

This document is the Accepted Manuscript version of a Published Work that appeared in final form in:

Siddharth Sareen, Alevgul H Sorman, Ryan Stock, Katherine Mahoney, Bérénice Girard. 2023. **Solidaric solarities: Governance principles for transforming solar power relations** *Progress in Environmental Geography*. 2. DOI (<https://doi.org/10.1177/27539687231190656>).

© The Author(s) 2023

This manuscript version is made available under the CC-BY-NC-ND 4.0 license

<http://creativecommons.org/licenses/by-nc-nd/4.0/>

Solidaric solarities: Governance principles for transforming solar power relations

Abstract

Solar energy has become the world's cheapest and fastest scaling electricity source. Multiple societal sectors are electrifying, and the scale and pace of change give some hope of near-future rapid climate mitigation through solar rollouts despite the bleak record to date. Critiques of utility-scale solar development foreground injustices like displacing marginalised groups and perpetuating resource inequity. Governance scholars argue for stringent regulations towards just transitions, and community energy research shows that smaller-scale solar solutions hold promise in being more equitable. Our contribution argues for the possibility of redistributive and emancipatory solar development, drawing from scholarship on governance (institutional configurations, policy mixes and cross-sectoral regulation) and scale (comparative energy geographies with attention to context-specificity and trans-local connection). We conceptualise and operationalise the term 'solidaric solarities' as modalities of harnessing solar energy to advance empowerment, interconnectedness and community wealth for victims of energy injustices. This focuses on political economy issues, where solar development can advance solidarity with historically marginalised groups, to create affordable distributed future renewable energy systems. The analysis underpinning this normative orientation leverages secondary research and scholarly expertise on solar rollouts. We offer pragmatic governance principles informed by values that engender solidarity, illuminating potential pathways to enable solidaric solar transitions.

I Introduction: Conceptualising solidarity in solar energy governance and geographies

Solar rollouts – the implementation and embedment of solar energy technologies into our energy systems – constitute the most rapidly advancing energy transition worldwide. They open vistas of possibility for low-carbon energy transitions at an unprecedented pace ([Luderer et al. 2022](#)). While not yet directly displacing fossil fuel systems, their scale is changing electricity mixes and making electrification of other sectors a plausible decarbonisation strategy in the 2020s. Solar rollouts are a form of *solarity*, namely 'a state, condition, or quality developed in relation to the sun, or to energy derived from the sun' ([After Oil Collective 2022](#)). The promise of harnessing abundant solar energy for human activity is welcome in a world challenged by climate change to rapidly displace fossil fuels and power systems with renewable energy sources ([Koretsky et al. 2022](#)). *Prima facie*, solar rollouts thus fit

what [McCarthy \(2015\)](#) has famously termed (and critically problematised as) a ‘socioecological fix’.

Solar scholars point to injustices perpetrated by their most rapid and large-scale forms – solar plants in the hundreds and thousands of megawatts (MW). These injustices, documented in diverse forms at multiple scales and geographies ([Samarakoon 2020](#); [Sovacool et al. 2022](#)), can lead to sacrifice zones ([Brock, Sovacool and Hook 2021](#)) and dispossession ([Stock 2022a](#)). Injustices span displacement of marginalised groups, ecosystem changes, and complex knock-on effects of rapid changes in land use. These patterns are often driven by elite actors with preferential access to financial capital and the support of state institutions for easy licensing to prioritise rapid solar growth. The massive-scale commodification of solar energy along these lines can be interpreted as a mere continuation of extractive capitalism under the auspices of saving the planet, and continued pressure – even if green – is liable to produce unjust, ‘unexpected and counterintuitive effects elsewhere’ (Boulding 1978, 352). Thus, a rapid and large-scale ontology of solar rollouts and ownership structures appears likely to constitute forms of solar energy that are elitist, exclusive, and exacerbate existing inequalities, leading to eventual energy marginalisation ([Sanusi and Spahn 2020](#)). Ultimately the continued promotion of energy systems which fail to address these injustices potentially prejudices acceptance of energy transitions themselves, with corresponding implications for the success of the climate change agenda. Quite ironically, while the realisation of the climate change agenda implies redressing a series of injustices, dispossessionary modalities of solar development, rapidly elaborated for climate mitigation, may reproduce climate vulnerability for marginalised groups. In practice, then, large-scale solar rollouts may be a limited ecological fix, but are hardly a social one given what [Lennon \(2021\)](#) refers to as ‘intersecting precarities’.

Although possibly less rapid and with currently less megawattage capacity in global trends, smaller-scale solar rollouts nonetheless hold considerable promise of upscaling and equity through replicable community-scale models ([Luke and Heynen 2020](#)). Examples of upscaling are increasingly available in multiple contexts ([DellaValle and Czako 2022](#)), showing that cost-competitive alternatives to large-scale solar do exist and can advance just transitions. Yet these are typically not favoured by existing energy sector political economies or tend to fall back into dominant governance regimes, due to infrastructural path dependence and bureaucratic lock-ins. Common explanations of barriers offer rationales of increased transaction costs to enable many small-scale projects to make up a large share of the electricity grid mix. However, many accounts emphasise the system efficiencies of distributed energy generation systems, indicating that the crux of the matter lies in how contrasting spatial ontologies distribute benefits among solar actors ([Cruz 2018](#); [Delina 2020](#)). In light of advances in digitalisation of energy systems and especially electricity grids in order to drive further decarbonisation across sectors, the integration of distributed solar power on grids with energy flexibility technologies has become trivial from a purely technical perspective ([Lüth et al. 2018](#)). The persistence of scalar biases in favour of large-scale solar thus indicates – often intractable – incumbent politics, and a lack of investment in equitably reconfiguring the electric grid beyond infrastructural upgrades and technological innovations.

Rather than naively hopeful analyses or the by-now well-rehearsed gloom of cataloguing rampant energy injustices, we echo the ‘photovoltaic realism’ of [Cross \(2019\)](#); as cited in [Samarakoon, Bartlett and Munro 2021](#)), by engaging with political economic issues. While mindful of empirical trends, we nonetheless remain open to multiple futures, e.g., more community-oriented large-scale solar rollouts, and more hopeful configurations of well-

financed and scalable small-scale solar solutions. We argue that to identify ways towards such desirable sustainable futures, we need a fit-for-purpose conceptualisation of solar power. For this, we draw on *solidarity* as an important concept that is under-theorised in energy studies. Solidarity is ‘the tie which binds all of us human beings to one big moral community’ ([Bayertz 1999](#), 5). Building from this concept, we conceptualise *solidaric solarities* as modalities of solar rollouts that respect and advance this grounded interconnectedness and normative commitment to energy justice. We define them as modalities of harnessing solar energy to advance empowerment, interconnectedness and community wealth for victims of energy injustices, towards redistributive and emancipatory solar development. We aim to operationalise this coinage to systematically empower disadvantaged actors to channel the sun to advance community wealth building ([Lacey-Barnacle, Smith and Foxon 2023](#)), while also networking solar subalterns across geographical scales and engendering alternative solar configurations that may function as reparations for patriarchal and petro-racial colonial-capitalist ruination and dispossession.

Undertaking this analysis entails unpacking the power relations at work in configuring solar rollouts in terms of their spatial ontology, ownership and distributive outcomes ([Horstink, Wittmayer and Ng 2021](#)), towards which we draw from energy governance research. However, as solar rollouts take place in close entanglement with increasingly digitalised energy infrastructure ([Kangas et al. 2021](#)) evolving into more complex and cross-sectoral socio-technical systems (i.e., including electric grids, land uses, energy storage technologies), we also draw from scholarship on cross-sectoral regulation. This emergent aspect of solar governance research constitutes a key socio-material thrust of our study. Moreover, we mobilise instructive empirical examples from diverse contexts, energy geographies and spatial scales in order to ensure that our analysis extends across comparative energy geographies ([Munro and Samarakoon 2022](#)). This entails drawing from the energy geographies literature which explicitly addresses multi-scalar aspects. Within this, we emphasise trans-local connection as an important yet under-studied aspect related to solidaric activities. This enables us to balance attention to context-specific solarities and its wider effects elsewhere. To systematise our inspiration from governance and energy geographies research into an analytical lens, we emphasise purpose, process and scale in relation to key aspects of solar development.

We acknowledge extant scholarship on solidarity in established scholarly traditions. Economic anthropologists and sociologists in particular have contributed insights on related concepts of reciprocity and redistribution, going back to [Mauss’ landmark essay \(1990 \[1925\]\)](#) on gift-giving and exchange, with more recent engagements making explicit links from this to solidarity (e.g., [Molm, Collett and Schaefer 2007](#); [Córdoba, Peredo and Chaves 2021](#)). Notably, [Roediger \(2019\)](#) expresses unease with the fluidity of solidarity as a concept, and emphasises the need to exercise caution in using it. In their edited collection on solidarity and difference, [Fleischmann et al. \(2022\)](#), 233) trouble Western notions of solidarity, highlight its multiplicity of interpretations, and champion its potential to advance ‘understanding of subjectivity shaped by power relations embedded in multiple social experiences’. It is beyond the scope of this article to unpack these complex debates that span many fields and sectors. Rather, we seek to systematise and mobilise existing conceptualisations of solidarity and elevate this debate in energy studies. Hence, while taking instruction from broader scholarship on solidarity, we are interested in drawing together and analysing fertile articulations by scholars of solar development to fashion *solidaric solarities* as an engaged heuristic with direct application to engender equitable solar rollouts.

