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Culture of Sustainability *Culture della Sostenibilità*

International Journal of Political Ecology

ISSN 1972-5817 (print) 1972-2511 (online) web: culturesostenibilita.it

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To cite this article: Caffentzis G. (2020). On Two Notions of Work/Energy: Energy Transformations and Class Struggle. *Culture della Sostenibilità*, 25: 7-26. DOI 10.7402/CdS.25.02



2020 · Istituto per l'Ambiente e l'Educazione Scholé Futuro Onlus



Published on line: 31 luglio 2020



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On Two Notions of Work/Energy: Energy Transformations and Class Struggle¹

George Caffentzis²

With the transformation of values into prices of production the very basis for determining value is now removed from view...This confusion on the part of the theorists [between surplus-value and profit and between the rate of surplus-value and the rate of profit] shows better than anything else how the practical capitalist, imprisoned in the competitive struggle and in no way penetrating the phenomena it exhibits, cannot but be completely incapable of recognizing, behind the semblance, the inner essence and the inner form of this process.

(Marx 1981: 268-269)

Abstract

In the late 1970s the Midnight Notes Collective introduced into the discourse of the anti-nuclear power movement the notion of “Work/Energy” to counter the description of the capitalist crisis of the time as a physically defined “Energy Crisis”. Since then Jason W. Moore in his important book, *Capitalism in the Web of Life: Ecology and the Accumulation of Capital* (2015) has used the phrase “work/energy” to describe the transitions in the world-ecology of the period between the 1600s and the present. Though these two notions of work/energy are similar, there are some significant differences between them. In this paper, I will examine the role that energy, and its 19th century science, Thermodynamics, plays in Marx and Engels’ theory of value. I will then specify the conceptual differences and political consequences of the more recent notions of “work/energy” in the 21st.

¹ Questo testo è stato presentato dall’autore al seminario dal titolo “Ambientalismo operaio e giustizia climatica” tenutosi a Parma il 10 giugno 2019 e organizzato dal Centro studi movimenti dell’Università di Parma.

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■ Introduction

The origin of the “work/energy” concept can be traced to the 1970s. A key political question of the time was whether the anti-nuclear power movement could bring together the workers’ and the ecological movements so that, at least conceptually, they could escape the political contradictions they faced at the time.—e.g., between the nuclear power lobby’s “Jobs, jobs, jobs first” drum-beat vs. the environmentalists’ call for “a healthy planet”. Could the “red” of the workers’ movement merge with the “green” of the environmental movement? Indeed, there was a wide-spread suspicion that if Marxist Anti-capitalism of the Left was unable to develop an effective answer to this question, its very existence would be in jeopardy because environmental issues were becoming central to the anti-capitalist politics of the late 20th and early 21st centuries.

The Midnight Notes Collective (of which I was a founding member) was one of many “affinity groups” that found themselves in the midst of this red/green divide. Under the assumption that Marx’s critique of political economy is still the most cogent analysis of the waged workers’ reality in capitalism and the ecological studies of the finite limits of the raw materials vital to the production of most industrial commodities as investigated by the “Club of Rome” the Midnight Notes Collective developed some new concepts that, instead of posing the environment and class struggle as separate entities, they brought the working class interests and demands into the anti-nuclear power movement of the day.

There has been a renewed interest in the “red and green” alliances on the Left recently, with the rise of the anti-climate change movement and the intensification of the resistance to fossil fuel extraction in response to the world-wide crisis of profits in the Great Recession of 2008 (known as “anti-extractivism”). This development is especially cogent with the rise of a whole new discourse since the introduction of the term, the “Anthropocene”, in the scientific literature since 2000. For if the gate-keepers of such a “hard science” like geology, that is so central to the workings of capitalism’s basic energy sectors like the oil and gas industry, are being forced to accept a new terminology that questions many of the dichotomies that were standardly accepted in their field until recently (e.g., the division of Nature and Society), then one can only assume a similar impact would be felt in the analysis of capitalism in the light of the Anthropocene. This is especially true in the case of the critics of capitalism like Timothy Mitchell (Mitchell 2011), Andreas Malm (Malm 2016) and Jason W. Moore [(Moore 2016), (Moore 2015)]. Indeed, there is an effort by some like Jason Moore (Moore 2016: xi) and Andreas Malm (Malm 2016: 391) to rename the geologists’ Anthropocene as the “Capitalocene” in order to emphasize the point that the normal functioning of the capitalist system is having an immense impact on basic geological measures like average sea level, global atmospheric temperature, and the amount and distribution of fossil fuel energy resources across the planet and at the same time the functioning of

capitalism is profoundly being changed in the reflux of their feed-back loop.

In this paper I will examine two meanings of an important term in the new discourse —work/energy--and the systematic and political differences they entail in order to survey the conceptual terrain of this “new science”. I will begin with an examination of the place energy has in Marx’s critique of political economy, then give an account of the notion of work/energy I have developed with my comrades beginning in 1980 and then examine Jason W. Moore’s version of work/energy. I conclude with a sketch of the political consequences of these conceptual differences.

■ Marx, Engels and Thermodynamics

Although “work” and “labor” are central to the Marxian ontology, the concept of energy was even more crucial in the development of Marxism. There is good evidence to support the claim that the architecture of Marx’s theory of value was borrowed from the science of Thermodynamics. Marx and Engels were *bricoleurs* extraordinaire, ready to use any tool that was at hand to solve a problem. Marx famously coquetted with Hegel’s dialectical categories, but he also flirted, less famously but more pertinently, with Thermodynamics, *the science of Energy* of his day.

