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SOLAR COMMUNISM

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ABSTRACT: A global economy powered by non-solar energy sources is limited by global warming, finite reserves and concomitant insults to the Earth's biosphere, including our own species. Some of these impacts, such as loss of biodiversity, will be irreversible. Without constraints on the reproduction of capital, the global driver of the contemporary environmental crisis, these impacts will intensify. This is not a necessary outcome for an economy utilizing the high efficiency capture of solar energy, a conclusion informed by consideration of the heat budget of the Earth's surface and the laws of thermodynamics. Such a solar-based economy managed by containment of the socially modified environment is a necessary condition for a global civilization realizing the Marxian concept of communism.

The main purpose of this paper is to provoke a rethinking of the Marxian concept of communism as a prospect for global civilization, particularly with respect to its energetic basis and the problem of optimizing society-nature relations now and in the future. This reinterrogation requires an understanding of the physical concepts of energy and entropy (i.e., thermodynamics). I will argue that these considerations lead to the conclusion that both solarization of the global economy and the application of the containment and precautionary principles are necessary for the ultimate realization of planetary communism, and these requirements should inform a viable socialist strategy.

Ever since Georgescu-Roegen (1971) revived entropy as a preeminent indicator of the ultimate limits of a growing economy, entropy has been employed to impute a theoretical physical basis for social prognostication (see Martinez-Alier, 1987). A considerable literature has appeared (see Daly and Cobb, 1989, for a representative use of Georgescu-Roegen's concepts; Rifkin, 1980, 1989, for a popularization). Georgescu-Roegen's writings have had wide influence on leading contemporary environmental theorists, such as Herman Daly, a seminal thinker on "ecological economics", as well as those with a Marxist perspective (e.g., Altvater, 1993, 1994; Dryzek, 1994).

However, a fog of confusion has been generated by Georgescu-Roegen's conceptual foundation. I will attempt to dissipate this fog, leaving visible what is of theoretical and practical usefulness to the issue at hand, the rethinking of the material basis for Marxian communism and prerequisites to its achievement.

We will begin with a look back at the formulation of the concept of entropy and the theory of the heat death of the universe, and its reincarnation in the use/misuse of thermodynamic entropy in contemporary studies of the environmental limits of economic activity.

1. Entropy and heat death

The thermodynamic concept of entropy arose directly from Carnot's theorization of the operation of the steam engine (see Cardwell, 1989). This theorization led to the formulation of the second Law of thermodynamics: the entropy of an isolated system (i.e., closed to transfer of energy or matter) must increase as a result of any change therein. There are dozens of equivalent ways of expressing the second law (the first states the

conservation of energy). One other formulation is relevant here: heat cannot flow from a cooler to a hotter reservoir without any other change (i.e., work must be done). The increase of entropy is equivalent to the increased inability of an isolated system to do work, resulting from the degradation of low entropy energy into waste heat (an isolated system is defined as being closed to both energy and matter transfers in or out, while a closed system is only closed to matter transfers). Entropy has been loosely defined as the measure of the disorder of a system. More precisely, thermodynamic entropy is the "randomized state of energy that is unavailable to do work" (Lehninger, 1965). In the classical interpretation, ultimately, all processes in the universe must lead to its "heat death" as the potential for further change is ended. As Cardwell put it:

"The cosmic role of heat, first discerned at the end of the eighteenth century and eloquently described by writers like Fourier and Carnot had thus, by way of Joule, Rankine and Kelvin, achieved its final definition by Clausius. This is not a balanced, symmetrical, self-perpetuating universe, as the development of rational mechanics, building on the foundations of Newton's *System of the World*, seemed so confidently to indicate. It is a universe tending inexorably to doom, to the atrophy of a 'heat death', in which no energy at all will be available although none will have been destroyed; and the complementary condition is that the entropy of the universe will be at its maximum." (Cardwell, 1989, 273.)

Not surprisingly, heat death was not accepted by Engels and most later Marxists, since this scenario embodies a deeply pessimistic perspective of natural evolution. Engels' (1987) decisive rejection is found in Dialectics of Nature. He asserts that the heat radiated into space must by some as yet unknown mechanism be re-utilized in the eternal cycle since motion in the universe is inexhaustible (see 561-563, 334). Haeckel (1900) shared Engels' view of the inexhaustibility of motion in the universe while accepting the applicability of the Second Law in local systems (246-247). The categorical rejection of heat death became accepted canon in official Marxism-Leninism:

"the "theory of the heat death of the universe" is completely unfounded and ignores the law of conservation (sic) and transformation of energy which asserts the indestructibility of motion not only quantitatively but also qualitatively, i.e., that motion cannot exist in only one form." (Afanasyev, n.d., 69)

And similarly:

"For systems consisting of an infinitely great number of particles (the Universe or the world as a whole) the concept of the most probable state loses its meaning (in infinitely large systems all states are equally probable). By taking into account the role of gravitation, cosmology arrives at the conclusion that the Entropy of the Universe grows without tending to any maximum (the state of thermal balance). Modern science proves the complete groundlessness of the conclusions of the allegedly inevitable thermal balance and "thermal death" of the world." (Frolov, 1984, 126-127.) (Note that another assumption of official Marxism-Leninism, the infinity of the universe, is used here to prove the invalidity of heat death.)

