1
Introduction

The question of whether and how we can collectively steer our economy and society onto a lower carbon development trajectory is among the most pressing that the world currently faces. Runaway climate change threatens the very habitability of the earth: systematically undoing progress made in advancing the human condition and rendering impossible the achievement of the Sustainable Development Goals (SDGs) agreed in 2015. But despite rhetorical embrace of the concept and need for transition by governments, businesses and international organisations, critical applied analysis of what a dramatic shift in the structures of production and consumption, and, more challengingly, the (re)alignments of political and economic power that would be required to achieve and sustain a low or zero carbon economy would imply, is sorely lacking. The need for fundamental transformations in the way we produce, consume and distribute energy is glaringly obvious, despite painfully slow progress in the shift away from our fossil-fuel dominated world. A series of factors conspire to make the need for deeper transformations and nearer-term energy transitions acute and urgent. Today's energy system is not fit for purpose on a number of grounds.

Firstly, there is the growing threat of climate change and the need to drastically and rapidly decarbonise energy systems which continue to be heavily reliant on fossil fuels. If, as a global community, we are serious about keeping warming below 2°C (let alone 1.5°C), large swathes of existing reserves of fossil fuels will have to remain in the ground un-burned (McGlade and Ekins 2015). Even to keep warming below 2˚C, 80 per cent of coal, oil and gas reserves are now un-burnable (Carbon Tracker Initiative 2013). Carbon embedded in existing fossil fuel production will take the world far beyond safe climate limits (SEI et al. 2019). Yet money is still being funnelled into extracting more, with US$50 billion going towards new oil and gas projects alone. Doubts concerning the scale of non-existent negative emissions technologies (Keary 2016) and the limited development of carbon capture and

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storage built into models mean that the proportion of un-burnable reserves may be even higher (Anderson and Peters 2016).

The latest findings of the Special Report of the IPCC SR15 call for carbon to be cut overall by 45 per cent by 2030 and for investments in fossil fuel extraction and unabated power generation to fall by up to US$0.85 trillion over 2016–50 and unabated (without CCS) coal to zero by 2030 (IPCC 2018), while the Paris Agreement calls for net zero emissions by 2050. For this to be achievable, emissions of greenhouse gases (GHGs) needed to peak by 2020 with the gap closed by 2030 (UNEP 2018). SR15 makes very clear that staying below a 1.5˚C warming limit cannot be achieved through business-as-usual economics, politics and behaviours. Limiting warming to 1.5°C requires 'transformative systemic change', involving the upscaling and acceleration of far-reaching climate mitigation across regions and sectors. Even assuming full implementation of unconditional nationally determined contributions (NDCs) and a continuation of climate action similar to that of the existing NDCs, global average temperature will increase by 2.9–3.4°C above pre-industrial levels (UNEP 2018). This implies catastrophic consequences, especially for many of the world's poorest and most vulnerable populations that have contributed least to GHG emissions.

While transitions are underway in various countries, limiting warming to 1.5°C will require a greater scale and pace of change to transform energy, land, urban and industrial systems globally. Progress is being made, but not fast enough. There is an urgent need for more rapid and deeper transitions to limit warming to 1.5°C. Such transitions have been observed in the past within specific sectors and technologies. But the geographical and economic scales at which the required rates of change in the energy, land, urban, infrastructure and industrial systems would now need to take place are larger and have no direct documented historic precedent (IPCC 2018). We are in many ways in uncharted territory, therefore.

But we can use historical examples to inform our understanding of the likelihood and possibility of rapid change of the sort required to steer the global economy onto a 1.5°C compatible pathway. It is also the case that never before have we faced a pressing need for transformation of complex social systems to ensure planetary survival. Even managing threats of nuclear apocalypse is down to inter-state diplomacy and bargaining, albeit with important pressure from social movements. But they do not imply change at every level of society in terms of all aspects of production and consumption, as is required for energy transformations. The omnipresence of energy in all aspects of human life poses particular challenges to our ability to reorganise energy systems in the face of climate change.

Climate change is not, of course, the only environmental driver of the need for energy system reform. The global health crisis caused by air pollution from cars and

pollutants from fossil-fuelled power stations adds another significant dimension to the crisis. Globally, there are 7 million premature deaths annually from exposure to air pollution (one in eight of total global deaths), dubbed the world's 'silent killer' by the World Health Organization (WHO). Indoor air pollution, largely from wood-burning stoves, is responsible for 3.3 million deaths per year in low- and middle-income countries in the South-East Asia and Western Pacific regions alone (WHO 2014).

Secondly, there is the ongoing challenge of energy security. States continue to fulfil their growing energy needs through a range of geopolitical strategies, from diplomacy and multilateralism to violence and war. This makes energy an issue of high politics. As Moran and Russell (2009: 2) note:

> It is in the energy sector that strategic planners now find it easiest to imagine major states reconsidering their reluctance to use force against each other. 'Energy security' is now deemed so central to 'national security' that threats to the former are liable to be reflectively interpreted as threats to the latter. In a world in which territorial disputes, ideological competition, ethnic irredentism and even nuclear proliferation all seem capable of being normalized in ways that constrain the actual use of military force, a crisis in the global energy supply stands out as the last all-weather *casus belli* when the moment comes to hypothesize worst case scenarios.

They continue: 'The possibility that access to energy resources may become an object of armed struggle is almost incontestably the single most alarming prospect facing the international system today. The political stability of advanced societies and the continued prospects for economic and social improvement in developing countries are both irreducibly dependent on avoiding such a conflict' (Moran and Russell 2009: 2). And yet nurturing and inflating that possibility (fuelling 'petroleum anxiety' (Klare 2009)) provides a useful way for the military establishment to secure for itself additional resources such that 'the possibility of war to seize or defend energy resources provides a much-needed rationale for preserving the heavy conventional forces that still consume the lion's share of defense spending around the world' (Moran and Russell 2009: 2). An analysis of the exercise of incumbent power in shaping and resisting energy pathways needs, therefore, to consider the key role of the military (Johnstone and Newell 2018; Cox et al. 2016).

At the time of writing, the threat posed to energy security of regimes in places as diverse as Iran and Venezuela is being invoked by military actors as a reason to enhance their role in those regions through covert and overt means. Disruptions by terrorist organisations such as Al-Queda to key energy infrastructures, such as oil and gas pipelines, also form part of this complex geopolitical mosaic where between 1990 and 2005 alone there were more than 330 terrorist attacks against oil and gas facilities (Haynes 2009). At the same time, energy resources can be mobilised as an alternative to the use of force: wielding the 'energy weapon' obviates the need for military ones (Moran and Russell 2009).