Marx and Engels were most interested in the notion of “energy transformation” that was central to mid-19th century thermodynamics. The key words of the physics of their day were, besides “energy” itself, “transformation”, “conservation” and “equivalence”. It was exciting for scientists to discover that electricity, mechanical motion, heat, and so many other forces (known and unknown) that were yet to be identified can be transformed into each other *equivalently* to conserve an abstract but beguiling physical entity: energy. As Engels still excitedly put it 1885 in his second Preface to *Anti-Dühring*:

That the quantity of motion (so-called energy) remains unaltered when it is transformed from kinetic energy (so-called mechanical force) into electricity, heat, potential energy of position, etc., and vice versa, no longer needs to be preached as something new; it serves as the basis which has already been secured for the now much more pregnant investigation into the very process of transformation, the great basic process, knowledge of which comprises all knowledge of nature.

(Engels 1976: 14-15)

I locate Marx’s vision of capitalism’s functioning in this energetic transformation framework and not in Hegelian dialectics. Not only did the steam engine transform heat into mechanical power, but capitalism, according to Marx and Engels, itself was a gigantic engine that transforms labor power, machine motion and natural resources into surplus value. Indeed, Marx’s vision of capitalism is of a system of transformations that has as its basis a common pool of surplus-value from which each capitalist claims his/her own profit accor-

ding to his/her capital invested. This is the logic of the famous Chapter 9 of Book III of *Capital*, the “Transformation of Commodity Values into Prices of Production”, that is the source of the transformation “problem”. Marx boldly demonstrates that transformation is not the problem, but the solution.

Marx’s interest in applying the notion of transformation in his work on *Capital* in the 1860s is a good example of his prescience, for the notion of transformation was percolating throughout the mathematics and the science of the times. For example, in 1872 Felix Kline outlined his “Erlanger Program” as: “Given a manifold and a transformation group acting on it, to investigate those properties of figures on that manifold which are invariant under [all] transformations of that group”. (Klein, 1872) “Invariance under transformation” became a primary organizing principle of any field that wanted to take on the role of a science.

Marx, of course, predominantly writes of Value in *Capital* not of Energy. What is their relation? One way of seeing the relation of energy to value in Marx’s critique of political economy is to glance at the tables of contents of *Capital*’s three volumes. They are dominated by transformational terms like “metamorphosis”, “transition”, “transferring”, “conservation”, “conversion”, “circuit”, “reproduction”, “formation”, and, most important for my argument, “transformation”. Value became the “what” which was transformed in Marx’s critique as Energy was the “what” that was transformed and studied in the physical sciences.

These value transformations happen “behind the backs” of most capitalists and workers. Indeed, they appear at first to be falsified by empirical reality. But as we know from the history of science, scientists rarely reject attractive hypotheses simply because they are falsified by observation. After all, the Copernican hypothesis appeared to 16th century critics to be blatantly falsified by empirical evidence. They pointed out that they do not feel like the earth is rotating about a thousand miles per hour beneath their feet and that there was no sign of the “parallax effect” that should have been observable, but was not with the instruments of his time. (Kuhn, 1958).

What does Marx mean by “transformation”? Consider this definition: there must be a “definite process” that accomplishes every transformation of X into Y and that the result of every transformation of X is never “just” Y, there is a “supplement” of semantic surplus which is also the source of illusion. [A similar point can be made of energy transformations, after all, it is only in rare experimental conditions –as, for example, the experiments Joule performed with his famous paddle and calorimetric devise--when energy in form X is (almost) completely transformed into energy of only one form Y, in Joule’s case the transformation of mechanical energy into heat energy.]

Let me illustrate this definition in a number of different settings in *Capital*. In the case of the transformation of Money into Capital, for example, the *process* of the transformation is the circuit M-C-M’ and the *supplement* is the confusion of Money with Capital by identifying M-C-M with C-M-C (hence the confusion of the capitalist with the greedy miser). The later circuit is finite,

since the whole point of exchange is to sell the commodity one has in order to buy the commodity with a use-value one wants, while the M-C-M circuit does not aim to possess use-values; it calls for money (hopefully, *more* money). Marx writes about the supplementary confusion:

Use-values must never be treated as the immediate aim of the capitalist, nor must the profit on any single transaction. His aim is rather the unceasing movement of profit-making. The boundless drive for enrichment, this passionate chase after value, is common to the capitalist and the miser; but while the miser is merely a capitalist gone mad, the capitalist is a rational miser.

(Marx, 1976: 254)

Another example of this transformation/supplementary-illusion process, among more than a dozen others is the case of the transformation of the Value and Price of Labor Power into Wages. The process is one that begins from the hidden substratum, “the essential relation manifested... in the value and price of labor-power” and appears in the phenomenal form “value and price of labor”. The transformation, in this case, goes from a coherent truth (what actually is bought in the transaction between workers and capital is labor power *not* labor) to a confused appearance (one’s wage is payment for labor performed during a particular period of time, labor-time). This is not an innocent switch, for then “All labor appears as paid labor” (Marx, 1976: 680). The exploitation of the worker is transformed out of existence. “World history has taken a long time to get to the bottom of the mystery of wages; but despite this nothing is easier to understand the necessity, the *raison d’être*, of this form of appearance” (Marx, 1976: 680-681).

