

The Evolving Borderland of Energy Geographies

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Dr. Jennifer Baka, Penn State Department of Geography

Ms. Saumya Vaishnava, Penn State Department of Geography

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ABSTRACT

Energy geographers have characterized energy as a borderland topic because of its ability to straddle and interconnect different geographic concepts and debates. In this review, we evaluate how the borderland of energy geographies has been emerging in recent years by analyzing scholarship on energy published in top geography journals and a leading energy studies journal, *Energy Research & Social Science*. In part 1 of our review, we evaluate how the borderland of energy geographies is evolving by mapping the geographic range of empirical studies, the processes and types of energy systems being researched and the key geographic concepts/theories engaged across the four main sub-fields of geography. We find that energy geographies scholarship has primarily centered on the Global North, remains focused on the extractive and production phase of energy development and is evolving across and within three of the four sub-fields of geography. Energy transitions, governance, justice, space and landscape are key topics and concepts examined. Notable under-representations include a relative lack of energy geographies scholarship within physical geography, as well as limited studies that engage geographic concepts to study the transportation sector, unconventional energy development and the food-energy-water nexus. In part 2, we identify three broad research themes to expand the frontier of energy geographies: 1) geographies of energy knowledge production, particularly indigenous knowledge; 2) materializing energy, especially through engaging political-industrial ecology; and 3) advancing geographic thought by critically assessing how studying energy advances/challenges/transforms core geographic concepts and debates. Collectively, our review demonstrates that energy geographies has established firm footing within and across geography. Deepening engagement with emerging trends elsewhere in geography and the social sciences will not only help to better conceptualize what a geographic perspective on energy means but will also help to make clearer sense of the rapid economic, social, environmental and political transformations currently underway within the global energy system.

Introduction

The global energy landscape has rapidly transformed over the last decade. Key changes have included the rapid development of hydraulic fracturing, the expansion of low carbon energy policy initiatives, and the declining cost of renewable energy technologies. The resurgent field of energy geographies has emerged to provide a geographic perspective on these transformations, examining the new spatial, cultural, human-environment and geopolitical relations that have resulted. Since 2015, two theoretical reviews (Calvert, 2015; Huber, 2015), two edited handbooks (Bouzarovski, Pasqualetti, & Broto, 2017; Solomon & Calvert, 2017) and an introductory textbook (Bridge, Barr, et al., 2018) have been published to further establish the field. At the same time, a new journal, *Energy Research and Social Science* (ERSS), was started to better advance social science inquiries into the role of energy in society (Sovacool, 2014) and, more recently, to probe how energy research could inform social sciences (Van Veelen, Pinker, Tingey, Taylor Aiken, & Eadson, 2019). Collectively, we identify over 400 articles that have been published since 2015 that study energy through a geographic lens. In this review, we synthesize this literature to better understand how the field of energy geographies is evolving and where it can go in the future.

In his article conceptualizing energy geographies, Calvert (2015) characterizes the field as an academic borderland because energy is a cross-cutting topic that can straddle and interconnect

different geographic concepts and debates. We organize this review around the concept of borderland in order to map out how and where energy geographies are being studied and to identify research gaps and emerging themes. This broader level overview is warranted in light of recent literature reviews on certain aspects of energy geographies, including community energy (Creamer et al., 2018), energy democracy (Becker & Naumann, 2017) and nuclear geographies (Alexis-Martin & Davies, 2017) as well as special journal issues on relevant topics, such as spatial relations (Castán Broto & Baker, 2018) and energy infrastructures (Bridge, Özkaynak, & Turhan, 2018).

The review is organized in two parts. In part 1, we analyze how the energy geographies borderland is unfolding, in terms of the geographic range, types of energy processes and systems being studied. We then evaluate the distribution of energy geographies scholarship across the four sub-fields of geography—human, GIScience, physical, nature-society—identifying the main concepts/theories engaged and key topics studied within and across sub-fields. In part 2, we take stock of our analysis by identifying emerging themes within energy geography as well as areas where energy geographies might better engage with ongoing debates within geographic scholarship more broadly. We identify three such themes and gaps: 1) geographies of energy knowledge production; 2) (re)-materializing energy; and 3) re-conceptualizing geographic theories through the study of energy. We present these findings after a brief review of methods in the next section and offer concluding thoughts on the future of energy geographies in the final section.

