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The Problem of Energy

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Abstract
Energy forms and their extensive scale are remarkably significant for the ways that societies are organized. This article shows the importance of how societies are 'energized' and especially the global growth of 'fossil fuel societies'. Much social thought remains oblivious to the energy revolution realized over the past two to three centuries which set the 'West' onto a distinct trajectory. Energy is troubling for social thought because different energy systems with their 'lock-ins' are not subject to simple human intervention and control. Analyses are provided here of different fossil fuel societies, of coal and oil, with the latter enabling the liquid, mobilized 20th century. Consideration is paid to the possibilities of reducing fossil fuel dependence but it is shown how unlikely such a 'powering down' will be. The author demonstrates how energy is a massive problem for social theory and for 21st-century societies. Developing post-carbon theory and especially practice is far away but is especially urgent.

Keywords
Anthropocene, climate change, energy, fossil fuels, post-carbonism

Introducing Energy

In 1776, the year that Adam Smith published *An Inquiry into the Nature and Causes of the Wealth of Nations* which described the powerful advantages of the division of labour (Smith, 1979 [1776]), the diarist and biographer James Boswell visited the world's first ever factory. This 'manufactory' established by Matthew Boulton was located at Soho near Birmingham. It was powered by James Watt's steam engine which burnt coal and turned the resulting heat into motion. Boswell proclaimed: 'I shall never forget Mr Bolton's [sic] expression to me: "I sell here, Sir, what all the world desires to have – POWER"' (Morris, 2010: 491). And power there has been in plenty since that fateful moment as fossil fuel-based energy was initiated in England in the later 18th century (1776 was also the year in which American Independence was declared).

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This special issue explores many of the implications of that fateful moment as all the world desired and began to obtain that 'power'.

Developing coal-based power led the 'West' to develop a different trajectory from the 'East'. Until the 18th century, China and India were the largest economies in the world, generating one-third of world income (see Lovell, 2006; Morris, 2010; Tyfield, this issue). In particular, China was the location of much technological advance and invention, such as cast iron, ploughshares, stirrups, gunpowder, the printing press, paper money and the magnetic compass. China thought of itself as the centre of a civilization stretching back at least two millennia. And much of its imperial power was based upon controlling water power. Wittfogel (1957) argued that the cost of such hydraulic construction and its maintenance required a despotic political and social structure so as to extract labour. Those controlling the complex irrigation systems of a hydraulic network wielded power through what Wittfogel called an 'oriental despotism'.

This linking between water power and despotism indicates that energy systems and social systems are often highly interconnected. They are not independent, although the forms in which societies are 'energized' are often hidden from direct observation, especially in the case of larger and more distant forms of energy. Also, much of the time people do not use 'energy' as such but rather obtain, buy and use various goods and services. Energy demand is the outcome of what people are *doing*, of the interlinking of practices and energy-intensive material arrangements (see Shove and Walker, this issue). The form and scale that this energizing takes will be mostly unknown to those participating within such practices, such as taking a humble shower each day.

Until the 18th-century development of fossil fuel energy systems located within new 'manufactories' such as Matthew Boulton's, energy was based upon the muscle power of humans and animals (80–85%), wind, water and the burning of charcoal and wood. These were localized, with the energy generated being put to use very close to where it was produced. Energy was mostly localized with little in the way of surpluses that could be sold or circulated elsewhere.

Such 'energy-localism' dramatically changed as the fossil fuels of coal, gas and oil were deployed over the past two or so centuries. Their use engendered large energy surpluses and facilitated the development of novel 'energy converters' (see Cottrell, 2009, on 'energy and society'). These fossil fuels now account for over four-fifths of the world's current energy provision (Huber, 2009).

This growth of what can be called 'fossil fuel societies' with their large-scale energy converters meant that the non-fossil fuel economies of India and China went into relative decline from the 18th century onwards. Burning mobile fossil fuels became central to the modern energizing of societies. Indeed burning fossil fuels to generate heat, power and

movement is the *most* significant feature of the modern world. There is no clean, dynamic and fast modernity without very large amounts of the dirty fossil fuels of coal, gas and oil being combusted (Clark and Yusoff, this issue).

