# HEAT, TIME AND COLONIALISM

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> How much blood there is in my memory …
> Look at the tadpoles of my prodigious ancestry hatched inside me!
> Those who invented neither gunpowder nor compass
> those who tamed neither steam nor electricity …
> *Heia* [praise] for those … who give themselves up to the essence of all things …
> free of the desire to tame but familiar with the play of the world …
> Pity for our conquerors, all-knowing and naïve![1]
>
> Aimé Césaire

> There is no document of civilization which is not at the same time a document of barbarism.[2]
>
> Walter Benjamin

## *Introduction*

Climate movements and energy transition movements customarily ask how energy might be generated and distributed more justly or democratically. Or how it might be made "green" or "renewable".

But one thing they usually don't talk about is whether energy *itself* is unjust and undemocratic. And whether energy *itself* is anti-green.

These questions need to be asked. Because if energy itself, as commonly understand today, is implicated in the ecological devastation of colonialism, then there's no point in continuing to talk about it as if it were an uncontroversial, apolitical goodie that everyone wants and has "rights" to. Or as if it were a substance that could someday, somewhere, be painlessly, fairly harvested and equitably distributed.

Instead of just being accepted unthinkingly, the theory and practice of energy that have been dominant in industrialized societies since the mid-19th century need to be more consciously engaged and questioned on feminist, anti-racist and anti-colonialist grounds. Energy movements cannot restrict themselves only to fighting for "just distribution" of energy; "fair" ways of extracting and processing coal, oil, gas or uranium; democratic control of energy utilities; or nonexploitative, renewable energy production. All of these goals are self-contradictory. Like "Third World development" or capitalist labour, the energy that we have known since the 19th century is not a thing. It's a colonial process of reorganizing living human and nonhuman territories into hierarchies favourable to capital accumulation.

Nor are the injustices connected with that process "bugs." They're "features." In a sense, they're the whole point of what we call energy. You can't contest them without contesting energy's hegemony. They follow directly from the accumulation imperative to get something for nothing while shifting negative consequences off on others via the violence of patriarchy, colonialism, white supremacy and ecological degradation. Addressing these injustices, like addressing those tied to development and capitalist labour, requires a broader perspective.

## *A Misnomer*

Ironically, it's 19th-century thermodynamics itself – the very science responsible for formalizing the concept of energy dominant today – that provides one key for a more political understanding.

These days, industrial capital says that energy is a substance that must constantly be replenished because it is constantly running out. Hence the incessant hunt for more oil fields or sites for dams or wind or solar farms to provide "society" with more of this resource.

Most economists, environmentalists, social movements, democrats and anti-capitalists repeat this story without asking questions. For example, when they frame "energy justice" as being about the fair distribution of a measurable thing.

But the story is false. It's not energy that industrial capital needs. Energy is around us always – in every quiet lake, in every plume of smoke, in every rock pile. It's never consumed, it's never used up, and it doesn't have to be sought anywhere. Instead of being depleted, energy merely changes from one form to another.

Thus when coal is burned, producing ash and carbon dioxide, its energy doesn't disappear. Some of it is merely transformed into heat. And that heat can be further transformed into mechanical energy or electricity – the deployment of which leaves a residue of yet more heat.

Similarly, when the sun's hot photons arrive on earth, their energy doesn't disappear. To a large extent, it's radiated back into space in the form of the heat of cooler photons – although increasing amounts are now sticking around in the form of global warming.

In short, if energy as such was what industrial capital was looking for in all those coal mines and biomass plantations, it could have saved itself the trouble. Energy is automatically conserved everywhere. There's never any need to find sources of it.

### *What Industrial Capital Really Needs*

So what is capital looking for, if not energy?

Industrial capital expands and intensifies its exploitation of labour through machines. It needs machines to boost productivity, control and concentrate workers, spread the wage labour relation, accelerate turnover and appropriate new feedstocks. From capital's point of view, that's what all those metal-punching devices, computer server farms, containership engines and hydroelectric turbines are for.