1.

2. Methods

We broadly followed the methods used by Sovacool (2014) in his literature review of energy studies. He combines a quantitative analysis of over 4,000 articles with a qualitative analysis of the key research questions and foci from the quantitative analysis. Similar to Sovacool, we aimed to characterize the breadth of energy geographies in this paper. In contrast to Sovacool, we discuss main research foci within part 1 of our paper and identify emerging themes and research gaps in part 2 of the paper. We hope this helps to chart a future course for this rapidly evolving field.

We focused on articles in order to utilize search and citation tools available through article databases. As such, our database is non-exhaustive as it excludes monographs and debates that are occurring in cognate fields, such as water and resource geography, that are likely influencing the field of energy geographies. Further, we focus our analysis on papers published in English. This may exclude debates occurring in non-English publication outlets.

We assembled our database in three steps. First, articles from 40 geography journals¹ were searched to identify articles that included the term “energy”² in the title, abstract or keywords from January 2015 to January 2019. This search yielded 292 articles. Second, we compiled a list

¹ We selected a range of 40 geography journals to represent the four geography sub-fields. We prioritized the top geography journals, as ranked by the 2017 Journal Citation Reports, and added ten regional geography journals and *Progress in Physical Geography*. Journals were searched in the Web of Science database.

² We found that “energy” returned the highest number of relevant articles in the Web of Science in comparison to cognate words, such as “power”. We also triangulated our findings by searching the Web of Science for articles published by a sample of authors in the two handbooks of energy geographies to ensure inclusiveness (Bouzarovski et al, 2017, Solomon and Calvert, 2017).

of core geographic concepts used to study energy by coding the articles from step 1. Third, articles from ERSS were added to the database by searching the journal for articles that included one or more of the key geographic terms identified in step two in the title, abstract or keywords. This yielded an additional 134 articles for a total of 426 articles. The articles were then coded, mainly by reading the abstracts, to identify the country of focus, type of energy systems/processes studied, sub-field and concepts/theories engaged.

3. The Academic Borderland of Energy Geographies

In this section, we evaluate how the energy geographies borderland is emerging by mapping the geographic range of empirical studies, the processes and types of energy systems being researched and the key geographic concepts/theories engaged within the literature across the four main sub-fields of geography.

Figure 1 depicts the geographic range of empirical case studies. The majority of studies focused on energy geographies of the Global North, with the United Kingdom (n=68) and the United States (n=48) alone making up a third of all the articles. Much of this scholarship has focused around topics of low carbon energy transitions, energy justice and the relationship between energy and urbanization. Significantly fewer articles were published on the Global South, with articles mainly focusing on China (n=24), India (n=10), Kenya (n=7) and South Africa (n=7). Energy access, especially improving energy access through building off-grid renewable energy systems, and the political economy of energy resource use were key topics of this literature. However, limited attention has been paid to electrification through grid extension, especially in countries such as India, or on everyday engagements with energy systems in Global South, particularly in urban areas. The role of the financial sector in energy system expansion is a growing area of research within energy geographies of the Global South (Baker, 2015; Merme, Ahlers, & Gupta, 2014). This disproportionate geographical coverage indicates a potential western bias in energy geographies scholarship, at least in terms of coverage in English language journals.

Figure 1: Geographic Borderland: 2015-2019

[Insert Figure 1 here]

We also analyzed the different energy processes (Table 1) and types of energy (Table 2) being studied by energy geographers. In terms of energy processes, roughly 82% of articles studied a specific phase of energy transformation (extraction/production, infrastructure/transmission, consumption).³ Close to 50% of articles/chapters that studied an energy process focused on the extraction and production phase of energy. This finding illustrates Huber's (2017a) claim that geographers (and political ecologists) tend to primarily focus on the extractives phase of energy. In conceptualizing the field of industrial political ecology, Huber advocates for geographers to shift their attention to other phases of energy development, as other phases, in his case, industrial processing, tend to be dominated by a smaller number of actors who wield more control over the metabolism and environmental degradation associated with energy systems (Huber, 2017a, 2017b).

