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The Map is Not the Territory:

a sympathetic critique of energy research's spatial turn

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Abstract

Energy research in the social sciences has embarked on a 'spatial adventure' (Castán Broto and Baker, 2017). Those setting out on this journey have started from different disciplinary and theoretical locations, yet a "map" of sorts has begun to emerge. Made up of epistemological positions, conceptual vantage points and lines of enquiry, this map demarcates and structures the growing field of energy geography providing a more-or-less agreed guide to the territory. In the paper's first half I reflect on the scope and significance of the spatial turn in energy research. I describe the map now guiding much spatial research on energy, identifying core ideas around which spatially-sensitive social science energy research has come to cohere, notwithstanding its heterogeneity and internal diversity. I offer a supportive reading. In the second half, I offer a more critical reading of the adventure so far, arguing that it is unnecessarily limited in its reading of space. The full potential of a spatial perspective for social science research on energy has yet to be realised. I outline three pathways for realising some of this potential - geographies of knowledge production, differentiation and disassembly – and show how each takes energy research's spatial adventure in new directions.

Keywords: Geography, Space, Energy systems, Disassembly, Energy geographies

1. Introduction

The transformation of energy systems in response to economic, political and environmental objectives can take multiple forms and raises a range of issues. The matter of *space* in relation to energy system transformation, however, now presses on academic and policy communities to a remarkable degree, and across a range of policy domains from energy security, climate change and infrastructure planning, to industrial strategy, economic competitiveness, foreign trade and international development. It is clear that, willed or otherwise, energy system transformation involves a reworking of many familiar and relatively durable ‘energy geographies’. Illustrative examples include the proliferation of new energy landscapes associated with renewable electricity generation or unconventional fossil fuels; multi-scale geographical shifts in energy demand linked to a growing global-urban middle class; the reassertion of domestic fossil energy production by a number of national governments (e.g. Turkey, South Africa, Poland, UK, US) as a response to perceived vulnerabilities around security of supply; and accelerating cross-border flows of energy investment, including the build-up of major energy infrastructures (gas pipelines, electricity transmission systems, shipping terminals) underpinning new patterns of energy trade.

As a consequence, it is no longer tenable for social science research to understand energy systems without some consideration of space. Indeed, social science energy research’s “spatial adventure” [1] is well underway and, in the first half of the article, I reflect on the scope and significance of this spatial turn. I outline a shared appreciation for the spatialities of energy systems that has taken hold within social science energy research, and distil five commonly held ideas about space that run through this work. To give a name to this set of ideas and its role in guiding contemporary work, I refer to it as a map: made up of epistemological positions, conceptual vantage points and lines of enquiry, this map orientates and structures the growing field of energy geography providing a more-or-less agreed guide to the territory.ⁱ I offer a supportive reading that acknowledges the importance of these ideas in rendering visible a set of previously overlooked questions and claiming researchable territory.

The second half of the paper offers a more critical reading of the adventure so far. To capture the essence of this critique, I deploy the maxim in the paper's title – "the map is not the territory."ⁱⁱ I argue that social science's spatial adventure in energy research is sufficiently advanced that it has generated a map of sorts – a set of commonly held positions that orientate current work - by which to understand the geographies of energy systems. However, we should not mistake this map for the territory itself: the territory is richer and more rewarding than suggested by the current map. I argue that further adventuring is not only possible, but also necessary if the full possibilities of a spatial perspective are to be realized. I identify three lines of enquiry – geographies of knowledge production, differentiation, and disassembly – as pathways by which social science energy research's interest in space can be extended. These pathways not only generate new understandings about the significance of processes now shaping energy systems in important ways: they will also enable grounded and richly geographical accounts of energy system transformation to emerge, with the capacity to speak back to research in human geography on the spatial constitution of society. ⁱⁱⁱ

2. Energy research takes a spatial turn

Social science energy research that is spatially-sensitive and alive to geographical difference is not a new phenomenon (for discussion of earlier work see [8, 9, 10, 11]). A previous generation of spatially-minded researchers also engaged with a world in which energy resources, markets and infrastructures were in a state of flux [12, 13, 16, 17]. The development of national electricity transmission systems and centralized generating facilities in Europe in the 1960s, for example, attracted exploration of the changing geographies of electricity generation, transmission and distribution [14, 15, 18, 19, 20]. While some of this work fell into the long geographical tradition of descriptive regional studies, there were also efforts to systematically analyze and theorize (in the sense of developing general principles) the forces shaping energy economies and their broader social implications. Manners (1964) *The Geography of Energy*, for example, forged a link between energy and spatial planning by teasing out key variables - transport, markets, political factors - influencing the spatial distribution of energy production, transmission and

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consumption in the UK, Europe and the United States. Similarly, transformation of the global oil market in the 1970s and subsequent policy focus on renewable, nuclear and coal-to-liquids technologies, propelled “an orgy of energy-related writing” that included accounts with a strong spatial sensibility [21, p. 572; see also 16, 22]. For example, Odell’s (1970) classic *Oil and World Power*, which ran to eight editions, examined the role of oil companies, markets and resource-holders in shaping geopolitical relations during one of the most turbulent periods in the sector’s history. This is not the place for a review: suffice it to say, however, that the differences between current work on the spatialities of energy and an earlier generation of spatial adventurers are fewer than we might find it convenient to think. There is an impulse evident in the ancestral record to understand a world in motion, and to inform and shape its unfolding future, that is familiar and which make it impossible to claim thinking about energy in spatial terms is original. It is stretching things, however, to suggest the record reveals a “three-decade history of energy geography as a coherent sub-discipline in the field” [11, p. 2], as what came before is far patchier, and less unified, than such a characterization suggests.

