being acquired in this context and related land grabs have produced severe conflicts over dispossession and declining access to commons land globally (Dell’Angelo et al., 2021). In addition to land acquisitions, the appropriation of water resources located in and around the concession areas accompany this process. Because of water’s fluid nature and its key role in supporting larger ecological cycles, associated water grabbing may affect even more land users in surrounding areas (Franco et al., 2013). Second-generation biofuels are based on non-food crops and organic residues that do not compete directly with land uses primarily for food production. While they have been argued to be less conflict-prone, they may still compete indirectly with multifunctional land uses, including food crops. Ariza-Montobbio (2010) describes this for the case of *Jatropha curcas*, a perennial, non-edible crop used for biodiesel production. The rapid expansion of Jatropha in Tamil Nadu, India, promoted by the government and companies as a pro-poor crop with agronomic viability on marginal lands, has provoked that many poor farmers have put barren land in production and substituted food crops such as groundnut with *Jatropha* under contract farming schemes. However, the program failed to deliver promised yields and incomes, leaving many farmers with reduced access to firewood and fodder for their cattle, as well as shortages in food provision, that is, edible oils. Only large farmers seemed to be able to benefit from this development, while poorer ones abandoned the plantations or uprooted the crops, facing increased vulnerabilities due to important livelihood losses (ibid).

The links between the global biofuels complex and local land dispossessions are most apparent when the crops cultivated on grabbed land are explicitly used for biofuels production. However, the mechanisms through which biofuels have changed the politics and practices of land uses are frequently more complex and subtle, shaping processes of exclusion from land in various ways. On the one hand, the global rise of biofuels has impacted local land uses by triggering an overall demand for cultivable land as well as increases in food commodity prices (HLPE, 2013). This has provoked the 'rediscovery' of the agricultural sector to investors and opened up new arenas of land and commodity speculation (Fairbairn, 2014). In this context, land concessions are acquired but not necessarily directly related to biofuel production processes. Sometimes land is not even put into production, while leaving customary users without access to land (Merian-Research & CRBM, 2010). On the other hand, the flexible uses of biofuel crops in agro-industries, including their multiple uses for food, fodder, and biofuels, has enabled investors to adapt their production patterns to diverse markets. Borras et al. (2015) describe how this greater flexibility and multiple uses of 'flex crops' has altered the political economy of land uses: market competition is intensified, while power relations between investors, traders, local land users, and laborers are changing. Finally, the discursive power associated with biofuels as a 'sustainable' energy source has allowed investors to enhance their negotiation power by legitimizing their claims over land through obtaining a 'green license' to operate (see Hunsberger & Alonso-Fradejas, 2016).

Large-scale biofuels remain a highly contested renewable energy sources, not only because of the associated processes of land grabbing and changes in the politics and practices of land uses, but also because of their low energetic performance and their devastating environmental impacts such as biodiversity loss or deforestation (Giampietro & Mayumi, 2009). For moving toward just and more sustainable biomass uses, a different production, processing, and consumption model is needed. Small-scale and localized bioenergy uses outside the webs of global commodity flows and investments have much to offer to promote renewable energy use at the local level, compatible with current land uses of the small-farmer economy.

Hydropower

Hydroelectric dams have become a key component of global policies toward the increase of renewable energies (IHA, 2020). As a major recipient of Clean Development Mechanism (CDM) credits, the sector has long been considered relevant to tackle climate change (Haya & Payal, 2011). Its predominant role today is confirmed in many national energy transition plans for its flexibility and energy storage services that will complement other renewable energy sources such as solar and wind. Hydropower is therefore often touted as the transition energy per excellence (FLEXHYDRO, 2020; IHA, 2020; IRENA, 2020). In a post-COVID 19 scenario, hydropower is furthermore promoted as a promising force for recovery for its critical role in delivering clean, reliable, and affordable energy (IHA, 2020; IRENA 2021).