Indeed 'western civilization' was not necessarily superior to the rest of the world. It was not just the Enlightenment or western science or liberalism that secured the 'West', but it was as much the contingent carbon resources that enabled it to dominate the last two or so centuries (Morris, 2010). The 'West's' dirty carbon resources lying beneath the ground that could be combusted enabled it to emerge from the shadows of the 'East' and develop at an exponential rate its economy, its wealth and its staggering new forms of power.

How societies are 'energized' is crucial for how they work, how they are 'powered'. Schumacher writes: 'There is no substitute for energy. The whole edifice of modern society is built upon it . . . it is not "just another commodity" but the precondition of all commodities, a basic factor equal with air, water, and earth' (quoted in Kirk, 1982: 1–2). This 'basic factor' cannot be dispensed with. Its varied forms structure the social, temporal and spatial organization of societies and of 'life' itself. Modern life is much less a 'bare life', and more one where bodies are heated, clothed, powered, mobilized and dependent upon many material objects (Agamben, 1998; Shove et al., 2009). The powering of societies and life depends upon which systems of energy production, distribution and consumption are dominant. These systems include muscle power, wood, wind, sail, water, sun, coal, gas, oil, hydro-electricity, geo-thermal and nuclear energy. Systems range from small-scale localized production, often in the home or village, to huge global networks, where power or its source travels along very long routes from other societies or even continents.

This special issue explores the economic, social and political implications of many transformations of energy. It especially concerns the vast fossil fuel systems through which societies since the 18th century have been 'powered up' and which 'energize' the modern world. This world is only possible through getting fossil fuels out of the ground and then burning them on a gigantic scale. While oil can be turned into many kinds of 'product', most oil and almost all the gas and coal extracted from under the ground have been burnt, as heat is converted into energy.

Social Theory

It is the presumption of this special issue that social theory has insufficiently explored these systems that energize societies and engender different habits and practices. One way of thinking about this is in terms of the changing metabolic relationship between the physical world and human societies. Marx argued that workers act upon nature and in so

doing change that nature. And in changing nature they also change themselves. There is a socio-natural metabolism central to historical processes of change and development (Marx, 1976 [1859]: 283; White and Wilbert, 2009). Humans are part of the natural world, but in working on nature they transform themselves and that world. New socio-natural forms are generated by the bourgeois class; Marx and Engels (1888 [1848]: 57) describe these as involving: 'more massive and more colossal productive forces than have all preceding generations together'.

Significant here are new kinds of circulation, of people, objects and energy made possible by the novel energy converter of the coal-powered railway. The circulation of commodities represented a major upward shift. Production involved speeding up the conditions of exchange through the machine-based movement of goods and people. Objects were increasingly produced in new factories but then consumed in other places, often quite far away. These new systems of coal power and movement resulted in the increasing 'mastery' of the physical world. Unlike, say, water or wind power, coal was both more concentrated and a more mobile energy form. According to Marx, these new uses of nature led to capitalism's increasing 'rift' with nature, not only robbing workers but also robbing the soil. Marx (1976 [1859]: 638) writes how capitalist production undermined the original sources of all wealth, which are twofold: 'the soil and the worker'.

We consider here some of the historically embedded ways, or systems, in which social practices were established and sustained, especially through this 'carbon metabolism' with nature (Geels, this issue; Szerszynski, 2010). That metabolism laid down enormously powerful habitual patterns of life, a 'carbon-metabolic profligacy' that underpins what humans now are, and what they could and should do within the modern world. Historically, increased levels of social complexity, communication and capacities have been inseparable from rising levels of fossil fuel energy. Contemporary societies have come to be dependent upon an energy intensity impossible before the growth of fossil fuel combustion.

Indeed Bauman (2000) famously described the 20th-century development of movement as a 'liquid modernity', and he contrasted this with a more fixed and stable older modernity. But, curiously, what he did not examine was how there was in fact a literal liquid – oil – that made possible this modernity, oiling the wheels of a globalizing mobile society and its liquid lives and loves (oil is not in the index of this seminal text). Twentieth-century discoveries of oil enabled societies to be powered up in novel ways, so developing and reinforcing western liquid modernity. But social theory never noticed how liquid relations depended upon dirty oil or 'black gold', of which around 85 million barrels are currently burnt each and every day (a barrel is 42 gallons: Urry, 2013b).