We crystallise a core set of values within solar governance and geographies that can constitute solidaric solarities by consolidating the richness of recent literature and our collective expertise as interdisciplinary social scientists studying solar energy. To operationalise this conceptual insight, we condense the analysis to a set of governance principles that the multiplicity of stakeholders enacting and impacted by solar rollouts can use to shape solar development. Rather than a solarity attuned to the reductive telos of rapid mitigation alone, a solidaric solarity aligns closely with just transition ambitions ([Sareen and Shokrgozar 2022](#)). Yet we acknowledge an important distinction between justice and solidarity, the former heavily theorised in energy social science, whereas the latter remains under-theorised yet critical for engendering empowerment through alternative energy regimes like solar photovoltaic (PV) systems.

We argue that solar development needs specific governance principles for solidaric solarities, informed by normative values that orient implementation and influence governance. Moreover, [Sovacool et al. \(2023\)](#) call to pluralise energy justice supported by feminist, antiracist, indigenous and postcolonial perspectives. In engaging with this, we situate our solidaric solarities argument at the core of the recent review by [Upham, Sovacool and Ghosh \(2022\)](#) which highlights three schools of thought (energy justice, sustainability transitions, and energy democracy) within the just transitions literature, each with different assumptions, lenses and actors in terms of agency. We hold that by embracing values that constitute solidaric solarities, with pluralised perspectives on justice and situated within the tripod schools of thought, it is possible to incorporate place-specific considerations of both scale as well as governance. This is vital in order not to be co-opted by dominant incumbent actors and energy system logics that reproduce spatial ontologies and ownership patterns associated with inequitable distributive outcomes. It is also important in order to reflect context-specific, situated values which vary across different geographies. Our conceptualisation of solidaric solarities explicitly targets both governance and scalar issues to match the multi-scalar socio-materiality of solar rollouts. Acknowledging the entanglement of solar rollouts with trends such as digitalisation, and the complexity of energy geographies with diverse electricity grid mixes and tensions with cognate aspects like land use and energy storage technologies, governance principles can inform critical choices that align action with 'photovoltaically realistic' just energy transitions. Grounding our argument in energy governance scholarship enhances wider applicability of proposed governance principles.

The article is structured as follows. The next section reviews energy governance and energy geographies research, and through it develops our methodology, visualised as a heuristic. We then deploy this to interrogate what constitutes solidaric solarities in an analytical section, which culminates in a table with values backed by examples from scholarship. The subsequent section operationalises these values into two core governance principles to advance solidaric solar development. Finally, we offer concluding reflections on the merits and limitations of centring solidarity in research on the governance of energy transitions.

II Review and methodology: Towards identifying principles of solidaric solarity

During rapid socio-technical transitions based on innovation without adequate anticipatory regulation, such as solar development, innovation and regulation scholars have shown that self-interest tends to take precedence. An analysis by [Hess \(2014\)](#), however, indicates how overlapping interests can forge political coalitions between quite unlikely partners such as grassroots organisations and technology industries. Furthermore, [Matschoss et al. \(2022\)](#) point out that social innovations can propagate due to supportive policy mixes, meaning that

regulatory support can itself act as a form of solidarity for bottom-up alternatives that counter injustice in energy transitions. Other scholars have shown how energy transitions such as coal phase-out can pose dilemmas between injustice and solidarity ([Brown and Spiegel 2019](#)). *De facto* justice does not always engender unity or empowerment for victims of solar injustices. This motivates our emphasis on solidarity, which implies unity with the victims of injustice and can advance towards alternative governance structures mindful of ensuring positive effects on others. Solidarity is concerned with actions that engender empowerment and affective attributes such as support, empathy, allyship, and aspects portended in relation to collective moral determinations of cosmopolitan justice which holds individuals to be worthy of equal concern, respect and protection. The latter is underdeveloped compared to distributive, procedural and recognitional aspects of justice, all of which contain spatial dimensions ([Sovacool et al. 2019](#)). Below, we draw out key claims on energy governance (how the field of actors is structured and steered) and energy geographies (how solar development is spatialised and socialised) from thematic research. This leads into a visual heuristic for assessment of solidarity in solar development.

2.1 Energy governance: Institutional configurations, policy mixes and cross-sectoral regulation

A.

Institutional configurations: Scholars of energy governance have underlined how power asymmetries between financial and political actors at different scales shape policymaking and regulations. In the global South, transnational actors and capital, such as international donors and large corporations, often have a central role in shaping the discourse and overall trajectory of the solar rollout ([Newell and Phillips 2016](#)). National actors, such as state elites and incumbent players, also often have undue influence, as socioecological relationships on the ground are routinely held subsidiary to national visions of transition ([Rignall 2016](#)). Expressions of dissent and local resistance are subdued in the name of national interest despite the actual beneficiaries often being corporate players ([Bedi 2019](#)). Regulations often facilitate certain players and erect barriers for others, typically enabling non-transformative technological substitution. The scalar bias towards utility-scale solar is an example of such a dynamic, as it is often upheld by power asymmetries between large-scale actors who secure requisite capital and licences, and smaller-scale actors who require longer timeframes and face greater institutional barriers to advance solar development ([Sareen and Haarstad 2021](#)). Dispossession is a common corollary to capital accumulation, produced again through unequal power relations between marginalised rural inhabitants and project developers with high social and financial capital ([Yenneti, Day and Golubchikov 2016](#)).

Yet dominant actors and regulations are changing in response to advancing energy transitions ([Sareen et al. 2022](#)). One reading is that this merely conveys the impression of (cosmetic) change as a means to preserve the status quo. In many cases, we indeed observe gradual and limited institutional change, which does not threaten incumbents' dominant position in any substantial way ([Koretsky et al. 2022](#); [Leiren and Reimer 2018](#)). But, in some cases, institutional reconfiguration constitutes an attempt to undertake adaptive regulation – undergirded in more equitable accountability relations – to generate public benefits during solar rollouts. Accounts of remunicipalisation show what is at stake in terms of citizen empowerment and equitable revenue sharing ([Cumbers and Becker 2018](#)). Yet changing the scale of where authority is exercised alone is inadequate, as unequal power relations exist at lower scales, too. Thus, ensuring systems of checks and balances remains vitally important

([Hanke, Guyet and Feenstra 2021](#)). While social movements can be powerful in catalysing change ([Temper et al. 2020](#)), the challenge of institutionalising such change despite incumbency remains a key one to create lasting impact on benefit distribution in solar rollouts. Initial forays have yielded many lessons, but imbibing them for institutional innovation remains a context-specific challenge.

A main takeaway from energy governance research for solidaric solar development is that while institutional configurations are often undergirded by power asymmetries in which undue influence is given to powerful actors at the national and transnational scales, they can be changed and new regulatory assemblages can be constructed. What this institutional and infrastructural assemblage can be attuned to accomplish is a function of the socio-political shifts that political coalitions ([Hess 2014](#)) and popular mobilisations ([Temper et al. 2020](#)) secure through contestation and negotiation, in order to move into closer alignment with situated just transition objectives. Hence, institutional reconfiguration is a matter of context-specific popular legitimation.

B.

Policy mixes and cross-sectoral regulation: Solar rollouts are not only inevitably subject to political dynamics and regulatory inertia, but also to existing infrastructures and potential for grid connectivity ([Sareen 2022](#)). Electricity infrastructures are highly heterogeneous across the solar implementation landscape: some awash with excess capacity, others in disrepair or in need of strengthening or expansion. The implementation of solar infrastructures also unfolds according to energy needs, which includes industrial demands, residential needs and mixed-use temporal configurations that facilitate capacity addition. However, despite advocacy of the capabilities approach ([Day, Walker and Simcock 2016](#)), and ideals of adequate levels of energy service provision ([Bouzarovski and Petrova 2015](#)), servicing energy needs themselves typically entails normative and political calculations of value based on capital accumulation strategies and investor interests. More generally, solar energy and capital flows are often path-dependent on the incumbent fossil energy regimes they seek to replace ([Sareen et al. 2020](#)). The logic of existing modalities in energy systems, such as base-load models associated with coal-dominated grids, continues to hold embodied sway in decision makers' activities ([Roy and Schaffartzik 2021](#)). As such, the global proliferation of solar energy infrastructures and technologies has thus far produced uneven energy geographies, often adding more electric power for the powerful and paradoxically exacerbating the darkness of the powerless whose struggles with energy poverty persist ([Stock 2021a](#)).

Solar rollouts are also often outcomes of navigating multiple dynamics related to land use linked with livelihoods (e.g., agriculture, pastoralism), ecosystems (e.g., deserts, forests), and infrastructures (e.g., industrial, residential). Existing and conflicting land uses, tenure regimes and zoning ordinances complicate land acquisition and enclosure processes. Recent implementation of utility-scale solar infrastructures on rural lands with marginal soils has disrupted agrarian livelihoods through the dispossession of land and dislocation of resource access ([Bedi 2019](#)). Importantly, studies show that navigating these dynamics complicates optimal cross-sectoral governance. For utility-scale solar, key land use regulation challenges include balancing low-carbon energy production gains with ecological impacts, and with the demographic and cultural changes associated with transitioning traditionally agricultural areas to sites of energy production ([Uebelhor et al. 2021](#)). Models that make use of the built or disused environment for solar energy production advantageously reduce land demand pressures. However, regulatory planning challenges arise where drivers of higher urban

density (beneficial for energy efficiency and transport energy cuts) reduce space for solar installations. This limits beneficiaries and diminishes the efficiency of installations ([Poruschi and Ambrey 2019](#)). These findings link to broader uncertainties for community energy and prosumer models to deliver just transitions ([Hanke, Guyet and Feenstra 2021](#)).