Studies of energy consumption, which represent about 47% of articles, has been a growing area of interest within energy geographies, particularly regarding how energy consumption

³ The remaining 17% of articles studied energy more generally, particularly in terms of energy transitions, which represented 14% (n=58) articles. The energy transitions literature is reviewed in our discussion of Figure 2.

shapes everyday livelihoods (Ahlborg, 2018; Davies & Doyle, 2015; Pickerill, 2015; Shirani et al., 2017) as well as how uneven access to energy is facilitating increases in fuel/energy poverty (Bouzarovski & Thomson, 2018; Hilbert & Werner, 2016; Petrova, 2018; Robinson, Bouzarovski, & Lindley, 2018). Yet, research on energy consumption could be further expanded by more systematically analyzing energy services, such as transportation. To date, energy geographers studying transportation have largely focused policy strategies for decarbonizing the transport sector, with a special focus on electric vehicle adoption (Broadbent, Drozdowski, & Metternicht, 2018; Pettifor, Wilson, McCollum, & Edelenbosch, 2017; Sovacool, 2017; Sovacool, Kester, Noel, & de Rubens, 2018). If a recent special issue of ERSS on transportation and energy justice is indicative (Simcock & Mullen, 2016), geographers are beginning to explore the linkages between energy consumption and equity, inquiries that should be deepened and extended. Our review did not turn up energy geographies scholarship on the aviation sector, which would be another ripe area for geographic inquiry, given the linkages between aviation and climate change.

Although studies of energy infrastructures and transmission represent only about 3% of articles, this is a growing area of research within energy geographies, as Bridge et al.'s (2018) recent 28-article ERSS special issue on energy infrastructures and the political economy of national development attests. Emerging themes on infrastructures within energy geographies include financialization (Knuth, 2018) and the political geography of energy infrastructure expansion, particularly natural gas infrastructures in Europe (Bouzarovski, Bradshaw, & Wochnik, 2015). Yet, other significant topics of energy infrastructures are under-explored. Except for Harrison's (2016) historical analysis of electric grid expansion in the Jim Crow South of the US, limited research has been done on transmission planning, electricity grid expansion/upgrading. Further, limited geographic research has been done to examine key infrastructure projects, such as China's Belt and Road Initiative and natural gas pipeline expansion in the US. Energy geographies would be well-served by turning attention to these topics.

[Insert Table 1 here]

Regarding the types of energy studied within extraction and production (n=171), renewable energy, particularly wind and bioenergy, comprised about 57% of articles that studied a specific energy type. Fossil fuels, particularly oil and gas, represented just over 30% of articles. Studies of nuclear energy made up 6% of the articles, many of which center around the emerging field of nuclear geographies (for a review see Alexis-Martin & Davies, 2017). While this represents a good diversity of energy types being studied, there remains room for improvement, particularly in the area of unconventional energy, which includes technologies such as hydraulic fracturing, coal-bed methane, tar sands, enhanced oil recovery, amongst others. While unconventional energy has been robustly studied across the social sciences (Neville et al., 2017), only a small percentage of this scholarship has engaged geographic concepts to evaluate the significance of this energy type (Beebejaun, 2016; Delgado, 2018; Fry, Brannstrom, & Murphy, 2015; Fry, Briggie, & Kincaid, 2015). A more systematic geographic analysis of hydraulic fracturing, for example, would be a valuable contribution towards understanding the broader significance of this technology, particularly how it has transformed economies, environments and landscapes.

[Insert Table 2 here]

Figure 2 summarizes how the energy geographies borderland is emerging conceptually by mapping energy geographies scholarship across the four sub-fields of geography (internal square), highlighting the main theories/concepts engaged within each sub-field (bold, adjacent to respective sub-field) and summarizing some of the main research topics within each sub-field-concept pairing (boxes), which are color coded to reflect the geographic location of studies comprising the topic.

Figure 2: Conceptual Borderland: 2015-2019*

[Insert Figure 2 here]

*The diagram represents the top concepts and topics in and across sub-fields, not the entire suite of concepts/topics identified in our analysis.

**The top theories and concepts engaged in each sub-field are adjacent to the respective sub-field square. For example, GIScience mainly engaged theories of scale.

**Marxist political economy concepts include spatial fix, dispossession, metabolism, and financialization. Post structuralist concepts include both Foucauldian theories/concepts on power/knowledge, governmentality, discourses and science and technology theories/concepts on Actor-Network Theory, assemblage, hybrid natures.