Most social thought has been premised upon the division of the natural and human worlds. Social thought stemmed from the Enlightenment view in which it was presumed that the human world can be known, mastered and made perfect. 'Modernity' involved the belief that human progress should be evaluated in terms of the human domination and exploitation of a separate nature. The realization of the collective powers of humans resulted in remarkable increases in the rates of extraction, organization and expropriation of energy, so making possible a modern society.

There was presumed to be a chasm between nature and humans, with energy clearly lying within 'nature' and not something having much to do with humans, their activities and their modernity. Energy was back there in the physical world, often out of sight and unrelated to humans and their rational mastery of the world. Indeed fossil fuels were dead matter with no one able to represent them and speak up for their long-term interests. They had no voice in what Latour (1993) calls the 'parliament of things'. Since there was no articulation of their interests they came to be exploited as though they were just laid out and waiting for the modern world to expropriate as fast and furiously as possible. Human freedom resulted from enslaving nature, we can say.

But Latour and others go on to show that this separation of the physical and social worlds is a myth since 'we have never been modern'. Energy especially shows what we can call the 'hubris of the modern'. The human and physical/material worlds are utterly intertwined and the dichotomy between the two is a construct that mystifies understanding of the problem of energy, as various contributors here document and detail. As a consequence there is a major challenge to much analysis and politics since energy and its colossal energy converters cannot be simply subjected to human mastery and necessarily transformed in a benign direction.

Indeed a limit of much environmentalist social thought has been a 'hubris of the modern'. It is often proclaimed that if only humans understood the world better, then they would pursue rational policies to reduce their carbon footprint and this would save the earth from irreversible climate change and long-term energy insecurity. This view of human enlightenment is sometimes linked to an individualistic 'behaviour change' policy programme that focuses upon rational actors being encouraged or nudged to think and act differently (see Banister et al., 2012).

This human-centred thinking ignores ways in which long-term path dependencies lock humans-and-nature into energy systems and related social practices, dependencies with much irreversible momentum (see Geels, this issue). Harvey specifically develops this argument through identifying the path dependencies of a 'food–energy–climate change trilemma' (see Harvey, this issue). There are strong interdependencies

between the growth in food demand, the decline and increasing insecurity of fossil energy and anthropogenic climate change arising from land conversion and its uses for food and energy. The trilemma represents an unprecedented challenge to achieving any large-scale reduction in emissions.

Another way in which the human–nature divide is being transcended is in how social theory focuses upon ways in which social and cultural phenomena are themselves vital or exhibit energy (see Fraser et al., 2005). It is argued that life cannot be understood mechanistically but through vitalist processes. Social and cultural phenomena are characterized by notions of process, by energy rather than fixity, by becoming rather than being, and by movement rather than stasis. In the informational age, information itself is increasingly characterized as being dynamic, vital and energetic.

Vitalist thought draws upon the scientific analysis of energy systems. Such forms of energy depend upon the irreversible flow of time resulting in loss of organization and an increase in disorder within open systems. This stems from the Second Law of Thermodynamics. But Prigogine (1997) shows how new orders can in fact arise far from equilibrium (see also Biel, 2012). These dissipative structures, islands of new order within a sea of disorder, maintain or even increase their order at the expense of greater overall entropy. Thus turbulent flows of water and air, which appear chaotic, are highly organized. Such analyses by Prigogine and others of self-organizing orders overcome the dichotomies of determinism and chance, nature and society, being and becoming. Thus physical systems do not exhibit and sustain unchanging stability as much social thought has always presumed. More generally, there has been 'complex systems' thinking in the social sciences and analyses of new kinds of order, such as of the new order of 'online communications', the scale of which dwarfs older print-based orders, as interestingly shown by Al Gore (2013; see Urry, 2003, for many global examples of how 'new orders' can emerge).

But for all the interest in the vitalist character of life and the social, what is mostly ignored is how contemporary cultures presuppose huge concentrations of energy so as to power the modern world and its machines. These machines include, as Sheller (this issue) shows, many made out of shiny aluminium. There is nothing weightless or immaterial about this modern world, with billions of laptops and mobiles dependent upon large-scale hydro-electric schemes that power the turning of bauxite into shiny aluminium. Such schemes involve vast relocations of nature and populations. Social theory is mostly oblivious to the ways in which consumer goods and services and many forms of life are dependent upon, and locked into, massive, material transformations of the physical and social worlds of the 'other'.

