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# Volatile Photovoltaics: Green Industrialization, Sacrifice Zones, and the Political Ecology of Solar Energy in Germany

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The development of solar energy has been depicted as a paradigmatic break in unsustainable global growth, largely because it is framed as an innovation with minimal carbon emissions. On the contrary, drawing on literatures from spatial justice and political ecology, including on authoritarian populism, this article analyzes the rise and fall of the solar industry and the associated failures of “green industrialization” in Bitterfeld, East Germany—an area that is characterized by political, economic, and social peripheralization, marginalization, and the rise of the far right. The development of solar energy, we argue, is merely the latest iteration of an industrial growth model that is rooted in a similar modernist mode of development. Based on original mixed methods field research in eastern Germany, it argues that many of the same inequalities that characterize fossil fuels and “gray” (de)industrialization—undemocratic and unsustainable industrial processes, the concentration of corporate power and profits, and externalized waste and pollution—are replicated by solar energy. What is distinct is the fact that such contemporary “green” manufacturing processes appear to negatively affect a wider and more dispersed range of spatial locations, also denying these locales the benefits of accumulation, production, and consumption. This unevenness reflects the reconfiguration of global supply chains over the past thirty years and the nature of green production processes that depend on a wider range of inputs that invariably produce localized sacrifice zones. We offer a spatial justice framework for solar energy, zooming in at the manufacturing stage, to explore the multiple sacrifice zones at the different stages of solar energy. Finally, we highlight the politics of resignation that is the product and foundation of capitalist realism that serves to dispossess communities around solar energy manufacturing sites in eastern Germany and might feed into the rise of the populist far right. The article contributes to the emerging critical literature that analyzes the dark side of renewable energy and, in doing so, reveals the social and ecological costs of energy transitions that continue to be underresearched yet deserve heightened attention.

*Key Words:* authoritarian populism, decarbonization, green (de)industrialization, industrial strategy, peripheralization, renewable energy, solar photovoltaics.

Around the world, cities, companies, governments, and households are coming to embrace solar energy as a core part of a shift toward “sustainability,” decentralization, community ownership, and enhanced control over the energy supply (Allen, Lyons, and Stephens 2019; Brisbois 2019). For some, decentralized renewable energy supply has even become part of agendas to promote “energy democracy,” attempts at transforming energy systems so that they become lower carbon but also more pluralistic and civic minded (Delina 2018; Szulecki 2018; van Veelen and van der Horst 2018).

In Africa, Adams and Acheampong (2019) wrote that “democracy and investment in renewable energy should be given priority on [the] Africa agenda to mitigate climate change” (1), with solar energy offered as a paradigmatic example. In India, Shidore and Busby (2019) framed solar energy as a vital part of a pathway to become more energy secure nationally as well as a mechanism to address energy scarcity and poverty. In Canada, Dolter and Boucher (2018) discussed solar energy as an instrumental part of achieving energy justice, following work from Sovacool and Dworkin (2014) showcasing solar

energy as part of a policy mix for “global energy justice.”

This study, however, calls into question whether solar energy and the objectives of democracy, equity, and justice always go hand in hand, especially when one considers upstream aspects such as solar energy manufacturing in marginalized communities such as those in eastern Germany. The study renews attention on the spatial justice implications of so-called green energy supply chains and the greater recognition of the increasingly invisible and dispersed impacts of green industrialization.

It further points to the resignation and disillusion in response to the failures and contradictions of green industrialization, embedded in wider antidemocratic and populist responses to deindustrialization, political marginalization, and lack of agency and decision-making power on the community level. This study suggests that political decisions that are attributed to (“free”) market dynamics can feed into such responses. It illustrates the “politics of resentment” (Cramer 2016) that can be triggered by false green promises and the need to take seriously the rural–urban divide and the spatial dimensions of energy (in)justice. Consequently, it calls for greater democratic control over energy generation, supply, and demand decisions and more locally grounded imaginaries and models of energy and economic (de)growth, especially, but not exclusively, at the manufacturing stage.

This article examines these themes through the lens of eastern Germany’s experiment with solar panel manufacturing during the 2000s in the Bitterfeld region.<sup>1</sup> Based on a mixed-methods research design involving expert interviews, community interviews, and site visits in eastern Germany, the study finds that the industry collapsed due to global competitive pressures (leading to job losses locally). It finds that the benefits of solar itself now accrue far from social and ecological “sacrifice zones” (Healy, Stephens, and Malin 2019)—in German households that use the panels and, primarily, the (multinational) corporations that accumulate the profits. This dynamic contrasts with previous waves of industrial development in the Bitterfeld region where the lignite coal, chemicals, and photography industries led to the concentration of both capital and the legacies of pollution in a much narrower sphere, with the region at that time serving as the sacrifice zone for East German industrialization.

The rise and fall of the solar industry thus need to be read against the background of longer histories and experiences of rapid regional industrialization characterized by severe air and soil pollution and other forms of ecological harm and the even more rapid deindustrialization that had socially disastrous consequences. The resignation that follows reflects what we analyze as “capitalist realism” (Fisher 2009) or the “politics of resignation” (Benson and Kirsch 2010), which feed into the rise of authoritarian populism (Hall et al. 1985).

The article proceeds as follows. We first introduce our conceptual approach of spatial justice and the political ecology of renewable energy, with explicit attention to the links to dispossession, deindustrialization, and the rise of authoritarian populism. We then explain our case study selection in eastern Germany and its background before explicating our mixed-methods research design consisting of original interviews and site visits supplemented with literature reviews. Finally, we discuss our core results organized around the three themes of (1) the emergence of solar manufacturing; (2) its collapse; and (3) the resulting disappointment, resignation, and sacrifice.

## Conceptual Approach: Spatial Justice, Authoritarian Populism, and the Political Ecology of Renewable Energy

Although the processes affecting Bitterfeld in particular, and renewable energy infrastructures such as solar photovoltaics (PV) more generally, are complex and multiscalar, the energy geography, energy justice, authoritarian populism, and political ecology literatures offer some compelling heuristics through which to interpret them.

Despite its focus primarily on urban struggles for contested space, Soja’s (2010) notion of spatial justice is apt here, because it calls on research to better recognize how social hierarchies are embedded in spatial consciousness. For Soja (2010), to understand the dynamics of an urban area, research must become aware of the outcomes of spatial injustice and how injustice manifests itself across economic, social, and political orders that embed the “unjust geographies” of a city. Soja (2010) discussed four methods by which one can challenge spatial injustice, methods that we believe are transferable to low-carbon technology or sociotechnical infrastructures.

The first is spatial consciousness, or reimagining the city (or, in this case, a technology or an industrial supply chain) not as neutral but instead an active struggle over resources and thus competing interests. The second is the ability to change geographies, to view ourselves as spatial beings with the ability to shape, influence, and direct future outcomes. The third is participatory democracy and a call for more inclusive, representative forms of decision making that better reflect the interests of local communities or marginalized groups. The fourth is sustainability, that cities (and in our case technologies) orient themselves toward a long-term holistic sustainability that does not sacrifice the needs of the future for the needs of the present, or ecological sustainability at the expense of economic sufficiency.

