David Thomas. "Keeping the Lights On: Oil Shocks, Coal Strikes, and the Rise of Electroculture." *Mediations* 32.1 (Spring 2018) 95-124. www.mediationsjournal.org/articles/lights-On-electroculture.

Keeping the Lights On: Oil Shocks, Coal Strikes, and the Rise of Electroculture

David Thomas

Writing as the belle epoch drew to its acrimonious conclusion amid a hail of pickets and truncheons, Raymond Williams took issue with a stagist model of social analysis that has remained a stubborn feature of historiographic writing into the present. Williams complained that a scholarly preoccupation with "epochal" social formations often occluded recognition of the historical movements and tendencies that were concurrently active "within and beyond" the "dominant" regimes.[1] Intent on moving beyond this kind of blinkeredness, he prompted cultural sociologists to focus more intently on the effects of "residual" and "emergent" forces, thereby attempting to grasp historical and cultural processes in all their contingent and mutually determining dynamism.[2] In this chapter I apply Williams's triadic conceptualization of social process — one attentive to the effects of residual, dominant, and emergent forces — to the study of energy systems and their attendant "energy cultures." I attempt to draw out the political implications of these imbricated systems' different technological and social compositions. Repurposing the term "electroculture,"[3] I claim that a distinctive set of social formations and relations of production emerge in the wake of the 1970s energy crisis, as policymakers start to develop electricity into the signature fuel — and material medium — of a sweeping cybernetic restructuration of the global energy system.[4] Yet, in accord with dynamics that Williams found to be typical of historical process, the mainlining of these new technologies not only changed the structural practices of the dominant petroculture, it also served to reactivate residual modes of class struggle that had first been developed in the heyday of steam. As Britain's miners attempted to assert their interests in the context of a changing energy system they used modified versions of their old steam-era tactics to force the British government into an embarrassing series of political capitulations. The short-term success of their struggle hinged on the historical irony that the U.K.'s electricity — the lifeblood of the cybernetic turn — was in large part a product of domestically mined coal.

In discussing "energy cultures" in this fairly loose and expansive fashion, I define "culture" in the broadest possible sense, and again I follow Williams in considering it as the shared experience of "the institutions, manners, habits of thought, and intentions" that together constitute a way of life.[5] Yet in focusing on energy I also take up Imre Szeman and Dominic Boyer's claim that "[w]e can no longer fully understand developments in culture, society, politics, and economics without paying attention to the role played by energy in each domain."[6] I build on this contention by attempting to parse the distinct forms of life and modes of struggle that arise through the socio-ecological production of the different — and overlapping — energy systems that are concurrently operative in a given time and place. For energy systems do not simply "power" life in a hidden or subterranean fashion. They are instead lived in such a complete way that we can begin to identify "the institutions, manners, habits of thought, and intentions" that are proper to each. Despite the near self-evident truth of this claim, however, it has taken a surprising amount of time for historiographic analysis to acknowledge how fully questions of energy have determined the unfolding of political struggle and technological development. Indeed, as I review key materialist accounts of the miners' strikes and the cybernetic turn, it is clear that — with the notable exception of George Caffentzis — contemporary commentators have a tendency to overlook energy's central significance. Thus at the same time as this paper seeks to revive some of the central categories of Williams's historiographic theory, it also seeks to address the energy lacuna that reside at the heart of his account of this cycle of struggles.

The Body Electric — Defining Electroculture

The logic of understanding steam and petroleum systems as "residual" and "dominant" is perhaps obvious enough not to warrant too much explanation. But the idea of petroculture being slowly modified and displaced by the emergence of electroculture is arguably more contentious. Can electricity even be said to be a fuel? There is something inherently ambiguous about the abundant and precisely controlled electron flows that now mediate and animate so many facets of life and work in the present day. For one thing, we can never be entirely sure of their provenance. Though "noiseless and, at the point of conversion, absolutely clean," we know that electricity is produced through diverse means.[7] Some, such as nuclear fission and coal combustion, threaten titanic forms of ecological misadventure. Others, such as solar and hydro, promise to help the world system evade the grim prospects of climate change and nuclear disaster. No such ambiguity surrounds the combustion engine. We have but to turn the key to see the chemical agents of anthropogenic climate change escaping from the tailpipe. Yet in activating an electrically powered device we are left unsure if the current that supplies it is carrying us into a cleaner future, or a hotter, darker, and dirtier tomorrow.

Electricity's ambiguity stems from the fact that — unlike the other fuels that we routinely use in the course of a day — it cannot be traced back to a signature raw material such as natural gas or oil. In the bulk of its industrial and commercial forms, we encounter electricity as a flow of electric current produced through the turbine-driven rotary stimulation of electromagnetic fields. Channeled through the conductive mediums of wires and cables, traveling at somewhere between 50 to 99 percent of the speed of light, electricity is deployed on a planetary scale with industrial force. Moved with infinitesimal precision through silicon microchips in the near instantaneous interplay of billions of mutually responsive transistors, electricity serves as the universal medium of late capital's social-machinic cognition. This comprehensive range of applications has allowed developers and policymakers to use electricity as a terraforming agent, a means of propulsion, and an unrivaled means of informational production and exchange. Energy historian Vaclav Smil writes that the "precise control" of electrical delivery now ranges "from less than one watt for the most efficient microchips to multi-gigawatt flows in large national or regional grids," while its "focused applications" can be found "on any conceivable scale… from micromachining to powering the world's largest excavators and the world's fastest trains."[8] The near universal range of the potential use values of electricity — even commercial electric flight now seems within reach — allows global governance to countenance the possibility of a wholesale transition to a post–fossil fuel economy.[9]

Yet although the distinct features of what I define as electroculture begin to predominate in the wake of the 1970s energy crisis, it can of course be argued that electroculture began its emergence much earlier. Key breakthroughs in electrical engineering — including the development of experimental electrical trains — were made throughout the nineteenth century, and the world's first electrical supply network was operational by the century's close. The rapid pace of technological innovation that characterized the two world wars also led to key electromagnetic communicational developments such as radio, sonar, and the proto-computer, the Turing machine. In the immediate postwar period, electric lighting and consumer electronics such as refrigerators and radios began to wind their way into the vast bulk of households in high-income countries, while state subsidized research and development departments established the foundations of what Ernest Mandel describes as a "third industrial revolution."[10]

It was not, however, until the oil shock of the 1970s that global governance began in earnest to build toward deploying electricity as its signature fuel and its key instrument of worker control and production management. Doubtless, much of the groundwork had been laid in the immediate postwar period. Written at the close of the 1960s, Mandel's magisterial *Late Capitalism* had already identified the harbingers of a "third industrial revolution" centered on computing technology and the intensified automation of the productive process. Yet Mandel's work, so pioneering and prescient in its vision, was still in some respects the fruit of a more energy-innocent age, one that had not yet been compelled to fully countenance the complex socio-ecological contingencies and consequences of capital's ever-deepening dependency on fossil fuels. Indeed, from our own vantage, it is genuinely surprising that the 1975 English translation of *Late Capitalism* declines even to index the word "energy." Historiography's apparent reticence to grasp the historically determinative significance of energy is, however, in no way characteristic of attitudes in policy making circles of the era. Arriving only a few years after the first publication of Mandel's magnum opus, the 1970s energy crisis brought the matter of energy to the forefront of policy making agendas. And as the initial computational research that Mandel so exhaustively documented concurrently issued in the development of the microchip — Intel launched the world's first commercial microchip, the 4004, in 1971 — the stage was set for the full emergence of electrocultural policymaking.