'Modernity' has been energized, made vital, through powering up systems that make it contingently stabilized. It involves many material

transformations to realize speed, science, consumer commodities, electric lighting, smooth aluminium laptops and mobiles, container ports, fast-moving trains and cars, planes and airports, global markets, long-distance supply chains, landmark buildings, and fleeting senses and impressions (see Nye, 2010, on the wonders of lighting the city). The modern world and 'the transient, the fleeting, the contingent', as Baudelaire (1981: 403) put it, presuppose systems that mostly involve extracting, burning and distributing fossil fuel-based energy that comes from under the ground. Some unimaginably old *and* astonishingly dirty fossil fuels make that modern world contingently possible. It is the characteristics and possibilities of a 'post-carbon' theory, society and practice that we should be debating and 'energetically' developing.

A further reason why social theory should be bothered by energy is that relations of power depend upon which energy forms are dominant. Systems of heating, powering and moving objects transform power between social groups both within and across societies. And such power relations between groups in turn transform the relative significance of different energy systems. These systems and their relative strength have huge consequences, for economies, cities, inequalities, mobilities, material worlds, migration, gender relations, foreign policies, income, well-being and cultures (on the consequences of oil for contemporary societies, see Urry, 2013b). As energy use became organized on a much larger scale, so inequalities increased and greater divisions of interest arose between social groups with regard to energy extraction and use. Big energy we might say is a 'great divider'. As Illich (1974: 27) argued, only 'a ceiling on energy use can lead to social relations that are characterized by high levels of equity'. As energy use grew and there was less of a ceiling, so greater inequality and more divisions of interest between social groups developed. This has been taken to the extreme in many oil-producing states. Untold riches and ostentatious display sit side-by-side with impoverished and immobilized migrant workers, as in contemporary Qatar which seems to be purchasing most of the world's luxury brands.

These energy systems are enormously costly – there is rarely a 'free lunch', but the bill is often paid by those not actually consuming the lunch. Marriott and Minio-Paluello (this issue) graphically show such inequalities in the case of those living near the oil road that takes oil (and gas) away from the Caspian Sea area to Bavaria. They describe the carbonized practices upon which the high-energy mobility culture in western Europe depends, and the forces resisting any shift away from this petroculture and the effective 'powering down' of society.

These points can be well seen in examining some differences between coal and oil societies. The affordances of fossil fuels are not all the same nor similar in their socio-political implications.

Coal and Oil

We have seen the significance of the coal-based steam power that developed in the 'West' during the 18th and 19th centuries. This set societies, first in Europe and then in North America, onto a different path of development from the 'East'. Nobel prize-winner Paul Crutzen argued that this initiated a new geological period of human history, the 'Anthropocene', following the Holocene. In this new period, human activities exert a major impact upon almost all aspects of the earth system, an impact equivalent to a great force of nature (see http://www.anthropocene.info/en/anthropocene; accessed 18 September 2012).

These coal-fired steam engines generated novel workplaces, new industries and products, huge factories, vast cities and machine-based movement, the railway system. They all depended upon coal extracted from the many shallow and open-cast coalmines. Coal-based energy was especially significant for powering human movement. Prior to the 19th century, movement was based on human power (e.g. sedan chairs), animal power (e.g. horses for riding or pulling carriages) or wind power for sailing. Coal-powered railways, the first 'mobile-machines', re-structured physical and social worlds. In 1901, HG Wells predicted that future historians would take 'a steam engine running on a railway' as the 19th century's central symbol (quoted in Carter, 2001: 8). For the first time, people and objects, including coal itself, travelled faster than galloping horses. Marx (1973: 524) thought that the circulation of commodities via new forms of transport and communications (train, mail, telegraph) represented a huge upward shift in annihilating space by time.

Coal enabled the production and consumption of many large systems, generating the equivalent horsepower of millions (see Tyfield, this issue, on King Coal). In the 20th century, coal-fired power stations were central to enabling electricity systems to be developed and form national and international grids designed to prevent blackouts and deal with uneven electricity demand (see Hughes, 1983). Nye (2010: 131) analyses both how closely coupled systems can in fact generate blackouts through cascade effects, and that power failures may turn an urban landscape dysfunctional. He describes them as 'anti-landscapes', a 'man-modified space that once served as infrastructure for collective existence but that has ceased to do so . . . Subtract electricity for more than one week from the networks sustaining American cities and suburbs, and they risk becoming uninhabitable.'