We interpret Soja's (2010) call for more just, contingent, deliberative, and sustainable spatial geographies as extremely relevant to current debates over the justness (or unjustness) of renewable energy and, in particular, solar energy but also to understand green industrialization. Indeed, various literatures have confirmed, using different methods of analysis in distinct geographic places at different parts of the solar life cycle, how solar energy might not always promote the underlying goals of community empowerment, energy democracy, worker well-being, or environmental prudence. The pioneering work of Mulvaney (2013, 2014) demonstrates some of the occupational hazards facing solar workers and manufacturers, especially those exposed to unsafe levels of cadmium, used in thin-film solar PV designs. Looking at the siting and land politics of solar energy parks in India, Yenneti and Day (2015, 2016) and Yenneti, Day, and Golubchikov (2016) revealed injustices of process, planning, and misrecognition in how such facilities are sited regardless of community concerns.

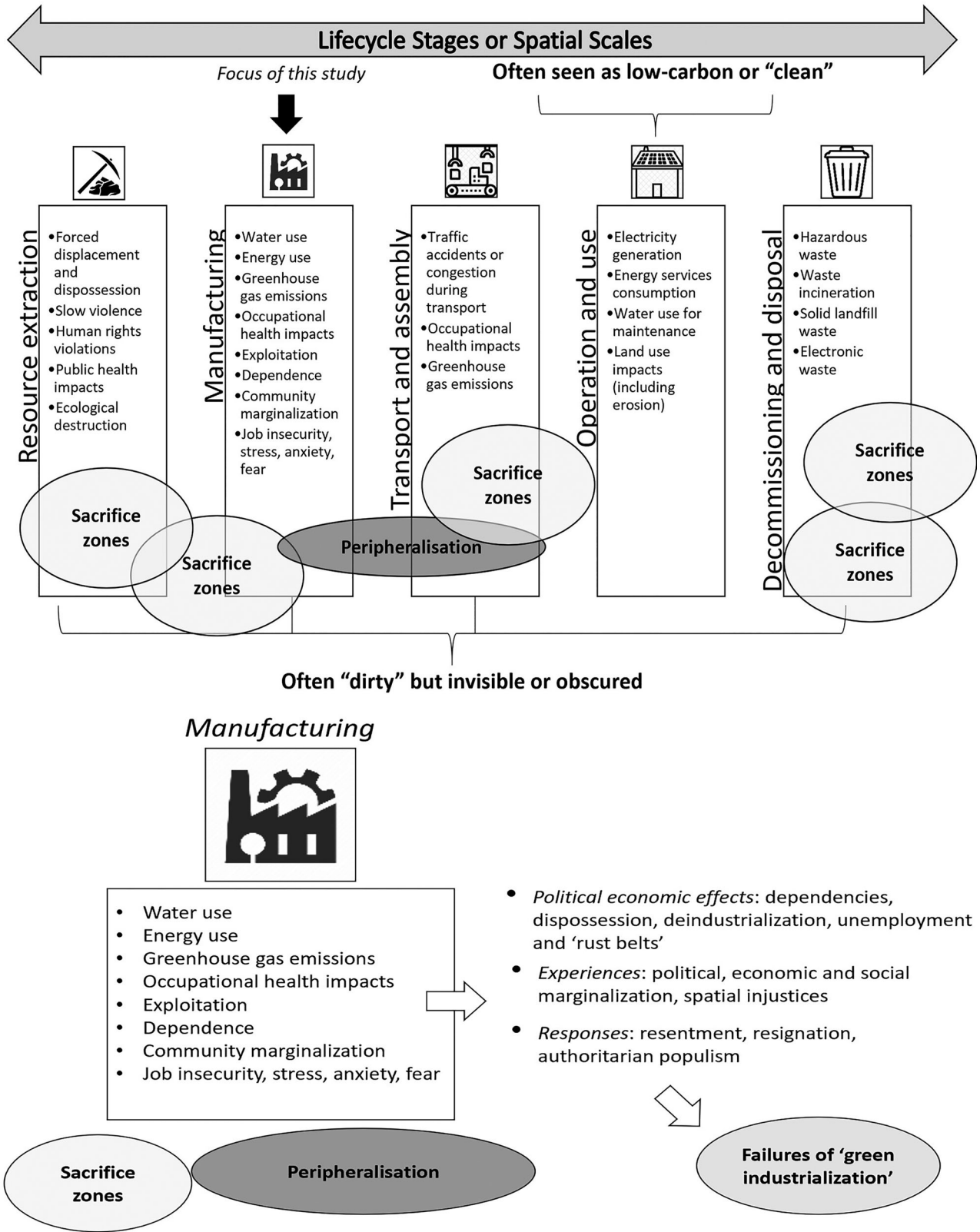
At the extreme other downstream end of the solar life cycle, Cross and Murray (2018) examined the intricate afterlives of discarded solar panels and their burgeoning waste flows in Kenya. Salim et al. (2019) conducted a meta-analysis of hundreds of academic studies published on the sustainability of solar PV and noted that many heavy metals embedded within solar systems are hazardous for workers or the environment, especially lead, lithium, tin, and cadmium, which can pose toxic risks during their manufacturing or disposal. Nevertheless, they cautioned that

“little attention has been paid to the potential environmental and human health related impacts associated with PV systems, if not properly managed at the end-of-life” (Salim et al. 2019, 540).

In this way, solar energy becomes just another global commodity, just another node in a network of global factories and logistic networks contributing to “friction” (Gregson, Crang, and Antonopoulos 2017), and also interconnecting with waste streams, global recycling networks, and systems of resource recovery (Gregson and Crang 2015; Gregson et al. 2015). Many such networks and flows are organized not by national borders but the permeable boundaries of sociotechnical systems, markets, or supply chains (Kama 2014, 2015; Sovacool et al. 2020). Within this complex multiscale system, energy vulnerabilities are coproduced with spatial advantage and therefore embed spatial disadvantage (Golubchikov and O'Sullivan 2020).

To envision such complexes, we advance in this study a framework for “embodied energy injustices” (Healy, Stephens, and Malin 2019) or “whole systems” and “multiscale” energy justice (Sovacool et al. 2019). As the top panel of Figure 1 shows, at the macrolevel the spatial injustices of solar energy cut across at least the five scales or life cycle stages of resource extraction, manufacturing, transport and assembly, operation and use, and decommissioning and disposal. The resource extraction stage encompasses raw material extraction, mining, and refining with the displacement, slow violence, and suite of other socioenvironmental impacts it brings. These injustices and sacrifice zones are not static—with changing policy and regulatory environments and political economies of energy, they can shift geographically and temporally. The displacement of solar manufacturing from Germany to areas with lower environmental safeguards, explored later, illustrates one such shift at the manufacturing stage and the development of deep-sea mining (Childs 2020) for tellurium and other rare earth elements for high-performance solar panels demonstrates the movement and generation of new sacrifice zones on the sea floor.

Manufacturing, which we explore in this study and which is depicted in the bottom panel of Figure 1, reflects the processing, material cultivation, and fabrication of solar components at a more local or community scale. Although manufacturing details vary based on the type of PV module (thin film,



**Figure 1.** A spatial justice framework for solar energy. The top panel shows at the macro or “whole systems” scale, and the bottom panel shows the micro or “community” scale of manufacturing.

mono, poly, or multicrystalline, dye-sensitized, quantum dot, etc.), material cultivation encompasses mining, refining, and purification of all of the silicon and other required metals and minerals for the cells, glass, frame, inverters, and other required electronics (Nugent and Sovacool 2014). Petroleum extraction for plastics, natural gas extraction used for heating, and effectively any other material extraction and processing needed to create the PV module and finished electronics are also included, as are wiring, encapsulation, and any other processes by which the modules and electronics are fabricated and finished (Nugent and Sovacool 2014). The transportation and assembly stage involves the transport of panels and installation along with the balance of the system, including mounting structures, cabling and interconnection components, and inverter. The operation and use stage, often the most visible, is where the solar panel is “used” but also maintained, inclusive of cleaning of the modules and any other processes that occur while it is in use. Scott and Smith (2017) showed how solar panels might clash with arable land and food justice concerns throughout these stages, triggering resistance informed by right to landscape claims. The final stage of decommissioning and disposal reflects the afterlives of the product and whether they enter waste flows or are instead repurposed or recycled. Healy, Stephens, and Malin (2019) added that across the life cycle of energy systems, far too much focus examines social and environmental issues at just one point of this chain (e.g., environmental impact assessments or social and environmental impact assessments), operation, and use consumption, thereby obscuring other impacts upstream or downstream.