There are mainly four types of hydropower plants, namely run-of-river (RoR), storage, pumped storage, and offshore hydropower. Of special relevance in an energy transition scenario are the first two. RoR schemes are a series of hydropower plants interconnected through tunnels and water discharges along the same river and its tributaries. They are considered less harmful for local ecologies and are particularly promoted in narrow valleys and on smaller rivers. Pumped-storage hydroelectricity is believed to allow energy saving from other renewable energy intermittent sources for periods of higher demand, while pumping water into reservoirs during off-peak. The recent boom in hydropower investment includes refurbishing of old storage projects as well as greenfield projects. Apart from traditional funding agencies such as the World Bank, new actors are gaining prominence in the dam building market, including international investment funds, the Chinese government and state companies, and climate finance (Siciliano et al., 2019). New large-scale dam projects are in the pipeline in the Brazilian Amazon, in the Yangtze basin in China, in the Andes, in Sub-Saharan Africa, and in the Mekong and Ganges–Brahmaputra basins (Zarfl et al., 2015). Countries like Mexico, Turkey, India, and the Balkan republics have witnessed an unprecedented boom in RoR dam construction while unfinished large-scale projects are also being completed, such as the Ilisu dam on the Tigris river (Islar, 2012).

The socio-ecological impacts of dams have been largely addressed in the academic literature (Kirchher, 2016; Lerer & Scudder, 1999; Moran et al., 2018), and were extensively denounced by environmental justice organizations and local groups (see McCully, 2001). Socio-environmental conflicts arise in the impacted areas, both upstream and downstream the barrage. Upstream territories are usually affected by the submergence of vast portions of forests, Indigenous and common lands, villages, and even cities. However, downstream communities and their fisheries are also heavily affected by dying rivers, water contamination, and slope destabilization, among other impacts. Furthermore, the blasting for tunneling the water in RoR schemes undermines underground water sources leading to deforestation and soil depletion (Baker, 2014; Asher and Bandhari, 2021). Conflicts can also emerge over the associated infrastructure for hydropower, such as power transmission and distribution infrastructures developed across the territory. This is particularly true along the new ‘hydropower extraction frontiers’, that is, regions and river basins previously unexploited. Canada and the US, for example, plan a series of high-voltage transmission lines to transport hydropower electricity from Canadian dams to US cities. US-based groups have largely questioned the viability of these electricity corridors and protested against evictions and impacts, which often affect Indigenous territories[3].

According to a recent analysis of the hydropower conflicts registered in the EJAtlas, the loss of livelihoods, forced displacement, lack of compensation, flawed impact assessments, and the lack of community consultation are the most reported reasons for opposition and mobilization against hydropower projects by local actors (Temper et al., 2020). Contentious hydropower projects tend to register a higher level of social conflict compared to other renewable energy sources. Demands of opponents include recognition of rights enshrined in current national and international law, adequate Environmental Impact Assessments (EIAs), and thorough studies of alternatives to hydropower for energy generation before clearing new projects. However, in many cases, local populations and supporting organizations demand the ultimate cancellation, or the dismantling of plants, moratoria, and the adoption of alternative management and economic plans for the region (ibid). Dam building is often part of a larger plan for exploiting natural resources and controlling access to territories, commonly threatening local populations with resource grabbing and violence (Del Bene, Scheidel, & Temper, 2018). Environmental defenders belonging to farming and Indigenous communities are particularly hit by violence, repression, and criminalization of protest, especially in countries such as Colombia, the Philippines, Brazil, Mexico, and Honduras, among others, according to Global Witness (2020). This happens to such an extent that dam building often replicates similar patterns of injustices of other extractivist activities such as oil drilling or mining (Del Bene, Scheidel, & Temper, 2018).

Hydropower is certainly of relevance for future energy generation. However, the spatial implications of the expanding dam sector for land grabbing need close attention, as well as the rise of the demand for resources for the construction of barrages, roads, and other associated infrastructures, such as cement, sand, metals for power transmission cables, or power houses. Issues such as the size, governance, property, control, maintenance, and eventually dismantling of the plants need to be thoroughly analyzed altogether. Future decisions cannot be taken only on technical grounds of power capacity but by discussing what the energy is used for and by whom. Principles of 'energy sovereignty' of local communities can represent the basis of more just and distributed energy systems (Del Bene, Soler-Villamizar, & Roa-Avendaño, 2018).

