



Carbonscapes and beyond: Conceptualizing the instability of oil landscapes

Håvard Haarstad and Tarje I. Wanvik

University of Bergen, Norway

Abstract

Geographers tend to see energy systems as intricately interwoven with society and relatively resistant to change. We argue that there is a danger of exaggerating the permanence and stability of the energy–society relationship. Therefore we propose a framework that is more open to instability and transformation. Using assemblage theory, we frame the social and material landscapes of oil – carbonscapes – as having emergent capacities for change built into their relations of exteriority. We illustrate this by discussing instabilities at particular points within the global oil production network: extractive hot zones, energy distribution infrastructures, and urban spaces of consumption and practice.

Keywords

assemblage, carbonscape, energy, instability, materiality, oil

1 Introduction

To most geographers concerned with energy, evidence of our dependence on fossil fuels is everywhere. This is despite recent rapid developments in renewable energy technologies, coal divestment campaigns, evidence of ‘peak car’ trends, ambitious new emissions targets in major cities and oil price volatility. According to recent geographical and social science scholarship (e.g. Urry, 2013, 2014; Huber, 2013; Watts, 2013), the political and material landscapes of our fossil fuel society are as robust as ever. Much of our built environment has been constructed around energy matrices of affordable and abundant petroleum, which in turn steers and regulates energy-related behaviour. These landscapes have certain visible and obvious artefacts signalling the centrality of oil to our economy and culture, such as gas stations, oil rigs, tankers, pipelines and extraction

sites. Hegemonic social and cultural artefacts embed fossil consumption in our lives, such as symbolism attaching car ownership to freedom and success. This means that the barriers to low carbon transition are not just technical or financial, they are also mind-sets and socio-cultural practices. As Matthew Huber puts it in his recent book *Lifeblood*, the main barrier to change is ‘the *cultural and political structures of feeling* that have been produced through regimes of energy consumption’ (2013: 168, our emphasis).

In turn, the interweaving of material, social and cultural forms and artefacts creates solid structures of ‘petroculture’ (Marriott and

Corresponding author:

Håvard Haarstad, Department of Geography, University of Bergen, Norway.

Email: havard.haarstad@uib.no

Minio-Paluello, 2012), ‘fossil capitalism’ (Huber, 2013; Watts, 2013), ‘carbon lock-in’ (Unruh, 2000) or ‘carbon democracy’ (Mitchell, 2011). Urry (2014: 3) suggests that energy systems and their lock-ins are ‘not subject to simple human intervention and control’. Not all accounts are dystopian, but in much of the geographical and social science scholarship there is a clear tendency to stress path dependencies and inertia that shape society’s relationship with energy (Shove et al., in press; Bulkeley et al., 2013, 2014; Rutherford and Coutard, 2014; Hodson and Marvin, 2010; Bridge et al., 2013; Calvert, 2016). Calvert (2016) suggests that in the recent revitalization of energy geographies, there has been a greater stress on the political, economic, technological and cultural work done to establish and maintain energy systems. We argue that the stability and permanence of society’s relationship with carbon tends to be exaggerated.

While there are obvious structures of inertia and permanence, the carbon–society linkage is also characterized by rupture, unpredictability and instability. Yet existing theoretical analyses often employ frameworks that are embedded in systems thinking, in which the parts are imagined to be closely co-articulated and co-dependent. It is worth debating whether the popular vocabulary of ‘regimes’ and ‘lock-in’ has certain debilitating effects and whether we should pay more attention to volatility and change. If not, we would suggest there is a danger that we reproduce the narrative of the inevitability of oil that the fossil fuel industry has carefully constructed. We will also miss important opportunities to sharpen conceptual frameworks in energy geography.

The aim of this article is to conceptualize the socio-material landscapes created by fossil-based energy systems in ways that are open to appreciating their instabilities and identifying windows for transformation.

We use the term ‘carbonscape’ to describe the theoretical and conceptual concerns at hand.

Carbonscapes, then, are the spaces created by material expressions of carbon-based energy systems and the institutional and cultural practices attached to them. As many theorists have alluded, carbonscapes are shaped at the intersection of infrastructures, technologies, the built environment and various social, cultural and political regimes that govern them (Rutherford and Coutard, 2014; Huber, 2013; Urry, 2013, 2014; Mitchell, 2011; Watts, 2013). While a common theoretical stance is to depict the co-articulation of these elements as a coherent totality or as a stable organic whole, we want to theorize carbonscapes as more contingent. Assemblage theory, which is gaining ground in geography, provides us with a set of conceptual tools with which to achieve this. It promotes an ontology that dismisses the idea of systems as stable, organic wholes in favour of an ontology of *entities without essence* that are held together in more or less impermanent relationships. Seeing carbonscapes as singular, coherent systems makes it difficult to appreciate change, because many co-dependent parts have to change at the same time. In thinking in terms of assemblages, however, we illustrate how carbonscapes are composed of various interrelated parts subject to change and destabilization through their involvement with other assemblages. This enables us to appreciate changes and ruptures that may not overthrow ‘the system as a whole’, but nevertheless represent significant change.

Our argument is organized in the following four sections. In Section II, we discuss theoretical approaches to three different types of carbonscapes: energy production, energy distribution infrastructure, and spaces of consumption and practice; we hold that these prevailing theoretical frameworks overemphasize their permanence. In Section III, we begin conceptualizing the instability of carbonscapes and outline how concepts from assemblage theory can be helpful. Section IV exemplifies relationships between stability and change in the three different types of carbonscapes. Section V

concludes by reflecting on the role of instability in our understanding of the geography of energy.

II Geographies of stability and change in fossil society

Several commentators have recently noted the re-emergence of energy as a concern for geographers (Bridge et al., 2013; Calvert, 2016; Pasqualetti and Brown, 2014; Zimmerer, 2011). There also appears to be corresponding and relevant trends in related fields outside of geography, such as anthropology (Boyer, 2011), sociology and critical theory (see special issue of *Theory, Culture, & Society*, 2014, vol. 5, issue 3) and history (Kander et al., 2014). Even though 'energy geography' can be considered a distinct subfield of geography (Calvert, 2016), it is informed by a wide range of scholarship. Geographers have typically had much to say about the landscapes and material artefacts around energy and resource sectors. Energy is also a key topic of enquiry in studies of natural resources, political economy, cities and other interrelated fields (Bakker and Bridge, 2006; Calvert, 2016).

A central claim for geographers has been that resources and energy should be understood as interconnected networks tying together sites and scales, e.g. through a commodity chain framework (Bridge and Le Billon, 2013; Bridge, 2008). In turn, debates in the literature about material geographies of fossil society have been concerned with all points along this chain, including, first, spaces of extraction and energy production (or what we will later term 'extractive hot zones'), second, infrastructures for energy transport and distribution and, third, the urban spaces of consumption and practice. What is typical about these perspectives is that energy and resource regimes are seen as materializations of different types of power and, despite involving tensions and contentious politics, are quite resistant to change.

First, on the spaces of extraction and energy production: many geographical and critical analyses have either implicitly or explicitly been developed as a critique of the mainstream and hegemonic 'resource curse' literature. Literature on 'the curse', dominated by economics and political science, has seen extractive spaces as cursed by economic and political processes at the national scale (see for example Mehlum et al., 2006; Humphreys et al., 2007). Geographers, anthropologists and others have argued that the malaises of many extractive spaces are far more complex and must be understood in terms of both skewed distribution of costs and benefits locally, enclave formation and spaces of enclosure, and unequal integration with the global political economy of oil (Haarstad, 2014b; Logan and McNeish, 2012; Bebbington et al., 2008; Stevens and Dietsche, 2008; Kirshner and Power, 2015). Yet in broadening out the scope and complexity of the processes underlying 'the curse', geographers tend to deepen the view of the grip that oil extraction has on social development trajectories. Watts (2004), for example, has suggested that we should be attentive to how oil is 'inserted into an already existing political landscape of forces, identities and forms of power' (2004: 76). Elsewhere he draws attention to the global regime of accumulation that envelops oil extraction (Watts, 2013).

