Roads to an energy commons

From People & Nature

The articles in this collection, published on peoplenature.org in 2021-22, focus on the role of fossil fuels in capitalist society, and discuss issues about the transition away from fossil fuels, and away from capitalism. The first article, by Simon Pirani, discussed the way that energy has been turned into a commodity under capitalism, and asked whether and how it could be decommodified. The second article, by Larry Lohmann, argued that the very concept of "energy" had to be challenged more robustly. Several further contributions to discussion followed, from Larry, Simon and David Schwartzman. While none of us think the last word has been said on these issues, we hope that the discussion will be taken up, and maybe taken in other directions, by others. With this pamphlet we hope to make our conversation accessible to a wider readership. 17 February 2022.

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How energy was commodified, and how it could be decommodified

By Simon Pirani[1]

Introduction

This paper aims to contribute to discussion about prospects for transforming energy production and use. The starting-point is that not only do the technological systems that use energy need to be transformed, in order to avert dangerous climate change, but that such a transformation will be achieved most successfully as part of a movement towards a post-capitalist society.

Commodification matters, first, because it is one of the ways that capitalism has shaped existing technological systems that use energy. Second, because a movement towards post-capitalism would, by destroying the social relations of which commodification is part, put an end to commodification. By thinking about the role commodification plays now, we will better be able to imagine ways of superseding it and the social relations of which it is part. This, in turn, will help us better to envisage what sort of energy use we want, to supersede what we have now.

[1] I presented a version of this paper at the Energising Political Ecology session of the on-line conference of POLLEN (Political Ecology Network) in September 2020. I thank the participants, and especially Siddharth Sareen and Stefan Bouzarovski who organised the session. I also thank Gavin Bridge and Les Levidow, who commented on a draft. All the opinions expressed, and any mistakes, are mine alone. I welcome comments and correspondence to simonpirani[at]gmail.com

The paper discusses (i) the history of the commodification of energy, (ii) the present situation and (iii) the future, and the possibility of decommodification. First, here are some points about how I define "energy" and "commodity".

To a physicist, energy is usually the "ability to do work", a definition that includes human and animal labour power. That definition may be too broad for people, including me, writing about energy in its social context. I describe labour as labour, and define energy as *work done by physical or chemical resources, mobilised by people for that purpose*.[2] This "work" might include running a power station, providing motive force for a car or airplane, or warming a room. Fossil fuels, non-fossil energy sources including solar radiation and wind, and manufactured forms of energy including electricity are often described as energy carriers, i.e. physical phenomena that carry within themselves this "ability to do work".

Commodification has influenced the ways that energy and energy carriers are defined, because many people – including, but not only, politicians and economists – refer to "energy" as something that is being, or even must be, bought and sold. Actually, that buying and selling is very recent in historical terms, became systematised even more recently, and is still not ubiquitous, as I discuss below. This use of the term "energy" tends not only to disguise the fact that energy is taken by humans from our natural surroundings, but also to obscure the distinctions between its different forms.

In the late 20th century, as commodified energy systems became more complex and concerns about them became central to environmentalism, researchers distinguished: *primary energy* (e.g. coal, oil or sunlight); *final energy* (e.g. electricity or heat produced from coal or gas, gasoline refined from oil); *useful energy* (e.g. electricity for a factory, heat from a stove, the movement of a vehicle burning gasoline); and, finally, *energy services* (the use of the factory tools powered by electricity, the cooking of food, the vehicle getting from place to place).

The concept of *energy services* was proposed in 1972 by Warren Devine, an advocate of solar power, as a means of focusing on energy-efficient ways to deliver the end uses that were assumed by the consensus to require complex fossil-fuelled systems.[3] Devine used the term to make transparent the way that energy systems worked, but, as it has come into mainstream use, energy services has taken on meanings shaped by economics. Too often, energy services are seen as an immutable and unquestionable quantity of energy required for economically-defined purposes, rather than as a means to question the logic of economic activity. Socially critical analysis needs to acknowledge that energy services, a valid term for technological analysis, includes the whole gamut of uses of energy, from those uses that meet human need, to a horrific array of anti-human and/or alienated uses produced by late capitalist society.[4]

So, to early 21st century city people, gas for a stove, electricity for a factory or fuel for a vehicle is presented as "energy" ... that needs to be paid for. This false representation is a function of commodification. In considering this, Karl Marx's focus on "commodity fetishism" remains useful. He believed that social relations between people were presented to them in "the fantastic form of a relation between things". This was truly weird, he argued; an analogy could only be found in "the mist-enveloped regions of the religious world".[5] In particular, he had in mind the social process of labour: people work together to make things, but the outcome is presented to them not as a relationship between themselves, but as a relationship between products (commodities). Moreover, the labour power that people expend itself gets commodified, i.e. sold by workers and bought by employers.[6] The social processes and interactions with nature that bring gas to a stove or electricity for a factory are reduced to, and obscured by, cash payments. This view of commodities, as imbued with all the social relations produced historically by capital, is wider than the definition, predominant in economics, of commodities simply as articles that can be bought and sold.[7]

Central to Marx's view of commodity fetishism was that it obscured the contradiction between a commodity's use value, and its exchange value in markets. This mystification persists in energy research today: the idea of "energy demand" elides the need for energy services (the need for a use value) with the economist's concept of demand for a commodity. Looking at how energy was commodified in the first place may help us to unpick this.

[2] This is close to the *Oxford Dictionary* definition of energy as "the means of doing work by utilising matter or radiation". See also Simon Pirani, *Burning Up: a global history of fossil fuel consumption* (London: Pluto, 2018), p. 4

[3] W.D. Devine, "Energy accounting for solar and alternative energy sources", in: T. Nejat Veziroglu, *Alternative Energy Sources II. Volume 9. Conservation, Economics and Policy* (London: Hemisphere, 1981), pp. 3815-3844; Daniel Spreng, *Net-Energy Analysis* (New York: Praeger, 1988); Pirani, *Burning Up*, p. 27

[4] By uses "for human need" I mean e.g. to prepare meals, light rooms, etc, and by "anti-human and/or alienated" e.g. production and use of military jets, luxury villas and products of planned obsolescence. Of course there is a huge grey area in between, that can be disentangled only with a series of value judgments. This is touched on below (The future. Question 1), but a detailed discussion would be the subject of another article

[5] Karl Marx, *Capital*, vol. 1, Chapter 1, section 4

[6] Karl Marx, *Capital*, vol. 1, Chapter 6

[7] The *Oxford Dictionary* defines a commodity as "an article or raw material that can be bought and sold, especially as a product as opposed to a service", or, separately, as "a useful thing". Another example: a commodity is "an article of commerce or a product that can be used for commerce" (Scott Barrie, *The Complete Idiot's Guide to Options and Futures* (New York: Penguin, 2002), p. 278)

The past

For thousands of years, the main sources of energy for agriculture and industry were the muscle power of domesticated animals and of humans themselves. This was supplemented by energy that humans took from their natural surroundings with relatively simple technologies such as windmills and water wheels. Energy carriers such as wood and coal were collected by users and, with the growth of markets and urbanisation, began to be bought and sold.

For these energy carriers to become commodities, it was necessary not only for the capitalist mode of economic activity to appear, but for it to become dominant in some countries, as it did in the 18th and 19th centuries. Capital's accumulation and expansion drove social and technological changes. Labour power was commodified. In industry, the big shift was from water and wood power to coal and steam, in Britain in the late 18th century and more widely in Europe and north America in the early 19th century. As factory-based wage labour spread, urbanisation, which had been underway for centuries, accelerated. This cut people off from the natural surroundings from which they had once accessed energy. Energy carriers were then supplied commercially to townspeople.[8] All these processes turned coal, wood and other fuels into commodities. Through the 19th century, the technological systems that used these fuels became more firmly embedded in economic systems (finance capital) and social systems (class exploitation, imperialist domination) that characterised capitalism. Thermodynamics and other ideas about energy systems developed by the ruling elite normalised and excluded from analysis these social and economic relations.[9]

The "second industrial revolution" of the late 19th century produced two significant new technologies: electricity production and networks; and, a couple of decades later, oil for motor transport. Oil would become the quintessential commodity. Electricity, on the other hand, would become a battleground, between corporations who sought to market it as a commodity, and local and national governments who sought to provide it as a service. In the course of these battles, socialists – from Fabians who saw municipal services as "embryos of the collectivist state" to anarchists who saw it as a bulwark for superseding the state – looked to electricity, if freed from capitalist control, as a technology with powerful potential to improve people's lives. But it was not only anti-capitalist forces that favoured state provision of electricity: no other industry except railways was anywhere nearly so capital-intensive, and it was widely believed that the state should provide electrical infrastructure in order to support economic development.[10]

The provision of electricity as a state service in the UK, the most urbanised country in the world in the late 19th century, is attributed by Ellen Leopold and David McDonald to "municipal enterprise", that was itself a product of public health policy. While some municipal services were bought and sold, services such as gas and water were paid for collectively through rates rather than by individual transactions. Municipal government appropriated powers of private enterprise in a potentially profitable area. In the UK, electricity was mostly provided by municipalities from its inception in the 1880s until 1948, when it was nationalised. Municipal provision was predominant in continental Europe, too. (Note that electricity or gas, provided as a service, stopped being treated as commodities in the narrow, economists' sense, while the challenge to commodification, in Marx's sense, was a limited one.) In the USA, by contrast, electricity provision was initially dominated by private corporations, who were interested mainly in supplying paying (industrial and residential) urban customers; it took the 1929 economic crash to produce state-financed rural electrification and to advance publicly-owned utilities. In the post-second-world-war boom, outside the USA – not only in Europe, but also in parts of the global south where urban electrification had begun – the international trend was towards nationalisation.[11]

[8] Pirani, *Burning Up*, Chapter 1; David Nye, "Consumption of Energy", in F. Trentmann (ed.), *Oxford Handbook of the History of Consumption* (Oxford: Oxford University Press, 2012), pp. 307-325., pp. 310-311

[9] Larry Lohmann and Nick Hildyard, *Energy, Work and Finance* (The Corner House, 2014); Matthew Huber, "Energizing Historical Materialism: fossil fuels, space and the capitalist mode of production", *Geoforum* 40 (2008), pp. 105-115. On thermodynamics and other ideas about energy, see: Cara New Daggett, *The Birth of Energy: fossil fuels, thermodynamics and the politics of work* (Durham: Duke University Press, 2019).

[10] William Hausman, Peter Hertner and Mira Wilkins (eds.), *Global Electrification* (Cambridge: Cambridge University Press, 2008), especially pp. 18-24

[11] Ellen Leopold and David McDonald, "Municipal socialism then and now: some lessons for the global south", *Third World Quarterly* 33:10 (2012), pp. 1837-1853; David Nye, *Electrifying America* (New York: MIT Press, 1990); Richard Rudolph and Scott Ridley, *Power Struggle* (New York: Harper & Row, 1986); Hausman et al, *Global Electrification*

The present[12]

During the late 20th and early 21st centuries, the trade of energy carriers as commodities expanded to become a globally dominant system. As a result of the disputes over oil prices between consumer and producer nations in the 1970s, bilateral contracts for oil, the largest-volume energy commodity, were largely superseded by market trading. Larger proportions of gas, coal and uranium, too – as well as metals and minerals that are not energy carriers – were traded across borders and on markets supported by increasingly complex financial instruments. From the 1980s, energy commodities were central to so-called globalisation and financialisation.

All this was part of the deep-going changes in capitalism, including the ever-widening commodification not only of industrial labour and domestic labour, but also of "culture, free time, illness, education, sex and even death", as some Marxist writers saw it. By the turn of the century, others wrote of "new enclosures" by which commodification spread both geographically and into areas of life previously outside its sway.[13] Ultimately, commodification was and is a battleground.

Electricity provision was an example of this. State-financed electrification, pioneered in the 1920s by the Soviet Union, became from the mid 20th century a watchword of "development" in China, India and across the global south. From the 1990s, with the adoption by leading capitalist nations and the international financial institutions of the "Washington consensus", there was a concerted drive to privatise electricity provision. Attempts, hugely damaging but mostly unsuccessful over time, were made by the IFIs and multinational corporations to impose the neoliberal "standard model" of privatisation and "market liberalisation" on countries outside the rich world. Very often, after the neoliberal offensive, fossil-fuelled power stations owned by the multinationals sold electricity to poorer countries' state- or municipal-owned utilities, who sold it at lower prices to industry and households, with the state bearing the losses.

The conflicts were not limited to electricity. Oil products, too, were bought by many government-owned companies at world market prices, and resold to households at a loss. From the late 1990s, energy commodities often had a central place in the struggle between working populations and governments over living standards. After the Asian financial crash of 1997, governments' IFI-supported attempts to raise the prices of e.g. diesel, cooking oil and electricity, produced strikes and riots; several governments fell as a result. In the former Soviet Union, the onslaught on working people's living standards during the 1990s slump was balanced by the continued provision of cheap gas and electricity; even in the 2010s, post-Soviet governments hesitated to tamper with these. In South Africa, where the black population had been systematically deprived of electricity access under apartheid, attempts from the 1990s to provide it on a commercial basis led to widespread resistance and demands that the service provision model be adopted. And in newly-urbanising areas across the global south, electricity companies found themselves in conflict with shanty-town dwellers in particular, and urban residents in general, over payment for electricity. Time and again, the companies faced resistance, based on the perception that electricity was a right for which people believed they should not have to pay – a manifestation of what what E.P. Thompson called "moral economy".[14]

The new waves of commodification were always contested and constrained. The commodified energy markets were, and are, far from all-embracing. In 2018 the IEA and other international agencies counted 789 million people who had no access to electricity. A further 2 billion had no access to clean cooking fuels and technologies (i.e. they cook with biomass, charcoal or, in some cases, coal).[15] There are major caveats: primarily, that many people counted as having electricity access, certainly hundreds of millions, actually have only irregular and/or limited supplies. Nevertheless, these numbers indicate the limits to the commercial markets in energy carriers, and, in that sense, to commodification. Those counted as being without electricity – more than one-tenth of the world population – mostly in rural areas in poorer countries, may sometimes pay somebody for fuels, but are essentially living outside the commodified energy system. The 2 billion who have (some) electricity access but can not afford e.g. gas, kerosene or electricity to cook – more than one-third of the world population – give us a rough indication of the numbers living on the edges of that system.

