Technics & Transition

Contesting capitalist value relations in the Australian energy sector

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The work presented in this thesis has not been previously submitted for a course at the University of Sydney or for a degree or diploma at any other higher education institution. To the best of my knowledge and belief, the thesis contains no material published or written by another person except where due references are made.
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Abbreviations

**AEMO**: Australian Energy Market Operator
**AEMC**: Australian Energy Market Commission
**AER**: Australian Energy Regulator
**ANT**: Actor-Network Theory
**ARENA**: Australian Renewable Energy Agency
**CSIRO**: Commonwealth Scientific and Industrial Research
Organ
**DER**: Distributed Energy Resource
**EEI**: Evolutionary Economics of Innovation
**ETC**: Economics of Technological Change
**NEM**: National Electricity Market
**MPE**: Marxist Political Ecology
**SNALT**: Socially Necessary Abstract Labour Time
**SRES**: Small-Scale Renewable Energy Scheme
**STC**: Small-Scale Technology Certificate
**STS**: Socio-Technical Systems (not to be confused with Science and Technology Studies)
**VPP**: Virtual Power Plant
**PPA**: Power Purchasing Agreement


Introduction

Given the central place of energy in mediating the socio-ecological interface, how we conceptualise energy transition will greatly impact the shape of society to come. And yet, technocratic evolutionary models that separate questions of economic organisation from their social and ecological contexture prevail. Economists concerned with energy transition frequently take the socio-technical systems (STS) approach, which avers interrogating the entrenched power relations maintaining the predominance of market-dependence and commodification in energy transition. Consistent with the other prevailing contemporary narrative, that of the accelerating proliferation of network technologies (Greenfield 2017), the STS imaginary frames energy transition as a massively dispersed coordination problem whose solution lies in promoting technical systems through market-based mechanisms. Transition becomes a problem of technological viability followed by economic feasibility, arbitrated by financial assessments such as Bloomberg New Energy Finance group’s authoritative annual New Energy Outlook.¹

Despite the inadequacy of this approach, acknowledged even by leading financial analysts, policy across the OECD and in Australia remains tied to the incentivisation of increased renewable uptake through market-based-mechanisms (Climate Council 2017). Maintaining the stability of the socio-economic

¹ BNEF’s 2017 publication expected $10.2tn to be invested in new power generation worldwide by 2040, of which renewables composed 72%, with wind and solar accounting for 48% of installed capacity and 34% of electricity generation. Nevertheless, they concede that ‘the rate of decline in emissions is not nearly enough for the climate. A further $5.3tn investment in 3.9TW of zero-carbon capacity will be needed to ensure a 2-degree-warming scenario.’ See: Bloomberg New Energy Finance, 15 June 2017, New Energy Outlook 2017.
system, and as such, ‘sustainability’, has come to signify the maintenance of the preexisting (and culpable) mode of production, rather than protection of the ecosystem whose endangerment was the *raison d’être* of environmentalism (Paton 2008). Critical voices highlight the undemocratic imposition of such technology upon us, the growing distance between those with a grasp of these technical systems and those without, and the inadequacy of market-based mechanisms in precipitating a sufficiently rapid transition (Dean 2009; Goodman and Rosewarne 2011; Swyngedouw et al. 2015). Yet few consider the potential of such technological ensembles to facilitate an ecologically acceptable future, as the technologists would have it, *and also* to democratise the underlying social relations of ownership of energy production.

Contemporaneously, there are calls for critical thought to turn toward an ‘ecosophy’, an ‘object-oriented ontology’, a ‘post-humanism’, a ‘planetary consciousness’, to reframe our philosophical models toward a less harmful existence, to dwell more attentively in the Anthropocene (Guattari 2000; Morton 2013; Braidotti 2010; Chakrabarty 2016). This growing chorus asserts that mechanistic analytical tools have become obsolete, that the shifting ground - the complex crisis of convergence which ‘changes everything’ - requires new synthetic and interdisciplinary approaches in the social sciences (Klein 2015). The recent emergence of ‘energy humanities’ is testament of this drive to critically engage the technical and natural sciences (Mitchell 2011; Huber 2013; Szeman and Boyer 2017). Its scholars’ common refrain is that each ecological event is invariably socio-economically mediated, that energy resources only become so through the means of production that necessitate and create them. It has generated two salient concepts in ‘energopower/energopolitics’ and ‘energy democracy’. The first beckons an alternative ‘genealogy of modern power that rethinks political power through the twin analytics of electricity and fuel’ (Boyer 2014: 22). The latter
describes an ideal-type model for ‘socially just, sustainable and collectively controlled energy arrangements’ (Transnational Institute 2016: 4). However, this tradition is rooted in critical anthropology, whose localist politics have also been ignored by eco-Marxists, disregarded for failing to launch a deeper critique at the value-relation.

Nevertheless, ecologically-oriented historical materialism does provide a more tractable understanding of the interface between human and extra-human nature as dynamic, constantly transformed by human labour and its products. In John Bellamy Foster’s well-known formulation, the human acts ‘upon external nature and changes it, and in this way he simultaneously changes his own nature’ (Foster 2000: 157). This is developed around the central metaphor of metabolism, inspired by the scientific-materialist aspects of Marx’s own commentary (Marx 1976: 284-90). Jason Moore’s (2015) recent intervention contends that this metabolic metaphor does not go far enough, for it still poses extra-human nature as an externalised phenomenon without facilitating an understanding of how capitalist projects themselves internalise and are internalised by extra-human natures. He writes,

a reading of metabolism that takes seriously the centrality of value as a logic of re/producing the flow of life helps us see how capitalism has created and transcended limits. Taking an expanded conception of value-relations, we can better interpret the ways in which the worlds of humanity-in-nature become valued and de-valued over the past five centuries, converting the globe into a vast storehouse of unpaid work/energy… Marx’s conception of value relations, in other words, provides a way of seeing the exploitation of labour-power and the appropriation of unpaid work as a singular metabolism of many determinations. (Moore 2015: 81)
In updating value-relations to account for the co-production of ‘abstract social labour’, the substance of capitalist value, and ‘abstract social nature’, the reconstituted extra-human natures put to work for reproducing capitalist value-generation, world-ecology hopes to reintegrate ecological historical materialism and value theory. Imperative to this analysis are capitalist technics, ‘crystallisations of tools and ideas, power and nature [in order to] appropriate the wealth of uncommodified nature in service to advancing labour productivity’ (Moore 2015: 59). Surprisingly little attention has been paid to the dynamic by which technics condition appropriation and exploitation. The means of energy production, as a fundamental appropriative technics, must be given greater consideration. The following chapters attempt to address this lacuna in ecologically-oriented historical materialism by proposing different points of departure for understanding technicity in capital.

This thesis investigates the opportunities and constraints facing an approach to energy transition in Australia which addresses the ecological problem of carbon emissions as not divorced from the socio-political and technical context, but fundamentally constituted in and through that context. A historical materialist methodology is adopted to gain a realistic assessment of the institutional actors and how their interactions shape the topology of the energy sector. The analysis proceeds from a present conjunctural moment of energetic, economic, and ecological ‘triple crisis’ (Dawson 2010; Chester 2013a; Geels 2013). Crises typically present disregarded possibilities as newly opportune. This investigation considers the internal relations between each dimension of the conjunctural crisis, and how their conjoined resolution can herald deeper transformation in the social relations around energy production.

Chapter 1 develops a critical methodological and conceptual approach toward energy transition around Moore’s ‘world-ecological’ Marxism (2011, 2015a). It provides two core
concepts in the ‘world-ecological surplus’ and its tendency to fall, and ‘Cheap Energy’, arising from the use of appropriative technics. Nevertheless, the framework is critically probed for its dichotomised treatment of exploitative and appropriative processes, and for lacking institutionally-cognisant texture; its civilisational-scale explanans erases the constitutive role of states, firms, social movements in materialising the value-relations that perform or resist how capitalism ‘organises nature’ (Out of the Woods 2016). Moore’s framework might usefully be supplemented with insights from Marxist state theory (Jessop 2016; Parenti 2015) and financial and post-Fordist value theory (Bryan et al 2015; Marrazzi 2010) to develop a robust critical framework that illuminates the financial-technical elements of the present convergent energy crisis and generates points of departure for tractable political responses.

Chapter 2 presents three engagements with theories of technicity that sets the world-ecological framework in dialogue with the prevailing mainstream Socio-Technical Systems (STS) transition theory, the dominant approach to conceptualising energy transition. By tracing STS’s genealogy to Schumpeterian economics, a connection to Marxist theories of long-wave technological change is revealed, whose chief difference turns upon the presence of a value-theory and the explanatory role played by labour and class struggle (Tyfield 2014). The second engagement presents anthropological theories of energy technologies, which prove more attendant to how social relations are influenced by infrastructures and discourses than world-ecology or STS. Finally, the chapter elaborates a philosophical approach to technicity as bounded by socio-economic context (and hence, capitalist value-relations) whilst creative of new social opportunities (such as communal syndicalism and/or networked individualism).

Chapter 3 presents a world-ecological account of ‘Cheap Energy’ in Australia, with emphasis upon the interrelations of
the state-system, capital, energy infrastructure and climatic feedback. A twofold narrative emerges, in which the state-system mobilises its strategic projects through, on the one hand, national developmentalism promoting domestic energy security and, on the other, international competitiveness, creating the conditions for Cheap Energy exports (Baer 2016; Crough & Wheelwright 1982). The present ‘triple crisis’ is illuminated by reference to the ‘negative-value’ (Moore 2015: 275-9) faced by capital sunk in energy projects due to the effects of an unruly climate, and social contestations whose cumulative effect has forced energy onto the political agenda, entrapping the state-system further within the ‘climate dialectic’ (Goodman 2016). At this conjuncture, competing fractions of capital in concert with the state-system operate to mobilise contemporary technics that extend the commodity frontier, such that a new wave of Cheap Energy may be unleashed.

Chapter 4 considers distributed energy resources (DERs), such as household solar photovoltaics, with respect to the expanding commodity frontier. Universally available and relatively cheap, they present a genuine alternative to centralised and market-dependent electricity production. An analysis of independent, state-commissioned and network enterprise-funded assessments finds that their rapid uptake in Australia has challenged the viability of centralised electricity infrastructure and the financial energy market it underpins (Jacobs 2017; Finkel et al 2017; AEMO 2016). Interested capital has therefore sought to incorporate these newly autonomous generators into the value-relation through numerous means, which are considered in turn. The response of the state-system has been contradictory, developing technologies that render extra-human natures (most saliently solar irradiation) legible, whilst subsidising the uptake of DERs through market-based mechanisms. The chapter concludes with a critical value-theoretical appraisal of the use of networked and financialised technics to capture DERs through
household attentional labour absorbing the risk of energy market volatility.

The thesis concludes with an overview of the scope of community energy projects in Australia and a reflection on their capacity to prefigure an ‘energopolitics’ that meaningfully breaks with the capitalist value-relation. Considering the insights and limitations of autonomist Marxist literature and evidence from comparative case-studies of the German and Danish energy decentralised energy transitions, such projects are unlikely to transform social relations at the scale required to challenge centralised profit-oriented energy generation. Rather, by engaging a state-system already trapped within the pressure of the ‘climate dialectic’, such projects can achieve horizontal tesselation and vertical growth necessary to outweigh countervailing pressures to integrate DERs into centralised infrastructure and its attendant national electricity market. Whether such developments contribute toward the project of ‘solar communism’ (Schwartzman 2016), ‘energy democracy’ (Scheer 2007), or are recuperated into a reconfigured ‘green capitalism’ (Paterson 2016) will depend upon a highly contingent coalitional grassroots politics already prefigured but yet to achieve critical influence within the state-system.
Chapter 1. An Appraisal and Extension of World-Ecology

Approaching energy transition critically demands a synthetic analysis sensitive to the interlocking political, economic and ecological determinants and effects of the mode of energy use and production. Jason Moore’s world-ecological framework provides such a political-economy, developing an account of the double-internality of socio-economic projects and ecological processes, revealing capitalism as at once a ‘way of organising nature’ and enmeshed and reconstituted ‘in the web of life’. It integrates the insights of Luxemburgian-Gramscian geographers, an attendance to global socioeconomic dependencies of the Annales-school and world-systems theorists, and the patterns of socio-ecological metabolism revealed by ecological-Marxism. This chapter moves on to consider the criticism that have been raised of world-ecology’s lack of political tractability, which are addressed through a supplementation of its value-theory and institutional-theory.

1.1 Genealogy and methodology of world-ecology

Early commentators noted that Marx’s analysis of capital as self-expanding value (M-C-M’ or C-M-C’) required the extension and intensification of market-oriented production. Its geographic implication is the extension of commodity frontiers through processes of ‘primitive accumulation’ that liberate labour, land and resources to become internalised into markets and commodification. However, whilst Marx consigned this process to the pre-history of capital, geographers following Luxemburg understand these processes as continually ongoing, the necessary double to capitalist production. For Luxemburg, the realisation of surplus value ‘requires as its prime condition...that there should be strata of buyers outside capitalist society’ (Luxemburg [1913]2003: 332). Rather than relegate
‘primitive accumulation’ to capitalism’s past, ‘capitalism in its full maturity also depends in all respects on non-capitalist strata and social organisations existing side-by-side with it ... since the accumulation of capital becomes impossible in all points without non-capitalist surroundings’ (Luxemburg [1913]2003: 345). In accounting for the material projects that constitute such outward expansion, Harvey (1981) provided a critical theory of ‘spatial fix’, referring to the dynamic by which the initial flexibility achieved for capital through the built environment, i.e. capital-intensive infrastructures, becomes a fetter on future accumulation, necessitating their destabilisation. Harvey further extended Luxemburg’s analysis into the neoliberal era, wherein he identified financialised ‘accumulation by dispossession’, such as through the imposition of ‘debt encumbrancy’, as the prevailing mode through which core capitals seek to resolve the contradictory outcomes of their activities abroad (Harvey 2003: 74).

World-systems theory, following the dependency-theorists of the 1960s, emphasises the world-system, rather than nation states, as the primary unit of social analysis, explaining the uneven and combined development of the global economy. Wallerstein’s (1974) account of the stratification of global economic power relations traced how regional patterns of class conflict affected associated modes of agricultural production, while Braudel’s (1979, 1981) contribution emphasised ecological factors in the making of world-systems. The capitalist world-economy was first posited as the outcome of a conjuncture in which the interests of states, seigniors and city-states favoured outer rather than inner expansion (Moore 2000: 133). Arrighi periodised the development of the world-system according to systemic cycles of accumulation, characterised by the alternation of epochs of material expansion with phases of financial rebirth and expansion. In phases of material expansion money capital “sets in motion” an increasing mass of
commodities (including commoditized labor-power and gifts of nature); and in phases of financial expansion an increasing mass of money capital “sets itself free” from its commodity form, and accumulation proceeds through financial deals. (Arrighi 1994: 6)

As will be seen in the next chapter, world-systemicists are in close dialogue with other theories of Kondratieff technological long-waves and present a geographic Marxist interpretation, highlighting the alternation between phases of continuous and discontinuous changes.²

O’Connor (1988) pioneered the critical albeit sympathetic ecological engagement with Marxist value theory, introducing the concept of a second contradiction of capitalism alongside the orthodox primary contradiction between the forces and relations of production (O’Connor 1988). This was between capitalist relations and forces on one hand and conditions of production on the other. While the primary contradiction promotes a tendency toward the overproduction of capital with an attendant economic crisis leading to restructuring of productive forces and productive relations, the second contradiction leads to the underproduction of capital, and the restructuring of the conditions of concrete production and the social relations they entail (O’Connor 1988). Burkett (1999) demonstrates how as human labour is the constituent substance of value, the non-human ‘natural’ conditions of production become devalued, and its throughput increasingly intensified through its ‘free appropriation’ to maximise the productivity of the more valuable labour component, with increasingly

² Although Arrighi does suggest that ‘secular price cycles and systemic cycles of accumulation are completely out of synchrony with one another. A financial expansion is equally likely to come at the beginning, middle, or end of a secular (price) cycle’ (Arrighi 1994: 7).
devastating ecological consequences. Foster’s (2000) well-known theory of socio-ecological ‘metabolic rift’ considered Marx’s concern with the effects of capitalist agricultural practices upon soil fertility, understood as generating a ‘rift’ in the ‘metabolic interaction between man and the earth’ through the ‘robbing of the soil of its constituent elements’ (Foster 2000: 156). In this manner, eco-Marxism developed a foundational socioecological concept, attendant to how economic developments ruptured ecological patterns of material exchange through which societies reproduced themselves.