As the bottom panel of Figure 1 illustrates, we focus on one of these neglected or obscured areas, that of manufacturing. This focal point allows us to depict the localized spatial dimensions of energy (in)justices along the globalized supply chain, and the promises and failures of green (de)industrialization. It is here that we see job insecurities, disappointment, the marginalization of communities, and the loss of hope trigger political responses such as resentment and possibly authoritarian populism (Hall et al. 1985; Fraune and Knodt 2018).

Drawing from Fraser (2017), we envision authoritarian populism as a response to failures of progressive neoliberalism, leading to the rejection of neoliberal ideology, corporate globalization, and

financialization and the political establishments within which these are embedded. Authoritarian populism often goes hand in hand with the rejection of austerity and precarious work, liberalization of trade and globalized supply chains, and political support for the “new (high-tech) economy” at the cost of manufacturing. Here, our conceptual framework points to how this is interlinked with the resignation following the failure of green industrialization and its associated false green promises.

Scholarship from the U.S. Rust Belt—the former manufacturing belt and the oldest and largest industrial area of the United States—shows how resentment following deindustrialization might trigger the rise of authoritarianism (McQuarrie 2017). Economic tensions speak to the overall decline of manufacturing belts and the fall of large industrial areas that were once centers of prominence and wealth but are now symbols of urban decay (Sugrue 2005). Such shifts in economic power are frequently accompanied by job and population losses as well as significant increases in private debt and a dependence on future imports (Chacko and Jayasuriya 2017). Political responses of crisis management that often promote austerity, a deepening of social fragmentation, and the erosion of social safety nets might further contribute to distrust in political institutions and the loss of legitimacy of so-called democratic capitalism (Streck 2012; Chacko and Jayasuriya 2017; Norris and Inglehart 2019).

Places can be viewed as products of the systemic forces of state and capital (Scott 1998) and expressions of the needs of state and capital—but they are also shaped by community agency and structures of feeling, narratives, identities, political subjectivities, and moral values (McQuarrie 2017). The rise in populism and turn to authoritarianism is not the direct result of deindustrialization or the decline of manufacturing, this scholarship suggests, but a consequence of the erosion of the social and political institutions that buffered citizens from the effects of industrial decline, triggering anger and the politics of grievance and reparation (McQuarrie 2017; Knuth 2019).

Such resentment might stem from a dislike of the “elite” and new business ventures seeming to back them, as well as a distrust that such actors and their allies will respect community values, allocate resources fairly, or fully appreciate place-based identities (Cramer 2016). It also reflects an increasingly

justified acknowledgment that processes of globalization and capitalism have often only increased the volatility and inequality of local supply chains and manufacturing clusters connected to it (Bello 2018; McCarthy 2019). In other words, this shows how *space matters* in understanding energy injustices and authoritarian populism, and we need to understand lived experiences of social and political aspects, not just economic marginalization, to explain these phenomena.

Our framework helps characterize such shifts in political and ideological alignment and balance of forces to explain the more recent rise in nationalist, protectionist politics that are

resonant with broad-brush appeals to “the people,” in which candidates are rewarded for “strong man” talk that pits insiders against outsiders of different colours, religions and origins; growing concern over the “mobile poor,” including refugees and migrants whose presence seems to threaten a shrinking resource base; appeals for security at the expense of civil liberties; a concerted push to increase extractive capitalism at all costs; and, finally, a radical undermining of the state’s ability to support the full range of citizens, while utilising state powers to increase surplus for a minority. (Scoones et al. 2018, 1)

This cultural backlash can be seen in the rise of the far right and the increasing popularity of right-wing parties, such as the German *Alternative für Deutschland* (Alternative for Germany [AFD]). To understand how the twofold deindustrialization has played into these processes in Bitterfeld, where the AFD has gained more votes than any other political party, we engage with Fisher’s (2009) conceptualization of “capitalist realism,” the lack of imagination of alternatives, and how this further drives authoritarian populism.

As a final step, we need to link our framework back to the political ecology of solar manufacturing, or the “greenness” in green (de)industrialization. The relationship between authoritarianism, populism, and environmental politics has recently received increased attention (McCarthy 2019). Important here is that this relationship often plays out directly through “tensions between rural and urban areas” (McCarthy 2019, 302) and in reaction to the mechanization of labor, globalization of markets, volatility of resources, and inequalities (Bello 2018; Scoones et al. 2018). Claims to resource nationalism and resource sovereignty, for instance,

might represent critiques of neoliberal inequality and structural dispossession (Myadar and Jackson 2019). These inequalities can be simultaneously economic and ecological, triggered, for instance, by the outsourcing of pollution to rural areas, where resistance might be less powerful, and labor and rent cheaper.

For example, resource extraction can become an important mobilizing issue for populism given how extraction is connected to place-based and class identities, nationalism, and masculinity (Kojola 2019). Environmental displacement and marginalization, and the sense of crisis they bring, can nationalize and naturalize precarious identities of place, class, and resources. Huber (2013) introduced the concept of energy populism to show how the protection of cheap fossil fuels is understood as standing up for the people, based on idealized and romanticized imaginaries of the past, and tied to white, rural masculinity and extractive labor (see also Balls and Fischer 2019). Building on this work, Kojola (2019) introduced “extractive populism,” in which “heroic male miners can provide material resources to secure the nation against foreign enemies while restoring heteronormative middle-class families” (373).

Right-wing politicians and parties support extractive industries and anti-environmentalism not only because of its political and economic allure but because it justifies morally the degradation of the environment to achieve these ends. The “cultural and affective power of mining and how it provides legitimacy and mobilizes white and rural people ... defending rural livelihoods and sense of place can motivate support for nationalist, racist, and capitalist political projects, which demonstrates the contradictions in moral economies of resource extraction” (Kojola 2019, 378). Populism thrives when people feel a sense of crisis, and particularly in “resource-dependent communities that face economic depressions and a sense of insecurity created by boom-and-bust cycles” (Kojola 2019, 378). Thus, environmental conditions and calamities become intertwined with political, economic, and social tensions and trends (McCarthy 2019). The climate change denial and pro-coal attitude of the AFD, for instance, capitalizes on these tensions, disappointments, and frustrations with green industrialization (as we return to in our case study later). This highlights, once again, the social nature of ecological conflicts (McCarthy 2019) and the relationship between ecology, social degradation, and erosion of democracy that is key to political ecology (Brock 2020a).

