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Post-Capitalist Ecologies: Energy, 'Value' and Fetishism in the Anthropocene*

*Alf Hornborg**

Abstract

This article argues that the widely acknowledged socio-political and ecological ills of capitalism are consequences of organizing human society by means of general-purpose money, which inexorably tends to increase global inequalities and accelerate the destruction of natural resources. Although Karl Marx and some of his followers have recognized the incompatibility of conventional money and their visions of socialism, political regimes inspired by Marxist thought have ubiquitously succumbed to the logic of money. The contemporary acknowledgement of the causal significance of particular artifacts can serve to vindicate the long-standing critique of money fetishism, and to render superfluous some of the esoteric elaborations of Marxist theory. Recent eco-Marxist critiques of what is theorized as the capitalist underpayment of ecological use values, understood as energy, paradoxically reflect a mode of thought shaped by the capitalist market, viz. the underlying assumption of an abstract equivalence among incomparable qualities. Technologies, like the money which makes them possible, in Marxist theory tend to be visualized as intrinsically innocent artifacts detachable from the unequal societal contexts in which they have emerged. To prevent such technological fetishism from continuing its destructive historical course, the money artifact itself must be redesigned so as to insulate local survival from the ravages of global capital flows.

Keywords: Money; capitalism; ecology; energy; value; unequal exchange; technology; fetishism

I would like to address a topic that is central to political ecology and that I hope will engage most of you, whether you agree with me or not. The topic is what it means to be “critical,” “radical,” or a “leftist” today, and how to integrate a fundamentally Marxian perspective on the world with concerns over global environmental degradation and climate change. I will be talking particularly about the complex relation between energy and money, and about how even eco-Marxian theories of ‘value’ may be constrained by the conceptual hegemony of money and exchange

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value. I will suggest that our best hope of a post-capitalist future beyond the disastrous risks of the Anthropocene is to take a very critical look precisely at this human artifact that we call money. Given the widespread consensus and voluminous deliberations on the sociopolitical and ecological ills of an abstract system referred to as “capitalism,” my main point is that money is the elephant in the room.

Capitalism as the Logic of Money

To most of us, even to Marxists, money is like water is to fish—and yet the intrinsic logic of this human invention is nothing less than *capitalism itself*. As we can see in *Grundrisse* ([1858] 1993), Marx himself seems to have been profoundly aware of this,¹ which raises the question of why neither he nor most of his followers made the very artifact of money the primary target for reform.¹ Although Marx and a small minority of Marxists envisaged post-capitalist society as necessarily moneyless, such visions have universally been dismissed by practical politicians as utopian (Nelson 2001a; Buick 2011). In contrast to ‘utopian socialists’ like Robert Owen, political regimes inspired by Marxist theory have generally not contemplated radically transforming the role of money.² Yet money in its present form—that is, what anthropologists refer to as “general-purpose” money—inexorably generates not only increasing global inequalities but also the appalling degradation of the biosphere with which we are all so concerned. The basic conundrum of money is that it is simultaneously an idea, or *sign* (a unit of account), and a potent material force. Money is represented as a reflection of some underlying and more material level of reality to which it refers, yet in itself it organizes that material reality. This duality explains Marx’s contradictory approach to money, as evident in his critique of utopian socialists like the Owenites, whose ambition to abolish money he dismissed as “useless and idealistic” (Nelson 2001b, 46). Rather than seeing money as the source and essence of capitalist property relations, Marx argued that money could only be dethroned by first transforming the social relations of production.

¹ As with so many other aspects of Marx’s creatively “undisciplined” thinking, his understanding of money has become the focus of exegesis and voluminous academic deliberation (e.g. Sieber [1871] 2001; de Brunhoff [1973] 2015; Nelson 1999, 2001b; Moseley 2005).

¹ As we shall see, precisely the same question can be raised regarding Marxian approaches to technologies.

² Serious visions of a moneyless economy were nevertheless integral to Bolshevik discussions in Russia in the years following the revolution in 1917, as well as to debates in Cuba in 1963-1965 (Nelson 2001a, 505-510). A prominent proponent of the abolition of money was Che Guevara, whose decision to leave Cuba was prompted by his defeat in the debate over this issue.