Value is mobilised in the world-ecological framework for its succinct expression of the antagonism of monetary accumulation and material transformation in commodity production, and for its conjoined treatments of capital accumulation as an objective process and as a subjective project. For Moore, it offers ‘a promising way to comprehend the inner connections between accumulation, biophysical change, and modernity as a whole’ (Moore 2011: 20). Moore’s chief departure from orthodox Marxist value theory arises in his account of how the productivity of socially necessary abstract labour time (SNALT), still taken to be the fundamental ‘substance’ of value, rises not only through capitalisation of the means of production, but also through incorporating appropriated work/energy of human and extra-human natures into production. Moore writes,

the tendential generalisation of value relations works through a dialectic of capitalising production and appropriating reproduction. Value is encoded simultaneously through the exploitation of labour-power in commodity production, and through the appropriation of nature’s life-making capacities. (Moore 2015: 13)

Moore proposes a ‘general law of underproduction’, linked to Marx’s better-theorised tendency to the overproduction of capital
goods. This account sees the circuit of capital as a socioecological relation composed of ‘constant’ capital – itself comprised of fixed capital (machinery and extra-human forces of production that outlast the production cycle) and circulating capital (energy and raw materials used up during the production cycle) – and ‘variable’ capital (i.e. labour). For Marx, ‘the rate of profit is inversely proportional to the value of the raw materials’, and yet the dynamism of capitalist production ensures that the ‘portion of constant capital that consists of fixed capital … [tends to] run significantly ahead of the portion consisting of raw organic materials, so that the demand for those raw materials grows more rapidly than their supply’ (Marx [1883]1959: 118-9). The availability of cheaply acquired inputs thereby becomes the condition for large-scale industry and expanded commodity production in general.

The world-ecological surplus refers to the share of surplus value produced through accumulation by appropriation, which can proceed by either pivoting off biophysical reproduction, or on the geological extraction of minerals and energy (Moore 2011: 21-22). It occurs when relatively small amounts of capital are set in motion to appropriate disproportionately greater volumes of unpaid work/energy. Echoing the tendency of the profit rate to fall, the ecological surplus also bears a tendency to fall through four conjoined processes: (1) general “wear and tear” of extra-human natures through entropic degradation, (2) the mass of accumulated capital tending to outpace the mass of appropriated work/energy, (3) the contradiction between the time necessary for the reproduction of capital and that for the rest of natures, (4) capital’s operation generating wasteful negative-value, i.e. the ‘historical natures that are increasingly hostile to capital accumulation’ (Moore 2015: 98). When the underproduction of the conditions for production threaten to fetter the continued accumulation of capital, ‘world-ecological revolutions’ are set in motion to achieve an ecological-surplus that enables continued capital accumulation in the mid-to-long term (Moore 2015: 150).
The role of technics is critical in this process, whereby ‘innovations of capital, science and empire forge a new unity of abstract social labor, abstract social nature and primitive accumulation [whose] successful converge restores the [Cheap Nature] (Ibid). In contrasting technics to technology, Moore defers to Mumford’s (1934) characterisation of technics as ‘extra-economic processes - perhaps directly coercive, but also cultural and calculative - through which capital gains access to minimally or non-commodified natures for free’ (Moore 2015: 95). Technics provide the social contexture that directs technologies and gives them significance, enabling ‘technological revolutions [to become] epoch-making only when joined to those imperial and scientific projects that revolutionised world-ecological space’ (Moore 2015: 153). Elsewhere, they are described as the crystallising of ‘tools and knowledge, nature and power, in a new world-praxis that reduced both “man” and “nature” to abstractions’, which embodied capitalist power and production through ‘a vast cultural-symbolic repertoire that was cause, condition and consequence of modernity’s specific form of technical advance’ (Moore 2015: 174-5).

Developing a world-ecological approach to historicising Cheap Energy requires enfolding energy resource measures into an historical-relational frame; something Moore (2015) attempts to achieve with ‘Energy Returned on Capital Invested’, a model of accumulation that unifies energy and capital as joules per dollar (Moore 2015: 106). The question of a ‘peak’ in Cheap Energy is therefore measurable by the peak ‘gap’ between capital set in motion to produce a given commodity and the work/energy embodied in the commodity. Yet this is methodologically problematic, requiring an incommensurable mix of specific work/energies, as ‘energy/material flows can be measured but they cannot be counted, for capital’s dynamism counts only what it values, i.e. labour productivity’. Instead, the world-ecology of Cheap Energy is less concerned about the specific
mechanism of its extraction and more concerned about how capitalism reduces its basic costs of production (Moore 2015: 145-7). Energy sources are particularly significant to the world-ecological framework as the value of energy is closely linked to the productivity of labour-power, and rising energy prices and stagnant labour productivity growth are closely linked (Jorgenson 1984: 26-30).

Through the *technics* of industrial capitalism, coal was central to advancing labour productivity thanks to steam power and new frontiers of appropriation. Similarly, resource geography has demonstrated how petroleum-based energy ‘crises’ have been inextricable from oligopolistic market control necessitated by the materiality of oil (Bridge 2010: 318). In the neoliberal era, the rise and fall of oil as primary commodity is partly explicable by financialisation as ‘an increasingly important socio-ecological vector [which has induced] underinvestment in the extractive apparatus proper in favour of short-term speculative movements’ (Moore 2015: 148). The financialisation of commodity markets increasingly dissolves the boundaries between separate energy commodity price-determinants, no longer simply determined by their supply and demand (Tang and Xiong 2011).

Moore proposes that capitalism’s original underproduction crisis is re-emerging through an unstable combination of physical depletion, climate change, new anti-systemic movements and financialisation (Moore 2015: 91-92). The strategic question not posed by Moore, however, is how to ensure that such a convergent crisis only affects the errant structures of capital while ensuring that sustainable social relations can arise concurrently (Nelson 2016). To this end, Moore proposes the groundwork for a post-human labour politics, arising from the excessive liveliness of nature in general: ‘all life rebels against the value/monoculture nexus of modernity, from farm to factory… Extra-human natures, too, resist the grim compulsions of
economic equivalence’ (Moore 2015: 205). Yet, as Nelson (2016) argues, Moore’s critique of Nature/Society dualisms fails to attend to the intersectional processes through which these categories themselves are transformed as the line separating production and reproduction (and thereby capitalisation and appropriation) is reworked throughout capitalist history … Moore leaves the category of labour unproblematised, sidelining qualitative and historical changes in the way that socio-ecological capacities are both exploited and appropriated (Nelson 2016: 12-13).

Moore’s call for a ‘socialist ecology’ using non-capitalist technologies (particularly agronomies such as agro-ecology and permaculture) does not articulate the criteria for what makes technologies inherently non-capitalist. As Nelson highlights, even technologies celebrated for inaugurating postcapitalist ecologies may become recuperated into capitalist military and industrial research (Ibid). To develop a critical engagement with technics, value-relations and post-capitalism, we must inquire into the changing ways that Nature/Society operate as ‘real abstractions’. Hence, before moving on to marking out a critical theory of technicity, we will turn to Marxist theories of finance, biocapital, and spatial politics, which together elucidate the kinds of social forms within which non-capitalism may flourish.

1.2 Challenging value in world-ecology: Marxist theories of finance and biocapital

How can we draw boundaries between exploitative and appropriative processes, given the operation of contemporary financialised and technologically-mediated value-generating activities? As Political Marxist historians have demonstrated, the law of value can only become operative where the capitalist mode of production prevails, where the means of production are themselves exchanged and the producer faces the direct
necessity to expend an amount of labour-time on them (Weeks 2010). Robert Brenner illustrates this point with respect to *market-dependence*, a state where economic producers are devoid of the full means of subsistence and the ability to secure such subsistence by force from direct producers, who must buy their inputs on the market and sell their products on the market and thereby be subject to competitive constraint (Brenner 2007: 60-1). But what of unpaid activities that produce work/energy within the reach of capital - are they subsumed in value-relations, performing appropriative support to capitalised commodification, or do they exist ‘outside’ of it? With the near-total enclosure of non-capitalist geographic boundaries, contemporary Marxist approaches have broached these questions through an account of the intensification of conditions for the value-relation, through the production of the bio-economy, mediated by the operation of finance.

The Italian tradition of Autonomist workerism, pointedly rejects the world-systems functionalist account of finance as ‘signs of autumn’ of world-systemic cycles, and prefers to see its ‘pervasive character in a capitalism that has assumed a radically new character in the last decades to the point where the very distinction between “real economy” and “financial economy” is today unfounded’ (Braudel 1984: 246; Mezzadra 2010: 11). This approach looks to the capitalisation of social relations to incorporate those not traditionally thought to be value-generating; an approach with origins in feminist Marxism’s illumination of unpaid socially reproductive labour and in the German *Neue Marx-Lektüre* tendency, who saw in the dialectic of the value-form an account of how the material aspects of social life are dominated by abstract ideal social-forms of value (Reichelt 1996: 46-47). The rise of information technologies and social networks have enabled collaborative efforts between humans (as well as non-humans) to co-create cultural/virtual worlds. Because of the rise of the ‘network effect’, entrepreneurial effort has redirected into the conversion of such
networks into value (Castells 2004). The intensification of social aspects of market-dependence have thereby become closely connected with financialisation, which provides technical means by which the value of various aspects of production can be measured and equivocated when production is no longer about remunerated labour and discretely produced commodities. Valorisation processes require financial capital to become productive of the bioeconomy that ‘produces value by extracting it not only from the body functioning as the material instrument of work, but also from the body understood in its globality’ (Marrazzi 2010: 49). The consumer coproduces value in free labour, through creating markets, producing performance, managing risk, optimising platform-based assets such as software beta-testing, ‘a winning model for investors since it harnesses, incorporates, and valorises the social and technological labour of users’ (Terranova 2010: 155-156). Large quantities of surplus-value are unleashed, set in motion by Post-Fordist accumulation processes decoupled from investment in constant and variable capital and redirected into ‘apparatuses of producing and capturing value produced outside directly productive processes’ (Marrazzi 2010: 55). The increased quantity of living labour thus explains the devaluation of classical means of production, with the consequent recourse to speculative ventures to increase shareholder value (Ibid: 63). As Wark summarises, ‘finance both predicts and actualises futures in which private companies extract value from the knowledge society, where the boundaries of who “owns” what can never be clear’ (Wark 2017: 67).

Marxist perspectives of financialisation emphasise the importance of engaging with finance as a value-generative phenomenon, one that foundationally alters social and natural relations in accordance with equivalence and exchangeability. Moreover, such an approach is uniquely positioned to reveal how and why these processes, working through the risk-commodity, entail labour exploitation (Panitch and Gindin 2008: 308). One strand
proposes to focus on the production of financial risk as value-generative (Bryan & Rafferty 2006; Bryan et al. 2015; Christophers 2011 and 2016). Market-based finance commodifies risk in the value-form of financial assets such as derivatives, which are priced, traded, bought and sold in financial markets. By applying abstraction to risk, modern finance brings to bear a significant technical apparatus upon particularised risk portfolios, rendering qualitatively different underlying assets through processes of ‘blending’ (Bryan & Rafferty 2006). The SNALT of ‘society at large’ produces this value via the financialisation of everyday life, which has rendered many processes of social reproduction subjected to financial rationalities, where financial assets are produced by ordinary people ‘who in the course of social reproduction find themselves making increasing numbers of contractual payments ... and by the financiers who perform the technical work of turning these payments into fungible risk assets’ (Christophers 2016: 8). Surplus-value arises as the amount paid by waged workers for risk absorption ‘bears no necessary relation to the value of the financial risk we crystallise ... it depends on conditions in the market for our risk-generative capacity’ (Ibid: 9). Such an approach can equip us to ask, how do individuals and households position themselves vis-à-vis finance capital with respect to the shifting of risks and rewards in a manner that enables the extraction of surplus value?

While the ceaseless vitalism of capital envisaged by Marxist theories of biocapitalism and financialisation have little to regarding the ecological and biophysical limits encountered by unlimited capitalist expansion, their illumination of contemporary transformations of labour and value problematize the clear dialectic that Moore sets up between appropriative and exploitative processes. By synthesising ecological, Autonomist, and financially-oriented Marxist value-theory, we can develop a better picture of how financialised capitalism deepens and extends commodity frontiers, and the socio-ecological outcomes thereof.
1.3 Towards a world-ecological politics: state theory and the ‘constitutive outside’

The world-ecological approach provides important contexture for the global, ecological, value-relational context of the operations of technical systems in mediating the coproduction of human and extra-human natures. Its explicit focus on ‘world-ecological agencies’, however, loses texture in micro and meso-level analysis that accounts for how technics actually operate, and in particular how they affect and are affected by the structure-agency problematic. Consequently, it has been charged with lacking an actionable theory of political action. This final section considers Marxist engagements with state theory and local economies to provide guidance for an empirical analysis that identifies how world-ecological value-relations percolate in and through sub-world-systemic actors.

Synthesising the insights of his predecessors, most pertinently Gramsci, Poulantzas and Milliband, Bob Jessop’s (2016) ‘strategic-relational approach’ (SRA) provides a useful methodology for conducting Marxist state analysis. The SRA understands the state-system as a social relation that reflects the balance of forces prevalent within a social formation, but also inscribed with ‘strategic selectivity’, meaning that (a) its capacity to shape certain outcomes faces in-built biases privileging particular agents whose position is determined through path-dependence, and (b) that the effects of state power create differential (rather than absolute) constraints and opportunities for different agents. The state-system’s formal separation from

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3 This criticism was pre-empted by Arrighi (1994) himself, who noted that “our analytical construct [world-systemic cycles of accumulation] … offers a limited view of what goes on in the middle layer of market economy and the bottom layer of material life. This is simultaneously the main strength and the main weakness of the construct” (Arrighi 1994: 25-26).
the capital relation, enabling it to exert extra-economic force to ensure preconditions for accumulation are achieved, also enables it to exert institutional power in ways that may be highly dysfunctional for capital accumulation (Jessop 2016: 189-210). Its organisational coherence and functional coordination cannot thus be pre-given but is the product of state projects that affect its institutional structures. Similarly, its capacity to promote forms of economic development and maintain legitimacy is also highly contingent, and emerges through state strategies, i.e. forms of socio-economic (and we may add, ecological) intervention. In the financialised contemporary global economy, the state-system has turned away from governance and increasingly to governmentality and meta-governance in pursuing its strategies and projects, with the effect of depoliticising decisions of production, circulation, distribution and consumption through their delegation, privatisation and denial.\footnote{With respect to such ecological regulationary mechanisms reflecting these processes, see: Bryant, G 2016.} This has had the general effect of increasing the operating space available to financial capital within the state-system, by forcing governing parties to recourse to ‘fast policy’ and frequent regulatory withdrawal in order to keep up with the compressed temporality of financial cycles (Holloway 1994).