This notion of transformation (as a process from hidden “truth” to apparent “illusion”) becomes standard usage in *Capital III*. For example, Marx writes of the crucial relation between two transformations:

It is the transformation of surplus-value into profit that is derived from the transformation of the rate of surplus-value $[s/v]$ into the profit rate $[s/v+c]$, not the other way round. In actual fact, the rate of profit is the historical starting point. Surplus-value and the rate of surplus-value are, relative to this, the invisible essence to be investigated, whereas the rate of profit and hence the form of surplus value as profit are visible surface phenomena.

(Marx, 1981: 134)

Or again on the relation between profit and surplus value:

Thus even if the rate of profit is numerically different from the rate of surplus-value, while surplus value and profit are in fact the same and even numerically identical, profit is still for all that a transformed form of surplus-value, a form in which its origin and secret of its existence are veiled and obliterated.... It appears to consciousness as if capital creates this new value in the course of its movement through the production and circulation processes. But how this happens is now mystified and appears to derive

from hidden qualities that are inherent in capital itself. The further we trace out the valorization process of capital, the more is the capital relationship mystified and the less are the secrets of its internal organization laid bare.

(Marx 1981: 139)

In other words, the process of valorization is what brings about the transformation from surplus-value to profit, just as the process of competition is the transformation mechanism that brings about the transformation of profit into average profit. But here too the process of transformation creates illusions and reversals of explanatory power:

In competition, therefore, everything appears upside down. The finished configuration of economic relations, as these are visible on the surface, in their actual existence, and therefore also in the notions with which the bearers and agents of these relations seek to gain an understanding of them, is very different from the configuration of their inner core, which is essential but concealed, and the concept corresponding to it. It is in fact the very reverse and antithesis of this.

(Marx, 1981: 311).

Thus, there is a hidden reality that is *transformed* into a visible appearance that, once established, becomes *self-explanatory*! For example, once capitalists have a sense of what is the average rate of profit for their era, it becomes regulatory and the basis of compensation (without, of course, explaining *why* it is what it is).

Capitalism is an “upside down” system that, on top of it, acts “behind everyone’s back”. It is a system of exploitation that adamantly and constitutionally refuses to reveal itself as such. What would happen if all the participants (both capitalists and workers) rid themselves of their superficial knowledge and had knowledge of capitalism’s “inner core” and “the concept corresponding to it”? Marx left this experiment for a future generation.

Indeed, Marx’s vision of capitalism is of a system of transformations that has as its basis a common pool of surplus-value from which each capitalist claims his/her own profit according to his/her capital invested. To illustrate his case Marx devises a “thought experiment”: he imagines the “zero-worker” capitalist, i.e. “a capitalist who employed no variable capital at all in his sphere of production, hence not a single worker (in fact an exaggerated assumption), would have just as much an interest in the exploitation of the working class by capital and would just as much derive his profit from unpaid surplus labor as would a capitalist who employed only variable capital and therefore laid out his entire capital on wages” (Marx, 1981: 299). This allegiance to the common pool of surplus value is the objective bond of the capitalist class. Indeed, *this allegiance makes out of a motley set of competing capitalists a class (with a inside and an outside) whose members are self-reflexively inside the magic circle, i.e., this is not a fact about them, but it is them, though they do not know it.*

Competition which is taken as the definition of capitalism (or, as in this era of euphemism puts it, “the market”) is simply a mechanism that sorts out what is always already created in the production process (surplus value). Hence, what divides capitalists is always subordinate to and functional for their unity: the common lust for surplus and the common fear of this lust’s revelation (since such a revelation would point workers’ attention to their exploitation, expropriation and extinction that are at its roots).

It should be clear that the illusions created by these transformations are not ideological projections, i.e., they are not detachable from the productive base in the way that legal and cultural constructions are. Ideological constructions can be changed without putting the survival of capitalism in question. For example, in the *ante bellum* US property law was used to justify the practice of employing “slave catchers” to go into the so-called “free states” and capture run away former slaves and return them to their masters. This law was based on the commercial maxim that one’s property rights over a possession are still in force if the property was a human being who was residing in “free states”. Later, this ruling was rejected under readings of the Constitution that put human beings (not convicted of a crime) outside of the class of possible objects of ownership. This change of ideology did not end capitalism as the slavocrats continually warned it would.

But if transformations involving the value of commodities ($v+c+s$) and the commodities’ price of production ($((v+c)+r(v+c))$, where “ r ” is the rate of profit, and the transformation of the value of labor-power and wages or other similar transformations stopped operating, capitalism would be threatened with collapse, since these transformations are functional to the very operation and reproduction of the system. They are real abstractions, “abstraction not as a mere mask, fantasy or diversion, operative in the world (Finelli, 1987; Ranci re, 1989). (Toscano) For if there was no difference between the value of a commodity and its price of production, there would be no investment in high organic composition industries and if there was no difference between wages and the value of labor-power, the theft of the value creativity of workers would become so obvious the wage contract would be flatly rejected by one of the two parties to the labor contract: the worker.

Moreover, Marx argued that the major revenues of the capitalist ruling class (profit, interest and rent) are transformations out of this pool of surplus value that is created by the system of exploitation of labor as a whole. The endless busyness of the horizontal surface of capitalist society (with its long and intertwined organic-chemistry-like molecular circuits built from blocks of $M-C-M'$) is matched by an equally active vertical dimension connecting the surface with the hidden “essence” or “core”. There are more than enough secrets, deceptions and illusions in this world of business to satisfy any deconstructionist philosopher or postmodern literary critic. An exquisite problem arises from this world of mirrors endlessly reproducing itself: the distortions are infinitely multiplied, the confusions are stirred into ever greater confusion, and the illusions become even further sources of illusion. Thus the origin of

an individual capitalist's profit in a common pool of surplus-value is hidden to him/her, but the very lack of explanation of its source creates the plausible impression that it is *sui generis*! Hence arises the "magic" of compound interest and all the other fairy tales capital tells to itself in the moment when it needs a shot of boosterism. In other words, capitalism not only exploits, it aims to make this exploitation inexpressible and untraceable.