Solar rollouts are also shaped by utopian discourse on sustainable solar solutions to the climate crisis. Societal imaginaries drive rollouts while often legitimating the reproduction of inequitable production relations ([Stock 2021b](#)). Specifically, evolving techno-industrial dynamics due to sectoral coupling are shaping implementation, as solar is systemically coupled with other transformative infrastructures, like transport electrification, hybrid fuel investments like green hydrogen based on solar-powered hydrolysis, and energy storage technologies like batteries ([Goodstein, Hunter and Lovins 2019](#)). As a potential key contributor to green hydrogen and European electricity decarbonisation by 2050 ([Kakoulaki et al. 2021](#)), solar development interfaces with the transport sector both through battery storage technologies ([Yung Yap, Huin Chin and Klemeš 2022](#)) and in broader sectoral electrification ([García-Olivares, Solé and Osychenko 2018](#)).

Given these power dynamics, socio-technical entanglements and dominant pathways, solar development governance must address the complex socio-political milieu of 'solar+', where the '+' encompasses the multi-scalar and cross-sectoral regulation of aspects cognate to solar energy that constitute future energy systems ([Silva and Sareen 2021](#)). The scholarship presented above highlights a problematic incapacity of current approaches to adhere to varied policy demands, particularly relative to delivering a just energy transition. A well-rounded governance paradigm related to solar rollouts could more effectively engender the rapid elaboration and scaling of solar energy required to mitigate the climate crisis, while also circumnavigating and ameliorating injustices associated with trans-local solar value chains.

2.2 Energy geographies: Scale, context-specificity and trans-local connection

Solar rollouts and the spatial rearrangement of energy sources are subject to multifaceted feasibility and land availability considerations, which structure new possibilities ([Geels 2005](#)) or vulnerabilities ([Capellán-Pérez, De Castro and Arto 2017](#)) for solar innovation. This is especially so when accounting for associated factors like trade, with China the global manufacturing hub for solar PV modules. Space and the ways in which territories are opened up for solar development can promote socio-technical transformation, but equally reproduce business-as-usual geographical and geopolitical power constellations ([Avila et al. 2022](#)).

Actors within a given energy system (national or sub-national) tend to focus on solving its challenges directed from the centre to the periphery ([Tirado-Herrero and Fuller 2021](#)). Yet, diverse small-scale and distributed 'smart' local energy systems offer rich insights into transition dynamics and leapfrogging options, with scope to transfer insights on some fungible models across contexts. Studies show that solar innovations applied at a local scale offer opportunities to respond to path dependencies and context specificities, for just and decolonial implementation modalities ([Álvarez and Coolsaet 2020](#)). However, local planning and policy does not necessarily translate into desired socioecological outcomes, referred to as 'the local trap' ([Brown and Purcell 2005](#)). Rather than romanticised, celebratory narratives of solar rollouts to 'end darkness', as shown for the case of Malawi ([Samarakoon, Bartlett and Munro 2021](#)), local strategies require keen attention to scope for systemic, structural injustices to arise, even as they offer insights into possibilities of bottom-up solidarity with vulnerable populations.

Recognition that context-specificity matters implies working with the feasibility of models within a given political economy. This in turn requires an acute understanding of how particular aspects of energy geographies – for example, fossil fuel abundance or scarcity, renewable energy sources and existing energy infrastructure, the spatiality of energy demand – are linked with situated political economies. Solar actors are mobile across geographies and solar policies are not shaped in national vacuums, but rather benefit from cross-pollination across sectors and contexts. Large-scale solar rollouts have leveraged this (e.g., reverse e-auctions, plant monitoring technologies) in ways that may hold promise for smaller-scale solar rollouts to attain rapid replication in many places. [DellaValle and Czako \(2022\)](#) show a number of projects where such efforts are underway.

Governance principles can benefit from drawing on diverse global experiences across heterogeneous energy geographies, as well as on context-specific political economic trends, in order to shape solar development in closer alignment with solidarity rather than injustice, with an emphasis on smaller-scale replication in multiple energy geographies (using frontrunners as pilots for validation). Equitable governance and socio-political understanding can be enhanced by attending to scalar choices and geographical characteristics in tandem. Finer scales increase resolution and enable responding to local needs, to co-create the integration of solar technology with users' visions. [Kurtz \(2003\)](#) articulates this as the need for nuanced formulations of scale beyond analytical characterisation, to combine regulatory frameworks and territorial self-determination practices and thereby enhance cultural legitimacy. Thus, while seeking inspiration from diverse energy geographies, solar development requires customisation to specific local contexts, needs and situated publics.

2.3 The solidarity of solar

Bearing in mind the insights on energy governance and energy geographies above, we approach solar energy development in terms of the balance between its purpose, process and scale (see [Figure 1](#)). Purpose ranges between utilitarian and solidaric, process is characterised on a spectrum from unjust to just, and scale extends from large-scale to small-scale. While these spectra of purpose, process and scale should not be taken as strict dialectics between polar opposite driving forces, they represent the ranges we find empirical examples positioned across as a useful heuristic.

Values that faci

Utilitarian

Small-scale

03

Go

Figure 1. Governance and scalar heuristics to assess the solidarity of solar. [OPEN IN](#)

VIEWER

The governance focus, applied to purpose, process and scale, opens up insights into the configuration of authority as institutional logics which are unmade and made anew with the rapid proliferation of solar energy sources. Our cross-sectoral regulation lens emphasises relations across sectors with aspects cognate to solar rollouts, such as electricity grid mixes, land use changes and energy flexibility technologies. Our focus through both angles brings a reflexive governance perspective to solar development at diverse scales, backed by contrasting motivation and through multiple modalities of implementation. Our latter analytical approach attends comparatively to energy geographies, recognising that complex interdependencies of geophysical and built environments have shaped context-specific energy systems over time, and condition solar rollouts and their political economy. These interdependencies play out in varied ways at and across different scales – potentially misconstrued as complementary and/or contradictory when comparing across diverse energy geographies – serving distinct purposes at each, with specific processes often at play in solar development at particular scales. Our analysis in the next section deploys this framework and draws upon case examples to identify core values to influence governance principles that we argue are essential to move toward solidaric solarities.

III Analysis: Governance and geographies of solar development

In this section, we apply the core scholarly insights from the vantage point of the lenses of governance and geography to analyse ways forward for redistributive and emancipatory solar development—rather, alternative configurations of solar that embody *solidaric solarities*. To be precise, solidaric solarities are not *a priori* redistributive and emancipatory in their effects, but embody values, attributes and normative commitments that must be coupled with supportive and empowering actions to create the conditions for emancipatory and redistributive solar energy systems. Based on a review of solar energy governance and energy geographies scholarship, we first highlight the need for solidarity in relation to each field, and then identify scope to enable more solidaric solar development globally, before enumerating essential (yet not exhaustive) values for engendering solidaric solarities.

3.1 The need for solidaric solar energy governance

Actors safeguarding existing institutional configurations, implementation modalities and power relations of fossil-based energy systems seek to ensure gradual incrementalism over transformative change. Policymakers and regulators who embody entrenched resistance to new governance mechanisms typically wish to avoid a complete sectoral overhaul and are wary of its deep political impacts ([Sareen and Kale 2018](#)). They limit the potential for change by greening discourses even as they stymie the most innovative and radical potentialities of solar development. This perpetuates priorities such as supplying large amounts of cheap electricity while hastening climate mitigation rather than enhancing end-user control and advancing solidarity. This is apparent in targets and metrics focused on installed capacity rather than social gains ([Arabindoo 2020](#)). Scholarship also shows many cases in which incumbents limit the disruptive potential of existing policy instruments by giving pushback to rules that threaten their position, for example, the move from feed-in-tariffs to solar auctions in Germany ([Leiren and Reimer 2018](#)). This can also be illustrated by the evolution of feed-in-tariffs in France, which, upon their introduction, represented a shift to decentralised energy politics. A 2010 moratorium and subsequent policy adjustments however prolonged pro-incumbent legacies of centralised, top-down energy production planning ([Cointe 2017](#)). Thus,

the global solar governance and regulation landscape is quite heterogeneous, leading to uncoordinated and divergent outcomes that may, in aggregate, fail to achieve transnational climate and energy targets ([Sanderink 2020](#)).