Pertinent to the world-ecological project, the state-system has been recently characterised as an ‘ecological’ or ‘technological’ regime by political ecologists and resource geographers. For these scholars, the state-system plays an important role as ‘socio-ecological membrane’: through its functions as the instantiator of a place-based property regime (and therefore as landlord of last resort), by producing and maintaining infrastructure crucial for capitalism’s reproduction, by regulating the conditions for market creation and operation, and by engendering the knowledge-based practices that make biophysical reality economically legible and accessible (Parenti 2015; Andreucci et al. 2017). State-systems as
‘ecological regimes’ must negotiate two sets of contradictions. The first relates to managing the consequences of the degradation of conditions of production (consequences of O’Connor’s second contradiction) for capital, labour, and the wider public while maintaining its own fiscal stability and credibility as governing body (Castree 2008). The second, described as the ‘climate dialectic’, arises internal to the complexity of consequent state regulatory actions, leading to dysfunctionality and inadequate management of economic-environmental contradictions, with the result of either regime change or system transformation as well as the growth of the state’s interventionist role (Goodman 2016). The consequent ‘fixes’ preferred by states in the neoliberal mold are to either address contradictions internal to the state by off-loading responsibilities to the private sector and/or civil society groups, or otherwise to avoid internal contradictions altogether by adopting a ‘minimal state’ stance. In performing these multiple often-conflicting roles, the state-system necessarily operates with similarly contradictory ecological and financial value frameworks. Thus, to resolve the ecological contradictions of capital, the state is required to call on information from outside capital, from science and law, and to translate between their distinct logics (Robertson & Wainwright 2013).

Human geographers have foregrounded the spatiality of these processes, with the implication of the uneven distribution of energy outcomes, the co-existence of multiple energy transition pathways existing at different governmental and organisational scales, and the geographic results of the creative and destructive consequences of energy transition (Brenner 2004). The territoriality of energy infrastructure networks have thus been assessed in terms of their contiguity (dispersion/density), connectivity, and centralisation (Hess 2004). As Bridge et al. summarise, the question of a desirable energy transition is one which turns upon ‘fundamentally a geographical project: it not only requires societies to commit massive investment to redesign
infrastructure, buildings, and equipment, but also to make choices from a range of possible spatial solutions and scales of governance’ (Bridge et al 2013: 332). Here again the state plays an important role in regulating the ‘territoriality’ of energy regimes, most pertinently through overseeing the construction and maintenance of infrastructural technologies that distribute energy between generators and consumers. To this end, the state-system has been shown to be predisposed historically to facilitating centralised and capital-intensive fossil-fuel energy projects (Mitchell 2011).

J.K. Gibson-Graham’s (2006a, 2006b, 2015) project of querying the nascent ‘capitalocentrism’ of Marxist political economy provides conceptual and methodological resources to read difference into societies characterised by capitalist value-relations. In doing so, they shed light upon the virtually unlimited noncapitalist activities that co-constitute the same socio-economic space seen by Marxists through the value-relational lens as subservient to capitalist production (2006b: 70-74). Theirs is thus a ‘flat’ political-economic ontology, which avers structuralist vertical models. Against the appropriation-exploitation dialectic of Moore, then, which further invigorates the ‘leviathan that swallows its neighbours and cohabitants’, internalising most productive activities into the same capitalist world-ecological system, Gibson-Graham seek to reveal the ‘constitutive outside’ of capitalism (2006a: xxiii-xxiv). Acknowledging the difficulty faced by horizontalists such as the Italian Autonomists before them, Gibson-Graham suggest the concept of ‘community economy’ as a ‘new nodal point [around which] an alternative fixing of economic identity’ may cohere into a counterhegemonic politics (2006b: 78). Constructing community economies entails acknowledging the diverse socio-economic needs and already-existing institutions specific to communities, and proposing models of transactions, labour, and enterprises that are noncapitalist - i.e. communal, independent - that can address them (2006b: 169-175). Another major
departure from Marxist orthodoxy is their incorporation of subjectivity, arguing ‘the process of subject formation is key to any political project, especially if collective action is to take place’, and strategies of ‘resubjectification’ that enable subjects to release themselves from their allegiance to capitalist identities (2016: 11). While their methodological demand to ‘perform diverse economies’ is not entirely taken up here, it nevertheless motivates consideration of the ambivalent role played by household and community energy projects vis-a-vis capitalist energy sectors.

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World-ecology critically engages with energy transition as a capitalist project of ‘ecological revolution’ ensuring the conditions for ongoing capital accumulation amidst amplifying negative socio-ecological feedback. Despite its focus on the world-system and ‘territorial agencies’, there is no coherent singular agency of capital; such projects to extend and deepen the commodity and appropriation frontier occur through a rather ill-defined technicity, altering the nature of labour as well as the technologies available to us. Clearly, the state still plays a critical role in mediating these processes, as do, increasingly, financial markets and instruments. As we experience an accelerating global energy transition, is there a place for the kind of localist political economy described by Gibson-Graham amidst such imposing techno-politics? In the next chapter, we turn to interrogate this question more deeply by way of the history of economic and philosophical approaches to technicity and energy transition.
Chapter 2. Critical Theories of Technicity and Energy Transition

This chapter presents three engagements with technicity that develop the world-ecological approach around energy transition. The first considers socio-technical systems theory (STS), the prevailing neo-Schumpeterian approach to energy transition, and its predecessors in evolutionary economics of innovation (EEI) and economics of technology change (ETC), via their common origins with world-systems theorists in the study of Kondratieff long-waves. The second considers anthropologies of energy, which proves more attendant to the micro-politics and social significance of energy technologies, infrastructures and discourses, creating space for localised and potentially counterhegemonic materially-discursively informed politics. The final engagement considered is philosophical, providing the insight that technology must be relational, consisting of a *bounded openness* to radical recuperation – tools that privilege value-generating processes insofar as they emerge from capitalist research programs, yet capable of being turned toward non-capitalist social relations within the appropriate political milieu.

2.1 Schumpeterian and Marxist precursors

Economic accounts of technological development originate in the study of ‘long-waves’ developed by Nikolai Kondratieff, who observed a historical record of long-term cyclical rises and falls in the values of economic price indicators (Kondratieff 1935: 105). For Kondratieff, their regularity implied an endogenous cause, refuting that neither changes in technique nor wars, revolutions or the expansion of the world economy’s frontiers were the primary determinants of long-waves (Ibid: 112). Nevertheless, the study of long-waves stimulated a protracted debate regarding their causal origins, between
entrepreneurial-technology-innovation-centric (Schumpeterian) models, and capital-accumulation- centric (Marxist) models.

Marxist accounts have emphasised the contradictions of capital in explaining the technological changes attendant to the Kondratieff long-term cyclical dynamic. Marx’s analysis focused on the labour-saving dimension of technical change, which notwithstanding Moore’s addition of the appropriation dynamic linked increased labour productivity to increased capitalisation (Elster 1983: 177-179). Understood through a class-analytic lens, technological change is an induced substitution responding to declines in profitability stemming from wage-level increases (Rosenberg 1969, 1976). Ernest Mandel (1964, 1980) applied this framework to the study of long-waves, suggesting that decisive victories of capital over labour in class struggle open new avenues for profitable accumulation thereby enabling greater investment and utilisation of technical possibilities previously possible but unfeasible, generating a long-wave upswing, while growing working class strength alongside building capital intensity reduce the average rate of profit and collapse investor confidence, thereby generating a long-wave downswing. For Mandel, while accepting that ‘innovations inevitably result from the very operation of the [capitalist] system’, interrogating their determinants discovers ‘material rewards, social (ideological) pressure and specific institutions such as transformation of the system of higher education; systematic organisation of scientific research; development of the so-called applied sciences; increasing autonomisation and profitability of research activities…’ at the heart of technologies developed in capitalist societies (Mandel 1993: 323).

Schumpeterian accounts have charged the Marxist explanation for minimising the role of institutional measures, taken by states and firms alike to reduce the uncertainties inherent to innovation, which encouraged the experimentation that made
innovation commonplace (Rosenberg 1994: 93-97).\(^5\) Schumpeter’s mature theory of ‘creative destruction’, referring to the endogenous processes of new technical combinations that incessantly revolutionised the economic structure, set the agenda for the Evolutionary Economics of Innovation and the Economics of Technological Change (ETC) (Schumpeter 1943). Prominent neo-Schumpeterian Carlota Perez introduced ‘technological styles’ as a ‘paradigm for the most efficient organisation of production, i.e. the main form and direction along which productivity growth takes place within and across firms, industries and countries’ (Perez 1983: 363). She suggests that techno-economic subsystems only contingently coexist with the social-institutional framework within which they are embedded, and relative degrees of mismatch between the two lead to differing kinds of crises, forcing either restructuring of the socio-institutional framework to facilitate innovations complementary to the emergent style (an upswing crisis) or blocks to the diffusion of the new style leading to social-political crisis (downswing crisis) (Tylecote 1993: 19-22).

Long-wave theorists typically understand the role of energy vis-à-vis particular fuels as ‘key factors’ that enable major advances in the potential productivity across economic sectors, which typically fulfil the criteria that they are (a) perceived to have a low and rapidly falling relative cost, (b) with an apparently almost unlimited availability of supply over long periods, (c) with clear potential for its incorporation in many products and processes throughout the economic system (Freeman and Perez, 1988: 48). Utilising a model of global energy shifts that incorporates geopolitical rivalry, commercial competition and social unrest as key determinants, Podobnik’s account notably

\(^5\) Emphasising initially the independent progression of scientific research as the primary dynamic driver (Schumpeter 1934) and later the role of large corporations in influencing the diffusion of new technologies (Schumpeter 1939).
provides a synthesised account that acknowledges the critical role of civil social movements in steering the global energy regime away from nuclear energy during the 1980s. (Podobnik 1999: 158).

2.2 Sociotechnical systems theory: a critical review

STS emerged at the convergence EEI and ETC in the neo-Schumpeterian heterodoxy. Its core progenitors utilise a Kuhnian category-idealist methodology, centralising the study of ‘technological regimes’ (i.e. paradigms), which refer to the research heuristics of engineers and, more broadly, the rule-set that guides innovators and commercial developer’s actions involved in technical development (Nelson and Winter 1977, 1982; Rip and Kemp 1998). Transformation of such regimes thus depends upon change in its constitutive rules, and radical innovations are those which effectuate such an outcome. Its transition theory aims to describe and understand how technological innovation, considered desirable for more sustainable societies, are either resisted or established (Markard et al 2012). It introduces the ‘multi-level perspective’, which envisages successful innovations as emerging from small niches and moving toward wider applications, thus reconfiguring the socio-technical regime. At the micro-level, it envisages ‘niches’ within which innovations emerge as experiments in relatively protected spaces, at the meso-level, ‘regimes’ exist, which consist of networks of actors, guiding rules and material and technical elements, while at the macro-level, ‘landscapes’ predominate, which describe the slow-changing factors that influence a variety of regimes (Grin et al 2010). When ‘external factors’ come to bear increasing pressure on a socio-technical regime, STS envisages a reorientation of social actor-networks, potentially sufficiently destabilised to see widespread dealignment, before becoming reinstitutionalised upon new ‘sustainable’ technological innovations (Verbong and Geels 2012). Its ontology thereby rests upon an uneasy dualism
between a thickly descriptive account of micro- and meso-actor-network processes, while externalising and bracketing out the ‘slow-changing’ cultural-structural factors that constitute a sociotechnical regime ‘landscape’.

Questions of governance are characterised as problems of ‘strategic niche management’ and ‘transition management’ through the protection of budding innovation programs prior to their exposure to competitive forces (Rotmans & Kemp 2008). In approaching energy sector shift, however, STS has typically promoted market liberalisation as the most critical external stimulus to the system in effectuating ‘radical innovation’, thereby enabling ‘a general broadening of innovation routes’ (Markard & Truffler 2006, 2008). In the wake of the 2008 financial crisis, its scholars have attributed the collapse of ‘green financing’ to government policy withdrawal and consequent lacking investor confidence, yet propose deepening infrastructure privatisation as solution to ongoing policy deadlock (Geels 2013: 93). Whilst much of the post-crisis literature considered the conditions necessary for reinvigorating innovation, relatively little analysis has considered what conditions are needed to enable already-existing technologies to break the deadlock of the present sociotechnical system (Arranz 2017: 125). Concerned primarily with economic drivers such as subsidies and price as key to regime destabilisation (and only mediated by extra-economic factors), STS scarcely considers the factors cohering to produce resistance – factors which are consigned to the ideologies stemming from the intentional landscape. To this end, Arranz notes that it is only ‘regime outsiders with both a radical (enough) ideology and influence

6 The same authors nevertheless acknowledge that laissez-faire governance models have not transformed utilities’ underlying investment behaviour, such that ‘generation technologies, network structures, power consuming appliances, etc. have not much changed since the beginning of liberalisation’.  

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over economic factors [that] can destabilise the energy sector’, a finding that, despite its idealism, demonstrates the necessity of studying the societal aspects of destabilisation (Arranz 2017: 139).

The chief difference between neo-Marxist and neo-Schumpeterian perspectives on techno-economic change turns upon the endogeneity of politics in the analytic treatment. For STS, politics is typically understood as an epiphenomenon of an autonomous techno-economic trajectory, while for the neo-Marxist perspective, politics-culture is constitutive of techno-economic change through, for example, spatio-temporal fixes and modes of regularisation-societalisation that structure the political-economic space (Tyfield 2014: 109-112). Moreover, as Antonelli argues, ‘consistently with the dominant view that technological change is exogenous … very little attention has been paid to the analysis of the determinants of innovation’ (Antonelli 2011: 29). STS’s theoretical framework inherits from Schumpeter an assumption about the spontaneity and autonomy of innovation without querying the social presuppositions of a systemic subjective drive across all economic life to innovate. Preferring to see how new technologies fire the imagination of prospective entrepreneurs, STS tends to ignore the material social context; such as the role played by capitalist value-relations in enabling the dominance of certain social relations. Rather than interrogating the supposed benefit of emerging technical paradigms, STS tends to focus on providing policy advice to minimise the economic problems caused by the techno-economic cycle’s ‘creative destruction’, such as through ‘adaptive regulation’ to restrain its excesses.