In addition, Figure 1 indicates that renewable energy supply chains, adoption processes, and political ecology more generally are punctuated by struggle and the creation of sacrifice zones. These themes buttress a line of emerging work revealing that low-carbon transitions are locally disruptive processes (Dütschke and Wesche 2018; Dunlap 2019; McCauley et al. 2019). They can displace people from their livelihood; dispossess them of their land (Baka 2017); or even challenge their heritage, tradition, and cultural identity, an example here being the social embeddedness of coal mining in parts of the United States (Carley, Evans, and Konisky 2018). It depicts, also evident in Figure 1, how particular sacrifice zones can emerge for particular communities at acute exposure to disruption. Lerner (2010) noted that sacrifice zones, initially termed to describe communities at risk from the negative radioactive side effects of nuclear weapons processing, now denote any community disproportionately exposed to some sort of elevated hazard or at the frontline of exposure, such as military bases, heavily polluted industries, or mines. Holifield and Day (2017) added that a sacrifice zone can particularly reflect polluted and degraded areas associated with new extractive activities such as energy production. “Energy sacrifice zones” link vulnerable communities along the “energy continuum” (Hernández 2015) or life cycle stages of solar energy. Alongside sacrifice zones, spatial injustices can create or worsen patterns of peripheralization (Blowers and Leroy 1994; Blowers 1999; O’Sullivan, Golubchikov, and Mehmood 2020), a process of marginalizing particular communities that tend to be geographically remote, economically marginal, politically powerless, culturally defensive, or environmentally degraded. In essence, peripheralization suggests that noxious industries and unwanted energy infrastructure will invariably migrate to communities that lack the political, social, and economic strength to oppose them, especially indigenous peoples and communities of color, often at the extreme social and geographical periphery of society (Rasmussen 1998; Park and Sovacool 2018) and often reinforcing environmental injustices and degrees of environmental racism.

In sum, we position ourselves conceptually within a political ecology, authoritarian populism, and spatial justice perspective. We seek to unveil how political, social, economic, and environmental factors fuse together to create winners and losers and

worsen some fundamental patterns of exclusion and inequality across space and time (Peet, Robbins, and Watts 2011; Brock and Dunlap 2018; Sovacool 2018; Sovacool, Tan-Mullins, and Abrahamse 2018). The supposed “greenness” and “cleanliness” of industrial-scale renewable energy generation has come under increased criticism, laying bare the continued reliance on extractive operations, green grabbing (Fairhead, Leach, and Scoones 2012), and resource use in countries of the Global South, rather than challenging resource exploitation, (neo)colonial dependencies, inequalities, and ecological degradation (e.g., Bonds and Downey 2012; Zehner 2012; Dunlap 2018a, 2018b, 2019; Sánchez De Jaegher 2018). Such projects constitute, critics claim, a continuation of old patterns of accumulation and degradation, hiding the true costs of extractivism, while greenwashing corporate and state involvement in the accelerating climate crisis and opening new “green” markets. Dunlap thus coined the term *fossil fuel +* to highlight the continuities with conventional fossil fuel generation and the political-economic violence inherent to their operation in the name of the green economy (Dunlap 2018a; Dunlap and Brock forthcoming). More often than not, political ecology work illustrates that the benefits of such technologies continue to accrue to global (corporate) elites, rather than communities near the project sites, who pay the social and ecological costs for their development. Granted, in our case, even though solar industrialization developments were “cleaner” than previous industrial developments in the region (e.g., chemicals, coal, or photography), in the socioeconomic and political-cultural spheres in particular the boom failed to live up to its promise.

### **Case Study Selection and Background: German Green Industrialization, the Co-Option of the *Energiewende*, and the Move to the “Dirtiest Town of Europe”**

Germany has become renowned over the past twenty years as a country that has made significant advances in moving toward a so-called low-carbon economy. This has been attributed to its major planned transition toward renewables, the *Energiewende* (von Hirschhausen et al. 2018). The *Energiewende*, initially a grassroots initiative coming



out of the antinuclear movement,<sup>2</sup> was coopted (or further facilitated, depending on your interpretation) by the state when it began to affect the monopolistic German business structures and has now “become trapped in government regulations tailored to fit the interests of the big energy suppliers” (Acosta 2018). It came to encompass energy efficiency, energy security, renewables, and nuclear phaseout. Politically, the *Energiewende* and its supporting legislation (the *Erneuerbare-Energien-Gesetz*, or Renewable Energy Act) was enabled by the significant influence of the Green Party, which was important in shaping the antinuclear and pro-renewables nature of policymaking in Germany from the 1990s onward (Lauber and Jacobsson 2016).

As a result of the *Energiewende* policy efforts, and despite continued reliance on lignite and hard coal, until 2019 Germany led the world in its total installed capacity of solar PV panels per capita (German Federal Ministry for Economic Affairs and Energy 2017; “Top Five Countries” 2020). It has the fourth greatest total capacity of solar PV installed anywhere in the world, with 49 gigawatts installed at the end of 2019, providing 8.2 percent of gross national supply (Fraunhofer 2020; International Energy Agency 2020). This means that 37 percent of Europe's solar PV is installed in Germany, followed by Italy at 16 percent (International Energy Agency 2020).

This rapid diffusion of solar energy was achieved by creating an early domestic market through specific policy support measures, such as the national Feed-in Tariff, which guaranteed a fixed power price for solar power producers for a twenty-year period (Fraunhofer 2018b). As well as stimulating high levels of solar energy consumption at household and commercial levels, Germany also attempted to catalyze new domestic “green” industrial sectors, primarily in wind energy and solar PV. It stimulated these through the provision of investment grants in the (new) eastern states of Germany and through the provision of research support (Fraunhofer 2018b). By 2007, Germany was the largest producer of solar panels globally, and a German company (Q Cells) led the international rankings in production volume.

The area around the eastern German town of Bitterfeld–Wolfen, in Saxony, became central to these efforts, with the area becoming branded as Solar Valley. Several of the largest firms, including Q Cells and Solar World, were located in the

region. The sector employed 15,000 people nationally and at least 5,000 full-time, permanent employees in Solar Valley itself (Fraunhofer 2018a). Q Cells became the innovator and leader of the industry.

Bitterfeld has an industrial history that has profoundly shaped the region, socially, culturally, and geographically. The discovery of lignite coal and the development of the chemical and film industries in the nineteenth century led to rapid economic and population growth. Initially delivering chemicals to companies in Berlin and West Germany, the area then became an industrial powerhouse during World War I. Small and medium-sized companies were quickly bought up by larger holding companies and later became East German or Soviet state property (Freier 1995).

The boom of the coal, chemical, and film industries came at enormous social and ecological costs, the extent of which were suppressed by the East German regime and its security apparatus. In 1988, an illegally filmed documentary first showed the degree of industrial pollution in what was widely regarded as Europe's most polluted town. It showed an area devastated by mining, industrial chimneys emitting exhaust fumes of different colors, degraded and grimy housing areas, toxic waste dumps, and heavily polluted rivers and local ecosystems. Residents and employees reported high levels of illnesses including bronchitis, croup, lung diseases, and fluoride toxicity. Regular chemical accidents were hardly reported on, and monitoring and regulation by the East German government was negligible. In return for the corporate harm (Benson and Kirsch 2010) caused by industrial production, employees received slightly above-average wages and subsidized hard liqueur (Schnaps) during the winter months. When industries—especially the coal industry—collapsed with the fall of the Berlin Wall, many thousands lost their jobs and the area lost almost half of its population. As Maron (2009) noted, “Many people never recovered from the shock, became depressed or withdrew in shame, or lost their inner strength. Others adapted to their new, ‘reduced’ lives” (2, authors’ translation). This is the backdrop against which the solar industry set up in the area, and Solar Valley promised regeneration and green industrial development.