The significance of contemporary spatial adventures, then, rests not on the idea that energy and geography might be a borderland worthy of exploration. Rather it lies in the volume of research now being done and, more importantly, in the emergence of some shared (and quite specific) conceptual understandings that now frame work in this area.^{iv} There are significant differences within contemporary spatially-sensitive research on energy to be sure, yet it is possible to identify a set of conceptual commitments that much of this work holds in common. Importantly, recent research goes considerably beyond the entry-level geographical argument, which is to acknowledge that infrastructures, technologies and policies have spatial outcomes. By contrast, it recognizes that space and place “do stuff” to energy systems, giving them shape and form in often profound ways. As a consequence, space and place complicate how social science has conventionally thought about energy systems. For example, thinking about space in the context of energy systems foregrounds questions about geographical difference and multiplicity; it highlights relations of position and connection; and draws attention to spatial configurations and scales of organization [24]. The combination of intensity of engagement with the geographies of energy and a widely (if not universally) shared conceptual position suggest we may be witnessing a

“spatial turn” in social science energy research, of which this special issue is one manifestation.^v Such a turn is significant not because it acknowledges there is a spatial dimension to energy systems: that argument has been made for some time now, and it reduces space to a second-order explanation, with research documenting spatial variation and interpreting it as localised inflections of an underlying a-spatial essence (the economic rationality of market participants, the state’s structural power, or ecological imperatives for systemic change). Rather, the significance of the contemporary spatial turn in social science energy research is that, for an increasing number of researchers, thinking about space opens up disruptive and generative research possibilities. That is, space is more than geographical variation and a source of ‘local color’. It matters, profoundly. Taking space seriously in social science energy research leads researchers to ask different questions about energy systems, and admits alternative sites, actors and practices as legitimate objects of research. In this way, thinking about space can bring into view the analytical limits (and social consequences) of more conventional frameworks that treat space as an unproblematic substrate on which technical, economic and/or political action unfolds.

The spatial turn in energy research finds expression in three broad contributions that are moving research on energy beyond a narrow focus on the geographical outcomes of energy production and consumption. First, there is an attentiveness to the way relationships between energy and society take different forms across time and space. Energy may be one of the Grand Challenges for the 21st century, but this challenge is not the same everywhere: it is made up of several distinct, although often inter-related, problems which find expression through different geographies (urban/rural, global North/global South, net energy exporter/importer). Here the interest in space has primarily been about acknowledging geographical forms of difference. But, by acknowledging spatial difference, space has also begun to fold back into the research process in interesting ways: it disrupts the process of question formulation, because where one is situated spatially makes a difference to the questions that need to be asked; and it illuminates the geographical particularity of assumptions about actors, institutions and processes embedded in theoretical frameworks and research methods.

Second, the sensitivity to space has drawn increasing attention among energy researchers to the ways in which energy systems (resources, technologies, organizational forms and

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operating criteria) underpin geographies of everyday life. Recent work is interested, for example, in how and by whom energy is consumed influences the spatial and material forms of cities (urban morphology), the distribution of manufacturing activity at the global scale (economic globalization), the possibilities for collective action (democratic politics), and the connections and responsibilities created between consumers and 'distant others' (politics of consumption).

A third contribution has been to insist on the dynamic, uneven and contested spatiality of energy systems, and has taken a variety of forms. Recent work has been particularly effective at highlighting the emergence of new energy landscapes [27], practices of energy consumption [28] and novel networks among actors in the energy/climate policy space [29]. The attention here to processes of change focuses on the dynamic quality of energy systems, while embedding these processes in socio-political structures at different spatial scales. The prevalence of landscapes, practices and networks (and other spatial architectures) in contemporary energy research acknowledges the "polymorphism" of contemporary spatial forms [30, 86]. It has also taken the form of critique, and a re-working of core models guiding social science energy research, such as the multi-level perspective (MLP) which examines transitions as the outcome of interactions among three different scales of organization: niche-level innovations, established regimes and an exogenous landscape [84]. In the case of the MLP these efforts have sought to enrich its grasp of the politics of transition [31, 32]; accommodate a richer notion of space within its geographically-impooverished understanding of niche, regime and landscape [24, 33]; and develop a "spatially-explicit second generation MLP" that accommodates the role of distance, spatial difference (in innovation characteristics, for example), and geographical reach across scales within accounts of socio-technical transition [34]. The most thorough-going sympathetic critique of transitions theory in an effort to accommodate space, however, is Gailing and Moss's [35] careful conceptual analysis of the *Energiewende* structured around institutional change, materiality, power and space. Reflecting perspectives from political science, planning studies and human geography, they conclude that more research attention is required on the production of space and uneven development, the scaling of governance, and the materiality of transitions. The scope of their proposal for future work exemplifies the shared appreciation among social science

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researchers for the spatialities of energy systems which I identify in this paper, and which I now develop below.

3. The map: five commitments now guiding spatial research on energy

Having outlined in general terms social science energy research's spatial turn, the next section refines the argument by identifying five conceptual commitments around which much spatially-sensitive social science energy research has come to cohere, notwithstanding its heterogeneity and internal diversity. I argue that these are sufficiently shared they serve as a 'map' that now guides much spatial research on energy. In identifying and naming these shared positions as 'commitments' I am necessarily stylizing and abstracting from a wide range of work. The purpose is not to suggest all research is of a piece, but to distill some base-line conceptual positions that underwrite much contemporary research. In this section, I offer a supportive reading that acknowledges the importance of these commitments in rendering visible a set of previously overlooked questions and claiming researchable territory, and in establishing a conceptual foundation to the field of energy geographies upon which it may subsequently be possible to build.

3.1 We are all socio-technical now

An underpinning premise of most contemporary work is that more is at stake in energy systems than the capture, conversion, distribution and consumption of energy. The primary insight of the socio-technical perspective, regarding the reciprocal and co-productive relations of social structures and technical systems, now frames a wide range of research on the spatiality of energy systems. This first commitment is not a uniquely spatial perspective as it underpins much social science research on energy (including a lot of which appears in this journal). Nonetheless, it is foundational for nearly all research on energy with a spatial sensibility, given its emphasis on contextualizing interactions among people, social structures and technical systems in space and time. The upshot of the core claim, that energy systems are entangled within social processes, is that they can – and, indeed, must – be analyzed and examined by languages and registers that go beyond the physical and technical.