Instead of losing ourselves in libraries of abstract theoretical arguments on all the possible complexities of the logic of “capitalism”—whether viewed from a bourgeois or Marxian perspective³—we need to take a detached, second look at the seemingly self-evident, cultural idea of money, namely the idea that everything is interchangeable on the same market. This idea—this artifact—makes it possible to purchase human time as well as entire ecosystems as market commodities. This prompts everyone to accumulate as many abstract claims on other people and resources as they can, which implies wanting to pay as little money as they can for what they buy. Even if it may sound like an outrageous simplification, this is the common denominator behind slavery and climate change. As long as we don’t question the idea of money itself, both slavery and environmental degradation will be understood as consequences of “underpayment”—whether underpayment of labor or underpayment of “ecosystem services”—but the notion of underpayment only makes sense as long as we remain confined within the conceptual universe of general-purpose money which assumes that everything has a correct price. It implicitly accepts the ideological illusion that in principle all things can be exchanged at rates that can be objectively established as equal and fair. The illusion of abstract equivalence among incomparable qualities—the very foundation of capitalist social organization—is as misleading in terms of its implications for social justice as it is in terms of ecological sustainability (Nelson 2001a). This illusion is encapsulated in the universally employed but insidious concept of ‘value.’

The logic of capitalism has been intricately elaborated by both bourgeois and Marxist economists, all similarly eager to discover the covert regularities and trajectories of societies organized in terms of money. The complex implications that can be derived from the rather simple idea of money have preoccupied vast numbers of theorists and mathematicians united by the assumption that this social invention is as immutable as natural law. The potential repercussions of various economic policies and regulations have been traced and debated by countless people committed to the conviction that there is no alternative to general-purpose money. As traditional world-system cores in the 1970s faced economic decline and fiscal deficits, the so-called neoliberal program emerged as a reflection of the imperatives for efficient capital accumulation inherent in the logic of money. Regardless of how repulsive we find the prescriptions of neoliberal economists, they appear to have spelled out the polarizing logic inscribed in the idea of money itself. In this convoluted sense we may have to concede that the

³ Note that this includes the entire literature on economics since the mid-nineteenth century. Whether bourgeois or Marxist, this literature shares two fundamental features: 1) its conceptual commitment to the idea of money and 2) its esotericism. The latter feature should be difficult to defend for academic theorists allied with social movements aiming to emancipate the global proletariat.

policies advocated by Thatcher and Reagan—and no less the trajectories of post-Maoist China and post-Soviet Russia—reflect some fundamental requirements on the management of money. Given the conceptual constraints of general-purpose money and their specific definition of market “efficiency,” perhaps mainstream economists cannot be blamed for endorsing economic policies that increase the abysmal global inequalities and threaten to make the planet uninhabitable for human beings. The absurdity of allowing a specific human artifact to drive our species to extinction must clearly remain beyond the pale for people whose daily activities and sense of meaning hinge on remaining within the conceptual constraints provided by this artifact. Like the ancient Easter Islanders chipping away at their stone statues, we are prevented by our cultural priorities from actually dealing with the fact that we are destroying our ecological context.

The Money Artifact as the Root of All Evil

Although to some theorists it may sound impermissibly reductionist, most of the ills of the system that we refer to as “capitalism” can be derived from a simple logic inherent in the artifact (or meme) of money itself. It is the idea of money that makes it possible to purchase and own labor and land, and the commodification of labor and land are of course fundamental to capitalism (Polanyi 1944). To refer to what is commonly vilified as “capitalist property relations” without tracing them to money is to omit the core issue. When Marx captured the central element of capitalism in the formula $M - C - M1$, his point of departure was the existence and possibilities of money. And since the accumulation of money is physically boundless and infinitely attractive, humans over the centuries have devised numerous strategies for aggrandizing their monetary wealth. Alongside mercantile and industrial investments, we have recently been reminded of the potential for financial speculation, tax evasion, bribery, and a wide spectrum of corrupt and clearly criminal ways of making more money. The “human weakness” identified by the Financial Crisis Inquiry Commission (2011, xxiii) as underlying the Wall Street meltdown in 2008 is no doubt pervasive among humans, regardless of political regime. Much everyday media attention is devoted to revealing and morally denouncing the avarice of politicians, corporate executives, and other public figures. But should we really be shocked and indignant because some humans do what very many of us would do if we had the chance? As Marx observes in *Grundrisse*, “greed as such [is] impossible without money.” Greed is built into the very idea of money.