After Oil? — The Energy Crisis and the Electrical Fix

The emergence of electrocultural policymaking in key economies such as the U.S. and the U.K., unfolds through two key initial phases. In its first phase the dominant concern of policy makers — spooked by the prospect of peak oil — is that of energy efficiency. Yet, in time, the immediacy of concerns over the burgeoning stagflation crisis begin to override the initial long view. In the U.K., electrocultural policymaking enters its second phase at the cusp of the new decade as Tory party think tanks begin to consider redirecting information technology as a means of improving the "economic efficiency" of the entire productive process. As other governments plotted a similar course, and as the original goal of energy efficiency was made increasingly subordinate to the concept of cost efficiency, the total energic inefficiency of the world system increased dramatically. Commodity production became a fully globalized phenomenon, distributed across immense intercontinental tracts of time and space. The search for deeper profit margins ("cost efficiency") saw capital reaching out beyond the old industrial zones, undertaking kilowatt-hungry logistical projects whose end goal was the exploitation of less politically enfranchised workforces. As this tendency became increasingly normative, the effect of this cybernetically orchestrated, just-in-time productive process was to make global GDP contingent on a globalized energy system that relied on continually escalating levels of electrical input. Concurrently, under the ideological banner of "globalization," shipping lanes and supply lines multiplied and proliferated, leading to the consolidation and expansion of a global seaborne petroculture. This restructuration led to massive carbon outputs, and dependency on coal (and, ironically, oil) has only substantially increased year over year in the aftermath of the oil crisis. In their initial attempts to improve capitalism's energic efficiency, planners accelerated carbon emissions as they increasingly redesigned the global energy system around coal, an energy-dense fuel whose combustion is now regarded as the single greatest source of global carbon emissions.[11]

The proximate causes of our own climate quandaries are, then, in evidence in the "fixes" that capital's developers and policymakers supplied to an earlier series of problems that first erupted around the so-called energy crisis. The "oil shock" had been very keenly felt in the United States; indeed, disquiet rippled throughout oil-dependent economies of the global north. With oil production in the U.S. in apparently terminal decline, the Organization of the Petroleum Exporting Countries (OPEC) began to flex its new-found political clout, enacting an oil embargo in response to the U.S.'s support of the Israelis during the 1973 Arab-Israeli War. The resulting shortfalls in oil supply had complex and varied consequences, helping to destabilize the already sluggish global economy, and forcing the Global North to reconsider the geopolitical ramifications of its oil dependency. A new "energy security" discourse emerged in key policy making circles of high income countries.[12] Oil companies began to diversify, investing in coal production in low-income countries, while governments began to consider how they could lessen their dependency on OPEC. In addition to the immediate geopolitical considerations, the jarring prospect of fossil fuel exhaustion — prefigured by the depletion of the U.S.'s vast oil reserves — lurked in the background, and determined the subsequent strategizing by elites.

The response of planners and experts was more considered than a simple reshuffling of their primary fuels. As elites began to consider the prospect of transitioning away from "the oil-auto assembly line economy of the post-war era" their emphasis was not just lessening oil dependence, it was also on increasing the efficiencies of the entire energy system.[13] In 1975, key U.S. energy advisor — and one time member of the Manhattan Project — Edward Teller drafted a document that exemplified this logic. Moving away from the rough parity that had been established between oil and electricity consumption in the U.S.'s postwar years, Teller's "Energy: A Plan for Action" "envision[ed] a radically new system where electricity would demand 50 percent of the total energy, with transportation reduced to 11 percent."[14] Though anti-nuclear activism and concerns over profitability hindered the development of the nuclear generators that Teller saw as crucial components of this plan, and though electricity use has yet to overshadow transportation to the extent that Teller projected, his roadmap for energic consumption proved influential. The erstwhile dominance of oil slipped into decline as coal began to regain its market share. And as the planners' IT-driven restructuration began to unfold, the British coal industry, which had been in constant decline in the postwar period, temporarily regained political traction.

But to supply this emergent electro-economy it would initially be necessary to once again ramp up coal production and bring a new generation of nuclear reactors online. Britain was at the forefront of these developments, with the publishing the government white paper the *Plan for Coal* in 1974, and the commissioning of a new series of nuclear reactors the following year. At the heart of the *Plan for Coal* was a new cybernetic flow monitoring system, dubbed MINOS (Mine Operating System), a "highly centralized, hierarchically organized system of remote control and monitoring in mines comprised [of] a series of computerized systems, which allowed control room operators, as remote supervisors, to collect data and monitor the work of the miners."[15] This system offered an exemplary instantiation of the strategy that Teller proposed, in which cybernetic systems were mainlined as a means of pushing back against the "inefficient" depletion of the earth's reserves of usable energy:

> Computers have been introduced in central control stations to control inertia for the purpose of optimizing the use of energy by drawing at any time on the cheapest available source of electricity. These computers are also beginning to be used to store and display data about the state of the major components of the generating plants and transmission lines.[16]

In the British context — and extending somewhat beyond the plan Teller proposes here — cybernetic technology would be used to manage the energy commodity chain's every stage, from extraction of raw materials, to distribution of the final product. Faced with the contradictory demand to ensure economic growth while reducing inefficient energy expenditures, the precision with which electricity could be delivered and monitored helped establish it as the informational medium and preferred fuel of the cybernetic restructuration. The functioning of the global economy's fixed capital rapidly became, in Smil's words, "universally" contingent "on electronic monitoring and automation" as "electricity's role as the controller, regulator, and enabler of materials and information flows became… fundamental" to every aspect of the productive process.[17] From this juncture onward capital became more and more irreversibly dependent on electrical current, to such an intrinsic and intensive extent that it would soon become easier to imagine the end of the combustion engine than the end of computing.

By increasing efficiencies, engineers hoped to forestall the danger of resource depletion. Yet in a historical irony that was intrinsic to this particular strategy, the very methods used to ward off the danger were themselves dependent on electrical current. Planners found themselves locked into a recursive loop in which they improved energy efficiency at the same time as electrical demand underwent ongoing expansion. Smil identifies the essential fallacy at the heart of this "anti-limitationist" approach by repeating " Jevons's venerable paradox" that "it is wholly a confusion of ideas to suppose that the economical use of fuel is equivalent to a diminished consumption. The very contrary is the truth."[18] But despite its apparent contradictions, the anti-limitationist strategy helped to kick-start the frenzied pace of innovation that has defined the tech industry since the early 1970s, leading to the "rapid doublings of performances" and "relentless decline in prices" that has characterized the industry in the intervening decades.[19] A relatively simple material strategy underlies the subsequent complexification of computational technology, in which developers sought an "ever-denser" concentration of transistors on microchips, in order to accelerate the number of multiple inter-transistor exchanges that could be executed in increasingly tiny fractions of time.[20] Innovations within this sector reshaped the productive process, and its attendant social relations, to such a comprehensive extent that it became difficult to grasp the full scale of their impact.

Importantly, however, it has thus far proved all but impossible to replicate the technological gains made in the area of microprocessing in the domain of energy production itself. While consumers in high-income countries have been acclimatized to exponential growth rates in the speed and complexity of information technology, we have yet to find "any established energy production or conversion technique" capable of following the "path of improving performance" that characterized the "microchip era" that was initiated in 1971.[21]

One way to conceptualize the divergent technological tendencies that have subsequently defined electroculture is to distinguish between the system's "input" and "output" sectors. In the latter sector, microprocessing technology spearheaded a massive cybernetic transformation of the productive process, one that was premised on unlocking the unique material properties and use values of electricity. Although the effects of these developments were certainly felt in the former sector — most notably in management's deployment of cybernetic flow-managing technologies in mines and power plants — no comparably radical revolution of electricity generation actually materialized. Instead, as the projected transition to nuclear stalled it could even have been said to have undergone a prolonged regression, as policy makers and investors increasingly fell back on technologies whose fundamental operational principles were known to the nineteenth century. Identifying this problem, while critiquing the key fallacy at the heart of capital's stubborn attachment to its anti-limitationist energy strategy, Smil writes:

> Any expectations that the future performance gains of renewable energies in general, and solar PV [photovoltaic] electricity generation in particular, will resemble the post-1971 record of packing transistors on microchips are thus a consequence of succumbing to what I have called Moore's curse, an unfortunate categorical mistake that takes an exceptional performance as a general norm of coming technical innovation.[22]

In referring to this "categorical mistake" as "Moore's curse," Smil alludes to Gordon E. Moore, the computer developer who first forecast microprocessing's decades of exponential developmental growth. Writing in 1965, Intel's cofounder correctly anticipated the annual to biannual doublings of transistor density that defined technological advance in the coming decades. This phenomenon — which has only begun to wane in very recent years — was subsequently dubbed "Moore's law."