Coal, moreover, is widely distributed and usually required large numbers of mainly male workers to mine it and get it to the surface. Starting from the 19th century, these workers were normally organized into trade unions so as to protect their rights and communities and to bring about some income redistribution. Coal mining often generated solidarity between workers and their families, all seeing themselves as part of an

'occupational community'. This solidarity was described in the classic study of a Yorkshire mining community, *Coal Is Our Life* (Dennis et al., 1956). Such solidarity historically generated mass demands for democracy, a coal-based 'carbon democracy'. Coal miners provided much industrial leadership in the 19th and first half of the 20th century – Mitchell (2011: ch. 1) describes these coalmining communities as a 'machine for democracy'.

And King Coal is not at all dead, as Tyfield (this issue) shows. Indeed the largest source of emissions growth in the coming decades will be burning coal in the large developing economies, the BRICS. Moreover, much low-carbon innovation and deployment will not develop *without* more coal being used, such as that necessary for powering electric cars. Thus there is much strength building up behind new discourses emphasizing the need for 'clean coal' and for developing the as yet unproven technologies of carbon capture and storage.

But for all the historic significance of coal, the 20th century was really an oil century. The mobile 20th century could not have happened without the moveable energy resource of oil. We can begin with Žižek (2008), who noted: 'Oil, our main source of energy – can you even imagine what kind of ultra-unthinkable ecological catastrophe must have happened on earth in order that we have these reserves of oil?' In that 'catastrophe' ancient fossilized organic materials settled on the bottom of seas and lakes and were buried. As further layers settled on top, intense heat and pressure built up, causing the organic matter to change into a waxy material called kerogen. With more heat, this turned into both liquid and gaseous hydrocarbons, or oil and gas. For most of human history these hydrocarbons were not seen as in any way useful 'resources' for human life.

However, over the course of the last century oil became like gold, or even better than gold, glistening as it spewed from land or sea. Upton Sinclair (2008 [1926]: 25) described an oil gusher:

> The inside of the earth seemed to burst through that hole; a roaring and rushing, as Niagara, and a black column shot up into the air, two hundred feet, two hundred and fifty – no one could say for sure – and came thundering down to earth as a mass of thick, black, slimy, slippery fluid.

The world's first gusher occurred at Spindletop in Texas in 1901, establishing the era of cheap, plentiful oil. Oil rapidly came to be used to power the newly developed cars, steamships, aeroplanes and some railways. Virtually free energy spurting out of the ground led many to believe that there really was a free lunch, especially for Americans who initiated the early 'burning' of oil within emerging 'mobility-systems' (Urry, 2007). There was (black) gold at the end of the rainbow with

little energy being expended to generate more or less free energy. As shown by Nye (this issue), the American 20th century would have been simply impossible without huge reserves of oil and the systems to refine it into petrol and diesel (and later kerosene to fuel jet planes), with continuing profound effects upon American politics and energy policy itself.

Oil became central to 'western mobile civilization' and especially to American domination (for details, see Mitchell, 2011; Urry, 2013b). Oil makes the world go round. It is energy-dense, storage-able, mobile, versatile, convenient and for most of the 20th century exceptionally cheap (still said to be cheaper than the same quantity of bottled water). The burning of oil provides almost all transportation energy (at least 95%), powering cars, trucks, planes, ships and some trains. It makes possible friendship, business life, professions and much family life (what can be called 'family miles'). Burning oil also enables the transport of components, commodities and food around the world, within trucks, planes and increasingly large container ships (up to 16,000 containers per ship). Almost all activities that presuppose movement rely upon burning oil; and there are few significant human activities that do not entail movement of some kind. Oil is an element of most manufactured goods and much packaging and bottling worldwide (95%). It is present in almost all food production and distribution for the growing world population through irrigation/drainage, pesticides and fertilisers, and moving food to market (see Harvey, this issue, and Pfeiffer, 2006, on what he calls 'fossil foods'). Oil is also used for much domestic and office heating, especially in oil-rich Middle Eastern societies. Moreover, there are few alternatives to burning oil. The global economy-and-society became dependent upon this one source of power, products and provision. All alternative fuels to oil have a poorer ratio of energy returned on energy invested (the EROEI ratio).