Dominant governance regimes of solar energy favour incumbent energy institutions, corporations and elites at the expense of marginalised populations whose energy poverty becomes a *raison d'être* for solar rollout, irrespective of inequitable implementation and ironic perpetuation of energy poverty. Solar energy rollouts are largely not being governed according to multi-scalar and cross-sectoral approaches. Where this does occur, cross-sectoral regulation of solar energy can promote injustices through system rigidity, risk transfer through financialisation, and unaccountable legitimisation practices. For example, incumbent fossil fuel energy regimes (e.g., coal) continue to exercise dominance over the energy sector in India, indicating rigid energy systems that resist renewable transitions ([Roy and Schaffartzik 2021](#)). In Lancaster, California, solar energy developers employed globalised financial innovations in the context of economic crises and regulatory changes that spread financial risks across projects and transferred them to the community ([Kennedy and Stock 2022](#)). Policymakers leveraged narrowly-conceived metrics to legitimate inadequate action towards solar uptake in Portugal's energy system ([Sareen 2020](#)). In Greece, regulatory amendments and a failure to adapt generous tariff timelines despite cost decreases for large-scale projects forced tariff cuts. This combined with the economic recession to negatively impact public perceptions and acceptance of solar rollout ([Nikas et al. 2020](#)). This implies denying citizens both the broader intrinsic benefits of the energy transition and more direct benefits such as enhanced control over energy consumption and ultimately costs. Thus, there is a clear need for more solidaric solar energy governance.

3.2 The need for solidaric solar energy geographies

Solar transitions have disproportionately burdened low-income communities of colour ([Carley and Konisky 2020](#)), marginalising populations that face additional barriers in adoption of rooftop solar systems ([Lukanov and Krieger 2019](#); [Reames 2020](#); [Sunter, Castellanos and Kammen 2019](#)). In the United States, majority Black neighbourhoods also disproportionately suffer from blackouts caused by substandard electricity infrastructures and less access to solar-generated electricity ([Brockway, Conde and Callaway 2021](#)). In manoeuvres to limit the financial risk to investors, as noted just above, developers of utility-scale solar infrastructures transfer social and ecological risks to adjacent communities. The manufacturing of solar panels can produce sacrifice zones defined by ecological toxicity and precarious labour ([Brock, Sovacool and Hook 2021](#); [Mulaney 2019](#)). At times, even solar energy cooperatives in Germany have been critiqued as 'commons on the inside', but 'capitalist on the outside' ([Bollier 2017](#), 47) depending on the market and extractive mechanisms that they rely on. A general critique of solar business models is that, within a market-based economy and a sector reliant on extractive minerals, they are known to (re)produce patterns of land and resource appropriation ([Ghosh, Bryant and Pillai 2022](#)).

The global imperative to implement large-scale solar infrastructures to swiftly mitigate the climate crisis has led to a 'global land rush' ([Scheidel and Sorman 2012](#)), often exacerbating land-use conflicts by 'green grabbing' productive spaces for marginalised producers ([Avila et al. 2022](#); [EJAtlas 2019](#); [Franco and Borrás 2019](#)). Acquiring space for utility-scale solar projects has often entailed the dispossession of land from marginalised farmers ([Bedi 2019](#); [Stock and Birkenholtz 2021](#); [Yenneti, Day and Golubchikov 2016](#)). Large-scale solar infrastructures can be conceived of as energy plantations, fraught with colonial-capitalist production relations that

racialise alienated peasants ([Stock 2022a](#)). Solar-related land enclosures have also dislocated energy impoverished populations from accessing firewood needed for cooking, disproportionately impacting resource dependent women ([Stock 2022b](#); [Stock and Birkenholtz 2020](#)). The distribution of solar energy is also inequitable, with marginalised populations facing interrupted or inadequate current despite proximity to solar parks ([Bedi 2022](#); [Stock and Birkenholtz 2021](#)). Yet even solar micro-grids unevenly distribute access to solar energy ([Cantoni, Caprotti and de Groot 2022](#); [Guillou and Girard 2022](#)), and can engender resource dispossession and conflict ([Nuru, Rhoades and Sovacool 2022](#)). Solar infrastructures are thus material artefacts that mediate social relations. With solar development emergent in unjust energy regimes, there is a clear need for solidaric energy geographies that trouble and transform existing power relations.

3.3 Scope for solidaric values to inform solar energy governance and energy geographies

The inequitable track record of solar development shows ample scope for policymakers, practitioners and wider stakeholders to be more attuned to the institutional logics and actors, regulatory frameworks and policy mixes, and diverse energy geographies of solar development.

Multi-scalar and cross-sectoral approaches to solar energy governance and regulation can promote a more equitable rollout of solar interventions. Through governing the 'solar+' socio-political milieu, decision makers can better account for embodied energy injustices throughout the value chain ([Healy, Stephens and Malin 2019](#)), and be accountable to those victims who viscerally embody these embodied energy injustices ([Stock 2022b](#)). Cross-sectoral regulation can engender equitable solar energy rollout through improved accountability relations that design, implement and regulate solar energy according to normative principles of equity ([Sareen and Shokrgozar 2022](#)). Such a transformation in accountability relations will likely include participatory design and decision-making, decentralised energy generation, and redistributive and reparative politics. Multi-scalar and cross-sectoral regulation can also forge solidarities across disparate cultural and energy geographies by creating the conditions of possibility for these participatory, decentralised and reparative solar relations to emerge, while networking them transnationally. Solar power should be used to empower the disempowered while also powering our lives. Our study builds on existing scholarship by [Sovacool et al. \(2022\)](#) that establishes a matrix of policy recommendations towards improved solar justice that include shared-ownership business models, improved governance and targeted interventions to prioritise areas that face excessive deprivation.

A core governance principle related to cross-sectoral regulation in solar development is a radical ethics of care and interdependency. Designing and implementing all solar projects and policies according to holistic guidelines of compassion and cooperation can prevent inequitable solar interventions from switching on in the first place. All institutions and stakeholders involved in and affected by solar rollout should be bound by such guidelines. While unlikely to immediately foster participatory, decentralised and reparative solar interventions, guidelines of compassion and cooperation will establish careful, reciprocal and redistributive accountability relations that serve as the preconditions necessary for the just and solidaric solarities we seek, despite diverse place-situated interpretations of solidarity and their trans-local implications for reciprocity and redistribution.

Yet being mindful of these governance principles is insufficient to engender equitable and empowering solar interventions. Victims of solar injustices rarely receive justice for the harms or deprivations they experience. Juridico-legal frameworks for rectifying wrongs do not often

lead to empowerment for victims, nor prevent future solar-related injustices from occurring, as exemplified in the patterns of dispossession we see occurring globally in relation to utility-scale solar rollouts. Additionally, the elevated burden of proof for victims to legally establish claims of the injustices they experience can preclude restitution, as their deprivations and dispossessions are, at times, not legible to the institutions tasked with the prosecution of injustices and the delivery of justice. Furthermore, the process of seeking justice generally implies considerable investment in terms of time and economic resource which may evade those in disadvantaged situations. As such, we recognise that justice often is inadequate for or beyond the de facto reach of victims of solar injustices, and weakly secured at best, as it does not preclude similar injustices unfolding in the future or elsewhere. Thus, we hold that there needs to be a transformation of accountability relations within solar interventions that actually engenders empowerment of stakeholders or victims.

To this end, [Table 1](#) enumerates a core set of values that, if utilised to guide the design and implementation of solar interventions, could facilitate more equitable solar development. In it, we describe values that should inform redistributive and emancipatory solar relations that embody solidaric solarities, to shift accountability relations from justice to solidarity. The table outlines a description of each value, examples of cases that embody these values, and supporting literature that delves deeper into examples and reflections for each value. However, each case may (and likely does) embody more than one value. We do not claim this list to be comprehensive nor a clean delineation between values and processes, but rather acknowledge overlap as well as gaps. Rather than providing a full review of the individual values inherent to each case, we use each case as a practical example to foreground one value. The values are structured consistently with our three spectra of purpose, process and scale, each subsumed within one of these for clarity of presentation, while being mindful that these values inherently also overlap with other spectra.

Table 1. Values informing redistributive and emancipatory solar relations that embody solidaric solarities.

| Spectra | Value | Description | Case | Su |
|---------|----------------|---|--|--|
| Purpose | Anticapitalist | Solar regimes and interventions not managed according to motives of profitability and growth | Art installations of the Rjukan Solarpunk Academy in Norway | Kalli Coll 202 and |
| | Antiracist | Solar interventions that actively empower racial or ethnic groups that have been victims of energy injustices | The Movement For Black Lives' (M4BL) Black Hive initiative of antiracist climate and energy justice activism | Lenn |
| | Decolonial | Designing solar regimes that seek to dismantle imperial, (neo)colonial and geopolitical power relations | Indigenous energy sovereignty through the Piitapan Solar Project by the Lubicon Lake Band of Alberta in Canada | Ger |