Geographers in three of the four sub-fields have been studying energy systems across the Global North and South, engaging a host of core geographical concepts/theories. In recent years, there has been a general lack of scholarship on energy within physical geography journals, which presents an important research opportunity for advancing energy geographies, particularly in light of environmental transformations engendered by the rapidly evolving global energy system as well as interests in the food-energy-water nexus.⁴

Nature-society geographers have engaged both Marxist-inspired political economy and post-structuralism theories/concepts to (separately) evaluate how energy projects are assembled (Bouzarovski et al., 2015; Yenneti, Day, & Golubchikov, 2016), financed (Baker, 2015; Hall, Foxon, & Bolton, 2016; Knuth, 2018; Merme et al., 2014; P. Newell & Phillips, 2016; Schmidt & Matthews, 2018), constructed and discursively framed (Hommes, Boelens, & Maat, 2016; Kuchler & Bridge, 2018) and how these practices impact processes such as governance (McCarthy, 2015; Muinzer & Ellis, 2017) and urbanization (Bulkeley, McGuirk, & Dowling, 2016; Dowling, McGuirk, & Maalsen, 2018). Nature-society geographers have engaged debates on dispossessions and land grabbing to evaluate renewable energy production, largely in the Global South (Baka, 2017a; Rignall, 2016; Yenneti et al., 2016). In contrast, work on energy systems in the Global North have largely focused on the political economic logics of developing and operating energy and emissions trading markets (Bridge & Bradshaw, 2017; Carton, 2017; Kama, 2014). Nature-society geographers have also studied imaginaries of energy futures/transitions and how imaginaries intersect with political economy (Angel, 2017; Burnham, Eaton, Selfa, Hinrichs, & Feldpausch-Parker, 2017; Hommes et al., 2016; Kuchler, 2017).

⁴ This finding is not to assert that physical geographers are not studying energy. Instead, we suspect that such physical geographers are publishing outside of geography journals, in fields such as sustainability science and geosciences.

Human geographers have been studying topics of energy transitions, governance, democracy and social movements primarily through the lens of energy justice, largely in the Global North (Chatterton, Anable, Barnes, & Yeboah, 2016; Finley-Brook, Williams, Caron-Sheppard, & Jaromin, 2018; Jenkins, McCauley, Heffron, Stephan, & Rehner, 2016; Walker, Simcock, & Day, 2016). GIScience has been using concepts of scale primarily to assist with energy project planning, particularly for analyzing how energy use shapes behavior and for estimating land availability for energy projects, especially solar photovoltaic potential (Calvert & Mabee, 2015; Watson & Hudson, 2015).

As evidence of the cross-cutting nature of energy geographies, we find that certain concepts/theories—landscape and space, place and territory—and topics—energy transitions and governance—straddle across sub-fields. Nature-society and human geography scholars have primarily engaged landscape to advance the field of energy landscapes, a stream of scholarship that broadly examines how livelihoods and cultures are intertwined through engagement with energy systems (Nadaï & Van der Horst, 2010; M. Pasqualetti & Stremke, 2018). A sizeable portion of energy landscape scholarship has focused on visualizing energy systems, mainly through maps and photos (Calvert, Greer, & Maddison-MacFadyen, 2019; M. J. Pasqualetti, 2009; M. J. Pasqualetti, Gipe, & Richter, 2002) or ethnographic descriptions of how engaging energy systems helps to influence cultural practices (Castán Broto, 2017; Nadaï & Labussière, 2010). Other scholars have also engaged landscape theory to understand and visualize attachment to place and attitudes towards energy project siting, especially in the Global North (Devine-Wright & Batel, 2017; Firestone, Bidwell, Gardner, & Knapp, 2018; Maehr, Watts, Hanratty, & Talmi, 2015; Sherren et al., 2016; Wuebben, 2017).

Within human geography and GIScience, geographers have been examining the cultural practices engendered by energy systems by engaging geographic concepts of space, place and territory. According to Bridge (2018), the so-called “spatial adventure” currently underway within energy studies (Castán Broto & Baker, 2018) has coalesced around three broad themes: 1) how energy differentially shapes energy-society relations across time and space; 2) how engagements with energy systems enable everyday life; and 3) the dynamic, contested and uneven processes through which energy influences a range of issues, including consumption, politics, technology development, amongst others. An overlap between energy landscape and spatial analysis is also beginning to emerge as Calvert et al. (2019) engage scholarship on energy landscapes, the production of space and materiality to examine the socioecological history of energy transitions in Bermuda.