In brief, energy is an essential aspect of Marxism or, to be more precise, energy transformations are the models of value activity.

■ Transformation, Energy, and Value

Marx's transformational vision of capitalism was similar to the "energeticists'" view of Nature in the last half of the 19th century; i.e., those physicists who intended to replace matter in motion as the primary focus of physics to the flow of energy. This connection is not arbitrary. First, etymologically "energy" is a compound word: $\epsilon\nu$ (in) + $\epsilon\rho\rho\epsilon\iota\alpha$ (work), and as the 11th edition of the *Encyclopedia Britannica* points out, "[it is] a term which may be defined as accumulated mechanical work, which, however, may be only partially available for use" (EB, article on "energy"). Therefore, it is rooted in the ontology of work as is Marx's (of course, the notion of work is different—though related—in both cases). Energy is simultaneously the most abstract of concepts and the most crucial from the point of view of a society built on value-creating work!

Most important was the place of conservation laws for both Thermodynamics and for Marx's theory of capitalism. The conservation of energy "law" is an essential ingredient of the explanatory heuristic in the energetic framework. For the surface of phenomena continually seems to violate the conservation of energy law. It is hard to trace in an obvious way the movement of energy from one phenomenal form to another. A pendulum is pushed, it swings and slows soon to a stop. Why doesn't it swing forever? It swings in an invisible medium that resists its movement, and this resistance creates turbulence and heat with every swing. The energy "lost" due to friction and drag on the first swing is E_1 and that lost on the n th swing is E_n while the initial energy arising from the fall of the pendulum's weight is E . At the end of the first swing the total energy is $E - E_1$, and at the end of the second swing the energy is $(E - E_1) - E_2$. Eventually on swing m , the loss of energy will be equal to the original energy E , i.e., $E - (E_1 + E_2 + \dots + E_m) = 0$. It is only with the conviction that a conservation law operates that one would launch a research program to determine the dimensions of E_1 similar to Joule's obsessive efforts aimed at eliminating the energy dissipating factors caused by the fall of the weights on the water in his device's calorimeter. Marx was similarly concerned about the division of value (especially surplus value) throughout the capitalist system. To trace out the "loss" (or actually diversion) of value in the system, to correct the misattribution of value to fictional categories (e.g., the identification of wages with

the value of labor power creates the illusion that workers are not exploited through the capitalists' appropriation of the surplus value they created or the identification of the rent on a piece of land with the "productivity" of the land) and similar efforts are crucial to understanding capitalism and form the basis of the Marxist analysis of capitalism. These efforts become more detailed as one moves from the first to the third volume of *Capital*. In the first volume the capitalist system is viewed literally extra-terrestrially, similar to the view of the earth as a thermodynamic system. For it is very easy to determine the amount of energy input E during, say, one year, since this energy is almost exclusively the sun's light and heat energy impacting on the earth's surface. It is a bit more difficult to determine the energy "loss" of the earth, E_L due to the reflection of solar light and the radiation of heat into space, given shifting cloud cover, changing chemical composition of the atmosphere, absorption of energy by the oceans, the leaking of heat energy of the molten core of the earth through volcanoes (both on land and below the seas), etc. But what is truly difficult to determine is the fate of $E_N = E - E_L$, the net energy. How much goes into photosynthesis? How much is transformed into stored energy? The debates around both global warming, climate change and the "Gaia Hypothesis" illustrate the claim that though the outlines of both macro-hypotheses are easy to establish, the fine points of both are hard to empirically establish. (The beautiful thermodynamical *qua* ecological studies of limnology in the 1940s perfectly illustrated this dialectic between easy whole and difficult part [Lindeman 1942]).

Marx certainly required his own conservation principles to carry on a more micro-analysis of capital. It was easy enough to treat the system as a whole and divide its functioning into a number of macro-variables, T , V , C , and S , but it is not easy to see how, e.g., T , the total value created by the totality of labor in a year (which plays the role of the sun light in this system), is distributed across industrial branches. The guide to this assessment must be based on some conservation principles like, e.g., the totality of profits, interest payments, rents and taxes should equal S , the total of wages should equal V and the total investment in productive capital should equal C . Such a value accounting of the capitalist system is achievable, just as the energy account of the earth is, but there is no Marxian "model" which has actually accomplished such a feat. It is not clear that there is any such a project to investigate the social universe on the agenda at the moment, although an energy account of the earth is the Holy Grail of many ecologists and climate scientists. But in either project, the conservation laws are crucial, since they provide a heuristic for hunting down the sources of explanatory lacuna.

■ The Midnight Notes conception of work/energy

Up until now I have been dealing with transformations (displacements under rules), but now I turn to "work/energy".

The phrase was introduced in the title of *Midnight Notes #2: No Future Notes: The Work/Energy Crisis and the Anti-Nuclear Movement* that was published in August 1979—the year of the Three Mile Island nuclear reactor’s partial meltdown. The phrase is not explicitly defined, but it clearly was introduced to counter the widely used description of the complex of volatile oil prices and ecological damage in the 1970s: the energy crisis. MN wrote then:

this crisis is by no means an energy-crisis. In a certain sense there was never and will never be a true energy crisis, because, by the first law of thermodynamics, there is always a constant amount of energy [in an energetically closed system]. What capital faces...is in fact not an energy—, but a work-crisis, a crisis of the transformation of natural and human energy into social energy, into surplus value and profits.