| Spectra | Value | Description | Case | Su |
|---------|---------------------------------|--|--|---|
| | Interspecies interconnectedness | Solar installations that prioritise more-than-human wellbeing and repairing of ecosystems | Landscape modelling in Arizona to inform solar development that does not harm vertebrate species nor degrade their habitats Ènostra project aiming to reduce environmental impacts of electricity production & consumption in Italy South East London Community Energy, aim to increase solar electricity being generated in London run by volunteers worried about increasing pace of climate change | Tho 201 202 |
| | Pluriversal | Reflective of multiple worldviews and alternative imaginaries while representing and affirming a diversity of lifeways | Solar river transport in the Achuar territory in the Amazons in tune with local practices | Aco Dem 201 and |
| Process | Careful | Production relations centred on compassion, kindness, assistance and mutual aid | Northland Solar Commons project in Northern Minnesota that invests solar revenues into community trust that benefits food sovereignty efforts of the Bois Forte Ojibwe Reservation | Milu 202 201 |
| | Cooperative | Management of solar through cooperatives of stakeholders and victims of energy injustices and according to inclusive and participatory procedures of decision-making | Farmer cooperative around solar irrigation pumps in India | Shal |
| | Democratic | Energy regime with participatory means of decision-making | Stakeholder engagement workshops oriented around participatory design and decision-making led by Saskatchewan Power Corporation in Canada The Energ'Ethique social enterprise embodies principles of democratic governance, an inclusive approach to membership and promotes a value of 'one person, one voice' and creates long-term partnerships with local actors through a rooftop solar initiative in France | Burl 201 Bou al. 2 |
| | Enduring | Social and material relations that are continuous over time and space; durable, reclaimed | Autoconsumption encouraging policies over time. Removal of 'sun tax' in Spain in 2018 | Sorn Cros |

| Spectra | Value | Description | Case | Su |
|---------|------------|--|--|------------------------------------|
| | | (as opposed to stranded) and refurbished | Economies of repair for broken solar PV in Kenya | |
| | Feminist | Configurations of solar power designed to empower people who have suffered energy injustices based on specific gender identities, biological sex or sexual orientation | Solar micro-grid launched and managed by women in Abs, Yemen Passive and active solar features help reduce energy costs in the Primavera Foundation's 'Las Aabelitas' affordable housing project which assists (among others) grandmothers tasked with childcare activities in Arizona, USA | Bell, Labu et a |
| | Levelling | Solar installations that use subsidies and income from PV as a poverty alleviation tool for vulnerable groups Installations that aim to reduce energy costs for energy poor populations | Solar PVPA projects in rural China used as tool to alleviate rural poverty and environmental inequality Community interest company helps with energy efficiency & burden of energy costs with focus on most disadvantaged community members | Che and |
| | Relational | Connections among solar groups that traverse political, cultural and geographical boundaries | Power Shift Network that connects different organisations of youth engaged in activism around climate justice and clean energy transitions | Kum 202 |
| | Reparative | Redistribution of capital and resource flows to stakeholders and victims of solar energy injustices | Community solar in New Orleans as energy reparations for Black Americans suffering from energy poverty | Luke |
| Scale | Communal | Solar infrastructures on lands that facilitate shared usage or accommodate informal tenure and access of resources | Agrivoltaic system that accommodates farming below solar arrays in the Kajiado region of Kenya | Barr 201, 202, 201 |
| | Situated | Solar interventions that are place-based, tailored to specific local context and designed according to the needs and aspirations of local community | Community implementation and management of solar streetlights to combat energy poverty in Detroit through Souldarity. Off-grid solar PV in in Mozambique as situated, sovereign and post colonial | Sian al. 2 |

[OPEN IN VIEWER](#)

Moving forward, solar governance and geographies should be informed by and take inspiration from many of the values outlined in [Table 1](#). Despite political intransigence, some of these values were prominent in many of the USA Green New Deal policies. Similar discourse is also

present across key European energy transition policy documents, along with the intrinsic principle of leaving no person or place behind. Our study amplifies [Sovacool et al. \(2023\)](#) clarion call for energy justice scholarship rooted in feminist, antiracist, Indigenous and postcolonial perspectives, as each of our identified values can be mobilised through these normative orientations and equitable applications. Our study also builds on the work of [Bell, Daggett and Labuski \(2020\)](#), who establish feminist guiding principles for more equitable solar development. This feminist solar justice framework recommends decentralised and community-based energy systems founded on relations of care and more-than-human well-being, combined with a reparative politics for victims of energy-related violence.

We acknowledge that the values listed in [Table 1](#) are subjective and normative, but this is precisely the point. We believe that uncritically elaborated, solar energy regimes have the tendency to repeat the dispossessions, erasures and deprivations pervasive in patriarchal and colonial petro-racial capitalist energy regimes. Thus, we enumerate the aforementioned values not as prescriptive for all solar projects, but as relational considerations that one should be mindful of when designing and implementing solar interventions. Only then can solar interventions be emancipatory and redistributive in ways that actually lead to empowerment, transcending solar justice and moving towards solidaric solarities.

IV Discussion: Governance principles and guiding values towards solidaric solarities

At present, solar power largely fails to empower the lives of people disproportionately impacted by energy injustices. As such, we highlight two governance principles (cross-sectoral regulation and comparative energy geographies) that can move us collectively towards more equitable solar governance and the geographic articulation of solar interventions. Conceiving of solar power relations in terms of purpose, process and scale, we highlight the aforementioned values ([Table 1](#)) for actors and institutions looking to engender equitable solar rollout within or beyond institutional configurations and across regulatory frameworks and disparate energy geographies.

Multi-scalar and cross-sectoral regulations established to govern solar rollout globally should be implemented according to equity considerations undergirded by a radical ethics of care and interdependency. These ethical principles directing governance of solar development can engender improved accountability relations, with the eventual goal of implementing solar interventions predicated on participatory processes, distributed generation and reparative politics. The ways in which decentralised governance mechanisms respond to situated, communal needs also bring about the discussion of polycentric governance systems that match geographical coverage ([Newig and Fritsch 2009](#)). While real-world examples remain fragmented in terms of implementation and scaling up ([Delina 2020](#); [Pickering, Bäckstrand and Schlosberg 2020](#)), examples of scaling out diverse communal energy projects increasingly abound. Ensuring temporal and spatial continuities (rather than discontinuities) is a key principle going forward in solar governance and geographies, especially to ensure that policies promote the shortening of spatial impediments between sites of energy production and consumption. Accountability in solar supply chains is an important criterion as well. Solar module lifetimes and e-waste should be subjected to mechanisms of liability and endurance by producers and policies that protect precarious e-waste labourers and impacted communities while supporting cradle-to-cradle design mechanisms.

Our governance principles of *cross-sectoral regulation* and *comparative energy geographies*, when influenced by solidaric values, can provide both a guiding light and a guardrail for policymakers, practitioners and wider stakeholders, aiding them in vetting or designing

inclusive projects that target vulnerable and marginalised populations as beneficiaries in alternative energy regimes. Of course, there will be many challenges in implementing a holistic regulatory framework that engenders the type of solidaric solar development illustrated above, such as the heterogeneity of energy geographies where these interventions would be implemented. Solidaric solidarities are plural and pluriversal, as they mould into situated conditions, historical contexts, and are respectful of cultures they emerge within. At present, there are complementary, contradictory and competing policies and regulations that govern solar rollout from the transnational to the local scale, which would need to be aligned to facilitate synchronous and aligned governance. Another challenge to establishing multi-scalar and cross-sectoral regulations for solidaric solarities is the differentiated positioning of actors and institutions within the solar value chain, as solar development produces uneven distributions of benefits and burdens. Prioritising the most marginalised to receive the biggest benefits should be a normative commitment across the board, yet asymmetric social power continues to influence solar development trajectories and may perpetuate procedural and distributional injustices in solar rollouts. Hence, the aforementioned values should animate the implementation of solar interventions.

Equitable governance of solar rollouts will need to be adaptive to heterogeneous energy geographies, socio-political and cultural milieus, infrastructural configurations and multi-scalar and cross-sectoral regulatory frameworks. Solar governance should strive to be iterative and contingent, adaptive to place-based exigencies, and responsive to community stakeholders. Networking this iterative and contingent approach to solar governance across borders and sectors will likely require the establishment of a representative consortium that engenders solidarity among solar groups, while also embracing and defending the adaptive and heterogeneous nature of solidaric solar interventions globally. Scalar networks provide vital support to policymakers, practitioners and wider stakeholders of more equitable solar interventions. Another challenge for solidaric solarities with improved accountability relations is to match the requisite speed and scale for climate action by 2030. Participatory, decentralised and reparative solar regimes, although likely more equitable, will need to assemble and mitigate greenhouse gases swiftly while prioritising equity. Such trade-offs between utility and equity will no doubt continue to complicate global solar rollouts – urgency must not be a justification for injustice – but informed by present solar inequities, it is incumbent on policymakers, practitioners and stakeholders to urgently strive for solidaric solarities, creating the conditions for emancipatory and redistributive solar energy systems.

V Conclusion: Transforming solar power relations

Solar rollouts globally are marred by myriad injustices experienced throughout the value chain and across disparate energy geographies. Yet these injustices are not intrinsic to the technologies and infrastructures themselves, rather they are material embodiments of the social and political relations through which they are deployed ([Temper et al. 2020](#)). As low-carbon solutions to aggressively mitigate the climate crisis, solar power interventions often reproduce the power asymmetries emblematic of fossil fuel energy regimes that drive the climate crisis. Marginalised populations that are disproportionately vulnerable to both the ecological degradation wrought by fossil energy and climate impacts increasingly find themselves doubly burdened by dispossessions and deprivations of unjust solar energy transitions. Recent studies have shown that large-scale solar infrastructures that swiftly scale to reach mitigation targets are deeply inequitable. Albeit sustainable, policymakers and practitioners must not relegate the vulnerable to suffer in solar sacrifice zones. Yet mobilisation around justice for victims often does not translate into actual empowerment or

the redistribution of resource flows, prefiguring patterns of injustices across disparate geographies and temporalities.