None of these devices consume any energy. What they do is convert one form of it into another.

In steam engines, heat becomes mechanical energy. In batteries, chemical energy becomes electricity and vice versa. In turbines, dynamos and windmills, mechanical energy becomes electricity. In electric motors, electricity becomes mechanical energy. On solar farms, the sun's radiation becomes heat or electricity. In light bulbs and laptops, electricity turns into heat and light. All that has to happen if workers are to continue donating their life activity to capitalists to create surplus value. Energy conversion on an ever-increasing scale is intrinsic to all forms of industrial capitalism, digital capitalism above all.[3]

The possibility of these conversions is formalized in the First Law of Thermodynamics.[4] The First Law is one of those "documents of civilization" that Walter Benjamin refers to in the epigraph, that is also a "document of barbarism." It's an expression of a hierarchy in the landscape. In this hierarchy, every "little energy" of the commons – cooking fuel collected from common woodlands, oil left underground, undammed streams – is seen as subordinate to that overarching, 19th-century Big-E abstract Energy.

In each energy conversion theorized by the First Law, something is lost irretrievably. Sadi Carnot, the first genius of thermodynamics, called these conversions "falls" (*chutes*).[5] They're like waterfalls. Once you open a sluice gate to let water run downhill to drive a waterwheel, you can't get the water back uphill to restart the process without expending more energy than you've released.

Similarly, when you burn coal, you can't reassemble the resulting heat, ash and carbon dioxide back into coal without using more energy than the coal gave you. With each energy conversion, energy gets dispersed across a greater number of microscopic states.[6] Thermodynamics' Second Law calls this an increase in entropy.

What capital needs for its machines is not energy as such but these "falls" in the landscape – differences between low and high entropy.[7] Gradients between hot and cold in heat engines. Gradients between the binding energy of electrons in molecular bonds and the heat generated in chemical reactions. Gradients

between short-wave solar radiation at around 5760 Kelvin and longer-wave radiation emitted by the earth at 255 K into an outer space standing at a temperature of 2.7 K. And so on. When capital burns oil or runs radiation from the sun through solar panels or industrial biomass plantations, it doesn't use up energy but rather pulls open various doors – usually violently – through which an entire territory slips more rapidly down those gradients, eroding the gradient itself in the process.

Naturally, the sequence and patterning of that door-opening has to suit the operation of capital's conversion devices. It's no good having a sluice gate if you can't open and close it at the right times; no use having a lot of coal if you can't apply heat and oxygen and vent carbon dioxide in rhythms and places that fit your machines' functioning. But whatever: the more intensively capital converts energy from one form to another, the higher the entropy of the system. And if that system is closed, the closer that entropy changes come to halting altogether.[8] It's this "entropy balance" that "sets the limit to the power of the engine."[9] The hierarchical landscapes of multiplying First Law conversion engines are also landscapes of increasing Second Law "waste." These, of course, are also hierarchically organized, in the form of relationships between energy beneficiaries and "sacrifice zones."

### *Entropy Chains and Entropy Exports*

Capital typically structures its unprecedented entropy increases in chains. Before hydroelectric dams and turbines can go about their entropy-increasing business, entropy-increasing concrete and steel manufacture has to take place. Entropy-increasing wind farms can't be built without previous entropy-increasing balsa extraction in Ecuador and other countries. Rising rates of entropy increase associated with the movement of electrons in millions of electric cars in the global North stem not only from the prior construction of dams, wind farms and other energy-conversion devices, but also from new waves of entropic lithium and copper extraction in the Atacama and elsewhere.