To focus on the exploitative and destructive logic of the idea of money might finally help us envisage the end of capitalism.⁴ To choose to scrutinize the implications of a

⁴ Envisaging an end to capitalism is no doubt preferable to imagining the end of the world, even if it is more difficult.

particular human artifact rather than immerse ourselves in theoretical deliberations on the structural ramifications of a specific “mode of production,” may be viewed as a concession to the radical empiricism of Actor-Network Theory (Latour 2005). The great differences in outlook between Marxism and Actor-Network Theory help explain why the attribution to money itself of all the evils of capitalism was not compatible with Marx’s project.⁵ Conversely, the ideological differences between them may explain why, remarkably, leading Actor-Network theorists such as Bruno Latour have chosen not to scrutinize the most quintessential human artifact of all. I am not suggesting that we think of money as having agency, which would be to fetishize it, but that we acknowledge the extent to which it encourages specific inclinations in the collective manifestations of human agency.

If acknowledging the significance of specific artifacts is tantamount to a concession to Actor-Network Theory, it is the only concession that a Marxist political ecology would need to grant to Actor-Network Theory. As I have argued in a recent article (Hornborg 2016b), artifacts may have fundamentally transformative social *consequences*, but never agency. A truly critical social theory will need to retain a realist ontology and robust analytical distinctions between the symbolic phenomena deriving from human society on the one hand, and the non-symbolic aspects deriving from pre-human substrates of the universe on the other. So-called posthumanist attempts to dismantle all distinctions between the social and the natural, humans and non-humans, and even subjects and objects, will not help us. To dissolve such distinctions is not to challenge power hierarchies—on the contrary, it is to abandon our capacity to do so. Maintaining such analytical distinctions—frequently rejected as “Cartesian”—has very little to do with the mind-body dualism articulated in the seventeenth century by René Descartes. Fortunately, most eco-Marxists stay away from the so-called post-Cartesian deliberations of the posthumanists.⁶ A coherent political-ecological understanding of the Anthropocene can only be built on the analytical distinction between the societal logic of capitalism (i.e., money) on the one hand, and the pre-symbolic and non-human aspects of the biosphere revealed by sciences such as thermodynamics, geochemistry, and ecology on the other. Only by recognizing this distinction can we identify the potential for human choice and the extent of political responsibility.

To attribute a pervasive social causality to a specific human artifact does not mean subscribing to Actor-Network Theory or more generally to a posthumanist outlook. The recent

⁵ As Nelson (2001b, 60-61) observes, “Marx is mainly engaged in criticizing, correcting and perfecting abstract theories, despite his claims to being a materialist, which one might expect to imply a more empirical bent.”

⁶ An unfortunate exception is Jason W. Moore (2015).

discovery that human society is transforming planetary carbon cycles should least of all lead to a dismantling of social science (Hornborg 2015). The notion of the Anthropocene risks making a social process look like the inevitable product of human biology. It is obvious that no other species could have invented capitalism, but as Andreas Malm and I argued in a frequently cited article (Malm and Hornborg 2014), we have to keep in mind that the so-called Anthropocene is the creation of a minority of the human species in its struggle to dominate and exploit the global majority. It was to make this point that Malm coined the currently influential concept of the Capitalocene.

The Spirit of Marx

Before continuing, I want to propose that we should watch out for dogmatism, that is, the kind of knee-jerk reaction to unfamiliar and undigested thoughts which relegates them to the opposite camp (as if there were always only *two* options: one with and one against; one authentic and one heretical; one radical and one bourgeois, and so on). Like other movements and faiths, Marxism has suffered from processes of internal contradiction, exclusion, and fragmentation. There are thus obvious analogies between the historical development of Marxism and that of Christianity. Although Marxism and Christianity are often viewed as opposed to each other, the analogy between them is not far-fetched. Both aspire to provide a holistic worldview embodying not only analysis but also moral and political imperatives and visions of the future. Both are fundamentally committed to justice and to the compulsion to challenge illegitimate power and inequalities. Both are based on the revelations and subversive proposals of venerated founding figures. And both may actually belong to the same millennial tradition of ideas challenging the deification of money. The Christian socialist R.H. Tawney (1972) traced a genealogy from St. Paul and Thomas Aquinas to Karl Marx.⁷ Indeed, those of you who have read Pope Francis' (2015) encyclical *Laudato si'* will no doubt have recognized many of the convictions and prescriptions of political ecology.