(MN Collective, 1979: 7)

In fact, the phrase is only directly used in the last sentence of the text: The problem for the anti-nuclear movement is not to provide a solution to the work/energy crisis but to intensify the refusal of the nuclear and “alternativist” future that capital will try to synthesize in its search for survival.

(MN Collective, 1979: 38).

It is only in *Midnight Notes #3: The Work/Energy Crisis and the Apocalypse*, published in November 1980 – the year of Ronald Reagan’s presidential election – that an effort was made to introduce something of a definition. MN wrote: “The proper name for the crisis then is the ‘work crisis,’ or, better, the ‘work/energy crisis.’” The definitional effort continued:

For the problem capital faces is not the quantity of work per se, but the ratio of that work to the energy (or labor power) that creates it. Capital is not just the product of work. Capital is the process of work-creation, i.e., the condition for transforming energy into work.

(MN Collective, 1979: 3)

It is a ratio between quantities measured in socially necessary labor time (S, C and V) and energy measured in Joules or British Thermal Units³ (J). This is an attempt to bring together two previously disparate forms of measurement; the thermodynamic terms for quantifying energy with an expanded Marxist labor theory of value, measuring value creation. It would be the culmination of David Hume’s program of bringing together Newtonian measures with the application of “the experimental philosophy to moral subjects”. Hume saw his project was to bring about a Copernican Revolution in the “sciences of man”. (Demeter 2016) A similar development arose in the creation of mixte modali-

³ The term “Joule” within the International System of Units (SI) describes the energy expended by one Newton (the force required to make a mass of one kilogram accelerate at one meter per second) applied to an object weighing one kilogram over the distance of one meter. One joule is thus a sizable amount of energy. If one imagines pushing one kilogram (roughly 2.2 lbs.) over one meter to accelerate it this is roughly commensurate with throwing a largish rock through a pane glass window.

ties in the 19th century under the rubric, “psycho-physics”.

It is denominated by, say, socially necessary labor hours per Joule or British Thermal units and it intuitively measures how efficiently energy is normally used to create value through the labor process. It is “the ratio between the amount of work that creates surplus-value and the quantity of energy produced by the resource base to create this value measured by socially necessary labor time”. Symbolically, it would specify a family of ratios numerated by value measures and denominated by energy measures where one rough example would be the GNP divided by the total energy production. This ratio would be for 2016, \$18,624 billion/83.4 quadrillion Btu, or roughly in reduced terms \$1/4,600 BTUs., for every dollar of created in the US economy 4,600 BTUs must be expended. The definition of a BTU is the amount of heat needed to raise one pound of water at maximum density through one degree Fahrenheit, equivalent to 1.055×10^3 joules, In other words in order to create \$1 for the US economy there must be employed enough heat to raise 4,600 pounds of water one degree Fahrenheit!

Work/Energy crises arise when tangentially less work (or its hoped for result, value) is created out of a given amount of energy. These crises lead to energy regime transitions that are intended to increase the work/energy ratio. Some transitions were successful, for example, from solar energy resource bases powered by wind, water, and animals to coal-based industry (Malm, 2016) or from coal to oil-powered industries (Mitchell, 2012); but some were failures, for example, the oil to nuclear power transition of the last half of the 20th century never happened. By “failure” I mean that on average world-wide there are three new nuclear power plants introduced a year during the last decade, whereas there was twenty-two per year in the decade between 1975 and 1984.

The use of the phrase, “work/energy”, was quite limited in the 1980s and 1990s and when it was used largely due to references to “The Work/Energy Crisis and the Apocalypse”.

What use is the work/energy ratio? An oarsman proletarian on a ship driven by muscle power is not the “same” proletarian as the one monitoring a submarine’s nuclear reactor. A different set of rules apply to exploit their labor and a different logic of refusal applies to different forms of motive power. So, for example, an enslaved proletarian is hardly a crewman who would be appropriate to a nuclear submarine or to a space colony (for the latter see “Mormons in Space”, an essay co-authored by Silvia Federici and myself) (Caffentzis, 2013: 58-65). Similarly, an assembly line staffed by artisans would be problematic for capitalists as well. This connection between workers and the technological means of production was understood by the political economists of the eighteenth and nineteenth century like Adam Smith and John Stuart Mill whose critique of chattel slavery, e.g., was based on its inefficiency, for no reasonable capitalist would want to have slaves tending machines that cost many times the slaves’ value. In other words, slave production could only be compatible with the lowest technological level because the slave could be expected to “labor as little as possible” and be “inefficient and unproductive”

respectively (Smith, 1998: 438) and (Mill, 1961: 251). So whenever there is a change in the energy resource base of capitalism, there is a necessary change in the social character of the proletariat that will make the new base productive of surplus-value. What is crucial for capitalism, then, is neither Work nor Energy alone, but Work/Energy, i.e., the ratio between the amount of work that creates surplus-value and the quantity of energy produced by the resource base (Midnight Notes, 1992).

The chain of causation also goes the other way. For changes in the work/energy ratio are caused by proletarian action. As Timothy Mitchell has powerfully argued and documented, the reason why there was a shift from coal to oil was not due to the superiority of the latter substance for industrial production, but it was because miners and their strikes began to pose a serious challenge not only to their immediate bosses, but to the entire capitalist system by creating a new level of working class power:

Workers were gradually connected together not so much by the weak ties of a class culture, collective ideology or political organisation, but by the increasing and highly concentrated quantities of carbon energy they mined, loaded, carried, stoked and put to work... More than a mere social movement, this socio-technical agency was put to work for a series of democratic claims whose gradual implementation radically reduced the precariousness of life in industrial societies.