These chains only multiply overall entropy increases. In coal-fired generating plants, 60 per cent or more of the fuel's chemical energy is lost as waste heat. An additional percentage of the electrical energy generated is then dissipated into heat in transit to – for example – high-frequency trading server farms or cryptocurrency "mines" stuffed with computer processors that need built-in cooling systems to dispel their own waste heat. Even the most up-to-date efficient light fixtures lose at least 20 per cent of the electrical energy feeding them. Their light is then partly downgraded again into heat on contact with, say, a billboard on an empty street at night.[10]

If you want to maintain gradients between low and high entropy in a certain chosen part of the universe to keep your chains of machines running, you have no choice but to export high entropy into surrounding parts. If entropy is about territory (in a more than spatial sense), it's also about one territory's relations with another. Here is a sentence from physics: "The extent to which the boundary is flexible in exporting entropy is a critical factor in calculating how far the system can evolve away from thermal equilibrium."[11] Here is a sentence from sociology: "Unequal exchange in the world system is what reproduces machines, and machines are what reproduce unequal exchange."[12] The connection between what these two sentences are saying is extremely complex. But there is a connection.

When the International Energy Agency compiles statistics about energy "consumption," therefore, the exercise is more propaganda than science. What are called "Ministers of Energy" are in reality "Ministers of Entropy Flow." Their brief is to help wrench open their territories' entropy doors and, if possible, keep their territories in such a state that they can continue to be wrenched open. The "energy" that today's policymaking classes chatter about so fluently is better described as forcible territorial and interterritorial political reorganization in the service of the governance of capitalist labour.

### *Necessary Distinctions*

For sure, entropy doors are constantly being opened even without the say-so of any Energy Minister or coalition of transnational corporations. In fact, the door-opening process is nothing less than "what makes the world go round," in the words of quantum physicist Carlo Rovelli. It is "what causes events to happen in the world, what writes its history."[13] What some 19th-century physicists dramatically interpreted as the universe's prolonged one-way trip toward *Wärmetod*, or "heat death," is, paradoxically, what gives it life –

just as capital's energy conversion devices function only when they move toward eliminating the gradients that make them work.

But these doors have never been opened in the same ways at the same rate in every territory of the universe in every epoch. Entropy increases unevenly, at different paces in different places. Often the pace is very slow.[14] Hydrogen and oxygen molecules can float around peacefully in a bottle for centuries, despite the fact that their combined internal bond energies are greater than that of the water that they could produce. Only when a spark is introduced will they react explosively to dissipate some of that internal energy into heat, forming the higher-entropy $H_2O$. Similarly, low-entropy oil that is left underground won't react with air to form heat and carbon dioxide for millennia unless it is deliberately unearthed and burned, opening channels that abruptly change it from a pool of low entropy into a larger expanse of residual heat and other "wastes" that capital is unable to recycle while still remaining capital.

Or look at those earthly territories of flowing water that are so often the focus of communal care across the world. For sure, these territories are in a state of higher entropy than the solar particles that, combined with gravity and other factors, indirectly give rise to them. Indeed, they owe their continuing life to entropic processes that, according to thermodynamics, drive all closed systems (and perhaps even the universe itself) toward stasis. All the same, they constitute basins whose local rate of entropy increase can remain relatively low for millions of years. Until capital suddenly boosts that rate by seizing control and converting the kinetic energy of those flowing waters into electricity via hydroelectric dams, again leaving behind a landscape of waste.

For sure, similarly, *chains* of entropy increase are a feature not just of capital's realm but of the universe itself.[15] For example, what makes possible the sudden huge increases in entropy when hydrogen starts to be converted to helium in newborn stars is prior, very gradual increases in the entropy of hydrogen clouds contracting under gravity.[16] By the same token, today's Arctic warming is down not only to fossil fuel combustion but also to the reduced albedo of seas freed of ice by entropic melting processes. Living human bodies themselves rely on delicately-paced chains of entropy door-opening (e.g., the oxidization of glucose, which outside the body would be more stable) combined with door-blocking (prevention of decomposition).

Human bodies, just like capital's engines, thus continually need to pass surplus entropy that they generate in one sphere on to bigger spheres inside or outside their skins.[17] All life needs the entropy slopes that it surfs on to be constantly flattening out. But it can't enjoy those waves indefinitely in a closed-off territory inexorably headed for the universal flatness of "heat death". The physics that describes how life goes on must be a "non-equilibrium" thermodynamics in which the breakers just keep on coming. And so for any science that explains the living planet.[18]

A radical energy politics, therefore, has to do more than just note the humdrum fact that capital, bodies and planets all change one kind of energy into another, and all organize the resulting entropy flows. It must show the *differences* in the ways they do so. It must map how these flows are structured in the overlapping, mutually-interacting territories of capitalists, commoners, and more-than-human communities – by whom, for what, why, and with what effects on whom where.