My point is this: Let us by all means remain inspired by Marx's pioneering and incisive insights into fetishism, accumulation, unequal exchange, and the economy of human time. But let us abandon the belief that to be inspired by those insights means having to be consistent with every *letter* conceived by a very prolific writer who died 133 years ago. Let us not allow our careful consideration of his categories and analytical framework to descend into exegesis and dogmatism. I am sure those past 133 years have left us with *something* to add and

⁷ Other prominent visions of a desirable society founded on the abandonment of money include Thomas More's 1516 deliberations on Utopia (see Nelson and Timmerman 2011, 18-19).

even to modify with regards to the Marxian framework. Let us be inspired by Marx's aspiration to understand the logic of the social system of which he was a part, including the cultural illusions through which it is reproduced, rather than to spend our time exploring in intricate detail the possibly refractive prism through which someone else struggled, however incisively, to grasp the operation of his own societal context 150 years previously. For me the issue is not precisely what Marx did or did not say, and whether he did or did not contradict himself, but how parts of his fundamental theoretical framework can be applied so as to challenge the political, economic, and ecological inequalities in the world today. This is in accordance with the *spirit* of Marx, if not always the letter.

Political Ecology, Marxism, and Energy

Political ecology initially emerged in the 1970s and 1980s among anthropologists and geographers who were dissatisfied with the functionalist assumptions of the school of cultural ecology. In the 1960s cultural ecology had focused on case studies of traditional subsistence practices in local communities as adaptations to the non-human environment. Pioneers of political ecology such as Eric Wolf, Harold Brookfield, and Piers Blaikie rejected functionalism and instead emphasized the role of power inequalities and global political economy in shaping human-environmental relations. They demonstrated how the local resource flows studied by cultural ecology were connected to the asymmetric metabolic flows of the world-system.⁸

It is a paradox that both political ecology and the cultural ecology to which it was opposed frequently refer to Marx. The founding figures of cultural ecology, such as Julian Steward and Leslie White, were heavily influenced by Marxist materialism. Although rarely viewed from a global perspective, energy flows were a central concern of cultural ecology. This concern with energy was Marxist in the crude sense of aspiring to explain cultural superstructures as reflections of material infrastructures, but for cultural ecology this approach had become a functionalist concern with 'adaptation' to the natural environment. Political ecology, on the other hand, while sharing the focus on the environment and natural resources, looks for explanations of human-environmental relations not in the local ecosystem, but in the global economic system which ultimately conditions local life. The energy flows that concern political ecology are not so

⁸ We could add that a similar tension between a conflict- and a consensus-based approach to human ecology has recently been revived in the opposition between political ecology and resilience theory (Hornborg 2009; 2013; Watts 2015). This means that after forty years since its inception political ecology still needs to expose functionalist assumptions in mainstream discourse on human-environmental relations.

much those of the local ecosystem as of the unequal metabolic flows within the capitalist world-system. The common concern with energy present in both schools, however, leads us to ask precisely what the relation is between Marxist theory and thermodynamics.

Although Marx and Engels were not persuaded by Sergei Podolinsky's ([1883] 2008) proposal in 1880 that the theory of surplus value could be phrased in terms of energy (Martinez-Alier 1987), and although the eco-Marxists John Bellamy Foster and Paul Burkett have consistently defended Engels' dismissal of Podolinsky as an "energy reductionist" (Foster and Burkett 2004; Burkett and Foster 2006), there are reasons to believe that what Marx had in mind in his deliberations on the exploitation of labor-power was actually something quite close to the concept of energy. Even Foster and Burkett attribute a thermodynamic foundation to Marx's theory of surplus value, and Foster has recently endorsed the "embodied energy" framework of Podolinsky's intellectual heir Howard T. Odum (Foster and Holleman 2014). What Podolinsky recognized was that Marx's central conviction—that economic value derives from the material agency of labor-power—suggests an intuitive attempt to integrate economics and thermodynamics.