The militarisation of energy resource management necessarily permeates the politics of competing energy transition pathways and responses to climate crises around securing borders, disaster risk management and policing migrant flows, where the spaces and infrastructures of the rich are secured from the poor and dispossessed in conditions of accelerated climate disruption. In this sense, militarism is often mobilised to protect the 'secure' and their assets and not the dispossessed, who in their role as migrants and refugees are constructed as threats to security (Buxton and Hayes 2016). For example, McDonald (2013: 46) reveals how a 2003 Pentagon report proposed that some states 'might seek to develop more effective border control strategies to ensure that large populations displaced by manifestations of climate change (whether rising sea levels or extreme weather events) could be kept on the other side of the national border' such that 'people displaced by environmental disasters or environmental stress may be positioned as threats to the security of the state rather than as those in need of being secured'. In their book *The Secure and the Dispossessed*, Buxton and Hayes (2016) show 'how the military and corporations plan to maintain control in a world reshaped by climate change. With one eye on the scientific evidence and the other on their global assets, dystopian preparations by the powerful are already fuelling militarised responses to the unfolding climate crises.' This is unlikely to form the basis of a progressive or effective response to global climate change. Dominant framings come from actors with a stake in protecting or expanding expenditure in their sector who benefit from threat proliferation which justifies their existence and, indeed, growth. The pitch to policymakers is around climate adaptation and their ability to secure assets and infrastructures and protect borders.

There have also been shifts in who provides energy security with the privatisation of security services and the reliance on market actors to secure energy supplies. This blurring of public/private and security/economy challenges traditional state-centric understandings of energy security (Buzan 1994). As we will see in Chapter 5 on 'governing' energy transitions, there is an ideological component to this. Moran and Russell (2009: 5) suggest: 'The fact that strong states have been prepared to trust their energy security to the workings of international markets is testimony to their faith in the efficiency of those markets and to their belief that the costs of war aimed at controlling energy resources would be so great as to outweigh the benefits.' This builds on the classic liberal peace doctrine of Doyle (1986), which suggests that economic interdependence reduces the prospects of war by heightening the mutual costs that would be incurred by the use of force. Of relevance to our concern here with energy transitions is the (contestable) claim that it was the 'market' that during the industrial revolution 'was asked to escort Western civilization across the rickety,

fog-shrouded bridge that connected its agrarian, wood-fuelled past to an industrial, fossil-fuelled future' (Moran and Russell 2009: 5). It is an open question whether 'the market' will be the principal mechanism of the transition away from the fossil-fuelled economy that the industrial revolution brought into being.

The relationship runs both ways, however, given that the 'international energy market has always rested on the possibility that major market participants might be required to use force to defend or manage its operation' (Moran and Russell 2009: 9). The issue is not just the inter-state politics of energy security, however. Everyday insecurity is also produced through extractivism as usual and its attendant violence. Land acquisition, including 'green grabs' of land for biofuel development (Borras et al. 2010; Harnesk and Brogaard 2017), renewable extractivism (Dunlap 2018), population displacement, pollution and ill-health are just some of the impacts of energy developments that poorer communities the world over are routinely exposed to (Newell and Mulvaney 2013). Export-led extractivism has led to intense social conflict and violence across the globe, as a glance at a world map of environmental justice and resource conflicts makes clear (EJOLT 2020). Violence and exchange, hand in hand.

The shifting geopolitics of energy have, nevertheless, reconfigured the ways in which states seek to provide energy security for their citizens and industries. Whether it is reducing imports of oil in India by adopting a 'solar mission', the USA's embrace of fracking to reduce oil imports from the Middle East, or the problems created by Europe's dependence on gas from Russia, in terms of an ability to stand up to geopolitical manoeuvres by the Putin regime in Ukraine and Crimea, energy is high politics and it was ever thus (Yergin 1991). In many contexts, moves towards lower carbon pathways are primarily driven by such preoccupations with energy security, especially where climate change alone may have less salience as a driver (Schmitz 2017; Kuzemko 2013).

Thirdly, energy poverty. With more than one billion people still lacking access to electricity, this is a critical issue. The 2030 Agenda for Sustainable Development has as one of its main SDGs to 'ensure universal access to affordable, reliable, sustainable and modern energy services for all' (SDG7). According to the United Nations, progress towards SDG7's ambition of access to affordable, reliable, sustainable and modern energy for all has now reached nearly 89 per cent of the global population. This leaves around a billion people without access to electricity (IEA et al. 2020). The SE4All initiative calls ambitiously for universal access to sustainable energy by 2030 (SE4All 2019). Delivering electricity services to nearly half a billion poor and marginal people in the least developed countries (LDCs) is particularly challenging given how tightly energy access is related to other development challenges. Energy is crucial for achieving almost all of the SDGs: from

eradicating poverty through advancements in health, education, water supply and industrialisation, to combating climate change. To date, however, 41 per cent of the world's population still cooks with polluting fuel and stove combinations, more than 80 per cent of the current final energy consumption relates to non-renewable energy sources, and the lack of laws on renewable energy within and across countries remains an obstacle to faster deployment of renewables. These net global figures also disguise huge disparities within and across countries and regions (IEA 2019).

Something that is often not afforded sufficient attention in discussions which frame the issue in terms of an energy trilemma is that global energy transitions will have to be socially just transitions in a number of ways. One of these is to ensure that the maldistribution of finance, technology and innovation in the global energy economy towards large industries and economies and towards richer citizens is redressed to meet the needs of those living in energy poverty. This is especially so where there are constraints on supply and there is a need for richer consumers to relinquish ecological and carbon space to poorer groups to meet their basic needs and to pursue pathways out of energy poverty. If low carbon energy access is the goal, as reflected in the ambition of initiatives such as SE4All, then there is a need to design more de-centralised, needs-focused and inclusive energy systems, attentive not just to hardware and financing gaps but to the multiple forms of exclusion that poorer groups experience from a range of services including those around energy (Casillas and Kammen 2010; Ockwell and Byrne 2017). This would imply and necessitate a shift in power too, where the central organisation of energy systems often reflects and reinforces elite power, leading to patterns of clientelism and rent seeking which frustrate attempts to democratise energy systems and increase their access and affordability (Newell and Phillips 2016). Energy poverty is not just a phenomenon that affects marginalised communities in the global South. Fuel poverty blights many communities, even those living in richer parts of the world where choices have to be routinely made between heating the home or eating because families cannot afford to do both (Bridge et al. 2018a). Poor insulation and lack of building regulations regarding energy conservation compound this situation.

Addressing the goals of energy security, energy poverty and climate mitigation simultaneously produces a complex series of energy 'trilemmas' (WEC 2012). For example, subsidies are provided to poorer communities for kerosene (ostensibly to alleviate energy poverty), but these lock in dependence on fossil fuels, building political constituencies that come to depend on their continuation (Skovgaard and van Asselt 2018). Likewise, fracking has been embraced by countries like the USA as a 'lower carbon' way of enhancing energy security. But while it may be less

carbon-intensive than coal and oil, it is still a fossil fuel that further locks in dependency on their use while crowding out alternatives and creating other problems such as water contamination and earth tremors (Tomain 2017). Similarly, biofuels have been embraced by some countries, especially Brazil, but can exacerbate the poverty of those whose land is acquired for their cultivation or of poorer consumers who see the price of maize rise because of demand for grains associated with biofuel expansion resulting in 'tortilla riots' (Smith 2000). As Watts (2007) puts it more polemically, '[t]he cars of the rich are now rivalling the bellies of the poor for corn, cane and edible oils'.

Some definitions of 'green energy policy' are both broad and under-specific when applied to 'any policy measure aimed at aligning the structure of a country's energy sector with the needs of sustainable development within established planetary boundaries' (Pegels et al. 2018: 26). But they also fail to provide an account of the politics of managing the conflicts and competing choices over how to reconcile shifts in the energy sector with broader social and developmental goals. Whether and how these goals can be achieved, by whom and under what conditions are first and foremost political questions. They are political because they affect some groups more than others, and have distributional consequences, and are ridden with issues of justice and differentiated responsibility. Introducing classic political economy questions, Abramsky (2010: 10) asks: 'Who will bring the transition about and for what purpose? Who will benefit and at whose expense?'