There is thus hope that governance principles, informed by values that facilitate solidaric solarly, can lead to equitable paradigm shifts in solar rollouts. Solar energy should increasingly be governed in accordance with multi-scalar and cross-sectoral regulation, apprised of comparative energy geographies that inform decision-making domains using examples that highlight best practices, best fit, and potential pitfalls in customisation. Our analysis shows the value of engaging with political economic realities in a balanced, pragmatic manner in order to contribute policy-relevant insights from research. Whereas solar transitions research has made valuable inroads on both techno-economic and socio-technical dynamics as well as concrete examples of solar injustice and solidarity, we find a conversation that synthesises these concerns both timely and useful. Targeting improvements in governance (institutional configurations, policy mixes and cross-sectoral regulation) and scale (comparative energy geographies with attention to context-specificity and trans-local connection), the governance principles for solar development hold potential for policy and practical impact if imbued with normative values that engender solidarity. Equally, we hope that our governance principles and solidaric values serve as a conceptual boundary object to draw diverse epistemic communities of solar research into closer engagement with each other.

While these governance principles undoubtedly hold potential to improve solar governance, they are unlikely to transform the social relations that reproduce solar injustices in isolation. Although infrequent, victims can receive minor restitution for wrongs experienced. Yet conceptualisations of justice are framed through political institutions with limited ability to systematically uplift vulnerable populations *en masse* and prevent future injustices. Thus, we believe that these governance principles, when informed by critical values supportive of solidarity, can engender a radical reorientation of solar power relations that both uplift and enlighten the lives of victims of solar energy injustices. Solar futures are bright in a carbon-constrained world, but solar interventions cannot continue to leave marginalised populations in the dark. May solidaric solarities usher in the just transition.

Acknowledgements

The authors acknowledge funding from the Research Council of Norway (grant 314022, ASSET), the European Union's Horizon 2020 programme (grant 101032239, Sun4All), the Akademia Agreement between University of Bergen and Equinor, and the Sustainability Transformation programme area at the University of Stavanger that made this collaborative research possible.

Declaration of conflicting interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) disclosed receipt of the following financial support for the research, authorship, and/or publication of this article: This work was supported by the Norges Forskningsråd (grant number 314022 Accountable Solar Energy TransitionS (ASSET)), the European Union's Horizon 2020 programme (grant number 101032239 Sun4All), a grant from the Akademia Agreement between University of Bergen and Equinor, and the Sustainability Transformation programme area at the University of Stavanger.

References

Acosta, Alberto. "El Buen Vivir: Sumak Kawsay, an Opportunity to Imagine Other Worlds." Icaria, Barcelona, 2013.

After Oil Collective. *Solarities: Seeking Energy Justice*. U of Minnesota Press, 2022.

Álvarez, Lina, and Brendan Coolsaet. "Decolonizing environmental justice studies: a Latin American perspective." *Capitalism nature socialism* 31, no. 2 (2020): 50-69.

Arabindoo, Pushpa. "Renewable energy, sustainability paradox and the post-urban question." *Urban Studies* 57, no. 11 (2020): 2300-2320.

Avila, Sofia, Yannick Deniau, Alevgul H. Sorman, and James McCarthy. "(Counter) mapping renewables: Space, justice, and politics of wind and solar power in Mexico." *Environment and Planning E: Nature and Space* 5, no. 3 (2022): 1056-1085.

Barron-Gafford, Greg A., Mitchell A. Pavao-Zuckerman, Rebecca L. Minor, Leland F. Sutter, Isaiah Barnett-Moreno, Daniel T. Blackett, Moses Thompson et al. "Agrivoltaics provide mutual benefits across the food–energy–water nexus in drylands." *Nature Sustainability* 2, no. 9 (2019): 848-855.

Bauwens, Thomas, Daan Schraven, Emily Drawing, Jörg Radtke, Lars Holstenkamp, Boris Gotchev, and Özgür Yildiz. "Conceptualizing community in energy systems: A systematic review of 183 definitions." *Renewable and Sustainable Energy Reviews* 156 (2022): 111999.

Bayertz, K. ed. *Solidarity* (Vol. 5) (1999). Dordrecht: Springer Science & Business Media.

Bedi, Heather P. "'Lead the district into the light': Solar energy infrastructure injustices in Kerala, India." *Global Transitions* 1 (2019): 181-189.

Bedi, Heather Plumridge. "Solar power for some? Energy transition injustices in Kerala, India." *Environment and Planning E: Nature and Space* 5, no. 3 (2022): 1146-1163.

Bell, Shannon Elizabeth, Cara Daggett, and Christine Labuski. "Toward feminist energy systems: Why adding women and solar panels is not enough☆." *Energy Research & Social Science* 68 (2020): 101557.

Bollier, David. "Re-imagining value: Insights from the care economy, commons, cyberspace and nature." *Berlin: Heinrich Böll Stiftung* (2017).

Bouzarovski, Stefan, and Saska Petrova. "A global perspective on domestic energy deprivation: Overcoming the energy poverty–fuel poverty binary." *Energy Research & Social Science* 10 (2015): 31-40.

Brock, Andrea, Benjamin K. Sovacool, and Andrew Hook. "Volatile photovoltaics: green industrialization, sacrifice zones, and the political ecology of solar energy in

Germany." *Annals of the American Association of Geographers* 111, no. 6 (2021): 1756-1778.

Brockway, Anna M., Jennifer Conde, and Duncan Callaway. "Inequitable access to distributed energy resources due to grid infrastructure limits in California." *Nature Energy* 6, no. 9 (2021): 892-903.

Brown, Benjamin, and Samuel J. Spiegel. "Coal, climate justice, and the cultural politics of energy transition." *Global environmental politics* 19, no. 2 (2019): 149-168.

Brown, J. Christopher, and Mark Purcell. "There's nothing inherent about scale: political ecology, the local trap, and the politics of development in the Brazilian Amazon." *Geoforum* 36, no. 5 (2005): 607-624.

Boulding, Kenneth E. "Future directions in conflict and peace studies." In *Conflict: Readings in management and resolution*, pp. 35-47. Palgrave Macmillan, London, 1990.

Buechler, Stephanie, Verónica Vázquez-García, Karina Guadalupe Martínez-Molina, and Dulce María Sosa-Capistrán. "Patriarchy and (electric) power? A feminist political ecology of solar energy use in Mexico and the United States." *Energy Research & Social Science* 70 (2020): 101743.

Burke, Matthew J., and Jennie C. Stephens. "Energy democracy: Goals and policy instruments for sociotechnical transitions." *Energy research & social science* 33 (2017): 35-48.

Cantoni, Roberto, Federico Caprotti, and Jiska de Groot. "Solar energy at the peri-urban frontier: An energy justice study of urban peripheries from Burkina Faso and South Africa." *Energy Research & Social Science* 94 (2022): 102884.

Capellán-Pérez, Iñigo, Carlos De Castro, and Iñaki Arto. "Assessing vulnerabilities and limits in the transition to renewable energies: Land requirements under 100% solar energy scenarios." *Renewable and Sustainable Energy Reviews* 77 (2017): 760-782.

Carley, Sanya, and David M. Konisky. "The justice and equity implications of the clean energy transition." *Nature Energy* 5, no. 8 (2020): 569-577.

Broto, Vanesa Castán, Idalina Baptista, Joshua Kirshner, Shaun Smith, and Susana Neves Alves. "Energy justice and sustainability transitions in Mozambique." *Applied energy* 228 (2018): 645-655.

Chen, Chien-fei, Jiaxin Li, Jing Shuai, Hannah Nelson, Allen Walzem, and Jinhua Cheng. "Linking social-psychological factors with policy expectation: Using local voices to understand solar PV poverty alleviation in Wuhan, China." *Energy Policy* 151 (2021): 112160.

Cointe, Béatrice. "Managing political market agencements: solar photovoltaic policy in France." *Environmental Politics* 26, no. 3 (2017): 480-501.

Córdoba, Diana, Ana Maria Peredo, and Paola Chaves. "Shaping alternatives to development: Solidarity and reciprocity in the Andes during COVID-19." *World Development* 139 (2021): 105323.

Cross, Jamie. "Selling with prejudice: social enterprise and caste at the bottom of the pyramid in India." *Ethnos* 84, no. 3 (2019): 458-479.

Cruz, Rizalino B. "The politics of land use for distributed renewable energy generation." *Urban Affairs Review* 54, no. 3 (2018): 524-559.

Cumbers, Andrew, and Sören Becker. "Making sense of remunicipalisation: theoretical reflections on and political possibilities from Germany's Rekommunalisierung process." *Cambridge Journal of Regions, Economy and Society* 11, no. 3 (2018): 503-517.

Day, Rosie, Gordon Walker, and Neil Simcock. "Conceptualising energy use and energy poverty using a capabilities framework." *Energy Policy* 93 (2016): 255-264.

Delina, Laurence L. "Climate mobilizations and democracy: The promise of scaling community energy transitions in a deliberative system." *Journal of Environmental Policy & Planning* 22, no. 1 (2020): 30-42.

DellaValle, Nives, and Veronika Czako. "Empowering energy citizenship among the energy poor." *Energy Research & Social Science* 89 (2022): 102654.

Dolter, Brett D., and Martin Boucher. "Solar energy justice: A case-study analysis of Saskatchewan, Canada." *Applied Energy* 225 (2018): 221-232.