(Mitchell, 2011: 27)

The move to oil was an attempt by capital to find an energy resource base that was able to undermine this power of the working class in the coal circuit. Many features of oil provided much more control over the energy resource base:

The ability to weaken the labor force by dividing it into separate racial groups, with managers, skilled workers and unskilled workers housed and treated separately, reflected the different distribution of oil production across the world compared to coal, and its development after rather than before the rise of modern industry.

(Mitchell, 2011: 36)

This analysis is an example of why it is important to understand the class dynamics that motivate many of the energy resource base transitions, for they are not determined by questions of scarcity and energy density, as the Limits to Growth theorists would have us believe today.

Throughout work/energy transitions since the 16th century, capitalist accumulation continued unabated. This demonstrates that the basic categories needed to constitute a capitalist society are not determined by the energy resource bases of the day. Profit, wage, rent, interest, value, surplus value, constant capital, etc. do not require a particular technology with an accompanying energy resource base. This is not to say that “anything goes” or that, for example, capitalism can point-for-point “return to a solar past”, since capitalism at its dawn confronted a world population a fraction of the present size and a

circulation process operating at a fraction of the present speed. But these differences do not affect the fact that capitalism is a very old social system that has been able to launch and survive many energy resource transitions due, in part, to the inability of its opposition to generate the social power necessary to overthrow it. Though the energy resource bases can change, what is crucial is that there will always be workers who have no direct access to the means of subsistence and production whose work can be exploited and turned into the many forms of revenue: profit, interest, and rent. As long as these workers are willing to accept a much lower energy density in the means of production (i.e., a return to an archaic technological level), then it is possible for capitalism to continue the accumulation process, for what is accumulated is not energy, but work. Will they? This is not clear, but there are indications of the terrain of struggle to come is the refusal of “extractivism”—i.e., the doctrine that the roots of economies is in the extraction and export of “natural resources”—especially by indigenous people in Latin America. (Zibechi, 2015; Vasquez, 2014; Caffentzis, 2004)

To go further into my analysis of the energy resource base, it is worthwhile asking the naïve question: For what purpose is this energy resource base being used? In most cases energy’s major purpose is to power machines (from trucks and tractors to electric power plants). So this brings us to the machine and to another naïve question: for what purpose is the machine to be used in capitalist society? Machines are certainly not introduced in order to reduce the pain and danger of the labor process. On the contrary, they are introduced to increase the profitability of the capitalists who own them via the productivity of the workers they exploit. More to the point, machines are themselves not simply accumulated energy from fossil fuels, but are rather the products of past labor – dead labor, in the historical materialist idiom – full of an accreted form of human labor waiting to be employed by new living labor. Machines, Marx reminds us, don’t wake up and decide to go to work of their own accord. The key issue for the individual capitalist is that s/he purchases a machine to use in the production of a commodity in order to keep up with the competition. But that does not answer the question; it simply defers it to the initial adopters of the machine in question who did not have competitive pressures to motivate the change. The key view that opens up the possibility of an answer is that machines are instruments in class struggle, since the boss can threaten to replace workers who are successful in increasing wages, reducing the workday and making claims on the productive apparatus. Of course, the substitution also has a mathematical aspect. For the cost of the machine (with its energy costs and its depreciation) must be less than the “savings” in the wages and other costs connected with workers’ struggles (e.g., sabotage).

There are additional attributes of machines that are useful in the class struggle, as Renfrew Christie pointed out many years ago:

Dead labor in the shape of machinery has another advantage over living labor. It does not talk back. It does not go on strike. It does not steal. It does not resist the designs of capitalists... Capitalists, therefore, use the

disciplines and skills of machines as substitutes for the withdrawable skills and calculated indisciplines of their class enemies, the workers.

(Christie, 1980: 14)

This connection between work and energy was well known to Marx and it helped structure *Capital I*. For it is no accident that Part 4, “The Production of Relative Surplus-Value”, which is comprised largely of a discussion of the role of machines in capitalism is followed by Chapter 11 on the successful centuries-long struggle to reduce the working day. For the more effective the class struggle is at the point of commodity production, the greater is the tendency of capital to increase mechanization and hence there is an increased need for power generated by energy resources. And here we can see that this energy resource base is crucial in replacing labor power (if it is full of struggle) and intensifying its exploitation. Thus, we often forget that computerization of production requires an increase in energy use. Most analysts have estimated that as much as 10% of world-wide electricity use is attributed to computer technology!

Let us examine the relation between energy needs and class struggle in a schematic way by assuming that the sum value of the totality of commodities (T) is constituted by constant capital (C), value of labor power (V) and the surplus-value (S), ($T=C+V+S$), and the rate of profit of the whole system is $S/V+C$. A successful class struggle is one that increases the value of labor power and reduces the rate of profit. How can the capitalists react to a decrease in the rate of profit? One answer is: to increase C in order to reduce the required number of workers and their wages (the wage bill, as it was known in nineteenth-century political economy) V, and also increasing S. In general, therefore a response to increased and successful class struggle is via an increase in mechanization and hence energy requirements of production. Indeed, one might say that in a capitalist society increased class struggle would tend to accelerate the use of its energy resource base. Consequently, as long as the struggle is kept under control, the drive to increase the pace of mechanization is reduced and hence the need for more energy is reduced. *This is the capitalists’ version of conservation!* But the struggle that escapes control (increasing V and decreasing S) and successfully resists the substitution by machines (keeps C level) is *the workers’ ecological path away from capitalism*. No wonder why there has been “a struggle between worker and machine”! As the Luddites taught Marx, “The instrument of labor strikes down the workers”. (Marx, 1976: 559) This struggle not only puts a brake on the accumulation process but, in the tradition of historical materialism, is the only formal path to anti-capitalist transition.