Soviet physicists and philosophers rejected heat death from a variety of positions. Even the great Lev Landau, not noted for his obsequious adherence to Marxism-Leninism, apparently rejected heat death from considerations of relativistic thermodynamics (Graham, 1987, 500, n. 39). Similarly, the eminent physicist and Einstein scholar B. Kuznetsov could not swallow heat death:

"Philosophy, in particular the philosophy of Engels, and 19th century statistical physics advanced rather convincing arguments against thermal death. Modern science, the theory of relativity and relativistic cosmology and, to no lesser extent, quantum mechanics, forces us to interpret the thermodynamics of the Universe from new standpoints that assumedly eliminate the inevitability of thermal death, although they still do not offer any concrete and unequivocal conception of the cosmic mechanism of forming temperature gradients, contrasted to thermal death" (Kuznetsov, 1977, 34.)

In other words, we are still waiting for the mechanism Engels was convinced could turn waste heat to low entropy energy! While a near consensus of rejection was held by the materialist camp, particularly of Marxist persuasion, supporters of the heat death scenario in the 19th and 20th century put it to good use in a broad range of ideological interventions. This history is discussed extensively by Martinez-Alier (1987) and will not be pursued in any detail here. One example will suffice: the argument for vitalism based on the purported anti-entropic quality of life and its evolution (e.g., Henry Adams, following Haeckel; see Martinez-Alier). The confusion embodied in this position is easily clarified by the fact that a living organism is an open system - the entropy in the environment therefore increases as a debt for any internal process - but this erroneous position lives on in many contemporary treatments (e.g., writings by creationists, followers of Lyndon LaRouche and by those who should know better).

Contemporary cosmologists have taken a fresh look at the heat death scenario. There is continued debate as to its validity in the context of cosmological theories of inflation, collapsing and expanding universes (see Davies, 1977, Barrow and Tipler, 1988, Coveney and Highfield, 1990, Barrow, 1994). For example, in a universe that will expand forever (cosmologists are still not sure whether our universe is in this class) the actual growth of entropy may never equal the maximum potential entropy, thus heat death may be indefinitely postponed (Barrow, 1994). With the increasing strangeness of new theories in theoretical physics it would be no surprise that the old heat death scenario may be reinterpreted in the future in a radically different form.

Whatever the eventual reinterpretation of ultimate heat death, its invocation in the present context and inconceivably far into the future is irrelevant to an understanding of the ubiquitous emergence of ordered (so-called "anti-entropic") systems in the universe (e.g., stars) and here on earth (e.g., life and society). This spontaneous self-organization of matter is consistent with the second law, since entropy always increases in the self-organizing system <u>plus</u> its environment. Ordering and its maintenance within the system generates a entropic flux passing into the local environment (see Bertalanffy, 1968, 40-41; on the thermodynamics of self-organization see Prigogine and Stengers, 1984).

The Earth is of course not an isolated system in a thermodynamic sense because of the incoming solar flux to the surface (and an equivalent radiant energy flux back out to space), but is closed to matter transfers (except for the trivial meteorite and space vehicle fluxes). (Footnote: We neglect here the energy flux coming from below the Earth's surface, arising from radioactive decay in the crust and mantle. While much smaller than the solar flux, this energy source is the basis of internally generated geologic activity such as volcanism, and is critical to the long term evolution of the crust and biosphere.)

Therefore, like the natural biosphere powered by solar energy, the ordering and maintenance of the material creation of human activity on the Earth's surface can continue far into the future by the export of an entropic flux into space, provided a long term energy source (the sun) is utilized.

2. Ecocatastrophe: the reincarnation of entropy in social prognostication

First the heat death of the universe, now immanent ecocatastrophe. In his writings, Georgescu-Roegen (see 1971) bridged the gap between entropy's earlier use and the contemporary interpretation bearing on economics, energy and the environment. (Footnote: Ironically, Georgescu-Roegen actually leaned at one point (1971; he changes his mind in 1976, 8) to rejecting the heat death scenario because of his favoring the steady-state cosmology (both entropy and matter are created and destroyed) while invoking entropic limits to economic activity, in his critique of neo-classical economic theory ("the ultimate fate of the universe is not the Heat Death... but a much grimmer state - Chaos"). Thus, while wavering on accepting the classical Marxist concept of the inexhaustibility of matter in motion on the scale of the universe, Georgescu-Roegen rejects its neo-classical analogue (economic cycle in a finite world without a limit) on the scale of the economy)

According to Georgescu-Roegen neo-classical theory conflicts with the second law: "the economic process materially consists of a transformation of low entropy into high entropy, i.e., into waste" (1971, 18) and as low entropy resources run out, especially fossil fuels, economic activity becomes increasingly limited by the accumulation of waste (pollution) and scarcity of energy (for a defense of the "orthodox" position see Arrow, 1981). Following Georgescu-Roegen's ideas, Daly and Cobb (1989) contend that we are rapidly approaching the physical limits to the further growth of the world economy since the growth of physical throughput will inevitably deplete the energy, materials and space on which it depends, with the concomitant progressive destruction of the biosphere. Future knowledge cannot "remove limits on the physical scale of the economy resulting from finitude, entropy, and ecological dependence" (Daly and Cobb, 1989, 199). (Footnote: This analysis has been recently critiqued (Boucher et al., 1993, drawing on Commoner's, 1990, arguments; also see Sagoff, 1995 and Daly, 1995 for a recent debate), and Daly himself has shown some indications that he has backed off from his original formulation, though it is repeated in the revised edition of Daly and Cobb.)