The future

Society is at the beginning of a transition away from fossil-fuel-based technological systems. There are dystopian scenarios in which global warming, constraints on natural resources, etc, will force a collectively paralysed society to change. For the purposes of this discussion, I discount these. It is far more likely that collectively – and notwithstanding the resistance of political and economic elites – we will act. People already are acting.[16] I also assume that to move away from fossil-fuel-based systems most effectively will mean challenging, controlling, combating and/or superseding capitalism. Here I argue that the concept of decommodification can help us work out effective actions to take. This is presented in the form of three questions.

Question 1: energy conservation

Should social and labour movements focus more consistently on energy conservation, by means of changing technological, social and economic systems, as the priority in dealing with global warming?Does rejecting the analytical frameworks of commodification help in this?

[12] This section summarises and develops points covered in Pirani, *Burning Up*, especially chapters 7, 9 and 12.

[13] The quotation is from Ernesto Laclau and Chantal Mouffe, *Hegemony and Socialist Strategy* (London: Verso, 1985). The effect of Fordism, they wrote, was "to transform society into a vast market in which new needs were ceaselessly created, and in which more and more of the products of human labour were turned into commodities. This 'commodification' of social life destroyed previous social relations, replacing them with commodity relations through which the logic of capitalist accumulation penetrated into increasingly numerous spheres". On "new enclosures", see Midnight Notes Collective, "The New Enclosures" (reprinted from *Midnight Notes* no. 10, 1990), and Werner Bonefeld, "The Permanence of Primitive Accumulation: commodity fetishism and social constitution", in *The Commoner*, no. 2 (September 2001) http://libcom.org/library/commoner-2-enclosures-mirror-image-alternatives

[14] E.P. Thompson, "The Moral Economy of the English Crowd in the Eighteenth Century", *Past and Present* 50 (1971), pp. 76-136

[15] IEA et al, *Energy Progress Report* 2020, p. 15 and p. 43

[16] See also Pirani, *Burning Up*, chapter 12, especially pp. 181-185

My answer to both parts of the question is, yes. We need to move from our current state, in which we live with technological systems largely dependent on fossil fuels, to a zero-carbon or near-zero-carbon state. In terms of technologies, there are four overlapping ways to do this: (1) reducing the amount of energy services provided (e.g. by not making unnecessary work-related journeys, not making and using plastic packaging, not making and using military jets); (2) reducing the amount of final energy needed to provide energy services (e.g. by insulating buildings to reduce heat demand, or substituting SUVs with bicycles); (3) reducing conversion losses in technological systems (e.g. by reorganising electricity networks, reducing waste in steel making, etc); and (4) replacing systems dependent on fossil fuels with systems powered by renewable sources (most obviously, but not only, electricity networks).

Given the threat that global warming poses, we can assume that all these methods will have to be used. The question of which of these methods should be prioritised, and how, is highly politically contentious. Populationists argue for reducing the amount of energy services by reducing the number of human beings; defence ministries, for cutting anything but military jets. Car manufacturers argue for reducing final energy demand by substituting SUVs not with bicycles but with electric SUVs. Oil companies argue for replacing fossil fuels, but not too soon. And so on. Usually, these arguments are underpinned by references to the "need" for "economic growth". All this reflects relationships of wealth and power. In opposition to these arguments, it is common ground among many socialist writers and degrowth scholars that drastic, systemic change is needed, that will not only expand the production of energy from non-fossil sources, but also transform the way that energy is consumed.

The obscuring power of energy-as-commodity plays a role here. The potentials of (1), (2) and (3) are often bundled together under the label "demand reduction", with the implicit assumption that energy needs to be understood as a market, governed by laws of supply and demand. This analytical framework is wrong: it assumes that demand, implicitly by individuals, is the main driver of fuel consumption, stripping out the social and economic processes that underpin the technological systems. Using this approach, researchers very often bundle together energy at different stages of conversion (e.g. crude oil, the gasoline produced from it, and the motion caused by burning the gasoline); this obscures the potential for energy conservation in technological systems (broadly, (2) and (3) above). In public discussion, "demand reduction" is often misunderstood as being about reducing the amount of energy services provided (i.e. (1) above) – and always those provided to ordinary citizens, rather than e.g. to manufacturers and users of military jets.

Another way in which the idea of energy-as-commodity mystifies the issues is that it assumes a commodity ("energy"), of which "the economy" needs a fixed amount. Much discussion on global warming is then diverted to the issue of technological means to "produce energy", including the substitution of fossil fuels by renewable sources as primary energy sources.

Such substitution is indeed necessary, if we assume that electricity generation will be a central element in future energy provision. There are many reasons to believe that electricity use might increase, even if total energy use falls, because electricity produced from renewables may be used to substitute not only for fossil-fuel-produced electricity, but for fossil fuels used in other ways (e.g. for transport or for industrial processes). But the narrative now dominant among politicians and energy corporations, that a straight swap from fossil fuels to renewables will satisfactorily resolve a large part of the global warming problem, is false. Expanding renewables, on the scale implied by mainstream narratives, without producing fresh crises e.g. in minerals supply may be difficult; to do so under capitalism, without reproducing and exacerbating the neocolonialist relations that underlie oil and gas markets, may be impossible.[17]

Another point often obscured by focusing on the switch from fossil fuels to renewables for electricity generation is that most fossil fuel use is not for electricity generation in the first place. Less than one fifth of global final consumption of energy, as measured by the IEA,[18] comes in the form of electricity – compared to one tenth from coal, four tenths from oil and about one sixth from gas. Biofuels used in poor countries, outside the commercial energy structures, account for about one-tenth. Of the electricity, less than 7% is generated from new renewables, one sixth from hydro and one tenth from nuclear; the other two thirds is from fossil fuels.[19]

Politicians are often pleased to report the progress – in some countries, very real progress – in switching electricity generation to renewables. But they have less to say e.g. about the direct consumption of gas – mostly for heating urban buildings, which can be retrofitted, using technology that has existed for decades, to reduce the final energy requirement to nearly zero, and where necessary fitted with electric heat pumps, incorporated into district heating systems, and so on. As for the oil-dependent urban transport systems that account for a mammoth share of final energy consumption, the politicians talk about electric vehicles, stepping around the realities that these may not reduce the carbon footprint of urban transport at all, unless and until renewables are supplying not only 100% of current electricity demand, but the additional demand from the EVs too.

On what basis can social and labour movements develop strategies that effectively oppose these false approaches? I suggest that, first, we need to see commodified energy as something that has emerged in the context of capitalist social relations; it is not the natural or only form of energy provision – any more than commodified labour is the natural

[17] See e.g. Richard Heinberg and David Fridley, *Our Renewable Future: laying the path for one hundred percent clean energy* (Washington: Island Press, 2016), pp. 47-80; the World Bank, *The Growing Role of Minerals and Metals for a Low Carbon Future* (Washington, World Bank: 2017)

[18] IEA national, regional and global statistics measure (i) Total Primary Energy Consumption, i.e. consumption of fuels and other primary energy carriers (nuclear, solar, wind, hydro, etc), and then (ii) Total Final Consumption, of primary energy carriers that are used by consumers without processing (e.g. natural gas for cooking), and secondary energy carriers produced by the transformation process (e.g. electricity, heat or oil products). The Total Final Consumption numbers exclude the energy used in the transformation processes (e.g. heat lost in power stations).

[19] In 2017, the last year for which IEA statistics are available, electricity accounted for 18.9% of total final consumption of energy; coal, 10.5%; oil and oil products 41%; gas 15.5%; renewables and biofuels (almost all non-commercial biofuels in poor countries) 11.1%; and heat 3%. Of the electricity, 6.6% is generated from new renewables; 15.9% from hydro; 2.5% from biofuels and waste; 10.3% from nuclear; and 64.7% from fossil fuels. IEA *World Energy Balances* 2019, p. II.5.

or only form of creative human activity. Long before commodification, humans began to access means of heat, light, motive power, etc, from nature; today, we can again aspire to accessing energy from nature not as a commodity, but in order to meet human needs. Decommodification opens up the prospect of moving away from the fossil-fuel-dominated technological systems of the present, that serve the needs of capital, to new technological systems fashioned to meet human need.

Envisaging the future in this way can inform discussion about the near-term strategy of social and labour movements, in the face of the urgent need to reduce fossil fuel consumption. Against calls by capital for techno-fixes, and for undifferentiated "demand reduction", we may develop strategies based on living better, while conserving energy. For example, trades unionists in Yorkshire are calling for a coordinated programme of retrofitting and decarbonisation of home heating, as an alternative to a scheme supported by oil companies to convert the gas network to hydrogen produced using carbon capture and storage.[20]

There is already a body of research arguing for energy conservation as an alternative to techno-fixes globally. One team sought to establish how targets accepted in the UN climate talks for limiting global warming to 1.5 degrees could be achieved, without using the negative emissions technologies (NETs) on which many of the IPCC's scenarios rely. They concluded that changes in "the quantity and type of energy services" could drive "structural change in intermediate and upstream supply sectors"; that energy end-use is "the least efficient part of the global energy system" and therefore has the largest improvement potential. They saw potential for global final energy use in 2050 to be 40% lower than at present. A second team envisaged ways to reach the 1.5 degrees target, "significantly reducing", but not eliminating, the levels of NETs used. A research group focused on the UK made proposals for reducing UK carbon emissions to zero (rather than "net zero", i.e. without NETs) by 2050, using today's technologies (i.e. eschewing techno-fixes).[21]

These publications indicate the potential of energy conservation and make a limited critique of energy demand. This critique could be extended by socially critical research that considers the potential of deep-going transformations of the way people live and work, going beyond capitalism. Rather than being limited to proposals for limiting energy use within capitalism, and the commodified energy system, such research could envisage the possibilities for energy conservation in a society in which production for profit by employed, exploited labour is superseded by purposeful activity for human need.

Question 2: decarbonisation and decentralisation of electricity

What sort of changes to social and economic systems are necessary, in order to realise the potential for energy conservation in electricity systems – and could decommodification be part of this?

Above I have argued that the political priority for tackling global warming should be energy conservation, as opposed to the focus on renewable electricity generation as a techno-fix. That said, I assume that the role of electricity in technological systems, which has been growing since the early 20th century, will continue to grow, and that generation from renewables will displace generation from fossil fuels in significant volumes. Here I comment on how electricity technologies are changing, and how – if social ownership and control can be achieved – they could be used by society to complement energy conservation and to provide for human needs, rather than being subordinated to profiteering imperatives.

Up to the 1980s, the trend in electricity generation was for the size of power stations, mostly coal-fired or nuclear, to grow. In many rich countries, new power plants have since that time tended to become smaller – due, first, to the diffusion of combined-cycle gas turbines, and then to the more widespread use of wind and solar.[22] The consensus among electrical engineers and researchers is that, as the proportion of electricity supplied from renewables sources grows, the tendency for the size of individual generation units will continue to fall. With current technologies, much electricity can be, and in some countries already is being, generated by household-sized solar and wind sources.[23]

This trend implies significant changes in electricity networks. They will need to be adapted, first, to cope with the variability of renewables-generated electricity (i.e. the fact that it is not constant, because the wind does not always blow and the sun does not always shine), and, second, increasingly to accommodate low-voltage microgrids (i.e. small-scale local grids that operate either partly or completely autonomously). A crucial obstacle is the difficulty of storing electricity: as storage technologies develop, there will be greater potential for 100%-renewable generation, and for integrating small-scale generating units. Especially at the scale of cities, other important technological potentials may be opened up by integrating electricity grids with other types of energy systems, particularly heat provision and transport (that is, e.g., surplus electricity on a windy day can be readily converted to heat, EVs can be used as batteries for the grid).[24]

For renewables-based systems, the costs are almost entirely upfront capital costs, and the operating costs are low. In economists' terms, the short-run marginal cost of generating the electricity is close to zero. Therefore the expansion of

[20] See: Simon Pirani (Gabriel Levy), "Insulate homes to tackle climate breakdown", *The Ecologist*, 2 September 2020

[21] Arnalf Grubler et al, "A low energy demand scenario for meeting the 1.5°C target and sustainable development goals without negative emission technologies", *Nature Energy* 3 (2018), pp. 515-527; D.P. van Vuuren et al, "Alternative pathways to the 1.5°C target reduce the need for negative emission technologies", *Nature Climate Change* 8 (2018), pp. 391-397; J.M. Allwood et al, *Absolute Zero* (University of Cambridge, 2019)

[22] See e.g. Amory Lovins et al, *Small is Profitable* (Rocky Mountain Institute, 2003); Walt Patterson, *Transforming Electricity* (London: RIIA, 1999)

[23] There are significant levels of household-scale generation in China, India and Australia. See, for example, Brandon Owens, *The Rise of Distributed Power* (General Electric, 2014), pp. 34-38; E. Judson et al, "The centre cannot (always) hold: examining pathways towards energy system de-centralisation", *Renewable and Sustainable Energy Reviews* 118 (2020;) M.L. di Silvestre et al, "How decarbonisation, digitalisation and decentralisation are changing key power infrastructures", *Renewable and Sustainable Energy Reviews* 93 (2018), pp. 483-498

[24] Summaries of the issues include: R. Hanna et al, *Unlocking the potential of Energy Systems Integration* (Energy Futures Lab briefing paper) (London: Imperial College, 2018); and Paul Komor and Timothy Molnar, *Background Paper on Distributed Renewable Energy Generation and Integration* (Bonn: prepared for the Technology Executive Committee of UNFCCC, 2015)

renewables endangers the standard market model for electricity systems – based on regulated sale of units of electricity as commodities in wholesale and retail markets. The proliferation of microgrids, which are increasingly able to provide electricity partially or completely independently of the large-scale grids to which markets are currently geared, presents further problems to those who control those markets. (There are similarities e.g. with the diffusion of digital technologies for recording music, which have reduced the short-run marginal cost of producing and distributing copies effectively to zero.)