This is also, of course, a map of never-ending political conflicts over extractivism, pollution and labour rights – as well as of the evolving political strategies of all the divergent actors.

## *Distinctions Ignored*

Those few conventional economists who, to their credit, take entropy seriously are not very helpful here. They tend to hide these maps. They focus on aggregate global *rates* of entropy increase under industrial capitalism – conceived as a generic "economic process"[19] – rather than the diverse, historical, underlying nonequilibrium *patterns* in which its authoritarian politics tries to organize the opening of entropy doors across the landscape.

As a result, when proposing ways forward, orthodox entropy economists such as Herman Daly predictably fall back on the classic, ever-failing fantasies of globally centralized, simplified capitalist environmental management: productivity increases, depletion quotas, population control, ecosystem service prices and so

forth. All to be administered by imaginary future global managers the mode of whose prospective rise to power is not mentioned.[20]

Another entropy economist, Kozo Mayumi, has made incomparably more important contributions to the political understanding of energy. Nevertheless, Mayumi too assumes that the conceptual baseline for approaching energy politics must be to imagine unspecified leaders selecting a universal *rate* of entropy increase within an ahistorical thermodynamic "system" the setting of whose borders also remains unexamined. He makes no effort to understand the historical politics through which *patterns* of entropy flow and system boundary-setting are established via racial, patriarchal and class domination. The "true question facing bioeconomic beings," he writes, "consists in the choice of the suitable rate of increase in entropy in the long term."[21] As if there could ever exist an undifferentiated, genderless, raceless class of "bioeconomic beings" happily waiting across the world to implement the judgements of benevolent, omnipotent experts whom some unknown party has somehow empowered to choose "the" single entropy rate increase "suitable" for the planet.

This is no way to bring about environmental change. As the Jamaican philosopher Charles W. Mills points out, this style of thinking is a mode of colonialist mystification. Unable to map contested territorial mosaics of entropy relationships, these proposals necessarily ignore what creates and recreates them. Erasing the actual history of what is today called energy, steeped in slavery, genocide, aboriginal expropriation and colonial rule over people of colour, they replace it with a "sanitized and idealized White time",[22] during which European intellectuals' disinterested discovery of the possibilities of harnessing jacked-up energy conversion to industrial machines is imagined to have supplied liberation to all humanity. Brushing aside energy history, such proposals are conceptually unequipped to find realistic ways forward through it.[23] To seek the roots of the current predicament in incorrect economics – or lack of proper communication between it and thermodynamics – is to fail to confront the real-world issues of machinic imperialism.

Well-intentioned movements for a global "energy transition," Green New Deal or "net zero emissions" tend to exacerbate this exercise in futility. Insofar as they recycle the idea that energy is colourless, genderless and all-inclusive, such movements cannot formulate energy justice as anything more than fair distribution of a cleaned-up, essentially white substance. Reparational justice – which requires a sense of nonwhite time and anticapitalist territories – falls by the wayside. The fight against colonialist processes of organizing landscapes around capital-friendly entropy flows – represented by, to take just one example, the struggle over the Dakota Access pipeline – is treated as if it could be ended by, say, value-added lithium processing in Bolivia or expansion of geothermal or wind energy in some other landscape.