Indeed, attempts to reorganise energy systems by decarbonising them need to start with an acknowledgement that it is the 1 per cent of the population that is disproportionately responsible for GHG emissions (Kenner 2019) and just 90 companies that have generated more than two-thirds of emissions since the industrial revolution (Heede 2014). Discussions about how to justly allocate remaining carbon space within and between countries and across competing social needs need to be cognisant of these historical and ongoing disparities and injustices. Whose energy needs are met, how and at what and whose expense? They are political questions because social groups are frequently included and excluded from decision-making about energy futures by design, or by default, on grounds of class, gender and race, for example, due to political marginalisation or barriers of (technical, scientific, economic or legal) expertise that are erected to delimit engagement. They raise issues of participation, representation and democracy. Whose interests are represented, whose voice is heard, who speaks for whom and whose knowledge counts? They are also political because they are ecological. They determine whether energy needs are met in ways congruent or incompatible with sustaining life on earth: polluting some environments and not others. Are energy pathways low carbon or resource intensive in terms of inputs, production processes and waste? Because of the fundamental and close relationship

between energy and growth, a theme to which we will return throughout the book, efforts to reorder energy systems and which may even imply or require different approaches to the pursuit of growth and well-being are deeply contested by incumbent actors that have expanded and profited from growth-oriented economies served by (thus far) cheap fossil fuels and legitimated by a pervasive modernist ideology that growth is infinite.

Emphasising these deeper political questions is not to say that technology is unimportant, nor cost and price signals, nor culture and society. They clearly are. But these too are political, even if not acknowledged as such in mainstream policy debates. Who decides which technologies should be supported with finance, policy, research and development, what level energy prices or carbon taxes should be set at, or which cultural changes should be promoted and whose cultures should change are questions of politics. They reflect power and uneven social relations which seek to keep difficult and contested energy policy choices on a manageable terrain, controllable by incumbent actors. Power is exercised in determining which questions can be posed and the basis on which they will be debated (if at all). I argue that Gramsci's (1971) notion of 'trasformismo' usefully describes the political attempt to manage this terrain: to ensure that politics and policy reinforce a market liberal approach to transitions *within* capitalism as opposed to more sweeping transformations of it (Newell 2018). None of these things are immune from political contestation or devoid of power relations and the sorts of social conflict that run through all other areas of human life. It is these aspects that I focus on here.

This challenges dominant conceptions regarding technology and progress, for example, where investment in the former is assumed and asserted to be a prerequisite to the latter. This is a conviction which Hornborg (2013: 48) suggests 'has for at least two centuries been fundamental to dominant conceptions of history, development and modernization', overlooking the fact that 'technological progress has been the privilege of affluent elites and the very existence of the new technology has relied on the appropriation of resources from an increasingly impoverished periphery'. Think of the links between steam technology in nineteenth-century Britain and the Atlantic slave trade, or, more generally and contemporarily, the ways in which embodied labour and resources from poorer parts of the world are extracted through uneven exchange (Patel and Moore 2017). This underscores the need to ensure that both the social justice and sustainability of new waves of technological venture feature centrally in our analysis.

Not only are energy transitions political; they are also historical because, as Abramsky (2010:10) puts it:

> Today's energy patterns are the cumulative product of hundreds of years of historical development. The energy system is the outcome of many different social relationships

through which human beings organise themselves in order to live, sustain and reproduce themselves over time. The energy system is intimately intertwined with the expansion of the social, economic and political relations of which it is a part.

He is right to further propose that '[s]truggles for control of energy (broadly along the lines of interstate, interfirm, and inter (and intra) class struggles) have had a crucial impact on the historical development of capitalism as a global set of social relations' (Abramsky 2010: 10). A green history of the world (Ponting 2007) would suggest that energy is a key factor in the rise and fall of previous civilisations and empires and underpins the ascendancy of key contender states such as China and Russia (Hill 2004). Hornborg (2013: 42) notes, for example: 'Agrarian empires were also ultimately dependent on the productivity of solar energy processed by plants, animals and humans and they too generally acknowledged (and in fact often worshipped) the sun.' What we have come to call land and labour are in fact the ultimate energy resources, as well as the sources of all wealth, as Marx pointed out in *Capital* (Marx 1974).

Energy transitions are also ecological because they imply resource extraction, throughput, exchange and disposal. They necessarily and inevitably reorder natures, produce new geographies and landscapes and constitute, as well as reflect, socio-natures which shape their social and environmental sustainability. They produce new circuits of extraction, exchange and consumption which play an important part in determining the very possibility of life on earth. The ecologies of energy transition form a key element of the analysis in this book, therefore.

1.1 The Argument

The essential argument advanced in this book is that climate change (re)presents, amongst other things, a legitimacy crisis for contemporary global capitalism, though not just global capitalism. Energy transitions form one site of struggle in this broader terrain. In intended and direct as well as unintended and indirect ways, climate change draws attention to, highlights and amplifies a series of tensions and contradictions that inhere in the project of industrialism.

This is apparent, firstly, in the inability to maintain levels of required capitalist growth while safeguarding a climate system fit for human existence. The best analysis available suggests that the conventional pursuit of growth in OECD (Organisation for Economic Co-operation and Development) countries cannot be squared with halting warming at 2°C, 3°C or even 4°C (Simms 2010). Tellingly, it was only in the wake of the financial crisis that in May 2009, the International Energy Agency (IEA) reported for the first time since 1945 that global demand for electricity was expected to fall. The same has occurred in the wake of the corona-virus pandemic which has shut down factories and severed global supply chains

(IEA 2020a). Abramsky (2010: 7) suggests: 'Only unintended de-growth had had the effect that years of international regulation sought to achieve.' For sure, there are sites of decarbonisation and some de-linking of emissions from growth in specific sectors at particular moments in time (Newell and Lane 2018). But Jevon's paradox – the fact that resource savings in a growth-oriented economy tend to get reinvested in more consumption – outweighs the effects of these incremental gains (Brockway et al. 2017). 'All the energy-efficient technologies in the world, though crucial to any long-term solution, cannot, *on their own*, square the circle by reducing the total emissions of a system whose survival is based on continual expansion' (Abramsky 2010: 8). And yet the drumbeat of support for the mantra of 'green growth' continues from governments, economists and international institutions such as the OECD (2011) and the World Bank (2012).

Secondly, these contradictions are manifest in a system which, through wage labour, ties the welfare of workers to such an irrevocably unsustainable project. This ensures resistance to systemic change which, while it might offer the long-term prospect of increasing both social justice and environmental sustainability, in the short term pits, a powerful and wide-ranging incumbency complex against a viable future for humankind. We see this in debates about 'just transitions', explored further in what follows, and in the role of some trade unions and 'astro-turf' organisations in mobilising workers and communities against international climate agreements such as Paris or Kyoto, or national-level climate policies such as carbon taxes or emissions trading that have provided bitter battlegrounds in places such as France and Australia (Hudson 2018). The ironic effect of this cumulative resistance to more ambitious action is to commit us to a warming world in which the livelihoods of the poorest and the most marginal will be most exposed to harm.