Wind Power

Wind energy has become a mainstream source of electricity production and a key part of ongoing efforts to decarbonize energy systems. Since 2004, global installed capacity and investments in the sector have increased substantially, positioning it as a cost-competitive alternative for fuel-based electricity production (REN21, 2020). This steady and progressive expansion in the sector has been mainly concentrated in the deployment of onshore commercial-scale facilities, with a noticeable increase of investments in countries of the global South (Bloomberg NEF 2019; REN21, 2020). Social and environmental impacts associated with the wind power sector are less visible than those triggered by biofuels, or fossil, nuclear, and hydropower projects (Temper et al., 2020). However, the large-scale deployment of wind energy facilities is triggering new demands over land and minerals, raising attention to potential resource grabs and local environmental injustices.

Like other renewables, wind power requires vast amounts of space to generate energy that fossil and nuclear resources can produce in focal points of extraction (Huber, 2015). This biophysical condition highlights that, if the level of energy flows continues to increase under a low-carbon system, area coverage of wind energy will have to increase in large magnitudes (Scheidel & Sorman, 2012). The spatial dimension bound to the expansion of wind power highlights the potential competition for land between electricity production and other land uses such as agriculture, forestry, and conservation. These processes, in turn, are particularly relevant for locations where rural communities' livelihoods and cultural identities depend on the recognition of land rights and the access to resources related to them. A second important demand of resources pertains to the variety of minerals required for the production of modern wind power technologies, including cement, cobalt, steel, aluminum, as well as rare minerals (World Bank, 2017). The socio-environmental impacts produced by mining activities have been largely studied, highlighting key concerns for environmental sustainability and social justice (e.g., Bebbington & Bury, 2013; Urkidi & Walter, 2011). The growing demand for materials that are bound to the expansion of wind power therefore raises attention to an amplified extractive frontier associated with decarbonization strategies (Lèbre et al., 2020). Finally, also the dismantling of old wind turbines poses a growing waste problem[4], and social justice concerns may arise in the future about adequate siting and handling of these new 'green' landfills.

Territories holding important flows of wind resources (e.g., coastal areas, peninsulas, and other vantage geographical locations) are becoming particularly attractive for wind power developers seeking to exploit commercial-scale electricity production (Hook & Sanderson, 2021). Large-scale wind power facilities are triggering an increasing number of local conflicts in different locations of the rural world (e.g., Avila-Calero, 2017; Avila & Rao, 2018; Dunlap 2018a, b; Backhouse & Lehmann, 2020; Lopez-Gomez et al, 2019; Zografos & Martínez-Alier, 2009). A systematic analysis conducted with the EJAtlas (Avila, 2018) highlights that groups mobilizing against wind power facilities commonly involve agrarian and Indigenous communities whose material and cultural existence is strongly attached to territories holding valuable wind resources. Additionally, a variety of environmental and conservation groups tend to raise concerns in terms of the large-scale disruption of biodiversity conservation efforts, particularly over birds and local vegetation cover. Wind energy has also the highest aesthetical landscape impact compared to other renewables (Ioannidis & Koutsoyiannis, 2020).

In addition to the tensions around land grabs caused by wind-farms, conflicts around the deployment of wind power megaprojects also raise concerns over the decision-making process regarding questions of where, how much, and for whom wind energy is being harnessed, distributed, and consumed (e.g., Howe, 2014; Franquesa, 2018; Baker, 2021). For example, in Mexico, Indigenous communities mobilizing against the deployment of an ambitious Wind Power Corridor located in the State of Oaxaca explicitly questioned the corporate profile of a large-scale infrastructure that not only dispossessed the communal lands of the Zapotec communities but was also designed to supply electricity to different industries and urban regions of the country. These mobilizations, in turn, led to a proposal to implement a cooperative wind power scheme in the region (Avila-Calero, 2017; Oceransky, 2010), as well as broader debates across the country to implement decentralized and autonomous renewable systems.