EJAtlas. Planta Fotovoltaica Los Prados (53 MW), Namasigüe, Honduras. (2019).
<https://www.ejatlasc.org/conflict/planta-fotovoltaica-los-prados-53-mw-namasigue-honduras>

Fleischmann, Alexander, Lotte Holck, Helena Liu, Sara Louise Muhr, and Annalisa Murgia. "Organizing solidarity in difference: Challenges, achievements, and emerging imaginaries." *Organization* 29, no. 2 (2022): 233-246.

Franco, Jennifer C., and Saturnino M. Borrás Jr. "Grey areas in green grabbing: Subtle and indirect interconnections between climate change politics and land grabs and their implications for research." *Land Use Policy* 84 (2019): 192-199.

Goodstein, Eban, and L. Hunter Lovins. "A pathway to rapid global solar energy deployment? Exploring the solar dominance hypothesis." *Energy research & social science* 56 (2019): 101197.

García-Olivares, Antonio, Jordi Solé, and Oleg Osychenko. "Transportation in a 100% renewable energy system." *Energy Conversion and Management* 158 (2018): 266-285.

Geels, Frank W. "Processes and patterns in transitions and system innovations: Refining the co-evolutionary multi-level perspective." *Technological forecasting and social change* 72, no. 6 (2005): 681-696.

Gergan, Mabel Denzin, and Andrew Curley. "Indigenous youth and decolonial futures: energy and environmentalism among the Diné in the Navajo Nation and the Lepchas of Sikkim, India." *Antipode* (2021): 1-21.

Ghosh, Devleena, Gareth Bryant, and Priya Pillai. "Who wins and who loses from renewable energy transition? Large-scale solar, land, and livelihood in Karnataka, India." *Globalizations* (2022): 1-16.

Guillou, Emmanuelle and Bérénice Girard. "Mini-grids at the interface: The deployment of mini-grids in urbanizing localities of the global South." *Journal of Urban Technology* (2022): 151-170

Hanke, Florian, Rachel Guyet, and Marielle Feenstra. "Do renewable energy communities deliver energy justice? Exploring insights from 71 European cases." *Energy Research & Social Science* 80 (2021): 102244.

Healy, Noel, Jennie C. Stephens, and Stephanie A. Malin. "Embodied energy injustices: Unveiling and politicizing the transboundary harms of fossil fuel extractivism and fossil fuel supply chains." *Energy Research & Social Science* 48 (2019): 219-234.

Hess, David J. "Sustainability transitions: A political coalition perspective." *Research Policy* 43, no. 2 (2014): 278-283.

Horstink, Lanka, Julia M. Wittmayer, and Kiat Ng. "Pluralising the European energy landscape: Collective renewable energy prosumers and the EU's clean energy vision." *Energy Policy* 153 (2021): 112262.

Kallis, Giorgos. "Socialism without growth." *Capitalism nature socialism* 30, no. 2 (2019): 189-206.

Kakoulaki, Georgia, Ioannis Kougias, Nigel Taylor, Francesco Dolci, J. Moya, and Arnulf Jäger-Waldau. "Green hydrogen in Europe—A regional assessment: Substituting existing production with electrolysis powered by renewables." *Energy Conversion and Management* 228 (2021): 113649.

Kamadi, Geoffrey. Kenya to use solar panels to boost crops by 'harvesting the sun twice'. *The Guardian*, Tue 22 Feb (2022). Accessed 08.12.2022 at:

<https://www.theguardian.com/global-development/2022/feb/22/kenya-to-use-solar-panels-to-boost-crops-by-harvesting-the-sun-twice>

Kangas, Hanna-Liisa, Kimmo Ollikka, J. Ahola, and Y. Kim. "Digitalisation in wind and solar power technologies." *Renewable and Sustainable Energy Reviews* 150 (2021): 111356.

Kennedy, Sean F., and Ryan Stock. "Alternative energy capital of the world? Fix, risk, and solar energy in Los Angeles' urban periphery." *Environment and Planning E: Nature and Space* 5, no. 4 (2022): 1831-1852.

Koretsky, Z., Stegmaier, P., Turnheim, B. and van Lente, H. eds., 2022. *Technologies in Decline: Socio-technical approaches to discontinuation and destabilisation*. Taylor & Francis.

Kothari, Ashish, Federico Demaria, and Alberto Acosta. "Buen Vivir, degrowth and ecological Swaraj: Alternatives to sustainable development and the green economy." *Development* 57, no. 3 (2014): 362-375.

Kumar, Ankit, and Gerald Taylor Aiken. "A postcolonial critique of community energy: Searching for community as solidarity in India and Scotland." *Antipode* 53, no. 1 (2021): 200-221.

Kurtz, Hilda E. "Scale frames and counter-scale frames: constructing the problem of environmental injustice." *Political Geography* 22, no. 8 (2003): 887-916.

Lacey-Barnacle, M., A. Smith, and T. J. Foxon. "Community wealth building in an age of just transitions: Exploring civil society approaches to net zero and future research synergies." *Energy Policy* 172 (2023): 113277.

Leiren, Merethe Dotterud, and Inken Reimer. "Historical institutionalist perspective on the shift from feed-in tariffs towards auctioning in German renewable energy policy." *Energy Research & Social Science* 43 (2018): 33-40.

Lennon, Myles. "Decolonizing energy: Black Lives Matter and technoscientific expertise amid solar transitions." *Energy Research & Social Science* 30 (2017): 18-27.

Lennon, Myles. Energy transitions in a time of intersecting precarities: From reductive environmentalism to antiracist praxis. *Energy Research & Social Science*, 73 (2021): 101930.

Lorenz-Meyer, Dagmar. "Becoming responsible with solar power? Extending feminist imaginings of community, participation and care." *Australian Feminist Studies* 32, no. 94 (2017): 427-444.

Luderer, Gunnar, Silvia Madeddu, Leon Merfort, Falko Ueckerdt, Michaja Pehl, Robert Pietzcker, Marianna Rottoli et al. "Impact of declining renewable energy costs on electrification in low-emission scenarios." *Nature Energy* 7, no. 1 (2022): 32-42.

Lukanov, Boris R., and Elena M. Krieger. "Distributed solar and environmental justice: Exploring the demographic and socio-economic trends of residential PV adoption in California." *Energy Policy* 134 (2019): 110935.

Luke, Nikki, and Nik Heynen. "Community solar as energy reparations: abolishing petro-racial capitalism in New Orleans." *American Quarterly* 72, no. 3 (2020): 603-625.

Lüth, Alexandra, Jan Martin Zepter, Pedro Crespo del Granado, and Ruud Egging. "Local electricity market designs for peer-to-peer trading: The role of battery flexibility." *Applied Energy* 229 (2018): 1233-1243.

Matschoss, Kaisa, Irmeli Mikkonen, Lea Gynther, Giorgos Koukoulfikis, Andreas Uihlein, and Ingrida Murauskaite-Bull. "Drawing policy insights from social innovation cases in the energy field." *Energy Policy* 161 (2022): 112728.

Mauss, Marcel. *The Gift: The Form and Reason for Exchange in Archaic Societies* (trans. W. D. Halls). 1990 [1925]. London: Routledge.

McCarthy, James. A socioecological fix to capitalist crisis and climate change? The possibilities and limits of renewable energy. *Environment and Planning A*, 47(12) (2015): 2485-2502.

Milun, Kathryn, and Martin Pochtaruk. "The Northland Solar Commons: An Industry, University and Tribal Community Partnership to Use the Sun's Common Wealth for Reparative Justice in Northern Minnesota." In *Proceedings of the American Solar Energy Society National Conference*, pp. 123-127. Springer, Cham, 2022.

Molm, Linda, Jessica Collett, and David Schaefer. Building solidarity through generalized exchange: A theory of reciprocity. *American Journal of Sociology* 113, no. 1 (2007): 205-242.

Mulvaney, Dustin. *Solar power: Innovation, sustainability, and environmental justice*. University of California Press, 2019.

Mulvaney, Dustin. Are green jobs just jobs? Cadmium narratives in the life cycle of Photovoltaics. *Geoforum*, 54 (2014): 178-186.

Munro, Paul G., and Shanil Samarakoon. "Off-Grid Electrical Urbanism: Emerging Solar Energy Geographies in Ordinary Cities." *Journal of Urban Technology* (2022): 1-23.

Newig, Jens, and Oliver Fritsch. "Environmental governance: participatory, multi-level—and effective?." *Environmental policy and governance* 19, no. 3 (2009): 197-214.

Newell, Peter and Jon Phillips. "Neoliberal energy transitions in the South: Kenyan experiences." *Geoforum*, 74 (2016): 39-48

Nikas, Alexandros, Vassilis Stavrakas, Apostolos Arsenopoulos, Haris Doukas, Marek Antosiewicz, Jan Witajewski-Baltvilks, and Alexandros Flamos. "Barriers to and consequences of a solar-based energy transition in Greece." *Environmental Innovation and Societal Transitions* 35 (2020): 383-399.

Nuru, Jude T., Jason L. Rhoades, and Benjamin K. Sovacool. "Virtue or vice? Solar micro-grids and the dualistic nature of low-carbon energy transitions in rural Ghana." *Energy Research & Social Science* 83 (2022): 102352.