Furthermore, Georgescu-Roegen claims to have discovered a Fourth Law of Thermodynamics:

> "A. Unavailable matter cannot be recycled.
>
> B. A closed system (i.e, a system that cannot exchange matter with the environment) cannot perform work indefinitely at a constant rate." (Georgescu-Roegen, 1989, 304).

This purported law, however, is sheer nonsense since it neglects to account for the possible flow of energy through the system which is defined as closed but not isolated.

By converting low entropy, high temperature energy (e.g., solar radiation) to high entropy, low temperature heat, work can be produced to recycle indefinitely (see e.g., Bianciardi et al., 1993). Unfortunately, many recent discussions repeat this erroneous concept (e.g., Altvater, 1994, Dryzek, 1994). Interestingly, in one paper Georgescu-Roegen (1976) defines “closed” as entailing “no exchange of matter or energy with [the] environment” (recall that in thermodynamics this is defined as an “isolated” system, not “closed”); he still maintains that according to the second law matter along with energy is subject to “irrevocable dissipation” (8). This confusion may be linked to his pessimistic view on harnessing solar energy (see below), since the latter is the relevant energy flux to consider for the closed but not isolated system containing economic activity on the earth’s surface. This distinction between closed and isolated systems is also central to the problem of optimizing society’s relation to nature (an issue to be discussed latter in the paper).

In Rifkin’s hands (1980, 1989) the entropy concept is extended to its apocryphal limits: entropy as a pollutant, as an indicator of cosmic disorder, the inexorable outcome of all economic activity, the mother of ecocatastrophe (note that Georgescu-Roegen enthusiastically endorses Rifkin’s treatment of the subject, in his After word to Rifkin’s book). To his credit, he does outline the necessity of shifting to a solar economy, albeit with a strong Luddite flavor. Rifkin favors a pre-industrial global population of less than 1 billion people (1989 edition, 254), and rejects the use of computers since they generate entropy (1989 edition, 190-191)!

While Georgescu-Roegen’s views on entropy and the economy are questionable, his work has stimulated welcome and wide-ranging debate on physical-environmental constraints of economic activity. As we will see in the next section, his critique is particularly fertile for an economy based on non-renewable energy.

3. *Thermodynamic entropy: its use/misuse and redundancy in ecological economics*

Before going further, it is helpful to distinguish between the entropy of thermodynamics, statistical mechanics and information theory/computation (see Proops, 1987; Rothman, 1989). The latter two “entropies”, particularly the statistical mechanical, have deep, though debatable connections to thermodynamic entropy. The entropy of information theory, especially as a measure of concentration to a set of probabilities (see Proops, 1987), has found wide and useful application in economics and the social sciences. In this discussion we will only consider the application of classical thermodynamic entropy to economics and the environment. Thus, I will not consider the interesting attempts to apply non-equilibrium and far-from-equilibrium thermodynamics to understand self-organization in the economic and social realms (see e.g., Dyke, 1988 and M. O’Connor, 1991).

A fundamental criticism of Georgescu-Roegen’s (and Rifkin’s) invocation of entropy is that material/energy transformations in an economy take place far from equilibrium, thus it is incorrect to use the thermodynamic entropy of near equilibrium processes for its description (see Morowitz, 1986). An analogous criticism has been made of its similar use in modeling biotic and climatic processes, but deep insights can be obtained from the near-equilibrium approximation if its limits are appreciated (see Schwartzman et al., 1994).

Does the thermodynamic entropy concept really give us any insight into the environmental effect of economic activity? As a first order deduction: in an economy run on fossil fuel energy, which of course has finite reserves, the second law simply indicates that energy to do work is not renewable, i.e., you cannot "reuse" waste heat ad infinitum (true of waste heat from using solar energy as well) nor can you regenerate the low entropy energy reserve (with solar energy the sun does this for you!) (see Rothman's critique of Rifkin; Rothman, 1989).

Beyond this basic insight, the concept is really redundant to a simple consideration of the energy budget alone in understanding anthropogenic heat pollution and the enhanced greenhouse, but is useful in considering gaining insight into issues of recycling and pollution and energy conservation. (Footnote: Evaluation of alternative ways of accomplishing the same goal (e.g., heating a house) using second law efficiencies (the ratio of the least available work that could have done the job to the actual available work used to do the job) can lead to substantial savings of energy; see Commoner, 1976, and Ford et al., 1975).)