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Causation within this broadly socio-technical perspective runs two ways. On the one hand is the general claim that energy systems are shaped by the political, economic and cultural structures prevalent in society. Accordingly, resources, technical systems and infrastructures are understood as social products, their scale, geographical reach and functionality shaped by prevailing distributions of social power and cultural desires. In the context of energy resources, for example, this work has shown persuasively that resources and infrastructures materialize (i.e. take form as an object of science, economy and law) as a product of social relations [36, 37]. In this way, the assembly of an energy system around biofuels or shale gas, for example, is “not about pulling together pieces of a jigsaw puzzle (because....) the pieces, and therefore the puzzle itself, are shaped in relationship to each other” [38, p. x]. The temporalities of social and technical structures need not align: the durability of many technical structures mean they may remain in the landscape, in use or in hibernation, long after the social forces and normative horizons that drove their creation [39]. A secondary claim reverses the direction of causation: energy systems may be social products but they are also technical artefacts that, via their interaction with social structures and human behaviors, give rise to social processes. In this way, it becomes possible to think about how energy systems give shape to social life in significant ways, and across a wide range of processes (living, working, circulating, securing, desiring). This recursive formulation – energy systems are shaped by social processes, and society is shaped in significant ways by energy systems - is a cornerstone of the socio-technical perspective. It guides many sallying forth on spatial adventures, even if its full insights (particularly around the second component) have yet to be fully developed.

3.2 Space is a product not a platform

The idea that space is socially produced, rather than lying outside social processes, has permeated human geography since the 1980s [40] and now suffuses research on energy geographies. It is hard to over-state the significance of this perspective, and its disjuncture with popularly-received understandings of geography as a set of fixed-dimensions: a stage upon (or, alternatively, a container within) which social action unfolds. This commitment seeks to reconnect the spatiality of energy systems with the economic, political, cultural and environmental processes around energy production and consumption. More specifically it embeds the former within the latter, a move made explicit in human geography research via Bridge, G. 2018. *The Map is Not the Territory: a sympathetic critique of energy research's spatial turn. Energy Research and Social Science* 36: 11-20.

reference to socio-spatial processes. The implication is that to explain uneven geographies of energy consumption within cities, for example, requires understanding the social processes that create differential opportunities and capacities for energy consumption (e.g. the labor market) and give them spatial form at the urban scale (e.g. the real-estate market). The “shift from conceptualizing energy as an economic asset or ecological phenomenon to conceptualizing energy as a social relation” is a distinguishing feature of contemporary work on the geographies of energy, and cuts across other forms of internal diversity and theoretical plurality [8, p. 110].

However, the real significance of this commitment to space as a social product lies in its radical rejection of space as an external realm of fixed dimensions. For example, energy geography’s interest in space is not that of a “cartographer to the social sciences” mapping social phenomena on a predetermined surface [40, p. 4]. Instead, research focuses on the social (and environmental) processes that shape the spatial form of energy infrastructures, supply chains and consumption practices. This is a post-Cartesian perspective, as it departs from a view of space as a plane described by absolute fixed points, as embodied in the coordinate system developed by René Descartes in the 17th century. It opens up the possibility of understanding how the variation, flexibility and dynamism of spatial forms in and around energy systems emerge from the intersection of social processes. Its recognition that the production of space is an open-ended process creates a space for progressive politics [41], in which alternative energy spatialities can emerge that redistribute social power and work against (rather than with) the political-economic grain.

3.3 Energy systems are spatially-constituted (rather than merely geographically-located)

Energy resources, infrastructures and sites of consumption all take up space in an obvious sense and can, of course, be described by their geographical locations. But the language of “spatial constitution” pushes beyond the mere fact of absolute location to examine how a variety of spatial relations make a difference to form, structure and function of energy systems. The commitment to understanding energy systems as spatially-constituted is a corollary to seeing space as a social product. It enriches the understanding of space in ways that go beyond connection and relational proximity, to include a range of cultural,

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environmental, and institutional forms of embeddedness. Work by Dahlmann and colleagues on electricity networks in Germany, for example, emphasizes the “multiply embedded nature of...electricity generation e.g. spatially, temporally, physically, institutionally” and how these different forms of embeddedness enable, constrain and otherwise shape processes of change [42, p. 2]. Attentiveness to spatial embeddedness is typically not a celebration of uniqueness or variation for its own sake, but a recognition of how distinctive characteristics influence and guide the evolution of the energy sector. Thus Dahlmann et al. found that “locational specific natural resource endowments, territoriality reflecting varying levels of institutional thickness and capacity, and embeddedness in specific historical path dependencies and geographical landscapes continue to exert strong forces on energy asset investment” [42, p. 19].

It is here, in the search for concepts able to express the social constitution of energy systems, that the time-worn geographical concept of landscape has found a renewed life [27]. Shorn of prior associations with the passive imprint of human activity, landscape has been re-tooled as a “dynamic entit(y) constituted by complex local, national and transnational flows of technology, funding and ideology” [44, p. 12]. For others, landscape expresses the spatial embeddedness of energy systems because it captures the complex processes of socio-material interaction around energy flows involved in living. Castan Broto, for example, argues (urban) energy landscapes materialize in different forms as a function of the combination of circulating energy-related materials and the “spatial choreographies” of human behavior [45]. In a twist on the embeddedness metaphor, landscapes act as “connective tissue, a highly contextualised membrane that helps society to mould and be moulded in relation to an energy system” [46].

A commitment to the spatially-constituted character of energy systems provides a way of speaking back to policy arguments that emphasize the spatial transferability of technology or policy success: a case in point is the application, to Europe, South Africa, China and elsewhere, of hydraulic fracturing techniques for the recovery of shale gas, based on the experience of the United States. Here an attention to space focuses on the particular (geological, institutional, legal) conditions that favored policy success in one setting, and which trouble assertions of fast policy transfer and replication of the ‘shale revolution’ in others. The deep contextualization implicit in ‘spatial constitution’ also opens an analytical

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window for understanding why energy infrastructures and resource projects are frequently sites of contestation [47]: it is a perspective familiar to political ecology, although not limited to it. Baka, for example, shows how the implementation of biodiesel plantations (*Jatropha*) in Tamil Nadu respond to urban demands for liquid fuel but are, at the same time, also acts of energy dispossession as they require the clearance of trees (*Prosopis*) that provide fuelwood for households and industry [48]. Recognition of the different ways in which these two fuel crops (*Prosopis* and *Jatropha*) are socially and spatially embedded makes visible a process that would otherwise be occluded: their 'non-substitutability' is spatially-constituted.