The operative perspective in this literature is typically that the local extraction spaces (and their patterns of underdevelopment, inequalities and environmental disruption) are intricately embedded in the broader political economy: multi-scalar complexes involving oil companies, political institutions and more. Much of this work is quite convincing, and foregrounding the power structures of the global regime of oil is an important part of its rationale. Yet in this sense it tends to present an image of relative stability and resistance to change, as local dynamics are closely embedded within the globalized regime. Even though the contentious politics of social movements and civil society

always remain part of the picture (see Bebbington et al., 2008; Perreault, 2006), the general perspective seems to be that the hegemony of oil capital is able to destabilize and undercut serious challenges to continued accumulation.

Second, many geographers and social scientists have looked at how the infrastructures through which energy and resources are distributed and transported shape relations of power. As Urry (2014), Mitchell (2009), Shove and co-authors (in press) and others have observed, energy infrastructures can be investigated for how they create order and embody particular forms of authority both through the 'things' that are necessary for them to function and through the discourses and practices that surround them. Their accounts have recognized that power relations are embedded both in the minuscule or 'background' material artefacts in society, or 'boring things', as Star (1999) labels them, as well as in larger machines and structures of modern culture (Winner, 1980). Social orders are not only a result of institutional and political practices but also, as Winner puts it, of 'tangible arrangements of steel and concrete, wires and transistors, nuts and bolts' (Winner, 1980: 128). By emphasizing the way inert infrastructures steer practices, this perspective also foregrounds stability and resistance to change.

Mitchell's work on 'carbon democracy' is particularly instructive in showing how the different infrastructures in use for large-scale distribution of coal and oil have effects on political practices. These two different types of energy sources (coal being solid with low energy intensity, oil being liquid with high energy intensity) require very different types of infrastructure, and these different infrastructure regimes have had correspondingly different political effects. Oil could be produced and transported in ways far less conducive to pressure from organized labour. Whereas the movement of coal tends to follow the centric networks of rail lines, with potential choke points at several junctures, oil flows more like a grid, with more than one

possible path and where blockages are more difficult (Mitchell, 2009). Similarly, Marriott and Minio-Paluello's description of the oil road between the Caspian Sea and central Europe frames large-scale infrastructure as the underpinning of power relationships of modern society. These power relationships, they claim, 'resist any shift away from this petroculture' (Marriott and Minio-Paluello, 2014: 83). These writers are certainly interested in social and political change. But by stressing the co-articulation of material infrastructures and political power, this change tends to be conditioned upon structural shifts in the broader energy system.

This insistence upon reading socio-political orders out of infrastructure is suggestive of Foucault. Indeed, these writers often employ Foucaultian notions of governmentality and biopower, again emphasizing the co-articulation of energy-related infrastructures with socio-political orders. For instance, Boyer (2014) proposes a theoretical entanglement of Foucaultian biopower with 'energopower', the harnessing of electricity and fuel for social purposes. Stengers (2013) stresses the way 'smart' energy technologies involve a particular discursive subject formation around 'energy-rational man'. In broad terms, the Foucaultian-inspired assessment of energy infrastructure stresses how power and authority are built into its material and social forms.

This is effective at revealing how both 'big' and 'small' infrastructural artefacts create and underpin social orders and regimes. Yet it is not easy to envision potentialities for change in these perspectives. Biopolitical regimes are portrayed as inherently stable. Instability, contingency and sites of contestation are difficult to identify. Episodes of systemic disruption (such as a blackout) are typically understood to reveal our thorough and complete dependence on the infrastructure system.

Third, we turn to sites of consumption and practice, in particular how oil and energy is

embedded in cities and urban technologies. Energy consumption is closely related to urban form and planning regimes (Newman and Kenworthy, 1989; VandeWeghe and Kennedy, 2007). Geographers have often understood cities as spatial and material expressions of particular energy regimes (Calvert, 2016; Rutherford and Coutard, 2014). Therefore, studying cities is a way to unpack society's relationship with energy. In *Lifeblood*, Huber (2013) examines how petroleum has shaped recent American history and landscape, and links the rise of the new right to the growth of a sprawling suburban landscape conducive to individualist, entrepreneurial rationality. Echoing Mitchell's (2009) call to 'follow the carbon', he suggests that energy provides an ecological foundation for a particular privatized socio-spatial existence and that suburban lifestyles are the spatial expression of our relationship with energy under contemporary capitalism. In his perspective, the forceful agents of change seem to be the corporate interests that have managed to deeply entangle American culture and fossil consumption throughout the 20th century.

There have also been some prominent contributions from geographers that have examined cities as sites for low-carbon transitions, approaching the work from perspectives of the various strands of socio-technical transitions literature (Bulkeley et al., 2013, 2014). Much of the sociotechnical transitions literature has evolved from a foundational paper by Rip and Kemp (1998), which takes as a starting point that established technologies are highly intertwined with 'technological regimes' (the rule-set embedded in practices, skills and procedures that mediate how specific technologies are conceived and introduced in society), and 'socio-technical landscape' (the larger social, economic and political system in which technological innovations arrive). A key idea is that opportunities for change are fostered in protected niches, and that actual change depends on how these niches interact with broader

regimes and landscapes. This basic framework has evolved into different strands – transition management, strategic niche management, the multilevel perspective on sustainability transitions, and technological innovation systems (Markard et al., 2012) – that each conceptualize relationships between stability and change in different ways. Geels (2013) suggests that cities can be considered such niches in which radical innovations take place.

Geographers have critiqued the undertheorized and unfounded spatial assumptions of the multi-level perspective (Coenen et al., 2012; Hansen and Coenen, 2015), but have also suggested ways to employ spatial vocabularies to inform perspectives on socio-technical regimes and transitions (Bridge et al., 2013). Rather than understanding radical transformations as arising in protected niches, geographers are typically more concerned with the cross-spatial and multi-scalar networks in which radical and transformative practices are engendered (Bulkeley and Betsill, 2013; Haarstad, 2014a). Yet the perspective has also been used productively in geography to theorize urban change and transformation. Bulkeley and co-authors (2013, 2014), for example, argue for a perspective on socio-technical regimes that is configured socio-spatially and structured through processes of political economy and political ecologies of infrastructure. They hold that analyses of socio-technical regime change must be understood in relation to the broader political economy of relations that go into maintaining and contesting urban infrastructures. Others have combined various metabolic and infrastructural perspectives to examine urban socio-technical regimes and how they are contested and reconfigured (McFarlane and Rutherford, 2008; Pflieger et al., 2009; Hommels, 2005).

Given the multifaceted conceptual framework it offers, it is understandable that so many are now using variations of the sociotechnical transitions literature as an inroad to analysing

processes of change. It also has some family ties to assemblage thinking, in the sense that ideas around the social construction of technology can in part be traced to Latour and actor-network theory (see Rip and Kemp, 1998), which has also stimulated assemblage thinking (Müller, 2015). But we prefer the assemblage framework to the sociotechnical transitions theory for several reasons. First, transitions theory is oriented primarily towards incremental changes that lead to systemic transitions over long time (Markard et al., 2012, state that transitions typically take 50 years or more), which overlooks the self-significance of pockets of radical transformation. Also, transitions theory is wedded to a systems perspective, which assemblage thinking attempts to break with, because in systems thinking change only becomes significant once it affects all the other elements in the system. Finally, a return to political economy and infrastructure in theorization of cities and urban low carbon transitions, which Bulkeley and co-authors (2013, 2014) argue for, is in danger of pulling us back into an emphasis on fixity and permanence. The political economy tradition in human geography has typically stressed how processes of capital accumulation shape socio-spatial change and the urban condition (Harvey, 1989). So while sociotechnical transitions literature is quite helpful in understanding cities as sites for low carbon transitions and changes in the sphere of consumption, it is not without problems. In particular, its systemic orientation prioritizes broad and long-term changes rather than specific ruptures and instabilities in cities and elsewhere.