Energy is indeed a common denominator of the various kinds of unequal exchange and asymmetric resource transfers that have been prerequisite to different modes of capital accumulation throughout history. Conceived as material infrastructure, the accumulation, maintenance, and reproduction of capital is as contingent on a net appropriation of energy as is the survival of any biological system. Without a continuous import of energy, a machine is as inanimate as an organism that has starved to death. These are facts of physics, but they cannot be translated into economics. Energy is expended (dissipated) in any production process, but the amount of energy expended cannot be translated into exchange value. In other words, exchange value cannot be analytically derived from the amount of energy expended.

'Value' is Measured in Money, not Joules

Note that I am not saying that Podolinsky or Odum were right in equating surplus value with energy, or that Foster and Burkett were wrong in endorsing Engels' rejection of an energy theory of value. But Foster and Burkett's defense of classical Marxism against Podolinsky, juxtaposed with Foster's recent endorsement of Howard Odum, is clearly contradictory. They dismiss Podolinsky as an energy reductionist while simultaneously representing Marxian theory as highly informed by thermodynamics, even referring to what they call Marx's "energy income and expenditure approach to surplus value" (Burkett and Foster 2006, 120, 126).

What, then, is the relation between energy and value, that is, between the biophysical and the economic? To what extent does it enhance our analysis to refer to energy as ‘use value’? ‘Value’ is a concept deriving from the market, and the only conceivable metric for measuring it is money. Regardless of whether it is provided by draft animals, human labor, or fossil fuels, energy is *not* a value. It is measured in Joules, not money. Marxian and ecological economics tend to describe the fundamental problem of capitalism in terms of the “underpayment” of biophysical phenomena such as labor-power, embodied energy, or ecosystem services, but this way of talking about unequal exchange suggests that there is a conceivable “real value” or “correct price” which would make the purchase of labor-power, energy, or ecosystem services fair and morally defensible. It suggests, contrary to the frequent assertions of Marxists, that use values are quantifiable and possible to compare with exchange values. I don’t think this is a reasonable approach. The pervasive inadequacy of compensation—the exploitative logic of capital—is inherent in the relation between money and thermodynamics, and a structural consequence of the systematic struggle of market actors to keep costs (whether for labor-power or other kinds of energy) lower than incomes. Whether we talk about internalizing “environmental costs,” valuing “ecosystem services,” or paying “environmental debts,” we are deluded by the same fundamental incommensurability between ecology and economics. Money cannot compensate for entropy. For money to increase, resources must be destroyed. This inexorably destructive relation between economics and thermodynamics leads us to ask, rhetorically, which of them we can change: the operation of money or the Second Law of Thermodynamics?

The Marxian emphasis on underpaid use values, not least the use value of labor-power, suggests an emergent concern with thermodynamics, as Burkett and Foster note. I would add that Marx’s prediction of a decline in the capitalist rate of profit can be understood as an intuitive understanding of problems of net energy, widely referred to as EROI (Hall and Klitgaard 2011), and of how diminishing returns increase with the expansion of technological infrastructure (what is referred to by Marxists as the ‘organic composition of capital’). Both Marxists and energy theorists acknowledge that more machinery means less surplus. Along with Promethean trust in technological progress (see below), the most difficult conceptual constraint for nineteenth-century Marxism was to analytically disconnect these concerns with the expenditure of physical energy in production processes from the all-encompassing discourse on monetary profits and economic value. The failure to analytically delineate energy vis-à-vis money is evident in Marx’s version of the labor theory of value. Rather than a genuinely interdisciplinary argument on the relation between energy and money, such as was provided by Nicholas

Georgescu-Roegen (1971) a hundred years later, parts of the theoretical edifice of traditional Marxism remain impaired by the aspiration to analytically derive monetary gain from expenditures of energy. The much-debated Marxian search for a solution to the so-called ‘transformation problem’ (how the labor value embodied in commodities supposedly translates into exchange value) is thus futile.

The struggles of eco-Marxists to adapt the labor theory of value to twenty-first-century concerns with global ecology are welcome but analytically convoluted. Eco-Marxists often suggest that nature’s energy is being underpaid in the same way that labor is underpaid. But to conceptualize the abuse of the biosphere as a matter of exploiting the unpaid “work of nature” (cf. Moore 2015) is difficult to distinguish from familiar mainstream claims that “ecosystem services” are not properly evaluated, or even that “environmental externalities” are not reflected in market prices. Nature has no use for money. In trying to integrate Marxism and ecology, the eco-Marxists not only tend to contradict classical Marxist theory (which would be fine, if it was made explicit) but offer us an awkward conceptual framework for understanding environmental degradation.