Do these new technologies create more favourable conditions to supersede the commodification of electricity? In my view, they may help. However, those who own and control electricity grids are well aware of the threat to their way of doing things, and are working out how to incorporate decentralised renewables into their "business models". In China, which has the world's largest fleet of wind turbines, the issue of curtailment – wind turbines being switched off to make way for coal-fired power on networks with insufficient flexibility and storage – has become a national scandal that the authorities are working to resolve. A similar dynamic is underway in Australia. In Europe, there have been occasions on which especially windy weather has led to a surge of electricity from wind turbines, driving wholesale market prices to zero and inducing panic among electricity utility managers. In the USA, home of electricity commodification, some of the large electricity utilities are investing substantial resources into incorporating, and keeping control over, decentralised resources in their areas of operation. (Portland General Electric calls it the "transformation to a clean energy future", FirstEnergy calls it "Energizing the Future".)[25]

Academic researchers who assume commodification as the norm are considering the potential for market reforms not only to accommodate renewables, but to create new markets in which "prosumers" (middle class households who invest in decentralised generation) can trade electricity along with larger companies.[26]

Other evidence of shifting dynamics between technological change and social relations is the recent proliferation outside the rich world of mini- and off-grid electricity systems, providing electricity to areas not previously electrified. Such systems supplied an estimated 150 million people in 2019, compared to 1 million in 2010. They vary in scale from solar home systems and solar lanterns to solar PV mini-grids serving e.g. a village. Research in India, Bangladesh and Sri Lanka shows that these systems are clearly located within the property relations that reinforce multiple burdens on the rural poor: capital costs are usually covered by state or IFI funds, but maintenance is usually in private hands, funded by service charges paid by users. Furthermore, the systems only provide a minimal electricity supply where there was none before: they do not come near to providing the all-day every-day connection to which rich world households are accustomed. And sometimes projects to establish such systems end in failure, for a range of reasons. On the other hand, these systems operate outside commercial energy markets. Geographically, they are either completely separate from, or not reliant on, the centralised grids; economically, they are not dependent on electricity exchanged as a commodity in wholesale markets.[27]

Could microgrids, combined with the most recent information and communication technology (ICT), combine to provide the basis for more far-reaching decommodification? Yes they could, says a growing literature from electrical engineers and ICT specialists who see the potential for an "electricity commons". Vasilis Kostakis et al argue that the integration of local microgrids could take a qualitative leap forward with the deployment of two technologies in particular – software-defined energy networks and packetised energy management – which enable "a computationally light but operationally efficient rule-based energy resource allocation".[28] These existing technologies would break down the barriers between production and use that dominate current systems. In conclusion they propose:

> [A] commons-oriented Energy Internet that may be a radical sustainable alternative to energy production and consumption. A commons-oriented Energy Internet is technically feasible given today's technological level. However, it requires a transition towards a new political economy framework centred around the commons. [In such a system] individual microgrids share their

[25] In Xinjiang and Gansu provinces up to 30% of wind power was lost due to curtailment in recent years. Dave Elliott, "Green power curtailment in China", *Physics Today*, 17 July 2019. On Australia, "International Electricity Summit Highlights: Australia", *Electric Perspectives*, Nov-Dec 2019, pp. 37-38. On the USA, Maria Pope, "Strengthening the Energy Grid", *Electric Perspectives*, March-April 2020, pp. 27-41, and Chuck Jones, "Delivering the Energy Grid of the Future", *Electric Perspectives*, Nov-Dec 2019, pp. 29-35

[26] F. Sioshansi (ed.), *Future of Utilities – Utilities of the Future* (Elsevier, 2016); Yael Parag and Benjamin Sovacool, "Electricity market design for the prosumer era", *Nature Energy* (1) April 2016

[27] On expansion of systems 2010-19, see IEA et al, *Tracking SDG7: the Energy Progress Report 2020*, p. 4, and IRENA, *Renewables 2020 Global Status Report*, p. 23. On south Asia, Debajit Palit, "Solar energy programs for rural electrification: experiences and lessons from South Asia", *Energy for Sustainable Development* 17 (2013), pp. 270-279. This is part of a large literature on implementation. See, e.g., Helene Ahlborg, "Changing energy geographies: the political effects of a small-scale electrification project", *Geoforum* 97 (2018), pp. 268-280, and Lorenz Bollwitzer et al, "Rethinking the sustainability and institutional governance of electricity access and mini-grids: electricity as a common pool resource", *Energy Research & Social Science* 39 (2018), pp. 152-161

[28] Vasilis Kostakis et al, "From private to public governance: the case for reconfiguring energy systems as a commons", *Energy Research & Social Science* 70 (2020). See also Pedro Nardelli et al, "Energy internet via packetized management: enabling technologies and deployment challenges", *IEEE Access* 7 (2019), pp. 16909-16924

> resources so that all microgrids can have energy available when needed. No one actually "owns" the generated output, since energy in this technical system is governed by all as a commons.

Such proposals are related to discussions of the technological potential for an internet "commons" free from the control of large corporates. For example, Michel Bauwens et al envisage a technologically horizontal and decentralised computer network not only as one in which computers can "interact with each other without going through a separate server computer", but also as "a social/ relational dynamic through which peers can freely collaborate with each other and create value in the form of shared resources".[29]

A central question, not answered in this literature, is how we envisage the transition from the current state, in which both electricity networks and the internet are almost completely enclosed under corporate control, to any such future state.

Question 3: decommodification

To what extent do current proposals from the political left (e.g. the "Green New Deal"), and actions at local and community level, address the issues – and what could the idea of decommodification add?

Energy supply technologies are central to our lives, and social and labour movements have long confronted the governments and corporations that control them. In recent years, labour movements and left political parties have tried to bring together these issues with policies to address climate change. At national level, in the USA and European countries in particular, left parties have adopted versions of the "Green New Deal"; at local and community level too, attempts have been made to bring these issues together.

In September 2019 the UK Labour Party conference called for a radical "Green New Deal" that included "public ownership of energy, creating an integrated, democratic system" and "large-scale investment" in renewables.[30] In December 2019 Labour suffered defeat at the General Election, due primarily to issues not directly related to energy, and, specifically, Brexit. Nevertheless, it is worth recalling the stiff resistance that this version of the "Green New Deal" – one of the most radical adopted anywhere – faced, not only from capital, but within the Labour party and trade unions.

Due to this resistance, the Labour 2019 manifesto committed to public ownership of the electricity grid, and electricity supply functions – but, crucially, not electricity generation. The manifesto included laudable commitments to a £250 billion "green transformation fund" and a major buildings retrofitting programme – but also promised state support for EV manufacture, on a scale that would have undermined decarbonisation efforts. It committed to a windfall tax on oil companies, and to "support energy workers through transition" to a renewable-dominated system – but both Labour and national trade union leaders maintained (and, with a few exceptions, maintain today) their silence on how the transition might begin in the British sector of the North Sea, which is pumping out oil and gas at a level incompatible with climate targets (e.g. by stopping award of licences or reversing the policy of "maximising economic recovery").[31] Labour also maintained, and maintains, its support for heavily-subsidised nuclear electricity generation projects.

This experience suggests that, even where a radical left social democratic leadership takes the helm of a major political party, it faces substantial resistance from powerful companies and their allies. Had Labour come into government, the radical measures set out in the manifesto would have been counteracted on one hand by the inertia of fossil fuel production and fossil-fuel-dominated industries, and the political pressure by those that control those industries and their allies, and on the other hand by the gaps in Labour's own policies.

The constraints on social-democratic political action at national level are reproduced at local level. The limitations on such action in the UK are exemplified by efforts in Glasgow to use a Sustainable City business model to implement energy conservation measures and investment in renewables. Janette Webb points to "the importance of the financialised governance of infrastructure, which makes the implementation of plans largely dependent on private investment". She concluded from a six-year study of Glasgow that the move from pilot energy projects to large-scale implementation was frustrated by the transnational owner of the city's electricity distribution network; by the global financial market in which that company, and the council, were facing each other on unequal terms; and by the constraints of central government policy.[32]

Another example is that of Berlin, where, against a background formed by Germany's national renewable energy policy (the Energiewende), a long-running campaign has been waged to return the city's privatised electricity and gas utility to municipal ownership. This was resisted not only by the multinational owners of the utility but by the city's authorities. Campaigners won a majority in a referendum on the issue in 2013, but were stymied by turnout requirements and political manoeuvring. Political conflict continued and six years later in 2019 the electricity grid was re-municipalised.[33]

Another important field of struggle over the future of energy systems is at community and local level. In the USA, a strong tradition of community energy projects – often organised and financed as cooperatives, usually centred on developing renewable energy generation independently of the large corporate utilities – has grown in recent years. Participants in this movement have embraced the principles of energy democracy and energy-as-commons. A recent summary of its aims proposed "energy democracy" as

> [A] way to frame the international struggle of working people, low-income communities and communities of colour to take control of energy resources from the

[29] M. Bauwens, V. Kostakis and A. Pazaitis, *Peer to Peer: the commons manifesto* (London: University of Westminster Press, 2019)

[30] The text of the resolution is at: <https://www.labourgnd.uk/news/2019/9/24/labour-backs-gnd>

[31] Labour Election Manifesto, December 2019, pp. 11-18; on the North Sea, see Oil Change International et al, *Sea Change: Climate Emergency, Jobs and Managing the Phase-Out of UK Oil and Gas Extraction* (2019)

[32] Janette Webb, "New lamps for old: financialised governance of cities and clean energy", *Journal of Cultural Economy* 12:4 (2019), pp. 286-298

[33] Ashley Dawson, *People's Power: reclaiming the energy commons* (New York: OR Books, 2020), pp. 173-194; James Angel, "Towards an energy politics in-against-and-beyond the state: Berlin's struggle for energy democracy", *Antipode* 2016. See also Lucy Baker et al, "Power struggles: governing renewable electricity in a time of technological disruption", *Geoforum* 118 (2021), pp. 93-105

> energy establishment, and use those resources to empower their communities. [...] It means bring energy resources under public or community ownership and/or control [...].[34]

Cecilia Martinez, a participant in the energy democracy movement advocates an "energy-as-commons" approach that would recognise energy not as a commodity but as "the transformation of a vast array of natural interactions and phenomena for societal use". A fundamental principle is that "these natural endowments should not be owned by, or belong to, any set of peoples, countries or corporations exclusively." Martinez's proposal are focused on developing principles of governance of energy commons at a local scale. Members of a community should not be reduced to consumers; planning projects are needed in which members of the community become "active planning agents".[35]

The tension between cooperativism and community initiatives that resist commodified relationships at local level, and social and labour movements that at least implicitly challenge the entirety of capital domination and the state, is as old as those movements are. Over the last 25 years, these tensions have played out in new ways. The establishment of autonomous administration by the Zapatistas in Chiapas, Mexico (from 1994); the "water wars" that fended off privatisation of water supply in Bolivia (from 1999); and the experiments with self-management of closed factories in Argentina (from 2001), could all be seen as reactions to commodification and attempts to free society from aspects of it.[36] All of these movements challenged the state; none of them superceded it.[37]

This question necessarily remains open. In a recent book surveying and discussing the US "energy democracy" movement, Ashley Dawson argues that communities aiming to establish "energy commons" independently from corporations and the state, can not avoid the issue of their relations with these forces. He asks:

> But who gains access to the new energy commons? And what is to stop the rich and powerful preying on the commons that communities have laboriously built?

He argues that "community solar power must deploy a politics that exists 'in-against-and-beyond' the state"; rather than "cultivating imaginaries of complete energy autonomy, advocates of energy democracy seek to intervene in what radical theorist Nicos Poulantzas called the 'relation of forces within the state'." [38]

James Angel argues that the example of Berlin both "inspires hope in the potential for commoning or democratising energy through the state", but also shows the limitations of such an approach, because the institutions of the capitalist state "will continually seek to frustrate such endeavours". Angel, with reference to theoretical work by Poulantzas, John Holloway, Bob Jessop and others, concludes that gains in this direction "will likely be hard to come by, incomplete and fragile", and should not detract from political action beyond the state.

> [I]nitiatives to democratise energy by working in-against-and-beyond the state leap towards the broader emancipatory project of transforming the relations of domination – from capital, to coloniality, to patriarchy – which both the energy system and the state are currently produced through and, in turn, reproduce.[39]

A corollary of this conclusion is that the issue of the extent to which social and labour movements will struggle in, against and/or beyond the state will be settled in real life, not just in analysis and research.

Concluding remarks

Here I point to two sets of conclusions about how the above discussion of commodification might help clarify some issues.

The first set of conclusions is about the commodified energy system. The view proposed here is that it it not ubiquitous, not a monolith and not all-powerful. Its reach is limited; hundreds of millions of people live outside it and on the edges of it. The neoliberal attempt to extend and reinforce the system's dominance in the privatisation and liberalisation drive of the 1990s came up against social reality – indeed, up against the state – in a wide variety of countries. The working of the neoliberal project was constrained, time and time again, by social conflict over the way that energy resources were supplied and the prices paid for them by working people. So the system can be challenged.