Thirdly, the contradictions are further magnified by the need to reverse centuries of extraction and exploitation by capitalist elites in the global North (with ample collaboration from elites in the global South), so that expansion of economic activity in parts of the world afflicted by extreme poverty can be accommodated by corresponding cuts in production and consumption in the global North consistent with remaining global carbon budgets that would keep the world the right side of a 1.5°C or even 2°C threshold of warming. This is the starting point for ideas about 'contraction and convergence' (GCI 2018) or the Greenhouse Development Rights framework (GDR 2018) or 'doughnut economics' (Raworth 2017) that seek to square efforts to meet basic human development needs with respect for planetary boundaries. But in a world economy characterised by uneven development and patterns of systematic exploitation of periphery countries by the core, this presents a full-frontal threat to capitalism as we know it and as it has been practised for the

last two centuries. It implies both more just allocations of responsibility for action going forward, as well as proper acknowledgement of accumulated carbon debts and the corresponding need for compensation for poorer countries. The global politics of uneven exchange and patterns of exploitation between core and periphery are deeply woven into the politics of energy transitions. Rather than addressing contemporary and historical inequities, the preference on the part of transnational elites has been to employ spatial and temporal fixes to displace solutions onto poorer regions of the world and into the future in order to outsource the painful politics of disruption and avoid threats to near-term capital accumulation.

The issue is clearly not just inter-state social conflict. Energy and its provision and distribution at times brings into sharp relief, at other times merely exacerbates, social conflicts and inequalities. Who and what is energy for? Many conflicts are over the maldistribution of energy and competition between industrial and social uses, urban and rural, rich and poor. The DESERTEC project that was touted as providing cheap and clean solar power for the whole of Europe was premised on erecting huge solar power farms across the Saharan desert in Northern Africa to meet the energy needs of wealthier European citizens (Newell et al. 2011). Opposition to wind farms often comes from the fact not that communities are opposed to the form of energy per se, but that they do not get to benefit from the electricity generated by the wind turbines. Patterns of energy access are often deeply racialised (Newell 2020a), as McDonald's (2009) work in South Africa shows, as well as often heavily gendered, especially in rural settings (Winther et al. 2017). Energy transitions are shaped by, and have to navigate, these deeply entrenched inequalities. If they are to succeed in being just as well as sustainable, energy transitions will need to help address these social cleavages.

To see off the evident and pressing need for transformation, in which energy is at the heart because of its relationship to growth, states and corporations have engaged in a project of what Gramsci (1971) called *trasformismo*, to accommodate the threat posed by climate change to the legitimacy of the economic system and the political systems and governance structures set up to steer it and manage its contradictions (Newell 2018). This is apparent in attempts to deflect, delegitimise and downplay calls for reduced consumption and production and more sustainable and inclusive models of economic development, and for redistribution, by focusing on the need for more: for more technology and finance, more markets and better pricing systems, enforceable property rights and enabling conditions for a new round of accumulation. It is apparent in claims by fossil fuel incumbents that their industries are vital to meeting the needs of the poor (WCA 2021), overlooking the fact that the majority of large energy consumers are other businesses and richer consumers, since many of the poorest people in

society are either not connected to the grid in large parts of the global South or living in fuel poverty in the North, or in claims that climate change measures will hit the poor hardest, overlooking the fact that poorer groups are the most vulnerable to the effects of climate change.

1.2 The Approach

The premise of this book is that much of the policy debate so far, as well as existing academic scholarship reviewed earlier, has failed to provide a fuller *political* analysis of historical precedents of when organised large-scale sociotechnical and economic change has occurred in the past and what lessons might be deduced for the current challenge of drastically and rapidly decarbonising the global economy. It is precisely such a political and historical analysis of transition that is proposed here. This requires the novel fusion of insights from technology and innovation studies, history, economics and international political economy (IPE) and ecology about how rapid shifts in systems of production and consumption can occur and be accelerated by political action. This is vital to appreciating the political enabling conditions for the much-feted new industrial or energy revolution now required to tackle climate change and enhance energy security. Rather than focus just on technology or finance in isolation, however, this project addresses the neglected political, historical and ecological dimensions of energy transitions. It seeks to revisit examples of previous transitions primarily told through the lens of socio-technical configurations, without sufficient attention to power and politics, and in so doing provide a more politically inflected account.

Simultaneously historicising, politicising, globalising and ecologising the study of energy transitions is no easy task. But it is nevertheless an important one. Bringing the four dimensions together firstly seeks to address the fact that historical work on transitions, of which there is a great deal in terms of specific case studies of sociotechnical transitions, is often insufficiently attentive to politics and political economy and often overlooks the ecological dimensions of transitions, especially beyond the narrow parameters of the case in question. Secondly, work on the politics and political economy of transitions, given its more contemporary nature, often underplays historical dimensions and is similarly negligent when it comes to the ecological aspects of transitions. Thirdly, work on the environmental impacts and implications of energy transitions, because of its basis in engineering, modelling and technology and innovation studies for the most part, is neither very historical in orientation, since it is often largely future oriented, nor explicitly political in terms of the competing actors, interests and uneven social outcomes implied by different scenarios and pathways.

The approach taken is highly interdisciplinary, drawing on insights from innovation studies on sociotechnical transitions (Geels 2005; Loorbach 2007), historical economics (Perez 2002, 2013; Pearson and Foxon 2012) and theoretical and conceptual insights from IPE (Cox 1987; Rupert 1995), political economy more broadly (Koch 2012; Malm 2016), as well as political ecology (Robbins 2004; Lawhon and Murphy 2012) to guide the empirical enquiry by highlighting key historical moments, actors and initiatives that warrant further investigation. The selection of examples referred to in the book is guided by the desire to illustrate their potential relevance to key aspects of contemporary debates about energy transitions in terms of who will produce what, where the finance will come from, how they will be governed and what the politics of mobilisation will look like. This locates contemporary developments as part of longer historical processes which need to be revisited in order to understand precedents for disruption, change and the realignment of economies, technologies and politics, as well as the (re)production of incumbent power. It highlights contradictions at the heart of capitalism, which compromises its ability to engage effectively in the sorts of energy transitions now required and the forms of politics to which it gives rise: both as the politics of *trasformismo* in order to manage those contradictions, and the politics of dissent and counter-movements which seek to contest the framings, practices and politics of orthodox transitions as part of a more ambitious project of transformation.

In this way, the book seeks to locate energy transitions as part of a necessary broader project of political, ecological and economic transformation comparable in many ways to the double-movements that Polanyi (1957 [1944]) described that sought to re-embed the market economy in frameworks of social and democratic control, though hopefully, in this case, with a more positive and lasting outcome. This is not about containing threats to the legitimacy of capitalism through incremental improvements and concessions to social and environmental movements or improving its governance. It is more about a redefinition and redirection of the purpose and orientation of the economy towards the needs (including for energy) of the majority of humans and non-humans on the planet. The German Advisory Council on Global Change has argued that the transformation towards a low carbon, sustainable global economic system should be radical, on a par indeed with the two great transformations that mankind has encountered so far: the prehistoric Neolithic settlement and the transformation of agrarian into industrial societies (WBGU 2013). The report also points to an important distinction in that the first two great transformations were natural, evolutionary processes, while the shift towards a new sustainability paradigm needs to be predominantly a planned, policy-induced process, though I would argue here that social mobilisation will also be critical. Who sets the terms of such a shift is a pressing question.