Attempts to sustain ongoing energy demands with an increasing share of wind energy production will involve an unprecedented demand for resources, particularly rural lands, but also minerals required for manufacturing technologies. These processes highlight the need for further scholarly attention on both the drivers, conflicts, and alternatives emerging at the frontiers of wind power as a decarbonization strategy. Conflicts emerging against the deployment of wind power facilities shed light on how ongoing strategies for wind power production are disproportionately affecting rural areas where existing users often have less power and fewer formal land rights (McCarthy, 2015). However, claims of mobilizing groups not only highlight the misrecognition of material, cultural and environmental values bound to their territories but also shed light on the lack of participation in defining the scale, control, and distribution of wind power production.

Large-Scale Solar Power

Solar energy is a renewable energy source propelling the heating and electricity sectors. The solar technology portfolio ranges from electricity production from solar photovoltaics (PV) and concentrated solar power (CSP), to solar thermal plants applied for (use water) heating. Today, and in future roll-out scenarios, the lion's share of solar energy is provided by solar PV and, to some extent, by CSP, with the consequence that environmental and land conflicts over the expansion of large-scale solar projects center around these two solar technologies.[5] Environmental injustices, including land dispossession, can occur along the entire value chain, ranging from the extraction of required raw materials (De Ridder, 2013), over exposure to toxic substances in the manufacturing process (Mulvaney, 2014), to the application and implementation of the solar technology itself on which we focus here[6].

Socio-environmental concerns expressed in local protests against solar PV projects include generally issues such as food and energy security concerns, displacement, corruption, irregular land-acquisition and dispossession, and the violation of human rights (see Temper et al., 2020). For example, Yenneti et al. (2016) describe land acquisition processes in the Indian *Charanka Solar PV Park*, in which vulnerable subsistence farmers were deprived of their livelihoods, grazing, and agricultural land, and dispossessed of their homestead. This suggests that the least advantaged groups seem to carry the greatest burdens in the implementation of 'green' mega-sized PV plants. By focusing on two further large-scale solar projects in India, Stock and Birkenholtz (2019) shed light on key events in such solar land grabs: acquired lands were previously defined and demarcated as 'marginal' or 'wastelands', then acquired by the state through extra-economic means, and finally allocated to the project developers. This resulted in land and energy dispossession of locals through the grabbing of agricultural land and the exclusion from fire-wood sources, creating landless peasants, dependent on wage labor. In such cases, climate capital invested into large-scale solar power is triggering a larger agrarian transformation involving the partial proletarianization of the peasantry (ibid). Such processes may also be marked by coercion and violence. For example, in the conflict over the large-scale PV plant *Planta Voltaica Los Prados* in Honduras, protesters were criminalized and threatened. The conflict culminated in the assassination of a protest leader (EJAtlas, 2019a).

Several other environmental justice concerns can arise in solar power conflicts. Structural exclusions from democratic processes, where local communities are not adequately included in the planning processes of solar power projects, and where their material and cultural values attached to land have not been respected, are further causes of (land) conflicts both in the global North and South. For example, the siting of the large-scale PV *Desert Sunlight Solar Farm* on Indigenous lands in the Californian desert triggered concerns over inadequate consultation and destruction of ancient sacred and tribal sites (EJAtlas, 2019b). Because of its close location to recreational areas and national parks, the project also provoked opposition by environmental groups. More generally, environmental concerns that may instigate conflicts over solar power plants include: impacts on wildlife, draining desert area groundwater sources through the use of water for facility cleaning (EJAtlas, 2019c), heat islands causing bush fires, potential intoxication with Cadmium-Telluride (EJAtlas, 2019d), reduction of air quality (EJAtlas, 2019d), deforestation (EJAtlas, 2021), (EJAtlas, 2019d), habitat loss (EJAtlas, 2019d), and other landscape impacts (EJAtlas, 2019b, 2019e; Ioannidis & Koutsoyiannis, 2020). Finally, conflicts over the unequal distribution of economic gains and opportunities, and the uneven consumption of electricity produced, have emerged as a result of large-scale solar projects. For instance, in India, in the *Kamuthi Solar Power Project*, a conflict is indicated with locals seeking jobs they were promised in return for allowing project development on peasants' land, but were ultimately denied (EJAtlas, 2019c). In the *Gujarat Solar Park*, villagers complained that developers increased electricity prices when they were initially promised free energy (Stock & Birkenholtz, 2019). In Mexico's largest PV project, the *Solar Park Villanueva*, workers set up blockades in protest against over ten months of unpaid salaries (EJAtlas, 2019f).