3.4 Attention to scale pays off

Scale is a well-worn instrument in geography's conceptual toolkit [24], although it is sometimes deployed more as a talisman than a sharp analytical tool. Contemporary work on the geographies of energy acknowledges the utility of scale in at least three ways. First, the multiplicity of scales (local, regional, national, global) provides a methodological entry point: understood as analytical dimensions [34], they offer several different perspectives onto a common process, such as energy transition or securitization. In this way, alternative scales can be harnessed to explore the specificities and limitations of analysis conducted at a single scale. Work on European electricity generation has shown how attention to scale reveals the "differentiated change processes occurring at EU, subregional and national levels" [42]: for example, findings about asset ownership at EU level (growing concentration) were not matched at a sub-regional level (declining asset concentration). An attention to alternative scales can do more than reveal different outcomes, however: it can also identify processes at work that are largely invisible to dominant analytical frameworks. Research on energy security has typically adopted a national scale of analysis, but geographers (and others) have sought to think about diverse practices of securing energy at other scales (household, community, urban). The social processes disclosed by these studies demonstrate the insufficiency of security as a concept for understanding the under-provision of energy services (particularly at household scales) and has encouraged development of the alternative lexicon of energy vulnerability: "a temporally dynamic framework that highlights

the pathways and risks that capture a household's propensity to become unable of securing inadequate heating, lighting and similar services" in the home [49, 50].

Second, there is recognition that re-scaling is a strategy of actors and institutions in the energy sector, and that attention to these strategies can provide a productive lens on processes of transformation and governance. Economic liberalisation of the energy sector, for example, not only changes ownership and commercial structures but also introduces new actors into the energy space. In the context of the UK electricity and gas sectors, for example, privatization and liberalization have rescaled the "national" energy economy via transnational ownership of core assets (LNG terminals, pipelines, electricity generating stations). In a similar way, renewed interest in the municipal ownership of gas, electricity and heat services re-scales ownership and governance of energy in search of more effective scales of addressing energy and climate concerns. Municipal provision has a long history and its return involves bringing back into public ownership assets that had previously been sold off and privatised, and/or replacing outsourced services with direct provision by local government. The municipalization of energy and water services has been particularly pronounced in Germany, where it has occurred in the context of the country's exit from nuclear power and the shift to renewables for production of heat and electricity [51]. Scale, then, has proven a useful instrument for examining the governance of energy systems and processes of change underway within them [26, 52].

Third, attention to scale complicates the false equation of place with the local and particular. By admitting multiple spatial scales simultaneously, and exploring how space is produced through their intersection, a much more fluid understanding of space as "contemporaneous co-existence" has begun to emerge within work on energy [41]. For example, recent work on the political economy of energy transitions in the global South, which highlights the influence of transnational capital and donor communities on the evolution of national energy pathways, illustrates the analytical value of holding together both global and domestic scale processes [32, 44, 53]. More generally, the concept of re-scaling is a provocation to think about the multiple scales that constitute contemporary spatialities (which are often so familiar as to pass unnoticed). It can be a means of opening up sensitivity to space in conversations about the transformation of energy systems already framed in technological or institutional terms; or, alternatively, exploring the relationship

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between energy and political-economic processes that are already understood through a spatial lens (e.g. economic globalization, political nationalism). For example, global shifts in manufacturing over the last forty years to take advantage of geographically uneven labor costs have been enabled by the falling significance of transportation as a proportion of total product costs. While the intensification of economic globalization via trade and investment has multiple proximate causes, it has been underpinned by cheap bunker fuels, marine diesel engines, and the exclusion of international shipping from the UNFCCC in economic globalization [54, 55]. Re-scaling can also be an overt political ambition. Such ambitions may take different scalar forms at any one time (as globalist, nationalist, municipal and communitarian energy imaginaries co-exist): in the current conjuncture, however, the spatiality of energy systems is often invoked in the cause of nationalist and populist imaginaries. From this perspective, a strategic goal like national energy security becomes scaled as a matter of increasing domestic supply (notwithstanding the capacity of technical failure, labor disputes and sabotage to disrupt domestic supply chains, and its erasure of alternatives such as supply diversification or enhanced domestic efficiency). The government of Turkey, for example, is currently justifying a large-scale expansion of lignite mining and the construction of coal-fired power stations as a response to rising gas imports; and the UK government has argued for the development of domestic shale resources in the context of the country's growing dependence on imported natural gas since 2000. In both cases rescaling, in the form of renewed domestic energy production, is equated in populist discourse with a restoration of strength and power. The scaling of energy as a nationalist economic and political agenda are also evident in the promotion of 'competitive' energy prices to stimulate national economic growth, and in the advocacy of domestic energy production as a cleaner and/or ethically superior alternative to imports (such as Canada's promotion of tar sands production as "ethical oil").

3.5 Energy supply and demand are material practices

"Energy" is a 19th century abstraction created for the purposes of comparing different materials and technologies. Its key value as a concept is that it makes commensurate things

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that are conventionally classed as different. Like other means of measure, it erases important differences so that functional (and commercial) value may be compared. An impetus of geographical research on energy has been to unpick this abstraction and re-materialise energy production and consumption by reference to specific materials and social practices. As the late David McKay [56], former chief scientific adviser to the UK's one-time Department of Energy and Climate Change, memorably put it "You can't power a TV with cat food, nor can you feed a cat from a wind turbine." The distinction here is between different physical forms (electrical, chemical, mechanical, kinetic) in which energy presents itself. But energy supply and demand are also differentiated in other socially significant ways. Energy stocks and flows take the shape and character of particular materials (coal, wood, animal dung) and places (narrow valleys for hydroelectric dam sites, uplands for the capture and conversion of wind energy); and energy demand takes the form of particular social practices and cultural norms around energy services (heating, lighting, power and transport).