You may of course ask why I choose to pick a quarrel with eco-Marxism rather than with mainstream economics. The answer is that I have been quarrelling with economists for thirty years and I know what kinds of arguments they will easily dismiss. Political ecology needs to exert itself analytically to assemble arguments that are not so easily dismissed. Contrary to Marxian value theory, we need to keep energy and money analytically distinct. To produce exchange value generally means to dissipate energy, as Georgescu-Roegen demonstrated, but exchange value cannot be analytically derived from the expenditure of energy. Yet this is the implication of the labor theory of value. Precisely because the Marxian critique of capitalism has for a century and a half represented the most radical challenge conceivable to business as usual, it is all the more disconcerting to realize that this critique has been couched in the categories (most centrally ‘value’) of the very system it claims to challenge.

Machine Fetishism and Unequal Exchange

Marx’s keen insights on the social repercussions of money did not prompt him to advocate a transformation of the money artifact itself, perhaps because the notion that specific artifacts can generate particular forms of social organization was not a prevalent component of European worldviews in the nineteenth century, or maybe because the prospects of transforming money seemed less realistic than a socialist revolution. In most modern Marxist thought it seems to be held that money—which, inspired by Shakespeare, Marx called the “universal whore” (Marx

1844)—could be extricated from its capitalist context and usefully deployed in the organization of socialist society. A similarly ambivalent stance characterizes Marxist relations to capitalist technology. Although Marx clearly understood the machines of his time as devices for exploitation, he believed that they too could be extricated from capitalism and made to serve the proletariat. Paradoxically, his point that technologies generate specific forms of social organization—as in his classical observation that “the steam-mill [gives you] society with the industrial capitalist” (Marx 1847)—can be viewed as a precursor to Actor-Network Theory,⁹ yet he must have visualized capitalist machines as intrinsically non-social products of engineering, that is, as “productive forces” detachable from their social context. This is a paradox, because it means that the theorist who taught us to understand how artifacts in capitalist society tend to be fetishized (to represent social relations as if they were relations between things) was himself suffering from the illusion which I have called “machine fetishism” (Hornborg 1992; 2001).

Most modern technology would not exist without what anthropologists call ‘general-purpose money.’¹⁰ Modern technological systems tend to be made possible by the differences in how human time and natural space are priced in different parts of the world. They are tantamount to displacements, by means of unequal exchange rates on the market, of work and environmental burdens to groups with less purchasing power. Globalized technologies, or symbiotic constellations of money and technology, are the most recent addition to the historical series of exploitative social arrangements beginning with slavery and serfdom. And yet modern technology is exactly what the so-called ‘ecomodernists’ hope will save us from economic and ecological collapse. The recently published *Ecomodernist Manifesto* (Asafu-Adjaye et al. 2015) is a paradigmatic illustration of the kind of technological fetishism that pervades so much of the contemporary deliberations on sustainability. The *Manifesto* seems completely oblivious of the fact that it is precisely the globally uneven accumulation of technology that has brought us to the brink of collapse. Globalized technologies are ways of saving time and space for some at the expense of time and space lost to others. The asymmetric global flows of resources are what make modern technologies possible (Hornborg 2013; 2016). And those flows are orchestrated by

⁹ Hylton White (2013, 679-680) argues that Marx was indeed “the theorist of a sort of actor-network,” whereas Latour, “by refusing to theorize social form as such, . . . ends up simply replicating the way that the society of the fetishism of commodities presents itself: as the only way of life we can possibly have.”