In broad terms, central perspectives on fossil-based society tend to stress the permanence and stability of energy regimes. The works cited above are obviously not exhaustive, yet from studies ranging from the spaces of oil extraction to the distribution and transport infrastructures to the urban spaces of consumption and practice, there is a tendency to emphasize the conserving and permanence-creating forces of

capital and energy materialities. Across these different perspectives, a common thread is that the socio-spatial embeddedness of energy systems creates path dependencies locking in carbon-based practices. While we largely share these observations, we have also come to think that the stability and permanence of oil landscapes tend to be exaggerated. When material infrastructures, socio-cultural artefacts and political structures are all understood as mutually reinforcing forces of conservation, the opportunities for change are difficult to identify, appreciate, and theorize. In most of the literature discussed above, a key theoretical objective has been to explain permanence and fixity rather than identifying the points of leverage for change.

Therefore, there is a need to reconceptualize the stabilities and instabilities of fossil society in ways that are open to new pathways for change and transformation. This should in no way reject the significant permanence created by the embeddedness of energy in various aspects of society – this would obviously overlook important historical experience. However, if we are to understand how stabilities interact with volatility and instabilities – which are also important aspects of historical experience – then we need theoretical frameworks that enable us to identify and analyse them.

III Conceptualizing the instability of carbonscapes

‘Carbonscapes’ are characterized both by path-dependencies and by rupture. The notion of ‘-scape’ plays off of *landscape*, a term that has a long trajectory in energy geography and the wider discipline (Calvert, 2016; Zimmerer, 2011). There is also a tradition of seeing landscapes as more than material artefacts but rather as permeated by, or constructed through, social, political, cultural and economic relationships (Mitchell, 2003). As Zukin (1992: 224) has explained, landscapes are ‘built around

dominant social institutions [...] and ordered by their power.’ In other words, when we use the notion of ‘carbonscape’ to describe the relationship between energy and society, there is an explicit recognition of how social regimes and power relations create order and inertia. The apparent inertia of energy landscapes can be illustrated by Table 1, which stipulates the lifespan for different types of energy infrastructure. Much of the infrastructure central to the current form of energy production has a lifetime of more than 50 years and urban plans potentially have centuries-long lifespans. This material inertia may serve to uphold the social orders that first produced the infrastructures, as suggested by the concepts of socio-technical *regimes* and carbon *lock-in* (Coenen et al., 2012; Unruh, 2000).

At the same time, there is more to carbonscapes than inertia – volatility and change are equally important parts of the picture. Andrew Moore’s photographs of the dilapidated and post-apocalyptic urban landscape of Detroit, the former Motor City of the world and (quite literally) engine of the US economy, are a reminder of that fact. (His book of photography, incidentally, is titled *Detroit Disassembled*.) As another example, the speed of technological advance and instalment of solar PV should also be considered a rapid change in global energy systems, having increased almost 70-fold from 2004 (2.6 gigawatts) to 2013 (177 gigawatts) (REN21, 2015). ‘Peak car’ has relatively quickly become accepted as a real trend in the US and Europe (Goodwin and Van Dender, 2013), contrary to the pessimistic prognoses of writers like Urry (2004) a decade ago. In the past few years the discourse has shifted from discussing ‘peak oil’ (diminishing reserves) to ‘carbon bubble’ and ‘stranded assets’ (having more oil than we can use). The petroleum economy itself is also subject to sudden jolts from unpredictable factors such as oil price instability, geopolitical threats to energy security, and terrorism. Everything seems stable, until it suddenly does not.

Table 1. Expected lifetime of energy-related infrastructure. Adapted from The Stern Review (Stern, 2007) and Wilkinson et al. (2007).

Infrastructure	Expected lifetime (years)
Urban plan	100+
Road/rail routes	100+
Hydro station	75+
Building	45+
Coal station	45+
Nuclear station	30–60
Gas turbine	25
Aircraft	25–35
Motor vehicle	12–20

Therefore, we have been wondering whether language such as ‘regimes’ and ‘lock-in’ may have certain debilitating effects. There is a danger that the resistant nature of the landscapes made by oil are exaggerated and that the theoretical frameworks available are so populated with concepts stressing inertia that instances of change are made invisible. This is a theoretical problem in the sense that we fail to theorize the relationships between stability and change properly. It is also a normative problem in the sense that we as theorists may reproduce the narrative of the inevitability of oil that the oil industry itself has so painstakingly created. The theoretical project should instead be to conceptualize carbonscapes in ways that take account of how structures of stability coexist and are interrelated with processes of change. Our intentions here resonate with J.K. Gibson-Graham’s (2006) project of destabilizing imaginaries of capitalism in ways that open spaces for negotiation and contestation.

To suggest a way forward, we will draw insights from theory on assemblages. Assemblage theory, developed by Manuel DeLanda following Deleuze and Guattari, is a theoretical framework in which instability and change are characteristic features (DeLanda, 2006). This perspective has recently gained ground in geography, probably because it allows for the

conceptualization of the entanglements of material, social and ideational elements (McFarlane and Anderson, 2011). Geographers working on energy and natural resources often use the term ‘assemblage’ casually, as Bridge and co-authors have done when stating that ‘landscape describes the assemblage of natural and cultural features across a broad space and the history of their production and interaction’ (2013: 5). Watts (2013) draws our attention to an aspect of what he calls the oil and gas assemblage: a global production network with particular properties, actors, networks, governance structures, institutions and organizations, but also a complex regime of accumulation and a mode of regulation, held together by the massive global oil infrastructure.

In a more specific theoretical sense, ‘assemblage’ is employed to describe constellations of social and material, expressive and physical components (Allen, 2011; McFarlane and Anderson, 2011; Ogden et al., 2013; Tsing, 2005). To Sassen and Ong (2014: 19), the ‘notion of assemblage is something that helps . . . to understand transformations and perhaps even historical turning points’ and is a perspective that allows us to actively destabilize powerful social categories. Assemblage thinking has together with actor-network theory been in the forefront of a revalorization of the material, or the co-constitution between humans and non-humans (Müller, 2015; Martinez, 2007). But even though the material realm is often associated with structure and inertia, the time-space of assemblages is imagined as inherently unstable and infused with movement and change (Marcus and Saka, 2006). As a contribution to geographical thought, assemblage theory can be useful for integrating materiality, power and scale into one single analytical framework.

Assemblages can be understood as entities without essence. They involve relations between both human and non-human components, and relational work is necessary to keep these components together. The component

parts are harbouring unexercised capacities that might produce very different properties if the entities were to enter into relations with other entities. DeLanda (2006: 10–11) refers to these relations as ‘relations of exteriority’. He argues that we must not confuse the properties of a particular entity with the capacities of its component parts to form relations with other entities. Instead of seeing social entities as totalities (organic wholes bound together by internal relations), assemblage theory stresses how the interactions between seemingly separate elements produce unstable and contingent entities, revealing the empirical stability of carbon-scapes as temporary, contingent achievements, always vulnerable to reconfigurations. Anderson and co-authors (2012) argue that this notion of relations of exteriority allows us to actualize ongoing processes of composition of different component parts, rethink social formations as complex wholes composed through diversity; and attend to the expressive powers of entities (Bennett, 2005; Gidwani, 2008; Latour, 2005; Ong, 2007). Thus, the assemblage’s only unity is that of co-functioning: it is a symbiosis, a ‘sympathy’ (Deleuze and Parnet, 2007 [1977]: 52). Rather than conceptualizing assemblages as seamless wholes, ‘relations of exteriority’ implies certain autonomy for the elements they relate (DeLanda, 2006: 10–11).