Since its peak in 2008, however, the market share of German manufacturers has dropped dramatically,

90 percent of German solar jobs have been lost, and almost every major solar manufacturer has filed for bankruptcy (Lütkenhorst and Pegels 2014). Solar Valley almost disappeared. These events were largely attributed to the rapidly declining costs of panel production and the corresponding investments into solar production capacity in East Asia, as well as subsidies from the Chinese government (Meckling and Hughes 2018). In 2008, “the Chinese government began providing large subsidies for solar companies, helping reduce the cost of manufacturing solar PV panels and increasing China’s solar panel manufacturing capacity tenfold” (Bell 2017, 554). The resulting oversupply drove down world market prices by 75 percent (Haley and Haley, 2013). Once these economic conditions were in place, the low complexity associated with PV production made it easy for production to relocate to countries such as China and Taiwan (Fraunhofer 2018b). Indeed, turnkey production lines that produce very good quality PV modules can now be bought off the shelf, enabling fast technology transfer.

It was not only German solar manufacturing firms that were unable to compete with falling global prices. Silicon Valley in the United States, once also envisaged as “Solar Valley” (Zachary 2008), also crumbled (Woody 2011). Major manufacturers were forced to declare bankruptcy and others were bought up by Chinese firms,<sup>3</sup> ending “the ‘renaissance’ of the US solar industry” (Caprotti 2017, 937). Meanwhile, increased competition from China led to lower environmental standards across the industry, as firms with higher standards, such as mandatory buyback recycling programs for old solar panels, were forced to cut costs or went out of business (Haley and Haley 2013; Harkinson 2013).

As factories started to close and jobs began to be lost in Germany to overseas manufacturers, the German government made the decision not to try to save the German solar manufacturing industry and actively campaigned for the European Commission not to take action against (illegal) Chinese subsidies, according to interviewees, and to allow the import of cheap (subsidized) panels (Clean Energy Wire 2018). This judgment was ostensibly based on the idea that where low-carbon technologies were made was not important; thus, if China could make the panels more cheaply, then it made sense for Germany to specialize elsewhere and to import panels from China. Others have argued, however, that

the German government shifted from supporting solar to supporting offshore wind and biogas under lobbying pressure from the “Big 4” energy companies because these large-scale investments were better suited to their business models (Kuzemko et al. 2017).

Although the experiences in Germany over the past decade are often rationalized as inevitable consequences of globalized economic competition (and were framed this way by some local residents interviewed), there are unappreciated socioeconomic impacts of the rise and sudden fall of the solar manufacturing sector for already peripheral regions such as Bitterfeld. Thus, this study aims to explore these impacts through the lens of Solar Valley in eastern Germany.

## Research Methods: Reviews, Interviews, and Site Visits

To investigate the political ecology of solar energy in the region, we first reviewed archival and commentary material; second, we conducted semistructured interviews with German experts; third, we interviewed community members in Bitterfeld–Wolfen and surrounding areas; and fourth, we carried out site visits in the Solar Valley region (summarized in Table 1).

Archival material was collected from Internet searches in English and German; from key academic databases, such as Web of Knowledge and Scopus; from the gray literature; and from online newspaper archives.

Seven expert interviewees were identified through snowball sampling. An initial list of key players in Solar Valley was constructed through Internet searches and the utilization of prior contacts in Germany, and subsequent relevant persons were discovered locally throughout the interview process itself. During each interview, we asked the following standard questions: How did the solar manufacturing experience affect the local community in Bitterfeld–Wolfen? Who benefited? Who or what was most affected by the collapse of the sector? Each interview lasted generally between 45 and 120 minutes, and respondents were guaranteed full anonymity to encourage candor and protect respondents from potential retaliation. Each participant was given a unique respondent number (e.g., GERE1).

**Table 1.** Methods used for this study, Germany, 2019

Method	Date	Respondents/types	Illustrative institutions or locations
Archival review	February and March 2019	Online research sites and newspapers	Fraunhofer ISF, <i>Mitteldeutsch Zeitung</i> newspaper
Expert research interviews	February and March 2019	GERE1–7	Research institutes, private solar firms, mayors' offices, unions
Community research interviews	February and March 2019	GERC1–7	Solar workers, local newspaper journalist, community members
Site visits and naturalistic observation	February and March 2019	Eight visits. Solar manufacturing sites, affected communities, administrative decision-making centers	Solar Valley, Bitterfeld–Wolfen, Halle, Magdeburg, local museum

Note: GERE = German expert interviews; GERC = German community interviews.

Given the research questions focused partly on community perceptions and impacts, expert interviews were complemented with interviews with community members in the Solar Valley region. These included persons who had worked in the solar manufacturing sector and those who had been directly or indirectly affected by its collapse. In total, seven community interviews were conducted, following the same script as the expert interviews. Each respondent was guaranteed anonymity and was also assigned a unique respondent number (e.g., GERC1).

Finally, to complement the interviews, we conducted eight site visits for naturalistic observation—encompassing three trips to Solar Valley itself, visits to the surrounding towns that benefited from investment and tax revenues, and visits to an industrial history museum. Each of these naturalistic site visits lasted between 20 and 180 minutes.

## Results: Industrial Strategy, Dispossession, and Sacrifice in German Solar Energy

Our results emphasize how solar energy first emerged as a core component of German industrial strategy, one intended to (perhaps ironically) promote domestic and local investment as well as provide jobs. This industrial revitalization was short-lived, however, leading to collapse and eventual processes of disappointment, peripheralization, and sacrifice.

### The Emergence of German Solar Industrial Strategy

According to key actors close to the policy process, the rush of investment into solar manufacturing in Bitterfeld–Wolfen in the early 2000s was facilitated by local government actors, who facilitated tax breaks and other financial incentives for interested companies, all against the backdrop of German industrial strategy (Pakiam, 2011). Other conditions also made the specific area attractive for solar investment, however, including very cheap land values; tax concessions from municipalities; the area's preexisting human resource and technical capacities in chemical and sealing industries, as well as, importantly, workers' willingness to do shift work and commute long distances (to which we return later); and the openness among municipalities to brokering concessionary arrangements on cost-sharing agreements around the setup of new industrial parks. As GERE2 explained:

The experience was a very brief but large bubble within the longer history of industrial production in the region. PV was for a time seen as the “savior” for the region. Solar developed in Germany because of well-educated workforce and infrastructure, supported with the major marketing angle of overseas firms is that the tech is still “engineering in Germany.” It was seen as fitting for the Bitterfeld region due to its experience of coating within the photography and chemical industry. ... Subsidies were given to firms on land prices and they were essentially the reason for the companies to come, along with the improved

infrastructure and convenient location close to Berlin and Leipzig. Also because the region has lower wages and expectations than the Berlin area, and it had a long history of industrial expertise to draw from spanning 125 years.

As they concluded, “People are always waiting for a job” in this region, making it an attractive anchor for solar investment and an ideal location for solar manufacturing.

GERE4 noted that at the height of this boom, things were looking good for Bitterfeld–Wolfen and the broader solar energy sector:

The fact that a young industry located its headquarters in the region was an added bonus, as this had added advantages for workers, who could buy shares in the firms, and local economy and politics, which had more direct influence and financial benefit. The first workers and investors became very rich because of the rises in share prices. At that time, Q Cells stood for innovation in the beginning and a new kind of tech for the region. It was recognized that the “already-settled” chemical industry could provide a good base of knowledge and infrastructure. The factory and industrial installations in Solar Valley were brand new and high tech, and the Solar Valley brand was attractive for new firms. The tristate Solar Valley Mitteldeutsch cluster attracted a lot of federal funds and worked to develop interfirm knowledge and production sharing.