Gailing and Moss (2016) summarise the critiques levelled at STS’s transition theory, concerning its oversimplification or exclusion of: (a) the dynamic/relational nature of the institutional context, (b) the hybridity of materiality and sociality, (c) critical analysis of the power dynamics influencing
agency and structure, and (d) the significance of the spatial (and scalar) context. To this end, they argue that transition literature tends to assume that innovators pursue only, or primarily, environmentally responsible interests, and ignore inequalities and the conflicts generated by energy transitions. However, as they counter,

Power is constitutive to the discourses, actor constellations, decision-making processes and consequences of sociotechnical transitions. Energy transitions, it follows, are inherently political: they are often subject to narrow interests, prone to unequal impacts and politically contested. They can transform institutional and governance arrangements, but they can also reinforce existing power relations. There is a need, therefore, to seek ways of conceptualising power in energy transitions which goes beyond simplistic notions of individuals having or not having power, entering instead a relational understanding of how power gets collectively produced and inscribed in new sociotechnical configurations. (Gailing & Moss 2016: 32)

In response, Gailing and Bues (2016) primarily use the post-structuralist Foucauldian notions of ‘governmentality’ and ‘depoliticisation’ as key concepts for elucidating power relations in their study of the German energy transition. They also engage Marxist political ecology (MPE), whose metabolic conceptual framework provides the best toolbox for understanding ‘the permanent flux in the contested making of capitalist socionatural network arrangements’ (Moss et al 2016: 58). The Socioecological metabolic framework provides a bridge between post-structuralistActor-Network-Theory (ANT) methodologies, associated with human/nonhuman assemblages of power relations, and spatial political economy.7 Energy systems play

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7 For a pertinent application of this methodology to the study of human/extra-human agency in electricity grids, see: Bennett, J 2010,
central roles in regulating these metabolic processes, and MPE’s accounting of its different sociomaterial components can follow the ANT assemblage methodology, considering, for example, the ‘physical energy structures, flows of electrons, gas molecules and steam, human workers, wind turbines, nuclear breeder reactors or coal-fired plants, firms and customers, inflows and outflows of money, energy and matter…’, while nevertheless accentuating the conflicts that come from political-economic decision making, a major lacuna in the STS framework (Ibid: 60). Synthesising the two approaches, MPE’s radical critique of capitalism overcomes ANT’s ‘flat’ constructivist approach whilst remaining attentive to ontologies that consider also the agency of non-human infrastructural actants and governmental modes of power. Nevertheless, despite their engagement with MPE’s metabolic metaphor, Moss, Gailing & Becker’s illuminating work eschews a class or value-theoretic analysis – something that may be rectified by the contextual use of world-ecology.

2.3 Anthropology of energy technologies

The anthropological study of infrastructure, utilising ANT methodology, has emphasised the materiality and spatiality of public energy infrastructures and their attendant social significances. Where STS writers (i.e. Helm 2011) propose the relative attractiveness of stable incomes deriving from infrastructure investment for capital during financial uncertainty, critical energy anthropologists have illustrated the paradoxes facing contemporary infrastructure planning, including those of ‘ruin’, ‘retrofit’ and ‘risk’ (Howe et al 2015). They write, ‘infrastructures, paradoxically, both mitigate and magnify precarity in the anthropocene’; while they are built to mitigate risk, they frequently introduces new risks, namely the amplified and cascading consequences to the collapse of nested and

sophisticated infrastructural systems. Additionally, just as overabundant, unevenly distributed and maintained infrastructures ‘become imbalanced in their installation, so too have climatological consequences been disproportionately felt’, such that old ‘predict and provide’ models that result in expanding infrastructural capacities to meet increasing demand are no longer environmentally, economically, or politically desirable (Ibid: 12). Speculative torrents of finance capital exacerbate this tendency of technical systems such as energy infrastructure toward amplifying instability. Moreover, financialisation also amplifies inequalities in benefits received from the ownership of public goods, which sees ‘key decisions relating to infrastructure investment increasingly being made by a tiny elite of fund managers… [biasing] energy investment against projects which benefit the poor, are sensitive to local needs, and are less carbon intensive’ (The Platform Collective 2016: 222).

The mobilisation of an existentially-charged discourse of ‘risk’, ‘energy security’ and the ‘securitisation’ of energy infrastructures as a policy objective has been shown to play a critical role in contemporary governance of energy transition (Bridge et al. 2015). Evoking concerns about the collapsing conditions of life, securitisation ‘licenses renewed state oversight of, and involvement in, decisions about the production, transportation and consumption of energy in countries … where the state has historically unwound itself from ownership and administration of the energy system’ (Bridge 2015: 330). Initially invoked by Western governments in response to the OPEC-induced oil crisis of the 1970s, ‘energy security’ resurfaced as a key concern during the 2007-08 oil price increases, at a time when fossil-fuel extraction rates are beginning to reach real geophysical limits (The Platform Collective 2016: 212). Moreover, the concept has demonstrated elasticity of application, recently used to legitimate neo-Colonial land acquisitions for large-scale renewable energy projects (Hamouchene 2016). It can thus be understood as a discursive strategy of final appeal, invoked to override other
concerns for fear of losing energy control, evocative of the collapsing conditions for life associated in the era of climate-change. Additionally, the mobilisation of discourses around ‘risk’, particularly in the mining sector, have also been critically determinant in legitimating state projects of regulatory withdrawal during the neoliberal era (Emel & Huber 2008: 1394). Insofar as what comes to constitute ‘risk’ is subject to social contestation, those agents better equipped to measure and manipulate the prevailing model of risk tend to dominate the balance of power over such projects (Ibid: 1397). As global financial market analysts have come to monopolise and mobilised the most sophisticated instruments of risk-calculation, the task of governing such risk is increasingly outsourced to such intermediaries, and away from centralised state-systems.

Boyer’s introduction of ‘energopolitics’ and its application to ‘revolutionary infrastructures’ reveals the role played by energy grid infrastructure in mediating potentially disruptive socio-ecological relations (Boyer 2014 and 2017). Infrastructures of vast temporality and scale are essentially reproductive, providing an ‘inertial force’ designed to facilitate flows and enable other social processes to happen. This also complicates the process of retrofitting or total reconstruction in order to avert catastrophe, reinforcing the centralised political-economic forces that produced them and continue capitalising from the commodity flows they enable. On the other hand, infrastructure is enabling, and by extension, revolutionary - it ‘stores the productive energies of labour (mental, material, natural) in such a way that they can be released later in magnitudes that appear to transcend normal inputs’, thus able to sustain entirely alternate social arrangements (Boyer 2017: 5).  

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8 Lenin’s famous aphorism that ‘communism is Soviet power plus the electrification of the whole country’ is pertinent (Lenin 1920).
Hermann Scheer, architect of the German energy transition, popularised the notion of a municipalised ‘solar economy’, which considers the critical importance of democratised social relations in securing the clean energy transition. Contrasted with fossil fuels, the generation of renewable energies can occur in potentially infinite number of places, where they must be harvested by localised technical means (Scheer 2007: 19). While the historic separation of energy production and consumption has created a steadily growing transmission infrastructure whose associated costs have steadily grown, he argues that modularised and decentralised generation guarantees security of supply and costing, since capital investment would not be affected by fluctuations in energy prices, and investments could be made on the basis of demand (Ibid: 22). In the German transition, the state-instituted feed-in-tariff, synergising with the burgeoning waves of information-technologies, was the single most effective policy instrument in accelerating decentralised renewable energy production, ‘erod[ing] the foundations of the ever-expanding networks of corporate power that the energy supply chains made possible’, despite concerted resistance from electricity utilities and the fossil fuel industry (Scheer 2002: 204). Such an erosion made possible publicly municipalising energy transmission across multiple provinces, safeguarding general energy supply while subsidising those left paying the rising costs for the upkeep of the system. Boyer claims:

Proliferating decentralised small-scale is our revolutionary path forward. Urban spaces and municipal politics - blending as they do relatively small spaces with relatively dense humanity - will thus become especially critical zones of experiment, engagement and transformation [and will allow] for more efficient and decentralised short supply chains that are also more susceptible to democratic political control. (Boyer 2017: 15)
The revolutionary ‘energopolitics’ made possible by energy technologies and infrastructures endorsed by Boyer provides a pertinent example of how technicity can be reconsidered in a more relational fashion. ‘Revolution’ need not be the only mobilisation of such a relational technicity. Karen Pinkus challenges the statist instrumentalisation of decentralised energy infrastructure to ensure grid functionality, envisaging instead an autonomous engagement, ‘perhaps disruptive, violent, effervescent, generous, or altruistic - [but above all] not dictated by the assumption that [grid] intermittency equals death’ (Pinkus 2017: 341). Behind approaches such as Boyer’s and Pinkus’ lies a more playful orientation to technicity than is offered by Moore (2015). The final section of this chapter proposes how such a relational ontology can overcome the limitations of world-ecology’s technological determinism.

2.4 The ‘bounded relationality’ of technicity

While the world-ecology framework has strived to incorporate a relational ontology to ecological political economy, it has nevertheless treated ‘capitalist’ technics as an instrumentalising and monolithic assemblage of processes, ‘crucial to successive reimaginings of global nature as a warehouse of free gifts’ (Moore 2015: 152). To this end, while acknowledging the ultimate functioning of such technics as ‘a cascading series of contingent but also quasi-determined and ‘teleconnected’ process’, Moore nevertheless succumbs to a technological determinism characteristic of modernist Marxist prioritisation of forces of production as drivers of history (Ibid, footnote 34). Critical theories of history, from within and without the Marxist lineage, have sought to provide more dialectical engagements with technology as something at once embodying a social collectivity and boundedly open to recuperation for emancipatory purposes.

Marx’s ‘Fragment on the Machine’ has provided a critical tool for theorists proposing an emancipatory orientation to
technology, most notably through the concept of the ‘general intellect’ (Hardt & Negri 2004; see also section 1.2.2). Unlike the STS perspective, which divorces technology from the social relations underpinning it, historian of technology - and critical reference for Moore - Lewis Mumford suggests that modern technics have, ‘produced a collective economy and its typical products are collective products… the work represents a collaboration of innumerable workers, themselves utilising a large and ramifying technical heritage’ (Ibid 354-355). Seeking to dispel the anti-humanist tendency within technologists’ accounts of technological change, Mumford writes that

Because of their independent source of power, and their semioperatic operation… machines have seemed to have a reality and an independent existence apart from the user… [and yet] from the beginning, the most durable conquests of the machine lay not in the instruments of themselves… but in the modes of life made possible via the machine and in the machine. (Mumford 1934: 322-323)

French philosopher Gilbert Simondon’s theory of ontogenesis elucidates the becoming of individuals as relational entities, and understood technics as a key locus of ontogenesis in modern socio-economic life. Technics are ‘a relational process of circumstantial creation and innovation wherein concrete machines are complex and dialogic with their environments, including their human ones’ (Simondon quoted in Letiche & Moriceau 2017: 4). The individual technical object is invented only through the emergence of a circular causality, wherein two sets of potentials synergise to form a single continuous system, which operates in a semi-automatic fashion. The two previously discontinuous technical elements, which presuppose a ‘pre-individual milieu’, are thus recomposed into a new technical individual, which exists with a degree of operational autonomy from its conditions of creation (Massumi 2012: 32). This emergent birth is the moment of ontogenesis, and it is
continually ongoing at the interface between environments and technologies, granting technical objects a synergetic nature (Simondon 2016: 11). The designer’s role in this process is robbed of the heroic brilliance of Schumpeter’s account, and reduced to that of bringing the two disparate elements close enough together that they cross the threshold into continuous individuality autonomously; ‘the designer is a helpmate to emergence’ (Massumi 2012: 26).

Beside Marx’s account of socio-economic alienation, Simondon also understood alienation to exist as a physical-psychological process, one which prevents ‘the continuity between the human individual and the technical individual’ (Simondon 2016: 117-118). To this end, the development of a ‘technical mentality’ (or culture) appropriate to the post-industrial age was a critical concern for Simondon, who recognised the possibility of such an outcome through the emergence of technics that facilitate networked and participatory communities (Combes 2013: 57-60). The post-industrial technical object was presciently understood by Simondon to be a fusion of two layers of reality, one stable, permanent, and adhering to the user, while another was modular, impersonal, and mass-produced by industry (Lotti 2015: 30). Such technologies provide tools with which a technical commons may be reinvigorated, ‘to be achieved in cooperation with technologies rather than in antagonism or separation’ (Ibid: 34). Moreover, as technical objects undergo individuation in and through the transformation of their associated milieu, they necessarily alter also the environment in which they operate; reconstituting existing communities by the creation of a new functionality, ‘modifying collective values and beliefs on the basis of [technics’] internal design, thereby … impacting collective and psychic individuation’ (Ibid: 30). In ontologically grounding energy infrastructure in a relational manner, Brian Larkin suggests that
Infrastructures are matter that enable the movement of other matter. Their peculiar ontology lies in the facts that they are things and also the relation between things ... they are objects that create the grounds on which other objects operate, and when they do so they operate as systems. (Larkin 2013: 329)

The radical openness of such a concept of technical ensembles such as infrastructures must be tempered by an opposing assessment of the value-relation within which they are situated and from which they arise. Bernard Stiegler investigated how technical systems are mediated through the socio-economic system, suggesting that the latter’s sub-system of prices and its organisation of production determine the economic interest of any particular technique, whose relevance is determined by innovators, who understand and seek to disrupt the rules of socialisation according to the material reward thereby gained: ‘the logic of innovation is constituted by the rules of adjustment between the technical system and the others’ (Stiegler 1998: 37). Critically, this mediation is qualitatively altered by the financialisation of economic organisation, which conditions the nature of innovation by subjecting it to the availability of highly mobile capital, whose accelerated liquidity engenders a new relation of technicity to time, one of ‘intensified and permanent innovation’ (Ibid: 38-41). The commercialisation of R&D departments penetrates their research orientations with industrial-economic considerations, and the consequent quickening of innovation turnover further threatens to amplify cross-domain instabilities, as ‘at a rhythm of constant innovation, unknown factors are no longer possible; the movement must be controlled at the risk of collapsing the global coherence of complementary systems operation’ (Ibid: 43). The development of state-based technostructures, which may regulate the transfer processes within and between the technological and socio-economic systems, has been a central response to this threat.
Marxian philosopher Andrew Feenberg looks to Marcuse (1960, 1961) in critically responding to constructivist science and technology studies which have illustrated the interpretative flexibility to which technologies are subject, seeing their ultimate functionality as indeterminate and often in dispute (Feenberg 2010: 15). Nevertheless, such approaches neglect the role of ‘technological hegemony’, which asserts itself through ‘technical codes’, i.e. the criteria that select ‘between alternative feasible technical designs in terms of a social goal and realise that goal in design’, with specific reference to technological rationality incorporated into the structure of machines (Ibid 17: 68). Through the incorporation of ‘technological rationality’, objects become divorced from their rich social embeddedness and are reduced/simplified to bring to prominence their functionalised aspect – within capitalist societies this process is intensified to facilitate commodification (Ibid: 208-212). Nevertheless, the products of commodity-oriented innovation must always be recontextualised into diverse social meanings when they are implemented by social users. In post-Fordist modernity, where networked communicative technologies suffuse social relations, rationalisation no longer stands opposed to culture as such but appears as a creative expression of it. Hence Feenberg writes, ‘the poverty of the actual techno-culture must be traced not to the essence of technology but to other aspects of our society such as the economic forces that dominate technical development’ (Ibid: 155).