Smil's somewhat classicist recasting of Moore's prediction is designed to illustrate that the cultural experience of these developments fatefully warped popular understanding of technological innovation. In contrast to Teller's hopes, it has thus far proved all but impossible to reconcile the conservation of usable energy with the rapid development of an ever-more automated and energy-hungry productive process. In Smil's estimation, the only reason that this situation surprises us is that consumers in high-income countries have been habituated to the lived experience of Moore's law, and have thus come to mistake an exception set of circumstances for a universal norm. A more sober appraisal of the underlying dynamics forces us to confront the fact that planners are given little scope to reduce absolute energy consumption when energy demands are at the same time being universally expanded in order to sustain the continually rising organic composition of capital.

From "Energy Crisis" to "Climate Crisis" — The Developmental Arc of Electroculture

There are, however, some signs of progress in the domain of renewable energy generation. Peter Simon Vargha — Chief Economist at Hungarian oil and gas company MOL — avers that there is good reason to anticipate a more rapid and economically viable energy transition than agencies such as the IEA (International Energy Agency) have tended to project. Indeed, highlighting "collapsing" renewable energy installation costs, Vargha argues that we are fast approaching a crucial "tipping point" in an emerging energy transition.[23] Writing in 2015, Vargha noted that rapidly changing energy markets have seen the IEA compelled to modify its renewable energy outlooks in a more favorable direction, with every recent report heralding a progressively larger market share for the emerging technologies. His reading of this overall trajectory was apparently confirmed as the IEA's 2016 WEO (World Energy Outlook) report recently trumpeted the "decoupling" of global emissions and economic growth.[24] An encouraging, but by no means, specular development lay behind the sweeping rhetoric: The IEA had found that global carbon dioxide emissions had held steady at 32.1 billion tons, "having remained essentially flat since 2013."[25] The institution's "preliminary data" suggests that emerging renewable energy markets played a key role in these developments and attributes much of the apparent success to progressive Chinese policy making initiates. They concluded that China's "restructuring towards less energy-intensive industries and [its] government's efforts to decarbonize electricity generation pushed coal use down."[26] To what extent this reduction of carbon emissions and coal usage simply indexes the much-storied slowdown of the Chinese — and, indeed, global — economy is something that the report declines to address.

Yet however capital's energy future actually unfolds, thanks in no small measure to Smil's decades of research, the basic outlines of electroculture's historical development are now clear. While the development of electricity's potential applications unfolded with intensifying velocity, the technologies used to *produce* electricity stagnated and became increasingly dependent on fossil fuel driven turbines. While decades of climate science struggled to divert policy making attention from "energy crisis" to " climate crisis" these divergent trends continued to ramify leading to a contemporary situation in which capital's championing of the apparently "immaterial" tech industry manages to both mask and exemplify its underlying and ongoing dependency on the carbon-driven engines of anthropogenic climate change. For the time being, the net effect of these dynamics is that the signature products of the tech industry — the microchip, device, server, automaton, and network — form a complete postindustrial circuit with the power plant and the strip mine.

The situation in which we find ourselves is not, as I have already begun to suggest, simply a product of random contingencies or inadequate foresight on the part of planners. The conflicted developmental arc of electroculture was determined as capital's general laws of motion — specifically the tendency of the organic composition of capital to rise — became embroiled with the complex material structures and feedback loops of the world's ecological systems. Compelled by its inner laws of motion to intensify the automation of the productive process, capital has become more and more deeply dependent on electricity, the indispensable fuel of its most sophisticated technologies, and the effective material lifeblood of its key monopolies in the tech industry.

It is no accident that it is within these fields that capital's postindustrial circuitry works at the highest rate of profit. Indeed, as the viability of the entire postwar valorization process became increasingly contingent on more and more rapid cycles of technological renewal, innovators in key sectors were well placed to effectively monopolize the "technical process." As Mandel demonstrates, in the postwar period "technological rents" become a key means of profit extraction as "discoveries and inventions which lower the cost of commodities but cannot be generalized (at least in the medium-run) become generalized throughout a given branch of production and applied by all competitors."[27] The structural dynamics that underlay the exercise of "technological rent" are facets of the general functioning of monopoly capital itself, where "difficulties of entry, size, of minimum investment, control of patents, cartel arrangements, and so on" allow key players to function as the gatekeepers of economic survival.[28] George Caffentzis identifies a similar set of fundamental patterns at play within the energy sector. In a key essay from the early 1980s, Caffentzis argued that utility companies and extractive industries were now effectively extracting a "power tribute" from a vast network of consumers who depended on electricity for the very reproduction of life.[29] It was not only the productive process that demanded escalating energy inputs, but the reproduction of human bodies was now a predominantly electrocultural phenomenon.[30]

Yet while this deepening electro-dependency resulted in an intensely sophisticated productive process, capital has yet to evolve a means of generating electricity that has proved capable of freeing it from the prospect of massive ecological blowback. In understanding this divergence it helps to recall there are two very different kinds of material and infrastructural challenge under discussion here. Microprocessing — the beating heart of the automotive turn — relies on the construction of tiny, intensely complex, channels and gates for electrical current. To give an idea of the current complexity of the technology we could look to the Xilinx, which chip boasts the largest FPGA (Field-Programmable Gate Array), containing more than twenty billion transistors. Energy production entails the massive planetary-scale harnessing of the world's contingently concentrated animate forces. The different scales of magnitude on which these tasks are necessarily pursued should not be overlooked, for as the mathematical biologist D'Arcy Wentworth Thompson demonstrated in his study of organic life forms, the intrinsic potentialities of material enterprises are always in key respects determined by the divergent ways in which physical forces impact material structures of different size.[31] Indeed, the scale of fixed capital's energy appetite has increasingly forced planners into a corner. As governments backed away from fission generators — in deference to public fears over the potential scale of nuclear disasters, and in response to unpromising returns on their investments in nuclear power — they retreated to the use of fossil fuels, a familiar set of energy sources that still, in time, served as the causes of a wholly unfamiliar set of world-ecological quandaries.[32] Yet in many respects the apparently divergent prospects of nuclear disaster and climate crisis simply recognize the same fundamental problem: postindustrial capital's energic appetite now necessarily plays out on a fully planetary scale, with fully planetary consequences.