Geographers have also sought to understand how everyday engagements with energy systems, particularly renewable energy, shape place. Geographers examining people-place relations have largely studied how such relations influence perceptions of energy projects (Devine-Wright & Batel, 2017; Firestone et al., 2018). Geographic inquiries into the territorial logics of energy projects have studied the discursive, legal and financial the processes through which areas are territorialized to make them suitable for low carbon projects (Harlan, 2018; McCarthy & Thatcher, 2017; McEwan, 2017). To further advance research on how energy shapes space, place and territory, energy geographers could better engage the emerging field of impact geographies, which has been established to provide a geographic perspective on social impact analysis (Haggerty, Kroepsch, Walsh, Smith, & Bowen, 2018).

Regarding cross-cutting topics, numerous sub-fields have been analyzing energy transitions and governance, often in tandem. Some key themes of the energy transitions literature are to

emphasize that energy transitions are inherently geographical (Bridge, Barr, et al., 2018), to critique and analyze how renewable energy transitions alter socio-ecological metabolisms, particularly processes of land use access and control (Harrison & Popke, 2018; Huber & McCarthy, 2017), to examine how energy transitions could be more just, particularly by reversing processes of uneven development that have long characterized energy systems (Bickerstaff, 2017; Jenkins et al., 2016; McCauley et al., 2019) and to caution that the capital intensiveness and spatial extensiveness of a large scale renewable energy transition, as currently envisioned, may further disenfranchise rural areas due to lower land prices and fewer land rights protections (McCarthy, 2015).

Concerning the overlap between energy transitions and governance, scholars have examined the new types of governance structures low carbon energy transitions could engender, particularly the potential to enable community energy systems (for a review see Creamer et al., 2018) as well as how energy transitions might (re)-shape policy frameworks, especially at sub-national scales (Homsy, 2015; Miller, Richter, & O’Leary, 2015). Other governance research has examined how energy transitions create new environmental subjectivities (Bulkeley, Powells, & Bell, 2015; Eadson, 2016) and alter patterns of both global capital flows and resource access (McCarthy, 2015). Additional studies focus on governing the green building sector (Gibbs & O’Neill, 2015; Walker, Karvonen, & Guy, 2015; Zhou, 2015) and smart technologies, such as smart homes and the smart grid (Gram-Hanssen & Darby, 2018; Lammers & Hoppe, 2019; Skjølsvold, Ryghaug, & Berker, 2015).

4. Frontiers of Energy Geographies

Overall, Figure 2 illustrates how studying energy deepens, straddles and interconnects geographic inquiry. Yet, as Bridge (2018) notes, there remain areas where the “map” of energy geographies is yet to unfold. We identify three such areas in this section for further developing the borderland—geographies of energy knowledge production, materializing energy and advancing geographic thought through energy—in hopes of charting the next frontier in energy geographies scholarship.

4.1 Geographies of Energy Knowledge Production

In recent years, geographers, particularly nature-society geographers and political ecologists, have been engaging Science and Technology Studies (STS) to better analyze how environmental knowledge is produced and with what effects (Goldman, Nadasdy, & Turner, 2011). While there is some precedent within energy geographies for engaging social theories of knowledge production (Barry, 2013; Bridge & Wood, 2010), more direct and sustained engagement can be forged in order to critically examine the multi-scalar transformations currently underway within the global energy economy. Some promising work is underway within the field. Of particular interest is Hesse’s (2019) work on the geographies of uncertainty within unconventional energy occupational health regulation, Baka et al.’s (2019) research on the construction of scientific expertise within US unconventional energy regulation and Kama’s (2016, 2019) work on the linkages between knowledge production and resource making. As evidence of the cross-cutting scope of energy geographies, Behrsin’s (2019) work integrates both STS and Marxist political economy in order to critique the scientific knowledge enabling renewable energy transitions.

While this scholarship helps to establish a foundation for intersections between energy geographies and STS, additional avenues can be explored. For example, engaging Lave’s (2015) research on the emergence of new environmental knowledge regimes and Goldstein’s (2015)

work on “divergent expertise” could help to better elucidate the actors/knowledge claims contributing to (or absent from) energy policy debates and decision making processes.