These material forms and practices are important for a range of reasons. They mean that energy resources are much less interchangeable than inventories of energy quantity might suggest. The much lower power densities of renewables vs. fossil fuels, for example, implies that harnessing an equivalent flow of power from renewable energy sources will involve spatial trade-offs: much larger areas of land must be dedicated to the task than for fossil or nuclear energy sources so that energy production once again becomes a significant driver of land use [57, 58]. The material forms of energy consumption (where and when they happen, the social practices that constitute energy demand) also influence the attachments that people form with energy services in ways that help explain the difficulty of changing behaviour [59, 60]; while differences in the scale, physical form, temporalities and location of different electricity generating technologies shape the politics of opposition and resistance [61]. More generally, the materiality of different fuels – such as the difference between solid coal and liquid oil, or the labour-saving capacity of electricity in the domestic home – give shape to political opportunities around class and gender. In short, the socio-political consequences of energy transition in the 20th century history are significantly more complex than a growing per capita availability of energy [23, 43, 62]. Attentiveness to

material form thereby restores some of the particularity and incommensurability that the invention of 'energy' was designed to erase.

The objective of this section has been to take stock of contemporary work on the spatiality of energy systems. Where others have emphasized recent work's theoretical plurality [8], I have instead identified a set of shared commitments. These are not inconsistent positions: work on energy geographies is delightfully plural in its conceptual roots, yet there is also a shared understanding of space that, to a substantial degree, reflects developments in human geography over the last few decades. The five commitments identified above are necessarily schematic and I am not suggesting everyone writing on the geographies of energy shares them and, still less, articulates each of them in full. In the context of a growing interest in the spatialities of energy systems, however, they characterize an emerging consensus position around how space and energy can be understood. They reflect an increasingly sophisticated approach to space within work on energy that is distinctive when set against the long record of work in this area; and they offer, for the first time I would argue, the possibility of a conceptual coherence that has not been there before. Taken together, they have the potential to provide a more robust foundation on which to ground energy geographies as a field of enquiry. Their effect is to transform the field from being a loosely corralled grouping of thematic interests having to do with energy into a set of claims about the relationship between energy and space, and about how this relationship can be understood.

4. Travelling beyond the map: realizing the full potential of social science energy research's spatial turn

The shared commitments described above constitute a map of sorts: through it sub-disciplinary "territories" like energy geographies are beginning to take shape. In identifying and naming these five commitments, I hope to further the consolidation of a geographical perspective within social science energy research and the development of energy geographies as a robust field of inquiry. In this section, however, I offer a more critical reading of the spatial adventure so far. The value of the maxim in the paper's title – "the

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map is not the territory” - is that it preserves a gap between the abstractions through which we understand the world and the world itself. It forces recognition that these are not the same thing. The overall argument in this section, then, is that the map may render the world graspable but is necessarily limiting.

There are two points here. First, the spatial turn in energy research has, in effect, simply brought spatially-sensitive research on energy more up to speed with developments in human geography over the last three decades. By and large, energy has not been a core locus of innovation for human geography during a long period (30 years or so) of far-reaching conceptual development.^{vi} As a result, the field of energy geographies has largely been an importer of concepts and approaches pioneered in geography’s other sub-disciplines: this, in part, explains the plurality of theoretical perspectives within contemporary work [8]. In this sense, the map simply allows us to think about energy in the way many human geographers now do in relation to other objects of enquiry.

Second, there are important processes underway in and around energy systems that the map alludes to, but which it does not adequately enable us to grasp. The next section highlights three processes – geographies of knowledge production, differentiation and disassembly – that illustrate the further potential of a spatial perspective, and its capacity for identifying and analyzing the processes reshaping contemporary energy systems: to adequately understand these three processes requires a spatial perspective, but also requires we venture beyond the map. Each of them, when made the focus of enquiry, disrupts conventional ways of understanding and conceptualizing energy systems, although in different ways. A focus on geographies of knowledge production, for example, highlights the constrained set of geographical and social contexts (see 4.1 below) through which the bulk of knowledge about energy systems has been generated. It suggests, a priori, the value of radically de-centering the sites and contexts in which research on energy systems is undertaken. A focus on differentiation or disassembly, on the other hand, shifts understanding by creating an alternative window on the processes shaping contemporary energy systems in global North and South: their value is that they bring something into view that is otherwise overlooked. As I outline below, all three are promising pathways to explore, and not only because their implications for energy systems are not currently well understood. Examining these processes in the context of energy systems, where each may

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be clearly observed, furthers a broader and more fundamental goal of “fac(ing) up to the challenges of space” for explanation within the social sciences [41, p. 8]. My argument is that, by paying attention to geographies of knowledge production, and processes of differentiation and disassembly, social science energy research has the potential to inform and critically extend the social science literature (primarily in human geography) on space and society.

4.1 Geographies of knowledge production: de-colonising energy geographies

Social science energy research, of which energy geographies is a growing part, is strongly inflected by concerns and conceptual frameworks developed in the global North. These bodies of work have emerged from a close engagement with energy systems and processes of change in a relatively small number of national crucibles (e.g. Netherlands, UK, Germany, United States). Set against the plurality of possible settings and scales in which to investigate relationships between energy and society, the geographies from and through which knowledge in this area has emerged are very particular. To a significant degree, the ‘map’ now guiding energy geographies derives from the exploration of large-scale energy networks in market-based industrialised economies characterized by formal energy actors (states, firms, non-governmental organizations) and the rule of law, and where research is shaped (if not directed) by policy concerns such as spatial planning, energy security, energy transition. Not all work reflects these origins, of course: alternative scales, particularly the urban, have complemented an initial national focus and, over the past few years there has been an increasing exploration of energy geographies in national and urban settings beyond the industrial core [32, 63, 64]. The point, however, is that the geographies of knowledge through which these fields emerged continue to loom large: in the sets of concerns through which research is framed, the theoretical and conceptual frameworks adopted, and methodological considerations such as presumptions about key actors.