Lights Out — Syndicalist Struggle in the Age of Microprocessing

With these far broader considerations in mind, I want now to return to the case study that anchors this essay. For despite the conflicted and confounding outcomes of the anti-limitationist turn to electricity, for the British coal miners of the 1970s the changing policy-making climate arrived as an unanticipated boon. In the golden age of Fordist petroculture, oil cut radically into coal's market share, but in the years following the oil crisis of 1973 this transition slipped into reverse. In the immediate postwar period, British coal supplied more than 90 percent of Britain's inland energy consumption: "This coal was priced below what it would fetch on the market, in order to subsidize the profits of the rest of British industry. Miners were constantly exhorted to produce, first by the 1945–51 Labour government, then by its Tory successors."[33] But in 1957 the industry went into steep decline as cheap oil began to displace coal as heavy industry's chief fuel. Things worsened in the 1960s as the development of the North Sea gas fields and the use of diesel engines on the railways deprived Britain's National Coal Board (NCB) of two of its key markets: "Coal dropped from 85.4 per cent of inland energy consumption in 1955 to 46.6 per cent in 1970."[34] As demand slowed, the NCB looked for ways to cut production costs, inaugurating a period of rapid mechanization. Here, the "most important development was the spread of power loading, which involved coal-cutting and loading in one single mechanical operation."[35] By 1968, 92 percent of British coal was power loaded, a dramatic rise from only 23 percent in 1957. As Alex Callinicos and Mike Simons write, "[t]he result of these changes for the miners was catastrophic. In 1955 there were 698 collieries. By 1971 the number had fallen to 292."[36] Concerns over global oil supply thus arrived at a particularly opportune moment for Britain's miners. As electricity emerged as the indispensable medium of capital's post-Fordist restructuration, some of King Coal's old luster returned. The emergent energy economy's intensifying reliance on the signature raw material of the steam era had the effect of revitalizing the residual strategies of Britain's trade union movement. Thus rather than a simplistic sequential development of energy infrastructures and corresponding modes of struggle — in which new political and technological modalities simply displace the old — we instead observe complicated interrelations between residual forms of class struggle and newly emergent productive forces.

The decade's definitive conflict arrived in 1974. Yet prior to the 1974 strike, global elites and labor unions had already begun to sense the slowdown that prefigured the oncoming global recession. In the years immediately prior to the oil crisis both parties had grown restive. On the cusp of the technocrats' full-fledged summons to post-Fordist electroculture, trade unionists had begun a return to modes of combative self-assertion not seen in Britain since the prewar period. In a pattern that would define British coal worker militancy in the aftermath of the belle epoch, the miners' first strike in 1972 — the first in some fifty years — targeted the nation's power stations. Arthur Scargill — the leader of the NUM during the famous 1984 strike — was then a rising force in the NUM's newly militant wing. Looking back on the successes of the early 1970s he describes the miners' methods: "We produced a thousand pickets in an hour and a half on Ipswich dock, and stopped the dock in an hour. We left a token picket at the docks, moved on, and closed down the power stations one by one. Within two days we'd shut the whole of East Anglia."[37] In tandem with the cessation of coal production, the miners' picketing strategy allowed them to choke off the coal supply to East Anglia's power stations.

On the ground, the conflict played out as an essentially logistical struggle that relied on identifying crucial chokepoints in the country's energy distribution systems. Yet these logistical struggles ultimately took their bearings in relation to a more theoretically grounded appraisal of the coal industry's changed structural position in Britain's real economy. The miners had ascertained that the circuit of money capital was now in key respects dependent on the electrical circuits of Britain's domestically powered grid. With this knowledge in hand, and against the backdrop of a waning oil supply, the miners exerted their new found political clout. Faced with energy shortfalls in oil and coal, Heath capitulated to the miners' demands, leading to a bump in pay rate that would set the terms for the subsequent strike of 1974. Only a year after the miners' successful strike, Heath responded to escalating levels of inflation by freezing pay levels throughout the public sector. This policy produced a pushback from workers who had seen real wages fall into decline under the very same set of economic pressures.

By 1973 the NUM was squaring up for another strike. In preparation, union leaders mandated a work-to-rule policy, eating into the nation's coal stocks. When the miners finally struck again in 1974 Heath put in motion a contingency plan that proved one of the most comprehensive political miscalculations of recent British history. In response to the threat that the miners now posed to the viability of Britain's coal-fueled power stations, Heath returned to the kind of emergency measures that Britain had relied upon in the course of the Second World War. In an attempt to manage consumption, and preserve the nation's scanty coal stocks, Heath mandated a "Three-Day Work Order" which dictated that commercial use of electricity be restricted to only three consecutive days in a week. The policy — popularly known as the Three-Day Work Week — revived the concept of rationing which had been such an entrenched part of the besieged islanders' wartime psyche.

Yet as "the lights went out" across the country, the Three-Day Work Week served as a punctual and spectacular demonstration of how contingent the postwar economy had become on electricity. This was an ill-designed form of political theater that effectively functioned as a monumental illustration of the miners' resurgent power at the heart of Britain's emergent electroculture. Compounding his first mistake Heath then called a snap election, proposing that it would determine "Who governs Britain?" The conservative government lost, returning Labour to power with a mandate to lessen industrial tensions.

In the miners' conflict with Heath it had become evident that the question of "who governs" — the question of sovereignty and popular legitimacy — was now in part contingent on who controlled "the lights." In the course of the strike of 1974, in their attempts to stake their claims to energy sovereignty, Pierre-François Gouiffes writes that "[b]oth parties deployed quasi-military resources during these conflicts."[38] It should be no surprise, however, that the government's and the miners' different assemblages of strategies and tactics should be recognized as "quasi-military resources" for, as Deborah Cowen has demonstrated, the very concept of logistics originated in the context of military planning. Indeed, the militaristic rationale of logistical practice has remained a crucial feature of its exercise, even in its most superficially benign applications.[39]

The same field of conditions that produced the planners' turn to electricity had thus presented Britain's miners with a complex confluence of pitfalls and opportunities. The bitter experience of contraction in the postwar years left the miners acutely aware of the threats that technological developments posed to the workforce. Yet taking heart from the new centrality of coal, and fired by the resentments of workers who were increasingly feeling the pinch as global boom turned to global downturn, the miners aimed to redefine how the *Plan for Coal* was implemented. For, while the miners could scarcely stand to reject the government's plans to revitalize their industry, it was clear that the cybernetic project at its heart promised to erode worker autonomy.

Given this field of conditions, what subsequently ensued was a struggle between the residual steam-era political strategies of a resurgent syndicalism and the new strategies of elites who increasingly repurposed electrocultural technologies in reactionary fashion. In their subsequent negotiations with the newly incumbent Labour government the mining unions attempted to hold ministers to their commitment to expand coal development while resisting the fully fledged implementation of MINOS. This strategy was still in effect in 1983, on the cusp of the confrontation with Thatcher. At the national level, the NUM's *Interim Assessment of MINOS* "focused upon the job loss projections which confirmed the existence of a major pit closure programme."[40] Yet "[r]ank-and-file miners who were experiencing the impact of MINOS upon the labour process... were equally concerned with the issues of deskilling and control."[41] In the course of the miners' discussion of the subject the NUM's South Kirby branch put forward a motion that was ratified at the union's 1983 conference:

> The draft agreement sought to establish a procedure for negotiating technological change with the *status quo* prevailing until agreement is reached. The agreement would have preserved jobs through reductions in working time... Moreover, it would have eliminated computer-based work-monitoring systems like FIDO which would be unlawful under the Swedish and Norwegian Work Environment Acts.[42]

Miners had long been famed for their success in holding Taylorist management techniques in abeyance. In 1925, Cater Gooderich argued "the very geography of the working place inside a mine" underpinned the miner's longstanding capacity for autonomous self-assertion. The characteristic technique of pit mining in the early days — the room and pillar method — saw men working in small teams, compelled to determine "where to cut and how much rock to leave in place to prevent cave-ins."[43] As Gooderich puts it "the miners' freedom from supervision is at the opposite end of the spectrum from the carefully ordered and regimented work of the modern machine-feeder."[44] The miners' evasion of full-bore Taylorist working conditions had thus been contingent on the ways in which their remote working environment — deep pits sometimes saw teams of men working over a kilometer underground — insulated them from the prying eyes of management.

It was now evident, however, that innovations in the microprocessing sector threatened to considerably expand the surveilling capacities of management. As computer monitoring and data collection techniques penetrated into the full depth of the mine, pit miners found themselves exposed, for the first time, to the possibility of constant real-time remote supervision. Moving information at near light speed from periphery to center, new cybernetic technology would allow management to vault the informational distance between coalface and command center. Harnessing the material properties of electricity, engineers furnished management with the capacity to assess situations and dictate actions in the most remote locations. Under such conditions, miners could no longer count on maintaining the modes of autonomous self-management that they had exercised in the days prior to the microprocessing revolution. The precision and speed with which electricity could be controlled promised to become the speed and precision with which workers could be managed.