Consider the energy budget at the Earth's surface. Globally the solar energy flux to the atmosphere/surface equals the flux radiating back to space, similarly for energy budget at the surface itself. Most of this solar radiation (visible light) is irreversibly converted to heat radiation (infrared) at the surface (other natural sources of heat such as geothermal are trivial compared to the solar flux). If the Earth surface were perfectly reflecting, with an albedo equal to one, then no heat radiation would be emitted. The natural greenhouse effect is caused by the absorption of heat radiation by molecules of water and carbon dioxide in the atmosphere and its re-radiation to the surface. Were it not for this greenhouse effect the Earth's surface would be about 30^{o}C cooler. Any economy based on energy sources other than the direct solar flux impinging on the Earth's surface (i.e., fossil fuels, the stored solar energy of past geological epochs, as well as nuclear and geothermal energy) must inevitably alter the heat budget by the emission of heat radiation over and above the natural flux from the surface. Such direct anthropogenic heat pollution presently accounts for 0.03% of the solar flux impinging on the land surface (Smil, 1992); localized however in cities and industrial centers, it produces the heat island effect, the elevation of temperature in and around cities (see further discussion of the latter in the next footnote). Much more serious is the well-known, enhanced greenhouse effect resulting from anthropogenic carbon dioxide and other gaseous emissions such as methane (see Lovejoy, this issue). A solar-based world economy would not affect the Earth's surface heat budget (except in its initial "parasitic" phase, relying on fossil fuels and nuclear power), providing the tapping of solar energy involves no net transfers of carbon dioxide, methane or other greenhouse gases to the atmosphere/ocean system (e.g. by deforestation, flooding from big hydropower projects). Tapping solar energy directly merely utilizes a small part of the immense flux to do work which ultimately would be simply converted into waste heat anyway, as in the case of natural heat budget (anthropogenic albedo changes such as making the surface darker may result in changes in the surface heat budget, but globally they are small compared to other effects).

Regarding the energy cost of recycling, cleaning up and/or restoring the biosphere, and mining/refining mineral ores with increasingly scarce concentrated sources, the same argument applies, since fossil fuels, nuclear and geothermal all insult the biosphere by incremental heat as well as by pollution effects (e.g., nuclear power results in significant thermal pollution of bodies of water along with the other well-known effects, nuclear power has been largely parasitic on fossil fuels). A non-solar economy must generate additional insults in the cleanup or recycling process, since its very use must pollute thermally and materially.(Footnote: These effects are of course on top of the problem of diminishing reserves of fossil fuels (see Lovejoy, this issue), finite lifetimes of geothermal reservoirs, all which make the “soft path” essential into the next century. A practical source of fusion energy might eventually be powered by the essentially inexhaustible supply of deuterium in the oceans, with minimal impact on the environment other than incremental heat production. Even if some form of “cold fusion” should ultimately be developed the incremental heat problem will remain. For an anthropogenic heat production of some 100 times the present, a 2^{o}C increase in the global mean surface temperature is estimated (Kellogg, 1978). However, since the release of anthropogenic heat would likely be highly localized, the heat island effect would be significantly magnified at production levels far below that value.) This is not a necessary outcome for a solar-based economy. It is curious that no recent literature on this subject makes this simple observation in a clearly stated argument that emphasizes its profound significance. Georgescu-Roegen (1976) makes the essential point at least once, but fails to develop it (in later writings, such as his after word in Rifkin (1980, 1989), he is less optimistic about the prospects for direct use of solar energy, seeing it as “parasites of the current technology” (1989, 304):

“any use of solar energy is *pollution-free*. For whether this energy is used or not, its ultimate fate is the same, namely, to become dissipated heat that maintains the thermodynamic equilibrium between the globe and outer space at a propitious temperature.” In a footnote to this passage he points out: “One necessary qualification: even the use of solar energy may disturb the climate if the energy is released in another place than where collected. The same is true for a difference in time, but this case is unlikely to have any practical importance.” (Georgescu-Roegen, 1976, 28).

In a more recent publication (Daly, 1992) defending Georgescu-Roegen, Daly makes no reference to this concept, although he comes close in two places (Daly, 1991, 226, cited in Haavelmo and Hansen, 1992, 42). More typical is Jacobs’ (1991) treatment. He argues that “solving the entropic problem” lies in the direct collection of solar energy, because it generates little or no pollution in use (115), but indicates in a footnote “All use of energy generates thermal pollution (heat)” This begs the question since what counts is incremental heat over and above the natural flux off the Earth’s surface.

However, there is an entropy concept which sheds some light on the impact of recycling and pollution, as well as the energy requirements of mining and refining mineral ores, one that is alluded to above, the entropy of mixing. Entropy is produced in any actually occurring process, including mixing heterogeneous substances. Faber et al., 1987, employ the concept of entropy of mixing in their treatment of resource extraction and pollution. A simple example is instructive: much more energy is required to recover the perfume molecules from a room than to transfer the perfume in a closed container. The entropy of mixing is a measure of the energy cost to recycle or restore the biosphere (e.g., partially restore strip mined land); the greater the dispersal of recyclable material or scale of physical disruption, the greater is the energy cost. It is also an index of the energy required for extraction of an element from an ore; in general, the lower the grade of ore (concentration), the greater the energy required. With pollutants, the relation of the entropy of mixing to adverse environmental impact is more complex. The same relation for recyclable material of course applies to the energy cost of cleaning up pollution. However, the more dilution occurs for a given amount of pollutant (e.g. Pb), the higher the entropy of mixing (for unmixed Pb sitting in a container, the entropy of mixing is zero), but the lower the impact on the biosphere, below a certain threshold concentration. Above this concentration, however, the impact is spatially widened and may become global (e.g., could chlorinated hydrocarbons, globally dispersed, be responsible for the apparent disruption of hormonal balance in various animals, including humans?).