To see racism as independent of historical territories in this way will only ensure that the natures of the future will be still more racist.[24]

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2 Walter Benjamin (1940), *Theses on the Philosophy of History*, VII.
3 Nathan Ensmenger (2018) "The Environmental History of Computing", *Technology and Culture* 59 (4), S7-S33.
4 George Caffentzis (2013) *In Letters of Blood and Fire: Work, Machines and the Crisis of Capitalism*, Oakland: PM Press; R. L. Coelho (2009) "On the Concept of Energy: History and Philosophy for Science Teaching", *Procedia Social and Behavioral Science* 1*,* 2648–2652.
5 Sadi Carnot (1988 [1824]) *Reflections on the Motive Power of Fire* (translated by R. H. Thurston, edited and with an introduction by E. Mendoza), Mineola, New York: Dover.
6 Ludwig Boltzmann (1974) "The Second Law of Thermodynamics," in Brian McGuinness (ed.) *Theoretical Physics and Philosophical Problems*, Boston, MA: D. Reidel Publishing Company, 12–32; Frank L. Lambert (2002) "Entropy Is Simple, Qualitatively," *Journal of Chemical Education* 79 (10), 1241-1246.
7 Clive L. Spash and Tone Smith (2019) "Of Ecosystems and Economies: Re-connecting Economics with Reality", *Real-World Economics Review* 87, 212-229, http://www.paecon.net/PAEReview/issue87/SpashSmith87.pdf.
8 Kozo Mayumi (2001) *The Origins of Ecological Economics: The Bioeconomics of Georgescu-Roegen*, New York: Routledge, p. 53; Axel Kleidon (2016) *Thermodynamic Foundations of the Earth System*, Cambridge: Cambridge University Press, p. 54.
9 Kleidon, op. cit., p. 75.
10 Vaclav Smil (2017) *Energy and Civilization: A History*. Cambridge, MA: MIT Press, p. 26.
11 Axel Kleidon (2010), "A Basic Introduction to the Thermodynamics of the Earth System far from Equilibrium and Maximum Entropy Production," *Philosophical Transactions of the Royal Society B* 365, 1303–1315, p. 1306.
12 Alf Hornborg (2001) *The Power of the Machine: Global Inequalities of Economy, Technology and the Environment,* Walnut Creek, CA: Altamira Press, 2001, p. 44.
13 Carlo Rovelli (2016) *The Order of Time* (translated by Carla Segre and Simon Carnell), New York: Penguin.
14 Hans Reichenbach (1971) *The Direction of Time* (edited by Maria Reichenbach), Berkeley: University of California Press, pp. 119, 127; A. Tsuchida and T. Murota (1985) "Fundamentals in the Entropy Theory of Watercycle, Ecocycle, and Human Economy," paper for the Conference on Man's Coevolution with the Biosphere in the Age of Advanced Technology, York University, Toronto, 21-15 January.
15 Frank L. Lambert (1998) "Chemical Kinetics: As Important As The Second Law Of Thermodynamics?", *The Chemical Educator* 3 (2), 1-6.
16 Rovelli, op. cit.
17 Mayumi, op. cit., p. 49; Boltzmann, op. cit, p. 24; Erwin Schrodinger (1967) *What is Life?*, Cambridge: Cambridge University Press.
18 Kleidon, op. cit. supra note 7; Mayumi, op. cit., p. 64.
19 Nicholas Georgescu-Roegen (1971) *The Entropy Law and the Economic Process.* Cambridge, MA: Harvard University Press.
20 Herman Daly (2018) "Ecologies of Scale," interview by Benjamin Kunkel, *New Left Review*, 81-104.
21 Mayumi, op. cit., p. 45.
22 Charles W. Mills (2014) "White Time: The Chronic Injustice of Ideal Theory," *Du Bois Review* 11 (1), 27-42, p. 39.
23 Paul Burkett (2006) *Marxism and Ecological Economics: Toward a Red and Green Political Economy*, Leiden: Brill, p. 128; John Bellamy Foster and Paul Burkett (2016) *Marx and the Earth: An Anti-Critique*, Leiden: Brill.
24 Thanks for comments and reactions to Clive Spash, Mohamed Suliman, Jutta Kill, Hendro Sangkoyo, Dunu Roy, Kathleen McAfee, Richard Widick, Ivonne Yanez, Nick Hildyard, Sarah Sexton and Vandana Shiva.