DeLanda characterizes socio-material assemblages along three dimensions. First, he distinguishes between processes that stabilize the emergent identity of assemblages (by sharpening their borders, or homogenizing their composition) from those that tend to destabilize this identity and hence open the assemblage to change. These are processes of *territorialization* and *deterritorialization*, respectively (DeLanda, 2006; Deleuze and Guattari, 1988). Second, the component parts are recognized by their *emergent capacities*, properties that are contingent by their interaction with other component parts. Finally, by employing DeLanda’s notion of the *assemblage converter* we can highlight the

catalytic impact of well-placed component parts in either transforming assemblages or ensuring that relations and parts remain stable (Wanvik, 2014). All three dimensions underscore the pivotal changeability and constant emergence of assemblages, rather than their stability and permanence.

Employing the vocabulary of assemblage theory allows us to better conceptualize the change and instability of carbonscapes. Instead of understanding the interweaving material, social and political structures or socio-technical regimes of 'fossil capitalism' (Huber, 2013) as stable totalities, this vocabulary enables us to theorize the interlinkages between stability and change: Carbonscapes have, since the industrial revolution, been subject to powerful *territorialization* processes that have embedded fossil-based infrastructures, both materially and socially. Since the Second World War, the suburbanization of many cities in the Global North has put in place sprawling urban form, in a material sense. Yet this has also bound conceptions of freedom and wealth together with high energy consumption, the private car, and the larger political-institutional and corporate structures of global oil markets. This *carbonscape assemblage* is strongly territorialized across a range of social and material processes and artefacts.

At the same time, the carbonscape assemblage is made inherently unstable through its relations of exteriority. It has no core, no essence and no fixed identity holding it together. The various elements through which it is composed – the political-institutional structures, the global oil markets, the material infrastructures and the socio-cultural discourses of freedom – are themselves integrated with other assemblages which subject them to specific pressures. For example, there are clear indications that young people are less likely to drive cars ('peak car') and researchers tie this to changing lifestyles and attitudes, new labour opportunities and processes of re-urbanization

(Newman and Jeff, 2011; Goodwin and Van Dender, 2013). In other words, the carbonscape assemblage is being *detrterritorialized* through its relations of exteriority with the labour market, which in turn is changed by deindustrialization and the shift towards services (among other things). It is likely that decreased car use among youth will gradually change socio-cultural discourses that tie the personal automobile to freedom. In turn, key elements that combine to form the unity of carbonscapes are in motion, which could potentially have detrterritorializing ripple effects across the larger assemblage.

From this perspective, transformation is not dependent upon some future overthrow of the 'system as a whole'. Change always occurs in particular assemblages by way of reconfiguration, adaptation and conversion. Dramatic changes in one assemblage can destabilize other assemblages to which it is attached. Assemblages can have *emergent capacities* for change that are difficult to see because change is contingent upon interaction with other component parts. For example, the 2011 Fukushima nuclear accident in Japan led to the decommissioning of German nuclear reactors and a significant policy push to strengthen the *Energiewende* towards renewable energy. This cannot be understood without attention to the emergent capacities in the German policy arena, such as the long-standing popular opposition towards nuclear energy, the long-term strength of the Green Party and emerging public support for sustainable energy production and consumption. In this instance, we can think of the nuclear accident as an *assemblage converter* that impacted particular well-placed components in effecting transformations across several interlinked assemblages. Thus, although a particular social formation appears strong, it is always dependent upon and embedded within other structures and processes that have greater capacities for change.

Our purpose here is not to argue for a complete adoption of DeLanda's assemblage theory

by energy geography (that would go against the very intention of assemblage theory). However, moving away from theoretically constructing near-total coherence around the elements of ‘petroculture’ (Marriott and Minio-Paluello, 2012), ‘fossil capitalism’ (Huber, 2013), ‘carbon democracy’ (Mitchell, 2011) or what we have here called carbonscapes helps us theorize and visualize change processes and potentials. Assemblage theory can provide us with an effective social ontology and a vocabulary for this purpose. Drawing on this theoretical perspective, we can summarily outline our view on carbonscapes:

- Carbonscapes are material landscape expressions of material and social processes that cross-cut spatial scales and localities.
- Carbonscapes are not coherent and integrated unitary systems, but rather *assemblages* combining material and social component parts in stable and unstable ways. These assemblages are strongly territorialized in some places and spatial scales and less so in others.
- Carbonscape assemblages have *emergent capacities* for change. These emergent capacities can be difficult to identify, but the integration of component parts in other assemblages (such as labour markets, technology and infrastructure, geopolitics) means that dramatic change can be affected from the border of an assemblage.
- Component parts of carbonscape assemblages can serve as *assemblage converters* when they happen to be well placed to create ripple effects. Change is never total, as totalities do not, empirically speaking, exist.
- In addition to episodes of dramatic change, carbonscapes undergo gradual processes of *deterritorialization* when the forces holding them together are

weakened, diverted or undermined. Physical manifestations may be abandoned, but are more likely to be converted to other uses.

IV Assembling and disassembling carbonscapes

Assemblage theory is useful as a complement to, or an organizing schematic for, geographical insights rather than as a replacement. We find it particularly useful to furnish the assemblage framework with geographical notions of materiality, power and scale; in fact, assemblage theory needs such conceptual furnishing in order to supply the appropriate analytical tools. Assemblage theory is arguably conducive to grasping what Jessop and co-authors refer to as the ‘inherently polymorphic, multidimensional character of sociospatial relations’ (Jessop et al., 2008: 389). Elsewhere we draw on Allen (2003, 2011) and Massey (1995) to show how assemblages must be understood as multidimensional and multi-scalar (Wanvik, 2014; Wanvik and Haarstad, 2015).

For understanding carbonscapes as assemblages, a particularly instructive geographical framing is that of global production networks of oil, or the hydrocarbon value chain. This captures how oil moves across space from the messiness and environmental externalities of extraction sites, through complex pipelines and tankers, mediated by the global financial sphere and national polities, to consumption sites. As Bridge and others have elucidated (Bridge, 2008; Bridge and Le Billon, 2013; Marriott and Minio-Paluello, 2012), through its movement across this chain, oil intervenes and is implicated in various political–economic struggles and landscape-forming processes at many sites. The carbonscapes at these sites are assembled through complex interactions with the globally integrated oil industry, geopolitical negotiation between

states, and multi-spatial infrastructures. Seen as a globally integrated totality, with a close integration of its component parts ensuring stability and coherence, the oil industry's ability to shape landscapes and politics seems omnipotent and ubiquitous.

However, it is not necessary to see the global oil industry as a coherent totality, as much of the literature tends to do. We can instead examine particular carbonscapes as smaller assemblages partially integrated in other assemblages of different scales, in which both stability and change are contingent upon a range of (de)territorializing processes, emergent capacities and the presence of converters. This can be exemplified by examining three different types of carbonscapes: (1) the extractive hot zone, (2) oil distribution infrastructure and (3) urban sites of consumption and practice.

1 The extractive hot zone

At the origin of the global hydrocarbon value chain, the carbonscapes of extractive hot zones are chaotic and disorderly; they are both literally and metaphorically built on sand. These places are anything but stable and permanent. For instance, witness Fort McMurray in Alberta, Canada, and the turmoil of the boom created by the bitumen extraction during the past decades. High crime rates, racism, excessive substance abuse, panhandling and sprawling shantytowns taint the city's recent history (fieldwork in Alberta, Canada, in 2014 and 2015). Explosive growth has put extraordinary pressure on both remote indigenous communities and local authorities.