Qualitative factors are of course critical to the actual impact of a pollutant. These factors include toxicity, biodegradability, residence time, instability, is the pollutant naturally occurring or artificial?, etc. There are analogous considerations for the energy required for extraction/refining a mineral resource (e.g., chemical and physical state, the technology employed). <u>These qualitative factors have no simple parameterization in an expression for entropy of mixing</u> (see Faber et al., 1987, 124). Even in a solar economy, some pollution could occur (of course adverse effects on workers and the community already occur in the embryonic renewable energy industry; witness Silicon Valley). The concepts discussed will have utility then, and during the solarization transition.

4. Solar communism?

Human needs, nature's needs. The relevance of the preceding discussion to a rethinking of the Marxist concept of communism will now be examined. According to the classical tradition, the communist socioeconomic formation can only be reached with an end to scarcity, presupposing an abundant and continuous source of energy. Is this concept now imaginable in any plausible sense that could motivate an effective political practice? In what follows, and despite anticipated derision from the postmodernist camp, I will argue for such a vision, one of a future that also necessarily entails the utilization of the full potential of the information revolution and a radical modification of present society-nature relations.

We begin with a consideration of human needs, since the promise of their satisfaction is central to Marx's concept of communism ("from each according to his ability, to each according to his needs"). Utopian thinkers historically have always postulated that human needs could be met at existing technological levels, but for class exploitation and oppression. The technology of every age has its utopia (e.g., Kropotkin, 1989, at the beginning of this century). Of course, each age, particularly contemporary capitalism has expanded the realm of perceived human need. Human needs are of course problematic, generated by political struggle and cultural history. Beyond physiological necessities (as the number of calories, vitamins etc. needed for optimal health, itself not entirely without uncertainty) and the other conditions for healthful life such as an unpolluted environment, adequate shelter, and loving relationships, our needs, both material and spiritual, are largely social constructs. Of course even the prospect of substantially extending the human life span will be a social construct, while becoming an arguably new entitlement for all human beings. Doyal and Gough (1991) have eloquently argued for an objective basis underlying common human needs worldwide. Nevertheless, many "needs" under capitalism are obvious creations of consumerism, itself a direct outcome of the unfettered reproduction of capital, and must be the terrain of political struggle since these "needs" in turn reproduce unhealthful conditions for both humans and the biosphere (e.g., polluting cars, wasteful packaging, high fat diets etc.). Further, both the ability and needs of a healthy biosphere are not without some uncertainty: for example, what constitutes sustainable yields of wood, fish, how much of the biosphere should be left relatively pristine in "biosphere reserves"?; etc.

An end to scarcity, at least in respect to objectively defined needs, could arguably only occur in a planetary civilization, given the great disparity in the human condition at present. Here again we can anticipate the continual creation of new human needs, with the elimination of old ones (e.g., with the extension of human life span, new possibilities for travel, like vacations on Mars!). However, all this speculation surely appears as escapist fantasy in face of the colossal challenges facing humankind today, with millions barely surviving even in the cities of the industrial world.

With the new level of anthropogenic impacts of capitalism on the biosphere, the "second contradiction" of capitalism as theorized by James O'Connor (1988; see also numerous articles since then in same journal), between the forces/relations and conditions of production (above all nature, but also the artificial environment, which of course includes the workplace and urban communities), has now emerged with global consequence. The second contradiction of capitalism forces a reexamination of the very principle proposed to guide a communist society: "From each according to her ability, to each according to her needs". Should not "each" and "her" now refer to both human beings and nature (ecosystems)? Further, if "socialism" as a transition to communism is to be viable, this new principle must arguably be progressively applied to this mixed social formation, between two modes of production. Indeed, the convergence of the green and socialist movements may be for the same reason a necessary condition for the very possibility of opening a path to communism via socialism.

Energetics. But what are the implications of the ecological question within socialist theory to the energetic basis of human civilization meeting both human and nature's needs? Bernal (1959) speaking from another age (only three decades ago!) believed that a source of abundant cheap energy (nuclear energy) could soon "liberate man completely from want" (270). It would be "freely available as air and light are today" (49), ironically echoing President Eisenhower's promise to the U.N. some years before. He observed that one possible drawback in its greatly expanded use was overheating the Earth's surface. Presciently, Bernal noted the following concerning solar energy:

"For this source of energy is so diffused that the real difficulty is in finding any cheap way of concentrating it from large surfaces...This may not always be so difficult. Indeed, by the use of cheap thermo-electric substances transforming the heat of sunlight directly into electricity, it may very soon be possible - at least in sunny climates to rival atomic energy in cheapness and certainly in simplicity and safety." (46.)

After Chernobyl and escalating costs of electricity from nuclear energy, the nuclear option appears much less attractive as an energetic basis of global civilization. What then of solar?

I contend “planetary solar communism”, harnessing the power of present and soon-to-be-developed technologies of information and renewable energy, is a plausible vision of future global civilization.