As we already have seen, in the postwar period, Taylorist production methods had already made some significant incursions into the miners' workspace. Yet, relative to other sectors, miners continued to enjoy high levels of workplace autonomy, and indeed, though in decline, the old room-and-pillar method was still in use in many quarters. As Timothy Mitchell observes "[t]he militancy that formed in these workplaces was typically an effort to defend this autonomy against the threats of mechanization, or against the pressure to accept more dangerous work practices, longer working hours or lower rates of pay."[45] The miners drew on this residual set of concerns and tactics that as they assessed the proposed introduction of MINOS. Of particular concern was FIDO (Face Information Digested Online), a crucial component of the larger system, one "that would allow extensive levels of [coalface] supervision over and above that which had previously existed."[46]

In forestalling the implementation of this fully electrocultural environment the miners attempted to revitalize a second set of strategies that were, in Timothy Mitchell's view, the most effective feature of their old modes of militancy. Mitchell argues that while the autonomous nature of their working experience had given miners a taste for self-determination, they were only able to exercise and defend this autonomy as they came to understand their crucial position at the heart of the steam economy's commodity chains. Strikes in the energy sector proved unusually powerful political tools because of the dispersed and widespread impact of energy shortfalls: "the flows of carbon that connected chambers beneath the ground to every factory, office, home or means of transportation that depended on steam or electrical power."[47] The outcome of these dynamics was that "[t]he flow and concentration of energy made it possible to connect the demands of miners to those of others, and to give that argument a technical force that could not easily be ignored."[48] For a time, electroculture's full emergence actually amplified the potential reach of the old methods. For in the decade or so that stretched from the oil crisis to the 1984 strike, control over domestic coal flows effectively acted as a proxy for control over the nation's electricity. The strikes of the early 1970s not only reminded the miners of how effective these residual methods could still prove to be, they also served to underscore how essential electrical circuits had become to the smooth functioning of the valorization process — to the circuits of investment, production, circulation and consumption that lay at the heart of capital's real movement.

But just as the unions were reviewing the ways in which the *Plan for Coal* could be turned to their advantage, so too with the Conservatives intent upon regaining the upper ground. These were the years that geographer Matthew Huber defines as the incubation period of neoliberalism.[49] In Britain, a chastened and radicalized conservative movement licked its wounds and began to await the opportunity to outmaneuver the miners. In particular, the conservative think tank the Selsdon Group had learned from the miners' successes. They mirrored the miners' strategies, drafting a new playbook of logistical tactics that explicitly understood political power in relation to the nation's grid system. Thus as the Conservative party began to draft a new economic strategy, one of its keys concerns was circumventing the miner's control of the British economy's energy inputs.

"The Enemy Within" — The Ridley Plan and the Changing Face of Energy Security

The Ridley Plan was circulated in 1977, and it proposed to reverse the British recession through the application of a new mode of quant-heavy corporate governance.[50] The first step toward the marketization of Britain's nationalized heavy industries was obtaining and publishing "unit costs." Ridley spelled out his rationale in the terms of new "cost efficiency" protocols: "any attempt to improve efficiency must start from unit costs."[51] Obtaining this information would allow the government to measure the economic efficiency of every sector, breaking each field down into its smallest constituent units in the hope of isolating, and expelling, elements that were punching below their weight. This was, of course, an atomizing discourse, which inherently subjected industries and workers to a panoptic mode of surveillance. Not for nothing was this process defined, by its exponents, as one of "fragmentation."

Ridley was explicit that this mode of economic rationality marked a departure from the kinds of industrial management that had prevailed in the postwar period, in which production costs had been determined by a "mixture of the political pressures and the union pressures."[52] In such a context "striving after efficiency" had tended to be "fruitless — because the financial inputs and the financial outputs were the product of political determination."[53] Informational analysis would play a key role in restoring industry to market "rationality." The shift of emphasis — from concerns over energy efficiency, to concerns over cost efficiency — is key to understanding the subsequent shape of Britain's economic reorganization, and defines two of the initial phases of the emergent electroculture.

In laying the ground work for the British energy sectors' entry into a more fully " globalized" energy market — a project that entailed restructuring the large publically owned industries that had prevailed since the postwar nationalizations — Ridley argued that the new Tory government's "principal instrumental of control should be to set each concern a financial obligation to achieve."[54] This new mode of "financial discipline" — government by audit — was tasked with establishing that "the required rate of return was entirely inflexible."[55] Spelling out this facet of his plan, Ridley deployed a phrase that was to serve as the Tory's primary cudgel of the mining sector: "If the required rate of return on capital was not achieved, either management must demonstrate that it was taking effective action to rectify the omission, or it must be replaced. Effective action might mean that men would be laid off, or uneconomic plants would be closed down, or whole business sold off or liquidated."[56] The goal of unit cost analysis was to identify and expel cost inefficient — or "uneconomic" — units. It should also be noted that audit management and computational technology were natural bedfellows, and the drive to render the productive process in the terms of unit costs was in key respects also a way of making it legible to the fast emerging computational matrix.

It is in the context of these cost efficiency discourses — which emerge in dialectical interaction with declining rates of profit, and the renewal of syndicalist struggle — that the Conservative government finally proved able to push the domestic energy market into completion with emerging extraction industries in low-income countries, many of which were in the Global South. The rise of electroculture's second, reactionary phase is crucial in the development of what we might term the last and largest phase of the fully dominant petroculture, a moment that arrives as the emergent force of microprocessing helps to orchestrate and stabilize the expansion of the just-in-time process's seaborne, and petroleum-powered, distributive matrix. Cowen describes the intensified relationship that subsequently developed between information technology, audit governance, and the logistical management of increasingly far-flung supply lines:

> At least as important as the rise of computer technologies that enabled new kinds of cost calculation... total cost analysis itself identifies for a firm the "opportunity to increase its profits that it could not have identified or taken advantage of in any other way." Total cost analysis produced new sources of profit with very different kinds of effects on corporate strategy, and this strategy was inherently spatial. Whether a firm invested in more warehouses, changed the location of production, or invested in more transportation infrastructure would all be decisions made relationally in the broader interest of total cost, or overall profitability.... Because of the "interdisciplinary" nature of the analysis, senior executive support was necessary to undertake total cost analysis, thus propelling logistical questions to a much higher level of management. In fact, with the adoption of total cost, corporate strategy became ever more defined by logistics.

Electronic technology's capacity to effectively collapse the informational distance between core and periphery would prove an indispensable material instrument of this new mode of governance. The spatial expansion of the productive process, the multiplication and coordination of supply lines, production plants, and distribution centers, would all be synchronized through the key electrocultural command centers of the newly emerging logistical giants.

Yet before British policymakers could begin to initiate this project it proved necessary for them to break the power of the trade union movement. In managerial circles the preferred term for this undertaking was "modernization," a phrase that implicitly consigned the objectives and commitments of the trade unionism to a now obsolete past. Roughly seven years after the Ridley report's first circulation, the Thatcher government began to follow through on its recommendations, announcing its ambition to "modernize" Britain's mining industry. The appointment of infamous union-breaker Ian MacGregor as head of the NCB signaled the government's turn to a more confrontational industrial strategy. As the first details of the plan began to hit the presses the government declared that it intended to close twenty "uneconomic" pits. The language was that of the Ridley Plan, and as the government prepared for inevitable strike action, they drew on the contingency plans that Ridley had outlined almost a decade ago. The report itself had actually been leaked to the press in 1978, and *The Economist* accurately summarized its contents in the following terms:

> (1) The group believes that the most likely battleground will be the coal industry. They would like a Thatcher government to: (a) build up maximum coal stocks, particularly at the power stations; (b) make contingency plans for the import of coal; (c) encourage the recruitment of non-union lorry drivers by haulage companies to help move coal where necessary; (d) introduce dual coal/oil firing in all power stations as quickly as possible.
> (2) The group believes that the greatest deterrent to any strike would be "to cut off the money supply to the strikers, and make the union finance them." But strikers in nationalized industries should not be treated differently from strikers in other industries.
> (3) There should be a large, mobile squad of police equipped and prepared to uphold the law against violent picketing. "Good non-union drivers" should be recruited to cross picket lines with police protection.[57]

The strategic core of the plan entailed circumventing the strategies that the trade union movement had employed to exert control over crucial energy flows. And as the Ridley Plan made clear, the Conservative's government's new energy strategy was not directed at engineering energy efficiency, it was instead designed to accomplish cost efficiency. In exercising this approach, the Ridley Plan instructed Conservative policymakers that they would be compelled to find new methods of ensuring a docile and compliant workforce.