In these unpredictable circumstances, several territorializing processes have taken place. With their traditionally shared interest in smooth operations of extractive industries, government and industry make every effort to include and integrate indigenous communities in the value chain to enable them to take part in the positive impacts of industrial developments (Brownsey

and Rayner, 2009). These efforts materialize through extensive consultation processes (Lawrence and Macklem, 2000), environmental impact assessments (Harvey and Bice, 2014; Morgan, 2012; O'Faircheallaigh, 2010) and impact and benefits agreements (IBA) (Fidler, 2010). Through these processes, government and industry comprise a joint role as assemblage operator, managing the territorializing efforts, maintaining and stabilizing the carbonscapes of extractive hot zones. However, most of these territorializing processes are delegated to industry, from consultations to self-assessments of environmental impact, to comprehensive local content schemes of labour and service deliveries, to bilateral negotiations of benefits to local communities. Hence, the governance regime within extractive hot zones of Alberta is greatly dependent on corporate profits to maintain a certain level of infrastructure and public services (see Wanvik 2015). This makes the governance of extractive hot zones highly vulnerable to deterritorializing processes and external shocks. The recent drop in global oil prices due to geopolitical tensions and competition over regional oil hegemonies has put tens of thousands out of work and sent government revenues through the floor. Assemblage converters in one part of the oil assemblage (oil price, geopolitical conflicts) on the global scale have led to major disruptions throughout the oil production hot zone.

From within, the material consequences of environmental degradation and the limited, non-renewable character of the energy resource threaten the existence of the extractive hot zone (Le Billon and Carter, 2012; Marsden, 2010; Nikiforuk, 2010). Here, by exposing its desert-like features, vast tailing ponds and huge open wounds in the boreal forest landscape to the world through the lenses of local and global media (Szeman, 2012), the resource depletion and imagery around environmental destruction become potential assemblage converters. Likewise, the social implications for tens of

thousands of indigenous communities bent on protecting their traditional land use rights comprise a destabilizing factor for the industrial activities feeding and forming the carbonscapes of extractive hot zones (Hanson, 2012; Hoberg and Phillips, 2011; Huseman and Short, 2012).

These different deterritorializing processes reveal potent emergent capacities of both human and non-human component parts within the carbonscapes of extractive hot zones. The fall in oil prices and subsequent dramatic layoffs and provincial government deficits partly contributed to a revamping of 'old-fashioned political tools', what has been termed a 'seismic shift' in the Canadian political landscape (Barber, 2015), in which the New Democratic Party won elections after 40 years of conservative rule in Alberta. Whether the environmental degradation has had similarly strong implications for emergent capacities is hard to tell, but combined with indigenous struggles for rights and title, we see the emergence of stronger, more elaborate and powerful indigenous rights movements with some remarkable breakthroughs in treaty negotiations across the Canadian Northern Territories.

2 Oil distribution infrastructures

A second way of exemplifying the instability of carbonscapes is to look at the infrastructures through which oil is transported and distributed (connecting the extractive hot zone and the consumption spaces). It is tempting to see the incredible complexity and embeddedness of networks of pipelines, rail lines, trucks and gas stations as a testament to the stability and deep territorialization of carbon society. Yet they are also highly vulnerable, contested and exposed, and thereby unstable. Consider how Putin's territorial ambitions in Eastern Europe and particularly Ukraine have reignited concerns about European gas supplies and the strategic interests of the EU and the US. The conflict exposes the vulnerability of Europe's energy security and

dependency on both Russian supply and the Ukrainian territory transit infrastructure. As Marriott and Minio-Paluello (2012) detail in their travel book, the attempt by BP and others to create an 'energy corridor' from the Caspian Sea bypassing Russian territory has been far from easy. As they put it, "'energy corridor" implies a space of calm orderliness, whereas in reality much of the geography covered is scarred by repression and turbulence' (2012: 7).

As many actors have realized, power relations can quickly shift when control is seized of critical infrastructure junctures through which energy and resources flow. Herod (2000) shows this with respect to labour organization in the US and 'lean' production, illustrating how capitalist reorganization and reterritorialization has contradictory effects on power relations. Other examples show how transit infrastructure developments can serve as assemblage converters, forging new alliances and interest coalitions between actors who are usually divided. As Naomi Klein (2014) describes in *This Changes Everything*, the resistance to TransCanada's Keystone XL pipeline has brought together unlikely allies and mobilized enormous protests in Washington, DC, such as the so-called 'Cowboy and Indian Alliance' of ranchers and indigenous peoples along the pipeline route. Klein claims the struggle against the pipeline has revived the American environmental movement. Whether or not this is the case, the Keystone XL project that was once considered an accomplished deal has become highly publicized, contested and protracted.

Petroleum distribution infrastructures tend to be quite permanent and stable. However, there are significant emergent capacities for change in the sense that they often cross disputed and conflict-prone territories, as well as environmentally sensitive areas, and are vulnerable at choke-off points. The economic and geopolitical significance of distribution infrastructures may enhance their permanence, but it also

embroils them in larger assemblages where they are exposed to shocks, e.g. the impact of the 2014 drop in oil prices on investments in oil infrastructure projects.

3 Sites of consumption and practice in urban contexts

Finally, carbonscapes of urban consumption sites can also be understood as being unstable. Cities and their suburban spaces of car-based lifestyles are the paradigmatic image of oil dependence and inertia (Huber, 2013). However, urban forms can also be subject to rapid change; seemingly inert urban forms can be retrofitted, converted and undermined. A range of cities have rapidly introduced initiatives and policies aimed at increasing urban sustainability and liveability over the past few years. For example, since the first major car-sharing scheme was introduced in Zurich in 1987, it has now been introduced in more than 1000 cities worldwide. Similar trends exist for bus rapid transit (BRT) systems, bike sharing, low emission zones and other policy initiatives (Global Commission on the Economy and Climate, 2014). Policies and initiatives in particular cities are parts of larger assemblages composed of transnational policy arenas, cross-scalar governance arrangements, socio-technical regimes and global economic interlinkages. The quick and widespread uptake of initiatives such as BRTs and car sharing illustrate how swiftly trends in urban policy are picked up at a variety of sites (McCann, 2011; Wood, 2015) and how, in turn, particular 'hot' policy ideas can serve as assemblage converters in cities. While these initiatives are not necessarily undermining urban carbonscapes 'as a whole', they can be expected to fragment, 'splinter' (Guy et al., 1997) and deterritorialize the assemblages of car-based urbanities.

Urban infrastructures are built to accommodate particular industries, socio-technical regimes or lifestyles, or as Shove and co-

authors (in press) point out, in *response* to changing social practice. Thus, it is not necessarily the lifespan of the infrastructures per se that influences their longevity, but rather the extent to which the industries, socio-technical regimes or lifestyles that *support them* change. In turn, urban structures can be as unstable as the global industrial dynamics and the socio-technical regimes upon which they have been built. For example, in Norway's 'oil city', Stavanger, large concrete bases of oil platforms (concrete deep-water structures, or *condeeeps*) were in the 1980s and 1990s constructed in close proximity to the city centre. As some of the largest man-made structures ever built, and visible to the city's residents as they were towed out to the offshore oil and gas fields, they expressed the labour power put into their construction and the position of the city in the global industry. However, with technology acting as a strong assemblage converter, the oil industry is increasingly using subsea installations rather than *condeeeps*. In the 2000s, the wharfs at Jåttåvågen where the *condeeeps* were built were converted into a modern urban space with sleek office buildings, apartments and stores, designed according to hegemonic ideas of compactness, walkability and public transport connectivity. A large concrete tower from the old days of rig construction has been left, and serves as a symbolic and emotional icon of the bygone era.