Traveling beyond the map, in this case, is not simply about doing more research outside the core. It means seizing upon the significance of space as a fundamental source of multiplicity and plurality, in order to de-colonise social science energy research [41]. This primacy of spatial difference, and its necessary relationship to multiplicity, means that what we know

about processes like energy transition, or consumer behavior and energy demand, are only ever situated forms of knowledge. In this way knowledge, just like other social processes, is spatially embedded and carries with it the imprint of the material conditions from which it emerged. While recent research is interested in working across multiplicity and learning from difference (e.g. comparing experiences of energy transition, or thinking through alternative cases of how urban energy infrastructures become politicized), the full critical potential of this insight for energy studies has yet to be realized. For example, as discussed above (Section 2) there is now a substantial critique of the limits of the MLP framework for understanding the spatialities of energy transition. A good part of that critique (but not all) has emerged from encounters with difference. That is, researchers have recognized the limits of the framework as they sought to understand the direction and scope of transition, and the social processes at work, in geographies outside of the Netherlands/northern Europe where it was first developed [32, 44]. Yet, in responding to those limits, the MLP retains its central role even as it is critiqued and reformulated: the encounter with difference may disturb the framework but does not transcend it.

What would it mean to theorize about energy geographies from elsewhere? On the one hand, encounters with difference with regard to fuels, infrastructures and energy practices reveal the “wide (and poorly fitting) conceptual categories” through which much energy research is framed [66], such as production/consumption, renewables vs. non-renewables, formal vs. informal, market vs. subsistence, and ‘global South’. Here empirical specification (i.e. thick description) of technologies, practices and infrastructures can serve to disrupt imported abstract modes of reasoning and drive the creation of alternative categories and/or rejection of those developed elsewhere. On the other, close attention to processes of social reproduction and their relation to patterns of energy use - such as the norms and desires shaping demand for energy-related services among the rapidly growing global middle class - enable accounts of social change that do not read spatial difference as a substitute for time. That is, they theorize the processes observed contemporaneously – i.e. in relation to other spaces – and not by reference to a temporal model of modernization in which every geography passes through a similar phase (e.g. industrialization, mass consumption).

4.2 Differentiation and specification: the making of materials and territory

Differentiation describes the process of producing and ordering difference. Specificity is an outcome of differentiation – expressed, for example, in the qualities of different materials or the content of territory - and enables the ordering of difference. Differentiation and specification are strategies central to the transformation of energy systems to meet desired goals of enhanced energy access, greater security, lower-carbon emissions or improved energy efficiency. An illustrative example in the context of decarbonization objectives, for example, is the way energy and climate policy seek to differentiate energy flows and manufactured products by inscribing them with markers of material difference (e.g. the CO₂ contribution of different fuels, such as the EU's Fuel Quality Directive focused on the greenhouse intensity of vehicle fuels; or energy efficiency ratings pursuant to the Energy Labelling Directive). These markers specify certain qualities and are designed to function within electricity, fuel and product markets by interrupting assumptions of fungibility. They do the work of material differentiation so that electrons, fuels or consumer durables in these markets are no longer the same, allowing investors and consumers to allocate capital based on this information with the goal of driving changes in patterns and rates of use. Another example is in relation to new electricity generating capacity, where a combination of decarbonisation and decentralization objectives mean policies frequently differentiate by carbon content, maturity of generating technology, and the scale of the generating unit. The UK's recent auctions for renewable electricity capacity, for example, distinguished between "established" (onshore wind, solar, energy from waste) and "less established" (offshore wind, gasification) generating technologies.^{vii} In a similar way feed-in tariffs differentiate by energy source (anaerobic digestion, combined heat and power, hydro, solar, wind) and capacity of the generating system (based on kilowatt output), with different prices paid for the electrons generated by each group. Differentiation is an important tool in the corporate sector for discriminating among potential targets for investment. It is key to the process of prospecting and quantifying both fossil and renewable sources of energy, and so lies behind the production of resource landscapes.

A focus on differentiation capitalizes on geography's long-standing interest in spatial difference, but shifts attention from thinking about difference as geographical unevenness to examining how difference is generated and made meaningful in ways that have economic

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and political effects. An objective is to denaturalize difference so that it becomes understood as more than a background condition, with differentiation recognized as a strategy central to ordering and transforming energy systems. A general goal of research, then, is to examine how difference works as a political technology [36] – how it is produced, normalized, monitored and maintained – and how making, recording and regulating difference is central to the transformation of energy systems and the production of new energy geographies. There are two areas in particular, however, where a focus on differentiation and specification can be applied to good effect: materials and territory.

Recent work on the geographies of energy makes several appeals to energy's *materiality* [37, 65, 67]. These appeals are not of a piece, however, as they seek to do several different things. For a few, materiality is nod to thermodynamic constraints and the heterogeneity of energy carriers (e.g. the different energy densities of coal, oil and gas) and energy conversions (e.g. the different power densities of renewables vs. non-renewables): understood this way, materiality makes it possible to think about geographical patterns of trade as an ecologically unequal exchange, in which highly ordered forms of matter (e.g. fuels) are appropriated and geographically transferred from place and consumed in another, in ways that differently expand the economic productivity of the consuming location [68, 69]. For others, the appeal to materiality is a critique of anthropogenic notions of agency [70]: here materiality opens up a way of thinking about the capacity of objects and materials to act in the world in ways that exceed human intention. With regards to differentiation, however, a third understanding of materiality is beginning to emerge in recent work. This centres on the process of "informational enrichment" by which material objects take form and shape and come to have material effects "through multiple layers of information production" [71, 36, p. 141]. In relation to subterranean energy resources, for example, the multiple layers of geological science, engineering, economic appraisal and property law that give these resources their material form also gather together different actors and relations. The observation regarding informational enrichment considerably sharpens this general socio-technical argument drawn from science and technology studies: that material objects do things in the world because of the way they enable constellations of actors to form in and around them. Its emphasis on information production provides a direct link to the process of differentiation and specification – i.e. how the qualities and properties of

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materials are established and made meaningful. If the appeal of materiality at a general level is that it pushes back against energy as a conceptual abstraction, this more specific understanding re-materialises energy by examining how materials (resources, technologies, infrastructures) are specified and differentiated through a range of social knowledges in ways that have political and economic effects: for example, how resources and fuels “qualify for markets” [72], “bear value” for the circulation of capital [73], or become “objects of dispute” [36].