Solar energy offered, in the words of other respondents, a potential manufacturing or industrial “renaissance” and “revitalization” of the entire region. GERC2 commented that because the “industry is young, it didn’t have tradition.” Although this would ultimately mean that there was less political will to save it when competition from China emerged, it initially meant that the solar energy sector was able to cultivate itself as new and modern. As GERC2 continued, the industry ultimately consisted “of a number of newly built factories on the green meadow. At the beginning, when the industry was new, everyone wanted to invest. There was some envy, too.” GERC4 added, “What is remarkable is how fast the solar companies grew, and from how far many commuted to get to work. From Dresden, Leipzig, Berlin.”

At its peak, the sector provided 5,000 to 6,000 jobs locally directly in solar and a further 15,000 indirectly in supporting sectors. It also brought tax revenues for local municipalities, facilitating community funds for new infrastructure, sports clubs, kindergartens, and public transport. It cemented partnerships between solar

firms and local businesses and led, for example, to sponsorship deals between local sports clubs and solar firms, such as Q Cells (e.g., Figure 2). Although the disaggregated local data on financial benefits to Bitterfeld–Wolfen are not available, they are likely to have been at least a third of national financial benefits of the solar manufacturing sector, which stood at 3 billion euros in tax revenue and 5 billion euros in income directly to employees (BSW-Solar Pressestelle 2009).

Perhaps most significant, however, was the way in which the arrival of the solar sector represented a psychological boost for the region itself, which had lived in the shadow of its wealthier western German counterparts ever since the fall of the Berlin Wall and the demise of the coal industry had led to an exodus of the population. The arrival of the solar industry was thus an opportunity for the eastern German region to get ahead in a “global industry of the future” (see Figure 3). As a local politician (GERE7) explained:

Everyone had high hopes that this would become an amazing story. There was never-ending euphoria, and the hope of well-paid jobs. Many who worked in other local industries quit their jobs and swapped over.

Not since the great photography companies such as Agfa had made Wolfen—now part of Bitterfeld–Wolfen—their home had the region been an industrial pioneer in this same sense. This alluring narrative continued to inform the city’s marketing, trying to capitalize on the green credentials of the solar industry to attract tourist development and selling the city as *Grüne Industriestadt am See* (green industrial city on the shores of a lake).

### The Collapse of Solar Energy Manufacturing

Such optimism, however, was short-lived. As explained previously, the solar energy sector began to falter in 2008, before completely collapsing, at least in Bitterfeld–Wolfen, shortly after (Vasagar 2013). As GERC2 explained:

It was all about international competition. The Chinese market surprised us, with lower labor costs and state subsidies. German producers had no chance. China wanted to be world leader.

Shares in German solar firms plummeted, companies went bankrupt, and more than \$20 billion in market value was lost, in what Vasagar (2013, 2) called an industry “meltdown” and a “rare disaster story for German manufacturing.” As GERE1 explained:



Figure 2. A sports club funded by Q Cells in Thalheim, complete with solar panels and floodlighting.

Such a capital-intensive industry with low long-term returns could not have survived in the context of overseas manufacturing price declines in East Asia. The worst impacts on the region were caused by overproduction prior to the financial crisis, after which further loans were not forthcoming. The losers here were the firms who had large debts and had to let hundreds of people go.

The fall of the solar sector thus had several key impacts. Thousands of full-time jobs in solar manufacturing were lost in the Solar Valley. Many of the people who lost their jobs at higher (managerial) levels were more mobile and so could move elsewhere in Germany to find work. A few were able to remain in the small number of solar research and development positions that remained in Germany, because the largely East Asian companies that bought out the German firms found the “Engineered in Germany” tag to be a strong branding pull. Lower skilled workers (who had been trained in the sector and were not unionized), however, had to seek new jobs—within the region’s chemical parks or the newly opened Porsche and BMW factories near

Leipzig, for example—or else they remained unemployed. GERC2 explained:

Even while it was collapsing, working conditions were good. But there was no labor agreement/union rate. Workers were not unionized. It was difficult for us to work with them. With bankruptcy it was very difficult. The labor market could not absorb the surplus labor immediately. We negotiated with them. There was a “transitional company” [*Transfergesellschaft*] that ensured that workers continued to get paid. Many worked reduced hours. Many ended up unemployed.

The municipalities also lost out in several ways. They missed the high tax revenues they had come to rely on for several years, with many of the amenities that had been sustained by solar wealth now lying dormant. As GERE5 explained:

A disadvantage for the community was that, as they were stakeholders in the businesses in Solar Valley and were co-owners of the water/security/road/waste water/street lamps/road gritting infrastructure (e.g., Thalheim village [part of Bitterfeld–Wolfen]), they not only lost revenues on lost profits that they had been enjoying,



**Figure 3.** The high-tech industrial facilities at Solar Valley, with a solar farm in the foreground.

but also had to bear some costs of site decommissioning, for example, paying for security systems to be deinstalled.

Figure 4 shows a multi-million-dollar abandoned factory at Bitterfeld–Wolfen's Sun Park. Furthermore, some municipalities that had entered into cost-sharing arrangements with private solar companies on industrial parks were left with debts to pay and no private-sector counterpart to share the costs.

### **Disappointment, Peripheralization, Resignation, and Acceptable Sacrifice**

The sudden collapse of German solar manufacturing resulted in understandable disappointment, leading to longer lasting dispossession and further solidifying the region as a sacrifice zone for high- and low-carbon development. Following decades of stagnation, high unemployment rates, and political marginalization, the solar industry offered a chance to overcome the legacy of deindustrialization and a promise to catch up with West German development. This was particularly evident at the time of Q Cell's stock market launch, which triggered political excitement and pride in the area. As GERE5 explained:

The big disappointment for the region was that it was seen as a chance for the East to catch up with the West and to excel in something new and futuristic. Thus, the collapse and the loss of really high-quality jobs was a major psychological blow to the region. It was a community, a family; people who worked in the Solar Valley were proud of their jobs and there was a deep sadness about this breaking down. Everything was moving very fast and then suddenly ... the catching up was over.

The emotional loss of the sector and the disappointment associated with high expectations turning to failure was significant. Indeed, the psychological impacts of the bankruptcies, and fears of a second deindustrialization in a region that was still suffering from the catastrophic declines of industry following the fall of the Berlin Wall in the early 1990s, might have been more salient than the job losses. These psychological impacts must be understood in the context of the depression and political resignation that were caused by decades of exploitation and feelings of acting as a “sacrifice zone,” as one respondent put it, for the industrial development of East Germany. In those days, when the Bitterfeld region was mining lignite to generate energy for Germany, “Berlin got the electricity, we got the ashes,” they noted. This shows how economic marginalization



**Figure 4.** An abandoned solar manufacturing factory at Solar Valley.

and peripheralization was exacerbated by political and symbolic marginalization and peripheralization (McQuarrie 2017; see also Cramer 2016; Hochschild 2018), which went beyond the material effects of the double process of deindustrialization.

In her novel about Bitterfeld, published after a newspaper report that she had written about the town was censored by the ruling East German Communist Party, Maron (1981) wrote:

The people of B[itterfeld] have adapted, they have got used to being residents of B[itterfeld] and to get covered with dirt. It may just be harsh and heartless to tell them: You have been forgotten, sacrificed for something more important. And I cannot change that. (45, authors' translation)

Following the fall of the Berlin Wall, people were then left to deal with the consequences of deindustrialization and unemployment and to catch up with capitalist (hyper)development, causing resignation and widespread depression. The fall of solar thus constituted the second crisis in many people's

lifetimes and meant, a local politician (GERE7) explained, that “many families were hit twice.”