What does this excursus into capitalist mathematics mean for the relation between energy and work? It demonstrates that class struggle has a profound effect on the use of energy in capitalism. It is only the “negative subjective” aspect of the work process that is a final limit to capitalism, not the “natural” aspect. The problem with this subjectivity is that it does not have clear limits! How much working class “patience” can capitalists count on? This is a

quantity (like future knowledge) that cannot be known in the same way, say for example, that the amount of petroleum in a given cubic volume of subsoil can be. Thus, a drama is proposed by this way of formulating the question of the end of capitalism. For it is perfectly possible for the wage and working conditions of workers to shrink to unprecedented levels without bringing about a revolutionary response. Indeed, we are seeing such a development in Greece right now where after more than a century of struggles to guarantee a less precarious life to the working class in Greece has evaporated without a fundamental break with the system (yet). Consequently, the end of capitalism seems to avoid dealing with the decisive question: when (if ever) will class struggle reach a point of total effective refusal in the face of deteriorating natural conditions?

■ Jason W. Moore's notion of work/energy

The attention toward the notion of “work/energy” changed with the 2015 publication of Jason Moore’s book: *Capitalism and the Web of Life: Ecology and the Accumulation of Capital*. Moore put “work/energy” at the center of his important book. But I do not use exactly the same “work/energy” notion that Moore does. In this section I will analyze and contrast my conception of “work/energy” with Moore’s in order to understand what are the differences and whether they have political consequences.

“Work/Energy”, in my terminology is a *ratio* of different units of value creation denominated by the energy exhausted in these units during the creation process. These units could range from micro-capitalist enterprises to the totality of capital. But as Hegel points out about Quantitative Ratios: “The two sides of the ratio are still immediate quanta: and the qualitative and quantitative characteristics still external to one another” (Wallace, 1892: 199).

I use the slash, “/”, to typographically express separation, not unity in the way Jason W. Moore takes it to be. The slash in Moore’s terminology when flanked by “work” on one side and “energy” on the other is not a ratio, but it refers to the common work done (mostly unwaged) by, for example, housewives, waterfalls, and convict labor or as Maria Mies puts it, “women, nature and the colonies” (Mies, 1986). It refers to the world-changing activities of devalued categories of beings. The vast pool of unwaged work done by women and by Nature (e.g., animals) for capital (their work/energy) cheapens the cost of production and reproduction. *That* is work/energy’s function for the system, according to Moore. It is a structural feature of capitalism similar to the pool of surplus value that flows to higher organically composed branches of industry that I discussed in the transformation of the value of a commodity into the commodity’s price of production. Its function is to provide surplus value to industries that do not create much surplus value but provides vital functions in the production and reproduction of the system as a whole.

Moore comments on this issue:

Work/Energy helps us to rethink capitalism as a set of relations through which the “capacity to do work” – by human and extra-human natures is transformed into value, understood as socially necessary labor – time (abstract social labor). “Work/energy” (or potential work/energy) may be capitalized - as in commodified labor-power via the cash nexus - or it may be appropriated via non-economic means, as in the work of a river, waterfall, forest, or some forms of social reproduction.

(Moore 2015: 14)

In fact, Moore differentiates his conception of work/energy from mine in the following words: “My use of work/energy extends it to capitalism’s unified logic of appropriating human and extra-human ‘work’ that is transformed into value” (Moore, 2015: 14). In other words, Moore’s slash is not the sign of a ratio (as is mine), rather, it is the sign of a synthesis of human and extra-human energy whose function in a capitalist society is the creation of value. But I hold that capital has not been able to dialectically transcend its separations, for after all, there is still a category of rent and a class of rentiers (rent receivers). Instead of suffering a euthanasia that Keynes suggested, there is a tremendous vibrancy in the class of rentiers in the early 21st century, if the residency of Donald Trump in the White House is any indication.

In fact, Moore attests to the importance of the concept of work/energy by writing that it “looms large in this argument. It allows us to pierce the Cartesian fog that surrounds the unity of human and extra-human work” (Moore, 2015: 14). But this “fog” is not simply a mental limitation, but it is rooted in basic (or even “sacred”) features of capitalist societies: property rights and rights to receive rental revenues.

I have an alternative Spinozistic notion of “work/energy” and have some criticisms of Moore’s conception of “work/energy”. First, it confuses what capitalism does with those who develop a *critique* of capitalism versus those who develop a *description* of it. For example, one might see capitalism as having the tendency to reduce all use-values into commodities, but that does not mean that this reduction is actually universal. There are counter-tendencies that put limits on commodification. A description of capitalism should recognize the incompleteness of commodification even though a critique would point out that capitalism inevitably leads to a totalization of alienation universal commodification would bring.

Also, it is not enough to say, as Moore often does, that an analysis is ontologically faulty simply because it is “substantialist” instead of being “relational”. This is too mechanical (in the pejorative use of the term) but it is hardly novel. For after all, the substance/function dichotomy is the product of neo-Kantian philosophers like Ernest Cassirer in the late 19th and early 20th centuries and revived by Philip Mirowski in his 1989 book, *More Heat Than Light: Economics as Social Physics, Physics as Nature’s Economics* [(Cassirer, 1953), (Mirowski, 1989)].