A transition to renewable energy from fossil fuels and nuclear energy, the “soft path” advocated by A. Lovins, will make possible a radically new global economy, sustainable and growing. As Barry Commoner (1990) has pointed out, we are far from approaching physical limits to growth. The world economy could increase its energy consumption say 10-fold by simply tapping 1% of the solar radiation now impinging on the earth’s land surface without altering the present heat budget of the earth’s surface via greenhouse gas emissions or direct waste heat production (unlike the use of fossil fuels and nuclear energy). The annual flux of solar radiation to the earth is approximately 10 times the total energy stored in the global coal resource or one million billion (10^{15}) barrels of crude oil (Smil, 1991). Contrary to Daly and Cobb’s (1989) generalization regarding the limits to economic activity, the use of solar energy will make possible an increase in the physical throughput (material processing) in the human-made technosphere without adverse impact on the biosphere, provided the production- consumption cycle is closed (i.e., recycling, waste-free technology). Actually, the restoration of the biosphere, along with the task of raising the quality of life of all to the highest world standards, may require a substantial increase in global energy consumption, until this transition is completed.

Nevertheless, there is deep skepticism with respect to the possibility of solarizing a modern industrial economy. Georgescu-Roegen viewed the technology of the direct collection of solar radiation as “feasible” but not “viable”, i.e., possible to construct and operate, but only by continuing to rely on fossil fuel energy inputs:

“all solar recipes <u>known at present</u> are parasites of the current technologies and therefore, will cease to be applicable when their host is no longer alive” (1981, 70-71). He argues that “in spite of the unusually large funds spent by public and private agencies bent on finding a solution to the unavoidable exhaustion of fossil fuels, it has not been possible to set up even a pilot plant in which solar collectors of one kind or another would be produced only with the energy collected by that conversion.” (198).

These views are surprising, given the fact that the utilization of fossil fuels was once “parasitic” on recently collected photosynthetic energy (i.e., food for humans, beasts of burden and wood). Nevertheless, Georgescu-Roegen’s views on solar technology’s viability are apparently shared by several later writers influenced by his thinking:

“Solar energy in no way offers a “Promethian” discovery like the harnessing of fire in the Neolithic revolution or the concentration of steam for energy in the Industrial Revolution. For solar energy converters require so much space and so many inputs that the gain in useful energy would be outweighed by the investment in energy and materials.”

(Altvater, 1993, 223-224).

However, Daly is not convinced Georgescu-Roegen is right on this issue (see Daly and Umana, 1981, 174). Even Arrow, Georgescu-Roegen’s “orthodox” economist opponent is more optimistic:

“We may evaluate new sources of energy in ways which use current prices based on current uses of nonrenewable sources of energy. Thus, photovoltaic solar cells are produced with conventional energy sources and priced accordingly. These availabilities and prices could not persist into an era in which all energy is solar. The means of acquiring solar energy would themselves have to be produced with the aid of solar energy...It seems very likely to me that even with existing techniques a world run purely on renewable energy (a stationary state) would be feasible. No doubt it would be a considerably poorer world than we have now, but we might expect technological improvements to remedy that. After all, no great breakthroughs in scientific or technological principles are needed, much less than for successful power from fusion; all that is required is a series of improvements which have quite frequently accompanied great expansions of an industry." (113.)

On the issue of "viability" of direct collection technology, one recent study (Kuwano, 1994) estimates an energy payback time (number of years that are required for solar cell modules to generate the same amount of electric energy as consumed in their fabrication) of 1-4 years for two different silicon-based photovoltaic systems. Photovoltaics now have a bright future as a preeminent renewable energy source (see Stone, 1993). Land use requirements are large, but not inconceivable, particularly if revolutionary new advances in photovoltaic conversion efficiency come to fruition (The Scientist, 1994). Stone estimates that all electricity generation requirements in the U.S. could be met by present silicon-based photovoltaic modules on a land area 140 x 140km, an area far less than that presently used for U.S. military installations (Golob and Brus, 1993). (Footnote: Plausible scenarios for the soft path are found in Pimentel et al., 1994 (for the United States) and Boyle, 1994 (for the world). For a critique of other technical objections see Schwartzman, 1995, and Sagoff, 1995, for a rebuttal of pessimistic views on solarization. Further discussion of the plausibility of a solarization scenario is found in Lovejoy (this issue).)

A future global economy energized by the direct collection of solar radiation, at high conversion efficiencies would be, to use that old Hegelian-Marxist metaphor, a negation of the negation of pre-industrial energetics powered by recent/current solar flux via photosynthesis, highly inefficient, the latter being first negated by industrial society powered by fossil fuels which released stored solar energy trapped millions of years ago (see Smil, 1991, for conversion efficiencies and multifold details).