This relatively rapid deterritorialization of an oil-industrial complex and the territorialization of a new urban consumption space was the result of several assemblage converters (technological innovation and new industry practices) and emergent capacities (the will to create spaces for modern, 'sustainable' living). Urban spaces are typically resistant to change, but they may have emergent capacities for transformation and are not determined by the longevity of infrastructures or the urban form. There are myriad examples of how components in urban spaces interact with larger assemblages and are operated upon by assemblage converters. These

Table 2. Assemblage analysis of the instabilities of the oil production chain.

Carbonscapes	Territorializing	Deterritorializing	Converter
Extractive hot zones	<ul style="list-style-type: none"> • Infrastructure • Environmental impact assessments • Impact benefits agreements • Employment • Royalties/taxes 	<ul style="list-style-type: none"> • Environmental impact • Social impacts • Climate discourse • Indigenous rights discourse • Market shifts • Changing global energy matrix (rise of renewables) 	<ul style="list-style-type: none"> • Sudden oil price changes • Local resistance movements • Geopolitical incidents • Environmentally damaging spills
Petroleum distribution infrastructure	<ul style="list-style-type: none"> • Militarization / Securitization • Regional / bilateral dependence • International agreements 	<ul style="list-style-type: none"> • Shifting global alliances and powers • Geopolitical tensions and insecurity • Changing global energy matrix (rise of RE) 	<ul style="list-style-type: none"> • Local/regional resistance • Environmental spills, media attention • Sudden oil price changes • Geopolitical incidents
Urban spaces of petroleum consumption	<ul style="list-style-type: none"> • Road networks • Spatial distribution of housing, industry and retail • Public transportation infrastructure • Embedded socio-cultural structures and practices (automobility) 	<ul style="list-style-type: none"> • Climate change discourse • General sustainability concerns • Regeneration of urban cores • Socio-economic shifts 	<ul style="list-style-type: none"> • ‘Hot’ policy ideas and initiatives • Rezoning • Technological innovation • Transformative leadership • Sudden oil price changes

assemblage converters may be new ‘hot ideas’ in urban planning discourses (McCann, 2011), new technologies, and many other factors. The point is that they may undermine the territorialization of oil-based carbonscapes in particular urban contexts. Table 2 presents an assemblage analysis of the production chain of oil by elaborating on the examples provided in the preceding section.

V Conclusion

When exploring the social orders and regimes surrounding oil we should pay more attention to the volatile nature of the energy–society relationship. From the bitumen boomtowns of extractive hot zones to the affluent urban spaces of the Global North, the extraction, conversion, transportation and consumption of energy are unstable processes that we use significant resources to contain, control and put into order.

Carbonscapes are maintained and contested throughout the global commodity chains of oil. Therefore, we need theoretical and conceptual frameworks that both recognize stability and enable us to appreciate instability and rupture. We hold that some of the most prevalent frameworks in operation are prone to address the inertia and permanence of carbonscapes rather than their instabilities, and in doing so may exaggerate their stability. Political economy frameworks, infrastructure perspectives, biopolitics and socio-technical regimes share an interest in structures that are maintained and ordered by dominant power relationships. In addition, there is a tendency to think in terms of coherent totality, whole systems articulated by the interrelation of infrastructures, institutions and practices. In thinking of carbonscapes as systems with closely intertwined and co-dependent parts, actual changes may be overlooked or simply dismissed as minor systemic adjustments.

There are certainly efforts to theorize change, e.g. in the sociotechnical transitions literature. Yet it remains within a systemic orientation that prioritizes broad and long-term changes rather than specific ruptures and instabilities.

We have argued that assemblage theory is quite helpful in disaggregating processes of carbonscape stability and instability. Our intention has not been to argue for assemblage theory per se but rather to take advantage of certain opportunities it offers. What is particularly liberating about the assemblage perspective is its insistence on understanding socio-material entities as lacking a coherent core, or strong internal relations holding them together. So instead of talking about techno-institutional complexes, regimes, or a coherent systemic 'fossil capitalism' held together by a co-articulation of institutions, infrastructures and practices (Unruh, 2000; Huber, 2013; Urry, 2013), we can talk about a looser association of different social and material elements drawn together and pulled apart by a range of different forces.

This is liberating because it frees us from the assumption that changes need to impact the fundamentals of larger socio-technical regimes to be significant. Instead, carbonscapes are always subject to both territorializing and deterritorializing processes, simultaneously strengthening and weakening the ability of carbon interests to order social practices. This enables us to recognize, for example, that while *automobility* has been territorialized in urban and suburban spaces through highway construction, shopping malls and socio-cultural discourses, it has also, at least during the past decade or so, been deterritorialized by new initiatives of urban regeneration, new and less car-centric cultural values, and widespread recognition of the importance of urban planning for sustainable and liveable cities. Whether or not this challenges the entire 'system of automobility' (Urry, 2004) is hard to say, but these changes are still significant and should inform empirical and theoretical analyses. For us, the important point is to illustrate that carbonscapes

are fragmented, contested and converted at particular sites. So, counter to Brenner and co-authors (2011), who suggest assemblage thinking blunts critical sensibilities, we find that assemblage thinking is helpful in opening spaces for negotiation and contestation.

Further work remains toward articulating how the tension between stability and instability of carbonscapes is worked out across scales, territories, networks and places. Ongoing work in geography debates how assemblage theory and spatial concepts can interact fruitfully (McFarlane and Anderson, 2011). A key theoretical challenge for understanding carbonscapes is to elaborate how stabilities and instabilities are worked out in different contexts and how various territorializing and deterritorializing processes play out differently locally, globally and at every scale in between (Haarstad, 2014a; Wanvik, 2014).

Finally, we end by returning to our introductory comment, suggesting that there is a normative rationale for shifting our attention towards instabilities and change. We are not necessarily suggesting that all our exemplified changes are 'good' in a normative sense. But destabilizing the permanence of carbonscapes may be productive in its own right. As noted in the introduction, the emphasis on structural constraints runs the risk of reproducing the oil industry's carefully scripted narrative of its own inevitability. Geographers are particularly well placed to go beyond the generalized and large-scale panorama of energy systems in which change is primarily gradual and *longue durée*. Whether we use assemblage theory or some other framework conducive to understanding instability, it is critical that the specific lens that spatiality affords us is also used to identify the cracks in the wall and the leverage points for transformation.

Declaration of conflicting interests

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

Funding

The author(s) disclosed receipt of the following financial support for the research, authorship, and/or publication of this article: Funding for the research discussed in this article comes from several sources, including the World Universities Network, Akademiaavtalen (University of Bergen/Statoil) and the International Migration and Ethnic Relations Network (IMER).