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This chapter engaged the world-ecological framework with Schumpeterian, anthropological, and critical philosophical theories of technicity to provoke a more fruitful analysis of the conditions in which technologies facilitate or resist the extension and intensification of the capitalist value-relation. It considered the prevailing theory of energy transition, STS, in the
light of its Schumpeterian methodological basis, critiqued for lacking an interrogation of how capitalist power-relations determine the dynamics of innovation that it promotes. By considering the social collectivity inherent to technical systems alongside their embeddedness within capitalist systems of innovation, a dynamic model of technicity is developed in order to be applied to the case-study of DERs in the final chapter. Before then, the next chapter considers the present conjunction of energy transition and crisis in Australia through the world-ecological framework.
Chapter 3. Cheap Energy in Australia: History and Crisis

The urgency of discourse about energy transition today must be situated within prevailing concerns about the contemporaneous ‘energy crisis’. This chapter reveals the current conjuncture in the power relations and political economy of this crisis as convergent between energy, climate and capital. Insofar as world-ecology emphasises the socio-ecological path-dependence of technical expansions of the commodity frontier, we first trace a history of Cheap Energy through the capital-state-techne nexus in Australia vis-a-vis the world-system. We consider how capital-intensive fossil-fuel extraction projects, and their vast attendant transmission infrastructures, have effectuated centralised governing bodies and coalitional power blocs with preferential strategic selectivity for energy industry capital. The deleterious socio-ecological consequences of this coalition have surfaced during the neoliberal era, when the privatisation and financialisation of energy infrastructure has removed the buffer of public-interest oriented policy. The triple crisis is explored through the accumulation of ‘negative-value’: extreme weather events, rising temperatures, and risky transmission infrastructure materially underpinning an electricity market exposed to volatile financial markets. In this context, the state-system is caught in a growing ‘climate dialectic’ that has increasingly come to politicise energy, as demonstrated by its highly contradictory responses to the 2016 South Australia blackout event.

3.1 The historic financialisation of Cheap Energy in Australia

This history considers the recent history of Australian Cheap Energy and its erosion with financialisation in the neoliberal era. It focuses upon the role played by the world-systemic power blocs between transnational industry and financial capital and
the state-system, with emphasis upon the latter’s use of strategic projects, manifested through mobilisation of particular discourses, the sponsoring of technological diffusion and the production and regulation of infrastructure.

The Coal-State Nexus and the World-System

The coal-mining industry in Australia fostered a close relation with the state-system, combining its activities with a state-sponsored ethos of frontier development and nation-building. Throughout Australia’s history from early colonial outpost to modern neoliberalised state, the state has operated to facilitate the expansion of coal mining particularly through its functions as landowner, infrastructure developer, subsidiser of new technologies, and regulator of energy markets. During its colonial period, this was primarily oriented to the maintenance of steady energy flows for the British empire, and much later directed to Japanese post-war reconstruction, and was thereby export-oriented from its inception (Richmond & Sharma 1983; Tsokhas 1986; Blainey 2006). Domestically, the emergence and expansion of electrification came to have a decisive influence on state coal-mining policy through the commissioning of coal production plants to fuel state electricity commissions. State-wide ownership and control of electricity production proceeded progressively from 1919 as comprehensive legal frameworks for industry regulation were developed and enabled the deployment of statewide transmission networks (Brady 1997). In the post-war period, the construction of the 4GW Snowy Mountains hydro-electric scheme, a critical federal state project involving Liberal and Labour administrations and financially buoyed by international capital from the International Bank for Reconstruction and Development, would enable the first interstate (NSW-VIC) transmission network interconnection, leading to the overall integration of the (South-Eastern) national electricity grid by 1995. Additionally, the Commonwealth Bureau of Mineral Resources, promoting a systematic
programme of research and geological surveying, facilitated the diffusion of technologies that initially developed as byproducts of the military innovations of the second world war generally quickened the pace of technical change in the energy sector, enabling the use of trained personnel, seismic surveys, aerial surveying and mapping, mineral-bearing land measurement (Brady 1997). This strategy was complemented by the Joint Coal Board and Coal Industry Tribunal, which oversaw the restructuring of the mining industry according to Taylorist principles of mechanisation and scientific management in response to prolonged energy sector industrial disputes (Tsokhas 1986: 225).

**Neoliberal Regulatory Capture and Deepening Primitive Accumulation**

During the neoliberal era, the export-orientation of Australian resource extraction further intensified, facilitated by the gradual withdrawal of legislated state-system regulation and the concomitant regulatory capture by fossil-fuel capital. Coinciding with Australia’s deindustrialisation, the energy sector transitioned from ultra-protectionist to highly liberalised during the 1980s, facilitating Australia’s ascendance as world leader in coal export (World Coal Association 2015). Crough and Wheelwright suggest that the transnationalisation of Australian energy investment was heralded by the political instability and resource nationalisms of key energy exporters of post-colonial states, particularly the OPEC, giving Australia a relative sheen of stability (Crough & Wheelwright 1982). Concurrently, the state-system’s project to pivot to world-leading aluminium production

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9 While US investment in mining in the Global South fell from 56% in 1959 to 32% by 1978, 85% of the increase in US foreign mining investment over that period took place in developed countries, and by 1980, the developed Commonwealth countries accounted for 75% of total capital expenditure by US companies in mining and smelting, increasing from 23% in 1970 (Crough & Wheelwright 1982, 110).
and export was facilitated by concurrent cheap energy flows directly into the local smelting plants and unprecedented public drawing upon foreign credit streams (Crough & Wheelwright 1983: 29). Consequent infrastructural projects of state governments involved the development of smelter-proximal power stations, yet were frequently mobilised to justify cuts in expenditure to other areas, most saliently in social welfare (Ibid: 30).

Australia’s devolved environment conservation regulatory regime was also cause and effect of the centrality of its fossil-fuel exports to its national developmentalist logic. Pursuant to the state project of ensuring favourable conditions for energy resource appropriation, Linda Connor writes, a ‘series of legislative changes marginalised rural landholders in the planning process and perpetuated the exclusion of Aboriginal traditional owners, while enhancing opportunities for capital accumulation by resource extractive companies in a context where minimal exports were playing a larger role in economic growth’ (Connor 2016: 235). While the only piece of national legislation was devolved to state-levels, state-level legislation would increasingly centralise decision-making.\(^\text{10}\)

This legislative pattern greatly reduced the influence of public submissions and democratic control over energy-generating policy. Rather, climate policy was effectively captured by the same interests that

\(^{10}\) This trend is discernible beginning with the \textit{Coal Acquisition Act 1981 NSW}, followed by the \textit{Coal Ownership (Restitution) Act 1990}, which vested coal ownership in the Crown, and the creation of ‘State Significant Development’ amendments to the \textit{Environmental Protection Act 1997 NSW}, giving the minister for planning centralised authority to approve any projects provided their conformity to developmentalist logic, to 2005 amendments withdrawing direct public stakeholder participation, and most recently legislated increases in the punitive measures for environmental protestors and moves to limit the appeal rights of third party objectors to energy mining developments.
bear greatest responsibility for greenhouse gas emissions (Baer 2016: 197). A consortium of energy industry peak bodies coalesced as the ‘Greenhouse Mafia’ in response to increasing climate cooperation around the Kyoto Protocol, and positioned themselves as the federal government’s chief consultative committee on climate policy (Pearse 2009).\textsuperscript{11} Granted this significant buffer from democratic accountability, the federal and NSW states continued to approve infrastructural developments with major carbon emission implications, most significantly the Newcastle coal port expansion, while the few challenges mounted by the federal state-system to this ongoing Cheap Energy regime have been successfully opposed by mining industry lobbying.\textsuperscript{12}

Despite the global rapid depletion of easily accessed coal and its growing costs of oil production, Australia experienced a historically unprecedented boom in energy minerals mining from 2003-2013. This development, driven in large part by novel sources of demand from the world-system - now Chinese steel and concrete manufacturing plants - uniquely produced concurrent and unprecedented peaks in Australian terms of trade and resource investment (Gregory & Sheehan 2011). Reserve Bank analysis observes that 80\% of financing for the 2000s mining boom was foreign-owned, reflecting the

\textsuperscript{11} Including the Australian Coal Association (ACA), a major donor to both Liberal and Labor parties, the Minerals Council of Australia (MCA), the Business Council of Australia and the Australian Greenhouse Network (AIGN), with the latter including every major fossil fuel company operating in Australia.

\textsuperscript{12} The Resource Super Profits Tax first floated by the Ken Henry review in May 2010 and endorsed by the Rudd government was quickly countered by mining-industry lobbyists partnered with the Coalition Government, which effectively led to significant weakening of proposed measures and the toppling of the Labor Rudd administration.
globalised financialisation of the world economy since the previous major mining boom in the early 1980s (Connolly & Orsmond 2011).\textsuperscript{13} Despite the global oversupply of coal and its structural decline as an industry, its deepening domestic extraction and export has been in large part facilitated by the ongoing federal state project to remain a ‘global energy superpower’, as promoted in its 2015 \textit{Energy White Paper} (Morrison 2015; Department of Industry, Innovation and Science 2015).

\textit{Electricity Infrastructure Ownership and the National Energy Market}

As with many other public goods, due to the capital-intensive processes necessary for the development of electricity networks and the long durations for their commercialisation to compensate initial capital expenditures, the state has typically lead the development of national infrastructure, and has consequently come to own much of the generation, transmission, distribution and retail aspects of the sector. Privatisation of the state-owned energy sector transformed it to become one of the most liberalised in the OECD, raising total proceeds in excess of $182bn since the late-1980s (Chester 2015). The combined state governments of Australia, agglomerated as the Council of Australian Governments (COAG), initiated the restructuring of the industry in concert. Once vertically-integrated industries had become disaggregated, competitive bidding for electricity generating contracts became

\textsuperscript{13} Oil and liquid natural gas projects accounted for 92\% of all advanced energy investment in 2011, with total capital expenditure valued at over $200bn, heralding Australia’s stepping into the world-leading position in natural gas exports (ABARAS 2011: 15). The total value of energy exports increased from $24.3bn in 2002-3 to $76.2bn by 2011-2 before falling to $59.8bn by 2015-6, with LNG rising from $2.6bn to $16.6bn and coal rising from $12bn to $34.5bn (Department of Industry, Innovation and Science 2017).
possible on the newly formed National Electricity Market (NEM), in May 1997.\textsuperscript{14}

From its inception, the creation of the national electricity spot-market required the expansion of attendant financial asset trading, primarily by hedging contracts reducing exposure to the volatility of spot-pricing of energy dispatches. This is driven by the necessary immediacy of electricity trading (it cannot yet be stockpiled to meet peaks and troughs in supply and demand) with its dispatch-based spot-pricing leaving participants vulnerable to highly volatile spot-market prices (Ruff 1994). Electricity prices are determined on the NEM by the AEMO matching generating capacity declared available by suppliers with the demand provided by distributors, attempting to achieve a least-cost solution to meet demand, assuming that bids reflect the marginal cost of bringing extra capacity into production. Critics have observed that in the day-to-day operation of the NEM, high levels of price volatility have not reflected supply shortages - and thereby indicated where extra generation capacity needs to be installed - but rather have been artificially created by generation companies exercising their market power via their ability to withhold capacity, permitted by the NEM’s rebidding rules.\textsuperscript{15} By 2012, trading of derivatives came to outweigh trade in the underlying assets fivefold, with the lion’s share of hedge contract trading undertaken by financial intermediaries (Chester 2012). This greatly expanded pool of electricity derivatives sold over the financial contracts market, rather than in the NEM directly, has a decisive influence on the

\textsuperscript{14} The NEM’s operations would be initially regulated by the NEMMCO, becoming the Australian Energy Market Operator (AEMO), the Australian Energy Market Commission (AEMC) and the Australian Energy Regulator (AER) in 2009.

\textsuperscript{15} A similar trend has occurred across the Californian electricity market, most notably the ‘Western Energy Crisis’ of 2000, caused by the illegal market manipulations of Texas energy consortium Enron.
actual prices for wholesale electricity, no longer formed in the context of supply and demand for electricity commodities but rather in the parallel financial market, whose price levels - assumed by market regulators to represent long-run marginal costs of production - tend to be overdetermined by broader financial market trends (Tang & Xiong 2011).

3.2 The present ‘triple crisis’: energy, capital and climate

Since the 2008 ‘global financial crisis’, numerous authors have described the state of the global economy as one of multiple crises across different domains converging through the homogenising dynamic of financial markets (i.e. Geels 2013; Chester 2013; Moore 2015). Moore (2015) rejects the analytic separation of environmental catastrophe from its social dynamics, developing instead an analysis of surfacing ‘negative-value’, which co-situates ongoing, impending non-linear shifts of the biosphere, rising costs of production, and the ongoing overaccumulation of capital. While these costs can be internalised into the logic of value via market-based mechanisms, their underlying nature as negative-value is primarily ecological, social, and political; they accumulate within commodity frontiers and problematise the feasibility of the ongoing appropriation of Cheap Energy.

Damaging ecological feedback into the energy system generated by the processes of Cheap Energy production is the most immediately apparent dimension of negative-value. This kind of damage occurs despite Australia’s relaxed environmental protection legislation, demonstrating the efficacy of negative-value irrespective of pricing measures which seek the ‘internalisation’ of costs through market-based mechanisms or penalties.
Australia is highly vulnerable to the southern climate oscillators El Nino-Southern Oscillation (ENSO), a one-to-eight year cyclic intensification of climatic patterns whose negative and positive phases, El Nino and La Nina, respectively, have the strongest influence on year-to-year climate variability for most of the country. While ENSO has occurred since prior to the general intensification of extreme weather events heralded by climate change, its most recent iterations have been the most historically damaging. The severe droughts of 1982, 1994, 2002 and 2006 are all associated with El Nino, as are the major Summer bushfire events including Ash Wednesday (16 February 1983) and the 2002-3 and 2006-7 bushfire seasons, with the lowest peak snow depths on record all measured during El Nino years, notably in 1982 and 2006 (BOM 2014). Further, the warmth of recent El Nino events have been amplified by background warming trends, amplifying the severity of droughts and extreme temperature events they bring (Williams et al 2001). The 2015-2016 El Nino event, among the larger occurrences on record, was notable for causing extreme coral bleaching in the Great Barrier Reef, prolonged heatwaves across Australia, a severely foreshortened the cropping season, and major shortages in precipitation in the Snowy Hydro catchment region causing a severe fall in power generated by the hydroelectric scheme to a historic low of 2605 MWh (Robbins 2015). Open-cut coal mines, which have become widespread across Eastern Australia during the late-20th century, are particularly vulnerable to extreme weather events and bushfires, the porousness of brown coal rendering it highly combustible during conducive environmental conditions (Melody & Johnson 2015). During the extreme heat events in summer 2014, embers spotting from nearby bushfires initiated a severe fire to breakout in

Despite this trend, however, BOM reports that not all major fires have followed El Nino years, with the Spring bushfires of October 2013 occurring during an ENSO neutral year and Black Saturday (7 February 2009) following a weak La Nina.
Hazelwood coal mine, Victoria, burning for 45 days, with total costs to public health, including the costs of relocating local communities in the wake of extensive fine-particle pollution, and mining infrastructure exceeding $100m (Parliament of Victoria 2014). Additionally, drought conditions affect mining and processing operations by creating inadequate water supply for extraction process, threatening production capacity to meet contractual commitments, intensifying conflicts with local communities over use of scarce common water sources, and reducing the availability of water for cooling in coal-fired power generation, which led to intermittent generator and network outages in Queensland throughout 2007 (AER 2007).