Though the discussion is divided into chapters on each of the key dimensions of transition - producing, financing, governing and mobilising – in practice, of course, they are intimately connected, as Figure 1.1 makes clear.

The research upon which the book builds draws on research projects, consultancy work and policy and activist engagements undertaken principally over the last ten years. This involved research projects on the governance of clean development in India, Argentina and South Africa (with a particular focus on the energy sector), work on the role of rising powers (China, India and Brazil) in energy transitions in South Africa and Mozambique, a project on the political economy of 'climate compatible development' in Kenya and consultancy work on, respectively, climate justice, pursuing clean energy equitably, the politics of rapid transitions, scaling behaviour change and supply-side climate policies.

These projects were conducted using a mix of methodologies including historical analysis to uncover the political conflicts and negotiations that attended previous major social-technical changes in energy systems, off-the-record conversations, informal networking and semi-structured interviews conducted over a number of years with key contemporary actors involved in both financing and delivering low carbon solutions, and those involved in the political work of assembling alliances, networks and associations that are seeking to build a low carbon economy. This includes informants in government, international organisations, business and civil society. It has also involved a large degree of participant observation in spaces, arenas and debates concerned with the political economies of energy transition. Over the course of the writing of the book, these range from direct participation in protests, media work and the organisation of local citizens' assemblies to respond to the climate emergency, through to involvement in national-level policy debates and strategy discussions with major campaigning organisations and funders of innovation and technology, consultancy work for donors, as well as the organisation of events and dialogues with business actors and governments involved in the UN climate negotiations.

The research undertaken for this book benefitted from my role as co-founder of the Rapid Transition Alliance, an initiative to source and share what I call 'evidence-based hope' among researchers and practitioners about the possibility of rapid transitions, from contemporary and historical examples across regions and sectors of the world.[1] This has involved meetings and discussions, media work and research and advocacy on the theme of transitions with a range of state (local and national), corporate and civil society actors. The contacts I have made, the observations I have been able to make, and the processes and spaces I have had the opportunity to access as a result of involvement in this initiative have yielded insights that inform much of what is contained in the book. Hence, though not

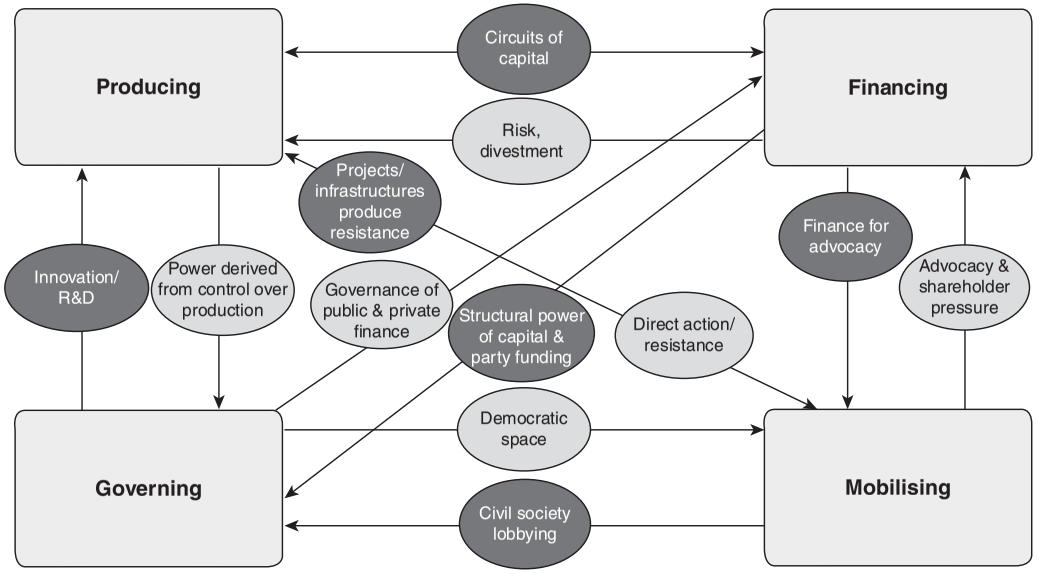

Figure 1.1 A map of some of the connections between the different elements of transition covered in the book

always explicitly highlighted in the chapters that follow, their presence is felt and informs many of the insights and conclusions that follow. These insights have been further enhanced by my experience of serving as a board member for Greenpeace UK and Carbon Market Watch in Brussels, two organisations engaged in different ways with a variety of aspects of the political economy of transition and ongoing debates about how best to accelerate energy transitions. Three other forms that participant observation took included my involvement with the UK local council group ADEPT (Association of Directors of Environment, Planning and Transport) as a member of their climate advisory board and presenter at their workshop with business partners on responding to the climate emergency, work with the group Carbon Trust around an event with business on 'The Business of Rapid Transition'[2] and work with Extinction Rebellion around my home city Brighton and Hove's plans for a citizens' climate assembly.

1.3 Why Energy? The Peculiar Politics of Energy

Energy is central to modern life. It is rightly described as the lifeblood of the economy (Huber 2013). At its most basic level it is defined as the ability to do work or the means of accomplishing work (Rosa et al. 1988). From transport and mobility to cooking and cooling, heating, industry and agriculture, energy is intimately linked to all economic and social activity. All production, movement and work implies the expenditure of energy. Energy then is a prerequisite to all other types of development and innovation in relation, for example, to agriculture, the use of water, industry, infrastructure and technology.

The need to generate heat, light, to transport ourselves and to produce goods and services characterises all of human civilisation. However, modern industrial and contemporary society in particular makes unprecedented demands of its energy systems to accommodate the ever-expanding desire for comfort and convenience of its richer classes above all; around heating, cooling and control of homes, to be able to consume food products from the other side of the world, or to travel long-haul for holidays. This requires twenty-four/seven delivery of energy, globally connected infrastructures and integrated grids able to accommodate fluctuating, but generally increasing, demand. All of this comes at a cost for some people and some environments more than others, premised as it is on systems of uneven development and exchange. Meeting these demands eats into the remaining ecological space that, if equity had anything to do with it, should be reserved for poorer under-consuming classes. And it comes at a time when, in the face of climate change, we need to radically reduce levels of energy consumption and meet energy needs in different ways and do so within (unprecedentedly) short periods of time (IPCC 2018). This is

not to imply that these shifts are driven by ever more consumerist and materialist societies, though that is part of the story (Kasser 2016). The restlessness of capital and the need for ever-increasing returns require these increases in demand to feed profits, searching out new markets and outlets for investment in energy-hungry technologies and infrastructures. This is why, in many energy projections, the role of conservation, efficiency and demand-side measures is often so neglected. The assumption is that demand will continue to increase, and we need to find new resource frontiers, develop new technologies and build new infrastructures to meet that demand.