To focus on differentiation via *territory* (and territoriality) is to highlight and problematize the geographical and spatial forms created through energy systems and their transformation. Territory here refers to the spatial configuration of energy systems: it references their connectivity and integration across space as well as their boundedness and separation, and acknowledges that territorial form is not a given but an area of strategy in which, at any one time, several alternative territorial formations in play. Coutard and Rutherford, for example, highlight how energy infrastructures take different territorial forms, from urban networks and off-grid systems to national and continental scale infrastructures [74]; while Gailing and Röhring examine the “energy region” as a distinctive territorial form promoted by the federal government for delivering Germany’s energy transition [75]. The latter illustrates how territorial differentiation (boundary drawing) and specification (determining territorial qualities) shape the geographies of the *Energiewende*. Land access policies for energy infrastructure or resource development provide a similar illustration: they differentiate space according to the perceived suitability for energy resource development, specifying (via recourse to physical science, economic knowledge and land law) areas open for development and separating them from those off-limits. The allied concept of territoriality is useful here, as it refers to the strategic processes “behind territory” [76, p. 5] and “applies to the geographical strategies of partition and integration employed by economic and political actors (states, firms) in the exercise of authority and/or commercial power” [24]. A focus on territory, then, draws attention to the spatial constitution of energy systems but, more particularly, to the process of spatial differentiation – of establishing connections and separations – that lie behind it. McEwan, for example, examines the zonal territorial form associated with renewable power promotion in South Africa, highlighting the experimental differentiations drawn by the

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zones which are “forms of spatial and political-administrative exceptionality...that allow political and economic actors to exercise authority and commercial power” [63, p. 2]

4.3 Destabilisation and disassembly: tackling incumbency

Destabilization and disassembly provide novel perspectives on processes of change in energy systems. Recent work on energy transition has drawn on a range of conceptual perspectives in trying to account for the emergence, evolution and path-dependence of energy systems, including actor-network theory, technological innovation systems, assemblage thinking, the multi-level perspective and relational networks. To an extraordinary degree, however, this work has focussed on innovation and the diffusion of new socio-technical configurations over time and space: the presence and significance of incumbent technologies, actors and institutions is acknowledged, but transition is largely understood as the assembly, proliferation and normalisation of new technologies and or policy frameworks. If current work has a theory of exit, it is one based on a general process of competition and a squeezing, normally via policy, of the commercial space for incumbent energy systems. Much less studied in the context of contemporary energy systems is the process by which dominant and seemingly-durable actors and institutions come into question and start being abandoned as the relations that have sustained an incumbent’s position begin to fray. As a consequence, socially important processes of change and transition have been understood primarily via processes of emergence and new formation, rather than destabilisation and disassembly, retreat or managed decline. The consequence, as Haarstad and Wanvik have recently pointed out in relation to fossil fuel landscapes, is that “stability and permanence in society’s relationship with carbon tends to be exaggerated” at the expense of understanding how this relationship is “also characterised by rupture, unpredictability and instability” [77, p.2].

In relation to decarbonisation objectives, the need for a managed retreat by carbon-intensive energy firms and the active disassembly of carbon-intensive energy networks are key features of the contemporary energy system. There is widespread acknowledgement

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(e.g. Paris Agreement) that an effective response to climate change requires the rapid dismantling of high-carbon energy systems, rather than relying on the take up of low-carbon technologies or practices of low-carbon living. Turnheim and Geels have argued that incumbent firms experience energy transition as a “destabilizing” political and economic process, characterized by declining financial resources and eroding public legitimacy: and it is recognised, more generally, that energy transitions redistribute costs and benefits and so are not neutral in their economic and political effects [78]. However, processes of destabilisation and disassembly, and the temporal dis-junctures associated with retreat and managed decline, are under-studied in relation to their significance. For example, the economic power of several large incumbent firms in the energy sector has begun to look unfamiliarly precarious in the past few years. European utility companies, for example, have experienced something close to an existential crisis in the context of decarbonisation in the power sector. The value of the top 20 energy utilities in Europe halved between 2008 and 2016, as regulated utilities owning nuclear, coal and gas assets were squeezed in the power market by the growing penetration of renewables and the falling wholesale price of power [79, 80]. In the United States, the rapid take up of gas and renewables has driven a collapse in the fortunes of the coal sector, including bankruptcies of leading firms (e.g. Peabody, Arch Coal, Alpha Natural Resources [81]). The oil sector has not been immune, with growing recognition of the financial risks arising from exposure to publicly-traded oil companies, with some reserves likely to become stranded in the context of action on climate change [82].

Destabilisation and disassembly are invitations to think about a world in motion that does not rely on tropes of emergence and innovation: they focus instead on the conditions of possibility that sustain durable structures over time and space, and the consequences for people and places when those conditions no longer hold. They also open opportunities to think about multiple temporalities, complicating the emphasis on stability within transitions theory [35]. For example, they provide a way to think about the temporal disjuncture between a strategy of rapid economic disinvestment (e.g. a retreat from coal) and the ongoing character of social reproduction in dependent communities, whether at household, urban or regional scale. It is, therefore, a perspective able to take seriously the processes of

economic disarticulation [83], abandonment, and loss – and the associated affective dimensions of anger, grief and hope in relation to place - that systemic change inevitably involves. Research pursuing this perspective is likely to adopt a strongly empirical orientation towards understanding how functionally durable structures respond to the temporalities of external shock, or erosion of the capacity for resilience through the accretion of stress, and the role of cultural imaginaries and practices that challenge the legitimacy of existing structures. It also draws attention to the strategies by which incumbent firms may seek to resist destabilization. These include technological responses (e.g. so-called sailing-ship or last-gasp effects, as competition from new sources accelerates incumbent innovation) and defensive political moves to limit or resist further systemic change (such as lobbying for policies which protect the interests of incumbents rather than supporting emergent rivals).^{viii} Research on past energy transitions has observed how “transitions are just as much about the decline of incumbent industries, as about the rise of new ones” [85, p. 5], although this insight has yet to be extended to contemporary processes in a sustained and systematic way. We currently know too little about on-going processes of disassembly, the sites and spaces in and through which it takes effect, or their significance for actors and places associated with the existing energy system.