The climatic instability and threat of cyclones and flooding heralded by La Nina have proven a greater cost to the Australian Energy Sector. The 2010–12 La Nina events, the strongest on record, caused widespread flooding across central Queensland after severe tropical cyclones (BOM 2012). Losses relating to these floods were evaluated at $30bn, with losses of $2.5b for the mining industry, not including consequently imposed legislative requirements for more stringent environmental protection (Easdown 2011). As summarised by the National Climate Change Adaptation Research Facility (2013), ‘changes to historical climatic conditions, combined with the changing costs of production, are likely to increase the efforts required to protect physical assets, worker and community health and safety, and improve the environmental performance of operations before, during, and after extreme weather events’ (Mason et al 2013). Salient events include the flooding of the Ensham open cut coal mine in Queensland, sustaining $300m damages after production stopped for 6 months; the flooding of the Queensland Baralaba open pit coal mine which was unable to produce coal for 5 months, and Victoria’s Yallourn open pit coal mine, the largest in Australia, which was permanently compromised in production capacity with electricity generation reduced by 25% for 6 months,
sustaining $109m in costs (Ibid: 5-6). Further flooding in 2013 once again caused widespread stoppages of coal mines across Queensland, with compounding environmental effects caused by toxic minerals released into local waterways (Chambers 2013).

On Wednesday 28 September 2016, multiple tornadoes buffeted central South Australia, simultaneously damaging two transmission lines and causing voltage dips across the South Australian grid, compounded by wind-farm power reductions due to the activation of in-built protection features. An automatic compensation mechanism increased power imported from the Victoria-South Australia interconnector, overloading and tripping the interconnector, separating the SA power system from the NEM. State-wide supply in SA was lost, restarting later that day and not fully replaced for two weeks (AEMO 2017). At the time, South Australia’s energy generation mix was composed of the highest proportion of renewable energy in the country (~49%). While the intermittency of wind power was not deemed a material factor in the blackout by subsequent inquiry, with responsibility solely placed on the severe damage to transmission infrastructure, the Australian federal government immediately placed responsibility on the high penetration of wind turbines in the state, with prime minister Turnbull suggesting that ‘energy security should always be the key priority [...] a number of the state Labor governments have over the years set priorities and renewable targets that are extremely aggressive, extremely unrealistic, and have paid little or no attention to energy security’ (Grattan 2016). The event bore significance as a catalyst of the contradictory pressures operating within the state-system, surfacing as a conflict of strategic projects between the state (left-)Labor governments of South Australia and Victoria, and the federal Liberal government. In 2017, South Australia surpassed its renewable energy target of 50% by 2025, while committing $500m to building and operating a 250MW gas-fired power plant and a highly
publicised 100MW solar battery plant in partnership with South African battery developer Tesla (ABC News 2014). In the previous year, the Victorian government committed to 40% renewable energy generation targets by 2025, legislated in the Renewable Energy (Jobs and Investment) Bill 2017 (Energy Victoria 2017) while its premier chastised the federal government for its ‘absence of policy certainty’, forcing states to shoulder the financial burden ‘to fill the void’ consequently left (Willingham 2017).

**Rising temperatures, peaking demand, and overaccumulated capital**

The artificial production of scarcity through overaccumulated capital is a core dimension of negative-value, with the effect of raising the costs of producing and consuming energy. Increased volatility and rising average wholesale and retail electricity prices has characterised the NEM’s operation a decade after the deep restructuring of the mid-1990s, with prices breaking from CPI and growing by up to 300% between 2005-2015 (ABS 2014; Chester 2015). The cause for these price rises has been the subject of considerable political and analytical controversy, and revolves around the three elements of electricity pricing: generation, distribution, and retail. At the level of generation, Clean Energy Council analysis suggests that these price rises are due to supply constraints, as Australia experiences persistent underinvestment in new electricity generation capacity to compensate for the closure of old coal power plants, the result

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17 The South Australia-federal government conflict was epitomised in an unscripted press conference confrontation between the SA premier Weatherill and federal energy minister, the former accosting the latter for the Commonwealth government’s ‘white-knuckled panic about national energy policy [and it’s] $2bn admission that the national energy market is broken’, while the federal Treasurer later entered parliament brandishing a piece of coal (Norman 2017b).
of a lack of investor confidence given federal policy uncertainty (Thornton 2017). Conversely, other independent analysts suggest that such supply constraint is artificially produced, as operation of the NEM enables market power abuse by generators who ‘economically withdraw’ from supply provision to inflate prices in the wholesale market (Mountain 2016b; McConnell & Sandiford 2016). This behaviour was identified in South Australia in July 2016, where gas and diesel generators’ withheld productive capacity until spot-prices exceeded $5000/MWh, and was exhibited by Victoria’s Snowy Hydro plant in 2015, whose ‘economic withdrawal’ produced $30m windfall profits (Mountain 2016b).\(^\text{18}\) Moreover, supply-constraints (whether artificial or real) must be assessed in their relation to peak demand, which in Australia has been decisively affected by increased air-conditioning uptake as average Summer temperatures rise (NEMMCO 2007).\(^\text{19}\) Nevertheless, financialisation of the NEM means that hedge contracting necessarily overdetermines final wholesale prices and thereby intervenes in the information signal transmission function of dispatch spot-pricing. Spikes or volatility in the resulting wholesale prices, occurring at consistently less than maximum demand levels, do not come to reflect shortage of capacity and fail to provide stimulus for new investment in baseload or peaking capacity (Chester 2013).

At the network level, the AEMC estimated in 2013 that increases in distribution charges would contribute 81% to the rise in national average electricity prices from 2012-2015, while

\(^\text{18}\) Most recently this occurred on February 10th 2017 in NSW, when the AEMO issued multiple requests for NSW generators to fill a 264MW shortfall to no response, despite underutilised gas firing plants.

\(^\text{19}\) This is quite separate from overall average electricity demand levels, which are forecast to grow at a slower rate due to increased energy efficiency measures.
the Independent Pricing and Regulatory Tribunal estimated that NSW network charges increased by over 90% in real terms between 2008-2013 (AEMC 2013; IPART 2012). Increased network charges are commonly attributed to rapid expansion of capital expenditure in the transmission network by network companies, whose “gold-plating” investments during this period were incentivised by a new valuative methodology employed by the AER which allowed the value of a network’s regulated asset base to affect its return on capital, thereby seeking to stimulate asset replacement of an old and fraying pole-and-wire network (Quiggin 2015; AER 2013). This regulatory incentive was suggested by AEMO analysis, who have notably followed forecasting models that consistently over-estimated future base-load electricity demand levels (AEMO 2016). Thus, network distributors have expanded network capacity beyond what was functionally necessary, creating a substantial risk of negative-value accruing from stranded assets as new distributed energy resource (DERs) technologies become increasingly taken up by households and businesses.

At the retail level, the Grattan Institute (2017) finds that since deregulation, retail companies across Australia (although particularly in Victoria) have preferred to generate super-profits by exploiting the complexity and lack of transparency in the tariff rate structures used in the retail market by offering conditional and limited discount periods while maintaining high standard contracts, rather than innovate in service-provision, as is expected by the common justification for market deregulation (Wood & Blowers 2017). These price effects are particularly impactful on vulnerable lower-income households, who typically have less capacity for undertaking the time-heavy procedures needed for discerning between the competing contracts available, as well as less disposable income with which to invest in smart-metering technology and distributed energy resources which reduce the long-run costs of electricity (Mountain 2016a; Chester 2013b). Increasingly, households turn to reducing their
overall energy consumption, which amplifies the long-term trend toward declining overall base load energy use, and further destabilises the existing overdeveloped energy transmission infrastructure (Gibbons & Singler 2008).

Socio-political contestations

As identified by Mitchell (2011) and Malm (2016), organised labour contestations were critical in raising the cost of production for energy extraction industrialists during the 19th and 20th century, a first instance of negative-value accumulating at the point of energy production. Steam-power fuelled by coal was economically advantageous for enabling rapid urbanisation which could attract large pools of cheap labour required by capitalist expansion, simultaneously providing inertia from intermittencies associated with extreme weather events and irregularities in the flow of renewable energies, and enabling an intensification of work performed by urbanised labour (Malm 2016: 148, 188). However, the centralisation entailed by coal also granted coal miners relative bargaining strength, amplified by their position and concentration at bottlenecks in distribution points of the new fuel source (Mitchell 2011: 19). The history of coal extraction in Australia, and particularly NSW, has certainly been shaped by militant labour union striking, particularly during the late-1940s until the early-1980s, a period of ‘disastrous’ industrial disputes which brought production across much of Eastern Australia to periodic standstills from energy supply shortages (Tsokhas 1986). The lack of accessible oil fuel (which had been managed into logistical supply chains that diminished militant worker resistance’s efficacy in hindering productivity in the United States) as a substitute predisposed industrial capital to demand harsh anti-union measures by the state-system to improve the constancy of energy flows (Tsokhas 1986: 225). Today, as legacy of the Joint Coal Board’s mechanisms of ‘soft-control’, coal mines are one of the most highly automated workplaces in the country, with extremely well
remunerated labour, and where industrial disputes and work-stoppages are relatively rare (Cosbey et al 2016).

Instead, negative-value as rising cost of production tends to occur through direct action techniques that stop work at critical coal and gas extraction and transportation points, organised by diverse social movements that form uneasy coalitions between local Indigenous activists, environmentalist groups and NGOs and local farmers (Connor 2016: 239). While such engagements aim to stop work on sites and harm the profitability of extractive activity, little quantified data exists regarding their impact upon the productivity of coal mines, export ports and coal-seam-gas wells. Nevertheless, such protests prompted the Federal government 2015 Energy White Paper to identify ‘anti-development activism’ including fossil-fuel managed funds divestment as ‘continuing challenges for resources development’ (Department of Science, Energy and Industry 2015). Such community challenges have included farmer-led opposition to the Shenhua Watermark Corporation open-cut coal mine proposal in the Liverpool Plains, resident-group Milbrodale Progress Association’s legal challenges to the Rio Tinto Warkworth mine extension, the complex coalition against the Maules Creek Whitehaven Coal mine, and most recently, the national movement to prevent the Adani Carmichael coal mine receiving federal approval, led by the Wangan and Jagalingou land council’s contested native title claim (Connor 2016; Burragubba & Johnson 2017). While meeting mixed success in preventing the development of energy projects, these coalitional agencies nevertheless create political toxicity surrounding the state-system’s legislative approval process, further deepening popular intuitions of political illegitimacy of governments finding themselves trapped within the ‘climate dialectic’ identified by Goodman (2016). Thus, the state-system, understood as a social relation, cannot but embody contradictory stances regarding its climate and energy policy when its energy regulatory policy remains captured by
transnational energy industry capital on one hand, while it concurrently requires formal democratic validation in electoral outcomes on the other, and consequent policy uncertainty that arises further discourages financial capital from investing in either fossil-fuel or renewable projects.

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This chapter has presented a history of Cheap Energy in Australia through an analysis of the close nexus between coal industry and state-system, emphasising how the state-system has facilitated the appropriation of large amounts of energy freely or close-to-freely through sponsoring technologies and infrastructures that enabled the expansion of commodity fossil fuel frontiers. During the neoliberal period, the withdrawal of direct government ownership over generation, distribution and retail of electricity has expanded the determining impact of financial actors in mediating the social-economic-climatic consequences of the operation of the electricity market, alongside a continued and expanded role of state regulation. The present period, since at least 2005, is characterised as one of converging crises within which climatic feedback, through extreme events and rising temperatures, have rendered the present network infrastructure an increasingly risky asset, vulnerable to increasingly consequential breakdowns. In this context, a new technics, based on the convergence of information technologies and renewable energies, has made possible an alternative, decentralised energy generation and distribution model, with potentially wide-reaching implications on the kinds of social-relations that it enables.
Chapter 4. Distributed Energy Resources and the Commodity Frontier

While energy transition is ongoing and seemingly inevitable, the final shape that its constituent social relations take is not. One strong tendency advocated by state-systemic and finance-industry actors is for a non-disruptive, ‘secure’, and hence centralised and privatised transition. Another countervailing tendency is toward decentralised and publicly-owned energy resources, made possible by distributed energy resource technologies (DERs). While such a transition heralds a clear potential for non-commodified and non-marketised social relations, as is recognised by Scheer (2002), Boyer (2017), Schwartzman (2017) among others, managerial approaches to DER transition have focused upon the innovation potential of the ‘smart-grid’ and prioritised methodological individualism in fostering attitudinal-behavioural change to adopt DERs. This chapter considers the responses of the state-system and capital tied to sunk costs in transmission and generation infrastructure to this emerging ‘technological style’ before providing an assessment on the world-ecological model developed above.

4.1 The renewable energy institutional framework

The technics developing around renewable energy technologies have been uniquely situated entirely within the neoliberal era. Unlike prior energy-sector technics, which have converged upon state-directed developmentalist narratives, renewable energy technology’s diffusion has been intimately linked with the operation of financialised market-based mechanisms. Within Australia, their financial feasibility has relied upon revenues generated through the selling of renewable energy certificates and from collecting highly-volatile electricity spot-market value, both of which are enabled and overseen by state-instituted markets in the RET and the NEM, respectively (Liebman 2014).
The RET, legislated by the federal state-system in 2001, creates a market for the trading of renewable energy certificates, which are provided to renewable energy generators who displace 1MW of fossil-fuel energy through either large or small-scale systems, with the overall aim of spurring 23.5% of Australia’s energy to be derived from renewable sources by 2020. The RET is composed of separate small-scale (SRES) and large-scale (LRET) schemes, with attendant small-scale technology certificates and large-scale generation certificates. Certificate generators include households, communities and businesses who voluntarily invest in small and large-scale renewable energy systems and create renewable energy to actively lower their consumption of main grid electricity. Certificate purchasers are industry groups mandatorily participating in the LRET, required to surrender certificates to offset the generation of emissions-intensive energy, based on the volume of electricity they acquire each year (minus exemption certificates), according to a magnitude determined annually by the CER (CER 2016). The Australian Renewable Energy Agency (ARENA) and Clean Energy Finance Corporation complement the RET scheme through financing and coordinating the administration of support for research and development, demonstration and commercialisation of renewable energy technologies.

Both forms of renewable energy certificates are floated on the RET. Nevertheless, while small-scale certificates have remained relatively stable due to the institutionalisation of a fixed-price clearinghouse, large-scale certificates have experienced severe price spiking, indicating persistent supply shortfall (Green Energy Markets 2017). This trend has been exacerbated by generator-retailer companies preferring to pay the cheaper legislated penalty and the provision of emissions exemption certificates for exposed industries in 2015 legislative amendments (CER 2017; Norman 2017a). Such institutional failures are typical of market-based mechanisms when scope for advantageous market behaviour is recognised by market agents.
with power over regulatory capture, as demonstrated by the history of emissions-trading schemes in Europe and internationally (Bryant 2016). Since the introduction of the SRES, solar PV has become the dominant DER, driven by their falling costs over 2009-10, the provision of small-scale certificates as subsidy, and the introduction of state-government feed-in tariffs (Jacobs 2017). From 2015-2016, the rate of DER uptake has fallen drastically, with the small-scale certificate multiplier diminished and the progressive withdrawal of feed-in tariffs (Ibid). Nevertheless, to date, small-scale renewable energy has exceeded 6GW of generating capacity, sufficient to displace 11.2 MWh of electricity per year, with household penetration rates of greater than 1 system per 5 households, the highest ratio in the world.