The fact that its provision is currently organised in such environmentally unsustainable and socially detrimental and uneven ways presents huge challenges for transforming energy systems, therefore. There is a particularly close relationship not only among energy, electricity and capitalism (Di Muzio 2015; Di Muzio and Ovadia 2016), but also between energy and industrialism. For much of modern history, energy systems have been organised around fire (Patterson 2015): burning oil for transport, gas to heat homes, oil to power industry, biomass to warm schools and hospitals. Increasingly, there is a move towards electrification – of trains and cars, of homes – as well as shifts towards more localised forms of (micro) energy generation less dependent on centralised infrastructures, pipelines and utilities to service energy needs which some describe as the 'democratisation of energy' (Tomain 2017).

The advent of the 2015 SDGs establishes a stand-alone SDG for energy focused on energy access, as was noted already. But there is also one for climate change and, as many people have pointed out, our ability to successfully address many of the SDGs will be undermined unless we get a grip on climate change (Ansuategi et al. 2015). The fact that the SDGs are both universal and indivisible creates both challenges and opportunities for accelerating more transformative energy transitions. On the one hand, there is scope to address energy more ecologically, holistically and synergistically, looking at its role in what is often referred to as the nexus of water-energy-food and opening up the possibility for more circular and life-cycle thinking. On the other hand, despite the trade-offs and contradictions that will emerge from attempting to deliver simultaneously on all the SDGs, the tendency to date, and the likelihood going forward, is that these tensions will be obscured amid pressure to act and report on the SDGs in rather tick-box terms where, despite some concessions and modifications, overriding political priorities of industrial growth will not be compromised.

1.4 Continuity and Change in the Study of Energy

Though many accounts achieve this feat, the history of the world to date cannot be meaningfully or accurately told without reference to the energy

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which has powered, enabled and frustrated the accumulation of power and the pursuit of social and economic ambitions over centuries (Yergin 1991; Smil 1994; Lohmann and Hildyard 2014). Early sociological work on energy took as given that energy is largely responsible for material differences between societies, and sought to develop grand theories to explain how and why some societies achieve greater material output than others (Spencer 1980), such that 'the ability to harness more and more energy to production lay at the foundation of the evolution of societies' (Rosa et al. 1988: 150). Early anthropological writing also suggested that levels of cultural development vary according to the amount of energy per capita harnessed and put to work, such that the evolution of culture was dependent upon degrees of energy intensification (White 1943). White (cited in Strauss et al. 2013: 17) wrote of a fuel revolution thus:

> By the beginning of the eighteenth century . . . cultural development had gone just about as far as it could on the basis of animate energy and wind and water; it could not advance appreciably farther without tapping new sources of energy. Herein lies the significance of the revolutionary achievement of harnessing the energy of fossil fuels. Vast amounts of energy were locked up in the earth's crust in the form of coal, oil and gas. The development of steam and internal combustion engines was the means of harnessing and utilizing these energies into ever increasing amounts. And the new technology was extended into all phases of life: into industry, transportation by land and by water, aviation and into the arts of war as well as those of peace.

Hence, in these (bio-)'energetics' approaches, the social advances and differences in levels of development could be accounted for by energy: the more consumed, the more advanced the society, where success was determined by the ability of societies to extract 'cumulative surpluses' from converting energy into productive purposes (Carver 1924) and the technological efficiency of its conversion. Buchan (1972: 163) wrote: '[D]evelopments in the use of energy . . . have shaped the course of modern history more than other forms of technological change', a point underscored by Clark (1990: 1) arguing in his political economy account of world energy in the twentieth century that it was 'no coincidence that several nations reached industrial maturity at the close of the nineteenth century simultaneously with the emergence of increasingly sophisticated energy systems'. In a similar vein, it has been suggested that 'the Darwinian struggle for existence is really a competition for available energy' (Rees 2020: 3). Ecologists such as Lotka (1922) formulated the 'maximum power principle' which suggests that successful systems are those that evolve in ways that maximise their use of available energy per unit time in the performance of useful work (growth, self-maintenance and reproduction). 'In the Anthropocene', Rees (2020: 3) suggests, 'no other species comes close to challenging humanity's energy hegemony'.

Such (bio-)energetic accounts are clearly problematic on numerous grounds, including the fact that very poor societies are in aggregate higher, but hugely unequal, energy consumers and the fact that energy interdependencies mean that levels of development and under-development are relational. Subsequent critiques of what I would call 'modernist' approaches to development (following Rostow's (1960) stages of economic development) and ideas about the 'energy ladder' (van der Kroon et al. 2013) drew attention to the limits of energy consumption. In particular, they referenced the second law of thermodynamics that energy, unlike materials, cannot be recycled such that there are inevitable limits to available useable energy (Altvater 2006; Soddy 1912). This line of critique was further developed by broader critiques of growth of which energy was just one element (Georgescu-Roegen 1971). This claim was, and in most quarters of the policy and corporate establishment still is, seen as heresy. It challenged the unquestioned, but deeply questionable, line of logic that because 'energy was essential to economic growth and since economic growth represented improvements in societal well-being, it was but a short step to infer that energy growth was essential to societal well-being' (Rosa et al. 1988: 158). This has stood up despite evidence that increased energy consumption above a certain level does not increase welfare and the same goes for growth. In echoes of the 'spirit level' argument (Wilkinson and Pickett 2009), and sharing the view of Buttel (1979) and others, Rosa et al. (1988: 159) show that

> while a threshold level of high energy consumption is probably necessary for a society to achieve industrialisation and modernity, once achieved, there is wide latitude in the amount of energy needed to sustain a high standard of living. Moreover, given that latitude industrial societies could choose slowed-growth energy policies without great fear of negative, long-term consequences to overall welfare.

This speaks to the much neglected need to address both supply-side policy (Erickson et al. 2018) which sets production limits, and demand-side policy, which has an explicit aim of reducing energy consumption (Green and Dennis 2018). It turns on its head the historical and ongoing assumption that increases in per capita energy use are a reliable and tenable indicator of progress, rather than providing a barometer of resource depletion on a finite planet.

Suggestive of the inevitability of transformation, either planned and nurtured or imposed and reactive, energy limits in this rendition imply crises for modern societies. As Rosa et al. (1988: 153) put it, 'since sustained periods of economic growth shaped the character of modern industrial societies, physical limitations on future growth portend fundamental changes in that character'. In part, this implies a shift in the concentration and organisation of power, the central theme of this book, since 'social power evolves and becomes more concentrated as the

harnessing of energy increases' (Rosa et al. 1988: 153). We will see in Chapter 6 in relation to discussions about community energy and democratising energy that part of the rationale is the desire to take back control of energy systems and to share the determination of collective energy futures. For the very same reason, unsurprisingly, incumbent actors alert to this potential threat resist such moves.

Though I have described them here in terms of historical debates about energy and society, their contemporary relevance could not be clearer. Because of the second law of thermodynamics, the organised and massive scale waste of energy cannot carry on indefinitely, even if it is powerfully driven by capitalist growth imperatives. In that sense, as other work on rebound effects and the limits of just scaling up renewable energy technologies within conventional productivist frameworks has shown (Zehner 2012), massive technological fixes, which form the dominant response to previous energy crises, will not solve and will almost certainly exacerbate the challenges we currently face. As Lovins (1977) argued, 'soft energy paths' imply a complete restructuring not just of energy supply systems, but of society itself. Entrenched assumptions that have sedimented into ideologies of development progress, espoused and backed with institutional and material power by states and global institutions, about the key to development being the presumed abundance of inexpensive, easily accessible and available energy resources, increasingly run up against the reality of 'un-burnable' fossil fuels and natural and social limits to extraction. The crisis we currently face results from a long history of failure to acknowledge the prospect of resource depletion, years of active climate denial and a reluctance to consider energy efficiency, conservation and reductions in energy demand.