By this juncture, the Tellerist goal of energy efficiency was already utterly subordinated to economic considerations, and the energic and environmental cost of outmaneuvering the miners accordingly gave the Selsdon group little pause for thought. Instead, the ensuing struggle coalesced around the miners' claim to not only have a say in wages and working conditions but to actually collectively determine the nature of their work. Essaying the fundamental stakes of the conflict, Raymond Williams unequivocally took the side of the miners, arguing that "to deny it or even qualify" the miners' claims to self-determination was to "subordinate a whole class of men and women to the will of others."[58] Williams writes that, as the struggle unfolded, "the term management mutated in the eyes of miners into a label defining the desire of the powerful to run a business for solely financial, rather than social, profitability."[59] As we have seen it was not only the miners that took this view of cost efficiency discourses, the Ridley Plan itself understood the stakes in precisely the same terms.

Yet the same logic that declared that an enterprise would be run "for solely financial, rather than social, profitability" also played out in an ecological register.[60] Indeed from today's vantage it is perhaps best to rethink Williams's contention in the terms of Jason W. Moore's world-ecology — audit governance proved to be a way of organizing not just the input and outputs of production, but nature itself.[61] In their attempts to revive the ailing economy, technocrats subordinated the industrial working class — and the energic flows of the world-ecology — to a managerial calculus that gave little consideration to socio-ecological "costs" that could not be rendered in the terms of "economic rationality." It is curious that this dimension of the struggle largely escaped Williams' notice. Indeed in his contemporary commentary on the 1984 Miners' Strike, Williams outlines the four "keywords" that, to his mind, defined the fundamental stakes of the struggle. The word "energy" is not found among them.[62]

Although the vying parties were focused of the foundational role that energy played in the struggle, even contemporary observers as astute as Williams found it hard to conceptualize how radically emerging technologies were changing the socio-ecological praxis of political struggle. Part of the explanation for Williams's uncharacteristic oversight is perhaps found in the fact that although elites would conclude this series of struggles through a vast cybernetic reorganization of socio-ecological forces, the final event in Britain's postwar mining struggles was internally structured around the question of worker autonomy. MacGregor understood the full dimensions of the miners' claim to self-determination. He was on record as stating that his primary concern over the mining sector was not the depletion of coal reserves, or the threat of cheap imports, it was rather that the miners had "evolved a feeling that [they] can be isolated from the benefits to the community as a whole — [they] can operate in a vacuum if you will, and set [their] own conditions for… operation."[63] The concern, then, in the 1984 strikes was explicitly that of worker autonomy, but it was at the same time clear — at least to the parties engaged in the struggle — that the effective exercise and maintenance of this autonomy was now contingent on control of electricity's circulation.

Cost efficiency management and worker self-management were thought, by both sides, to be fundamentally incompatible. It was precisely for this reason that the two parties assessed the value of cybernetic technologies in inverse terms. In the context of a sluggish economy, information technology offered social planners access to data that could be used to squeeze additional surplus value from their workers, a project that would entail fragmenting the effective exercise of solidarity, allowing managers to isolate and pick off the weakest members of the herd. From the miners' vantage it was evident that these technologies would decisively disable the material conditions on which the effective exercise of their autonomy was contingent. Yet in forestalling these developments the miners had at their disposal an array of techniques that had very recently proved capable of unseating the nation's government. As the final decisive strike loomed into view the miners and the government found themselves at opposite ends of electroculture's divergent "output" and "input" sectors. For the government to bring the full weight of its emerging electrocultural apparatus to bear, it was necessary for them to first wrest control of the nation's electricity generation from the miners' hands.

The events of the 1984 strike itself are well documented. The Ridley Plan's tool box of strategies and contingency plans finally prevailed over the miners, in the course of a year-long struggle that was waged at greater length and cost than either party had originally thought possible. In addition to the modes of logistical cunning that the Thatcher government employed, the unvarnished use of brute force became an increasingly integral element of their strategy as the confrontation came to a head. The effectiveness of the NUM's pickets was countered with the newly militarized police force that Ridley had first proposed in 1977. In preparing the public for these televised displays of state force, Thatcher infamously characterized the miners as "the enemy within," a phrase that bought the quasi-military nature of the conflict entirely to the fore, as the uninterrupted flow of energy supply lines was explicitly redefined as a matter of national security. According to the same logic NUM senior management also became the target of Britain's security establishment. MI5's assistant director Stella Rimington personally oversaw "the most ambitious counter- subversion operation ever mounted in Britain," a project that saw MI5 launch "the country's largest-ever bugging and telephone-tapping effort."[64] By this juncture, mining communities found themselves threatened with surveillance, cybernetic discipline, and a militarized police force. It is no accident that that these politically oppressive conditions so nearly foreshadow the experience of "surplus populations" in the post-Fordist economy. The experience of immiseration and disenfranchisement that has characterized life in the postindustrial rusts belts has been maintained through a fortification of the repressive arm of the state that has in many instances relied on the signature technological capacities of the cybernetic turn.

Currents of Capital — Electroculture in the Wake of Syndicalism

Yet although many features of the mining disputes were products of new dynamics brought into play by an emergent electroculture, other features were as old as what Andreas Malm calls " fossil capital."[65] Nothing better illustrates the paradigmatic aspects of the miners' struggle than the fate of Britain's mining industry in the aftermath of the failed strike. Reviewing the consequences of the wholesale implementation of MINOS, David Allsop and Moira Calveley observe that in tandem with the rise of "immaterial laborers" tasked with managing and "informating" the productive process, the same restructuration also produced a more highly-surveilled and data-disciplined coalface workforce: "[The] technology has allowed for the creation of information systems that have become 'information panopticons,' which are so all-encompassing that they 'do not even require the presence of an observer.'"[66]

The material properties of electricity were instrumental in effecting this state of affairs, allowing for the construction of vast "surveillent assemblages" that afforded management greater — and more centralized — control over a "fragmented" and globally distributed workforce.[67] The fragmenting impact of this electrical apparatus was evident to sociologists who surveyed working conditions in British pits of the mid-1990s who found that "the predominantly Taylorist design philosophy, with its emphasis on the removal of workers' skills and autonomy, has a negative impact on workers and serves to limit the potential of the new technologies, as well as stifling worker ingenuity."[68] Here, then, was the lasting impact of the emergent electroculture in Britain's mining sector. Britain's "rank-and-file" miners had clearly offered a more incisive appraisal of the long-term consequences of automation and cybernetic flow monitoring systems than was proffered by the techno-utopian theorists of immaterial labor. To paraphrase E.P. Thompson, the British working class was present at its unmaking.