The Climate Change Authority (CCA) is required to produce a biennial independent panel review of the RET, chaired by leading figures of the energy and resources industry. The most recent report surmised that the RET ‘promotes activity in renewable energy ahead of alternative, lower cost options for reducing emissions that exist elsewhere in the economy. In the presence of lower cost alternatives, the costs imposed by the RET are not justifiable’ (CCA 2014). Further, the review found that the RET required a further $22bn cross-subsidisation to ensure that its present targets are met, coming ‘at the expense of investment elsewhere in the economy and the additional generation capacity is not required to meet the demand for

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20 It was most recently chaired by Richard Warburton, chairman of Westfield Retail Trust, Magellan Flagship Fund and Citigroup, and chair of the Expert Advisory Committee on the Commonwealth EITE assistance program; Brian Fisher, executive director of ABARE; Shirley Veld, a former mining and energy executive (of WA’s Verve Energy, Alcoa Australia), and Matt Zema, CEO of the AEMO at the time.
electricity’ (Ibid). Consequently, ‘the adoption of a higher target and/or extension of the scheme beyond its current timeframe are inconsistent with the objective of reducing the cost of the scheme and would prolong a relatively inefficient approach to reducing CO2’ (Ibid). The Independent Review suggested that the SRES be fully wound back, as small-scale systems supported by the SRES had generated or displaced more electricity than initially projected at a cost two and a half times that of the large-scale scheme.

The ‘Independent Review into the Future Security of the NEM’ (hereafter the ‘Finkel Review’), released in mid-2017, explicitly acknowledged the failure of the existing NEM infrastructure to cope with ‘shifting policy imperatives and rapidly evolving technologies’ (Finkel et al 2017). The incorporation of DERs and reduction of inertia-providing fossil fuel sources created a void in the provision of essential security services, including technical requirements of frequency and voltage control and response to power system disturbances. Moreover, it found that DER incorporation increased the complexity of power system operation by necessitating the management of large amounts of data and developing software architecture for stable operation, potentially leading to synchronised battery charging and discharging onto the grid in response to price signals or coordinated aggregator action, amplifying ‘ramp events’, and thus undermining the AEMO’s supply/demand forecasts. To this end, the development of fast-frequency-response measures has been prioritised by the AEMO, by (a) requiring new non-synchronous generators (i.e. DERs and large-scale wind and solar) to have the capability to provide fast-frequency response, and (b) to subsequently establish a market for the provision of such services (AEMO 2017). Energy security can then be achieved through DER ‘orchestration’, i.e. ‘using communication signals to coordinate and optimise their dispatch in a dynamic manner’ (Finkel et al 2017: 63). To enable this kind of orchestration, however, the ‘AEMO requires data
on the location, capacity, technical characteristics, real-time output and consumption by controllable loads for new DER installations’, i.e. the integration of real-time data collection to enhance the ‘visibility’ of DERs (Finkel et al 2017: 63).

Market approaches to DER organisation are commonly promoted for implicitly solving the visibility problem. This is achieved by incentivising the provision of DER data by owners to market operators to participate in the market (New York ISO 2012; California ISO 2012; Essential Services Commission 2017). The marketisation of such services in turn depends upon the development of a commercially-integrated technical system that includes controls built into ‘smart’ inverters that enable local voltage control and power shutdown in response to high system frequency, along with new business models for energy intermediaries such as aggregators/retailers that can bundle multiple DERs together and manage their grid interaction. This is complimented by the creation of ‘platforms’, i.e. the systems used to deliver an internet-based service, optimising and controlling distributed generation and consider data from weather forecasts, device status, market conditions, to constantly control distributed generation systems, as well as facilitating market interactions by providing an arena for the trade of goods and services. These visions of DER-led transition aim to achieve the ‘smart grid’, characterising an energy network of two-way flows of electricity and information interspersed through a macro, integrated grid that ensures ‘the optimal combination of local generation, energy storage, energy efficiency and new uses of electricity integrated with central generation and storage’ (Gellings 2015: 139). Such a complex interlocking of multiple technological, commercial and governmental modes of producing, measuring and orchestrating a new ‘abstract social nature’ of captured solar irradiation constitutes a novel kind of emergent capitalist technics.
4.2 Technics and the expansion of the commodity frontier in DERs

State-mediated technics: Solar irradiation mapping

Numerous industry analysts and state regulators have sought to develop the means by which the commodity frontier may be extended to DERs, so that their increased uptake does not threaten to fetter the pre-existing centralised energy infrastructures. The state-system has introduced the Regulatory Investment Test, which requires network businesses to consider investment in DERs instead of expanding transmission infrastructure where financially feasible. ARENA has promoted the Network Opportunity Maps, developed by the Institute of Sustainable Futures, which complements such a project by visually integrating information regarding current and potential DER capacity with pre-existing energy infrastructure (Langham 2014).\(^{21}\) It builds upon avoidable network cost models previously developed by researchers partnered with ARENA, the NSW department of industry and energy network companies, which generated maps of network capacity and constraints, planned investment and the potential value of decentralised energy in electricity networks across the NEM, that are publicly available online.\(^{22}\) The model has been applied for mapping DERs in Victoria and rural areas of the NEM, and

\(^{21}\) The data integrated in the NOM includes proposed network investments, cost of capital, network service providers’ demand forecasts for each network asset, current capacity of lines and substations and hourly load data. The annual deferral value ($/kVA/yr) generated using such maps is calculated as: Proposed Network Investment ($) x (Cost of capital [% p.a.] + Depreciation) / support required in each year (kVA) (Dunstan and Langham 2016).

is fed into the Australian Renewable Energy Mapping Infrastructure data platform.

A number of public and commercial research bodies have deepened this mapping project by generating real-time solar irradiation forecasting services, tailored to DER requirements (ARENA 2016). Solcast is a commercial R&D firm whose technological apparatus integrates data generated by the Himawari 8 (a geostationary weather satellite which observes, tracks and predicts cloud coverage across the Southern hemisphere at great precision) with numerical weather sources and output from the solar PVs measured through smart-meters in an online interface, presenting this information for end-users to generate a solar radiation power output forecast (Engerer et al 2017). Similar technology is developed by the Australian PV Institute, also funded by ARENA, through its SunSPoT solar potential map.23 Although currently freely available online for interested households, Solcast and SunSPoT’s ARENA partnerships aim particularly to commercialise their irradiation-mapping technology, complementing the well-publicised state project of promoting commercial industry-academy linkages (Hare 2016; Martin 2016). The sophisticated technical system set in motion by their projects has contributed to the production of ‘abstract social nature’ in solar irradiation, reduced to quantifiable equivalence by ‘removing the distinction between reliability driven projects and those motivated by the delivery of market benefits’ (AER 2013). While these technologies prefigure a technical ‘commons’, open to recuperation by non-commercial actors, their embeddedness within state regulatory and conditional R&D subsidy frameworks predisposes their ultimate commercial enclosure.

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Smart-grids and the ‘prosumer subject’

The integration of these DERs into a robust electricity grid through the extensive use of internet-equipped technologies is referred to as a ‘smart-grid’, which plays a central role in technocratic visions of the urban energy transition. The International Energy Agency (IEA) define the smart-grid as ‘an electricity network that uses digital and other advanced technologies to monitor and manage the transport of electricity from all generation sources to meet the varying electricity demands of end-users’ (IEA 2011). The smart-grid is both discrete and networked, including sensor arrays and attendant software infrastructure, which monitor and enable optimisation of power flows along transmission grids. Solar PV inverters, which connect PV systems to a public grid, residential energy management systems, in-home displays and access to energy market information, as well as grid-ready appliances and devices, constitute the smart-grid. (Gellings 2015).

By encouraging the end-user’s increased interaction with communication technologies to achieve more efficient household energy supply- and demand-management, the ‘smart-grid’ is lauded by STS scholars for creating a new kind of subjectivity, the ‘prosumer’ (Rathnayaka et al 2011; Hertig & Teufel 2016). Australian case studies have considered the participant experience and behavioural changes in response to ‘smart-grid’ pricing/incentive mechanisms, i.e. dynamic tariffs, and/or home energy data feedback technologies (AEFI 2014). The clear majority of participants, according to the study, and particularly financially vulnerable households, experienced behavioural change, acting to flexibilize electricity consumption in line with market signals, with greater elasticity among more financially-vulnerable households. Another research cluster, collaborating with the CSIRO, found that while smart-grid technologies had a high level of acceptance among energy consumers and other stakeholders who accepted it as offering ‘a
genuine alternative to centralised grid supply’, most stakeholders believed that governments had the ultimate responsibility for energy security, supply, reliability, and providing a supportive regulatory and policy context to DER penetration. Nevertheless, most respondents expressed ‘a profound lack of confidence in government leadership to tackle climate change issues’ (iGrid Research Cluster 2011). In such a manner, subjectivist research considering smart-grid feasibility have (unintentionally) revealed the contours of the ‘climate dialectic’ within which the state-system is caught.

*Distributed energy trading, the ‘Sharing Economy’ model and novel financial instruments*

DERs enable partial use of the current centralised energy distribution system, causing potential underutilisation of the grid, consequent rise in consumer charges, and threatening the viability of generator-retailer utilities as they currently exist. State-industry partnerships have responded to this concern by implementing local electricity trading and local network charges, i.e. reduced network tariffs for electricity generation used within a defined local network area (Rutovitz et al 2016). Two such proposed models are (a) many-to-one, where many individual DER generators provide energy that is aggregated and transferred to a single site, and (b) one-to-many, where a signal generator’s energy output is ‘split’ and transferred to many individual sites, i.e. either a municipally- or community-owned ‘solar garden’ (McIntosh et al 2015: 5). Early analysis has suggested that when offered in tandem with local network charges, local electricity trading keeps electricity flows grid-connected and maintains grid utilisation despite threats of autonomous DERs. Retailer surveys have found evidence of receptivity, with some utilities beginning to perform aggregator services that combine multiple DER assets to form portfolios and sell the products or services derived from that portfolio either into the wholesale energy market to capture high spot
prices, directly to network businesses, or as an ancillary service to the AEMO (KPMG 2017). Control is key: as KPMG observe, ‘the products and services, and therefore value, of any one portfolio would be subject to the individual technologies captured and the ability for the aggregator to collectively control these assets’ (KPMG 2017: 77-78).

Another marketisation of DERs is through peer-to-peer trading, which requires the existence of suitable market trading platforms. Numerous start-up technology-based firms have recognised the potential for providing platform infrastructure for local electricity trading, and have begun partnering with ARENA and energy retailer-distributors to achieve market power. One such start-up, PowerLedger, utilises surplus renewable energy generated from residential or commercial DER, taking advantage of Blockchain technology, which uses a distributed ledger to facilitate settlements without an intermediary, creating an automated online trading platform for producers and consumers (PowerLedger Whitepaper 2017). PowerLedger is commercially deployed through Vector NZ and WesternPower, and achieved financing through publicly offering shares purchasable through cryptocurrency tokens (Scott 2017; Castles 2017). Its basis in Blockchain ledger and cryptocurrency technology is unique in enabling its peer-to-peer network to become profitable without requiring financial intermediaries, providing a trustless ledger system that settles payments transparently (PowerLedger Whitepaper 2017). Notably, blockchain-based peer-to-peer interactions prefigure energy exchange models that are decoupled from profit-generating value-relations, although remain at risk of becoming internalised into capital through their acquisition and deployment by major utilities.

Another Australian DER market developer, the Decentralised Energy Exchange (dEX) is a software-based platform created by Victorian technology company Greensync that enables
households and businesses to trade grid services provided by their DERs with local network operators (ARENA 2017). This open marketplace seeks to ‘make visible’ the value of energy generated by DERs via entering into power-purchasing agreements with retailers acting as energy service aggregators. The dEX was developed initially to promote demand management by assisting with spreading load-shedding, the voluntary reduction in electricity usage to prevent blackouts, by pooling the latent energy available behind-the-meter across the NEM, thus creating a virtual power plant (VPP). During peak events, the dEX offers households maximum grid price to surrender control of their DERs to network operators (Potter 2017). The VPP is also bundled into a financial product that enables customised portfolios of DERs to be built and dispatched as needed in response to market fluctuations, and hedging against exposure to energy pricing. Another response of retailers follows the popular Californian models of retaining ownership of DERs while leasing them to households or contracting price-purchasing agreements (PPAs), where households pay for the solar energy that the system on their rooftop produces on a per-unit basis.24 As with dEX and PowerLedger, Australian start-up firms promoting this ownership platform have sought to merge with major utilities and telecoms companies, using a sharing economy model to scale up the project rapidly (Potter 2016).

PPAs are increasingly important instruments of renewable energy project financing, defining the revenue and credit quality of a generating project, through circumventing utilities that are often unable to guarantee 100% renewable energy to customers. PPAs can be sleeved-physical, which are directly negotiated between corporate buyers and generators entering into associated arrangements, or synthetic-virtual, which are financial

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24 In 2014, 72% of Californian residential solar capacity was leased by third parties. See: Litvak, N 2015.
derivatives where parties agree to a strike price with payment flows determined by comparison against market prices. The latter do not involve the delivery of energy output to the buyer but typically involve the transfer of green certificates to the corporate buyer from the generator for demonstrating the renewable nature of energy to be delivered to the buyer (Hedges 2017). Major generator-retailers in Australia partnered with ARENA have also moved to capture the ‘innovation niche’ within VPPs, as heralded by AGL’s Adelaide test pilot that leases 1,000 inter-connected batteries to colocated households, generating 7 MWh of storage capacity and 5MW peaking capacity when discharged to the grid simultaneously during peak events (Vorrath 2017; AGL 2017). Such test pilots are strategic projects aimed at demonstrating viability for new business models that have not yet reached mainstream acceptance.25

Financial agents, in coordination with the state-system and renewable energy retailers, have also experimented with the provision of cheap loans for households to equip themselves with DERs and demand-management technology. The Tasmanian Energy Efficiency Loan Scheme (TEELS), launched in May 2017, exemplifies this tendency, a joint initiative of Westpac Group, the Tasmanian Government and Aurora Energy, to provide $10m to households and small businesses for DER purchases on application for a Westpac Credit Card (Sustainable Living Tasmania 2017).

4.3 A critical world-ecological assessment

South Australian minister for energy, Tim Koutsantonis, acknowledges that ‘energy is not a commodity to be traded on the marketplace; it’s an essential utility’ - or, at least, it is difficult

25 With noteworthy irony, the launch of the AGL-ARENA VPP partnership was chosen as the site at which South Australian premier Jay Weatherill confronted Federal Minister for Environment and Energy Josh Frydenberg.
to commodify (Harnsen 2017). Recent expansion of local electricity trading and peer-to-peer, peer-to-aggregator and peer-to-retailer DER energy markets, however, seem to indicate that the institutional space for commodified DER-generated electricity has expanded in response to growing concerns over the threat of widespread household grid secession. To what extent have the energy-sector’s actor-networks facilitated this marketisation of DERs?

Firstly, the pre-existence of a centralised grid infrastructure, and the substantial investment fixed in its materiality, creates negative-value for utilities and other electricity market actors, who are compelled to ensure that their fixed capital is not stranded. Secondly, the privatisation of state-owned network enterprises and the ensuing emergence of the NEM has, in large part, prioritised the ‘rationalisation’ of energy production according to the demands of financialised commodity markets, repressing the social interest, which cannot be adequately captured in derivative-determined price signals. Thirdly, the expanded NEM regulatory space of the state-system is predisposed to ensure the NEM continues operating reliably and achieving politically advantageous household energy prices. Thus, the Regulatory Investment Test and the RET market-mechanism effectively operate to tentatively encourage the development of DERs while ensuring they maintain integrated in physical grid infrastructure as well as the electricity market infrastructure it maintains. Fourthly, the state-system’s semi-independent research incubator organs, including ARENA and CSIRO have facilitated a technics which maps and thereby rationalises extra-human natures to become legible for commodification by market actors, most pertinently in solar irradiation mapping and the promotion of an integrated demand-management-capable ‘smart grid’. Fifthly, existing ‘gentailer’ enterprises have begun demonstration trials that orchestrate ‘smart grid-capable DERs into company-owned VPPs, achieving control over the resource and thus enabling
rent collection through its use. Finally, the emergence of numerous tech start-ups aiming to create platforms that ‘reveal’ the value of DER-based energy through ‘sharing-economy’-style marketability - frequently with state subsidisation - have generally sought not to destabilise pre-existing energy network enterprises through radically decentralised commercial models, but rather to partner with them to rapidly up-scale the commercialisation of their physical or digital technologies. Each of these tendencies, which have been illustrated in the sector survey provided above, generally reinforce the market-orientation of DER-generated energy, and thereby serve to internalise the potentially disruptive social relations they can entail.