Environmental policy. Solarization of the global economy is a necessary but not sufficient step towards radically limiting the environmental and ecological impacts of economic activity. I propose reconsideration of a radical solution to optimizing the relation of the technosphere to ecosphere: maximizing the containment of the technosphere, as originally argued by Taylor and Humpstone (1973), in a seminal, if now forgotten book. The technosphere is defined as the human created and modified environment while the ecosphere is the "natural" world (Commoner, 1990). (Footnote: The technosphere includes urban/suburban areas, roads, agricultural land, and forested land substantially modified by harvesting. Second growth forest (such as in much of New England, U.S.) is at the problematic boundary between the technosphere and ecosphere, since anthropogenic and natural perturbations often produce convergent results, but not necessarily at the same scale or speed (e.g., forest fires). However, to relativize humans and their technosphere as simply part of "nature" is an argument that can be used to justify any alteration of ecosystems as "natural" and therefore acceptable. The ecosphere and its subsystems ("ecosystems") exist with varying degrees of anthropogenic impact, that are increasingly well documented historically and spatially and distinguishable from natural processes (e.g., global pollution by lead, identified by isotopic tracing).) Other views of natural ecosystems absolutize aspects of their natural character; e.g., the phenomenon of temporary steady states is presumed to imply a state of permanent balance were it not for anthropogenic influences (Gore, 1992), an obsolete ecological concept (see Botkin, 1990).)

Today, the boundary between the technosphere and ecosphere is neither closed nor isolated (since they both exist on the Earth's surface, except in the most trivial sense they are presently closed with respect to the space environment, but not of course isolated because of the flux of radiation in and out). Implementation of solarization and the containment principle with respect to the technosphere will close the ecosphere to radiative inputs incremental to the surface fluxes, to inputs of substances and genetic information not naturally present (e.g., CFCs, chlorinated hydrocarbons, genetically engineered organisms) as well as to fluxes of naturally present substances above trivial levels compared to those in the ecosphere (e.g., nitrates; the anthropogenic flux of fixed nitrogen from fertilizer, power plants etc. is now approximately equal to the natural flux from nitrogen-fixing microbes and lightning).

The containment strategy is a marked departure from much of the Marxist (and Leninist) tradition. Marx (and Engels) wrote that "communism differs from all previous movements in that it overturns the basis of all earlier relations of production and intercourse, and for the first time consciously treats all natural premises as the creatures of men, strips them of their natural character and subjugates them to the power of individuals united." (Marx and Engels, 1947, 70). "Really free working...is the most intense exertion. The work of material production can achieve this character only ... when it is of a scientific and at the same time general character, not merely human exertion as a specifically harnessed natural force, but exertion as a subject, which appears in the production process not in a merely natural, spontaneous form, but as an activity regulating all the forces of nature." (Marx, 1973, 611-612). Frolov's (1989) position is typical for Leninists:

"It is the purposeful transformation of nature and optimization of biosphere on the basis of continued scientific and technological progress that will bring about harmonization of human interaction with nature" (Frolov, 1989, 12, italics in the original)

This view follows naturally from Vernadsky's concept of the noosphere, as a new stage of the global biosphere:

"Mankind taken as a whole is becoming a mighty geological force. There arises the problem of the *reconstruction of the biosphere in the interests of freely thinking humanity as a single totality*. This new state of the biosphere, which we approach without noticing it, is the noosphere." (Vernadsky, 1945, 9, italics in the original)

Vernadsky's conception of the noosphere converged with the ambitions of the socialist planners of the Soviet economy (Bailes, 1990), who were responsible for colossal industrial projects that resulted in enormous environmental destruction (Feshbach and Friendly, 1992; cf. Adabashev, 1966). Whether or not this outcome was "over determined" is another issue. Some of the biggest planned projects (e.g., the diversion of Siberian rivers to arid Soviet Central Asia) were narrowly averted as a result of the intervention of the Soviet ecological movement (Feshbach and Friendly, 1992).

Nevertheless, there is another legacy of Vernadsky, the science of biogeochemistry, which is of vital importance to understanding environmental impacts (e.g., global warming which is the product of anthropogenic effects on the biogeochemical cycle of carbon which consists of all the fluxes of carbon through surface systems, including the biomass) and optimizing the relation of society to nature (see Kamshilov, 1976). The incompleteness of our knowledge in this science, and especially the *possibility of inherent unpredictability of anthropogenic impacts* (Ayres, 1993) underlies the necessity for the containment and precautionary principles.

With the management of the global economy guided by these principles regulation and mastery of nature assumes a new content. No longer will nature be transformed and degraded. The ecosphere will be exploited as never before, but as a source of knowledge, and not material. Its biodiversity will be mined but not reduced. Knowledge of the ecosphere - its ecology, biogeochemical dynamics, biodiversity - will flow into the technosphere, driving its productive forces and internal transformation. For example, agricultural systems, a key component of the technosphere, will be transformed in multifold ways, with open field crops becoming polycultures, utilizing ecologic pest control ("agro ecology"; see Levins and Lewontin, 1985) and a big expansion of greenhouses, with potentially high productivity gains (see Taylor and Humpstone, 1973).