References

- Allen J (2003) *Lost Geographies of Power*. Oxford: Blackwell.
- Allen J (2011) Powerful assemblages? *Area* 43: 154–157.
- Anderson B, Kearnes M, McFarlane C and Swanton D (2012) On assemblages and geography. *Dialogues in Human Geography* 2: 171–189.
- Bakker K and Bridge G (2006) Material worlds? Resource geographies and the matter of nature. *Progress in Human Geography* 30(1): 5–27.
- Barber J (2015) Canada's political landscape undergoes seismic shift with election in Alberta. *The Guardian*, Toronto, 6 May.
- Bebbington A, Hinojosa L, Humphreys Bebbington D, Burneo M and Warnaars X (2008) Contention and ambiguity: Mining and the possibilities of development. *Development and Change* 39: 887–914.
- Bennett J (2005) The agency of assemblages and the North American blackout. *Public Culture* 17: 445.
- Boyer D (2011) Energopolitics and the anthropology of energy. *Anthropology News* 52: 5–7.
- Boyer D (2014) Energopower: An introduction. *Anthropological Quarterly* 87: 309–334.
- Brenner N, Madden DJ and Wachsmuth D (2011) Assemblage urbanism and the challenges of critical urban theory. *City* 15: 225–240.
- Bridge G (2008) Global production networks and the extractive sector: Governing resource-based development. *Journal of Economic Geography* 8: 389–419.
- Bridge G and Le Billon P (2013) *Oil*. Cambridge: Polity Press.
- Bridge G, Bouzarovski S, Bradshaw M and Eyre N (2013) Geographies of energy transition: Space, place and the low-carbon economy. *Energy Policy* 53: 331–340.
- Brownsey K and Rayner J (2009) Integrated land management in Alberta: From economic to environmental integration. *Policy and Society* 28: 125–137.
- Bulkeley H and Betsill MM (2013) Revisiting the urban politics of climate change. *Environmental Politics* 22: 136–154.
- Bulkeley H, Castán Broto V and Maassen A (2013) Governing low carbon transitions. In: Bulkeley H, Castán Broto V, Hodson M and Marvin S (eds) *Cities and Low Carbon Transitions*. London: Routledge, 29–41.
- Bulkeley H, Castán Broto V and Maassen A (2014) Low-carbon transitions and the reconfiguration of urban infrastructure. *Urban Studies* 51: 1471–1486.
- Calvert K (2016) From 'energy geography' to 'energy geographies': Perspectives on a fertile academic borderland. *Progress in Human Geography* 40(1): 105–125.
- Coenen L, Benneworth P and Truffer B (2012) Toward a spatial perspective on sustainability transitions. *Research Policy* 41: 968–979.
- DeLanda M (2006) *A New Philosophy of Society: Assemblage Theory and Social Complexity*. London: Continuum.
- Deleuze G and Guattari F (1988) *A Thousand Plateaus: Capitalism and Schizophrenia*. London: Bloomsbury.
- Deleuze G and Parnet C (2007 [1977]) *Dialogues II, rev. edn*. New York: Columbia University Press.
- Fidler C (2010) Increasing the sustainability of a resource development: Aboriginal engagement and negotiated agreements. *Environment, Development and Sustainability* 12: 233–244.
- Geels FW (2013) The role of cities in technological transitions: Analytical clarifications and historical examples. In: Bulkeley H, Castán Broto V, Hodson M and Marvin S (eds) *Cities and Low Carbon Transitions*. London: Routledge, 13–28.
- Gibson-Graham JK. (2006) *A Postcapitalist Politics*. Minneapolis: University of Minnesota Press.
- Gidwani VK (2008) *Capital, Interrupted: Agrarian Development and the Politics of Work in India*. Minneapolis: University of Minnesota Press.
- Global Commission on the Economy and Climate (2014) *The New Climate Economy Report*. Washington, DC: World Resources Institute.
- Goodwin P and Van Dender K (2013) 'Peak car': Themes and issues. *Transport Reviews* 33: 243–254.
- Guy S, Graham S and Marvin S (1997) Splintering networks: Cities and technical networks in 1990s Britain. *Urban Studies* 34: 191–216.
- Haarstad H (2014a) Climate change, environmental governance and the scale problem. *Geography Compass* 8: 87–97.

- Haarstad H (2014b) Cross-scalar dynamics of the resource curse: Constraints on local participation in the Bolivian gas sector. *Journal of Development Studies* 50: 977–990.
- Hansen T and Coenen L (2015) The geography of sustainability transitions: Review, synthesis and reflections on an emergent research field. *Environmental Innovation and Societal Transitions* 17: 92–109.
- Hanson LL (2012) Changes in the social imaginings of the landscape: The management of Alberta's rural public lands. In: Parkins JR and Reed MG (eds) *Social Transformation in Rural Canada: New Insights into Community, Cultures, and Collective Action*. Vancouver, BC: UBC Press, 148–168.
- Harvey B and Bice S (2014) Social impact assessment, social development programmes and social licence to operate: Tensions and contradictions in intent and practice in the extractive sector. *Impact Assessment and Project Appraisal* 32: 327–335.
- Harvey D (1989) From managerialism to entrepreneurialism: The transformation in urban governance in late capitalism. *Geografiska Annaler* 71B: 3–17.
- Herod A (2000) Implications of just-in-time production for union strategy: Lessons from the 1998 General Motors-United Auto Workers dispute. *Annals of the Association of American Geographers* 90: 521–547.
- Hoberg G and Phillips J (2011) Playing defence: Early responses to conflict expansion in the oil sands policy subsystem. *Canadian Journal of Political Science* 44: 507–527.
- Hodson M and Marvin S (2010) Can cities shape socio-technical transitions and how would we know if they were? *Research Policy* 39: 477–485.
- Hommels A (2005) Studying obdurancy in the city: Toward a productive fusion between technology studies and urban studies. *Science, Technology, & Human Values* 30: 323–351.
- Huber MT (2013) *Lifeflood: Oil, Freedom, and the Forces of Capital*. Minneapolis: University of Minnesota Press.
- Humphreys M, Sachs JD and Stiglitz JE (2007) Introduction: What is the problem with natural resource wealth? In: Humphreys M, Sachs JD and Stiglitz JE (eds) *Escaping the Resource Curse*. New York: Columbia University Press, 1–20.
- Huseman J and Short D (2012) 'A slow industrial genocide': Tar sands and the indigenous peoples of northern Alberta. *The International Journal of Human Rights* 16: 216–237.
- Jessop B, Brenner N and Jones M. (2008) Theorizing sociospatial relations. *Environment and Planning D: Society and Space* 26: 389–401.
- Kander A, Malanima P and Warde P (2014) *Power to the People: Energy in Europe over the Last Five Centuries*. Princeton, NJ: Princeton University Press.
- Kirshner J and Power M (2015) Mining and extractive urbanism: Postdevelopment in a Mozambican boomtown. *Geoforum* 61: 67–78.
- Klein N (2014) *This Changes Everything: Capitalism vs. the Climate*. London: Allen Lane.
- Latour B (2005) Reassembling the social: An introduction to actor-network-theory. In: Latour B, *Reassembling the Social: An Introduction to Actor-Network-Theory*. Oxford: Oxford University Press.
- Lawrence S and Macklem P (2000) From consultation to reconciliation: Aboriginal rights and the Crown's duty to consult. *Canadian Bar Review* 29: 252–279.
- Le Billon P and Carter A (2012) Securing Alberta's tar sands: Resistance and criminalization on a new energy frontier. In: Schnurr MA and Swatuk LA (eds) *Natural Resources and Social Conflict: Towards Critical Environmental Security*. Basingstoke: Palgrave Macmillan, 170–192.
- Logan O and McNeish J (2012) Rethinking responsibility and governance in resource extraction. In: McNeish J and Logan O (eds) *Flammable Societies: Studies on the Socio-economics of Oil and Gas*. London: Pluto Press, 1–44.
- McCann E (2011) Urban policy mobilities and global circuits of knowledge: Towards a research agenda. *Annals of the Association of American Geographers* 101: 107–130.
- McFarlane C and Anderson B (2011) Thinking with assemblage. *Area* 43: 162–164.
- McFarlane C and Rutherford J (2008) Political infrastructures: Governing and experiencing the fabric of the city. *International Journal of Urban and Regional Research* 32: 363–374.
- Marcus GE and Saka E (2006) Assemblage. *Theory, Culture & Society* 23: 101–106.
- Markard J, Raven R and Truffer B (2012) Sustainability transitions: An emerging field of research and its prospects. *Research Policy* 41: 955–967.
- Marriott J and Minio-Paluello M (2012) *The Oil Road: Travels from the Caspian to the City*. New York: Verso.