Turning to the role of financialisation in Marxist literature, we may also now consider how transformation in the operation of the law of value has affected the uptake and nature of DER diffusion. We initially consider Bryan et al.’s (2015) thesis that within financialised capitalism, risk itself becomes the dominant ‘substance’ of value, whose commodification in financial assets enables the shifting of risk-exposure onto illiquid households by highly liquid financial intermediaries. In this respect, the creation of the ‘prosumer’ subjectivity, of the rationally-acting engaged market participant who not only produces their own energy but is highly cognisant of their energy consumption and production vis-a-vis constantly updated market signals, is pertinent. The ‘prosumer’, equipped with demand-and-supply-management smart-grid technologies, alters their own behaviours in response to the dictates of market signals, an elasticity which is heightened in more financially vulnerable households. Thus, rather than shouldering the risk of fluctuating wholesale electricity prices compounded by grid-wide energy imbalances, energy network enterprises can effectively shift such risks onto newly exposed households, who are faced with even more variegated financial incentives for behavioural modification. Additionally, concomitant with Bryan et al.’s concern with the
leveraging and ‘bundling’ of household debt-repayment streams as a differential but generally low-risk financial asset in mortgage-backed securities, we may identify a similar dynamic operating in the moves by energy market actors to generate and exchange power-purchasing agreements with financial intermediaries based upon DER-generated and aggregated energy streams. This enclosure of decentralised energy streams is complementary with international financial funds’ ongoing turn to purchasing network transmission infrastructures put to tender by neoliberalised state-systems, as was noted in the previous chapter (NSW Treasury 2017).

Additionally, interest-free loan schemes as exemplified by the Westpac-Tasmanian TEELS, are provided to ensure that households can achieve greater energy expenditure-related savings and thereby stabilise their budgets and make more reliable debt repayments. There is little to prevent financial intermediaries from broadening the provision of such cheap loans, such as through mortgage-linked loans, the cheaper that DER-generated energy becomes, insofar as ensuring reliable streams of debt repayments are their chief concern. While the state-system’s endorsement of such financial instruments have been challenged by Tasmanian Greens MP Cassy O’Connor for ‘setting up a corporate credit scheme with a major bank that exposes Tasmanians to a high debt risk’, their systemic significance vis-à-vis the triple crisis has not yet been noted (O’Connor 2017). Here we note pertinence of the Autonomist cognitive-cultural approach’s thesis that in the post-industrial/network-society, the substance of value increasingly becomes attentional and desiring labour. Converging smart-grid capable and informational-communicative platform technologies that interconnect households and grid-service providing enterprises make possible the effective shifting of electricity market fluctuation risk-exposure onto households. This follows the post-Fordist tendency in advanced capitalist economies to appropriate value from socially-reproductive
activities, such as those concerning securing affordable energy, induced by the nascent proliferation of individualised demand-management technologies.

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Summarising the Marxist critique of the viability of a market-led energy transition, biogeochemist David Schwartzman writes that

We are now confronting a clean energy transition that is still too slow. And only when a more robust renewable creation is coupled with rapid phase-out of fossil fuels ... will there be any chance of avoiding climate catastrophe. There is every reason to believe that a full transition with these characteristics cannot be generated in the capitalist framework. (Schwartzman 2016)

In stark contrast to the steady market-oriented transition legislated by the Australian state-system, alongside Scheer’s more reformist prescriptions, Schwartzman articulates an alternate program of radical energy transition toward socialised ownership of the means of production, emphasising the importance of altering the social relations underpinning the energy system (Schwartzman 2017: 153). Nevertheless, as this investigation has shown, the inertia inherent to grid infrastructures and their attendant industrial-financial capital dampens the promise of social transformation through the state-led recuperation of energy generation. Against the optimism of Quiggin (2017), who suggests grid renationalisation as the solution to the compounding challenges faced by the NEM, we follow Jessop (2016) in seeing strategic-selectivity of the federal state-system as too deeply predisposed to further the conditions of value extraction to orchestrate the re-integration of the deeply splintered NEM and its private operators. Particular organs of the state-system have a greater capacity to facilitate the de-commodification of energy generation, such as
the South Australian and Victorian state-government projects to promote publicly-owned large-scale renewable generation projects and by the currently open-source nature of solar irradiation mapping technology. The most promising agents of radical energy-socio-ecological transformation remain the households and communities whose separate and collective efforts - made possible by technological mediation - prefigure a relation to energy that sidesteps market-dependency. These projects, which emphasise democratic ownership over DERs, operate tenuously outside of the standard operation of the law of value, and simultaneously threaten the security of the energy grid infrastructure as it exists in a market-centric framework. They are the subject of a brief discussion in the conclusion under Weinrub’s (2016) rubric of ‘energy democracy’, realising somewhat Gibson-Graham’s (2005, 2015) alternative modes of socio-economic provisioning that effectively carve spaces out from the totalising reach of the capitalist world-system.
Conclusion

Between the prevailing vision of a gradual, evolutionary transition in the socio-technical system toward market-oriented renewable energies, and the world-ecological critique of green capitalism, we may situate the ‘energy democracy’ paradigm, which rejects capitalist social relations whilst providing a positive program for energy transition. It has been described as:

A way to frame the international struggle of working people, low-income communities and communities of colour to take control of energy resources from the energy establishment and use those resources to empower their communities … Energy democracy seeks to reframe energy from being a commodity that is commercially exploited to being a part of the commons. (Fairchild & Weinrub 2017: 16)

The energy democracy paradigm brings together a concern for reclaiming ownership over energy generation and distribution while negotiating the complexities of scale and power in contemporary global capitalism. Its advocates advance a critique of ‘solar individualism – or techno-utopianism’, noting the propensity for a project such as the ‘smart-grid’, ostensibly based around empowering households to dictate the terms of their energy consumption and production, to be internalised into pre-existing capitalist social relations (Aronoff 2016). Centralised renewable energy generation, based on large-scale generating systems and a unidirectional distribution network would, according to the energy democracy approach, reinforce concentrated financial and economic power, aided by a corporate state apparatus unfettered by democratic restraints (Fairchild & Weinrub 2016: 21-22). Moreover, as Bohm et al. argue, ‘capital, the state and discourses of development continuously seek to ‘recuperate’ autonomy and make it work for their own purposes’ (Bohm et al. 2010: 27). These processes of recuperation are often part of the process of ‘accumulation
by dispossession’, the extension of private property rights and market rules into new jurisdictions and spaces of nature characteristic of the neoliberal era (Harvey 2003).

Rather, devolved modes of prefiguring system-wide transition via community or household-based energy generation models are closely related to the Autonomist tendency to eschew state-centric governance models for diverse ‘horizontalist’ social movements (Hardt & Negri 2004). Autonomists evoke the commons ‘viewed as collective spaces created ‘outside’ of the workings of capital, where different social relations and norms can be sustained’ (Cumbers 2012: 169). The technologically-mediated reintroduction of such a commons can enable democratic participatory and horizontal model of ownership, respecting local difference and diversity of ownership forms against market-driven capitalist or statist socialism, which invariably impose non-democratic modes of domination (Holloway 2002). However, energy democracy, when refracted through Jessop’s strategic-relational-approach, departs from the Autonomist tendency for essentialising the state-system as removed from social pressures. Instead, it endorses a ‘reconstituted and pluralistic approach to public ownership that prioritises economic democracy and public participation’, which recognises the relative advantages and disadvantages of the variegated modes of public ownership, whether fully decentralised, municipalised, regionalised or nationalised (Cumbers 2012: 224). As precursors, the energy transitions of Denmark and Germany have demonstrated the integral role of remunicipalisation for decarbonisation, enabled by strong historic localist traditions with high levels of cooperative and mutualist ownership across numerous economic sectors and facilitated by favourable regulatory regimes (Cumbers 2012 and 2016).

What, then, are energy democracy’s prospects in Australia? What historical traditions can enable or hinder the mobilisation
of such a program? As detailed in Chapter 3, the history of Australia’s energy regime has been dominated by state-led transnationalised coal production and electrification programs, and its electrification mostly coordinated by centralised administrative bodies. The lack of a strong pre-existing localist tradition in settler-colonial Australia, despite its European history, has hindered the rapid cultural take-up of communal energy projects. There nevertheless exists a budding movement around energy democracy, operating across multiple scales of governance, bolstered by the country’s significant advantage in availability of DERs and deep penetration of household photovoltaics. As of 2015, community energy in Australia includes 50 projects with a total generating capacity of 10MW, having attracted $23m in community-sector finance, and another 40 projects in development (C4CE 2015; Hicks and Mey 2014). The sector has received financing and coordinating support from the federal state-system through ARENA and the Solar Communities and Towns programmes (Frontier Impact Group 2017; Department of Environment and Energy 2015).

At a more devolved regional level, community energy projects also intersect critically with the ‘just transitions’ movement that has come to the fore in discussions of coalitional social movements facilitating the transition of rural and regional communities toward renewable energy (Canadian Labour Congress 2000, 3). Proponents of just transition, such as the International Trade Union Confederation, seek to overcome the hegemony of ‘jobs versus environment’ discourse as commonly mobilised by state officials working in tandem with fossil-fuel capital. Australian scholars argue that regional movements framed around just transition ‘are challenging and disrupting hegemonic identities of individuals and communities’ in regions historically tied with fossil fuels (Evans & Phelan 2016: 330). Such synergetic campaigns are critical for the demands of local energy democracies to congeal at wider scales. The analysis
forwarded above has furnished several promising points of departure for grafting such alliances. Within the urban context, contemporary informational technologies’ and communicative platforms’ tendency toward networked individualism suggests a further opportunity for energy transition to become devolved and brought into civil ownership. A critical understanding of the ‘bounded relationality’ of technology envisages the delinking of such technologies and platforms from the commercial imperative, against the recuperative efforts of energy capital. Blockchain-based currencies, whilst still in their infancy and relatively inaccessible to laypeople, are a promising avenue of non-capitalised tokens enabling networked interactions vis-à-vis the sharing of energy between households (Lotti 2015; Delahaye 2017; Greenfield 2017). Models of public platform ownership have been suggested by contemporary critics of technology and the ‘sharing economy’, although its application to energy-sharing has not yet been developed (Bratton 2015; Srnicek 2017).

For the sake of brevity, several aspects of the Australian energy transition and the DER quandary have not been addressed adequately in the foregoing discussion, nevertheless important avenues of enquiry. The first concerns large-scale renewable energy projects - the other, perhaps more energetically significant development - not considered in this work. Small-scale systems were the subject of this study for their promise in facilitating decentralised communal social relations. Therefore, the counter-case vis-à-vis large-scale renewable projects has not been explored here. Nevertheless, tracing the transnational political economy of such internationally-financed projects is an important task, and one suited to the world-ecological framework. The second concerns the class dynamics of DER ownership. While it has been the emphasis of this thesis to look towards modes of postcapitalist provisioning that seek to overturn class structures generated by capitalist value-relations, it shies away from concretely engaging with the class character
of households which have already taken up DERs, and the implications of this for further deepening or ameliorating pre-existing class division. Furthermore, while the capacity of DERs to be rapidly mobilised outside of urban areas clearly heralds material benefit for rural Indigenous communities, increasingly under threat by the withdrawal of state-services by a state-system operating in tandem with transnational extractive industry, the already-existing trends have not been the focus of analysis here.

The third avenue of research considers the tendency of the neoliberalised state-system toward authoritarianism when increasingly under pressure by globalised finance and the ‘climate dialectic’ (Jessop 2016; Bruff 2014). The implications of this have been particularly astute with respect to securing energy resources in the wake of ecological disasters (Red 2017). This has been considered with respect to the state-system’s invocation of ‘energy security’ as a discursive strategy of final appeal, although its materially-coercive aspects have mostly related to export-oriented fuel production, and so has not been a core concern of this thesis, which has chiefly considered domestic electricity generation, distribution and consumption. The clear significance of these trends to climate justice and world-ecological outcomes, however, justifies further enquiry. A final area of worthy research would uncover the global commodity chains and the attendant socio-ecological aspects of the production and distribution of household solar photovoltaic panels. The complex and often environmentally damaging practices involved in the extraction of their component metals and manufacturing have been noted elsewhere, although not yet integrated into critical global commodity chain political economies, a project complementary to the world-ecological analysis developed here (Fthenakis & Kim 2011; Turney & Fthenakis 2011).
This thesis has argued that for Australia’s ongoing energy transition to be socio-ecologically sustainable, it must move beyond a centrally-imposed technology-centric and market-dependent model, to incorporate models of socialised ownership over the generation and distribution infrastructure of energy. To develop this argument, the thesis moved through two parts: theoretical and empirical. Each engaged critically the extant scholarship concerning energy transition and technology and then brought a critical lens to bear upon Australia’s current transition.

The first part juxtaposed the mainstream and heterodox theoretical approaches to conceptualising energy transition governance, which were demonstrated to differ primarily over their incorporation of value and class-centric determinants of technical-social change. Both heterodox and mainstream approaches were criticised for maintaining essentialised theories of technology, either positing its neutral instrumentality or reducing it to an implement of domination for the capital relation. Rather, the ensuing discussion explored the potential of technical objects and systems to provide the material basis for alternative social relations. To provide a value and class-theoretic approach, the world-ecological framework was critically extended to emphasise a contemporary value theory that accounts for finance and broader forms of appropriated labour. Further, to maintain an institutionally-cognisant historical materialism, the framework was situated alongside contemporary debates over the role of the state-system and infrastructures in mediating socio-ecological conflicts.

The second part sought to bring this framework to bear in illuminating the determinants and possible pathways of Australia’s current energy transition. It began by tracing a brief history of ‘cheap energy’, emphasising the role of the state-system and its interaction with competing fractions of capital in securing energy for domestic and international consumption vis-
à-vis the world-system. Deregulation has exposed infrastructures to market-dependence and enabled the commodification of electricity traded over the NEM, accelerating the emergence of socio-ecologically growing negative-value. The threat of fettered capital has pressured the state-system to extend the commodity frontier through new infrastructures, markets, and technologies that enable new flows of secure and cheap energy. The thesis culminated in an investigation of distributed renewable energies (DERs) as technical objects predicated upon new abstract-social-natures, and systemised into a ‘smart-grid’ with potential to enable alternate social relations over energy generation. The hegemonic role of finance over the institutional orchestration of these technics was shown to threaten to co-opt their disruptive capacities by enframing their uptake in an individualised and market-oriented manner, where risk-absorption is forced onto households.

Critically, these technological and economic processes are continually contested. By bringing a relational concept of technicity and a spatially-sensitive politics to world-ecology, the approach developed here has sought to illustrate novel forms of commercial enclosure and the actual and potential sites of publicly beneficial recuperation within the Australian energy sector.
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