Pickering, Jonathan, Karin Bäckstrand, and David Schlosberg. "Between environmental and ecological democracy: theory and practice at the democracy-environment nexus." *Journal of environmental policy & planning* 22, no. 1 (2020): 1-15.

Poruschi, Lavinia, and Christopher L. Ambrey. "Energy justice, the built environment, and solar photovoltaic (PV) energy transitions in urban Australia: A dynamic panel data analysis." *Energy Research & Social Science* 48 (2019): 22-32.

Reames, Tony G. "Distributional disparities in residential rooftop solar potential and penetration in four cities in the United States." *Energy Research & Social Science* 69 (2020): 101612.

Rignall, Karen Eugenie. "Solar power, state power, and the politics of energy transition in pre-Saharan Morocco." *Environment and Planning A: Economy and Space* 48, no. 3 (2016): 540-557.

Roediger, David R. *Class, race, and Marxism*. London: Verso Books, 2019.

Roy, Brototi, and Anke Schaffartzik. "Talk renewables, walk coal: The paradox of India's energy transition." *Ecological Economics* 180 (2021): 106871.

Samarakoon, Shanil. "The troubled path to ending darkness: Energy injustice encounters in Malawi's off-grid solar market." *Energy Research & Social Science* 69 (2020): 101712.

Samarakoon, Shanil, Anne Bartlett, and Paul Munro. "Somewhat original: energy ethics in Malawi's off-grid solar market." *Environmental Sociology* 7, no. 3 (2021): 164-175.

Sanderink, Lisa. "Shattered frames in global energy governance: Exploring fragmented interpretations among renewable energy institutions." *Energy Research & Social Science* 61 (2020): 101355.

Sareen, Siddharth. "Metrics for an accountable energy transition? Legitimizing the governance of solar uptake." *Geoforum* 114 (2020): 30-39.

Sareen, Siddharth. "Drivers of Scalar Biases: Environmental Justice and the Portuguese Solar Photovoltaic Rollout." *Environmental Justice* 15, no. 2 (2022): 98-107.

Sareen, Siddharth, Jakob Grandin, and Håvard Haarstad. "Multiscalar Practices of Fossil Fuel Displacement." *Annals of the American Association of Geographers* 112, no. 3 (2022): 808-818.

Sareen, Siddharth, and Håvard Haarstad. "Decision-making and scalar biases in solar photovoltaics roll-out." *Current Opinion in Environmental Sustainability* 51 (2021): 24-29.

Sareen, Siddharth, and Sunila S. Kale. "Solar 'power': Socio-political dynamics of infrastructural development in two Western Indian states." *Energy research & social science* 41 (2018): 270-278.

Sareen, Siddharth, and Shayan Shokrgozar. "Desert geographies: solar energy governance for just transitions." *Globalizations* (2022): 1-17.

Scheidel, Arnim, and Alevgul H. Sorman. "Energy transitions and the global land rush: Ultimate drivers and persistent consequences." *Global Environmental Change* 22, no. 3 (2012): 588-595.

Schmelzer, Matthias, Andrea Vetter, and Aaron Vansintjan. *The future is degrowth: A guide to a world beyond capitalism*. Verso Books, 2022.

Shah, Tushaar, Abhishek Rajan, Gyan Prakash Rai, Shilp Verma, and Neha Durga. "Solar pumps and South Asia's energy-groundwater nexus: exploring implications and reimagining its future." *Environmental Research Letters* 13, no. 11 (2018): 115003.

Siamanta, Zoi Christina. "Conceptualizing alternatives to contemporary renewable energy development: Community Renewable Energy Ecologies (CREE)." *Journal of Political Ecology* 28, no. 1 (2021): 258-276.

Silva, Luís, and Siddharth Sareen. "Solar photovoltaic energy infrastructures, land use and sociocultural context in Portugal." *Local Environment* 26, no. 3 (2021): 347-363.

Sorman, Alevgul H., Xaquín García-Muros, Cristina Pizarro-Irizar, and Mikel González-Eguino. "Lost (and found) in transition: Expert stakeholder insights on low-carbon energy transitions in Spain." *Energy Research & Social Science* 64 (2020): 101414.

South East London Community Energy (SELCE). *Solar power for SE London*. SELCE, 2022. Available at: <https://selce.org.uk/se-solar/>

Sovacool, Benjamin K., Max Lacey Barnacle, Adrian Smith, and Marie Claire Brisbois. "Towards improved solar energy justice: Exploring the complex inequities of household adoption of photovoltaic panels." *Energy Policy* 164 (2022): 112868.

Sovacool, Benjamin K., Mari Martiskainen, Andrew Hook, and Lucy Baker. "Decarbonization and its discontents: a critical energy justice perspective on four low-carbon transitions." *Climatic Change* 155, no. 4 (2019): 581-619.

Sovacool, Benjamin, Shannon Bell, Cara Daggett, Christine Labuski, Myles Lennon, Lindsay Naylor, Julie Klinger, Kelsey Leonard, and Jeremy Firestone. "Pluralizing energy justice: Incorporating feminist, anti-racist, Indigenous, and postcolonial perspectives." *Energy Research & Social Science* 97 (2023): 102996.

Stober, Dina, Monika Suškevičs, Sebastian Eiter, Stefanie Müller, Stanislav Martinát, and Matthias Buchecker. "What is the quality of participatory renewable energy planning in Europe? A comparative analysis of innovative practices in 25 projects." *Energy Research & Social Science* 71 (2021): 101804.

Stock, Ryan. "Illuminant intersections: Injustice and inequality through electricity and water infrastructures at the Gujarat Solar Park in India." *Energy Research & Social Science* 82 (2021a): 102309.

Stock, Ryan. "Deus ex mitigata: Denaturalizing the discursive power of Solar India." *Environment and Planning E: Nature and Space* 4, no. 2 (2021b): 354-382.

Stock, Ryan. "Power for the Plantationocene: solar parks as the colonial form of an energy plantation." *The Journal of Peasant Studies* (2022a): 1-23.

Stock, Ryan. "Surya-shakti-sharir: Embodying India's solar energy transition." *Norsk Geografisk Tidsskrift-Norwegian Journal of Geography* (2022b): 1-9.

Stock, Ryan, and Trevor Birkenholtz. "Photons vs. firewood: Female (dis) empowerment by solar power in India." *Gender, Place & Culture* 27, no. 11 (2020): 1628-1651.

Stock, Ryan, and Trevor Birkenholtz. "The sun and the scythe: Energy dispossessions and the agrarian question of labor in solar parks." *The journal of peasant studies* 48, no. 5 (2021): 984-1007.

Sunter, Deborah A., Sergio Castellanos, and Daniel M. Kammen. "Disparities in rooftop photovoltaics deployment in the United States by race and ethnicity." *Nature Sustainability* 2, no. 1 (2019): 71-76.

Temper, Leah, Sofia Avila, Daniela Del Bene, Jennifer Gobby, Nicolas Kosoy, Philippe Le Billon, Joan Martinez-Alier et al. "Movements shaping climate futures: A systematic mapping of protests against fossil fuel and low-carbon energy projects." *Environmental Research Letters* 15, no. 12 (2020): 123004.

Tham, Y., and T. Muneer. "Energy co-operatives in the UK." *International journal of low-carbon technologies* 8, no. 1 (2013): 43-51.

Thomas, Kathryn A., Christopher J. Jarchow, Terence R. Arundel, Pankaj Jamwal, Amanda Borens, and Charles A. Drost. "Landscape-scale wildlife species richness metrics to inform wind and solar energy facility siting: An Arizona case study." *Energy Policy* 116 (2018): 145-152.

Tirado-Herrero, Sergio, and Sara Fuller. "De-centering transitions: Low-carbon innovation from the peripheries." *Environmental Innovation and Societal Transitions* 41 (2021): 113-115.

Uebelhor, Emma, Olivia Hintz, Sarah B. Mills, and Abigail Randall. "Utility-Scale Solar in the Great Lakes: Analyzing Community Reactions to Solar Developments." *Sustainability* 13, no. 4 (2021): 1677.

Upham, Paul, Benjamin Sovacool, and Bipashyee Ghosh. "Just transitions for industrial decarbonisation: A framework for innovation, participation, and justice." *Renewable and Sustainable Energy Reviews* 167 (2022): 112699.

Verde, Stefano F. Renewable energy cooperatives: the case of ènostra Community-led renewable energy initiatives. European University Institute, Florence School of Regulation, 2020. Available at: <https://fsr.eui.eu/renewable-energy-cooperative-enostra/>

Vila-Viñas, David, Juan Manuel Crespo, and Cheryl Martens. "Open Knowledge, Decolonial, and Intercultural Approaches to Communication Technologies for Mobility: The Achuar Kara Solar Project." In *Digital Activism, Community Media, and Sustainable Communication in Latin America*, pp. 97-123. Palgrave Macmillan, Cham, 2020.

Yap, Kah Yung, Hon Huin Chin, and Jiří Jaromír Klemeš. "Solar Energy-Powered Battery Electric Vehicle charging stations: Current development and future prospect review." *Renewable and Sustainable Energy Reviews* 169 (2022): 112862.

Yenneti, Komali, Rosie Day, and Oleg Golubchikov. "Spatial justice and the land politics of renewables: Dispossessing vulnerable communities through solar energy mega-projects." *Geoforum* 76 (2016): 90-99.