But often oil is a blessing *and* a curse for the places and peoples where it gets found. The prophetic title of the 2007 oil movie is *There Will Be Blood* (dir. Paul Thomas Anderson). And blood there has been in plenty, with murders, spillages, hostages, pipeline explosions, vast oil leaks, tanker fires, collapsing drilling rigs and so on. Places of oil exploitation are unlike coal mining communities since little solidarity develops between oil workers. Oil normally generates a different politics and one often pursued, such as by Thatcher in 1980s Britain, to undermine the organizing power of coal miners and their unions (Mitchell, 2011).

Oil and gas production are concentrated within a relatively small number of places, generating huge flows of income and wealth. US$7 trillion in profits were transferred from oil-consuming to oil-producing societies over the past 30 years. These flows of income and wealth transformed domestic and foreign policy relations and produce distorted alliances and connections. Oil mostly generates inequalities, autocratic government, militarization, corruption, instability and intermittent

protest and resistance. According to Maass (2009), crude oil generates a crude world. Overall, an exceptional infusion of oil wealth undermines many existing social institutions through what Karl (1997) terms the 'paradox of plenty'.

Collapse?

In burning all this fossil fuel, 2000 billion tons of CO_2 have been spewed into the atmosphere and will remain there for hundreds of years (Berners-Lee and Clark, 2013: 26). CO_2 emissions from 1850 to the present have increased exponentially and show no signs of slowing down, let alone going into reverse (p. 12). No benign solution is appearing to what Berners-Lee and Clark term 'the burning question'. Clark and Yusoff (this issue) show how combustion is a particular form of 'work' in which the energy held in the atomic bonds of a fuel is released through oxidation, so releasing heat and forming new chemical bonds. The history of the last two to three centuries has been one in which an exceptional channelling of such combustion within particular places and routes occurred, but which is producing a general heating up of the planet.

But this mass combustion of fossil fuels may contain the seeds of its own destruction. This parallels Marx and Engels' (1888 [1848]: 58) argument that modern bourgeois society 'with its gigantic means of production and of exchange, is like the sorcerer, who is no longer able to control the powers of the nether world whom he has called up by his spells'. They pointed to periodic crises of over-production whereby society 'suddenly finds itself put back into a state of momentary barbarism'. The profligate burning of fossil fuel-based energy could generate something similar, an outcome that most scientists had once thought impossible, namely, changing the earth's overall climate (Hansen, 2011). The world of culture and speed has met its match; the material world does matter, it seems, and can 'bite back' with interest.

The economies and societies of whole continents may experience transformed conditions of life through burning all that energy. The high-carbon world initiated in the 18th century could in fact turn out to be a passing moment in the long-term patterning of human history if, as many commentators now demonstrate, much of that fossil fuel must be left in the ground (Berners-Lee and Clark, 2013).

Many academics, commentators and film-makers are indeed examining whether the burning question will result in a 'catastrophic' new barbarism, similar to what Marx foresaw in 1848. It is increasingly argued that there has been simply too much combustion, with the result that the planet will heat up and become 'fiery' (see Al Gore's analysis, 2013, as well as Clark and Yusoff, this issue). President Clinton, using similar fiery language, observed on Earth Day 1993 that: 'unless we act now, we face a

future in which the sun may scorch us, not warm us; where the change of season may take on a dreadful new meaning' (quoted in Nye, this issue).

Tainter (1988) famously examined the ways that previous societies 'collapsed'. They came to be organized in ever more complex ways, often in response to short-term problems. But this complexity demanded greater amounts of high-quality energy, and yet increased energy was subject to diminishing returns. A growing set of energy and environmental problems reinforced each other across different domains. Tainter concluded that: 'however much we like to think of ourselves as something special in world history, in fact industrial societies are subject to the same principles that caused earlier societies to collapse' (p. 216).

From around 2003, many academic and popular texts as well as novels and films document such a thesis of 'collapse'. A 'new catastrophism' is emerging in scientific and social scientific thought (Giddens, 2009; Urry, 2011: ch. 2). Analyses examine multiple processes occurring across environmental, climate, food, water and energy systems. This catastrophism represents a change of *zeitgeist*, especially after the optimism within the rich north during the 'roaring' 1990s. Doomsday scenarios are now common. Martin Rees, former President of the UK's Royal Society, dystopically states that there is only a one in two chance of the human race surviving the 21st century (Rees, 2003).