Patterns of extractivism, forms of exploitation of poor and marginalized local groups, and hegemonic post-colonial structures commonly appear also in large-scale solar projects. These projects may involve 'green' land dispossessions and broader agrarian transformations through the reorganization of labor and land in the face of a globally ascendent, green neoliberal capitalism (Stock & Birkenholtz, 2019). Given the recency of the expansion of large-scale solar power, further research is needed to fully unpack the scale of solar land grabs emerging today. The question of how solar power development can adequately address issues of distributional and procedural justice, recognition of cultural and material values and access to energy for marginal groups remains central in the global energy transition. As for other renewable projects, smaller-scaled community-centered approaches, local ownership, and democratic control can potentially lead to more energy sovereignty. These are the crucial components of more sustainable, just, and resilient energy transitions that must be strived for.

Conclusion

Efforts to decarbonize the global economy are necessary. However, it is important to understand the socio-ecological impacts, power relations, and vulnerabilities manifesting in the expansion of current renewable energy frontiers. Understanding why agrarian and environmental conflicts arise over the expansion of renewable energies can help to address, and ultimately avoid, instances of what we term 'renewable grabbing': the appropriation of land and other resources for the expansion of renewables at the cost of local and customary users facing new environmental injustices.

Conflicts, playing out in different ways across the main renewable energy frontiers, bring to our attention the environmental injustices associated with such green transitions, as well as the demands made by affected communities to reshape energy transitions toward more just outcomes. For example, 'just transitions' proposals by global labor unions gaining momentum and visibility, are having direct implications on the articulation of distribution, recognition, and participation in the transition to a green economy (Stevis & Felli, 2015). Environmental justice movements that contest unjust and unsustainable energy projects globally point to a number of aspects needed to transform decarbonization pathways toward more just ones, including the need for better participation, localization, avoidance of environmental racism, shorter energy supply chains, and more generally energy sovereignty and sufficiency (Temper et al., 2020).

Tackling the climate crisis while centering on justice, sovereignty, and sufficiency must be at the heart of defining just and sustainable energy transition strategies. Further research can contribute to building these strategies, drawing lessons from conflictive renewable deployments, and providing alternative approaches to reverse its most recurrent adverse impacts. Aspects of recognition of both communities and ecologies at local scales are key in these alternative approaches, calling attention to the need for mandatory implementation of local consultations and participatory processes in designing social and environmental impact assessments of renewable energy projects. Aspects of procedure could also be further strengthened through the implementation of direct democracy mechanisms in territorial planning, favoring local participation, and recognition and protection of customary land rights.

Together, these elements could make important contributions to mitigating ongoing pressures over land and other resources associated with the implementation of renewable energy systems. However, genuine redistributive approaches in renewable energy implementation must work in tandem with structural transformations over the economic, political, and social structures currently driving the energy transition. Inter- and transdisciplinary research is required to understand and reimagine the interplay between the environmental, social, cultural, political, and economic dimensions entangled in the transition. This agenda could contribute to unveil and prevent injustices across different geographical scales, such as across North-South, center-peripheries, or urban-rural dynamics, and across the diverse points in the renewable energy value chain: across sites of mining extraction and energy production, spaces and cultures of energy consumption, and the 'green' waste disposal frontiers that are likely to emerge in the coming years.

Notes

1 See www.ejatlas.org
2 Other types of biofuels, not discussed here further, are for example algae-based biofuels (Doshi et al., 2016) and bioenergy for electricity and heating, based on wood-based sources. The latter may lead to land conflicts through the expansion of tree plantations at the cost of customary users (Kröger, 2016).
3 See for example NAMRA website: northeastmegadamresistance.org.
4 See for example https://www.bloomberg.com/news/features/2020-02-05/wind-turbine-blades-can-t-be-recycled-so-they-re-piling-up-in-landfills
5 The world's solar-thermal capacity is mostly limited to small household applications and is not discussed here further.
6 What remains to be seen is whether the dismantling of solar PV infrastructure after lifetime triggers new conflicts over waste disposal.

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