- Marriott J and Minio-Paluello M (2014) The political and material landscape of European energy distribution: Tracking the oil road. *Theory, Culture & Society* 31: 83–101.
- Marsden W (2010) *Stupid to the Last Drop: How Alberta Is Bringing Environmental Armageddon to Canada (and Doesn't Seem to Care)*. Toronto: Vintage Canada.
- Martinez N (2007) *Bolivia's Nationalization: Understanding the Process and Gauging the Results*. Washington, DC: Institute for Policy Studies.
- Massey DB (1995) *Spatial Divisions of Labor: Social Structures and the Geography of Production*. Hove: Psychology Press.
- Mehlum H, Moene K and Torvik R (2006) Institutions and the resource curse. *The Economic Journal* 116: 1–20.
- Mitchell D (2003) Cultural landscapes: Just landscapes or landscapes of justice? *Progress in Human Geography* 27: 787–796.
- Mitchell T (2009) Carbon democracy. *Economy and Society* 38: 399–432.
- Mitchell T (2011) *Carbon Democracy: Political Power in the Age of Oil*. New York: Verso.
- Morgan RK (2012) Environmental impact assessment: The state of the art. *Impact Assessment and Project Appraisal* 30: 5–14.
- Müller M (2015) Assemblages and actor-networks: Rethinking socio-material power, politics and space. *Geography Compass* 9: 27–41.
- Newman P and Jeff K (2011) Peak car use: Understanding the demise of automobile dependence. *World Transport Policy & Practice* 17: 31–42.
- Newman P and Kenworthy J (1989) Gasoline consumption and cities: A comparison of US cities with a global survey. *Journal of the American Planning Association* 55: 24–37.
- Nikiforuk A (2010) *Tar Sands: Dirty Oil and the Future of a Continent*. Vancouver: Greystone Books.
- O'Faircheallaigh C (2010) Public participation and environmental impact assessment: Purposes, implications, and lessons for public policy making. *Environmental Impact Assessment Review* 30: 19–27.
- Ogden L, Heynen N, Oslender U, West P, Kassam K-A and Robbins P (2013) Global assemblages, resilience, and earth stewardship in the Anthropocene. *Frontiers in Ecology and the Environment* 11: 341–347.
- Ong A (2007) Neoliberalism as a mobile technology. *Transactions of the Institute of British Geographers* 32: 3–8.
- Pasqualetti MJ and Brown MA (2014) Ancient discipline, modern concern: Geographers in the field of energy and society. *Energy Research & Social Science* 1: 122–133.
- Perreault T (2006) From the *guerra del agua* to the *guerra del gas*: Resource governance, neoliberalism and popular protest in Bolivia. *Antipode* 38: 150–172.
- Pflieger G, Kaufmann V, Pattaroni L and Jemelin C (2009) How does urban public transport change cities? Correlations between past and present transport and urban planning policies. *Urban Studies* 46: 1421–1437.
- REN21 (2015) *Renewables 2015: Global Status Report*. Paris: REN21: Renewable Energy Policy Network.
- Rip A and Kemp R (1998) Technological change. In: Rayner S and Malone EL (eds) *Human Choice and Climate Change*. Columbus, OH: Battelle Press, 327–399.
- Rutherford J and Coutard O (2014) Urban energy transitions: Places, processes and politics of socio-technical change. *Urban Studies* 51: 1353–1377.
- Sassen S and Ong A (2014) The carpenter and the bricoleur. In: Acuto M and Curtis S (eds) *Reassembling International Theory: Assemblage Thinking and International Relations*. Basingstoke: Palgrave Macmillan, 17–24.
- Shove E, Watson M and Spurling N (in press) Conceptualizing connections: Energy demand, infrastructures and social practices. *European Journal of Social Theory*.
- Star SL (1999) The ethnography of infrastructure. *American Behavioral Scientist* 43: 377–391.
- Stern N (2007) *The Economics of Climate Change: The Stern Review*. Cambridge: Cambridge University Press.
- Stevens P and Dietsche E (2008) Resource curse: An analysis of causes, experiences and possible ways forward. *Energy Policy* 36: 56–65.
- Strengers Y (2013) *Smart Energy Technologies in Everyday Life: Smart Utopia?* New York: Palgrave Macmillan.
- Szeman I (2012) Crude aesthetics: The politics of oil documentaries. *Journal of American Studies* 46: 423–439.
- Tsing AL (2005) *Friction: An Ethnography of Global Connection*. Princeton, NJ: Princeton University Press.
- Unruh G (2000) Understanding carbon lock-in. *Energy Policy* 28: 817–830.
- Urry J (2004) The 'system' of automobility. *Theory, Culture & Society* 21: 25–39.

- Urry J (2013) *Societies Beyond Oil: Oil Dregs and Social Futures*. London: Zed Books.
- Urry J (2014) The problem of energy. *Theory, Culture & Society* 31: 3–20.
- VandeWeghe J and Kennedy C (2007) A spatial analysis of residential greenhouse gas emissions in the Toronto census metropolitan area. *Journal of Industrial Ecology* 11: 133–144.
- Wanvik T (2014) Encountering a multidimensional assemblage: The case of Norwegian corporate social responsibility activities in Indonesia. *Norwegian Journal of Geography* 68: 282–290.
- Wanvik T (2015) Governance transformed into corporate social responsibility (CSR): New governance innovations in the Canadian oil sands. *The Extractive Industries and Society* 3: 517–526.
- Wanvik T and Haarstad H (2015) Råvaresonens geografi: Steder som flernasjonale ansamlinger [The geographies of primary commodity zones: places as multidimensional assemblages]. In: Aure M, Gunnerud Berg N, Cruickshank J, et al. (eds) *Med sans for sted: Nyere teorier [Sense of place: New theories]*. Bergen: Fagbokforlaget, 281–298.
- Watts M (2004) Resource curse? Governmentality, oil and power in the Niger Delta, Nigeria. *Geopolitics* 9: 50–80.
- Watts M (2013) Oil talk. *Development and Change* 44: 1013–1026.
- Wilkinson P, Smith KR, Beevers S, Tonne C and Oreszczyn T (2007) Energy, energy efficiency, and the built environment. *Lancet* 370: 1175–1187.
- Winner L (1980) Do artifacts have politics? *Daedalus*: 121–136.
- Wood A (2015) The politics of policy circulation: Unpacking the relationship between South African and South American cities in the adoption of bus rapid transit. *Antipode* 47: 1062–1079.
- Zimmerer KS (2011) New geographies of energy: Introduction to the special issue. *Annals of the Association of American Geographers* 101: 705–711.
- Zukin S. (1992) Postmodern urban landscapes: Mapping culture and power. In: Lash S and Friedman J (eds) *Modernity and Identity*. Oxford: Blackwell, 221–247.

Author biographies

Håvard Haarstad is research professor at the Department of Geography, University of Bergen. He is currently working on climate and energy transformations in urban spaces. As Fellow of the Bergen Research Foundation he leads a group examining cities and the politics of sustainability in Europe. His earlier work has focused on resource extraction and civil society politics, particularly in Latin America.

Tarje I. Wanvik is a PhD candidate at the Department of Geography, University of Bergen, with research interests in contested energy spaces, climate and energy transformation, governance innovations and corporate social responsibility. He has recently published in *Norwegian Journal of Geography* and *Extractive Industries and Society*. His professional background is from humanitarian aid, fundraising, advocacy campaigning, public relations, communications, corporate branding and media.

Haarstad and Wanvik coordinate the Spaces of Climate and Energy Lab (SpaceLab) at the Department of Geography, University of Bergen.