Based on our review, a notable underrepresentation within energy geographies is indigenous knowledge. While Curley’s (2018a, 2018b) work is helping to give voice to members of the Navajo Nation that are currently grappling with whether and how to transition away from a coal-based energy economy, additional research is needed in other indigenous landscapes enmeshed in energy development/transitions. The MHA Nation on the Fort Berthold Reservation in North Dakota is a notable research gap, particularly as the reservation lies within the Bakken shale basin.

4.2 Materializing Energy

Our review also highlights the need to better evaluate the materiality of energy, by which we mean examining how social, biophysical and environmental systems interconnect and transform within and across energy systems. While this is an emerging theme within energy and resource geography (De Laurentis & Pearson, 2018; Fatimah & Arora, 2016; Kuchler & Bridge, 2018), more research is needed to better understand the coupled biophysical and political processes shaping and shaped by energy systems and how these processes vary within and across energy systems. Closer engagement with the nascent field of political-industrial ecology (PIE) can help address this gap. Political-industrial ecology integrates theory and method from political and industrial ecology to better embed resource flows within their broader historic, political and environmental contexts (Baka, 2017b; J. P. Newell & Cousins, 2015; J. P. Newell, Cousins, & Baka, 2017). PIE scholars have examined how the concept of metabolism connects political and industrial ecology. To date, a large portion of research in both fields has engaged metabolism, mainly to study urbanization processes.

For example, industrial ecologists have frequently used metabolism analysis to conceptualize the stocks and flows of energy and materials shaping urban space (Kennedy, Cuddihy, & Engel-Yan, 2007). In contrast, political ecologists have used metabolism as a metaphor for examining the (frequently uneven) nature-society exchange processes mediating urban development, often situating findings within Marxist political economy theory (Heynen, Kaika, & Swyngedouw, 2006). Combining these two perspectives of metabolism within PIE, J. P. Newell and Cousins (2015) assert, could help to engender a “second wave” of urban metabolism research that is more methodologically and theoretically pluralistic, producing more “sustainable and just urban worlds” in the process (p. 721).

Yet, the potential of PIE is not limited to revitalizing urban metabolism research. When used to analyze energy systems, PIE could help to better reveal the spatial practices and politics interlinking and altering rural and urban regions (Baka, 2017b). As Mulvaney’s (2019) recent book on solar energy reveals, a careful examination of the metabolisms of energy supply chains could better reveal where environmental injustices occur. Additionally, when combined with broader social and political theory on materiality (Appadurai, 2015; Bennett, 2009) and more than human geographies (Braun, 2005; Sundberg, 2011), PIE could help to better quantify, animate and politicize the metabolic processes enabling energy systems. Understanding such processes is urgently needed in light of cautions about how a large-scale transition to renewable energy alters the metabolism of energy systems and increases the risk of land grabs, particularly in rural areas (Huber & McCarthy, 2017; McCarthy, 2015; Scheidel & Sorman, 2012).

4.3 Advancing Geographic Thought through Energy

Our final recommendation is conceptual. A core objective of energy geographies scholarship has been to advance a geographic perspective on the energy sector. As this analysis illustrates, the field has established firm footing for advancing this goal. As our borderland analysis illustrates, energy geographers have been engaging numerous core geographic concepts to study energy systems. Yet, to date, limited research has been done to consider how studying energy advances and/or challenges these core concepts. Given the volume of energy geographies scholarship in recent years, the field would be well served by such a critical reflection.

As one example, energy geographers could deepen their engagement with and analysis of scale. Aside from a handful of articles that examine the scalar interconnections of energy transitions and the food-energy-water nexus (Bijl, Bogaart, Dekker, & van Vuuren, 2018; Oudes & Stremke, 2018), there has been limited energy geographies research on the significance of scale within energy systems. Such research would be useful for better understanding the transboundary challenges within energy systems as well as the scalar challenges/politics of governing energy systems. To initiate such research, energy geographers could take better stock of how other areas of resource geography, most notably water, have engaged scale. Research on the politics of scale and rescaling within water governance would be a useful starting point (Cohen & Bakker, 2014; Cohen & McCarthy, 2014; Norman & Bakker, 2009; Perreault, 2005).