Containment of the technosphere is a radical application of the precautionary principle, as well as a solution to the problem of future generational representation in today's decisions, since it maximizes the preservation of the present ecosphere for the future. It is likewise a recognition of the inherent economic incommensurability of biospheric values, a recognition that appears impossible under unfettered capital reproduction, without real social governance of production and consumption (see discussion in Martinez-Alier, 1987, and Burkett, this issue). Containment does not necessarily mean a non-intervention policy to natural threats to the ecosphere, such as catastrophic volcanic eruptions, or impending large meteorite collisions (at least the latter could conceivably be averted by human intervention using nuclear weapons to divert the incoming body!). Further, the reversal of global anthropogenic alterations (e.g., elevated levels of carbon dioxide in atmosphere) may require breaching the containment barrier (e.g., sequestering carbon dioxide using solar based technology), but such breaches should be made with great care and only under extraordinary conditions. Since no single containment wall is impermeable, and the technosphere is by definition for human habitation, the technosphere should employ non-toxic, closed cycle technologies. The physical limits to decentralization of human settlement will likely be imposed by the globally agreed upon allotment of relatively pristine biosphere; one plausible scenario is the construction of Soleri's arcologies (1969), compact "cities in the sky" coexisting with dispersed small relatively self- sufficient communities/bioregions embedded in restored biosphere. Only the most naive can believe that something like the scenario outlined above could be achieved without a powerful transnational political movement organized at the grassroots. (Footnote: The relevance of the population growth question to technosphere-ecosphere relations deserves an extended treatment, which will not be attempted here. Implicit in this paper is the assumption that rates of population growth and the limits to the presumed carrying capacity of the biosphere are largely dependent functions of political economy and technosphere/ecosphere relations, and not independent factors driving the "environmental crisis". Even quite poor states in the Third World have achieved remarkable reductions in population growth under governments which foster high literacy, empowerment of women and provision of basic needs (see Sen, 1994). See Lovejoy, this issue, for further discussion.)

Information technology. A vision of solar communism also requires the realization of the full potential of the information revolution, opening up the possibility for the flowering of human creative life activity for all. Bernal (1959), like others of his time, predicted the vast expansion of automation in industry and service sectors, guided by the electronic computer, which would have the potential to substantially shorten the work week. We are now deep in this technological revolution. Of course, it would be naive to expect these new technologies of information and renewable energy in themselves, while necessary, to be sufficient to free labor time on an equitable basis nationally, much less globally; this is critical challenge for national and transnational labor and socialist movements. The creation of this disposable time for all was seen by Marx as the necessary foundation for communism:

"The free development of individualities, and hence not the reduction of necessary labour time so as to posit surplus labour, but rather the general reduction of the necessary labour of society to a minimum, which then corresponds to the artistic, scientific etc. development of the individuals in the time set free, and with the means created, for all of them." (Marx, 1973, 706))

Gorz has followed up Marx's insights in his conception of socialism (his coquetry with using the term "communism" was surely political expediency): "A new utopia is needed if we are to safeguard what the ethical content of the socialist utopia provided; the utopia of a society of free time. The emancipation of individuals, their full development, the restructuring of society, are all to be achieved through the liberation from work. A reduction in working hours will allow individuals to discover a new sense of security, a new distancing from the 'necessities of life' and a form of existential autonomy which will encourage them to demand more autonomy within their work, political control of its objectives and a social space in which they can engage in voluntary and self-organized activities" (Gorz, 1989, 101.) Gorz sees this struggle for emancipation as central in contemporary capitalism, increasingly incapable of providing full-time employment for all able-bodied workers. This critique has clearly influenced the program of the European greens (e.g., campaign for a basic income; see Van Parijs, 1991).

5. The transition

Socialist transition: this of course is the immense challenge now facing all who see this world with unfettered capital as an unacceptable reality and are not satisfied with patch-work reforms. The political economic obstacles to realizing the potential of information/renewable energy technology are formidable to say the least. While technocratic projections of Worldwatch (see Luke, 1994) are highly optimistic, the power of transnationals and nation states desiring to prolong global dependence on fossil fuels should not be underestimated. Likewise, plausible scenarios of continued neocolonial subjugation of the "south" under the rubric of promoting solar energy are conceivable (e.g., a Saharan photovoltaic network controlled by transnationals supplying power to Europe under highly unequal arrangements of exchange). However, a path to a viable socialism is necessarily a "soft" path, with a sustainability coalition providing critical political force. While a coalition for sustainability will overlap with the coalitions for disarmament and democratic reforms, drawing in diverse class and social forces, including at times even fractions of monopoly capital (Footnote: This suggestion I am sure will infuriate the purists.), progress towards a sustainable economy objectively advances the possibility of a new socialist economy. While there are sectors of capital that may at times support parts of a sustainability program (while opposing other parts; e.g., manufacturers of computer chips, electric cars or wind turbines may bust unions, use hazardous materials poisoning their workers and polluting their communities etc.) there are powerful sectors, notably the transnational petroleum corporations, that will vigorously oppose it (witness the Gulf War; see O'Connor, 1991). Their power can only be matched by the transnational solidarity of trade unions, the green and anti-imperialist/peace movements, of a level not yet achieved.

6. Conclusion

The heat death of the universe scenario of the 19th century has been resurrected as the attractor state for the global economy, a state of chaos and degradation, by Georgescu-Roegen and his followers. This conception is based on the mistaken conflation of the thermodynamic concepts of closed and isolated systems. A global economy powered by high-efficiency capture of solar energy avoids this attractor for the indefinite future. Solarization along with containment of the technosphere are material prerequisites for a global civilization realizing the Marxian concept of communism, while optimizing its relations to nature. These considerations should inform a viable ecosocialist movement.

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