Occasionally, such complacency is shaken by shocks to the system such as the 1974 oil embargo crisis or the Iranian revolution. Regarding the former, as Rosa et al. (1988: 160) suggest: 'With a stroke of the OPEC pen in 1973 the complacency of assuming forever expensive, plentiful secure energy supplies was all but shattered.' They continue: 'The embargo also sparked a fundamental shift in the definition of energy supply, from a solely technological problem to a bundle of social ones' (Rosa et al. 1988: 164). It is hard to over-state the rupture it caused. Odell (1981: 240) suggests that the prospect of reduced and uncertain supply of oil 'served to undermine the planning and policies of all western governments and so make it impossible for them to sustain the rising expectations of their populations for continued development'. As well as giving rise to the creation of the IEA as a means to co-ordinate the strategies of rich oil-importing countries, it also heightened interest in energy conservation and renewable energy, while also opening the way for a renaissance of nuclear energy and renewed efforts to develop domestic energy sources. In France, for example, just three months after the embargo, the

French government decided to raise the share of electricity produced by nuclear plants from 8 per cent to 70 per cent by 1985 and the Japanese government announced a fifteen-fold increase in their nuclear-generating capacity (Hammarlund 1976: 183). Energy crises can also often usher in shifts in social values and attitudes towards energy, around conservation in the wake of the OPEC crisis, or the delegitimisation in some quarters of fossil fuels in light of the climate crisis, or strong social reactions to nuclear crises in the wake of the Chernobyl and Fukushima disasters.

Indeed, shifts in the study of energy and energy systems are often driven by crises. Interest in the study of energy peaked in the wake of the above-described OPEC crisis, and from the early 2000s interest returned in the form of concern about dependence on oil from the Middle East, the theatre of wars in 1991 and then again in 2003. The current wave of interest in energy transitions is likewise prompted in large part by the climate crisis and the clear need for rapid transitions away from fossil fuels and deeper transformations in systems of energy provision underscored by the Paris Agreement and recent IPCC reports (IPCC 2018). The question is whether the climate crisis, which perhaps poses less of a threat to immediate access to supply or ownership regimes than the OPEC crisis, or is yet to manifest itself in steep price rises, can trigger another such shift in global energy policy. Rosa et al. (1988) draw an interesting and potentially important distinction between a 'crisis' and a 'predicament', where crisis refers to a rapidly deteriorating situation that can lead to near-term disaster, whereas predicament refers to a chronic problem that requires continuous attention. Crises come and go, often related to issue attention cycles, while predicaments persist unless resolved and since the current situation is characterised by powerful incumbency and 'slow violence' (Nixon 2011) for poorer populations, the prospects of its resolution can appear remote indeed.

1.5 Energy as a Change in State

Energy is intimately entwined not only with modern history and the world economy, but also with the form and practice of statecraft and international relations. Whether it is energy diplomacy and statecraft or electricity provision and the extension of the grid as a shorthand for modernity and delivering development (Gore 2017), energy often serves as both the end and the means of statecraft. Strauss et al. (2013: 12) note: 'Ensuring access to continued supplies of energy and other resources is one of the central functions of centralized political systems. Shortages of energy – blackouts and queues for gasoline – quickly become political problems and often have political antecedents.'

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Energy is also implicated in violent politics (Watts 2008), imperialism (Bromley 1991) and changing balances of power, for example, brought about by the shift in power in the world oil regime that occurred as producing and exporting nations took control over the supply and price of oil through collective action. It is often claimed that it is in the Middle East that the importance of the relationship between oil and world politics is clearest (Odell 1981). Yet claims of oil companies serving as agents of US imperialism were levelled by many Latin American countries in the 1970s in the era of dependence thinking leading to expropriations and the establishment of state-owned companies such as Petróbras in Brazil or in other cases the downfall of leaders such as Perón in Argentina. As Odell (1981: 223) notes:

> The international companies, moreover, effectively organised their activities around the world behind the guarantee of security offered by the political and/or military presences of the United States and the United Kingdom, which between them provided the home base for six and a half of the seven international oil companies (with the remaining half – the Royal Dutch part of Shell – domiciled in the Netherlands).

The protection afforded by states also means that, in exchange, demands can be made of companies in the pursuit of foreign policy goals such that oil companies were asked not to charge for the oil they sold to what was Western Europe as part of the Marshall Plan. Resources can also help build identities and forge regional alliances. As Odell (1981: 204) argues, echoing the point above about how energy co-operation, at times, also provides the means of avoiding war:

> [A]s a result of the economic and political advantages that oil revenues could buy, there would be an Arab Middle East with an enhanced cohesion and a more significant geopolitical potential among the power blocs of the world. This was achieved in 1973, when it became somewhat ironic to find the commodity which originally helped to divide the region into the spheres of influence of competing outside powers . . . emerging to provide the means whereby greater regional cohesion and strength between the Arab nations became a reality.

Though, as Hornborg (2013: 42) suggests, 'the particular way in which access to energy is significant for the economy seems to escape economics as a discipline', as ecological economists have focused our attention on flows of energy production and consumption in the global economy (Georgescu-Roegen 1971): the patterns of ecologically uneven exchange in both contemporary settings and historically accumulated carbon and other debts (Simms 2005). This seeks to challenge the modern world view, propelled by large-scale fossil fuel use of 'unlimited good', of a world beyond constraints (Hornborg 2013: 46). Others, such as Bellamy Foster (1999), have employed ideas of a 'metabolic rift' occurring as a result of the way that energy is produced and consumed under capitalism (drawing on Marx's understanding of the rupture in the metabolic interaction between humanity and the rest of nature emanating from capitalist production (Marx 1981)).

Energy systems are always in flux and being reconfigured to (re)align with shifting sites of production, patterns of consumer demand, the availability of finance, opportunities for the construction of infrastructures, changing political priorities and ecological shocks. They are constituted by assemblages of moving parts which create opportunities for disruption, change and alternatives. In many ways, transitions in energy systems are just one element or site of contestation in the broader relationship between energy and society. Sociological literature on energy and society (Rosa et al. 1988) and the cultures of energy studied by anthropologists (Strauss et al. 2013; Boyer 2014), are useful in comprehending this. The starting point is that 'energy, though fundamentally a physical variable, penetrates significantly into almost all facets of the social world. Life-styles, broad patterns of communication and interaction, collective activities and key features of social structure and change are conditioned by the availability of energy, the technical means for converting energy into useable forms, and the ways energy is ultimately used' (Rosa et al. 1988: 14). For anthropologists, meanwhile, '[a]n anthropology of energy must shuttle back and forth among laws of physics, opportunities and constraints of ecological systems, and processes of culture' (Strauss et al. 2013: 12).