¹⁰ In a nutshell, this argument on the modern money-energy-technology complex can be phrased in the form of a syllogism: If technology is a matter of access to energy, and access to energy is a matter of money, then technology is a matter of money (Hornborg 1998, 132).

money. If you cannot see the problem with money, you cannot see the problem with technology.¹¹

When we refer to the existence of a particular kind of technology, we tend to equate it with a corpus of know-how, a state of engineering, a set of ideas about how something can be achieved. My point is that this cognitive aspect of technology is no doubt a necessary condition for its existence, but it is not a *sufficient* condition. A prerequisite to modern technology as a physical phenomenon is an unequal or asymmetric societal exchange of resources such as embodied labor, energy, land, or materials. I am not referring here to technology conceived of merely as blueprints produced by inventors, but lacking material manifestation. Such ideas of engineering do not deserve to be called technology any more than a representation of a DNA molecule deserves to be called an organism. Technical blueprints and genetic codes are abstractions and both can prove to be unviable in real life. Both technological and biological systems are ontologically unfeasible without specific structures of material exchange with their environments. Just as the existence of the organism is contingent on certain flows of energy, water, oxygen, and so on, the existence of a technological system is contingent on specific flows of energy and materials, and at specific rates. These latter flows are organized by the economy. Technologies are thus contingent on the rates at which energy, materials, and other inputs and outputs are exchanged in human societies. In accordance with the Second Law of Thermodynamics, we know that the output of any technological system will represent less available energy or productive potential than the input required for its production. To be viable, in other words, a technological system must be reproduced through ecologically asymmetric resource flows. To not see this dependence of technology on unequal exchange is what I have called machine fetishism.

Contrary to mainstream conceptions of technological progress as local advances in engineering that could potentially benefit all humankind, I have argued that the technological infrastructures developed in wealthier parts of the world are products of accumulation based on global relations of unequal exchange with less affluent areas. Technological progress, in this view, is not so much a matter of ingenious and innocent breakthroughs in engineering as of devising

¹¹ The symbiosis of money and technology is well illustrated by the capacity of contemporary financial magic to propel physical production processes based on unconventional (and very low-EROI) fossil fuels extracted from tar sands or through fracking. Another example is the claim that photovoltaic energy—although low-EROI and heavily subsidized by fossil fuels (Prieto and Hall 2013)—is becoming economically competitive with fossil fuels, an assertion that is largely founded on the reduction of labor costs derived from shifting production of solar panels to Asia.

new and profitable systems for displacing work and environmental pressures to other populations and geographical areas. This is the essential rationale of globalized technological systems. Rather than an index of generalized human progress—the pure, transcendent knowledge epitomized by the myth of Prometheus—technology since the Industrial Revolution is fundamentally an arrangement for redistributing resources in global society. Most modern technology requires not just ingenuity and specialized knowledge, but also global discrepancies in market prices. It is thus as inextricably connected to societal injustices as slavery or serfdom. And it owes its existence to money. Like the money that engenders them, globalized technologies are inextricably *social*. The phenomenon of money cannot be grasped without recognizing its function as a mystification of unequal exchange, and the phenomenon of modern technology cannot be grasped without recognizing its reliance on money. To complete the syllogism, the phenomenon of technology cannot be grasped without recognizing its reliance on unequal exchange.

The mainstream conception of technology tends to remain immune to deconstruction by relegating the responsibility for its various deleterious political and ecological consequences to its misuse by unscrupulous corporations and politicians. There is a widespread belief that “technology as such” would not have to implicate injustices, and that this purified, cognitivist perception of technology can be distinguished and extricated from political contexts in which it is used in such a way as to generate social injustices and ecological degradation. This belief in a decontextualized, transcendent, and emancipatory science of engineering has been fundamental to classical Marxist visions of social progress.¹² Marx appears to have been convinced that the steam engine could serve the purposes of socialism without presupposing slavery and soil erosion in colonial cotton plantations, let alone global warming. The inexorable progress of the productive forces, according to the classical Marxist vision, would deliver humanity as a whole from what is dismissed in the *Communist Manifesto* as “the idiocy of rural life.” Again, such Promethean understandings of technologies as innocent manifestations of enlightenment, detachable from the societal contexts in which they have emerged, is what I refer to as machine fetishism.