Diamond (2005) famously maintains that environmental problems brought about the 'collapse' of previous societies. Populations typically grew and stretched particularly energy resources to their breaking point. Collapse typically occurred when societies were at the height of their powers and their carrying capacity was vastly overstretched. Diamond argues that human-caused climate change, the build-up of toxic chemicals in the environment and energy shortages could produce abrupt, potentially catastrophic decline. These processes could constitute a 'perfect storm', analogous to the combination of system processes that brought about the 'societal collapse' of the Roman Empire or Mayan civilization. Internal contradictions working slowly over time undermined and destroyed from within apparently dominant systems based upon using what were at the time extensive energy supplies. Could something similar happen during the course of this current century? Is the problem of energy a potentially catastrophic problem?

Post-carbonism

During most of the last century, vast supplies of carbon-based energy effectively powered up societies, and this high-carbon pathway was seen to be moving onwards and upwards. But now we are in the new century we see that the 20th century created a mirage, a vision of the future unsustainable into even the medium term. As McNeill (2000) notes

about that fossil fuel century: 'We have deployed more energy since 1900 than all of human history before 1900.' And there is no large-scale plan B that would enable most societies to continue to be energized and mobilized on this industrial scale around the world in the way that the 20th century set in place. Or rather it would not continue without huge transformations of the conditions of life for much of the world's population, something which Parenti (2011) argues is already occurring on a major scale across the 'tropic of chaos'. This section considers some of the possibilities and dilemmas of various alternatives to the high-carbon systems, practices and lives characteristic of the last century.

All large-scale energy systems are problematic, not just those based upon fossil fuels. Issues surrounding nuclear power are well-rehearsed, while Sheller (this issue) documents the dependence of the aluminium industry upon vast hydroelectric power for powering its factories. The aluminium industry is associated with almost all of the world's largest hydroelectricity generation plants, many of which have caused astonishing displacements of populations and livelihoods as well as many major environmental problems.

Geels (this issue) argues on the basis of the multi-level perspective with regard to sociotechnical transitions that developing renewable energy faces a really uphill struggle to move beyond the niche phase and is unlikely to accelerate much over the next 5–10 years. More generally, budgets for low-carbon energy developments are mostly low, not rivalling the energy intensity, transportability and costs of fossil fuels which are heavily subsidized in most societies. Nye (this issue) notes how past regime changes usually required 40 or so years and do not involve mere substitutions of one energy source for another. A new regime involves reorganizing society over many decades, including its transportation system, population distribution and the nature of work and sociability. These difficulties of making system transitions are reinforced by the problematic character of habits which are centrally involved in enduring social practices and socio-technical systems (Shove and Walker, this issue).

Many books, reports and articles now state that the remaining fossil fuel supplies need to be left underground in order to have a good chance of keeping temperature increases within a 2 °C limit (Berners-Lee and Clark, 2013; Hansen, 2011). But a further problem here is the size of the financial assets of 'carbon capital' that are valued on the basis of being able to extract and burn these fossil fuel reserves. Stock markets worldwide value the energy companies' huge reserves of fossil fuels as if they will be burnt, even though only 40 per cent should be burnt if global temperature increases are to be limited to 2 °C over this century. According to Will Hutton (2013) either there is a vast carbon bubble with investors and companies wildly over-speculating on the value of fuel reserves that will never be burned, or major corporations do not believe

that there is any chance of keeping to the limits on fossil fuel use that would contain global warming to a 2 °C increase. Burning all these carbon reserves would increase global temperatures by at least 6 °C. But if they are not burnt, then US$4 trillion of stock market value would be worth half this current value and there would be huge financial crashes easily as significant as that occurring from 2007–8 onwards (Carbon Tracker, 2013).

Cheap coal, gas and oil are the problem here because of how economic and social life came to develop, locking in corporations, societies and governments in path-dependent forms. It is hard not to see these forms of living as a global fossil fuel addiction. Such fossil fuels are all problematic, but in different ways. Coal, experiencing something of a renaissance, produces far too high GHG emissions. Gas and oil also produce substantial GHG emissions and need to be phased out. However, global oil supplies may have peaked. The Chief Economist of the International Energy Authority, Fatih Birol (2011), stated that crude oil production peaked in 2006 and what are increasingly left are 'oil dregs' (Urry, 2013b). According to former UK Chief Scientist David King the financial crisis of 2007–8 was partly an oil price crunch brought about by reduced supplies and dramatically rising prices (the price of crude rose 15 fold from the mid-1990s to the mid-2000s). The high price of oil was also a major contributor to the crisis in 2011–12 in southern Europe, which imports almost all its oil (Murray and King, 2012; Urry, 2013b: ch. 1). Almost every time there are oil shortages and price rises a world economic crisis occurs.