[34] Denise Fairchild and Al Weinrub, "Introduction", in Fairchild and Weinrub (eds.), *Energy Democracy: advancing equity in clean energy solutions* (London: Island Press, 2017), p. 6

[35] Cecilia Martinez, "From commodification to the commons: charting the pathway for energy democracy", in Fairchild and Weinrub (eds.), *Energy Democracy*, pp. 21-36. Another proposal on governanceis for a "sustainable energy utility" as a model underpinned by "community rather than technocratic institutions and values". See John Byrne, Cecilia Martinez and Colin Rugger, "Relocating energy in the social commons: ideas for a sustainable energy utility", *Bulletin of Science, Technology and Society* 29:2 (2009), pp. 81-94

[36] On Bolivia, see Oscar Olivera, *Cochabamba! Water War in Bolivia* (South End Press, 2004) and Karen Bakker, *Privatizing Water: governance failure and the world's urban water crisis* (Ithaca: Cornell University Press, 2010), chapter 6. On Mexico, Alex Khasbanish, *Zapatistas* (London: Zed Books, 2010). On Argentina, "Zanon: a factory in the hands of the workers – Argentina", *Wildcat* 68 (2006)

[37] See J.K. Gibson-Graham, *A Post-Capitalist Politics* (University of Minnesota Press, 2006). For a wider view of the commons, see Christian Siefkes, "The Commons of the Future: building blocks for a commons-based society", *The Commoner*, March 2009

[38] Dawson, *People's Power: reclaiming the energy commons*, pp. 146-147

[39] Angel, "Towards an energy politics".

Having said that, the commodified energy system is a central and powerful manifestation of capitalist social relations, made still more powerful by the way that capitalism itself changed in the late 20th century (globalisation, financialisation etc). This has implications for challenges to it in – as opposed to against and beyond – the state. Should left-leaning political parties come to government and attempt to implement versions of the "green new deal", the weakness of those programmes implicitly to challenge commodification – for example, by focusing on ownership of one or another aspect of the energy sector, but not addressing the commodified markets and their relations with the state – will take its toll. The dynamics at municipal level have been mentioned above with respect to e.g. Glasgow and Berlin.

The second set of conclusions concerns commodity fetishism and the way it works out with respect to energy. The false view of energy as a thing that is supplied to meet an abstract "demand" often conceals the character of demand, which brackets together both energy services needed by communities and households with demand generated by the logic of capitalist expansion that is of no use to people. An understanding of the social and economic relations that comprise "energy supply" (on one hand the technological stages of energy conversion, but also the social and economic relationships within which they operate) and "energy demand" must be unpacked. It is not only that the commodification of energy reinforces hierarchies of exploitation, it is that commodification in the context of the capitalist economy obscures the way that energy is both produced and consumed.

Decommodification of energy implies a set of social relationships in which humans take sources of energy from the natural world, and use them, free of commodified forms of exchange. While such relationships can be prefigured at community level, such projects will always be constrained by the larger, more powerful commodified energy system that overshadows them. In my view this does not mean that co-operative, local or municipal attempts to carve out spaces for "energy commons" should be abandoned, or that we should limit ourselves to repeating "system change not climate change". But we need to be aware that not only the state, but also the commodity form and the workings of the economy, are obstacles that we have to confront.

□■□

And if energy itself is unjust?

By Larry Lohmann

The way that industrial capitalism and 19th-century thermodynamic energy – the energy we talk about today – have constituted each other, and what this means for political movements, is something that colleagues and I been struggling to understand, off and on, for many years. So Simon Pirani's paper How Energy was Commodified, and How it could be Decommodified, was extremely stimulating for me.

I share Simon's view that understanding energy as commodity and as commons is crucial for the struggles ahead. But his paper also reawakened a certain uneasiness about the way issues of "energy democracy" and "energy justice" are typically framed by the left, especially in the global North.

Usually I abbreviate this unease by saying that the issue cannot be only that the distribution of energy is unjust or undemocratic (which it is). Or that structures of extraction, production, distribution, access, governance, planning and use of energy are unjust and undemocratic (which they are). There has to be a lot more. And that without taking account of this "more", the best-intentioned efforts to address these distributional/administrative/governance/cultural types of issue are eventually going to come to grief (or already have).

Simon's work helps pin down what some of this "more" is – namely that energy, when treated as a commodity, is always going to have these issues, and that the further step of searching out and linking together existing and potential moves toward energy-as-commons ought to be more integrated into popular strategy.

But I feel that there is more to this "more" than just the idea that energy has become a commodity – and that maybe, to some extent, it can be decommodified.

Maybe a better formulation would be that the "commodification" way of putting the matter still seems to me somehow incomplete insofar as it gives the impression of an identifiable, enduring "thingy thing" that at first was not commodified but now is.

My usual way of abbreviating this particular unease is to say that a critical approach to energy-as-commodity shouldn't leave out the fact that energy *itself* is unjust and undemocratic. That in some sense energy *itself* is part of the commodification processes of industrial capitalism. And that a concept of energy lifted unexamined from 19th-century capitalist science can be an alienating lens for left social movements to look at questions of livelihood, labour and climate change.

Looking through some recent volumes on energy democracy and energy justice (*Energy Democracy*, *Routledge Handbook of Energy Democracy*, *Handbook of the International Political Economy of Energy* – I don't keep up like I should), some of which are referenced in Simon's article, I find that what gives rise to my unease hasn't really changed over the years. The injustice and undemocratic nature of energy *itself* are still not recognized by the North Atlantic left, as far as I can see, any more than its "whiteness" is.

From my perspective, this lack of recognition is going to continue to have movement-building costs, not least when we're talking about movement-building with the grassroots in the global South. I've been reminded of this recently by, for example, movement colleagues in Indonesia expressing frustration with the obstacles that the clean energy/dirty energy discourse throws in the way of their ability to confront the joined-together assault on people's life-spaces that links fossil, geothermal, hydroelectric, nickel and cobalt projects. Or colleagues here in Ecuador who are documenting the social and ecological devastation wrought over the last two years by rampant balsa extraction for wind turbine construction in China.

For me, one of the lessons of such experiences is not just that there ought to be a "better", less commodified energy out there in the realm of possibility. Nor that the only way to deal with these kinds of strife is to chop the logic and make the

alliances that are necessary to replace false or misleading distinctions between different kinds of energy with true and correct ones. For example, to try to transcend or put into perspective the counterproductive, incoherent discourses of clean energy/dirty energy, green energy/brown energy, renewable energy/nonrenewable energy by means of a more relevant discourse, that of commons energy/commodity energy.

For me, instead, what such experiences point toward is the need to delve deeper into what energy *is*, where it came from, why it is colonialist in itself, and what that means for recognizing new and different possibilities of alliance-building. Without this inquiry, my fear is, it's not going to do the Indonesian or Ecuadorian situations much good just (for example) to let loose on them enlightened teams of collaborating social scientists and engineers with an Ostromian vision of energy commons constructed by salvaging capitalist energy detritus.

The problem, after all, is not that issues like those in Indonesia or Ecuador go unnoticed. Or that nobody is raising the alarm about them. On the contrary, they are attracting more and more notice, including even to a small degree in the global North, which is good. The problem, rather, is more that, without being conceptualized as stemming from the undemocratic and unjust nature, dynamics and geography of energy itself, they tend to be slotted into the category of problems awaiting a solution somewhere down the road, while energy itself remains untouched – and that, accordingly, industrial/digital capital accumulation remains undertheorized and the means of undermining it understrategized.

Energy keeps being subdivided into different kinds so that it can be claimed that growing worldwide strife, degradation and crisis stems from some particular way of *dealing* with energy, rather than also involving, ultimately, a reaction to the dynamic of evolving colonially-structured entropy territories that *constitutes* energy.

For me, backing up a step in order to get behind all this means reflecting once again on thermodynamics (which gives us our idea of energy) in the ways that George Caffentzis has taught us to do. Especially now that, in reaction to emerging forms of labour revolt, energy is increasingly being combined with Turing machines to help organize new areas of absolute surplus value extraction from living interpretive labour and ecosystem services.

Energy was born at the end of the heyday of absolute surplus value, when capital's idea had been just to move more and more people away from the land and previous rhythms of life and confine them literally and figuratively in ways that could increase the person-hours that they could dedicate to capitalist work. During that era, as Marxists point out, the classic way of increasing surplus had been to lengthen the working day, plus to continue to try, against enduring resistance, to clear away "Saint Monday" and other inconvenient manifestations of conflicting (often rural) temporalities, without necessarily trying to reduce the amount of social labour time necessary to reproduce the workers themselves – or even (it depends) always to mess with their residual reliance on remnant commons.

But with new forms of resistance to lengthening the working day came pressures to intensify the working hours that capitalists slowly came to realize that they were stuck with. Because it wasn't so easy any more to augment profits by stretching the working day to its limit and beyond. Because once workers had finally been pushed or pulled into new capitalist workplaces, their resistance partly morphed from general mulishness, refusal of linear absolute time, etc. into new forms of volatility, cunning, combination, foot-dragging, etc.

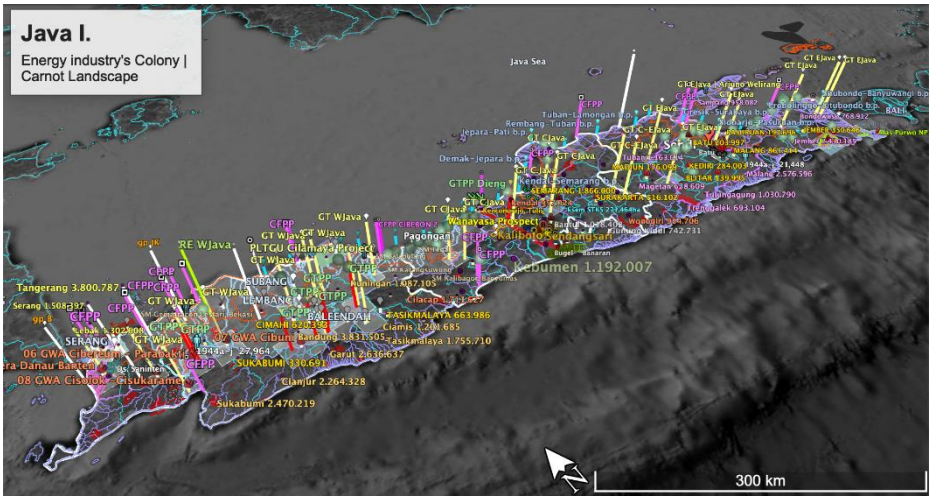
This was the origin of the "productivity" and "efficiency" discourses, when industrial machines really arrived in their modern forms. Not that industrial machines have not also been useful all along in dealing with the old capitalist problems of getting masses of people off the land into wage work (as witness one of the greatest rural-urban migrations of all time around the turn of the 21st century). But the machines had really found their first usefulness in the new stage of capitalist class struggle against ordinary people that arrived in the 19th century.

These machines' way of dealing with the new challenges to surplus-appropriation was not that they themselves constituted a new or "replacement" or "supplementary" source of living labour for the workplace (although they did help drag in much more of that living labour in the form of new human fodder). Nor did the machines "substitute" in any way whatsoever for the lamentably limited human workers beavering away alongside them. Instead, their mode of increasing surplus was by organizing that human living labour and those human lives along somewhat differently brutal lines and scales. In some ways, the living labour process became more intense. More intensely rapid-paced linguistic interactions, recognitions, gestures, actions and other language-games among the society of human (and sometimes animal) interpreters confined to the factory and its surrounding little shops were necessary to keep up with the repetitive, thundering machine motions. Different modes and intensities of living interpretive labour also became mandatory among the societies of workers charged with tending the plantations, or "machines on the land," that formed another pole of the new mechanization.

None of this in any way "turned humans into machines". On the contrary, it relied absolutely on bases of sociality and social/biological evolution established by and specific to the long non-capitalist history of the human species, even as it suddenly twisted them into various new hypertrophies and atrophies. One result was that the amount of social labour time necessary to reproduce the workers themselves decreased, meaning that the skimmable surplus increased in

proportion. Another outcome was that workers and their commons began to experience new and different ways of getting ecologically "maxed out" other than just having to be on site long hours – whether or not this happened in any particular case to translate directly into new forms of rebelling against capitalist work, or what normally goes under the name of "resistance".

One more crucial pole of this process was the emergence of energy between around 1800-1870. As Caffentzis notes, "relative surplus value is the type of production that is at the basis of thermodynamics' investigation of work/energy." But it's crucial in the 21st century to spell this out in somewhat more detail than George did in the 20th.



Java as energy. Each column indicates a site where materials violently extracted from sacrifice zones are to be deployed violently to wrench open "doors" facilitating accelerated erosion of entropy gradients, for example by geothermal fracking or hydroelectric dam construction. Graphic courtesy of Hendro Sangkoyo, School of Democratic Economics

One aspect of the First Law of Thermodynamics was its "level of generality and abstractness," which gave "enterprising spirits" ideas about the "possibility of producing work from novel, untoward sources." The very form of the First Law expressed the new estrangements characteristic of the epoch of relative surplus value. The flowing stream's *sui generis* relationships with the hill, the forest and the community do not disappear, but they now jostle with and are often bumped aside by the new relationships of equivalence between the forest (= abstract heat) and the stream (= abstract mechanical force) (as worked on by Julius von Mayer and James Joule), between chemical bonds and magnetism, between sunlight and electricity.

Capitalists' efforts to get their hands on surplus value now involve a new entity in the landscape – energy – whose presence changes everything else about it. The stream, the forest and the hill are now energy – not only a singular, unified, abstract resource and eventually a commodity, but even more fundamentally just a new "thingy thing" generated out of a set of new relationships and new temporalities.

Choosing between the older relationships linking the stream, forest, hill and community and the incompatible relationships linking mechanical force, heat and electricity quickly became, for 19th-century capitalists, a no-brainer – provided that the reorientation met the criterion of cheapness. And workers, while participating in machine development, suffered and joined in these choices. Making the stream, the hill, and the forest into "energy carriers," following the First Law, meant doing something politically different with them that revalued their prior mutual relationships, readjusted their relationships to livelihood, and steamrolled over various prior structures of significance they may have had.