Conclusions

For more than two hundred years fossil fuels have not only been fundamental to our technologies, but have also conditioned our ways of thinking about economics, even in heterodox economics, without us realizing how much our conceptions of economic growth and

¹² It is a paradox that historical materialists in this respect appear to conceive of technologies as ideas rather than as vortices in asymmetric societal flows of matter and energy.

technological progress have depended on the specific properties of fossil fuels.¹³ The contemporary money-energy-technology complex frames the conceptual horizons even of its critics. To envisage the road to a post-capitalist society as a matter of shifting energy sources and collectively controlling the money while basically retaining the conventional idea of money and hoping to maintain our current technologies and consumption levels is delusory. A vision of post-capitalism that holds on to the idea of general-purpose money is a contradiction in terms. The organizational inertia of general-purpose money runs counter to the ideals embodied in the notion of socialism. To suppress this inertia requires totalitarian regulation which runs counter to ideals of democracy and personal freedom. Rather than build society on a tension between the inertia of its artifacts and the political attempts to regulate it, it must be a better idea to design those artifacts so that their consequences are more closely aligned with political ideals.

If we seriously consider the predicament illuminated by Georgescu-Roegen, our only option for post-capitalism is *degrowth* (cf. Latouche 2012). And degrowth requires that we fundamentally transform our idea of money. As financial bubbles have grown and burst, we have recently been reminded that money is a magical artifact that can dissolve into thin air. What this should also remind us is that it is ultimately up to us to design money in a way which will keep the biosphere inhabitable and increase global justice. The rules that we have bestowed on our artifacts *can*, in principle, be changed, just as the rules in chess or *Monopoly* can be changed. It is symptomatic of fetishism to believe that the logic of the artifacts and regulations which rule our lives is as inexorable as natural law.

It is understandable that a general critique of money will seem incomprehensible to people who cannot see that the design of money is something about which we actually have a choice, but this just illustrates how constrained our imagination tends to be by the artifacts that currently rule our lives. I cannot bring myself to believe that it would be feasible to completely abolish money and markets in human societies, as advocated by proponents of “non-market socialism” (Rubel and Crump 1987; Nelson and Timmerman 2011), but I am convinced that money can be *redesigned* so that its inherent logic would be to increase diversity and sustainability, while reducing social inequalities and vulnerability (Hornborg Forthcoming). The main objective must be to distinguish between different kinds of currencies that serve morally incommensurable

¹³ It seems very naïve to believe that what the world’s leaders decided in Paris in December 2015 was to abandon what for over two centuries has been their main source of economic and technological growth, and what continues to account for 86% of global energy use.

purposes.¹⁴ Infant mortality and environmental degradation in sub-Saharan Africa must be insulated against financial speculation on Wall Street.¹⁵ It is incontrovertibly immoral to allow one person's survival to be geared to another person's strategies to accumulate extravagant wealth, as is currently the case. With the abandonment of a single and global general-purpose currency, we would dismantle the very foundation of capitalism as an inexorably destructive systemic logic. If market actors found it in their interest to distinguish between transactions conducted within a local sphere of exchange committed to subsistence and community on the one hand, and a global sphere of non-subsistence exchange and communication on the other, many of the conditions for unequal and unsustainable exchange would rapidly atrophy. Rather than a product of coercion, this would be a consequence of voluntary human agency guided by the transformed logic of their money artifacts. Whether our priority is to avoid global financial crises, increasingly obscene inequalities, or catastrophic climate change, we shall have to fundamentally redesign the operation of money. This is the only possible road to a post-capitalist society.

So, to finally return to my opening question, what does it mean to be “critical” or “radical” today, 133 years after the death of Karl Marx? It means recognizing that what mainstream economists celebrate as “growth” is really *accumulation*, and what they endorse as “globalization” and “free trade” is *imperialism* and *unequal exchange*. But underlying it all—and this is where the Left needs to rethink some of its basic premises—it means recognizing that our preoccupation with money and crucially also with “technological progress” can be understood as *fetishism*, in the sense that relations between people assume the appearance of relations between things..

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¹⁴ My proposal should not be confused with community currencies such as LETS, which have been rightly criticized for not actually challenging the formal market (Mellor 2005, 58) but instead forming local clubs for “surviving in the capitalist jungle” (Buick 2011, 151). The complementary currency I envisage is fundamentally different from LETS by being singular for each nation, by being issued and distributed by the authorities as a basic income for all residents, and by only being possible to use for purchases of locally produced goods and services (for details see Hornborg Forthcoming).

¹⁵ The challenge of insulating “democratically controlled local flows of money from global capital” (Mellor 2009, 36) is the widely experienced imperative underlying the many ultimately unsuccessful experiments with alternative economies from the Owenites to LETS.

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