But it is one thing to give an account of what Capital says of itself and quite another thing to specify what its critique states. Thus, Capital says that there is no surplus value created by the workers in the working day. We know why this analysis is so crucial, for if labor is not owned, then workers would have the right to demand ownership of the surplus value created in the part of the working day unpaid by the capitalists. It is a temporal *terra nullius*.

■ The conceptual differences: The importance of transformations and rent

As I argued above, for Moore the locution “Work/Energy” is a novel typological way of referring to a synthesis of Work (value creating human labor) and Energy (general movement of bodies in space). But this wholeness is not given; it is not just a “good idea” that spontaneously arose. The transcendence of the separation between Thermodynamics and Value Theory requires a struggle that has not yet been completed. For example, it is not enough to simply state that Africans were considered part of Nature who do not own themselves (hence “naturally” are wageless). Nor is the recognition of their humanity is not a permanent achievement, and even their approaches to the creation of value are reversible, as President Trump’s characterization of the continent of Africa as a “shithole”. Those without capital in a capitalist world are always in the beam of the Interrogator’s lamp.

Moore is a dialectical thinker who has a principle of critique that assumes a unified whole which he calls “world-ecology”, and those who do not share in that unity are dismissed. He seems to be saying, “give me an apparent dichotomy and I will show you a hidden unity”. For example, give me Nature and Society and I will show you first Nature-in-Society and Society-in-Nature and then Nature/Society, like the faces of Janus. Deconstruction is not an option for Moore.

Moore’s dialectical methodology was not Marx’s for Marx definitely was not a committed dialectical thinker. Marx’s critique of Hegelian methodology was widely known and commented upon in Marxist discourse. Among the many expositors of such an interpretation is Karl Korsch, who expressed it well:

The principles of the Marxian critique of existing society, being proletarian and no longer bourgeois are opposed to the philosophical system of Hegel, not only in content, subject-matter and aim, but quite as much in theoretical form. If Marx, indeed, took his start from a critical and revolutionary reversal of the principles inherent in Hegel’s method, he certainly went on to develop, in a strictly empirical manner, the specific methods of his materialistic criticism and research.

(Korsch 2017: 41)

This assessment is accurate to this day, capital is still Cartesian: it does not

categorize animals, environments and machines as value creators (however useful they are in the creation of value), since they are not considered owners of themselves who are capable of introducing an element of negativity in the creation of value. Moore confuses what capitalists and their political economists say of capitalism and those who develop its critique. For example, in capitalism there is a tendency to reduce all objects into exemplars of the commodity form, i.e., into a totalitarian neo-liberal economy. But this does not mean that this reduction is complete and that there are no counter-tendencies. We should recognize the difference between a self-presented *description* and a *critique*. Marx, in Chapter I of Vol. I of *Capital* differentiates between political economies (classical and vulgar) that were the objects of his critique. What does “critique” mean in this context? It means countering a false self-description. It is not enough to counter that an analysis of capitalism is ontologically faulty because it is substantialist instead of being relational. For after all, the “substance/relation” of the Neo-Kantians like Cassirer is not new, one thing is to give an account of what capital says of itself and what its critique states. The former stands within the object, Capital, while the latter stands outside (even though Capital presents itself as an infinite, self-reflexive totality which nothing escapes). Capitalists might say of housework that it is valueless and that workers in the working day create no surplus value. Such a self-presentation would look accurate to a capitalist, since s/he is dealing with a transformed world that constructs itself “behind her/his back”. It would be like going to the tailor who made your jacket and ask, “how does it look?”

Moore seems to have an ontological preference for relations over substances. But this preference is not superior *a priori*. As I commented on Mirowski’s critique of Marx as a substance thinker, “After all, in the history of science one can often find nodes of transition from substance to field and then back again. Think of the complex dialectical dance in the history of quantum mechanics from wave (field) to particle (substance) and back again” (Caffentzis, 2013: 185).

■ Conclusion: Political Consequences

What is remarkable in Moore’s book is the absence of the notions of the autonomy and self-activity of the working class, also there is no mention of class composition, and of class decomposition and class recomposition. This is a surprise because Moore has been very diligent in applying many of the post-1968 Marxist notions beside work/energy. These include unwaged labor, refusal of work, reproductive labor, new enclosures, basic commodity, and metabolic rift, world system theory. He is especially adept in using the concept of unwaged labor that the theorists of the wages for housework movement brought into prominence in the 1970s and which has now become a staple of anti-capitalist discourse in general and the basis of Moore’s (and Patel’s) “cheaps”, especially “cheap labor” (Dalla Costa, 1972 and James,

2015), and (Federici, 2013 and Patel and Moore, 2017).

Moore, however, shies away from the working class's autonomous aspects in the post-1968 theoretical revolution. Capital and its class expressions always appear in his book to be in command or fighting within itself. There is no autonomous Other that struggles within, without and against capital that is operated by a self-active working class of a particular class composition (analogous to capital's organic composition) undergoing decomposition and recomposition. The class struggle exists for Moore but it does not have much self-activity either in its waged and unwaged faces. It is as if the accumulated impact of waged industrial workers had no weight either in history past or in history future.

Let us remember the opening lines of the *Communist Manifesto*: "The history of all hitherto existing society is the history of class struggles" (Marx and Engels, 1967: 79) and the class struggle cannot be "related" out of existence?

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