The handful of workers that managed to keep their jobs now told of working conditions that proved less emancipated than scholars such as Maurizio Lazzarato had once anticipated:

> [Y]ou have got Big Brother watching from upstairs, so if you have a stand down, they will know up there and questions are asked (Tailgate, underground supervisor).
>
> They sometimes put the brake on if I am cutting too fast for them to cope with the coal that is coming off (Mechanics, face worker).
> They know what we are doing all the time and sometimes they slow down the machine (Winders, face worker).
>
> We are easily clamped and easily got at (Tailgate, face worker).[69]

The techno-utopians were not wrong, however, to identify the vast technical ambition of the new age of automation. Among managers in the mining sector it has now become fairly commonplace to anticipate the development of entirely unmanned coalfaces:

> We have the technology to take the men off the face, we haven't done that yet. They have coalfaces in Australia that have no men on them, but they have a different union system and union agreements. It is only on the coalface and in the headings, where machines are operated underground. Everything else is operated from the surface, conveyors, bunkers and stage loaders are all automatic (a U.K. Coal automation engineer).[70]

The end result of these kind of strategies has been the widespread blackboxing of the energy production process. The trajectory inherent in the energy security discourse of the early 1970s arrived at a strange apotheosis in which the energy production system was increasingly rendered secure, not against the depletion of fossil fuel reserves or the machinations of petrostates, but against workers themselves.

In truth, the need for wholesale automation is largely moot. Manned by small corps of engineers and technicians, heavily automated fixed capital allows for a workforce so small that it can be kept compliant with a handsome salary. As Nick Dyer-Witheford has recently demonstrated, in the post-Fordist economy elites have increasingly relied on automation to ensure the docility and security of key sectors of the economy.[71] In the decades prior to its recent dissolution, the fate of the U.K. mining sector provided an exemplary case of a broader tendency that continues to play out on a global scale.[72] These considerations draw attention to another facet of the turn to microprocessing that has perhaps been underplayed in the course of this discussion; for the microprocessing revolution has not only facilitated the precise remote management of workers, it is also — in tandem with the ongoing refinement and miniaturization of the electric motor — allowing for the machinic reduplication of even the most complex and highly-skilled forms of human labor.

In the face of automation on this kind of scale, the characteristic modes of self-assertion that the miners had once so successfully practiced have dwindled. Yet the net result of the rise of electroculture has not been to universally draw workers into the informational sector, as Lazzarato and others had once proposed.[73] Instead, alongside new crops of engineers and informational managers there has arisen an increasingly vast vulnerable sector of precariously employed service workers, who have as yet not successfully asserted their interests. As George Caffentzis puts it "[t]he burly, 'blue collared' line worker seems to blur in the oil crisis, diffracted into the female service worker and the abstracted computer programmer":[74]

> And it all feels so different! Your wages go up but they evaporate before you spend them, you confront your boss but he cries that "he has bills to pay," and even more deeply, you don't see your exploitation any more. On the line, you literally could observe the crystallization of your labor power into the commodity, you could see your life vanishing down the line, you could feel the materialization of your alienation. But in the

> service industries, your surplus labor seems to be non-existent, even "non-productive," just a paid form of "housework," cleaning bedpans, massaging jogger's muscles, scrambling eggs.[75]

Yet those that have managed to hang on to a wage in the service sector seem by some measures to be in a more favorable position than others among the growing numbers of people unable to access either a viable legal income or a stable means of subsistence. Many of those expelled from the industrial sector have had to contend with what we now know as characteristic features of life in the post-Fordist rustbelts, the triple-fronted trap of "destitution, drugs, and prison."[76]

It is salutary to note that elites are hardly in a position to welcome this increasingly volatile state of affairs. Indeed, in Marx's terms, we can see that capital has again emerged as a limit to itself. Yet the present form of its self-limitation proves in key respects particular to our own historical moment, and proper to the socio-ecological characteristics and energetic demands of post-Fordist electroculture. Contemporary capital's rising organic composition has not only left it entangled in a toxic, and climatically disruptive, coal dependency, it has also seen it unable to reincorporate living labor back into the productive process. As the research collective Endnotes write:

> [C]omputers not only have rapidly decreasing labour requirements themselves (the microchips industry, restricted to only a few factories world-wide, is incredibly mechanised), they also tend to reduce labour requirements across all lines by rapidly increasing the level of automation. Thus rather than reviving a stagnant industrial sector and restoring expanded reproduction — in line with Schumpeter's predictions — the rise of the computer industry has contributed to deindustrialisation and a diminished scale of accumulation — in line with Marx's.[77]

In short, the success of elites in countering the threat of worker militancy has also undercut their capacity to secure adequate rates of return on capital; the same strategies that secured the energy production process against sabotage and disruption have also spurred, rather than rectified, the ongoing freefall in rates of profit. Clearly, the emergence of electroculture — and the signature capacities and technologies that define it — has been instrumental in producing this field of conditions.

Yet in contrast to the original forecasts of Marx and Engels, Bue Rübner Hansen finds that "[w]hat is interesting and challenging" about today's situation "is that, unlike the immiseration thesis of the *Communist Manifesto,* [today's political strategy] is not predicated on a thesis of the gradual embourgeoisement of the world, or on the homogenization of the proletariat. The reality of surplus populations poses instead the issue of a generalized crisis of reproduction, and the multitude of survival strategies that arise from it."[78] The practices of Britain's mining communities during the year of the strike actually anticipated many of these "survival strategies." As the Thatcher government struggled to render Britain's mining communities superfluous to the functioning of the nation's economy — as they cut off the supply of money, and rerouted crucial goods and energetic flows from increasingly far flung corners of the globe — mining communities were thrown back onto the kinds of hard-scrabble survival tactics that have come to define the globe's burgeoning "surplus" communities in the aftermath of the informational turn.

Electroculture "After Oil" — Conclusions and Conjectures

Looking to the future as the global economy generates larger surplus populations, and as the energy demands of fixed capital continue of necessity to rise rather than decline, capital faces two key threats to its popular legitimacy that it has as yet no means to combat. The success of the British government in the early 1980s, and the experience of Britain's mining communities in those decades, ironically prefigured these dual dilemmas. Having once managed to cut off the monetary supply to mining communities while at the same time ensuring a steady supply of coal, elites now seem unable to incorporate increasingly large numbers of their surplus populations into the wage relation, and are as yet unable to wean the global economy off the coal dependency that serves as the primary engine of anthropogenic climate change.

As we have already noted, significant moves have been made toward a transition from fossil fuels to renewable energy sources, and in recent months the IEA's newest report has offered solace to those venture capitalists and governments that remain blithely optimistic that "innovation" can supply capital with adequate carbon neutral electrical inputs. Yet even analysts such as Vargha, who adopt a relatively optimistic stance, tend to concede that Smil's more circumspect appraisal of renewables is founded on a formidable body of scholarship. Indeed, in course of his critique of the IEA's historically cautious appraisal of renewable energy markets, Vargha poses a rhetorical question that lies near the heart of contemporary energy policy debates and investment strategies: "[S]o will solar and wind energy become dominant in a few years in energy demand?"[79] He answers by deferring to Smil: "Of course not. As Vaclav Smil has argued convincingly, such transitions are generally slow, because energy investments are capital intensive — we need a large new infrastructure to supply it."[80] In the course of the paper that Vargha cites, Smil explains why — despite robust government subsidies and widespread public support — the renewable energy industry still meets such a small fraction of global energy demand: "The slow pace of this energy transition is not surprising. In fact, it is expected. In the U.S. and around the world, each widespread transition from one dominant fuel to another has taken 50 to 60 years."[81] The fundamental challenge is infrastructural. Of the various renewable alternatives on offer, Smil finds that only solar energy can hope to match the quantitative heft of fossil fuels. But even allowing for the abundance of solar energy, Smil argues that a key impediment to a rapid solar transition is the fact that contemporary energy systems are contingent, not just on vast quantities of energy, but on vast quantities of densely concentrated energy. Developers have thus far only discovered this energy density in fossil fuels and nuclear fission. Consequently, a wholesale transition to renewable energies will "necessitate a fundamental reshaping of modern energy infrastructures."[82] Before it is able to collect and concentrate sufficient quantities of energy in the world's metropolitan zones and production plants, a post–fossil fuel energy system will have to compensate for the relatively low density of renewable energy dispersal, casting a wider net, and spreading a new photovoltaic apparatus over large expanses of the earth's surface. The kind of dispersed energy input infrastructure needed to accomplish this feat is poorly served by our own fossil fuel system which is presently dominated by the need to globally distribute highly concentrated fossil fuel energies, extracted at a relatively small number of key input nodes.[83]