These shifts are continuously recreated today and are instrumental in the hegemony of thermodynamic energy over other energies – over, for example, the nonthermodynamic "energy" that in many places around the world continues to inhere in noncommodity food. The stream's relations with the hill become important mainly only as a support, interchangeable with others, for the exploitation of time-intensive capitalist labour. Here is the birth of what is now called "extractivism", whether of coal, copper, lithium or balsa. Extractivism is an expression of a hierarchy in the landscape in which every "nonthermodynamic energy" of the commons – cooking fuel collected from common woodlands, oil left underground, undammed streams – is seen as subordinate to the overarching abstract energy developed in the 19th century.

Whenever we acquiesce in the unqualified use of the contemporary term "energy carrier", we are siding, whether intentionally or not, with this 19th-century European capitalist imposition. We are allying ourselves with capital against not only 19th-century commoners, but also many 21st-century commoners.

The same goes for a range of other terms that continue to appear year after year after year in the energy justice and energy democracy literature, including "energy source," "energy conservation," "energy services," "renewable energy," and "energy depletion." Hard as it may be, whenever we use these terms we have to ask ourselves, at the very least, whose side we are on, because we can't be on everybody's.

That's just the First Law. The Second Law of Thermodynamics spells out further injustices and antidemocracy that reside inside the energy that it, together with the First Law, helps define. Particularly revealing is non-equilibrium thermodynamics. Today this is considered to be on the cutting edge of physics, but it was already present in embryo in 1824 in the work of Sadi Carnot. Carnot explored the seeds of the idea that we might express today by saying that what capital needs for its machines, including computers, is not energy as such – which, after all, is never destroyed and whose supposed "sources" are everywhere – but "falls" (*chutes*) or gradients in the landscape from low to high entropy.

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 trapdoors – usually violently – through which an entire territory slips more rapidly down those gradients, eroding the gradient itself in the process. Violence is part of the picture because the

Schroedinger clarified that some such border action is necessary for living beings to stay alive. Twenty-first-century biology and physics have started to reveal some of the stupendously complex, evolved subtleties involved. But cruder forms of entropy politics are necessary for the labour exploitation technologies that industrial capitalism was forced to adopt as a result of the evolution of class struggle. Here the picture is more one of hierarchically-organized political relationships between, on the one hand, energy beneficiaries and their "dissipative structures" and, on the other, "sacrifice zones." These relationships have to be continually modified and shifted geopolitically as time goes on. This is what the Second Law euphemizes as a pan-human destiny of "heat death".

And since the Second Law forms part of the energy concept, it is also part of what the term "energy" also euphemizes, in the hegemonic sense in which the word is used today. Try as I might, I can't see how social movements to decommodify energy can succeed in broadening their bases sufficiently unless they de-euphemize these euphemisms and confront the fact that our 19th-century energy itself is violently colonialist – and that by definition there can be no such thing as "democratic energy".

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.

The rolling outcome of all this violence is accelerated flattening of entropy gradients within the relevant system that the labour-exploiting machines are using. The higher the intensity and extensiveness of energy conversions that capital pursues in line with the First Law of Thermodynamics, the swifter that equilibrium is approached in whatever system is being rejiggered. If the system is "closed," in the jargon of physics, the closer that entropy changes come to halting altogether.

This "entropy balance" is what "sets the limit to the power of the engine," in the words of one physicist. The hierarchical landscapes of multiplying First Law conversion engines are also landscapes of increasing Second Law entropy slope flattening and "waste." Which capital has to deal with if it is to keep its machines running in those landscapes or others.

This is where the colonialist frontier comes in. If we set our system border at the level of the heat engine, then delaying the onset of the equilibrium that capitalist violence hastens but which is anathema to capital's machines means (violently) going outside that border for more low entropy. If we set a new border at the level of [the heat engine + its extraction zones], then delaying the onset of equilibrium in that larger system means going outside *that* border in turn. And so on through various additional levels of the earth's thermodynamics, until we get to global warming and all the rest of it. In short, the Second Law demands that, where a system has to be maintained far from equilibrium, there has to be an ever-changing border politics to maintain that nonequilibrium through what physicists sometimes refer to in shorthand as low entropy imports or high entropy exports.

Another corollary that often seems to me to be glossed over even by some the ecological Marxist thinkers I most admire is that we need to be really careful with that neologism "work/energy". Sure, there is a close relationship between energy and the evolution of capitalist labour exploitation. But thermodynamic energy and capitalist labour are not the same, no matter how closely they are tied together spatially and politically. They cannot substitute for each other. They are not additive or mergeable in the way that capital would like us to think. To use Marx-like language, no amount of BTUs or megawatts can, by itself, create an atom of capitalist value. Or to revert to Marx's own lingo in *Capital*, in any particular case, energy-intensive mechanization

> alters only the quantitative relation between the constant and the variable capital, or the proportions in which the total capital is split up into its constant and variable constituents; it has not in the least degree affected the essential difference between the two. (See Marx, Capital vol. 1, end of chapter 8.)

What "energy carriers" carry is not the ability to labour. Energy does no capitalist work and in itself adds no surplus for capitalists to skim off. Its place is with machinery and algorithms – to augment and mobilize the sum of what Marx called dead labour – to speed up stereotyped motions or manipulation of representations, for example – and not to replace or add anything to living labour. (Energy does have an effect on the latter, of course, as mentioned above.)

Without industrial capitalism and its prior organization of dead labour, there would be no energy as we use the term today. Capital comes first, then energy. Nineteenth-century thermodynamicists' early identification of their new energy

as the ability to do "work" or carry out or perform "duty" is a typical capitalist mystification, something you might expect given their uniformly business or colonialist backgrounds. Of course, the fantasy that energy does capitalist work will probably go on proliferating in common scientific and political usage. But in my view, it should long ago have been weeded out of radical social movement thinking.

To put it another way, spinning machines cannot produce surplus because they cannot spin. Power looms cannot do capitalist work because they cannot weave. By itself, energy cannot run a power station, move a car forward, or even warm a room in the way required for even a fractional increment of capital accumulation. Spinning, weaving, running power stations, growing food, providing internet services, transporting goods, repairing metal punches or photocopy machines – all this happens only when living labourers can explain what they are doing to other people by reference to rules, when what they do can be done rightly or wrongly in the view of certain human communities. Capital has as yet no means for short-cutting either the long-evolved community norms and frameworks or the 3-billion-year-old biological structures that it relies on to create surplus. Sometimes it wishes it could get its hands on such means (think AI) using masses of thermodynamic energy, but it couldn't afford them even if it could figure out what they were.

In short, I agree that it's a "false view of energy" that it is a "thing that is supplied to meet an abstract 'demand'" identified by capital that "brackets together both energy services needed by communities and households with demand generated by the logic of capitalist expansion that is of no use to people." There certainly are ways of taking commoners' monkey wrenches to energy that could put "energy services" with a higher commoning content before the thoroughly commodified energy required by the logic of capitalist expansion. Indeed, as Simon suggests, this is a key part of anticapitalist strategy, and something that many movements are pursuing already.

But I feel like I would like to take this valuable line of thought further by noting that "energy services" themselves, because of their history and structure, are ill-suited in many ways to democratic commoning, anti-colonialism and anticapitalism. And that social movements that keep that firmly in view will stand a better chance of building broader and more powerful political networks in the future, because they will have opened themselves to voices, many of them outside the global North, that have been, at least implicitly, questioning energy itself. *17 December 2021*

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Thermodynamics: a metaphor or a science?

By David Schwartzman

Larry Lohmann's "And if Energy Itself is Unjust?" is a very interesting article, and it is nice to see thermodynamics revisited in the context of the capitalist physical and political economy. But this article deserves critique. Illuminating how the science of thermodynamics was born and how energy manifests itself in the context of capitalist economy, as Lohmann does, should not make this science in itself a necessary ideological servant of this economy.

Lohmann's invocation of the laws of thermodynamics, especially its second law of entropy is pure hybridism, the appropriation of a science into ideological metaphors, following the example of Bruno Latour's hybridism, so clearly unpacked by Andreas Malm's 2019 paper "Against Hybridism" (*Historical Materialism* 27.2 : 156–187). As Malm says:

> particularly in our rapidly warming world – we need to sift out the social components from the natural, if we wish to understand the crises and retain the possibility of intervening in them.

Since there is no scientific explanation of its thermodynamic reference, I take Lohmann's "flattening of entropy gradients" as a metaphor for the generation of waste and destruction of ecosystems as a result of extraction and creation of technological infrastructure such as solar panels.

The caption on the figure Solar Photovoltaic Resource in the US reads:

> The US as energy. Each colour indicates the theoretical potential for profitable annexation of territory on which materials violently extracted from sacrifice zones can be employed to accelerate conversion of light to other forms of energy, speeding up the flattening of entropy slopes.

But only a small fraction of the US land area, indeed world land area, mainly using existing rooftops, will be needed to create a photovoltaic energy capacity, along with wind farms sited in the ocean, to not only replace fossil fuels but even surpass their energy supplies. (See, e.g., the discussion in the Supplements of our paper "Can the 1.5 °C warming target be met in a global transition to 100% renewable energy?".

Indeed, the renewable energy transition includes real challenges of extractive industries especially mining which must be confronted, but in a full global transition terminating fossil fuels, it is the only path to having any chance of avoiding climate catastrophe, defined as breaching the 1.5 degree C warming limit, with horrors much worse than we now witness.

While entropy as a metaphor has its positive value, in Lohmann's case highlighting the destruction accompanying the creation of renewable energy supplies, and likewise for Robert Biel's *The Entropy of Capitalism* (2011), not going beyond this metaphor with an analysis relying on the science of thermodynamics will not make clear the critical implications of the second law to a renewable energy transition. In particular, we should recognize the potential of

this renewable energy transition to reverse Lohmann's "flattening of entropy slopes", by making possible industrial ecologies and efficient recycling of metals virtually terminating extractive industries.

This potential can only be realized in a simultaneous transition to a post-capitalist world, in a global Green New Deal driven by class struggle led by the transnational working class and its allies, particularly indigenous communities most impacted by extractivism. And this potential can only be realized with demilitarization of the global economy, freeing up vast quantities of metals needed for the transition to renewable energy and a truly green physical infrastructure derived from the dismantling of the fossil fuel/military industrial complex.

Tapping into a small fraction of the incoming solar flux will make this self-organization of global infrastructure and restoration of global ecosystems possible. An ecosocialist path will decommodify energy, creating a global solar commons. As defined in the second law of thermodynamics, entropy is a measure of the loss of energy available to do work, thermodynamic work, not to be conflated with the work derived from the appropriation of labour power in a capitalist economy producing surplus value.

The production of energy from burning fossil fuels, as well as nuclear fission, generates an incremental heat flux from the Earth's surface, unlike – to a good first approximation – the tapping of solar radiation to do work. The latter outcome is non-incremental because the interaction of low entropy visible light with the low albedo relatively dark Earth's surface generates a corresponding flux of high entropy heat (infrared radiation) whether work is done for human civilization or not, with this heat flux escaping to space.

In addition, burning fossil fuels is a prime source of anthropogenic carbon emissions to the atmosphere driving global warming, which is amplified by the melting of high albedo sea ice and surface snow at high latitudes. Hence, global solar power will then pay its "entropic debt" to space as non-incremental waste heat, without driving us to tipping points towards even more catastrophic climate change than has happened over the past few decades. For a fuller discussion see my 1996 paper "Solar Communism" (*Science & Society* 60 (3): 307–31), and my 2008 paper "The Limits to Entropy: Continuing Misuse of Thermodynamics in Environmental and Marxist Theory" (*Science & Society* 72 (1): 43-62). Also relevant is my 2021 book, *The Global Solar Commons*. *18 December, 2021*.

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Disentangling capitalism and physics, 'energy' and electricity

By Simon Pirani

Larry Lohmann's comments, "And if energy itself is unjust?", about my article on energy commodification, are really welcome. There is much we agree on: that we have to question whether there is, was or could be such a thing as "energy" that was not commodified and is therefore somehow OK; that the relationship of thermodynamic energy and labour is somehow at the bottom of all this; and that there is much wrong with the way issues such as "energy democracy" and "energy justice" are framed on the "left". (Actually I don't like the term "left", either, (a) because it obscures the fact that, whatever it might be, it certainly isn't the motive force of history in the way many of its adherents think, and (b) because it implies that I am part of some entity that doesn't include most working people, but does include people who think Putin is doing fine in Ukraine and Bashar al-Assad is an "anti imperialist" hero. But I digress.)

One way to take our discussion forward is to focus on four parts of it, where we don't see things in the same way, or haven't understood each other. Here goes.

1. How do we define "energy"?

When I read Larry's comments, I looked back at the introduction to my book *Burning Up*, where I first used the definition of energy he is questioning. In the introduction, I proposed to use the word "energy" in a way that does not include human labour, as "work done by physical or chemical resources, mobilised by people for that purpose". Part of the reason I went for this approach was to try to deal with an issue that Larry raises, that thermodynamic energy and capitalist labour (I'd say, labour under capitalism) are not the same, can not substitute for each other, and are not additive or mergeable as capital would have us think. I would have had to write the book very differently if I wanted not to use the word "energy" at all, or not to use other words, such as "democracy" and "socialism", that can be inscribed with different, indeed opposite, meanings by people who use them.

It could be said that my definition missed out the way that the concept of "energy" has been imbued with meanings by the social process during which it was first used, i.e. the work of physicists, and the philosophers, economists and others whose work influenced them, at the heart of 19th century British empire-building. And that process has not stood still: the way that the term has been used in the late 19th century and throughout the 20th century has added further layers, in particular in terms of "energy" as an extractivist process embedded in imperialist and neo-imperialist relationships. And Larry has said a great deal about the role of "energy" in the battles between capital and labour.

So I accept that. I think there are many circumstances in which people, including those on the "left", use the term "energy" in a way that obscures these historical and social realities. And I can see why Larry would want to stress that "energy" is something brought into being by capital – in order to emphasise his political point, against anyone who thinks that, if we could just remove the most egregious manifestations of neoliberalism, there is some pure "energy" waiting underneath to be recovered and used in the interests of society. There are indeed many people who think like this, and it's related to the view of technology that I'd say is (depressingly) dominant on the "left"– that technologies are somehow neutral and if we can e.g. only "nationalise them under workers' control", all will be good.