This second time around, the decline further entrenched the peripheralization of German households and communities. First, compared with the photography and coal industries, which were well unionized and much more embedded culturally and politically in the region, the lack of unionization and protection around the solar jobs—following years of neoliberal social reforms and increasing precarity and austerity caused by national government decisions—meant that there was little political activism around saving the jobs. As a local journalist (GERC6) summarized:

There was never a big outcry, a big scream when the solar industry fell, compared to the decline of the coal industry. It was noted, reported, but not that it was a huge catastrophe. There was creeping resignation.

Yet, many local people never shared the high expectations and the political enthusiasm in the first place and greeted the loss of solar with the attitude

that the solar experience had been a kind of “blip” or “bubble” that “no one had expected to last” (GERC5).

Finally, a strong notion emerged from our data that Bitterfeld was both a preventable but also acceptable sacrifice on the long and bumpy road toward solar manufacturing globally. GERE1 stated plainly:

The government had the chance to save the industry, but the ideology of free markets said that the sector had to fail. So they also eventually removed anti-dumping measures—which actually had the effect of temporally slowing down the energy transition in Germany.

GERE2 agreed and noted:

I do not believe anything could have been done differently to save the solar industry because there was no way of competing with China, and free markets need to be the deciders of where industrial production takes place. Wealth is created through free markets. We need to let those free markets function. Solar was the first time that Bitterfeld had had to compete with the world. Bitterfeld lost.

GERE4 remarked:

Regional politicians could not do anything because these were bigger questions of globalization. ... The government could have tried to give subsidies to the industry as it does with other sectors, such as the automobile industry, but it didn't want to.

GERC3 agreed and noted:

They [politicians] could have done something—they could have implemented subsidies or tariffs, as part of the German not-so-social market economy, but they didn't want to interfere with the market, they were following free market ideology.

This relative lack of interventionism is particularly noteworthy given current contestation and activism to “save” the ecologically disastrous lignite coal industry in eastern and western Germany, where corporate and state actors collaborate closely to position coal as integral to national interest, as “green” and sustainable, and as indispensable for energy security (Brock and Dunlap 2018; Brock 2019, 2020b). Unlike the solar industry, the coal industry is historically highly unionized, tied into regional and national policymaking, and—also thanks to trade union and climate justice activism—highly present in nationwide media coverage (Brock and Dunlap 2018;

Brock 2019, 2020b). Unlike solar manufacturing in Bitterfeld, coal policy is “high politics” and the cultural and political embeddedness of the sector in German society is far deeper. Coal phaseout thus comes with enormous compensation payments to the industry and promises of just transitions and new (green) jobs.

Others put the collapse of Bitterfeld in context by justifying it on the grounds that it still led to cheaply produced solar energy. GERE3 argued, for example, that for them, the lesson of Bitterfeld is this:

Broadly it really doesn't matter where the semi-conductors and panels are made, what's more important is producing energy. ... It's not the end of the world if that part of the value creation is based in Germany or not. ... At the time, everyone said we should try and compete with China on price, but it's not a fight we could have ever won ... now everything is done cheaply, cheaply, cheaply.

Implicit in this statement is that making solar energy more affordable for everyone is an acceptable consequence at any social or ecological price, even if it meant the Bitterfeld region had to suffer. The carbon reduction imperative is thus far removed from questions of local development, decision making, and power. This illustrates the green capitalist logic that underlies the large-scale rollout of “green” energy without consideration of the need to tackle the systemic problems, inequalities, and injustices associated with the political economy of energy.

Today's political situation, of course—the lack of social and cultural infrastructure and high support for the AFD—is not reducible to the consequence of the collapse of the short-lived Solar Valley dream but the outcome of a longer industrial history of green and nongreen industrial development, political marginalization, dispossession, and alienation. Although the local economy has recovered and unemployment rates have decreased, young people continue to leave the area for lack of cultural and recreational opportunities. As our field research revealed, parts of the city resemble a ghost town, with empty houses and barricaded widows, surrounded by large solar fields (and wind parks) that serve as a reminder of their failed hopes (Figure 5). The city is empty and sparking clean—no graffiti on many of the abandoned buildings, no noisy pubs or local youth hangouts. Many of the enormous East German-style apartment blocks have been torn





Figure 5. The clean but largely quiet and empty city of Bitterfeld, Germany.

down, and others are slowly aging, with an age average of almost eighty years, a local mayor reported.

The resigned acceptance of these processes of marginalization and dispossession is closely linked to the effects of globalization, trade liberalization, and their unequal effects across space and time. They encapsulate what Fisher (2009) has termed “capitalist realism,” or “the widespread sense that not only is capitalism the only viable political and economic system, but also that it is now impossible even to imagine a coherent alternative to it” (2). Such thinking entrenches belief in the inevitability of suffering in the name of “progress,” the need of sacrifice, resembling an almost postpolitical attitude where nothing can be done. Fisher (2009) called this a “pervasive atmosphere that affects people’s thoughts,” and a “kind of invisible barrier constraining thought and action” (16).

The sacrificing of Bitterfeld–Wolfen is the product of politics and a cause of populism: of increasingly precarious employment, flexibilization of work patterns and shift work, eroding class solidarity through weakening of trade unions, and the pervasive messaging from the political establishment as well as the mainstream media: “There Is No

Alternative” (Fisher 2009). The effects are depoliticizing and individualizing. Those losing their solar jobs received only marginal skills training and consultations with the unemployment center and health care for resulting anxieties and depression. Class struggle and solidarity, once an important part of the social fabric in Bitterfeld, have disappeared, allowing room for anti-migrant populism.

Political resignation is being harvested by extreme right-wing, allegedly anti-establishment political parties that promise an alternative: One in three voters in Bitterfeld–Wolfen voted for the far-right, openly racist, xenophobic, and Islamophobic *Alternative for Germany* in the 2016 election. The party’s recent success is grounded in the consequences or failure of modernization, including deindustrialization and prevarication under neoliberalism and unjust and unequal center–periphery relationships (Priester 2019). AFD politicians capitalize on people feeling “left behind,” having “lost control,” and being not just economically but culturally neglected (Priester 2019). The lack of social, material, and cultural infrastructure in Bitterfeld only speaks to this neglect.

Yet, the city was once a center of working-class organization—part of the “red heart of central

Germany” (Löhn 2011, 313), heartland of the social democrats and the Communist Party of Germany, and repeatedly home to strikes and labor struggles. It was central to the East German uprising of 1953 (Schröter 2016), when workers took over Bitterfeld governmental and police structures, releasing political prisoners and almost toppling the regime, until they were defeated by Soviet tanks (Löhn 2011).

Today, many are scared of globalization and “free trade” (Lobenstein 2017), disillusioned by rising inequalities and lack of opportunities. Having witnessed strong government and regional support for the solar industry—subsidies for solar manufacturers, low tax rates, a new Autobahn slip road, in addition to subsidies for solar installations on the national level—many perceive governmental action to prioritize corporate over human well-being (Lobenstein 2017).

The ongoing depression and cynicism, we suggest, are fed by “discontent about the present and the perceived inability to change the future” (Benson and Kirsch 2010, 459). Or, as Fischer (2009) compellingly wrote:

The hegemonic field which capitalist realism secures and intensifies is one in which politics itself has been “disappeared.” ... Capitalist realism doesn’t appear in the first instance, then, as a political position. It emerges instead as a pragmatic adjustment—“this is the way things are now.” This sense of resignation, of fatalism, is crucial to the “realism.” ... Capitalist realism isn’t the direct endorsement of neoliberal doctrine; it’s the idea that, whether we like it or not, the world is governed by neoliberal ideas, and that won’t change. There’s no point fighting the inevitable. (90)

This is particularly interesting given Bitterfeld’s location in the former East Germany. Fisher’s concept of the postpolitical was developed in response to the alleged “end of history” with the fall of the Soviet Union and the Berlin Wall. Despite some nostalgia, few reminisce about East German times in Bitterfeld—yet, there seems to be little imagination for political alternatives. The resulting crisis of imagination (Fisher 2009) is worse, arguably, than the material consequences of deindustrialization. The neoliberal subject, of course, is meant to be a consumer above all, in a system that alienates and individualizes and where consumer choice seems to be the most political act possible.