5. Conclusion

It is now widely recognised that energy encompasses far more than physical resources and conversion technologies with the capacity to do work. Energy is constitutive of modes of living and working, of patterns of trade and investment, and of political and geopolitical relations. The case for not ceding energy to the engineering and physical sciences, and examining it from the critical and applied perspectives of social sciences and humanities, has been well made [86, 87]. In this paper, however, I have argued that a distinctively spatial perspective in social science energy research has recently emerged, grounded in geography (where it has long roots) but also extending well beyond it. As a consequence, much contemporary social science energy research now engages the problem of space and in ways that go beyond a focus on location and distance, which characterised earlier, spatial

planning approaches. Infused by the social theoretic perspectives of human geography, anthropology, science and technology studies, and political science, recent work acknowledges space as a realm of socio-material processes with the capacity to disrupt conventional social science frameworks.

In an effort to get the measure of this spatial perspective, I have outlined five conceptual commitments broadly shared by contemporary work. I have suggested that these now constitute a map of sorts, in that they guide current work on the geographies of energy. In this paper, I have offered an appreciative evaluation of what this work has achieved and its significance. However, I have also offered a more critical reading of the adventure so far by highlighting how the emerging map may become unnecessarily limiting. The risk, in short, is that as spatially-sensitive social scientists working on energy we mistake the map for the territory: that, emboldened by an emerging and shared conceptual language for thinking about the spatialities of energy, we become comfortable with the broad contours it discloses and fail to see what it does not. The consolidation of research in this area, as evidenced by the growing stature of a subfield like energy geographies, is to be welcomed. But it is precisely at such moments of growing coherence that a critical field should also be looking for paths still to be taken, and asking how engaging energy from a spatial perspective might yet open up new research questions. 'The Map is Not the Territory' then, serves as a useful warning, directing analytical attention back to the world we seek to understand. This iteration between the world and the conceptual repertoire of spatially-sensitive energy research is critical because, out of this gap between territory and map, yet more thoroughly geographical accounts of the spatiality of energy systems can emerge. I have identified three potential pathways offering this possibility: geographies of knowledge production, differentiation and disassembly. Each focuses empirically on socio-material processes that are observable within contemporary energy systems; and each continues the spatial adventure by doubling down (i.e. pushing still further) on the possibilities of a spatial perspective. The provocation of this paper is that the full potential of a spatial perspective has yet to be realised within social science energy research: it is in this sense that I describe the three pathways as leading to more thoroughly geographical accounts of energy systems and their transformation. They are not intended to be exhaustive and, no doubt, others are

possible. Individually or in combination they have the potential to take social science's spatial adventure in energy research in new directions.

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ENDNOTES

ⁱ There is now a substantial literature that offers a critique of cartography and its primary object (the map) as a mode of representation [2, 3]. This work challenges the assumption, on which cartographic science depends, that a map is an objective representation [4]. Instead, it sees in maps (even the most apparently scientific kind) the workings of culture and the play of power. I do not take up this argument here.

ⁱⁱ This phrase comes from Alfred Korzybski (1953), a Polish-American mathematician and linguistic philosopher writing in the first half of the 20th century [5]. He sought to understand the process of abstraction through which reality is apprehended, represented and transmitted across space and time as part of the accretion of human knowledge and culture. The denial of identity ('it is not the territory') was central to his method for improving mutual understanding as it drew attention to the difference between representation and the object being represented. Korzybski's body of work on general semantics is not relevant here, but his maxim serves a useful purpose as it identifies and harnesses a gap (a non-equivalence) for the purposes of increasing understanding. I deploy his phrase here in the spirit of a constructive metaphor, rather than a literal allusion to Korzybski's work on the relationship of representation to reality.

ⁱⁱⁱ The briefest of encounters with post-colonial scholarship is sufficient to recognize that exploring and adventuring are problematic concepts, given their valorization by imperialist projects of territorial appropriation, the raced and gendered identities sustained through such endeavors, and the assumptions about ownership and prior occupation that frequently accompany such terms [6, 7]. I am mindful, then, that these are politically and morally freighted terms. However, I have temporarily set aside such concerns in the context of a special issue that embraces 'spatial adventures' as its theme, for the sake of developing an argument about how we might more fully realize the analytical potential of a spatial perspective for energy research in social science.

^{iv} An important enabling condition has been a convergence of interest in the spatiality of energy systems between geography (and other cognate social science fields) and energy studies [24]. Geography appropriated space and place as foundational concepts long ago. It holds no monopoly on these concepts, but the discipline has had time to develop a conceptual repertoire and theoretical language for thinking about spatial phenomena and their relation to social and environmental processes. For the energy studies community, an interest in energy's geographies highlights the spatial consequences of energy system transformation, but also recognizes space's disruptive effect on conventional methods of appraisal and policy formulation.

^v A "geographical turn" has been observed in transitions studies [25]; and a "spatial turn" in socio-technical research, noting its traditional neglect of "cities – and places in general" [26, p. 95].

^{vi} It is interesting to note, however, that some of the formative work developing a relational conception of space (e.g. [40]) came out of empirical research on deindustrialization and economic restructuring in coalfield communities.

^{vii} Differentiation here ensured no direct competition between the two categories, and led higher strike prices to be assigned to the latter group [88].

^{viii} So-called because a technological response to the onset of marine steam power was the development of iron-hulled clipper ships with steel masts and multiple sails in the second half of the 19th century [84].