But ... having said all that, to be analytically precise, there is a distinction between my approach, as per my definition, and Larry's approach, which leads him to say:

> Without industrial capitalism and its prior organisation of dead labour, there would be no energy. Capital comes

> first, then energy. Nineteenth-century thermodynamicists' early identification of their new energy as the ability to do 'work' or carry out of perform 'duty' is itself a typical part of capitalist mystification ....

I see what happened in the 18th and 19th centuries differently. I think that capitalist social relations, which had started to take root in agriculture long before that, congealed around, and became dominant in conjunction with, the new fossil-fuel-based technologies. My definition of energy, "work done by physical or chemical resources, mobilised by people for that purpose", would cover water wheels, windmills, dams and coal-fuelled metalworking in precapitalist societies. Larry's would not. His is a view not of "energy" in the way that I understand it, but of "energy as a concept developed by capital, starting in the 19th century", which isn't quite the same thing.

A third type of definition of energy current today is that used by university-based physicists. They refer to Newton's three principles, enriched by, but not negated by, both 19th century thermodynamics and 20th century relativity. Clearly their definition refers to things that were happening for millions of years before there were any humans, let alone capital and its systems of control. Again, to be analytically precise, neither Larry's definition nor mine would work to explain those things.

In social movements, definitions matter not because everyone has to say things the right way – indeed there's a danger of "political correctness" being used to shut up people who don't have the "right" education – but because words can be filled with damaging meanings that serve our enemies. This often happens with the word "energy". But, as people who are trying to understand the world and analyse it, we then need to clarify whether we should simply not use the word at all, or, if we use it, how.

2. In which ways do the laws of physics shape social processes?

In Larry's comments, and some of his other writing, he makes connections between the first and second laws of thermodynamics, and what I would call the contradictions of capitalism and the way that the process of capital accumulation increasingly ruptures humanity's relationship with its natural surroundings and hits up against natural barriers.

I am on perilous ground here, because my understanding of physics is limited. But let's start with the second law. I think I understand Larry's point about gradients running from low to high entropy. I think I understand that it's better to think not of capital "using up energy", but of it "pulling open various doors – usually violently – through which an entire territory slips more rapidly down those gradients". And I think I understand that the violence is used because "the sequence and patterning of that door-opening has to suit the operation of capital's conversion devices". So, to give an example I'm familiar with: the expansion of Russian and European capital in the late 19th century forced through the violent industrialisation of the Donetsk basin in eastern Ukraine. The pattern of urbanisation, the imposition of paid wage labour and all the rest was in many respects dictated by the ways in which the coal mines and steel mills were arranged, adjacent to each other. The coal was burned, to fire the steel-making process, in ways dictated by capital, resulting in a huge movement down the gradient to high entropy. (*Fossil Capital* by Andreas Malm describes very well how this happened some decades earlier in Britain.)

Larry draws a picture of this process going through "borders", and capital requiring a "border politics" to maintain the non-equilibrium of systems. He adds that cruder forms of "entropy politics" are needed for the labour exploitation technologies that capital is forced to adopt as a result of the evolution of the class struggle. These cruder forms of politics are conducted between energy beneficiaries and their "dissipative structures" on one hand, and "sacrifice zones" on the other. This is where I get lost. Larry apparently sees the operation of the second law of thermodynamics as THE crucial driver of capital expansion, class struggle and colonialism. I don't think that's right.

I think the fundamental drivers of capital expansion, class struggle and colonialism are social relations between people – capital's endless drive to accumulate, to subordinate labour to itself, to enrich itself and to reinforce and maintain its power through violence, chiefly but not only state violence. I see the harnessing of fossil fuels in prodigous quantities, from the early 19th century, as, in the first instance, a result of these processes. I think that these social relations, working through the expansion of capital, forced forward the development of technologies dependent on vast quantities of fossil-fuel-produced power, such as the steam engine and steel manufacture.

Many Marxists in the twentieth century failed to see the centrality to capitalism of fossil fuels, the prodigous energy throughput of fossil-fueled systems, and the operation of the second law of thermodynamics, in the first place through such systems. A more serious mistake was to see the technologies as somehow neutral, to think that you could abstract them from the social relations within which they emerged, and that "productive forces" were somehow inherently progressive. An even more serious mistake was to ignore the ways in which capital expansion, from the start, played havoc with our natural surroundings, and that disasters such as global heating are inevitable outcomes of capital expansion. I think it's past time that we got clear about the damage done by such mistakes, particularly in the form of the pernicious influence of Prometheanism, productivism and techno-optimism in the labour movement.

For all these reasons, I welcome Larry's work. I think that the second law of thermodynamics needs to be integrated into

complex that mostly funds it. Difficult – but not impossible. Because that science is not ONLY formed by that context, but by other contexts, including the physical realities it endeavours to explain.

I remain to be convinced that things are any different with thermodynamics. Yes, we need to overturn the idea that there is something called "energy", that if only freed from capitalist ownership can work to our advantage. We need to understand energy throughput through the capitalist economy, which includes the thermodynamics and the interactions with the natural world, as well as the social and economic factors. We need this understanding, to help us envisage what might supercede capitalism. But, as far as I understand, while the law of entropy is interpreted and mobilised by capital in fossil-fuelled energy systems, it also operated in physical reality before capitalism existed and will operate in any post-capitalist future.

analysis of social phenomena. But I don't think that, by itself, it's a sufficient explanatory framework for capital expansion and colonialism. There are other things going on. To go back to my example: the second law is useful in explaining the Russian colonisation of the Donbas, and part of explaining the colonisation of the Caucasus and Central Asia. But what about the Russian colonisation of Siberia? I think the chief drivers there were about geography and statecraft – control of trade routes, defence against Asian states, etc. Most of the mineral resources (gold, silver etc) were mined for their commercial value under capitalism, without much connection to energy production. The hydro and coal resources were only opened up in the late 20th century, more than a hundred years after colonisation. I don't know how the second law of thermodynamics came in, but it was not as direct as in Britain in the 1840s or the Donbas in the 1890s. I am sure we could think of similar examples from other empires.

My next question is about Larry's argument that the second law euphemises all these processes we have been discussing. Again, I need convincing. I don't doubt (i) that Kelvin, Joule and all those guys saw their science as part of a colonialist enterprise; (ii) that we can not understand physics or any other science as something that operates outside the social context, i.e. capitalism; and (iii) the whole idea of "energy" predominant in mainstream discourse, up to the present, normalises capitalism, including its violent and colonialist aspects.

Science is used by capital, bent to capital's purposes and deformed by capital. But that is not all it is. So, when you split an atom of Uranium-235 under the right conditions, you get a nuclear explosion, and in the mid 20th century gigantic research resources were put into understanding that, in order to develop the bomb. That cruel, inhuman result does not however negate the laws that physicists use to explain how that reaction takes place. A couple of generations of physicists were kept up at night by the fact that the science, legitimate on its own terms, was deployed to such catastrophic ends.

In the 21st century it's difficult to see how the science of nuclear physics can be extricated from the military-industrial

3. How do we envisage the transition away from fossil fuels?

Now about the first law of thermodynamics. Larry writes about the way that capitalism turned the stream and the hill into "energy carriers" for its own systems. He sees extractivism as an expression of a hierarchy in which "non-thermodynamic energy" of the commons is seen as subordinate to "an overarching abstract energy developed in the 19th century". I'm with him, that far. Where he loses me is with the conclusion that, whenever we "acquiesce" in the unqualified use of the term "energy carrier", we are siding, whether intentionally or not, with a 19th-century European capitalist imposition.

I don't see why, in discussions of technological systems, the term "energy carrier" necessarily has that function. As far as I know, this term began to be used in the US and Europe in the 1970s, i.e. when "energy studies" became a thing. It was used as part of "net energy analysis", which developed to illustrate the way that physical energy flowed through systems. (See e.g. David Reister and Warren Devine, "Total costs of energy services", *Energy* 6:4 (1981), and Daniel Spreng, *Net-Energy Analysis and the energy requirements of energy systems* (1988).)

"Net energy analysis" was developed in universities dominated by, and funded by, capital. Its authors basically accepted capitalism as an imperfect but also irreplaceable reality. They sought ways of measuring flows of energy that was separable from economics, even though they also referred to the monetary costs of energy. They analysed physical processes, to show what was going on in the technological systems developed by capital. They thought there were better ways of providing for populations' basic

needs than these systems. I doubt that any of them would agree with Larry or me that the problem is that the system's purpose is NOT to provide for people's basic needs, but to enhance the power and wealth of the ruling class. Nevertheless, their work is valuable. Can we not read it, and try to develop upon it, without acquiescing in an interpretation of the industrial revolution and subsequent development of technological systems that reduces natural phenomena to providers of value, and without accepting the way the term is now used by oil companies or international quasi-state agencies?

I also don't see why, by using the term "energy carriers", we are siding with capital against 21st century commoners who use non-thermodynamic energy. First of all, there is the research of the relationship between thermodynamic and non-thermodynamic energy systems by scholars grounded in "net energy analysis". The classic for me is *An Energy Analysis of Household Consumption* (2007), by Shonali Pachauri, about fuel use in Indian households. It is built on a huge body of field work, and written with great sensitivity to class, caste, and gender dynamics. I wouldn't agree with all of Pachauri's conclusions, which are couched in terms of "policy advice" to elites. But she is hardly the only person in academia who does worthwhile work and writes up the conclusions in that way.

Beyond this, though, is a wider, substantial point. Larry at least implies a dichotomy that reads "thermodynamic – big, capital-controlled and therefore bad : non-thermodynamic – small, outside capital's control, and therefore good". I am not suggesting that he thinks in those crude terms, but doesn't his logic lead in that direction?

There's a practical issue for social movements here. Newly-urbanising populations in developing countries, participants in the great rural-to-urban migration of the 20th and 21st centuries, are demanding electricity as a right, not a good. There were a series of struggles around this issue in the 1990s, especially sharp in South Africa and Brazil, but stretching far beyond. This demand can be understood as the "moral economy" of these working people. As far as I know, it is also potent in the villages from which this migration starts. When people get to know about some of the benefits that electricity brings, they want it.

Of course these processes are double-edged swords. They are stories of people in the shanty-towns being pulled into the orbit of capitalist relations – all the more so since, once they arrive from the countryside, they usually do wage labour in order to survive. In the countryside, too, the proliferation of off-grid or part-grid systems is often associated with the penetration of capital. So on one level, "electricity as a right" is a demand to be included in a thermodynamic, capital-controlled system, but without having to pay. But to my mind that is an entirely reasonable demand; it's one that socialists can and should embrace; moreover, the struggles I have mentioned are part of the struggle for a just, post-capitalist society. Recognising that does not mean making an absolute virtue of urbanisation, rural-urban migration, or "technological progress", as many 20th century Marxists did.

My question to Larry is: doesn't his interpretation of the dichotomy between thermodynamic and non-thermodynamic systems push these struggles to the sidelines?

Let's take this point about thermodynamic and non-thermodynamic energy, and the commons, a bit further.We could sum up the current plans of a significant section of the ruling class with regard to electricity systems as follows: they intend to replace coal- and gas-fired electricity generation with a combination of wind, solar, nuclear and gas ... and leave everything else, about the way electricity is delivered and organised, largely the same. Capital's control will be largely unaffected. I think that Larry and I both believe there is a serious danger of "leftists" and environmentalists buying into this "vision", which will do too little to address the danger of global heating, and nothing to address the inequalities and oppression bred by capitalism.

My question is: should we not develop our own ideas about electricity provision, that can be counterposed to this view? I briefly mentioned such ideas at the end of *Burning Up* (pages 188-190). I suggested that three types of changes that could hasten the transition away from fossil fuels:

1. "Changes to, or adaptations of, existing technological systems that could reduce fossil fuel use rapidly", such as the changes mentioned above. These could happen under capitalism, potentially in very bad ways.

2. Changes that amount to "superseding the technological systems in their current form". I included under this heading "moving to full integrated decentralised electricity networks, geared to multiple small electricity producers, managed by 'smart' technology, thereby reducing or ending the need for fossil-fuel-fired power stations. This would be (is being) resisted by electricity companies". I don't know whether this could happen under capitalism or not, but I would embrace attempts to move in that direction, which could be related to movements against capitalism.

3. "The transformation of the social and economic systems that underpin the technological ones." In plain language – moving past capitalism. I argued in the book that this would unleash the best opportunities for ending fossil fuel use, in large part because the uses of fuel would be transformed, thereby (in any scenario I can think of) be minimised.

Larry doesn't see how social movements to decommodify energy can broaden their bases sufficiently unless they refuse the euphemisms ("energy carriers", "democratic energy", etc) outright and "confront the fact that energy itself is violently colonialist". Clearly, the changes in rich-country electricity systems now are 100% predicated on such plunder, and this should be at the forefront for any and all social movements. And it isn't. And rich-country "leftists" who talk about large-scale wind and solar power, but don't consider whether or how this can be done without plundering minerals from the global south, deserve condemnation.

But there's no reason why the control of electricity systems by capital is inevitable, any more than there is a reason why the existence of capital itself is inevitable. And I don't see why there can not be discussions about, and actions around, transformations of the electricity system that envisage not the continued control of capital, but a struggle to go beyond capitalism.

4. Is there some meaning underlying the concept of "energy services", that we should try to get hold of?

Larry is as suspicious of the term "energy services" as he is of "energy democracy" and "energy carriers". In the last paragraph of his comments, he writes that "because of their history and structure", energy services are "ill-suited in many ways to democratic commoning, anti-colonialism and

anticapitalism". I agree, insofar as the idea of energy services – which, like "energy carriers", as far as I know, started to be used by liberal-minded researchers in the 1970s – always carried the idea of a "service" that had to be paid for. That is, a commodity, exchanged in the market, as part of the social relations of capitalism.