As a second example, engaging emerging work on visualizing political ecologies (Foo, 2019) could help to enliven conceptualizations of landscape within (energy) geography. The objective of this work is to challenge political ecology to reconsider its long-held notion that visualization tools often privilege elite knowledge over local knowledge, which can further exacerbate marginalization. Yet, the emergence of critical cartography (Crampton & Krygier, 2006), qualitative GIS (Jung & Elwood, 2010), citizen science (Kinchy, Jalbert, & Lyons, 2014), amongst others, offer avenues to better represent the multitude of perspectives shaping places and spaces of energy. Integrating such methods into political ecology and energy geographies could help to better reveal where environmental justices are occurring in order to more rapidly develop mobilization and remediation responses. Notable empirical examples of work that combines critical visualization and environmental justice that energy geographies could build upon include the EJOLT Atlas (2011) and FracTracker Alliance's Public EIA (2018) of the Falcon ethane pipeline in Southwestern PA.

Lastly, a sizeable volume of social scientific inquiries on energy are occurring outside of geography. For example, only about 13% of the 1,002 articles published in ERSS over the last five years explicitly engage a geographic concept to study energy. Energy geographers would do well to reflect on why this is in order to further establish the significance of a geographic perspective on energy. One strategy would be for geographers to participate more directly in energy policy debates and related research. For example, we found that a large volume of the scholarly debate on energy transitions and the food-energy-water nexus is occurring outside of geography journals, particularly in policy studies journals. Many studies of energy transitions engage the multi-level perspective (MLP) framework (Geels, 2002), a central framework in transition management studies that conceptualizes technology transitions as socio-technical systems. While some geographers have engaged the MLP and socio-technical systems theory to study energy (i.e., Baker, Newell, & Phillips, 2014; Calvert, Kedron, Baka, & Birch, 2017; Murphy, 2015; Shove, Walker, & Brown, 2013), geographers could do more to engage, critique and expand on this inherently geographic conceptualization of energy systems and policy. Regarding the food-energy-water nexus, Leck, Conway, Bradshaw, and Rees (2015) have

conceptually outlined pathways for geographers to more readily contribute to nexus approaches. Yet, as Albrecht et al's (2018) recent literature review of nexus scholarship underscores, social scientific contributions to nexus scholarship remain limited. Conceptualizing, evaluating and critiquing multi-scalar and multi-system interactions is perhaps one of the strongest attributes of geography. We thus encourage more geographic inquiry into nexus thinking, especially as transformations in the energy sector have engendered ripple effects through water and food systems, many of which are yet to be systematically examined.

5. Conclusion

In conclusion, our review demonstrates that the field of energy geographies is functioning as a borderland by deepening and broadening geographic scholarship within and across geography sub-fields. Energy geographers are studying a diversity of energy systems, including fossil fuel and renewable energy, often with a focus on the extraction and production phase of energy development. Energy transitions, governance and justice have been key topics within recent scholarship. Geographers are also engaging a range of geographic concepts to study these topics, particularly landscape, place and space as well as geographic debates on post-structuralism social theory and Marxist-inspired political economy.

Our analysis also reveals key gaps in recent scholarship. First, most of the literature tends to focus on energy geographies of the Global North. Second, energy geographies scholarship on energy infrastructures, notably transmission grids and pipelines, as well as on unconventional energy systems, such as hydraulic fracturing, could be expanded. Third, we also encourage further geographic inquiry into energy and environmental policy debates, particularly related to energy transitions and the food-energy-water nexus.

We also identify three broad areas of scholarship for expanding the frontier of energy geographies research. First, energy geographers could better engage with STS theory on construction of knowledge and expertise in order to better analyze how knowledge and decision making regarding energy are produced and with what affects. Indigenous knowledge is a significant gap within energy geographies literature, particularly as numerous indigenous lands throughout the world are currently at the center of various energy development projects. Second, energy geographies would be advanced by materializing the study of energy in order to better reveal how biophysical, political and environmental processes intersect and transform within and across energy systems. The emerging field of political-industrial ecology is well-suited to address this research gap, especially if political-industrial ecology were to better engage with social and political theory on materiality and more than human geographies. Finally, we encourage energy geographers to take better stock of how the study of energy advances and/or challenges core geographic concepts and debates. The concepts of scale and landscape are notable starting points to initiate such inquiries. Developing these areas within energy geographies will not only help to better conceptualize what a geographic perspective on energy means but will also help to make clearer sense of the rapid economic, social, environmental and political transformations currently underway within the global energy system.

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