It is here that the attempt to engineer an anti-limitationist response to anthropogenic climate change seems set to encounter profound challenges. The rapidity of information processing advance was in part premised on unlocking the intense energy density of the raw materials — coal, in particular — that fueled it. The pace of change that defined this era serves as no guide at all to the speed with which technology will develop if it is made to rely on weaker energy streams. In truth, however, such considerations seem for the time being entirely theoretical concerns, for, under capitalism, the viability of a renewable energy infrastructure will always remain contingent on its capacity to meet the ever-expanding demands of the planetary assemblage of fixed capital. Should innovations within the renewable energy sector fail to meet this demand, we can anticipate a return to nuclear power and intensified investment in geoengineering technologies such as carbon capture. Although the IEA's newest report tenders a more promising appraisal of the nascent capacities of renewables that the agency had thus far adopted, it remains the case that the end goal of a wholesale energy transition extends beyond simply arresting the ongoing expansion of fossil fuel demand pushing out toward the more distant prospect of actively reversing it. Whether this latter goal is actually compatible with "business as usual" remains the fundamental conundrum of all contemporary anti-limitationist energy policy.

Still, caveats aside, as global governance attempts to transition to a renewable energy base — leveling increasingly punitive legislation against the oil and coal industries — we can clearly observe electroculture moving into a third phase, one that sees it consolidate its new position as the dominant field of force within which other residual and emergent energy cultures now make their way. Naturally, the old petroculture infrastructure will continue to exert a profound residual influence in the decades to come. Indeed, as Kate Gordon remarks, "[e]ven if they're now, finally, cost-competitive at the point of sale, low-carbon technologies are still working within an infrastructure — a utility regulatory system, a power grid, a highway system, a combustion engine-centric fueling system — built for a world powered by fossil fuels."[84] Yet as capital attempts to supply itself an anti-limitationist fix to the problem of anthropogenic climate change, and as it remains apparently irreversibly locked into its self-defeating attempt to evade secular stagnation through an ever-intensifying automation of the productive process, there can be little doubt that its assemblage of electrocultural technologies and research hubs will remain indispensable tools.

Here a word of caution regarding the political potentialities of the transition to renewable energy infrastructure is in order. It has become a cliché to point out that fossil fuels are a form of solar power — one condensed, through the contingencies of the geological past, into locally distributed deposits of fossil-stored energy. The cliché is worth repeating, to the extent that it helps us conceptualize the full scope of this nascent infrastructural project. The size of the terraforming projects required to synthetically replicate this geologically-scaled process of energy concentration — one that took place over the course of five hundred million years — should at least lead us to raise the question of how benign renewable energy infrastructure would prove to be under the anti-limitationist prerogatives of electrocultural capital. It is quite conceivable that utility-scale solar facilities would in time — and in the course of attempting to not simply supplement but actually supplant and replace the existent fossil fuel dependent apparatus — develop a sprawling and uncanny resemblance to the Athabasca tar sands, those sites of late petrocultural sublime that Edward Burtynsky's aerial photography helped to make infamous.[85] Though the development of such utility-scale projects would help to significantly reduce carbon emissions, while releasing fewer toxins and pollutants, their vast scale would also threaten to transform the ecological dynamics of large tracts of the earth's surface, rendering them less hospitable to Indigenous life forms, and setting in motion a series of socio-ecological aftereffects that would in all likelihood serve as the proximate causes of a new set of ecological quandaries. In Moore's terms, we must remember that all energy systems and human economies are "co-produced" with nature, and that in our understanding of the contemporary moment — and the emerging "futures" that it bears within it *in potentia* — "[o]nly a conception of *historical nature* will suffice."[86] With these qualifications in mind, I offer two tentative conjectures about the likely outlines of a "renewable-driven" electrocultural capital.

> (1) Even if the transition proves economically viable, fixed capital's demand for solar-rich space is likely to follow a similar pattern to its voracious appetite for the time-condensed energy of fossil fuels. The IEA estimates that world energy consumption is due to rise thirty-seven percent by 2040,[87] a figure that seems somewhat conservative in light of the doubling of global energy consumption since 1971.[88] During the same decades conservative estimates see the global population projected

to rise by two billion, to over eleven billion total. The amount of arable land required to sustain this population will expand accordingly, and as the land footprint of a renewable energy infrastructure also rises — the projected square mile to megawatt ratio is still hotly contested, but a 2013 NREL (National Renewable Energy Laboratory) report puts the figure at 8.3 acres per MW — it becomes harder and harder to imagine a scenario in with an anti-limitationist strategy can perpetually prevail.[89]
(2) A "successful" transition to a renewable — or, for that matter, nuclear — energy base seems unlikely to have immediately propitious political consequences for the world's burgeoning surplus populations. For, under capital, such a transition would effectively guarantee the ongoing technical viability of the electrocultural apparatus that currently subjects them to surveillance, immiseration, and digital control. The one caveat to add here is that the project of constructing the sprawling infrastructure of a photovoltaic energy system would — in the initial years of its construction — likely demand a significant uptake of labor, though only in the very short term. Whether capital's beleaguered financial system and cash-strapped governments are actually capable of coordinating such a feat remains to be seen.

However these political and technological questions are ultimately resolved, it seems safe to conclude that there is no end to capital's electro-dependency in sight. While it is now technologically and politically conceivable that capital could entirely transition away from the combustion engine, there is no prospect of it departing from electricity, which functions as the material medium of its digital brains, and which is capable of being repurposed into its all-but-universal fuel. Just as the concept of petroculture has proved an important means of understanding how the world-system found itself in its contemporary climactic predicament, the concept of electroculture exposes key features of how capital will attempt to sustain its anti-limitationist energy strategy in the face of climate change. Yet as Williams first pointed out decades ago, if these kind of periodizing concepts are to remain incisive — and if our analyses are to "connect with the future as well as the past" — it is crucial that we avoid abstracting them into static systems.[90] We must instead remain attentive to the residual and emergent forces that are even now attempting to make the way within and beyond electroculture's newly consolidated dominance.

Notes

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3. The term "electroculture" was first coined to describe a set of techniques that employ electromagnetic technology to stimulate plant growth. My differing use of the word takes its bearings in relation to the concept of "petroculture," an analytical concept that was developed to explore how oil use has shaped technological, political, and cultural practice. In the spirit of Williams's historiographic intervention, I suggest that we can understand petroculture and electroculture as distinct but mutually determining socio-ecological forces. I argue that as electrocultural social formations emerge we can see them modifying and at last displacing the signal social forms and material practices of the dominant petroculture.
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18. *Energy Transitions* 150.
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22. *Energy Transitions* 124–25.
23. Peter Simon Vargha, "Does the IEA's New World Energy Outlook Miss the Global Transition?" *Energy Post* (November 30, 2015) http://www.energypost.eu/ieas-new-world-energy-outlook-miss-global-

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25. "Decoupling of Global Emissions and Economic Growth Confirmed."
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27. *Late Capitalism* 192.
28. *Late Capitalism* 192.
29. *In Letters of Blood and Fire* 30.
30. See Jasper Bernes's piece in this collection for an account of how energy-intensive agriculture and the reproduction of the body become foreshortened as form of energy capital.
31. D'Arcy Wentworth Thompson, *On Growth and Form* (Cambridge: Cambridge UP, 1945).
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