But I think there is another side of the concept that is useful. Those liberal-minded researchers wanted to distinguish between the "energy" used by individual consumers and "energy" as a big technological system. Here is Amory Lovins, writing in the 1990s about the arguments of the 1970s:

> Customers wanted not kilowatt-hours per se, but hot showers and cold beer, comfort and illumination, torque and electrolysis – the 'end-user services' that the energy provided" (Weizsacker, Lovins and Lovins, *Factor Four*, p. 156.)

Lovins has spent his whole life arguing that not only the shift away from fossil fuels, but the shift away from big fossil-fuelled technological systems, and the wastefulness inherent in them, can be made under capitalism. Larry and I would (a) not accept the assumptions that underlie Lovins's word "customers", and (b) draw very different conclusions about the reason these systems are so wasteful. Lovins says it is down to poor regulation of markets; Larry and I would see that wastefulness as a function of markets, and the broader system of which they are part.

I would go further. As I tried to say in my article about decommodification, I would see in the concept of "energy services" something of Marx's concept of "use value" of a commodity, as opposed to exchange value.

I haven't developed that thought sufficiently, but I think that it's an important research task to take apart "energy consumption" – i.e. understanding the qualitative difference between (1) fuel for cooking and lighting, and the electricity that shanty town dwellers demand, across the global south,

(2) Lovins's "hot showers and cold beer", archetypal comforts for hundreds of millions of people in rich countries that many people in the global south can not access, and (3) fuel for military jets, Range Rovers and plastics production, electricity for Bitcoin, and all the other "energy services" that could mostly be abolished tomorrow to the great collective benefit of humanity.

I would hope to supersede – rather than dismiss – the idea of "energy services", including past work by Lovins, and current work e.g. by Arnulf Grubler, Charlie Wilson et al, on the gigantic possibilities inherent in what they call "demand reduction". They propose, basically, that humanity could avoid climate disaster as it's usually defined (i.e. as 1.5 degrees of warming, and, yes, I'm fully aware of the scientism around such targets) by "demand reduction". There is a huge hole in their argument, i.e. they don't ask or answer the question of how this is going to happen, given that the entire economic system is geared to doing the opposite. But I still think it's important that they said it.

I very much hope this discussion continues, and certainly this web site is open for all constructive contributions. *4 January 2022*

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The class struggle inside energy

By Larry Lohmann

Reply to Simon (Disentangling capitalism and physics, energy and electricity, 5 January)

I don't want to overemphasize any differences Simon and I may turn out to have. From the perspective of capital, the two of us probably look like the same person. On the other hand, developing our mutual (mis)understandings as they play off each other is surely at least one tiny part of our own common project of helping organize for the future.

I don't think that Simon and I differ on the place of the modern energy concept developed during 19th-century industrialism[40] in understanding history. Simon suspects that the concept would not "cover water wheels, windmills, dams and coal-fuelled metalworking in precapitalist societies." But actually it would and it does.

More than that: it's commonly used even in popular depictions of *pre*history (as in the declaration "since humans were humans, we've used energy", from a graphic novel detailing possible low-carbon futures).

There's nothing wrong with this use of latter-day concepts in examining the past. That's how the art of history-writing goes forward. Nobody in their right mind would want to talk about another time using only the concepts current among the people who lived in that time. Including, I would argue, those people themselves – if only they had the chance to enter into dialogue with us.

My suspicion is that the more curious, open-minded denizens of the 18th century would be challenged, fascinated and perhaps delighted to hear of our (to them) bizarre view that a "horse pulling a treadmill and a coal fire heating a lime kiln [a]re in some sense doing the same thing." They would want to discuss this more, to find out what the hell we – seemingly

[40] Simon would need to convince me that there exists any serious difference between this energy concept and the other two that he distinguishes.

reasonable people – were talking about. The question is the class politics of such translational encounters, hypothetical or actual.

When we in industrialized societies face the 18th-century person, it is not just as people for whom the First Law of Thermodynamics became common sense because we learned it in the science classroom. It is also as inhabitants of a world in which, as a result of two centuries of class struggle, that law is bodied forth in countless ways in which it was not in those earlier times.

Bodied forth how? There's nothing new in the way light reaching the earth from the sun is transformed into heat, and heat into mechanical energy, mechanical energy into electricity, and mechanical energy into heat again through all the complexities of weather and living and nonliving beings. In deep space, the gravitational energy of contracting hydrogen clouds has continued for billions of years to be slowly converted into heat until stars ignite. And so on.

Nor is there anything new in the fact that no energy has ever been lost or gained in any such transformation. Whether in the 18th century or the 21st, energy merely gets dispersed through each conversion into a greater number of microscopic states, making it less useful to capital's machines. The Second Law of Thermodynamics calls this an increase in entropy. Quantum physicist Carlo Rovelli describes the process as an opening of an entropy "door" that enables a thing or a local territory to slip down a gradient from "low entropy" to "high entropy", eroding the gradient itself in the process. For example,

> wood does not start to burn on its own. It remains for a long time in a state of low entropy, until something opens a door that allows it to pass to a state of higher entropy. … This something might, for instance, be a match to light a flame. The flame is a process that opens a channel through which the wood can pass into a state of higher entropy … things remain trapped in basins of low entropy … until something opens a door onto a process that finally allows entropy to increase.

While entropy gradients last (and the hypothesis is that they will all eventually disappear), they make possible not only life but also the industrial machinery designed to dominate labour. *Pace* the International Energy Agency and countless other unscientific energy commentators, capital's engines have no need for energy. What they need are entropy gradients. Which, like all energy converters, they are in the business of eroding.

While capital's machines require the entropy slopes that they surf on to be constantly flattening out, they can't enjoy those waves indefinitely in a closed-off territory inexorably headed for the universal flatness of *Wärmetod* or "heat death". The breakers just have to keep on coming.

If the machines are to continue clanking and whirring away, helping to subordinate labour to capital, they need some means for importing low entropy and expelling high entropy across their boundaries. A locomotive needs not only workers shovelling in coal but also an atmosphere or reservoir of water to take away heat. What are called "Ministers of Energy" are in reality "Ministers of Entropy Flow." Their job, like that of their counterparts in East India Companies or trade, emigration or immigration agencies, is to manage transactions across borders. One key to this politics is the fact that the universe is a place where entropy increases unevenly, at different paces in different places. Entropy doors have never been opened in the same ways at the same rate in every territory in every epoch. Often the pace is slow. 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 (an "activation energy") is introduced will they react explosively to dissipate some of that internal energy into heat, forming the higher-entropy H_2O.

Many activation energies, moreover, can be introduced – or blocked – through the agency of living things. Living human bodies open entropy doors in some contexts (e.g., to oxidize glucose, which outside the body would be more stable) while locking them temporarily in others (e.g., to prevent decomposition).

Industrial capital hastens by millennia the opening of channels that abruptly change oil from a pool of low-entropy energy into a larger expanse of residual heat and other "wastes" that it can't recycle (if it is to remain capital). Or it invades watersheds whose local rate of entropy increase might otherwise remain relatively low for millions of years to convert the kinetic energy of flowing waters into electricity via hydroelectric dams, leaving behind a "prematurely" silted landscape. Thus while the general drift of the universe as a whole toward increased entropy is not subject to politics or biology, fleeting local patterns of entropy flow are.

Industrial capital's need to keep entropy slopes steep inside its labour-exploiting machines is at one with its need to accelerate the flattening of them outside, as well as in the larger system formed by the conjunction of the machine and its surroundings. Heat moves outside the machine as low-entropy energy moves in. This is true whether the device in question is a steam engine, a lithium-ion battery, a long-distance electricity transmission line, a solar cell, a wind turbine feeding "smart" technologies, or the global network of "smart" technologies itself.

Moreover, capital typically organizes its distinctive patterns of accelerations of rates of entropy increase in chains. In Rovelli's words, the "growth of entropy itself happens to open new doors through which entropy can increase further." Entropy-increasing concrete and steel manufacture is a prerequisite for entropy-increasing hydroelectric dams. Increased rates of entropy increase, associated with the movement of electrons in electric cars, stem not only from the prior construction of other energy-conversion devices, but also from new waves of entropic copper mining.

Entropy-increasing wind farms can't be built without previous entropy-increasing extraction of balsa to make turbine blades. 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 – cryptocurrency "mines" stuffed with computer processors that need built-in cooling systems to dispel their own waste heat. Even the most up-to-date 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.

The concepts "energy carrier" and "energy source" – and their forebears stretching back to the 19th century – normalize a peculiarly capitalist attitude toward what we have learned to call these "energy conversions." By commensurating and valorizing different conversions as potential helpmeets to accumulation, such terms often obscure contrasting patterns of restrictions on them essential to commoning.

The idea that oil is an energy source foregrounds the practice of putting it to work in the exploitation of human labour over the practice of protecting it in the soil. The idea that mountain streams are energy carriers is part and parcel of practices such as throwing solid concrete irrigation dams across them to maximize the dispersal of water across wet rice fields per unit of labour.

As such, it tends to disvalue (for example) the extensive physical/ritual work of instead maintaining porous, temporary arrays of stream-anchored bamboo stakes associated with the *mueang faai* irrigation system – which, instead of being linked to capital accumulation, is tied to contrastingly complex and extremely long-term patterns of subsistence, community justice and respect for nonhuman beings. And, not incidentally, also tied to slower rates of entropy increase in relevant watersheds and different political relations to territories outside those watersheds.

That is to say, a phrase like "energy carrier" normalizes particular political *landscapes* – what I've elsewhere called Carnot landscapes, after one of thermodynamics' first great pioneers Sadi Carnot. These are landscapes where distinctive, sweeping patterns of incessant mutual conversions among kinetic, electromagnetic, chemical, gravitational and thermal energy – geared to running the machines that industrial/digital capital requires to subordinate labour – guarantee correspondingly particular structures of waste proliferation and border politics.

Landscapes where people send transatlantic telegrams, drive tractors, and locate their houses as far from workplaces as they can are landscapes that include special arrangements of entropy doors – and rhythms of entropy door-opening – that extend way beyond the horizon and also include refreshed structures of racial, patriarchal and class domination.

I may be wrong, but my sense is that no academic has yet tried to map any Carnot landscapes in any systematic way. (Contrast the mapping of resource landscapes, which is a gigantic, self-reinforcing industry in academia and the consultariat on both left and right.) Still less do there exist maps that show how these entropy territories overlap and interact with the entropy territories of commoners and more-than-human communities over time.

To put it another way, the energy difference between the 18th and 21st centuries isn't that we have more of it (we don't) but that the political geography associated with class struggle has changed in ways that are more comprehensive than may at first appear if we fail to recognize the anachronistic character of terms like "energy source".

Pace Simon, there's obviously nothing here that would imply that "the Second Law of Thermodynamics [i]s the crucial driver of capital expansion, class struggle and colonialism."

Or that it's a "sufficient explanatory framework" for the colonization of Siberia or anywhere else. On the contrary, it's capital expansion and class struggle that drove the 19th-century capitalist innovations of industrialization, "energy sources", and colonialist Carnot landscapes organized (of necessity) along lines that can maintain industrial machines in a state far from the dead flatness of thermodynamic equilibrium.

Nor, obviously, is there anything here to imply that I think either that capital has "deformed" thermodynamics; or that thermodynamics springs from some unknown species of human-human relations that somehow excludes human-nonhuman relations; or that the fact that thermodynamics coevolved with 19th-century industrial capitalism somehow "negates" its laws; or that capital- controlled thermodynamic energy is "baaaaaad" while non-thermodynamic energies are "small, outside capital's control, and therefore good".

In fact, I don't have the dimmest idea what any of these attributions could even mean. Nor, I suspect, does anybody else. In my view, the frequency with which they nonetheless keep popping up almost by reflex in discussions like ours ought to tip us off that that their origin is psychological.

For me, the lingering, unfulfillable impulse to try to "purify"

science that they seem to reveal is a sign that a lot of us left intellectuals (and I include myself as well as my good friend Andreas Malm) are still somewhat unprepared for solidarity with the distinctive struggles against various elite priesthoods that have been underway for quite a few centuries now. These are struggles that, in a way, the "modern constitution" of more recent times only intensified when it started telling us that scientists, like the clergy, belong to a class through which the final authority of the Nonhuman Infinite speaks so that we may listen.

Anyway, for present purposes I would favour doing our best to set aside what I regard as an atavistic, unconscious class loyalty and instead emphasize Simon's and my mutual agreement that "we need to overturn the idea that there is something called 'energy' that if only freed from capitalist ownership can work to our advantage."

So what happens when we say to the 18th-century person, "Hey, that horse pulling your treadmill, that coal fire heating your lime kiln, not to mention your forest, your stream, your weather, your soils, your body, your food – guess what, they're all energy carriers"? There's no question about whether this is true or not. It is. The First Law of Thermodynamics is correct, as far as we know.

But as the 18th century person talks this over with us, and learns in time to describe herself and her surroundings and connections to distant locations in this novel way, it becomes gradually clearer both to her and to us that, earlier on, we of the 21st century had not just been sharing our ideas in a generous and open-ended way, as we had thought, but also normalizing a particular political settlement in which certain social relations have become partly invisibilized under the rule of capital.

She realizes bit by bit – and with mounting surprise – how sincere we were in thinking it was *normal* or *natural* to treat the things of her world as energy carriers. Meanwhile we realize bit by bit, to our own growing surprise, how sincere *she* was in formerly suspecting that we might be oddballs and weirdos because we acted in this exceedingly strange way. Both parties come to understand, as the conversation goes on, that our practice of unconscious valorization of certain relations of exploitation and patterns of entropy slope flattening was class bias. Gradually, we achieve together that growth in the awareness of oppression that Ashis Nandy once identified as the only defensible sense that can be assigned to the notion of progress.