The upshot of this argument is that 'business as usual' is impossible and there has to be the systemic reversal of fossil fuel-based energy systems around the world. Berners-Lee and Clark (2013: 27–8) argue that CO_2 emissions would need to decline to zero from 2014 until 2100 in order to produce only a 2 °C increase in global temperatures. This necessitates a most unusual economic, social and political programme, of developing global low carbonness. This would involve campaigning for reduced abundance to ensure reasonable abundance in the longer term and for the rest of the globe. Unlike many other political programmes and discourses, this means engineering lower consumption for oneself and one's own society as well as for all other societies. This programme needs to reverse the high-carbon systems that made life in the rich north comfortable and will be astonishingly difficult to realize. There was similar campaigning for low carbonness in the 1970s, but that soon collapsed in the face of new oil and gas supplies and the neo-liberal economic revolution from around 1980 (documented in Urry, 2013b).

Sustainability thus means not burning all that fossil fuel. Today's energy demand should not be met with renewable technologies being added onto that currently provided by burning fossil fuels. Rather, energy demand should be adapted to the feasible amount of power

that renewable sources could provide, although there is less agreement now on what counts as 'renewable energy'. Biel (this issue) examines visioning the desired energy outcome and then building back from it through the method of backcasting. This would analyse the array of changes that are required. He suggests science fiction writing can help to open up possibilities to be explored in envisaging and making better worlds. Shove and Walker (this issue; see also Shove et al., 2009) problematize the very notion of energy demand and argue that transforming demand rather than supply must be key to envisaging and realizing various futures.

Since the 1960s, although emissions have kept rising, some progress has been made in developing the discourses of cosmopolitan interdependence. Such a discourse assists in thinking about what a global powering down to a 'de-carbonized' future might really involve (see Tyfield, this issue). There is also some evidence of a plateau-ing of elements of carbonization in some of the countries in the 'rich north', including the miles travelled by cars within the US (Urry, 2013a).

Andre Gorz (1980: 27) presciently observed in the 1970s that: '"Better" may now mean "less": creating as few needs as possible, satisfying them with the smallest possible expenditure of materials, energy, and work, and imposing the least burden on the environment.' Many contemporary authors and activists are also now arguing for such a systemic downsizing, for doing with less. Recent examples of such manifestos include those produced by the transition towns movement (Hopkins, 2011), while others advocate the concept of de-growth (Latouche, 2009), post-carbon societies (Heinberg and Lerch, 2010), greatly increased material efficiency (Allwood et al., 2013), and the need for 'powering down' societies and not just economies (Urry, 2013a).

This current century is thus one where issues of climate, resources and energy are paramount, and there appear to be two possibilities: either a benign powering down or a much more catastrophic collapse as heat rises and there is simultaneously less oil to keep the world turning around (scenarios of four futures are examined in Urry, 2013b). Many authors in this special issue develop variations on one or other of these two possible futures.

But there is a really significant final problem here stemming from the neo-liberal deregulation from around 1980 onwards, the problem of offshoring. This involves most major corporations, many rich individuals and many governments systematically evading rules, laws, taxes, regulations and norms. Offshoring entails the most sustained of attacks on governance by national states and international organizations, and especially upon efforts to regulate and legislate on the basis of democratic control including present and future energy and emissions. Most offshoring practices are engineered so as to avoid regulations, to keep secret and to 'escape' offshore, helping to form an 'irresponsible' offshore class and

a more general offshore world. This 'irresponsibility' makes it very hard to ensure that energy, taxes, economies and societies are somehow locatable and accountable within each nation-state, this being necessary for a transparent low-carbon world to be set in train (see Urry, 2014).

In the context of this global offshoring and the inability to identify what resources could and should be organized and taxed locally, then a benign powering down future looks unlikely. Adam Smith, James Boswell, James Watt and Matthew Boulton would indeed be amazed how the fossil fuel societies that they saw the birth of in the late 18th century have turned out now to have such systemic dysfunctional consequences. Energy indeed is the root of very many problems, as examined in the articles in this issue.

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