As we will see, though literature on transitions purports to account for socio-technical transitions, work in that tradition sometimes offers a narrow and impoverished notion of what counts as the social and the political. While increasingly attending to a particular view of governance, it often has less to say about collective mobilisation, social hierarchies and inequalities and networks of power and questions of identity. Yet there are earlier bodies of research that can be usefully drawn upon to fill some of these gaps. Lewis Mumford's (1967 [1934]) work introduced the importance of social values to the study of energy, characterising key eras in terms of the relationship between dominant energy sources and technologies and predominant social values. For example, the ecotechnic epoch was dominated by water and wood, the paleotechnic with a coal-based energy system and the neotechnic resting on electricity-based energy systems. Cottrell (1955) also explored the multiple dimensions of social, political and even psychological change which accompanied the transition from low to high energy societies implying a 'total transition of society' (Rosa et al. 1988: 153). In recent years, this has given rise to a substantial body of work looking at consumer attitudes and the role of behaviour change led by psychologists (Whitmarsh 2009). It is clear that energy consumption and conservation practices are too complex to be explained by models of economic rationality which assume price signals will be received by utility-maximising and rational individual consumers, or linear attitude-behaviour-change models (Shove 2010). Yet Strauss et al. (2013: 22–3) claim:

There is a startling paucity of analysis of the everyday life of energy: how people view it, appropriate it, use it, conserve it- and why. If our current predicament of energy over-consumption has any chance of being nudged back in the direction of individual restraint and collective, society-wide conservation, changes will have to be made at the community, household and individual levels.

The invisibility of energy has also proven to be a challenge for efforts to change behaviours and energy consumption patterns where usually energy consumption is rendered visible only through meters, bills or receipts at petrol stations, for example, and as citizens we are often poor self-monitors of consumption. The use of smart meters on individual appliances is one attempt to address this characteristic of energy and work on behavioural change shows that improved monitoring and financial incentives to do so can bring down energy consumption. Again, social cleavages are key, with more affluent households investing in energy efficiencies and poorer ones reducing energy use through lifestyle adjustments. But practice theory also points to the way in which technologies, goods and appliances can themselves reshape practices. Wilhite (2013: 64) notes: '[O]nce in place and running in a home, household technologies such as refrigerators, cooking appliances, washing machines and air conditioners bear with them the potential to reshape practices.' This includes the ways in which devices notionally aimed at improving efficiency allow people to increase energy consumption in other domains as part of a rebound effect (Sorrell et al. 2020).

Clearly then, an adequate account of energy transitions has to be able to hone in and out of particular sites of change, moving across scales of governance, regions and sectors and drawing from insights from a range of disciplines. As we will see throughout the book, energy both produces particular types of political economy and is shaped in turn by diverse political and economic systems. This is so because of the materialities and material properties of energy: its lootability (Le Billon 2007); fluidity and transportability (in some cases) and its geographical concentrations (in others). Its value as a resource has a tendency at times to produce a 'resource curse' (Ross 2012), to enable a particular politics of rent-seeking – the desire to exercise control over energy decision-making to extract gains in negotiating contracts (Newell and Phillips 2016) – and sensitivity over its control in trade agreements (Newell 2007).

Energy sources at once embody geophysical properties and social characteristics. But while recognising the agency of nature, it is important not to fall into resource determinism where the availability or material properties of an energy source are assumed to dictate the nature of political orders in a causal or linear way. Around oil, for example, there is often a strong undercurrent of 'orientalist environmental determinism at play in accounts of conflict and international relations in the Middle East' (Hoffmann 2018: 40). Hoffmann's (2018) notion of 'social

energy' is helpful here. It treats energy not as biophysical matter, but as an historically and geographically specific set of social relations. Energy is understood, then, 'as a political category, a field of social change and contestation, rather than a limiting biophysical structure' (Hoffmann 2018: 40). This more dialectical understanding helps to de-naturalise dominant energy regimes and assemblages. In this rendition, social energy relations need to be contextualised within 'historically specific forms of power' which include 'technologies of energy extraction, production, consumption, transmission and storage, generated by specific social formations' (Hoffmann 2018: 42).

In this regard, Gavin Bridge's work also usefully unpacks the related processes of resource-making and state-making through analysis of political practices (Bridge 2014). Political imaginaries and work are required to construct energy resources as potential commodities that can be brought into 'commercial life' in terms that are intelligible to market society. Watts (2008) draws a distinction, for example, between oil as an artefact and oil as an artifice. According to Strauss et al. (2013: 19), 'oil exists as a material substance (an artefact) even as its existence serves to create social, political and economic structures (artifices) that organize societies for whom petroleum and its derivatives are foundational'. Transboundary forms of oil governance can be hindered by the fact that 'oil is pretty sneaky stuff, oozing in, around and across borders and making its transparent and forthright management elusive' (Strauss et al. 2013: 30). Hydropower produces its own peculiar politics because of its necessary displacements of human populations and natures, diversions of flows and redrawing of geographical, social and political boundaries (Swyngedouw 2015).

Energy sources also require particular types of infrastructure (Bridge et al. 2018b). Whereas oil can be easily transported, gas needs to be liquefied or transported through pipelines. Therefore, the technological and political challenges are greater for gas than they are for oil (Leal-Arcas 2018). As Ediger and Bowlus (2018: 22) show in writing about the battle for naval supremacy between Britain and Germany, '[o]il affected the outcome of the war itself and changed the nature of warfare. On land, the internal combustion engine powered the tanks, airplanes and transport vehicles of the Allies to victory, whereas the Germans relied on coal-powered railroads, and were unable to marshal resources and troops as efficiently across multiple fronts.' Infused with power relations, infrastructures shape our worlds in all sorts of ways. From transport networks that get us to and from places, pipes that carry our sewage, flood mitigation structures, or 'green infrastructures' in cities, to less tangible structures that shape economies, governance and representation, infrastructures mediate social-environmental interactions and establish knowledge structures. They also create vulnerabilities. Witness the impact on the

movement of oil, prices, access and competition and ultimately international relations when the Suez Canal was closed in the Suez war of 1956 and the Six Day War of 1967 (Odell 1981). Or, in a more contemporary context, the challenge of reducing the carbon in food miles when so much food is imported and delivered from farm gate to dinner plate through globalised supply chains, chains which get disrupted by financial as well as increasingly by climatic (and health) shocks. A key question is how we can understand and research infrastructures in ways that question perceptions of them as neutral or passive underlying material structures. This links well to how society-specific resource endowments and constraints partially condition particular pathways to development for nations or particular social classes within them.

Just as the characteristics or materialities of 'technology' contribute to the (re) production of different forms of governmental practice or governmentalities (Johnstone and Newell 2018), so too do particular types of energy require and assume a particular type of state. For example, nuclear energy requires a more militarised state. Quoting Denis Hayes, Hammarlund (1976: 187) suggests: 'The nuclear option requires ... widespread surveillance and police infiltration of all dissident organisations will become social imperatives, as will the deployment if a paramilitary nuclear police force to safeguard every facet of the massive and labyrinthine fissile fuel cycle.' Indeed, concerns around the 'plutonium economy' (Patterson 1984) and the 'nuclear state' (Jungk 1979) highlighted how the security implications of plutonium meant that there was a necessary level of secrecy and non-transparency, due to the nature of the materials being handled, which reduced democratic control.

Energy, then, is high politics. Energy is development. Energy is everywhere. But the ways we organise, produce and consume it are in constant flux and are now undergoing a profound reordering. So, how do we think about energy transitions?