It may be helpful to spell out at greater length exactly what *kind* of class bias this is. It isn't the class bias of the outraged utility executive in South Africa who is scandalized by the "thefts" of electricity by slumdwellers, who correctly believe that they have a right to it. Rather, it's something closer to the bias of the overseer or legislator who "took the common from off the goose" in the apocryphal English rhyme of the 17th century and then told the commoners that they were thereby being given a new freedom to sell their labour.[41] Or the bias of the 21st-century developer wielding keywords like "mobility" and "democracy", who is professionally obligated not to register the prejudicial nature of, say, plans to "compensate" commoners who are losing communal rights of way to superhighway construction.

But in reality, how far apart are these two class biases? We know from Marx that they both evolve as part of the same historical process. It can take nothing away from the struggle

[41] To call this a "class" bias is also anachronistic, of course, as pointed out by E. P. Thompson in "Eighteenth-Century English Society: Class Struggle without Class," Social History 3 (2), 1978, pp. 133-165. Using the word in this context, accordingly, would need a defence like the defence above of the use of the word "energy" in describing 18th-century politics.

of 19th-century Manchester machine operatives for a shorter working day or better wages to observe that their Captain Swing country cousins were engaged in a complementary struggle, even if it sometimes involved machine-breaking.

By the same token, it can take nothing away from the struggle of South African slumdwellers to get a fair share of the country's electricity to observe that other commoners around the world are engaged in a complementary struggle over Carnot landscapes, even if it involves in some sense "breaking" the hegemony of electricity itself. To my mind, to argue otherwise would be to fall in with capital's perennial attempts to divide and rule.

To put it another way, I've never subscribed to the blanket view that the master's tools can never dismantle the master's house. I think that, on the contrary, masters' tools are dismantling masters' houses all the time, in ecological struggles as well as on your average building site. For me, the kernel of truth behind the saying is only that you can't take hold of the master's tools without taking hold of their history and deciding what to do with it. You have to start from where you are and then, depending on your knowledge of how you got there, go somewhere else.

What might emerge from yet another lengthy conversation that we might envisage – this time between a South African slumdweller and, say, an anti-dam activist from the Narmada valley – is that the famous electricity "thieves" of Soweto and other communities are in effect taking the master's tool of electricity and using it to struggle against the rule of energy itself; while the Narmada protesters – in a way that could only become clear (if it does at all) through prolonged conversation – are, in a sense, seconding the demand for universal rights to electricity in South Africa.

This is perhaps just to recall still other conversations – not necessarily imaginary – among union leaders aimed at coming to some mutual understanding of whether or when or how wage demands (including the demand for wages for housework) might ultimately be partly reinterpreted as part of struggles to dismantle the wage itself, and vice versa.

I think Simon and I are again already in full agreement, however, that some masters' tools are less likely than others to be suited for dismantling masters' houses. Seizing the Fukushima reactors for the revolution would mean that workers would suddenly somehow have to take on responsibility for countless future deaths in the Pacific as well as the construction of an eternal centralized police force for isolation of various concentrations of radioactivity by all future civilizations. To change the example, taking over the means of production of contraceptive implants that in the past have commonly been forced on oppressed minority women is not going to be equivalent to seizing control of capital's condom factories. Since a woman pulling a gun on a man to make him put on a condom tends to spoil the mood, the device is bound to bear a different relationship to the future history of patriarchal coercion than Norplant or intrauterine devices.

The point is that taking hold of energy's history and deciding what to do with it isn't a programme over which anyone can have special authority, but can proceed only through long exchanges among separate parties with radically different starting points. My parable of imaginary discussions among such parties isn't just about conversational etiquette, but also about how possible scientific futures come to reveal themselves in the "re-entangling" (not "disentangling", as in Simon's title) dialectics of practical organizing.

As someone who has himself learned a lot from Amory Lovins, I appreciate Simon's closing efforts to make room for a Lovinsesque reinterpretation of "energy use-values" in this discussion. Simon notes that he, Lovins and I share the instinct that most people don't want or need "energy" per se, but rather something akin what Lovins calls "end-user services". For Soweto residents, these might include lighting at night; for US suburbanites, hot showers; for Pentagon planners, the supersonic interception capabilities of F-35 fighter planes.

Simon proposes that the phrase "energy services" be recruited to connote what he and I might call these "use-values", and suggests that one socialist way forward might be just to try to prune away those services that "could mostly be abolished tomorrow to the great collective benefit of humanity" without questioning the concept itself. Naturally that would include rejecting those F-35 capabilities as a defensible "energy service."

I still have doubts, however. Energy does have use-values, just as commodities and capital itself have use-values. But for me it doesn't follow that we don't need to question energy itself in the same way we question capital's other natures, as well as commodities and capital itself. To put it another way, for Lovins, capitalism is wasteful partly because it isn't taking advantage of all available opportunities for energy efficiency; for Simon and me, capitalism is wasteful because that's the way profits are made.

But look at it from a third point of view: that of the 18th-century human depicted by the historian Joel Mokyr in my opening example. Like us, she doesn't want energy as such, only the horse pulling the turnstile or the coal feeding the lime kiln. But she would probably be harder to convince than we are that it might be worthwhile or even possible to follow the roundabout, entropy-accelerating and colonialist procedure of turning her world into a Carnot landscape for the sake of some version of what that horse and coal are already doing, however "efficiently" that might be accomplished at the micro-level.

Or to put the matter in one final way: I don't think it's an accident that Lovins, normally the most thoughtful and resourceful of capitalist apologists, doesn't usually fare well in arguments in which he is gently reminded of Jevons paradoxes.

Reply to David (Thermodynamics: a metaphor or a science?, 5 January)

David's subtitle seems to me to be another instance of that stubborn and I think unconscious class prejudice that I referred to above (and which I reckon all of us intellectuals all have to struggle against in our own ways) rather than anything that could be assigned any meaning that I would want to call scientific.

I'm sure David will remember that metaphor tends to be constitutive of important scientific discoveries (Sadi Carnot's key insight that what drives a heat engine is a "fall" from hot to cold is a metaphor; "flattening of entropy gradients" is taken directly from the peer-reviewed physics literature). And I'm sure he knows that metaphors are also always popping up in the pursuit of "normal" science as well, if only

in the interest of saving tedious exposition. (Nonequilibrium thermodynamicists often resort to phrases like "entropy production," which is an odd formulation given the subject matter but for sure will help get you to the end of a physics lecture in the allotted time.)

To my mind, the reflex of trying to subordinate "merely ideological" metaphor to an entirely fictional "nonideological, nonmetaphorical" science that has never existed amounts to little more than instinctive defensiveness about priestly authority rather than a stance that could be backed up in patient, rational conversation.

David acknowledges the extractivism that would underpin "renewable" energy developments big enough to give capital an alternative to fossil fuels. Nevertheless, he defends such developments on at least four grounds:

> (1) Their construction is necessary to avoid climate catastrophe.
>
> (2) They actually "reverse" the flattening of entropy slopes.
>
> (3) "Efficient recycling of metals" can "virtually terminat[e] extractive industries".
>
> (4) "Only a small fraction" of world land and ocean surface is capable of providing the needed "energy supplies".

(1) is not immediately relevant to the issue Simon and I have been discussing, which is the political structure of modern energy and how to change it. But climate strategy is obviously one reason we are all having this conversation, and I think Simon and I would both have questions about solar or wind plans that neglect issues of energy commons, energy decommodification, demand reduction and (at least in my case) the politics of Carnot landscapes.

Myself, I would add that the "carbon confusion" that underlies programmes motivated mainly by a desire to manage molecule movements not only reflects a misunderstanding of the scientific nature of climate change itself but also is bound to undermine popular climate movement-building insofar as it entails the idea that politics can be left for a separate process.

I was a bit taken aback by (2) and (3) because they appear to contradict the Second Law of Thermodynamics whose importance I had assumed that both David and I are keen to stress. As George Caffentzis points out, one prime motivation for capital's "efficiency" obsession is precisely its realization that entropy slope flattening *cannot* be reversed on the global level, but only slowed down locally.

David's (3) and (4) both succumb, it seems to me, to a classic confusion between efficiency increases and an imaginary asymptotic approach to the elimination of entropy. Rather than fixating on percentages of abstract acreage and how they might be minimized, I would recommend instead paying closer attention to the exploitation and exhaustion whose intensification through "renewable energy" (and "energy efficiency") can only be made visible through conversations about the changing, dynamic geographic *patterns* of entropy flows across borders that help constitute different political regimes of mechanization.

I remember that more than 30 years ago, Finnish technical consultants who were assisting the Thai state to formulate a Forestry Master Plan were pleading, amid growing land conflicts, that they needed "only a few per cent" of the country's surface area for monoculture eucalyptus plantations to feed the pulp and paper industry.

Among the printable responses of the small farmers on the firing line was something along the lines of: "What is this 'few per cent' you are talking about that you profess to find so insignificant? They are our families' rice fields, the forest commons where we get mushrooms and veggies for our evening meal. Where do you want us to go once you get your 'few per cent'?" This is what comes, I think, of mapping resource landscapes without any thought of mapping Carnot landscapes as well. *17 February 2022*

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Climate mitigation and adaptation will require incremental energy from renewables

A rejoinder from David Schwartzman

On the use of metaphor, I said in my post Thermodynamics: a metaphor or a science?, that Larry is now responding to:

> While entropy as a metaphor has its positive value, in Lohmann's case highlighting the destruction accompanying the creation of renewable energy supplies, and likewise for Robert Biel's *The Entropy of Capitalism* (2011), not going beyond this metaphor with an analysis relying on the science of thermodynamics will not make clear the critical implications of the second law to a renewable energy transition.

Yes, of course I recognize the essential role of metaphors in the generation of scientific theories, as well as their use in more general discourse (for another example see the section "Other Uses of Entropy" in my 2009 paper "Ecosocialism or Ecocatastrophe?").

I am puzzled by Larry's claim that I defended by implication an unrestrained capital-driven renewable energy transition. I clearly advocated that this energy transition should be informed by an ecosocialist agenda, not relying on "green" capital to deliver a just process, rather strongly supporting the goals of decommodification and a global solar commons. My article "A Critique of Degrowth" goes into more depth on confronting the critically important challenge of extractivism in this transition. Here is a quote from this article:

> Extractivism is a very real challenge that must be confronted in a wind/solar transition terminating fossil fuels, to create a truly just process which protects the rights and health of indigenous people around the world, along with the workforce and communities affected. There are significant future opportunities to limit mining in this transition, namely recycling the huge supplies of metals now embedded in the fossil fuel and military infrastructures, substituting common elements for rare ones (e.g., batteries using NaS [sodium/sulfur], Fe/air [iron/air], etc.), enhancing public transit instead of

relying on manufacturing hundreds of millions of electric cars. There are now significant energy savings in recycling metals instead of mining their ores.

I take "reversing the flattening of entropy slopes" in the context that Larry put it, his claim that a renewable energy transition would necessarily entail the creation of sacrifice zones of extractive industries, thereby flattening of entropy slopes. I fail to see how my (2) and (3) claims cited in Larry's response contradict the Second Law of Thermodynamics. As far as my (3) and (4) claims, what Larry did not address in his response is the relevant aspect of the second law to the energy transition that I stressed:

> The production of energy from burning fossil fuels, as well as nuclear fission, generates an incremental heat flux from the Earth's surface, unlike – to a good first approximation – the tapping of solar radiation to do work. The latter outcome is non-incremental because the interaction of low entropy visible light with the low albedo relatively dark Earth's surface generates a corresponding flux of high entropy heat (infrared radiation) whether work is done for human civilization or not, with this heat flux escaping to space.

This entropy flux will not be eliminated in a wind/solar energy transition coupled with the phase out of extractivism. As I said: "Hence, global solar power will then pay its "entropic debt" to space as non-incremental waste heat, without driving us to tipping points towards even more catastrophic climate change than has happened over the past few decades."

Further, Larry's response to my post gives me this opportunity to further elaborate on this transition informed by an ecosocialist agenda, which will inherit the legacy of anthropogenic changes in the Earth's atmosphere (increase in greenhouse gases, especially carbon dioxide) and surface albedo such as deforestation and creation of urban heat islands. The latter will surely grow in intensity even if the 1.5 deg C warming target is not exceeded. We addressed this subject in our posted article "Urban Ecovillages":

> The challenge of extreme heat in these urban areas can be confronted in the transformation to green cities with more trees as in the case of Karachi …, making dark surfaces white, and of course air conditioning powered by renewable energy. In addition, a promising new technology, polymer film applied to building that radiates heat through the atmosphere to outer space, can potentially result in dramatically cooler conditions than its surroundings [references given in article].

Further, in regard to recognizing the profound anthropogenic changes in surface albedo already mentioned I point out:

> Rapid restoration of natural ecosystems and shift to agroecologies/regenerative agriculture are imperative and will contribute to climate mitigation but will be limited by future warming up to the 1.5 deg C target because of reduction in the capacity and saturation of the soil carbon pool. Hence, Direct Air Capture of carbon dioxide and permanent storage in the crust will be likely needed to meet this warming goal.

In addition to eliminating energy poverty, and bringing global life expectancies to the highest achievable level, climate mitigation and adaptation will require incremental energy supplies derived from wind and solar power over the present level. This level corresponds to 19 trillion watts, that will need to increase the global renewable energy supply to no more than 1.5 times the present level (More detail in this article.) *17 February 2022*

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A continuing conversation

□ *Simon Pirani adds: I thank David Schwartzman and Larry Lohmann for these two further contributions to our discussion, all of which were published on my blog, peoplenature.org. I do not think we have exhausted the subject matter, which is so relevant to discussions on human society, climate change and the transition away from fossil fuels. But the three of us have said plenty to start with, and we are now at a natural break in our conversation. I for one am going to think some more about the issues raised. If anybody else has something to add, that is very welcome: you can email comments to peoplenature[at]protonmail.com.*

□■□

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