The resulting resignation, or fatalism, is a hallmark of Blowers’s (1999) peripheralization thesis, according to which peripheral communities resign themselves to hardship and internalize the idea that they should be “grateful” for any benefits that come their way. As Blowers (1999) stated, however, subsequent boom and bust cycles can further heighten the preexisting vulnerabilities that remain from earlier experiences of hardship. It also shows how spatial inequalities can manifest themselves alongside social and economic inequalities that further propel “capitalist realism” and “politics of resignation” within these communities.

## Conclusion

The rise and fall of the solar manufacturing sector in the Bitterfeld region offers insights into the ways in which the whims of global “green” capital can create vulnerabilities and exacerbate inequalities, even in wealthy countries such as Germany (Bickerstaff, Walker, and Bulkeley 2013). In this case, the collapse of Solar Valley offers additional insights into experiences of dispossession and the processes through which peripheralization can be reinforced by even well-meaning attempts to revitalize regions and communities—double marginalized by its geographic location in the eastern part of the country. It also shows how in particular contexts, social, economic, and political aspects of peripheralization and sacrifice can be stronger drivers than environmental factors. Finally, it demonstrates that spatial justice (and injustice) can manifest itself not only through cities and spatial structures but also across the very sociotechnical systems society urgently needs to adopt to decarbonize. Given the sobering connections we find between populism, economic decline, and environmental degradation, failing to attend to the spatial justice implications of renewable energy life cycles also risks intensifying or emboldening a globally resurgent right.

This article has shown that “green” industrial development is by no means automatically social and just—or sustainable, for that matter. Although ecological pollution of solar production continues to be outsourced to the Global South, the social costs become visible even in those countries that have historically profited most from climate crisis, as well as from contemporary energy transitions to mitigate climate change. In our case specifically, the social

costs of green deindustrialization are grave in a country known for its “greenness,” Germany, which is often used as an example that other countries around the world should follow. Within the longer industrial history of the Bitterfeld region, the collapse of solar is clearly dwarfed in its significance by the decline of the photographic industry after more than eighty years, the demise of the coal industry after more than 100 years, and the fall of the Berlin Wall, the legacies of which continue to define the struggles in the region to the present day. Locally, people are therefore resigned about the loss of the solar sector, an attitude that is further comprehensible in the context of the now internalized logic of a contemporary global political economy—that “all that is solid melts to air” (Berman 1983).

Indeed, the current collapse of the wind energy industry in Germany suggests that no sector is safe from the forces of global competition (Bloomberg 2018) but that these forces are also the product of politics. It also implies that future sacrifice zones might be inevitable, as long as new manufacturing sectors emerge (in East Asia or elsewhere) to undercut manufacturing or labor costs or the renewable energy sector remains committed to what respondents termed “free market ideology” and an obsession over making clean energy “cheaply, cheaply, cheaply.” This commitment to markets and obsession with low cost all but guarantee that future peripheralization, given the mobility of capital and labor, unanchored to location, will continually search for profit margins and innovation at the expense of local communities. It lays bare the false promises of green industrialization and ecomodernism, feeding into the rise of populist right-wing parties such as the AFD. “That such an experience should stir populist anger should surprise no one” (Knuth 2019, 640). Yet, our conclusions here are tentative—the link between the lived experiences of (green) deindustrialization and resignation and the rise of populism and the turn to the right urgently require further investigation.

This article points to the spatial justice implications of green (de)industrialization and their links through social erosion, lived experiences of marginalization, and resignation—the localized effects of globalized supply chains and markets. In fact, the demise of solar manufacturing in Germany went hand in hand with the creation of new and much more destructive sacrifice zones in China, with Harkinson (2013) showing that many solar panel

manufacturers are now refusing to provide any information about their manufacturing practices at all, and others are cutting back on recycling programs and environmental commitments. In the German context, this has made the benefits afforded by solar energy manufacturing impermanent and inseparable from the more descriptive forces of capitalism.

The solar manufacturing industry needs to operate at a large scale to take advantage of economies of scale, interviewees explained, thus undermining attempts to decentralize and democratize energy provision. As both the rise and decline of German solar manufacturing but also the German *Energiewende* have shown, they do nothing to disrupt the global political economy and the power relations and inequalities—in Germany and in the world—that industrial-scale renewable energy systems are embedded in, and that need to be challenged as part of any more transformative and longer lasting “green” transition. The *Energiewende* has gone hand in hand with the continued reliance on lignite coal (the world’s dirtiest energy source), investments in oil and gas (domestic and abroad), and political support for many other ecologically destructive industries.

However “green,” capitalism continues to follow the logic of growth, competitiveness, and exploitation of natural and human resources at huge social and ecological costs. Although the *Energiewende* fosters a sense of cleanliness, greenness, and purity around German energy corporations and signals optimism about the green credentials of the German government, it also further obstructs meaningful attempts to build up local and community-owned and -operated energy systems. The German solar sector conservatively reinforces an inherently unequal global and national political economy, rather than fostering a radically restructured economy that runs on principles of solidarity and sustainability, not profit. Radical democratization and decentralization, the mandatory use of recycled materials, while curbing the power of corporations involved in the political economy of energy, with a strict (and strictly enforced) ban of all trade of electronic and other toxic waste together with fundamentally reformed regulations on trade of energy manufacturing resources prioritizing ecological and social justice concerns, might be a start.

The movement of capital, however contradictory and contested it is, leaves material and psychological scars for communities, as this case study on Bitterfeld has shown. Against all this uncertainty, at

least one thing remains certain. For Bitterfeld at least, and as GERE2 put it blithely, “the new horizon of solar energy has disappeared.” Moreover, as a local journalist (GERC4) concluded, although people in the Bitterfeld region “believe that another opportunity will come ... they may be wary of the risks of the renewable sector in the future.” Thus, these negative experiences could influence more broadly people’s perceptions about the potential risks and vulnerabilities of low-carbon transitions, questions about the ecological and social costs, and questions about for whom they are just and equitable. Whether such perceptions will affect Germany’s *Energiewende* or push investment in solar energy to be more just and equitable worldwide remains to be seen.

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## Notes

1. The town of Bitterfeld–Wolfen was formed in 2007 through the merger of formerly independent towns of Bitterfeld and Wolfen, as well as the municipalities of Greppin, Holzweißig, and Thalheim.
2. Antinuclear movements spread in Germany in the 1970s with local citizen initiatives organizing protests, demonstrations, rallies, and legal challenges against plans to build nuclear power stations. In 1975, 28,000 protesters occupied (and later reoccupied) the construction site of a nuclear power plant in Wyhl in the south of the country, leading the local government and administrative court to stop construction.
3. Of the three major solar players in 2010—Solyndra, Nanosolar, and MiaSolé (Woody 2010)—two are now bankrupt, and MiaSolé was acquired by the Chinese company Hanergy in 2013. For an analysis of the rise and fall of Solyndra, the “central actor within the ‘green’ niche around renewable energy in the US in the late 2000s” and recipient of major government loans, see Caprotti (2017, 938).

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